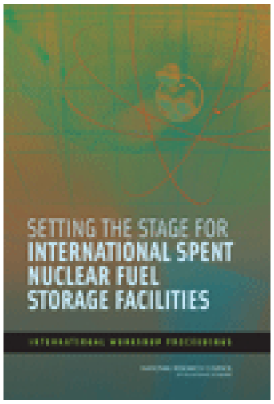

Setting the Stage for International Spent Nuclear Fuel Storage Facilities: International Workshop Proceedings

Glenn Schweitzer and Kelly Robbins, Editors, Committee on Issues in Consolidating Spent Nuclear Fuel at International Storage Sites, Office for Central Europe and Eurasia Development, National Research Council

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SETTING THE STAGE FOR **INTERNATIONAL SPENT NUCLEAR FUEL STORAGE FACILITIES**

INTERNATIONAL WORKSHOP PROCEEDINGS

Glenn Schweitzer and Kelly Robbins, Editors

Committee on Issues in Consolidating Spent Nuclear Fuel at
International Storage Sites

Office for Central Europe and Eurasia
Development, Security, and Cooperation
Policy and Global Affairs

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Preface

In May 2003, the Russian Academy of Sciences (RAS) and the National Academies organized an international workshop in Moscow on the scientific issues relevant to the establishment and operation of an international spent nuclear fuel storage facility in Russia. The papers presented at the workshop were published in 2005 in *An International Spent Nuclear Fuel Storage Facility—Exploring a Russian Site as a Prototype: Proceedings of an International Workshop*.

Given the broad international interest in this topic, the academies decided to organize an international workshop on important issues that were not on the agenda or were not adequately discussed at the first workshop. These issues included international monitoring at the facility, transportation requirements, liability and insurance concerns, and status of Russian legislation and regulations that are important in locating and operating a facility. Relevant experience from Europe, the United States, and Asia was also considered. The Workshop on Setting the Stage for International Spent Nuclear Fuel Storage Facilities was held in June 2005 at the Vienna International Center with the participation of the International Atomic Energy Agency (IAEA).

A second session of this workshop was held in Washington, D.C., in October 2005. At this session, an overview of new developments concerning the proposed facility was presented. Also, a representative of the U.S. government made a presentation on policy for shipments of U.S.-origin spent fuel to Russia by any country. The U.S. government was opposed to such shipments at that time.

This report includes the papers that were presented in Vienna and Washington, D.C. Together with the proceedings from the 2003 workshop, the report provides an overview of some of the issues that were of concern to the Russian government and to the international community at that time. Since the U.S. government modified its policy in 2006 so as not to oppose shipment of spent nuclear fuel to Russia, these publications take on additional significance. They provide useful background for those organizations and individuals involved in further development of an international spent nuclear fuel storage facility in Russia.

ACKNOWLEDGMENTS

Special appreciation is extended to George Russell, who had the foresight to provide generous financial support for both the first and second workshops and for the publication of the proceedings. Also, the support of the RAS, and particularly Academician Nikolay Laverov, was critical to the success of these workshops.

The statements made and views expressed are solely the responsibility of the individual authors and do not represent the positions of the Russell Family Foundation, the National Academies, the Russian Academy of Sciences, or other organizations where the authors are employed.

This volume has been reviewed in draft form by individuals chosen for their technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for quality. The review comments and draft manuscript remain confidential to protect the integrity of the process.

We wish to thank the following individuals for their review of selected papers: Mark Abkowitz, Vanderbilt University; Carl Alexander, Battelle Memorial Institute; Robert Bernero (Retired), U.S. Nuclear Regulatory Commission; Matthew Bunn, Harvard University; Margaret Chu, M.S. Chu & Associates, LLC; Charles McCombie, Arius Association; and Frank von Hippel, Princeton University.

Although the reviewers listed above have provided constructive comments and suggestions, they were not asked to endorse the content of the individual papers. Responsibility for the final content of the papers rests with the individual authors.

Special thanks are extended to Kelly Robbins for her translation of some of the Russian language papers into English.

Milton Levenson, *Chair*, National Research Council Committee on Issues in Consolidating Spent Nuclear Fuel at International Storage Sites

Glenn E. Schweitzer, *Director*, Office for Central Europe and Eurasia, National Research Council

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VIENNA, JUNE 1-2, 2005

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Welcoming Remarks

David N. McNelis
University of North Carolina, Chapel Hill

On behalf of George Russell, sponsor of this meeting, I would like to extend a welcome to this second interacademy workshop focusing on Russia's plans to host a site for the storage of spent nuclear fuel of international origin.

As some of you are aware, George Russell developed an interest in stored nuclear materials after traveling in Russia on numerous occasions and visiting nuclear sites elsewhere in the world. Subsequently, he created a small organization that I lead (Nuclear Fuel Cycle Technologies—NFCT), which has been sponsoring activities with a primary focus on the destruction of spent nuclear fuel.

Currently, he is sponsoring a number of graduate students in the Department of Nuclear Engineering at North Carolina State University. All of these students are working on some aspect of transmutation technologies or the thermal impact on repository design and performance.

George Russell also sponsored the first interacademy workshop on the international spent nuclear fuel (SNF) storage site, which was held in Moscow in May 2003. Russia is the first country that has offered to host a storage site for SNF of foreign origin that is not linked to a reprocessing plant. NFCT's interests include ensuring that an international body, presumably the International Atomic Energy Agency, would provide oversight for such an activity and develop international standards for siting, safeguards, and operations. NFCT also has an interest in reducing the number of sites around the world where SNF and other high-level radioactive materials are placed. With this in mind, NFCT is interested in the Russian site, which might be operated as a regional pilot program. Perhaps eventually there would be a small number of sites around the world where such materials are stored, reprocessed, or placed in geological repositories.

The other Russian project of interest to NFCT is still in the design phase.

While here in Vienna and over the next few months, I hope to develop an acceptable plan for the study. This work would be carried out in Dmitrovgrad, where one of the research reactors with an appropriate neutron spectrum would be used to expose partitioned components of the SNF or SNF segments. The isotopic inventory would be periodically assessed to determine the efficacy of the process and to compare the results with those produced by simulations of mathematical models. Although it is widely accepted that beneficial transmutation is possible, results to date have only been simulated.

With that brief background on NFCT's interests, welcome and best wishes for a productive workshop.

2

International Monitoring of Storage and Disposal Facilities: The Potential Role of the International Atomic Energy Agency (IAEA)

Bruno Pellaud[*]
Switzerland

Over the past few decades, the countries with operating nuclear power plants have attempted to develop domestic solutions to the disposal of what they consider to be radioactive wastes, be it high-level wastes resulting from chemical reprocessing of spent fuel at home or abroad or direct disposal of spent nuclear fuel. These efforts have been met with mixed success. Large nuclear countries, such as the United States, Russia, France, and the United Kingdom, have not yet succeeded in bringing into operation suitable disposal facilities. Small countries, in particular Finland and Sweden, have overcome the corresponding technical and political hurdles to achieve the objective of a truly closed nuclear fuel cycle—uranium ore out of geological formations, waste back into geological repositories. In most other countries, high-level wastes and spent fuel are simply stored temporarily in surface facilities, awaiting solutions of a more permanent nature. Therefore, the interim storage of waste (whether separated high-level waste or spent fuel) has become a necessary and crucial prerequisite to their final disposal.

Storage facilities are in operation and are being built in several countries. There is no international market for services in this area, although the Russian Federation receives Russian-supplied fuel from Russian-supplied power plants in Northern and Eastern Europe, with a potential longer term offer to do so for other spent nuclear fuel of non-Russian origin. In this context the storage of spent fuel has become a candidate for multilateral approaches, primarily at the regional

[*]Bruno Pellaud is president of the Swiss Nuclear Forum, former deputy director general of the IAEA in charge of the Safeguards Department (1993-1999), and former chairman of the IAEA Expert Group on Multilateral Nuclear Approaches (2004-2005).

level. Storage of special nuclear materials in a few safe and secure facilities will enhance safeguards and physical protection.[1]

The final disposal of spent fuel is clearly a candidate for multilateral approaches. Such an approach offers major economic benefits and substantial nonproliferation benefits, although it presents legal, political, and public acceptance challenges in most countries.[2]

WHAT ARE THE POTENTIAL HOST COUNTRIES?

Russia is the first country to express and formulate in some detail a willingness to receive foreign nuclear wastes. Are there others? First on the list should be countries with favorable conditions, that is, with a very stable geological underground of vast expanse. Australia is a prime example. However, political restraints—that is, the reluctance to import foreign wastes—preclude a selection solely on the basis of technical and safety arguments. In the context of "fresh fuel lease–spent fuel take-back" arrangements promoted in particular by the United States, an engagement of other large nuclear countries in that discussion would be quite welcome in terms of economics for the customer countries and nonproliferation for the world community.

The Russian Federation has stated its interest in storing spent fuel on a long-term temporary basis, a proposal that could possibly be extended to disposal later. The United States has expressed no interest in storing or disposing of foreign fuel whatsoever, having already been confronted with major public opposition to the repatriation of highly enriched uranium fuel from the research reactors exported by U.S. companies over the past decades. Yet in view of the somewhat exaggerated concerns expressed by the political establishment over the risks of the back-end nuclear fuel cycle, one would hope that the United States would volunteer to give shelter to the spent fuel of the world, which frequently contains U.S. technology or uranium. A few years ago the large U.K. company BNFL (British Nuclear Fuels PLC) tried to develop an elegant solution, which would have allowed it to complete its nuclear services (from cradle to grave) over the whole fuel cycle through a partnership with Australia, the country with the best geological sites in the world for ultimate disposal.

WHO ARE THE POTENTIAL CUSTOMERS?

By customer one understands here countries that would ship nuclear wastes beyond their own borders for storage or disposal. It can be assumed as a premise

[1]IAEA Working Group on Multilateral Nuclear Approaches (MNA). Report of February 2005, § 304 (*www.iaea.org/Publications/Documents/Infcircs/2005/infcirc640.pdf*). Accessed online March 13, 2008.

[2]Ibid., § 301.

that there would be no export from large countries with large nuclear power programs (as well as from nuclear weapons states). The potential customers would be, first of all, small countries with a few nuclear plants, with or without a suitable geology yet seeking more economical solutions by regrouping their resources. Also possible are countries with a sizable nuclear power program but with few suitable geological sites, for example, Japan.

NO "SHIP AND FORGET"

Transfers of nuclear waste from the exporting country to the host country of an interim storage facility or a final repository would be done under various bilateral or multilateral agreements at the commercial and governmental levels. All participating countries would presumably be signatories to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, the major legal instrument prevailing in that field.[3]

The joint convention applies to spent fuel and radioactive waste resulting from civilian nuclear reactors and applications and to spent fuel and radioactive waste from military or defense programs, if and when such materials are transferred permanently to and managed within exclusively civilian programs or when declared as spent fuel or radioactive waste for the purpose of the convention by the contracting party. The convention also applies to planned and controlled releases into the environment of liquid or gaseous radioactive materials from regulated nuclear facilities.

The obligations of the contracting parties with respect to the safety of spent fuel and radioactive waste management are based to a large extent on the principles contained in the IAEA safety fundamentals document, *The Principles of Radioactive Waste Management*,[4] published in 1995. They include, in particular, the obligation to establish and maintain a legislative and regulatory framework to govern the safety of spent fuel and radioactive waste management and the obligation to ensure that individuals, society, and the environment are adequately protected against radiological and other hazards, among other things, by appropriate siting, design, and construction of facilities and by making provisions for ensuring the safety of facilities both during their operation and after their closure. The convention imposes obligations on contracting parties in relation to the transboundary movement of spent fuel and radioactive waste based on the concepts

[3]IAEA. 1997. The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, IAEA Information Circular INFCIRC/546. Vienna: IAEA. Available online at *www.iaea.org/Publications/Documents/Infcircs/1997/infcirc546.pdf*.

[4]IAEA. 1995. The Principles of Radioactive Waste Management, Safety Fundamentals Series No. 111-F. Vienna: IAEA. Available online at *http://www-pub.iaea.org/MTCD/publications/PDF/Pub989e_scr.pdf*.

contained in the IAEA's *Code of Practice on the International Transboundary Movement of Radioactive Waste*.[5]

The joint convention does consider the international aspects of waste management, for example,

> convinced that radioactive waste should, as far as is compatible with the safety of the management of such material, be disposed of in the State in which it was generated, whilst recognizing that, in certain circumstances, safe and efficient management of spent fuel and radioactive waste might be fostered through agreements among Contracting Parties to use facilities in one of them for the benefit of the other Parties, particularly where waste originates from joint projects. (Preamble, p. xi)

> and

> **Article 1. Objectives**

> The objectives of this Convention are:

> (i) to achieve and maintain a high level of safety worldwide in spent fuel and radioactive waste management, through the enhancement of national measures and international co-operation, including where appropriate, safety-related technical co-operation. (Article 1, Objectives, p. i)[6]

The joint convention does not envisage an international verification system to ensure that national waste facilities respect the safety requirement spelled out in the convention, whether or not a national facility contains foreign waste. However, one may predict that facilities containing foreign waste will be verified to some degree by the exporting countries. For domestic and international political reasons, there will be a need for some monitoring of spent fuel storage and disposal (even waste) after shipment, to protect the exporting country politically from accusations of irresponsible dumping. International waste management solutions will not be of a simple commercial nature along the lines of ship and forget.

The IAEA Expert Group on Multilateral Approaches brought together by the IAEA Director General in 2004-2005 took a serious look at this matter, and it supported the principle of multilateral storage and disposal arrangements:

> The IAEA could facilitate this arrangement by acting as a "technical inspec-

[5]IAEA. 1990. Code of Practice on the International Transboundary Movement of Radioactive Waste, Information Circular INFCIRC/386. Vienna: IAEA. Available online at h*ttp://www.iaea.org/Publications/Documents/Infcircs/Others/inf386.shtml*.

[6]IAEA. 1997. The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, Information Circular INFCIRC/546. Vienna: IAEA. Preamble, p. xi, and Article 1, Objectives, p. i. Available online at *www.iaea.org/Publications/Documents/Infcircs/1997/infcirc546.pdf*.

> tion agency" assuring the suitability of the facility and applying state-of-the-art safeguards control and inspections.[7]
>
> It is also important that international oversight of an MNA [Multilateral Nuclear Approach] be arranged, as needed, to achieve confidence of partners on adequate safety and physical security of the proposed facility.[8]

In several cases, domestic policy in the customer's state will require assurances that the transferred waste is properly managed and not simply dumped at some faraway site. This would in particular be the case for Switzerland. The new Swiss Nuclear Law, which came into force in February 2005, addresses the issue in Article 33:

> A permit will be granted for <u>the export of nuclear waste …</u> when the following conditions are fulfilled…:
>
> 1. The recipient State has approved the import of nuclear waste under a government-to-government agreement;
> 2. A suitable nuclear installation is available in the recipient State with corresponding up-to-date scientific and technical standards;
> 3. Transit States have approved such transports;
> 4. The sender has firmly agreed with the recipient of nuclear waste—with the endorsement of the authority designated by the Swiss Government—that such waste can be returned to the sender in case of necessity.

Should Switzerland export waste, the second paragraph above will clearly oblige the federal government to ascertain in one way or the other that the installation is and remains suitable and that it will satisfy state-of-the-art technical requirements and standards.

What is remarkable in this law is that a mirror clause applies to the *import of nuclear waste*! With a strong chemical industry, Switzerland has a long experience in bidirectional international transfers of toxic waste—with the import and export of various kinds of waste and ensuing optimization and specialization of disposal facilities. All such transfers occur under the stringent regulations of the international Basel Convention with special rules applying to transfers within the OECD (Organization for Economic Cooperation and Development).[9]

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[7]IAEA. 2005. P. 94, §304 in Multinational Approaches to the Nuclear Fuel Cycle: Expert Group Report Submitted to the Director General of the International Atomic Energy Agency, Information Circular INFCIRC/640. Vienna: IAEA. Available online at *http://www.iaea.org/Publications/Documents/Infcircs/2005/infcirc640.pdf.*

[8]Ibid., p. 102, §339.

[9]Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal. 1989. Available online at *www.basel.int.*

FROM BILATERAL TO INTERNATIONAL MONITORING THROUGH THE IAEA

At first the parties—sender and recipient—would agree on some kind of bilateral monitoring by dedicated bilateral teams or international commercial companies that provide technical services focusing on quality, environmental, health, safety, social accountability, and information management issues, such as *Bureau Veritas* or *Société Générale de Surveillance*. One can think of a possible minor initial role for the IAEA in such schemes to add a level of international confidence.

At a later stage, after the establishment of many bilateral arrangements, some kind of international monitoring may become more judicious. Various organizations could fulfill such a function. This is the reason for raising the question of a potential role for the IAEA.

What kind of monitoring or, rather, what kind of assurances are to be provided?

First, one should clearly understand that such monitoring would have nothing to do with nuclear safeguards, with the mandate of the IAEA to ensure that the nonproliferation commitments of the host country are being respected. IAEA safeguards would be a parallel and independent activity of the agency. In any case, the providing state would have no proliferation concerns as do Russia and the United States since proliferation has already occurred there. In nonnuclear weapons states—for example, Australia—normal safeguards would apply independently and would be sufficient. However, in the case of the nuclear weapons states, the supplying countries would certainly want to ensure that nuclear waste transferred under a storage/disposal agreement would not be diverted to the host country's weapons program.

The IAEA monitoring could deal with the following areas, with a scope depending on the bilateral transfer agreement concluded between the parties:

- **Technical design**—proper international design standards. In line with the Joint Waste Convention, the facility will have to satisfy international state-of-the-art design norms as well as technical and quality assurance (QA) standards. A customer country would want to delegate the monitoring to the IAEA, with a stop-and-go authority or only a warning function.
- **Safety**—design and operation to exclude accidents. The design, maintenance, and operation procedures of the facility should exclude the possibility of nuclear accidents. Review of national enforcement should be included.
- **Environmental**—design and operation to exclude environmental damage. The design, maintenance, and operation procedures of the facility should exclude the possibility of radioactive contamination of the environment above a certain limit for the whole operational life of the facility, in accordance with domestic and international norms.

- **Security**—design and operation to exclude misuse and thefts. Formulation of the Euratom Treaty, Article 77, would be relevant for that task: "In accordance with the provisions of this Chapter, the Commission shall satisfy itself that, in territories of Member States, a) ores, source materials and special fissile materials are not diverted from their intended uses as declared by the users." When translated into a joint international facility, this would read: "The IAEA shall satisfy itself that, in the storage or disposal facility, spent fuel and other materials are not diverted from their intended uses as declared by the users." Under this heading, the physical protection of the nuclear materials should be fully implemented in line with the IAEA-defined guidelines.[10]
- **Financial management**—sound use of invested resources, especially in the case of joint financing of facilities. Different models are possible—for example, financial matters only in the hands of the recipient country (with no monitoring) or a joint trusteeship is set up (in which case the monitoring could be bilateral or even with a third party at the table, for example, the IAEA).

INSTITUTIONAL INTERGOVERNMENTAL ARRANGEMENTS

There is a need for a solid nuclear legal and regulatory basis in the recipient country. IAEA publications include many details about the requirements for setting up a firm legal basis that will create the necessary trust of the international partners.[11] As already noted, the intergovernmental arrangements should refer specifically to international legal instruments in order to help create a smooth legal overlap between giver and recipient countries, for example, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, referred to above.

A number of detailed legal questions will need to be settled between the partners, such as long-term liability (whether it is the responsibility of the host country or a shared responsibility) and ultimate ownership of the nuclear waste (whether it belongs to the host country or the providers), especially in relation to the retrievability of buried nuclear waste, a decisive factor for some countries, as exemplified above by the last mentioned paragraph of the Swiss Nuclear Law.

BUSINESS AND COMMERCIAL MODEL

There is also a need for a solid business and commercial basis between the partners to clearly understand who is responsible for providing the services

[10]IAEA. 1999. The Physical Protection of Nuclear Material and Nuclear Facilities, Information Circular INFCIRC/225, Rev. 4. Vienna: IAEA. Available at *http://www.iaea.org/Publications/Documents/Infcircs/1999/infcirc225r4c/rev4_content.html.*

[11]Stoiber, C., A. Baer, N. Pelzer, and W. Tonhauser. 2003. Handbook on Nuclear Law. Vienna: IAEA. Available online at *www-pub.iaea.org/MTCD/publications/PDF/Pub1160_web.pdf.*

and financial contributions necessary to ensure smooth operation of the partnership—for example,

- a trusteeship of recipient countries and providers
- joint definition of the kind of services expected from the IAEA
- monitoring services to be paid to the IAEA on a time and expenses basis
- a monitoring model established by the IAEA (the agency could refuse to engage if the scope would be incomplete, since its reputation would be at stake)
- IAEA reports made to the trusteeship on a yearly basis and succinctly in its own annual report

IAEA ADMINISTRATIVE MODEL

How would the IAEA organize such monitoring work internally? Once again, it should be emphasized that such activity has no relationship to nuclear safeguards; these would not be safeguards inspections. Therefore, the work would not be entrusted to the Department of Safeguards of the IAEA, but rather jointly to the Department of Nuclear Energy (Division Nuclear Fuel Cycle and Waste Technology) and the Department of Nuclear Safety and Security, performing here an agency service to its member states.

In practical terms the agency would set up ad hoc internal teams, with personnel drawn from these two departments, with the occasional involvement on a personal basis of some safeguards inspectors and with safeguards technical support. At any rate, because of the required confidentiality, there will be no team of external experts, as on IAEA peer review missions in the safety and nuclear licensing fields.

As far as practical verification arrangements are concerned, the IAEA would make use of human and technical resources to carry out its monitoring functions. There would be human inspections with physical and visual review of facility features, the taking of environmental samples to assess possible leaks and spills, and so forth. The technical equipment in support of inspections would include radiation detection equipment, seals, and sampling equipment. In special situations the IAEA could also call on remote monitoring—that is, using tamperproof digital cameras to transmit pictures back to IAEA headquarters on a regular basis or upon image changes.

The IAEA would have to report in an appropriate fashion on the findings of its verification activities. Upon detection of irregularities, this would be done as soon as possible to the partners, on a confidential basis. Once a year the IAEA would submit to the partners a confidential annual report. However, by its very status as an independent international organization, the agency would need to report briefly once a year to its own constituency, the IAEA Board of Governors, on the general scope of the controls performed.

3

Status of Liability and Insurance Laws for International Shipments of Spent Nuclear Fuel

Norbert Pelzer
University of Goettingen

INTERNATIONAL SHIPMENT: A CHALLENGE FOR THE LAW OF CONFLICT

Exposition of Legal Problems

The international shipment of spent nuclear fuel is the movement of such materials from one national jurisdiction to at least one other national jurisdiction. In the case of transit, there are one or more additional national jurisdictions involved. While the shipment is in the territory of a certain state, it is subject to the laws and regulations of that state. This also includes the civil liability regime. The changing of jurisdictions during transportation, of course, requires the carrier or the sending operator and the receiving operator to meet the requirements of the legislation of the state whose territory they are passing through. In particular, carriers and operators have to take care that their third-party liability insurance or any other financial securities to cover liabilities are in line with the applicable legislation.

International shipments of spent fuel, therefore, pose problems to carriers and operators. But they also create problems for potential victims of nuclear incidents during transport. The following questions have to be answered:

- Which court is competent to hear claims?
- Which law is applicable to the incident?
- Is there a guarantee that the judgments of a competent court will be acknowledged and enforced in the country of the person liable?

- Is there a guarantee that compensation amounts awarded can be freely transferred to the state of the victim?

These questions are basic ones that are typical of the international law of conflict. They imply a great number of difficult legal problems, and, being a lawyer, I would like to qualify them as a kind of "gourmet dinner" for lawyers. There is no doubt that gourmet dinners are a costly pleasure. Clever attorneys try to find the place where the best dinner is served; this is called "forum shopping." Lawyers shop for the most favorable law applicable. In summary, the legal difficulties consequential to any international nuclear transport accident very often form a major hurdle for quick and smooth compensation for damages. Neither victims nor persons liable can be satisfied by that situation. This holds particularly true if we take into account that nuclear incidents are politically sensitive events, and the political elements of such incidents contribute to the complexity of the case.

What can be done to prevent or at least mitigate such an unfavorable legal situation?

Global Treaty Relations

The answer is simple: We need treaty relations among all states involved in a certain transport or—even better—we need global treaty relations. Such an international regime based on an agreement would do away with the often incalculable risks of the general rules of private international law. The agreement should contain rules on a single competent court, it should contain rules on the applicable law, and it should ensure the enforcement of judgments and the free transfer of money. Such an agreement would certainly be the ideal situation, but since we do not live in an ideal world, we have to see what reality is offering us.

There are international nuclear liability conventions that also apply to international shipments of spent nuclear fuel, and these conventions contain all the elements enumerated above. Currently, the following international nuclear liability conventions exist:

- Worldwide international nuclear liability conventions:
  — Vienna Convention on Civil Liability for Nuclear Damage of 21 May 1963 (35 state parties)[1]
  — Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage of 12 September 1997 (5 state parties)[2]
  — Convention on Supplementary Compensation for Nuclear Damage of 12 September 1997 (3 state parties but not yet in force)[3]

[1]IAEA Doc. INFCIRC/500 = UNTS, vol. 1063, p. 266.
[2]IAEA Doc. INFCIRC/566 = 36 ILM 1461 (1997).
[3]IAEA Doc. INFCIRC/567 = 36 ILM 1473 (1997).

- Regional international nuclear liability conventions:

—Paris Convention on Third-Party Liability in the Field of Nuclear Energy of 29 July 1960, as amended by the Additional Protocol of 28 January 1964 and the Protocol of 16 November 1982 (15 state parties)[4]

—Protocol to Amend the Convention on Third-Party Liability in the Field of Nuclear Energy of 29 July 1960, as amended by the Additional Protocol of 28 January 1964 and the Protocols of 16 November 1982 and 12 February 2004 (the later not yet in force)[5]

—Brussels Convention of 31 January 1963 Supplementary to the Paris Convention of 29 July 1960, as amended by the Additional Protocol of 28 January 1964 and the Protocol of 16 November 1982 (12 state parties)[6]

—Protocol to Amend the Convention of 31 January 1963 Supplementary to the Paris Convention of 29 July 1960 on Third-Party Liability in the Field of Nuclear Energy, as amended by the Additional Protocol of 28 January 1964 and the Protocols of 16 November 1982 and 12 February 2004 (the latter not yet in force)[7]

Unfortunately, only 50 states are contracting parties to these conventions. All the other states of the world, including those with major nuclear programs, are not parties to any of these conventions. Among those states are the United States, Canada, China, Japan, India, South Korea, and South Africa.[8] Many of the states not party to the conventions nevertheless enacted nuclear liability legislation that in substance follows more or less the principles of the international nuclear liability conventions.

Consequently, there are three groups of states:

- States party to the international nuclear liability conventions
- States having enacted national nuclear liability legislation without being party to any of the conventions
- States without any specific nuclear liability legislation

There are 20 million shipments of radioactive materials transported annually. Each shipment is made up of either a single package or a number of packages transported from one location to another. The overwhelming majority of these

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[4]Reproduced in OECD/NEA, Paris Convention on Third Party Liability in the Field of Nuclear Energy, etc., Paris, 1989, and available on the Internet at *http://www.nea.fr/html/law/nlparis_conv.html*.

[5]Not yet officially published. The text is available on the Internet at *http://www.nea.fr/html/law/paris_conv.html*.

[6]See footnote 4 and *http://www.nea.fr/html/law/nlbrussels.html*.

[7]Not yet officially published. The text is available on the Internet at *http://www.nea.fr/html/law/brussels_supplementary.html*.

[8]The box at the end of this paper shows the participation of states with civilian nuclear programs in the nuclear liability conventions.

shipments relate to non-fuel-cycle transports, while only a very small fraction relate to fuel-cycle transports, which includes the transportation of spent nuclear fuel.[9]

Below, I deal first with international shipments among contracting parties to the nuclear liability conventions and, second, with shipments between states without respective treaty relations.

THE TRANSPORT REGIME OF THE INTERNATIONAL NUCLEAR LIABILITY CONVENTIONS

Basic Concept

The leading concept of the international nuclear liability conventions is that all liability for nuclear damage is concentrated on the operator of the nuclear installation in which the nuclear incident took place or the installation from which the nuclear material originates. This so-called legal channeling of liability to the operator liable is supported and strengthened by a number of additional elements. One of those elements is the liability for nuclear damage occurring during the course of transportation. As a general rule, it is not the carrier that is held liable for a nuclear incident but rather the sending or receiving operator of a nuclear installation. The carrier can only be held liable in exceptional cases and following a special procedure: Provided the installation state has enacted relevant legislation, a carrier of nuclear material may, at his request and with the consent of the operator concerned, be designated or recognized as the operator with respect to such nuclear material. If the requirements of that procedure are fulfilled, the carrier is treated like an operator of a nuclear installation situated within the territory of that state.

Concentrating Liability on the Operator of a Nuclear Installation

The provisions for liability for nuclear damage caused during the course of transport are identical in all of the three international conventions providing the basis for nuclear liability, namely the Vienna Convention (VC), the Paris Convention (PC), and the Convention on Supplementary Compensation for Nuclear Damage (CSC). It is obvious that this identical approach simplifies the legal situation. The respective provisions in the three conventions are Article II para. 1 sub-paras. b and c VC, Article IV PC, and Article III para. 1 sub-paras. b and c of the Annex to the CSC. The Revision Protocols to the Paris Convention and the Vienna Convention did not change the transport provisions in substance.

[9]See information from the World Nuclear Transport Institute on the Internet at *http://www.wnti.co.uk/nuclear-transport-facts/facts-and-figures/key-facts*.

The contents of the conventions' liability provisions on transport follow a simple pattern: The sending operator is liable for nuclear damage

- before liability with regard to nuclear incidents has been assumed pursuant to the express terms of a contract in writing by the operator of another nuclear installation;
- in the absence of such express terms, before the operator of another nuclear installation has taken charge of the material;
- if the nuclear material is intended to be used in a nuclear reactor with which a means of transport is equipped, the sending operator is liable before the person duly authorized to operate such reactor has taken charge of the materials;
- in case of a transport sent to a person within the territory of a noncontracting state, the operator is liable before the material is unloaded from the means of transport by which it has arrived in the territory of the noncontracting state.

If the nuclear material is sent to a nuclear installation, the liability of the receiving operator is formed in a symmetric way: The receiving operator may either assume liability pursuant to the express terms of a contract in writing or, in the absence of such terms, after he has taken charge of the nuclear material. If the material is sent from a means of transport equipped with a nuclear reactor, the receiving operator will be liable after he has taken charge of the nuclear material. If the nuclear material was sent with the written consent of the receiving operator from a person within the territory of a noncontracting state, the receiving operator will only be held liable after the material has been loaded on the means of transportation by which it is to be carried from the territory of that state.

The structure of this transport liability concept is clear and simple. It is stipulated that transportation only takes place between the sending and receiving operators of a nuclear installation, and one of them is held liable exclusively. A consequence of this structure is that material that is sent to a person who is not an operator in the sense of the convention, for example, a professor at a university or a research laboratory, the sending operator remains liable for damage caused by that material.

Deficiencies of the International Regime

As long as the transportation takes place only between or among contracting parties of the same convention, there is no problem in determining the competent court and applicable law. The respective jurisdiction provisions in the conventions (Article XI VC, Article XIII PC, Article XIII CSC) clearly define the competent court. As a general rule, it will be the court of the country in which the nuclear incident occurred. The court will apply the *lex fori*, and judgments will be enforced in the territories of all contracting parties. All victims will be treated equally in accordance with the respective articles of the conventions. In summary and in principle, among contracting parties, law of conflict problems do not exist.

The conventions offer a widely unified nuclear liability regime that is designed for the specifics of the nuclear risk. In particular, they ensure that the operator has and maintains insurance or other financial security to cover its liability (Article VII VC, Article X PC, Article V Annex to the CSC). There is, however, no harmonization of the individual liability amounts, and consequently, also among contracting parties there remain differences, which may be considerable.

The benefits of being a party to the conventions only apply to those states that are party to the same convention. If a person in a VC state or a CSC state suffers damage from a transportation for which the operator of a PC state has assumed liability, neither the Paris Convention nor one of the other two conventions will apply. In principle, there is no link among the three conventions: Their territorial scope of application is limited to the contracting parties, and vis-à-vis other states, the general rules of the law of conflict have to determine the applicable law, including the competent court. This unfavorable situation will be slightly improved when the Revision Protocols to the VC, the PC, and the CSC attract considerably more states and enter into force respectively. These new instruments provide for a broader territorial scope of application and extend their benefits in a well-defined way also to noncontracting states (Article I A VC rev., Article II PC rev.[10]). However, such territorial extension is only a unilateral act of the parties to the conventions and does not do away with the private international law problems with regard to noncontracting states.

International Bridging Instruments

To make things even more complicated, we have to take into account that there are two international instruments that aim to bridge the international conventions and thus at least mitigate or even entirely abolish the drawbacks of the application of general private international law rules.

The first instrument is the CSC, which is not yet in force. Obviously, if there were universal adherence to this instrument, or at least adherence of the main players in the shipment of spent nuclear fuel, this convention would create treaty relations among the parties to the VC, the PC, and the so-called annex states with their domestic nuclear liability legislation (Article XIV CSC) and thus would provide legal harmonization among the participants.

Regarding the VC and the PC, the Joint Protocol relating to the application

[10]With regard to the CSC, the Annex to that convention does not contain any territorial restrictions of the national law; however, supplementary compensation under the CSC shall only be made available in accordance with the restrictions under Article V.

of the Vienna Convention and of the Paris Convention of 21 September 1988[11] establishes a bridge between the two conventions by extending the benefits of both instruments mutually. The choice of law rules in the protocol determines the competent court and the applicable law. There is no need to resort to the general rules of private international law. Currently, the protocol has 25 parties only, namely 15 Vienna states and 10 Paris states.[12]

Assessing the International Regime

A summary of this short exposé of the liability situation under the international nuclear liability conventions is encouraging and discouraging at the same time.

As long as nuclear incidents occur within the "family" of one and the same convention, the legal situation related to the choice of laws and the substance of the law applicable is satisfactory, although liability amounts sometimes may be insufficient. When, however, the state of the operator that is liable and the state of the victim are parties to different conventions, compensation for nuclear damage is subject to the general rules of private international law, which is a field of law difficult to predict. The joint protocol solves the problems only to a territorially limited extent. The CSC is not yet in force and may offer only a medium- or a long-term perspective. There are some 50 states in the world that are parties to the nuclear liability conventions, and even among them there is no satisfactory harmonization of the liability regime.

INTERNATIONAL SHIPMENTS OUTSIDE THE REGIME OF THE INTERNATIONAL NUCLEAR LIABILITY CONVENTIONS

General Sources of the Law of Conflict

In case of shipments among or to and from states not party to any of the nuclear liability conventions, senders, consignees, and carriers have to deal with the question of the relevant court and the applicable law on the basis of the general rules of private international law. Such general sources might be regional or universal treaties or, as applicable, national law of the states involved in the shipment. State involvement may be, *inter alia,* based on the nationality of the persons involved in the incident, either as tortfeasor or as victim, of the place where the incident took place or on a contract concluded and designed for a specific shipment.

[11] IAEA Doc. INFCIRC/402.
[12] IAEA Doc. Registration No. 1623.

Jurisdiction

There is no worldwide international instrument regulating jurisdiction. The efforts of the Hague Conference on Private International Law to establish a global regime have not yet been successful.

At the regional level, there exist European instruments on jurisdiction, namely the Brussels Convention of 1968[13] and its successor, the European Union (EU) Council Regulation No. 44/2001 of December 22, 2000, on Jurisdiction and the Enforcement of Judgments in Civil and Commercial Matters.[14] There is also the Lugano Convention of 1988[15] on the same subject. All three instruments contain more or less identical rules on jurisdiction. The victim has a choice of the court: He may sue at the court of the place of the defendant's domicile or at the place where the incident occurred. The place of the incident includes both the place where the tortfeasor acted or where the damage was suffered.

If there are no international instruments applicable, the jurisdiction will be determined by national law. Obviously, there exists a great variety that cannot be elaborated on here. One might, however, conclude that in most states rules similar to those of the European instruments apply.

In the context of this workshop, U.S. law surely is of greatest interest. Since I am speaking in the presence of our U.S. colleagues, I am most reluctant to make statements on the U.S. law. Generally speaking, the United States is not a state with a unitary civil law system. The individual states have competence in civil law matters, a fact that may entail considerable differences. Generally speaking again, I would like to say that U.S. courts claim a very broad approach to international jurisdiction. Even rather transient contacts may be sufficient to make U.S. courts competent. This is called "long-arm statutes."

With regard to the Russian statutes, I shall entirely refrain from any statement. Since I cannot speak Russian, I would have to rely on secondhand sources, which I do not accept as a sound approach to a foreign law system.

The Applicable Law

The competent court, in general, will apply its domestic law to the case. If the respective country has enacted special nuclear liability legislation, the principles of that legislation will mostly be similar to the law of the international nuclear liability conventions. This applies, for example, to Canada, Japan, and South Korea. The U.S. law also belongs to this group, but in the U.S. nuclear liability law there are also elements that are not entirely compatible with the law of the conventions.

The great majority of states did not issue special nuclear liability laws.

[13]Official Journal of the EC No. L 299/32 (1972).
[14]Official Journal of the EC No. L 12/1 (2001).
[15]Official Journal of the EC Nos. L 319/9 (1988) and L 20/38 (1989).

The applicable statutes will be the general civil code and, as the case may be, environmental liability law, water law, and other sources. General civil liability law mostly is based on fault on the part of the tortfeasor and is not limited in amount.

Recognition and Enforcement of Judgments, Transfer of Compensation Amounts

Recognition and enforcement of judgments in a state other than the state of the court in most states require an express agreement between the states concerned. Some states recognize and enforce foreign judgments on the basis of reciprocity, as, for example, Russia in accordance with a decision of the Supreme Court of the Russian Federation of 7 June 2002.[16] Many states concluded relevant agreements with their neighboring states, but there is no global instrument of that type. At the regional European level, there are the instruments referred to above, in particular EU Regulation 44/2001/European Community.

In most states national currencies are freely transferable. However, this issue must be addressed, as the case may be, to ensure that victims receive their compensation.

CONCLUSION

This brief overview of the problems of nuclear liability connected with the international shipment of spent nuclear fuel shows a multicolored picture. It also shows that operators and carriers face complex problems if a nuclear incident occurs during the course of a shipment.

If the nuclear incident and the damage suffered occur within the territorial scope of application of one of the three international nuclear liability conventions, the law of that convention, as implemented by the respective contracting party, applies (Box 1). That law includes rules on the relevant court, the applicable law, the recognition and enforcement of judgments, and the free transfer of compensation amounts. If, however, the nuclear incident is not entirely covered by one convention, the people involved in the incident easily may get lost in the jungle of private international law. Both victims and persons liable will face major legal problems.

If the amounts covering the operator's liability are limited, or even if the liability is unlimited, there will be major problems if, under general law of conflict rules, several courts have jurisdiction and distribute the money without knowing about the total extent of the damage.

The corollary for the subject of this workshop, namely International Repositories for Spent Nuclear Fuel, is quite obvious: International repositories *per*

[16] The judgment is in German translation reproduced in Praxis des Internationalen Privat- und Verfahrensrechts (IPRax), 2003, pp. 356 et seq.

BOX 1
Nuclear Power Generating Countries' Participation in Nuclear Liability Conventions

World's nuclear power generating countries that are contracting parties/states to the:

- Paris Convention on Nuclear Third Party Liability, amended 1964 and 1982 (PC)
- Brussels Supplementary Convention, amended 1964 and 1982 (BSC)
- 1963 Vienna Convention on Civil Liability for Nuclear Damage (VC)
- Protocol to Amend the 1963 Vienna Convention (VCP)
- Convention on Supplementary Compensation for Nuclear Damage (CSC) (not in force)

Note: The 2004 Protocol to Amend the Paris Convention has been signed by 16 countries but has not yet been ratified, approved, or accepted by any of the signatories. The 2004 Protocol to Amend the Brussels Supplementary Convention has been signed by 13 countries and ratified by one (Spain).

Argentina: VC, VCP, CSC
Armenia: VC
Belgium: PC, BSC
Brazil: VC
Bulgaria: VC
Canada
China
Czech Republic: VC
Finland: PC, BSC
France: PC, BSC
Germany: PC, BSC
Hungary: VC
India
Japan
Korea
Lithuania: VC
Mexico: VC
Netherlands: PC, BSC
Pakistan
Romania: VC, VCP, CSC
Russian Federation: VC
Slovak Republic: VC
Slovenia: PC, BSC
South Africa
Spain: PC, BSC
Sweden: PC, BSC
Switzerland
Taiwan
Ukraine: VC
United Kingdom: PC, BSC
United States

SOURCE: Schwartz, J.A. 2006. International nuclear third party liability law: The response to Chernobyl, p. 72 in International Nuclear Law in the Post-Chernobyl Period: A Joint Report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency. Paris: OECD.

definitionem need international shipments of spent fuel. It is, therefore, one of the essential prerequisites of the operation of an international repository for spent fuel that the state in the territory of which the repository is operated and all those states that are planning to use the repository are contracting parties to the same international nuclear liability convention.

4

Insurance and Liability in the Transport and Reception of Fuel for Storage in Russia*

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LEGISLATIVE BASE

In the Russian Federation, civil liability for losses and damages caused by radiation (nuclear harm or damages) and its financial aspects are governed by the following regulatory and legal documents:

- Federal Law on the Use of Atomic Energy (No. 170-FZ, dated November 21, 1995)
- Civil Code of the Russian Federation (adopted by the State Duma on October 21, 1994)
- Vienna Convention on Civil Liability for Nuclear Damage (May 21, 1963, Vienna)
- Provisions for Licensing of Activities Involving the Use of Atomic Energy (Resolution of the Government of the Russian Federation No. 865, dated July 14, 1997)

The Federal Law on the Use of Atomic Energy (Chapter XII, Articles 53-60) is the fundamental document governing liability for radiation-related losses and damages to legal entities, individuals, and the health of citizens. These articles cover the handling of spent nuclear reactor fuel imported from foreign states for temporary technical storage and (or) processing, including

*Translated from the Russian by Kelly Robbins.

- transport of spent nuclear fuel through Russian territory in the process of its import or export,
- its temporary technical storage in spent fuel repositories in Russian territory,
- export of the products of spent fuel processing, and
- export of radioactive waste after spent fuel processing to the country from which the spent fuel came.

FEDERAL LAW ON THE USE OF ATOMIC ENERGY

Under Article 53 of this law, civil legal liability for losses suffered by organizations and individuals due to radiation impacts associated with the use of atomic energy is borne by the operating organization in accordance with Russian Federation legislation (through licensing procedures). Compensation is due for damages to the lives and health of citizens caused by radiation impacts or a combination of radiation impacts and toxic, explosive, or other dangerous effects.

If in addition to losses caused by radiation effects, there are other losses that cannot be quantified separately from those due to radiation, these losses are also subject to compensation on the basis of this federal law.

Under Article 54, which defines the grounds for civil legal liability, the operating organization is liable *regardless of fault* for losses and damages caused by radiation effects. However, the operating organization is exempt from liability for losses and damages caused by radiation effects arising as a result of *force majeure*, military actions, armed conflicts, or the intentional actions of those suffering the losses or damages. If the operating organization proves that the losses and damages are completely or partially the result of intentional actions by the victim, the operating organization is completely or partially relieved of liability for compensating this individual or entity. Exemption from paying compensation for losses and damages is granted according to judicial procedures.

Forms and limits of liability (Article 55) on the part of the operating organization for losses and damages caused by radiation effects are established by Russian Federation legislation (through licensing procedures), depending on the type of facility using atomic energy. The maximum limit of liability for any one incident may not exceed the amount established by international treaties signed by the Russian Federation.

The operating organization (Article 56) is required to have financial resources equal to the liability limit established by Article 55 of the federal law. The financial resources required of an operating organization in the event compensation for radiation-related losses and damage is needed consist of state guarantees or other guarantees, as well as the organization's own funds and its insurance policy. The presence of documented confirmation of these financial resources is a *necessary condition for the operating organization to receive a license* from the relevant state safety regulatory agency to operate a nuclear facility, radiation source, or storage site. The conditions and procedures for providing insurance for civil legal liability for radiation-related losses and damage, the procedures and financing sources of the insurance fund, and the procedures for payment on social guarantees are established by Russian Federation legislation.

Neither the insurer nor any other individual providing financial guarantees regarding this liability in accordance with Article 56 may suspend or terminate insurance or other financial support without providing written notice three months in advance to the relevant state safety regulatory agencies. The same applies for financial guarantees during the period of transporting nuclear materials or radioactive substances when the insurance or financial guarantees cover the transport of nuclear material or radioactive substances.

When losses or damages exceed the *liability limit* established by Article 55 of this federal law for a given operating organization, as well as in situations stipulated in Russian Federation legislation, compensation for losses and damage above this limit are paid by the government of the Russian Federation (Article 57) by providing the amounts needed to compensate fully for the losses and damages incurred.

There is *no statute of limitations* regarding claims for compensation for radiation-related losses and damages to the *lives and health of citizens*. The statute of limitations for claims for compensation for radiation-related losses and damages to property or the environment is three years from the date when the victim became aware of or should have become aware of the violation of his rights.

Under the above-mentioned federal law, the Russian Federation Law on Environmental Protection, and other laws and regulatory acts of the Russian Federation and federation subjects, the operating organization is liable for radiation-related damages to the environment (Article 59). Lawsuits claiming compensation for losses are filed against the operating organization by state agencies and relevant environmental protection agencies.

Radiation-induced harm to the lives or health of personnel (including those on business travel) at nuclear facilities, radiation sources, and storage sites (Article 60), as well as the lives and health of personnel engaged in any other work with nuclear materials or radioactive substances in connection with fulfillment of their job duties, is subject to compensation in accordance with Russian Federation legislation. In this regard, note the following provisions of this federal law:

- Liability for compensation for nuclear-related damages lies exclusively with the operating organization (nuclear facility operator; Article 53).
- Liability for nuclear-related damages attaches regardless of any fault on the part of the operating organization (nuclear facility operator; Article 54).
- The government of the Russian Federation pays compensation for nuclear-related damages over the contractually established level of insurance coverage (Article 57).

- An operating organization may be licensed to engage in activities involving the use of atomic energy only by presenting documented confirmation of the availability of financial resources to compensate for nuclear-related damages (Article 56).
- Suspension or termination of insurance on a nuclear facility is impossible without notification of the Federal Service for Environmental, Technological, and Nuclear Oversight (Rostekhnadzor) three months in advance of the suspension or termination. Insurance on the transportation of radioactive materials may not be suspended or canceled during the period that the shipment is under way (Article 56).

THE 1963 VIENNA CONVENTION ON CIVIL LIABILITY FOR NUCLEAR DAMAGE

The Vienna Convention on Civil Liability for Nuclear Damage (hereafter the Vienna Convention), dated May 21, 1963, was ratified on March 21, 2005, by Russian Federation Federal Law No. 23-FZ on Ratification of the Vienna Convention on Civil Liability for Nuclear Damage.

The provisions of the articles included in Chapter XII of the Federal Law on the Use of Atomic Energy on the whole reflect the provisions of the articles of the Vienna Convention, which lays out the system recognized by the international community for handling civil liability for nuclear damages.

A number of documents, including laws and associated acts (provisions, regulatory documents, and so forth) must be developed in order to implement the Vienna Convention in the Russian Federation. For example, the Federal Law on Civil Liability for Causing Nuclear Damage and Its Financial Aspects is currently under development, and the contents of its articles are based on provisions in the Vienna Convention. The draft of this law is currently under final revision, taking into account the results of its second reading in the Russian Federation State Duma.

FEATURES OF CURRENT RUSSIAN LEGISLATION ON COMPENSATION FOR NUCLEAR DAMAGES

Following are some features of Russian Federation legislation regarding compensation for nuclear damages:

In addition to third-party liability, the operating organizations bear absolute and exclusive liability for damages to the *environment* resulting from radiation effects. Lawsuits for compensation of losses are filed against the operating organization by federal government agencies, relevant local government agencies, and specially empowered government environmental protection agencies.

Absolute and exclusive liability of the insurer extends to *not only nuclear facilities* as understood under international conventions but also activities associated with the use of radioactive substances and ionizing radiation sources that are not considered nuclear materials under international conventions. Furthermore, the articles of Chapter XII formally *do not cover spent nuclear fuel* as one of the usage categories in the Federal Law on the Use of Atomic Energy defined in Article 3 inasmuch as spent nuclear fuel is not mentioned in Chapter XII.

The party suffering the nuclear damages has *no right of redress* (see page 12).

Liability for causing nuclear damages during the transportation of radioactive cargo (spent nuclear fuel) shifts to the Russian recipient (operating organization) *from the moment the transport vehicle crosses the state border of the Russian Federation,* not the moment when responsibility for the cargo is transferred. Accordingly, in the shipment of radioactive material to a foreign recipient, the nuclear liability of the Russian operator terminates only at the moment when the transport vehicle and its cargo leave the territory of the Russian Federation.

No determination has been made regarding the *maximum level of civil liability* by the organization operating a nuclear facility for causing nuclear damage as a result of a nuclear incident at the facility.

Passage of the Law on Civil Liability for Causing Nuclear Damage and Its Financial Aspects will eliminate a number of discrepancies between Russian legislation and international norms.

THIRD-PARTY LIABILITY INSURANCE

The introduction of nuclear insurance in Russia may be considered to have started as of the date when the Federal Law on the Use of Atomic Energy went into effect in 1996 and especially when the Provisions for Licensing of Activities Involving the Use of Atomic Energy were issued in 1997, inasmuch as licensing was an effective tool for promoting "mandatory" insurance of the activities of operating organizations that use atomic energy. The same period saw the creation of a voluntary association of Russian insurance companies planning nuclear insurance activities (the nuclear insurance pool).

The requirement of "mandatory" civil-legal liability insurance for losses and damages caused by radiation effects, the creation of the insurance fund, and the payment of social guarantees is included in Article 56 of the Federal Law on the Use of Atomic Energy.

In accordance with Point 12d of the Provisions for Licensing of Activities Involving the Use of Atomic Energy (No. 865, dated July 14, 1997), a license for a particular type of activity involving the use of atomic energy may be obtained if the applicant has documents confirming the availability of financial resources to cover civil-legal liability for losses and damage caused by radiation effects. This license is issued by Rostekhnadzor.

In issuing licenses for transborder shipments of radioactive materials, Rostekhnadzor proposes that the following recommendations be observed:

- The baseline liability limits recommended by Rostekhnadzor should be used in considering the question of the financial resources required to cover third-party liability for nuclear damages during the transitional period.
- Coverage for terrorist acts and theft of radioactive materials should be included in the insurance contract.
- The insurance policy must be issued by a Russian insurer.
- Liability on the part of the insurer begins (ends) at the moment the transport vehicle and its cargo enter (exit) the territory of the Russian Federation.
- The coverage amount in the nuclear liability insurance policy for Russian territory must be as close as possible to the liability limit of the insurer for transport of the given cargo in the territory of a neighboring state.
- Insurance coverage in the territory of the Russian Federation must be no worse than the policy conditions for liability insurance for the transport of the given cargo in the territory of a neighboring state.

General principles for nuclear insurance are based on the Civil Code of the Russian Federation (Articles 927-970 of Chapter 48, "Insurance"). Civil liability insurance for operating organizations/atomic energy facilities (the insured) by the insurance company (the insurer) is based on a contract between these organizations documenting all basic provisions of relations between the insured and insurer. The contract is the fundamental document defining the subject of agreement, contract duration, procedures for premium payment, coverage limit, premiums, insurance awards and compensation payments, special conditions, and so forth. After paying the premium, the insured receives from the insurer an insurance policy that indicates the object insured, the coverage limit (liability limit on the part of the insurer), and the dates on which coverage under the policy begins and ends.

The organization issuing the insurance (the insurer) must meet the following requirements:

- Insurance is issued only by insurance organizations that are (1) registered in the Russian Federation, (2) licensed according to established procedures by the Department of Insurance Oversight of the Russian Ministry of Finance to provide civil-legal liability insurance to operating organizations during the transport of nuclear materials, and (3) operating according to procedures established by Russian Federation legislation.
- As a rule, contracts for insurance covering the transport of nuclear materials are concluded with insurance companies that are licensed by the Russian Federal Security Service to engage in operations associated with the use of information classified as state secrets.
- In accordance with the recommendations of the Order on the Creation of a Single Insurance System under the Russian Ministry of Atomic Energy (Federal Atomic Energy Agency [Rosatom] Order No. 255, dated April 22, 1996), insur-

ance contracts are concluded with insurance companies belonging to the Russian Nuclear Insurance Pool.

- The insurance company must have qualified personnel competent in issues regarding nuclear insurance and nuclear and radiation safety to fulfill the company's obligations regarding the insurance contracts it has signed.
- The insurance company must have sufficient financial resources and stability.

CONCLUSIONS

The Russian Federation has created a legal foundation that defines the basic principles for civil liability for losses and damages caused by radiation effects (nuclear harm or damages) as well as its financial aspects.

The Russian Federation's ratification of the Vienna Convention is a very important step on the path to achieving universal international law and order with regard to the safe use of atomic energy.

Adoption of the Vienna Convention is a serious incentive factor in the development of special legislation to ensure financial guarantees for compensation for nuclear damages. The draft Federal Law on Civil Liability for Causing Nuclear Damage and Its Financial Aspects is in the development stage. A wide range of related legal acts specifying fundamental legal and legislative provisions remain to be developed.

Nuclear liability insurance practices have developed in the Russian Federation on the basis of principles of absolute and exclusive liability of the insurer and the presence of a maximum liability limit for the nuclear facility operator above which damages are covered by the state. This is in accordance with the principles of the Vienna Convention regarding compensation for nuclear damages and with the national laws of many countries.

In the event that a contract is signed regarding the processing and (or) temporary technological storage of spent nuclear fuel of foreign origin in the Russian Federation, the coverage amounts in the nuclear insurance contracts for such risks will be set at the level stipulated in the Vienna Convention.

Taking into account the nuclear risk insurance practices that have taken shape in Russia with regard to shipments of nuclear materials, it would be expedient to apply a system of reinsurance for insurance covering risks of transporting spent nuclear fuel of foreign origin.

5

Overview of National Laws in Relation to a Regional Repository: Legal and Other Nontechnical Aspects of Multinational Repositories*

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INTRODUCTION

Numerous nontechnical considerations, such as politics, economics, ethics, and environmental concerns, influence the legal framework for implementing disposal of radioactive wastes. Such considerations are the basis of any legislation and are reflected in national laws and international legislation. Some of these aspects are of special significance in relation to legislation on multinational repositories and therefore also have to be taken into consideration when discussing the legal framework. For this reason the subtitle "Legal and Other Nontechnical Aspects of Multinational Repositories" is added to the title of this presentation, and the second part is devoted to those issues.

The third part describes some issues of national legislation concerning multinational repositories but also touches on international legal instruments. These have a strong impact on or are even part of many national laws. In addition, some current initiatives for multinational repositories are briefly mentioned. These also influence national legislation on multinational repositories.

First, some notes on terminology. The title uses the term "regional" repositories. In a strict sense, regional repositories are repositories for radioactive waste (RAW) used by several countries situated in the same region of the world. The similar term "multinational" repository would be used simply for repositories

* The information in this paper is current as of 2005, although there may have been changes since that time. For an update, see Arius, 2007, Newsletter 14, Baden Dättwil, Switzerland: Arius, available online at *http://www.arius-world.org/pages/pdf_2006/AriusNewsletter14.pdf.*

used by several countries without reference to the location of the user countries. "International" or also "supranational" repositories are terms often used for multinational or regional repositories that are supervised by a supranational organization. For legal issues, however, these differentiations are irrelevant. Therefore, the term "multinational" repository is used here.

RAW as used here comprises in general all civilian radioactive material for which no further use is foreseen, including spent nuclear fuel (SNF), if there is no intention to reprocess it.

NONTECHNICAL REQUIREMENTS ON REPOSITORIES FOR RADIOACTIVE WASTE: KEY CHALLENGES

Requirements on Both National and Multinational Repositories

As we all know, nuclear energy is a controversial political issue in many countries, much more so than any other source of energy. Maybe because of the bombings of Hiroshima and Nagasaki or nuclear weapons in general or the deliberate policymaking of certain pressure groups, there is widespread irrational fear of nuclear energy and the technology and infrastructure that surround it. Even though it is broadly accepted that, from a technical viewpoint, nuclear energy can be managed safely and there is no adequate replacement for nuclear energy in many countries, many people are still unwilling either to trust the nuclear industry or to conserve energy; but they still want to have a say in many fields concerning nuclear energy. This often comes to the fore when proposals are made for the disposal of RAW. Therefore, the societal and political processes leading to legislation and even to authorizations are a very important factor in all fields regarding nuclear energy.

As one of the consequences, various principles and standards governing RAW disposal have been developed in different countries and internationally. Some are obvious and universally agreed to; others are more debatable. Thus, it is commonly agreed to and regarded as a minimum standard that repositories for RAW must be ethical, environmentally sound, safe, secure, and economical. These agreed-upon standards are fundamental to legislation on multinational repositories. For these characteristics to be achieved, some specific conditions must be fulfilled:[1]

Ethical: There is no question that a repository for RAW must be sited and operated on the basis of ethical principles. However, the term "ethical" is probably the one that is the most controversial and the one that is interpreted most

[1] Boutellier, C., and C. McCombie, 2004, Problems of an International Repository for Radioactive Waste: Political and Legal Aspects of International Repositories, 10. AIDN/INLA—Regionaltagung der Deutschen Landesgruppe, 2-3 September 2004, Celle, Germany.

diversely by different individuals, organizations, and countries. Several factors are involved:

- There is the common belief that disposal of RAW should be dealt with now rather than left for future generations.
- It is widely agreed that each country has the responsibility to ensure that its wastes are managed in a safe and environmentally sound manner.

Taking responsibility for the correct disposal of one's RAW means adopting a clearly safe solution for both humankind and the environment. Meeting this responsibility does not necessarily mean disposing of RAW within one's own territory. In many cases, however, there is a tendency to aim for this in order to ensure that the required standards are met. This tendency may result from fear that earlier bad examples of dumping hazardous wastes abroad in unsuitable places might be repeated.

For RAW, however, ensuring proper standards for transboundary shipments is not a problem, since there exist legal bases that prescribe exact conditions and requirements to be met. For example, Article 27 of the Joint Convention and Euratom Council Directive 92/3 on transfers prescribe the conditions under which RAW may be exported to or imported from another country.

As there is no ethical—and as a consequence no (international) legal—obligation to dispose of RAW only in the state of its origin, properly implemented multinational repositories are certainly "ethically responsible."[2]

- Another principle of ethics is that no region should be forced against its will to host a repository for RAW. Even in purely national repository programs, this goal is very hard to fulfill, given the strong local political opposition generally encountered in repository siting projects. In some countries, therefore, the national government may formally impose a solution. For multinational concepts, however, national and local acceptance is an absolute prerequisite.
- As the last item of ethics it should be mentioned that no advantage may be taken of politically weak and/or less developed and/or poor areas. It is not ethical to offer large sums of money as compensation to a poor and/or less developed area that is not technically suitable for hosting a safe repository. Nevertheless, fair compensation for accepting the responsibility should be offered to any hosting area and community.
- Finally, it is worth recognizing, that some countries apply policies (as opposed to laws) against multinational disposal concepts and justify these by arguments of ethical responsibility. But in practice the policies often reflect instead a pragmatic reaction to the concern that multinational initiatives might disrupt

[2] See also Dietze, W. 2004. Legal Issues Involved in the International Disposal of High-Level Radioactive Waste, Waste Management 2004 Conference, February 29-March 4, 2004, Tucson, AZ.

national repository planning. Examples are Sweden, France, and the United Kingdom.

Environmentally sound: The net environmental impact should be positive, with global, national, or local benefits being sufficient to outweigh any localized potentially negative effects.

Safe: The public and the environment must be protected from the harmful effects of radiation.

Secure: The term "security" is used in connection with potential misuse of the radioactive materials for illegal actions (by terrorists, rogue states), which clearly must be avoided.

Economical: While meeting all the above-mentioned conditions, a repository for radioactive waste should be as economical as possible. If it costs too much, it is simply not realizable. Multinational repositories can ease the burden of costs as these may be shared and there are clear economies of scale.

Additional Legal Requirements on Multinational Repositories

All the standards to be met and the above-mentioned problems to be solved apply while implementing any repository for radioactive waste. A multinational repository for radioactive waste, however, may encounter several problems and challenges in addition to those experienced in purely national repository projects. Some of these additional challenges in the field of legislation are listed here:

- The applicable laws in connection with multinational repositories in the host country and in the potential user countries must be made compatible.
- The legal form of a company or joint venture in charge of a repository must be defined.
- The shared liabilities (e.g., potential remediation costs) and benefits (e.g., the potential value of spent fuel as an energy source) must be regulated.
- Another important challenge is enforcement of internationally agreed upon laws (which in general is based on voluntary participation and application).

THE LEGAL FRAMEWORK FOR MULTINATIONAL REPOSITORIES

Legal Instruments and Laws in General

The nuclear power community agrees that repositories for radioactive waste, whether national or multinational, are technically feasible with today's technology and can fulfill the commonly agreed upon safety and other technical requirements. Experience, however, has shown that political and sociological opposition presents large obstacles on the way to implementing repositories for RAW—national and international. These political and sociological opinions have an enormous impact on laws governing the disposal of RAW and on their application in practice. Laws are, in a way, a mirror of public attitudes toward a certain issue, although due to the usually long duration of the law-making process they often lag behind the current situation. Yet laws are not made forever, and as public opinions or needs change, they may be amended and adapted. This gives hope that amendments may eventually make multinational repositories possible, even in countries that currently have different laws.

National Laws

In practice, every country using radioactivity for civil purposes has established laws and a legal system covering the disposal of RAW. Many of them prescribe that disposal of their RAW must take place in their own country. Some laws also contain specific articles that deal with aspects of multinational shared repositories and the country's approach to participation therein. Other countries do not explicitly treat the issue of multinational repositories in their legislation. However, from the fact that they permit in their laws export of their own RAW, it may be concluded that they leave the international option open (i.e., they could indirectly allow participation in a multinational repository).

I restrict myself here to the question of whether a particular country allows export and/or import of RAW. This is crucial and decisive for the country's position toward multinational repositories. If export of RAW is prohibited, participation in a multinational repository is out of the question. If import of RAW is not allowed, this country cannot be a host country of a multinational repository, at least not under its present legal situation.

Table 1 summarizes some countries' answers to these questions and, where available, their attitudes and/or policies regarding multinational disposal of RAW.[3]

Before looking closer into legislation, I would like to mention the fact that looking at an isolated article or law can give an incomplete or wrong picture. Articles and sections of laws and laws themselves are always part of a whole system, and this system or framework must be considered too. For example, the term "RAW" is used in many laws. What does it mean? Is SNF included in RAW? This question may not be fully answered with a simple *yes* or *no*. It has to be given the typical answer of lawyers: it depends. It depends on the fuel-cycle policy of a country and on the waste disposal system it has chosen as a consequence. Some countries, after having removed the fuel elements from their reactors, will not use these further. The fuel is considered RAW and must be disposed of accordingly. In these countries RAW includes SNF. Other countries consider spent fuel a valuable resource that may be reprocessed. Therefore, SNF is considered a usable raw

[3]See also Table 4, pp. 90-91, in Boutellier, C., and C. McCombie, 2004, Technical Report on Legal Aspects, SAPIERR, Support Action: Pilot Initiative for European Regional Repositories, Work Package 1, Deliverable 2, available online at *http://www.sapierr.net*.

TABLE 1 Export, Import, and Transfer of RAW: Attitudes Toward Multinational Repository

Country	Import of Foreign RAW for Disposal Permitted?	Export of RAW Permitted?	Disposal Policy for RAW, Attitudes Toward Multinational Repository
Austria	No	Yes (conditions)	Return to USA (research reactor only)
Belgium	Yes (conditions)	Yes (conditions)	Dual track First priority national
Bulgaria	No	Yes	Return to Russia
Croatia	No	Open	No official policy
Czech Republic	No	Yes (conditions)	Dual track First priority national
Finland	No	No	National only
France	No	Yes (conditions)	National only
Germany	Yes (conditions)	Yes (conditions)	National only
Hungary	No	Yes	Dual track
Italy	No	Yes (for treatment)	No official policy
Latvia	No	Yes (conditions)	Dual track
Lithuania	No	Yes (conditions)	Dual track
Netherlands	Yes (conditions)	Yes (conditions)	Dual track
Romania	No	Yes (conditions)	No official policy
Slovakia	Yes (conditions) for treatment, no for disposal	Yes (conditions)	Dual track First priority national
Slovenia	Yes (conditions)	Yes (conditions)	Dual track
Spain	Yes (conditions)	Yes (conditions)	No official policy
Sweden	Yes (small quantities, conditions)	Yes (conditions)	National only
Switzerland	Yes (conditions)	Yes (conditions)	Dual track First priority national
United Kingdom	Left open	Left open	Geological disposal strategy being developed

material, not waste. Their RAW will not include SNF, but rather substances, such as vitrified high-level radioactive wastes (HLW) and technological wastes from reprocessing. This example demonstrates that when comparing laws of different countries care must be applied and the overall framework of the particular laws must be considered too.

Countries that treat the issue of multinational repositories in their legislation do so in a variety of ways. The range extends from prohibiting multinational solutions completely to prescribing them as a goal.

Many nations prescribe in their laws that a national solution must be found for their own RAW (i.e., a repository within their own country). Some states strictly demand an internal solution only and prohibit consideration of multinational options. Others take a broader approach in that they follow a "dual-track policy" in the sense that they look for a national solution but also consider multinational options. Other countries even prescribe explicitly in their legislation that multinational solutions may or even must be considered.

An example of a country with strict laws against multinational solutions is Finland. Finland clearly prohibits any import and export of its RAW. Examples of different approaches are Switzerland and Austria. Switzerland lays out fair, symmetrical conditions for import and export of RAW.[4] Austria explicitly obliges its authorities to consider cooperation with other member states of the European Union and other countries that have ratified the Joint Convention.[5] The Austrian law also explicitly states the reasons for cooperation: balance of risks, optimization of radiation protection, and minimization of costs. Austria may be cited as a typical example of a country with little RAW, so little that the costs of a national repository would bear no sensible relationship to the amount of RAW to be disposed of. Examples of countries with legislation or official documentation indicating that they are following a dual-track policy are Belgium, Bulgaria, Czech Republic, Hungary, Germany, Lithuania, the Netherlands, Slovakia, Slovenia, and Switzerland.

Other countries have not yet decided which path to follow or have a national repository R&D program but have not yet made a clear decision for or against participation in a multinational repository. Examples are Croatia and Spain.

Given the fact that a great number of countries recognize the advantages of multinational repositories, it is interesting—but disappointing—to see that importing RAW for disposal is currently prohibited in most countries.

In general, export of RAW needs an authorization that may be granted only with restrictive conditions being applied. Quite often these restrictions refer to international legislation such as the Joint Convention and Council Directive 92/3 (both discussed in detail below). This is one point where international legislation comes into play.

As mentioned above, in the field of RAW disposal, politics and policies play an extremely important role. For example, a decision on fulfillment of the conditions on import and export of RAW is in reality a question of policy rather than law. Therefore, an overview of the legal situation could not be complete without a glance at some policy or political statements.

Here are some examples:

- The United Kingdom has left open the question of whether its RAW may be exported and has agreed to accept foreign waste for disposal under an equivalence principle, but the former implementing organization in the United

[4] § 34 Kernenergiegesetz, March 21, 2003, entered into force February 1, 2005.
[5] § 36b section 2 Strahlenschutzgesetz, amendment entered into force December 2004.

Kingdom, Nirex[6] (not the government however), has expressed strong views against multinational repositories.

- Sweden and France, whose laws allow export (and for Sweden also import under certain conditions), apply policies (but not laws) against multinational disposal concepts.
- In Australia one state (Western Australia) has passed a law against importing foreign waste, but the national government—despite having a strong policy against import—did not consider that a specific federal law was required to block this.
- Some countries (e.g., Czech Republic, Lithuania, Slovenia) have official governmental policy documents that encourage the waste agency to study the possibility of multinational disposal.
- The United States is not considering import or export of commercial spent fuel, but it has repatriated research reactor fuels.[7] Also, government officials are on record as supporting the concept of small countries collaborating to implement multinational repositories.
- Russia took back fuel from other states of the former Soviet Union, is taking back research reactor fuels, and is the only country today that is officially interested in the possibility of hosting a multinational storage (and perhaps disposal) facility.

Legal Instruments at the International Level

International legislation plays an important role in promoting international collaboration, including initiatives in the field of RAW management. Such international legal instruments directly affect national laws as well as concepts for multinational repositories. Therefore, a selection of the most relevant conventions, treaties, and laws in this field is mentioned below. The description is restricted to those aspects most relevant to multinational repositories for RAW.

- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (in short the Joint Convention):[8] The core provisions of the Joint Convention oblige the parties to observe the general safety requirements.

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[6]Nirex was merged into the United Kingdom's Nuclear Decommissioning Authority in April 2007.

[7]Since the presentation of this paper at the workshop, this policy is changing as the Global Nuclear Energy Partnership program develops.

[8]Adopted September 5, 1997, entered into force June 18, 2001, 42 signatories, 34 parties (as of March 29, 2004). See Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, reproduced in IAEA Information Circular INFCIRC/546, available online at *http://www.iaea.org/Publications/Documents/Conventions/jointconv.html*. For more information, see *http://www-ns.iaea.org/conventions/waste-jointconvention.htm*.

The Joint Convention further imposes obligations on the contracting parties in relation to the transboundary movement of spent fuel and radioactive waste. These are contained in its Article 27. They require an authorization by the country of origin of the RAW to be transported and the approval of the state of destination. Further, shipments of RAW may not be authorized to a destination south of latitude 60° south (Antarctica)[9] nor to a country that does not have the technical, legal, or administrative resources to manage the RAW safely. In addition, it obliges the countries of dispatch, in case a shipment of RAW cannot be completed, to take the RAW back.

The legally binding part of the Joint Convention does not contain any provisions on multinational repositories. However, its preamble states that RAW should, as far as it is compatible with the safety of the management of such material, be disposed of in the state in which it was generated. At the same time it recognizes that in certain circumstances safe and efficient management of SNF and RAW might be fostered through agreements among contracting parties to use facilities in one of them for the benefit of the other parties.

As the Joint Convention imposes the enactment of legislation regarding management of RAW/SNF as well as prescribing its content, it directly influences national laws on the disposal of RAW and therefore multinational repositories. If only one of the partners of a multinational repository is party to the Joint Convention, the latter will directly influence and determine the legal rules of that repository.

- Code of Practice on the International Transboundary Movement of Radioactive Waste (Code of Practice):[10] The main parts of the Code of Practice have been taken over by Article 27 of the Joint Convention. In other points it goes beyond the prescriptions of the Joint Convention. These points remain in force as recommendations and serve as assistance in interpreting the Joint Convention.
- Council Directive 92/3 Euratom on the supervision and control of shipments of radioactive waste between Member States and into and out of the Community (Council Directive on transfers):[11] The Council Directive on transfers applies to shipments of RAW between member states of the European Union (EU) as well as into and out of the EU. Its prescriptions regarding

[9]This ban is based on Article V, Section 1, of the Antarctic Treaty of December 1, 1959 ("Any nuclear explosions in Antarctica and the disposal there of radioactive waste material shall be prohibited."). Available online at *http://www.state.gov/t/ac/trt/4700.htm*.

[10]Adopted by the IAEA General Conference September 21, 1990. See Code of Practice on the International Transboundary Movement of Radioactive Waste, IAEA Information Circular INFCIRC/386, available online at *http://www.iaea.org/Publications/Documents/Infcircs/Others/inf386.shtml*.

[11]Directive dated February 3, 1992, in force since January 1, 1994. Available online at *http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexplus!prod!CELEXnumdoc&numdoc=31992L0003&lg=en*.

transport are basically identical to those of Article 27 of the Joint Convention. The Council Directive on transfers is applicable to all EU member states.

- Convention on Environmental Impact Assessment in a Transboundary Context (Espoo/EIA Convention):[12] The Espoo/EIA Convention stipulates the obligation of the parties to assess environmental impact of certain activities at an early stage of planning and to notify and consult each other on all major projects under consideration that are likely to have a significant adverse environmental impact across boundaries. It also prescribes the procedural steps to follow when realizing a project subject to the convention. Installations for storage or disposal of RAW are subject to this convention.
- Euratom Proposal for a council directive (Euratom) on the management of spent fuel and radioactive waste (Euratom Proposal or Nuclear Package):[13] In late 2002 the European Community (EC) developed a draft waste directive aimed at bringing about progress toward safe long-term management of SNF and RAW. Some of the most important general points contained in the original proposal were as follows:

1. Each member state was required to establish a clearly defined program on long-term management and disposal of RAW with a definite timetable for each step.
2. The program could include shipments of RAW and/or SNF to another member state or third country if such shipments are fully in compliance with existing EU legislation and meet further standards.
3. Disposal in stable geological formations (granite, salt, clay) was acknowledged to be considered the safest and most sustainable solution for the management of high-level and long-lived RAW.
4. A very ambitious timescale for development of appropriate disposal site(s) was foreseen.

Objections against the Euratom Proposal were raised by many stakeholders. They objected to the overly ambitious timescales, some to the encouragement given for regional solutions and a few—primarily the United Kingdom—objected to the identification of geological disposal as the preferred long-term solution. As a result, the text was amended and demoted to a nonbinding resolution. However, efforts are still under way by the European Commission to develop a waste

[12]Adopted in Espoo, Finland, in spring 1991, entered into force September 10, 1997, 30 signatories, 40 parties. Initiated at a seminar on environmental impact assessment in Warsaw, Poland, 1987, organized by the United Nations Economic Commission for Europe. Available online at *http://www.unece.org/env/eia/eia.htm#Text*.

[13]First published by the European Commission on November 6, 2002, final proposal of January 30, 2003, available online at *http://www.euronuclear.org/info/nuclearpackage.htm*. See also Arius Newsletter No. 8, August 2004, The EC Waste Directive: A Complex Evolution, available online at *http://www.arius-world.org*.

directive, and the latest drafts continue to acknowledge the potential benefits of regional repositories.

Table 2 gives an overview of some countries and their status of ratification of the international legislation mentioned above.[14]

Current Initiatives for Multinational Disposal

Despite the existing, mainly political, barriers there is increasing support at the international level for multinational repositories. Over the years there have been numerous proposals published for multinational repositories or storage schemes and several initiatives and projects have been launched. Some selected examples are mentioned here:

- International Atomic Energy Agency (IAEA) Expert Group on Multilateral Nuclear Approaches (MNA): This expert group was established by the IAEA as part of efforts to prevent the spread of nuclear weapons. It focuses on security issues of proliferation-sensitive parts of the nuclear fuel cycle. Among other approaches it is considering for the back end of the nuclear fuel cycle are multilateral approaches to the management and disposal of SNF and RAW.[15] For further information see the dedicated IAEA web site at *http://www.iaea.org/NewsCenter/Focus/FuelCycle/index.shtml*.
- Arius, the Association for Regional and International Underground Storage: Arius was set up in Switzerland by waste management organizations from several countries as a noncommercial body to promote the concept of multinational facilities for storage and disposal of all types of long-lived nuclear wastes.[16] Further information is provided on its web site, *http://www.arius-world.org*.
- SAPIERR, Support Action, Pilot Initiative for European Regional Repositories: SAPPIER is a project within the sixth framework program of the EU, which is designed to explore the feasibility of regional repositories in the EU.[17]

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[14]See also Table 1, p. 86, in Boutellier, C., and C. McCombie. 2004. Technical Report on Legal Aspects, SAPIERR, Support Action: Pilot Initiative for European Regional Repositories, Work Package 1, Deliverable 2, available online at *http://www.sapierr.net*.

[15]The group consists of 23 experts drawn from as many countries and is chaired by Bruno Pellaud, former IAEA deputy director general and head of the Department of Safeguards. The group released its findings on February 22, 2005, in its report entitled Multilateral Approaches to the Nuclear Fuel Cycle, available online at *http://www-pub.iaea.org/MTCD/publications/PDF/mna-2005_web.pdf*.

[16]The eight organizational members of Arius are (as of June 2005) Kozloduy NPP (Bulgaria), PURAM (Hungary), ENEA (Italy), Obayashi Corp. (Japan), Radiation Safety Centre (Latvia), COVRA (Netherlands), ARAO (Slovenia), and Colenco Power Engineering (Switzerland).

[17]The following 14 countries are participating in the SAPIERR working group: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Hungary, Italy, Latvia, Lithuania, the Netherlands, Romania, Slovakia, Slovenia, and Switzerland. For further information, see Boutellier, C., and C. McCombie. 2004. Technical Report on Legal Aspects, SAPIERR, Support Action: Pilot Initiative for European Regional Repositories, Work Package 1, Deliverable 2, available online at *http://www.sapierr.net*.

TABLE 2 Ratification/Adoption of International Conventions/Treaties

Countries	Joint Convention	Espoo/EIA Convention[a]	Council Directive 92/3 re. Transfers
Argentina	Yes	No	Binding to all EU Member States
Australia	Yes	No	
Austria[b]	Yes	Yes	
Belgium[b]	Yes	Yes	
Bulgaria[c]	Yes	Yes	
Canada	Yes	Yes	
Croatia[c]	Yes	Yes (accession)	
Czech Republic[b]	Yes	Yes	
Finland[b]	Yes	Yes (acceptance)	
France[b]	Yes	Yes (approval)	
Germany[b]	Yes	Yes	
Greece[b]	Yes	Yes	
Hungary[b]	Yes	Yes	
Italy[b]	Yes (signed)	Yes	
Kazakhstan	Signature only	Yes (accession)	
Latvia[b]	Yes	Yes (accession)	
Lithuania[b]	Yes	Yes (accession)	
Netherlands[b]	Yes	Yes (acceptance)	
Norway	Yes	Yes	
Poland[b]	Yes	Yes	
Romania[c]	Yes	Yes	
Slovakia[b]	Yes	Yes	
Slovenia[b]	Yes	Yes (accession)	
Spain[b]	Yes	Yes	
Sweden[b]	Yes	Yes	
Switzerland	Yes	Yes (accession)	
Ukraine	Yes	Yes	
United Kingdom[b]	Yes	Yes	
USA	Yes	Signature only	

[a]The EC has also signed and ratified the Espoo convention.
[b]Member state of the EU.
[c]Candidate country to the EU.

The SAPIERR project has compiled information on the legal situation with respect to a European regional repository. The project is further described on its web site: *http://www.sapierr.net/index_01.htm.*

- Euratom Proposal for a council directive (Euratom) on the management of spent fuel and radioactive waste: The proposal has launched a broad discussion on—among other topics—multinational repositories, but unfortunately has yielded only a nonbinding resolution. Nevertheless, it led to acknowledgment of multinational repositories.
- IAEA—Russia Initiatives: The director general of the IAEA and the responsible Russian minister recently agreed that a special conference on the

possibility of a Russian multinational repository would be held in 2005. This will take place in July of this year. The Russian and American national academies of sciences have also been studying the concept. The present meeting in Vienna is a follow-on to that organized in Moscow in 2003.[18]

CONCLUSIONS

- In many countries national laws do refer, at least indirectly, to the possibility of multinational repositories for RAW. However, few countries explicitly treat the issue of multinational repositories in their legislation.
- National policies and legislation differ greatly in their treatment of waste import/export, both being basic conditions for multinational repositories.
- National legislation and even more national policies in several countries reject the concept of waste import and sometimes even export. Although ethical arguments are sometimes put forward in justification by such countries, these are never given as such in the legislation.
- There is growing support in international organizations (in particular the IAEA and the European Commission) for multinational repositories.
- International organizations and also most nations recognize the right of individual countries to collaborate in the development of multinational repositories. However, they also recognize their right to prohibit the import and/or export of RAW.
- They also recognize that multinational repositories are ethically justified and can bring global advantages in safety, security, environmental protection, and economics.

[18] Further information on other proposals may be found in Developing Multinational Radioactive Waste Repositories: Infrastructural Framework and Scenarios of Cooperation. 2004. Vienna: IAEA. Available online at *http://www-pub.iaea.org/MTCD/publications/PDF/te_1413_web.pdf*.

6

Current Russian Legislation Regulating Procedures and Conditions for the Import of Foreign Spent Nuclear Fuel*

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BRIEF HISTORICAL BACKGROUND

Prior to the passage of the current legislation, spent fuel from nuclear facilities built abroad with technical assistance from the former Soviet Union (Russian Federation) was imported for temporary technical storage and/or reprocessing on the basis of commitments undertaken in relevant intergovernmental agreements. In particular, these included agreements with the governments of Bulgaria (October 1, 1981, and March 27, 1984), Czechoslovakia (April 30, 1970; November 15, 1976; November 27, 1980; and December 8, 1982), Hungary (August 14, 1986), and Finland (May 14, 1969).

The volume of spent nuclear fuel from the 24 VVER-440 and VVER-1000 reactors at nuclear power plants built with technical assistance from the former Soviet Union totaled more than 350 metric tons annually. In accordance with the intergovernmental agreements, the spent nuclear fuel was returned to the Soviet Union after being kept in storage facilities at the nuclear power plants (for at least five years).

Prior to 1989, Soviet organizations accepted spent nuclear fuel from foreign power plants through the Atomenergoeksport All-Union Association of the USSR Ministry of Foreign Economic Ties. As of January 1, 1989, responsibility for handling the receipt of spent nuclear fuel in the Soviet Union was assigned to the Tekhsnabeksport All-Union Association of the USSR Ministry of the Atomic Energy Industry.

*Translated from the Russian by Kelly Robbins.

Order No. 2302-rs of the USSR Council of Ministers dated October 24, 1978, which governed basic conditions for the import of spent nuclear fuel into the Soviet Union, specifically established that spent fuel from nuclear power plants built abroad according to Soviet designs was to be accepted without compensation.

The condition of acceptance without compensation was adopted in previously signed contracts based on the nature of the nuclear fuel cycle at that time. It was believed that the reprocessing of spent nuclear fuel was an economically efficient process that would allow useful isotopes to be extracted (particularly uranium and plutonium) for subsequent use in the fuel cycle. Based on this assessment, the countries that possessed spent fuel hoped to sell it. Such offers for Soviet organizations to purchase spent fuel came from the former German Democratic Republic (the Bruno Leuschner nuclear power plant), Finland (the Loviisa nuclear power plant), and others. For these reasons, during the period up to 1980 the acceptance of spent fuel without compensation was a more favorable contract condition for the Soviet organizations involved.

Following issuance of the above-mentioned order of the USSR Council of Ministers, contracts signed by Atomenergoeksport included the condition that spent fuel was to be accepted by the USSR without compensation and stipulated only that foreign customers should pay for the costs of renting the special means of shipment provided as well as the services of consultants and Soviet specialists involved in transporting the material.

Order No. 641-rs of the USSR Council of Ministers dated April 1, 1988, made a partial change in Order No. 2302-rs dated October 24, 1978, by requiring that services provided in connection with the receipt of spent fuel by the USSR be conducted on a commercial basis. However, in connection with the Russian Federation Congress of People's Deputies Resolution on Developing the State Program for Managing, Reprocessing, and Storing Radioactive Wastes and Spent Nuclear Materials and Urgent Measures to Improve the Radioecological Situation in the Russian Federation (dated June 22, 1990), the Russian Federation Council of Ministers was assigned the task of preparing recommendations on prohibiting storage in the Russian Federation of the end products of the activities of atomic facilities from other republics and countries as of January 1, 1991.

On April 21, 1993, Russian Federation Presidential Decree No. 472 on Fulfillment by the Russian Federation of Intergovernmental Agreements on Cooperation in Constructing Nuclear Power Plants Abroad (with amendments of April 20, 1995, and April 6, 2000) instructed the Russian Ministry of Atomic Energy along with interested Russian ministries and departments to ensure compliance with obligations contained in intergovernmental agreements made by the USSR up to 1991 on cooperation in the construction of nuclear power plants abroad that specifically called for the shipment of nuclear fuel from Russia and the return of spent fuel from these plants to Russia for reprocessing. The decree stipulated the following:

- development of procedures for Russian enterprises to accept and subsequently reprocess spent nuclear fuel from foreign nuclear power plants,
- provision of hard-currency proceeds for conducting environmental improvement and socioeconomic development programs in regions where atomic industry facilities are located, and
- insistence that all relevant contracts with foreign customers include the provision that any rejected radioactive wastes created during reprocessing are to be returned to the country that sent the spent nuclear fuel to Russia.

On April 20, 1995, Russian Federation Presidential Decree No. 380 on Additional Measures to Strengthen Control Over Fulfillment of Environmental Safety Requirements in the Reprocessing of Spent Nuclear Fuel (with amendments of March 1, 1996) gave the government of the Russian Federation three months to develop and ratify procedures for the acceptance of spent nuclear fuel from foreign nuclear power plants for temporary storage and subsequent reprocessing at Russian enterprises and for the return of radioactive wastes and materials created during reprocessing.

The procedures for acceptance of spent nuclear fuel from foreign nuclear power plants for temporary storage and subsequent reprocessing at Russian enterprises and for return of radioactive wastes and materials created during reprocessing were approved by Russian Federation Government Resolution No. 773 dated July 29, 1995, and went into effect as of September 1, 1995 (with amendments of July 10, 1998).

These procedures cover spent fuel accepted for reprocessing by the Mining-Chemical Complex in Zheleznogorsk, Krasnoyarsk Territory, from nuclear power plants constructed abroad before 1991 with technical assistance from the Soviet Union, those newly built abroad as part of Russian Federation projects, and those built by other countries. The procedures include the following points:

- import of spent nuclear fuel from foreign nuclear power plants for subsequent reprocessing at Russian enterprises with the aim of extracting valuable components (plutonium and uranium) for further use and solidifying radioactive fission products,
- acceptance of spent nuclear fuel on the condition that any radioactive wastes created and any reprocessing products not intended for further use in the Russian Federation are to be returned to the country of origin, and
- return of uranium and plutonium to any state that does not possess nuclear weapons only on the condition that all nuclear activities of this state shall be guaranteed by the International Atomic Energy Agency (IAEA).

The procedures also stipulate the possibility of accepting spent fuel from foreign nuclear power plants built by other countries in accordance with intergovernmental agreements.

The specific quantity of spent fuel subject to acceptance for reprocessing is determined by the Russian Ministry of Atomic Energy depending on annual orders from organizations and firms operating nuclear power plants abroad, the conditions of permits from the State Inspectorate for Nuclear and Radiation Safety for the relevant types of activities, and the production capacity of radioactive waste processing enterprises, given the environmental situation in the region where they are located. These decisions are coordinated with federal and regional environmental protection agencies, executive branch agencies in Russian Federation members, and local government agencies.

Total radionuclide content (activity) in the solidified radioactive wastes returned to the country that supplied the spent nuclear fuel is determined on the basis of mutually agreed upon methodology, considering the time that the fuel was received and the time the solidified wastes have been held in storage.

The time that the solidified radioactive wastes are held is specifically established in each contract but does not exceed 20 years, depending on the need to reduce radiation and heat exchange to levels that will ensure the safe transport of solidified wastes to the country that supplied the spent nuclear fuel.

CURRENT RUSSIAN FEDERATION LEGISLATION

Legislative acts and regulatory-legal acts of the president and government of the Russian Federation have now been established to define the legal bases for the import of foreign spent nuclear fuel into the Russian Federation. Procedures and conditions for the import of foreign spent fuel are governed by the following regulatory-legal documents:

International Conventions

- The Vienna Convention on Civil Liability for Nuclear Damage, dated May 21, 1963 (ratified by the Russian Federation on March 21, 2005)
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (submitted to the State Duma for ratification)

Federal Laws of the Russian Federation

- Federal Law on the Use of Atomic Energy (No. 170-FZ, dated November 21, 1995)
- Federal Law on Environmental Expert Review (No. 174-FZ, dated November 23, 1995)

- Federal Law on Radiation Safety for the Population (No. 3-FZ, dated January 9, 1996)
- Federal Law on Environmental Protection (No. 7-FZ, dated January 10, 2002)
- Federal Law on Special Environmental Programs for Rehabilitating Areas Contaminated by Radiation (No. 92-FZ, dated July 10, 2001)

Decree of the President of the Russian Federation

- Russian Presidential Decree No. 828 on Affirming the Statute on the Special Commission for Issues Related to the Import into the Russian Federation of Foreign Irradiated Fuel Rods and their Components (dated June 10, 2001)

Resolutions of the Government of the Russian Federation

- Statute on the Import into the Russian Federation of Irradiated Nuclear Reactor Fuel Rods, affirmed by Resolution No. 418 of the Government of the Russian Federation dated July 11, 2003
- Statute on the Development of Special Environmental Programs for Rehabilitating Areas Contaminated by Radiation, affirmed by Resolution No. 421 of the Government of the Russian Federation dated June 14, 2002
- Statute on the Financing of Special Environmental Programs for Rehabilitating Areas Contaminated by Radiation, affirmed by Resolution No. 588 of the Government of the Russian Federation dated September 22, 2003
- Rules for Confirming Expenditures for the Management of Irradiated Fuel Rods from Nuclear Reactors and the Products of Their Reprocessing, affirmed by Resolution No. 587 of the Government of the Russian Federation dated September 22, 2003

Federal Norms and Rules on the Use of Atomic Energy

- Dry Storage Sites for Spent Nuclear Fuel: Safety Requirements (NP-035-02)
- Safety Rules for the Shipment of Radioactive Materials (NP-053-04)
- Radiation Safety Norms (NRB-99): Hygiene Regulations (SP 2.6.1.758-99)
- Basic Sanitary Rules for Radiation Safety (OSPORB-99: SP 2.6.1.799-99)
- General Provisions for the Safety of Nuclear Fuel Cycle Facilities (NP-016-2000)
- Basic Rules for Accounting and Control of Nuclear Materials (NP-030-01)

BASIC PROVISIONS OF CURRENT LEGISLATION

Federal Law on the Use of Atomic Energy

In accordance with Article 64 of the Federal Law on the Use of Atomic Energy,

> The import into Russia of spent nuclear fuel from foreign states for temporary technical storage and (or) reprocessing is carried out according to procedures established by Russian legislation and international treaties of the Russian Federation.
>
> The import into Russia of irradiated nuclear fuel rods produced in foreign states (irradiated fuel rods of foreign manufacture) is carried out on the basis of a positive recommendation by a special commission created by the president of the Russian Federation. Members of this commission include its chair and 20 commission members (five representatives each from the president, the Federation Council of the Federal Assembly, the State Duma of the Federal Assembly, and the government of the Russian Federation).

Procedures for the submission of recommendations of candidates to represent the Federation Council and the State Duma are determined by each corresponding house of the Russian Federal Assembly.

The special commission presents the president and the houses of the Russian Federal Assembly with annual reports on the status of affairs with regard to the import into Russia of irradiated fuel rods of foreign manufacture.

The statute on the special commission is affirmed by decree of the president of the Russian Federation.

Federal Law on Environmental Protection

In accordance with Article 48 (Point 4) of the Federal Law on Environmental Protection,

> The import into Russia of spent nuclear reactor fuel rods from foreign states for temporary technical storage and (or) reprocessing is permitted if a *state environmental impact review* and other state expert reviews of the project as required by Russian legislation have been conducted and if there is proof that the *overall risk of radiation impacts will be reduced and the level of environmental safety increased* if the given project is implemented.
>
> The import of irradiated nuclear reactor fuel rods into Russia is carried out on the basis of international treaties of the Russian Federation.

The same Article 48 (Point 4, Paragraph 3) emphasizes that procedures for the import into Russia of irradiated nuclear reactor fuel rods are established by the government of the Russian Federation based on the fundamental principles of *nonproliferation of nuclear weapons*, environmental protection, and the economic interests of Russia, taking into account the *priority of the right to return radioactive wastes created as a result of reprocessing* to the state from which the nuclear materials came or to facilitate their return.

Federal Law on Special Environmental Programs for Rehabilitating Areas Contaminated by Radiation

The Federal Law on Special Environmental Programs for Rehabilitating Areas Contaminated by Radiation sets forth the main features of state regulation of relations regarding the development and implementation of special environmental programs for rehabilitating radiation-contaminated areas.

Special environmental programs are focused on ensuring the safety of the population, reducing the overall risk of radiation impacts, and improving the environmental situation in radiation-contaminated areas by means of carrying out measures to rehabilitate such areas and decommissioning and eliminating radiation hazard facilities removed from operation.

Special environmental programs are financed using hard-currency proceeds received from foreign trade operations involving irradiated nuclear reactor fuel rods and placed into a special account in the targeted budget fund of the federal executive branch agency responsible for state management of the use of atomic energy.

The government of the Russian Federation approves the list of foreign trade operations involving irradiated nuclear reactor fuel rods and the hard currency funds received from these operations and used to finance special environmental programs.

Procedures and priorities for funding special environmental programs are established by the government of the Russian Federation in coordination with government entities in the various federation members. Top priority is accorded to special environmental programs in those federation subjects that are the sites of organizations conducting activities related to the reprocessing of irradiated fuel rods from foreign states. A state environmental impact review is required for a *unified project* involving a foreign trade deal associated with the import into Russia of irradiated nuclear reactor fuel rods from foreign states and the implementation of a special environmental program or programs to be financed by funds received from this trade deal. Foreign trade deals involving irradiated nuclear reactor fuel rods are concluded by organizations specially authorized by the government of the Russian Federation only if the state environmental impact review results in a favorable recommendation.

The limit on the number of irradiated nuclear reactor fuel rods imported into the Russian Federation each year is set by the government of the Russian Federation in cooperation with government entities in the various federation members that are the sites of organizations conducting activities related to the reprocessing of irradiated fuel rods from foreign states and their temporary technical storage, depending on the capabilities of these organizations over the entire period of storage and reprocessing of the rods, the status of the environment in their area, and principles of radiation equivalency.

In accordance with the federal law on the federal budget for the relevant year, 25 percent of hard currency proceeds received in the special account of the targeted budget fund of the federal executive branch agency responsible for state management of the use of atomic energy from foreign trade operations involving irradiated nuclear reactor fuel rods is transferred to the budgets of government entities in the various Russian Federation members that are the sites of organizations conducting activities related to the reprocessing of irradiated fuel rods from foreign states and their temporary technical storage. These transferred funds are to cover expenditures approved under procedures established by the Russian Federation government for managing irradiated nuclear reactor fuel rods and the products of their reprocessing.

Statute on the Import into the Russian Federation of Irradiated Nuclear Reactor Fuel Rods

Ratified by Russian government Resolution No. 418 on July 11, 2003, the Statute on the Import into the Russian Federation of Irradiated Nuclear Reactor Fuel Rods is an important document in the development and implementation of the federal laws mentioned above. This statute establishes procedures for the import into Russia of irradiated nuclear reactor fuel rods as well as the return of these fuel rods or the products of their reprocessing (including radioactive wastes) to the state that supplied them, based on the principles defined in Point 4 of Article 48 of the Federal Law on Environmental Protection.

Certain concepts used in the statute include the following:

- “Irradiated fuel rods of Russian manufacture”—fuel rods originating in the Russian Federation and irradiated in a nuclear reactor in a foreign state.
- “Irradiated fuel rods of foreign manufacture”—fuel rods originating in a foreign state and irradiated in a nuclear reactor in a foreign state.
- “Temporary technical storage”—temporary storage of irradiated fuel rods and products of their reprocessing in specially outfitted repositories for the purpose of increasing safety and reducing the costs of their subsequent management.
- “Unified project”—documents prepared in connection with the proposed signing of a foreign trade contract to carry out operations involving irradiated fuel rods, with these documents being subject to a state environmental impact review and developed and agreed upon in accordance with established requirements. These documents include the following:

1. Draft of foreign trade contract (indicating the amount of money expected to be received as a result of its implementation and the costs of managing the irradiated fuel rods and products of their reprocessing, with all amounts to be approved according to established procedures).

2. Special environmental program (programs) to be carried out using the proceeds of foreign trade operations involving irradiated fuel rods.

3. Materials documenting the overall reduction of the risk of radiation impacts and increased level of environmental safety as a result of implementation of the unified project, as well as timelines for the temporary technical storage of the irradiated fuel rods and products of their reprocessing as stipulated in the foreign trade contract.

4. Other documents subject to state environmental impact review in accordance with the demands of Russian Federation legislation, including the conclusions of the Federal Service for Environmental, Technological, and Nuclear Oversight (Rostekhnadzor, formerly Gosatomnadzor) and the Federal Agency for Healthcare and Social Development of the Russian Ministry of Health.

The statute establishes that foreign trade contracts for the import of spent fuel rods into the Russian Federation are concluded with the aim of facilitating

- temporary technical storage of irradiated fuel rods, with subsequent mandatory return to the state that supplied them, and
- temporary technical storage of irradiated fuel rods, with subsequent reprocessing.

Irradiated fuel rods may be imported into the Russian Federation (Article 5 of the statute) provided there is a favorable ruling issued by the state environmental review panel on the *unified project* prepared by authorized organizations and coordinated with the Russian Ministry of Atomic Energy (Minatom; currently with the Federal Atomic Energy Agency, Rosatom) and if the authorized organizations have the appropriate licenses from the Russian Ministry of Economic Development and Trade and the Russian Federal Inspectorate for Nuclear and Radiation Safety (Gosatomnadzor; currently Rostekhnadzor).

Unified projects associated with foreign trade operations involving irradiated fuel rods of foreign manufacture that receive a positive ruling from the state environmental impact review are sent by Minatom (now Rosatom) to the special commission on the import of foreign-made irradiated fuel rods into Russia, which was established in accordance with Russian Presidential Decree No. 828 dated June 10, 2001.

Responsibility for losses and damage suffered by legal entities and individuals as a result of radiation impacts related to the import of irradiated fuel rods into Russia or the return of these fuel rods and the products of their reprocessing from Russia to their state of origin is determined in accordance with Russian legislation and international treaties to which Russia is a party (the 1963 Vienna Convention on Civil Liability for Nuclear Damage).

Responsibility for providing *physical protection* during the import of irradiated fuel rods into Russia and the return of these fuel rods and the products of their reprocessing to their state of origin is established by international treaties of the Russian Federation in accordance with the 1980 Convention on the Physical Protection of Nuclear Material.

The statute also stipulates that irradiated fuel rods are imported into Russia subject to the limits established annually by the Russian government on the basis of Rosatom recommendations, which are coordinated with the Russian Ministry of Natural Resources and government entities in jurisdictions that are the sites of organizations involved in reprocessing imported irradiated fuel rods and maintaining them in temporary technical storage.

Irradiated fuel rods are imported into the Russian Federation for temporary technical storage with subsequent mandatory return to the state of origin on the following conditions:

1. An international treaty signed by the Russian Federation must contain the *commitments and guarantees of the sending state* to accept the irradiated fuel rods back from the Russian Federation upon conclusion of their temporary technical storage.
2. The duration of the temporary technical storage of the irradiated fuel rods is based on the materials included in the unified project and defined in the appropriate signed foreign trade contract, and this duration must not exceed the technically permissible term set based on the particular characteristics and condition of the irradiated fuel rods and the means and conditions of their storage.
3. The foreign trade contract for the import of the irradiated fuel rods for temporary technical storage with subsequent mandatory return must include provisions outlining the procedures for the interaction of the parties involved if the established duration for temporary storage is changed. The contract must also stipulate the appropriate guarantees on both sides.
4. If it becomes necessary to extend the term of temporary storage and (or) subsequent reprocessing of the irradiated fuel rods in the Russian Federation, services are rendered by the authorized organizations in accordance with the statute.

Irradiated fuel rods are imported into the Russian Federation for temporary technical storage with subsequent reprocessing on the following conditions:

1. An international treaty signed by the Russian Federation must contain commitments on the reprocessing of the irradiated fuel rods upon conclusion of their temporary technical storage.
2. The duration of the temporary technical storage of the irradiated fuel

rods and the products of their reprocessing is based on the materials included in the unified project and defined in the appropriate signed foreign trade contract, and this duration must not exceed the technically permissible term set, based on the particular characteristics and condition of the irradiated fuel rods and the products of their reprocessing and the means and conditions of their storage.

3. The foreign trade contract for the import of the irradiated fuel rods for temporary technical storage with subsequent reprocessing must include provisions outlining the procedures for interaction of the parties involved if the established duration for temporary storage of the irradiated fuel rods or the products of their reprocessing is changed. The contract must also stipulate the appropriate financial guarantees on both sides.

4. The foreign trade contract for the import of irradiated fuel rods of Russian manufacture may include conditions for them to remain in the Russian Federation unless otherwise specified in international treaties to which Russia is a party.

5. The foreign trade contract for the import of irradiated fuel rods of foreign manufacture must stipulate the conditions for subsequent return of the radioactive wastes to the state of origin unless otherwise specified in international treaties to which Russia is a party.

Products of reprocessing are returned to the state of origin based on the following conditions:

1. Products of reprocessing must be returned so as to observe international commitments of the Russian Federation regarding the nonproliferation of nuclear weapons.

2. The international treaty to which the Russian Federation is a party must contain provisions spelling out the obligations and guarantees of the supplier regarding the acceptance of the products of reprocessing and regarding provision of opportunities to verify that the supplier maintains the conditions necessary for accepting and safely managing these materials.

3. The foreign trade contract must indicate the nomenclature, composition, physical form, quantity, and type of packaging of the products of reprocessing subject to return.

Irradiated fuel rods and the products of their reprocessing must be *transported* within the Russian Federation in accordance with established federal norms and rules on the use of atomic energy, special transportation rules, and hazardous cargo shipping rules, with an eye to existing international norms for the safe transport of radioactive materials. Entry points along the Russian state border through which irradiated fuel rods and the products of their reprocessing may be transported are determined by Rosatom and the Russian State Customs Committee.

One important requirement in this statute is found in Point 14: "The technical characteristics of irradiated fuel rods intended for import into the Russian Federation must meet the requirements of Russian regulatory documents on the safe management of irradiated fuel rods" (burn-up, time of storage in holding pool, specific energy generation, and so forth).

Services may be rendered to the supplying state with regard to management of the products of reprocessing if this meets the principles of nonproliferation of nuclear weapons, which is specifically covered in the relevant international treaties to which the Russian Federation is a party.

Irradiated fuel rods are returned to their state of origin upon the conclusion of their temporary technical storage in accordance with the commitments and guarantees made by that state. The quantity of products of reprocessing subject to return to the supplier state is determined according to methods agreed on by the parties based on the condition of equivalence of activity of the irradiated fuel rods previously imported for reprocessing and the activity of the reprocessing products being returned, given the natural decay of radionuclides during operations related to the temporary technical storage of irradiated fuel rods and the products of their reprocessing, as well as during reprocessing of the fuel rods.

Rosatom, the Russian Ministry of Natural Resources, and Rostekhnadzor monitor the timely return of irradiated fuel rods and products of their reprocessing to the state of origin with which the Russian Federation has signed an international treaty calling for Russia to import irradiated fuel rods for temporary technical storage and reprocessing on the condition that the products of this process are to be returned.

Rostekhnadzor, the Federal Agency for Healthcare and Social Development, the Ministry of Civil Defense Affairs, Emergency Situations, and Elimination of the Consequences of Natural Disasters, and the Ministry of Natural Resources work in their areas of competence to provide state oversight of nuclear, radiation, and fire safety, as well as state monitoring of environmental safety at all stages in the management of irradiated fuel rods and the products of their reprocessing.

Information on the import into Russia of foreign irradiated fuel rods and the return of these rods and reprocessing products to the state of origin is provided by Rosatom to the special commission on the import of irradiated fuel rods of foreign manufacture, and the commission uses this information to prepare an annual report on the state of affairs in this sector.

DOCUMENTS ON ISSUES RELATED TO THE IMPORT OF SPENT FUEL AND THE DEVELOPMENT OF SPECIAL ENVIRONMENTAL PROGRAMS

In addition to the federal laws and statutes discussed above, the Russian Federation has issued a number of documents regulating the *internal* activities of Russian organizations to ensure that the import of irradiated fuel rods does not lead to a worsening of the overall radiation and environmental situation.

These documents include the Statute on the Special Commission on the Import into Russia of Irradiated Fuel Rods of Foreign Manufacture, which was developed in accordance with Article 64 of the Federal Law on the Use of Atomic Energy. The main tasks of the special commission include

1. issuing rulings on proposed imports of foreign irradiated fuel rods into Russia and preparing the appropriate recommendations to the government of the Russian Federation;
2. preparing recommendations to the president of the Russian Federation on matters related to imports, storage, and (or) reprocessing; and
3. collecting and analyzing materials on import matters.

This commission, which was formed in accordance with Russian Presidential Decree No. 858 dated July 31, 2003, consists of leading Russian scientific, public, and political figures. Zhores I. Alferov, academician, Nobel laureate, and State Duma deputy, has been appointed to chair the commission.

The following documents have been developed and put into force in order to implement the Federal Law on Special Environmental Programs for Rehabilitating Areas Contaminated by Radiation:

- Statute on the Development of Special Environmental Programs for Rehabilitating Areas Contaminated by Radiation (This statute defines procedures and timelines for the development of special environmental programs for rehabilitating areas contaminated by radiation and financed with proceeds from foreign trade operations involving irradiated nuclear reactor fuel rods.)
- Statute on the Financing of Special Environmental Programs for Rehabilitating Areas Contaminated by Radiation (This statute defines procedures and priorities for the financing of special environmental programs that have undergone state environmental impact review as part of unified projects that include foreign trade deals associated with the import into Russia of irradiated nuclear reactor fuel rods.)
- Rules for Approving Expenditures for the Management of Irradiated Nuclear Reactor Fuel Rods and the Products of Their Reprocessing (These rules establish a list of eligible costs for managing irradiated fuel rods, as well as procedures for determining and approving these expenses.)

FEDERAL NORMS AND RULES ON THE USE OF ATOMIC ENERGY

The Russian Federation has developed a number of regulatory documents to facilitate monitoring of the safety of spent fuel management at all stages in the fuel life cycle, including documents on the management of radioactive wastes created during both the technical storage of spent fuel from nuclear reactors and the reprocessing of this fuel. These documents include the following:

Dry Storage Sites for Spent Nuclear Fuel: Safety Requirements (NP-035-02)

These requirements regulate matters of safety specific to dry storage sites for spent nuclear fuel as sources of possible radiation impacts on site personnel, the population, and the environment, and they establish requirements for ensuring the safety of these facilities. The document covers dry storage sites for spent nuclear fuel intended for the storage of such fuel from both power and research reactors and nuclear power units from ships and submarines. In these sites the heat given off by radioactive decay is dissipated by forced air circulation and (or) natural air convection.

Safety Rules for the Shipment of Radioactive Materials (NP-053-04)

The rules establish safety requirements for the shipment of radioactive materials, including requirements regarding operations and conditions associated with the movement of radioactive materials. They also define the process, which includes preparation, loading, dispatch, and transport, including temporary (transit) storage, as well as unloading and reception of the radioactive materials and their packaging at the destination point.

The rules cover the shipment of radioactive materials by all types of transport via ground, air, or water and are in effect over the entire territory of the Russian Federation.

In addition, the rules cover the shipment of radioactive materials, including the shipment of radioactive materials that are components of items, the operation of which is associated with the shipment.

Basic Rules for Accounting and Control of Nuclear Materials (NP-030-01)

These rules set forth the basic requirements for nuclear materials present in any chemical compounds and physical forms, as well as criteria for their accounting and control. The rules cover activities associated with the production, use, reprocessing, and transport of nuclear materials.

General Provisions for the Safety of Nuclear Fuel Cycle Facilities (NP-016-2000)

This document regulates safety matters specific to nuclear fuel-cycle facilities as sources of possible impacts on personnel, the population, and the environment. It establishes criteria, principles, and general requirements for nuclear and radiation safety at nuclear fuel-cycle facilities.

CONCLUSION

At present the Russian Federation has the necessary legislative and regulatory base for the import (export), storage, and reprocessing of foreign spent nuclear fuel.

7

The Importance of Storage and Disposal in Multinational Approaches to the Fuel Cycle

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THE GLOBAL NEED FOR STORAGE AND DISPOSAL FACILITIES

Virtually all countries in the world with nuclear power programs have concluded that geological disposal is a necessity if we are to make the nuclear fuel cycle safe and environmentally acceptable without putting undue burdens on future generations (International Atomic Energy Agency [IAEA] 2002). For technical reasons related to the initial rapid decay of radioactivity and heat output, disposal of spent nuclear fuel (SNF) or high-level wastes (HLW) can take place only after storage periods of decades or more. For societal or economic reasons, some countries have decided on much longer interim storage—for example, the Netherlands intends to store for 100 or more years—although it is nevertheless recognized that geological disposal is the only feasible subsequent step.

Even for countries that would like to move relatively quickly to disposal, storage has become a key issue. This is because, unfortunately for the progress of nuclear power, moving toward geological disposal has proven to be a very difficult task, even in the most advanced countries. There will be no SNF/HLW repository in operation until the next decade, and many countries are looking toward the middle of the century. For the larger advanced nuclear programs, the problems are mainly societal issues associated with achieving sufficient public and political acceptance for specific sites for a national repository. For small countries, however, countries with limited nuclear power programs, or countries with no nuclear power but long-lived wastes from other applications, a national deep geological repository may be ruled out on economic or environmental grounds. If SNF and HLW are not to remain dispersed for indefinite periods in dozens of surface storage sites around the world, these small countries need access to geological repositories.

This implies that multinational facilities for the disposal of SNF/HLW are a prerequisite for the sustainable, safe, and environmentally friendly use of nuclear power and other nuclear applications. Other activities in the nuclear fuel cycle—uranium supply, enrichment, fuel fabrication, reactor construction, and reprocessing—are all provided as international services. The same status must be achieved for disposal. For storage the economic arguments for multinational facilities are more debatable, since the facilities are less costly and the economies of scale less dramatic. There are, however, other strong arguments for rationalizing global storage strategies, as pointed out in the following section.

NONPROLIFERATION AND SECURITY OF INCREASING IMPORTANCE

In addition to the economic, safety, and environmental benefits that multinational repositories can offer, the nonproliferation advantages have often been stressed (IAEA 2004, Stoll and McCombie 2001). In recent years, in particular following the series of terrorist attacks from 2001 onward, increasing attention has focused on both nonproliferation and security aspects (see Alvarez et al. 2003, U.S. Nuclear Regulatory Commission [USNRC] 2003, National Research Council [NRC] 2005). Repeated statements by the director general of the IAEA have pointed out the need to control the most sensitive parts of the fuel cycle (e.g., ElBaradei 2003). It is important to note that these include not only enrichment of fissile uranium and reprocessing, to separate plutonium, but also long-term storage and disposal of SNF/HLW. This point is made clear in the February 2005 report published by the Multinational Approaches (MNA) Expert Group that the director general set up in mid-2004 (IAEA 2005a). The MNA report addresses the security and nonproliferation issues in a manner directly applicable to all aspects of the nuclear fuel cycle and suggests five specific approaches for multinational initiatives. The implications of these proposals for storage and disposal concepts are discussed below.

ASSURANCE OF NONPROLIFERATION AND OF SUPPLY AND SERVICES

The MNA group sets out as the deciding factors influencing the assessment of multilateral approaches assurance of nonproliferation and assurance of supply and services. The former objective is clearly easier to achieve if multinational storage and disposal facilities can be made available. There are currently 35 countries with nuclear power plants (with more than 500 plants operating, being constructed, or planned) and a total of 69 with research reactors. A total of 674 research reactors were operational, shut down, under construction, or planned in 1997, according to the most recent survey in the IAEA database *(http://www.iaea.or.at/worldatom/rrdb/)*. Leaving spent fuel in all of these locations for many decades is obviously less proliferation resistant than collecting the material into a smaller number of facilities with very strong safeguards. In practice the existing strict controls of the IAEA and European Atomic Energy Community (Euratom) might even be enhanced by a further level of direct international control over a storage or disposal facility for SNF.

For the short and intermediate time frames, shared storage facilities alone would suffice to contain the proliferation risk. Shipping spent fuel removed from reactors to one of a few centralized facilities as soon as it has cooled enough for transport would be a sensible approach. Technically, with assured centralized interim storage, the question of implementing repositories could be postponed. There have been various proposals from potential hosts and user countries for shared storage facilities (see, e.g., Bunn et al. 2001, Ansolabehere et al. 2003). However, in practice, as is strongly emphasized in the IAEA multinational storage report (IAEA 2005b), it will be difficult to transfer SNF/HLW to another country for storage without some clarity on the endpoint of the agreement. Returning cooled spent fuel to many countries after several decades would simply reinstate the current proliferation risks of dispersed storage. Returning HLW from reprocessed spent fuel reduces proliferation risks by retaining central storage of plutonium, but it increases security concerns. Moreover, accepting returned HLW would compel small countries to seek national deep disposal solutions—in which case they may as well have retained the fuel for disposal.

In short, the assurance of nonproliferation sought by the MNA group is best attained by early implementation of shared storage facilities, with the essential ingredient of an agreed upon further step of disposal in multilateral repositories—either in the countries storing the waste or in a limited number of other volunteering host nations.

How could one guarantee assurance of supply and services in a situation where many countries are relying on storage or disposal facilities being available in another country? One obvious answer is to have more than one multinational facility and thereby avoid the danger of creating a monopoly. An alternative or a complementary measure is to have direct international guarantees that avoid monopolistic behavior. One way to achieve this is for the IAEA itself to guarantee continued provision of storage and disposal services. This could be done by establishment of specific internationally operated facilities, whereby agreements with the host country or countries would be required. An alternative is that the IAEA promotes binding arrangements between the service providers, ensuring that each will agree to take over the commitments of others should these cease to provide promised services for storage or disposal.

The MNA group recognizes in its report that there is currently no international market for storage or disposal and recommends that the IAEA support the concept by assuming political leadership to encourage such undertakings.

Specific ways forward are possible based on both of the multinational repository scenarios defined by the IAEA—"partnering" and "add-on" (by a large nuclear nation), as documented in TECDOC-1314 (IAEA 2004). These possibilities are discussed below.

SPECIFIC SCENARIOS FOR MULTINATIONAL APPROACHES TO DISPOSAL

The add-on scenario is one in which a large nuclear program accepts wastes from smaller ones. There are several conditions that could enhance the probability of an add-on scenario being successfully implemented:

- The international community should recognize that any country offering storage or disposal services is potentially a contributor to global safety and security.
- A willing host country (or countries) must come forward and should be able to demonstrate to the international community that it has the necessary level of support for the project within the host country.
- Appropriate benefits for the host(s) must be agreed on. These need not be purely financial; strategic and political issues may also be involved.
- The potential user countries of a multinational repository must not abdicate all responsibilities. They should, singly or as a structured group, develop mechanisms to assure that the safety standards in a multinational repository are not lower than those that each would accept for a national repository.
- International or supranational bodies (e.g., the IAEA or European Commission [EC]) must be willing to play an active role in developing and controlling the multinational initiatives. This involves not only safety, security, and nonproliferation aspects but also the assurance of supply issues discussed above.
- Real interest in sending spent fuel to any country with an international repository will be shown by small countries only if existing backlogs of stored spent fuel, HLW, and long-lived intermediate-level waste (LL-ILW) can also be transferred, since complete avoidance of the need for an expensive deep repository will be the driver.

In recent times most discussion of the add-on option has revolved around concepts in which Russia acts as host country. Over the past few years Russia has been seriously examining the issue of spent fuel import and is currently the only country supporting this at the government level. Specific proposals that could advance the Russian initiative are included at the end of this paper.

For the "partnering" scenario, in which a group of usually smaller countries cooperate to move toward shared disposal facilities, exploratory studies have been performed most recently by the Arius Association, which also co-manages the EC's Support Action: Pilot Initiative for European Regional Repositories

Box 1
SAPIERR
Support Action:
Pilot Initiative for European Regional Repositories

- Project dates: 2003-2005
- Managed by DECOM (Slovakia) and Arius
- Main deliverables

  — Legal report (Boutellier, 2004)
  — Inventory teport (Stefula, 2004)
  — Options and scenarios of regional disposal (draft)
  — Future research and technical development recommendations

- Final Workshop: Brussels, November 9, 2005

(SAPIERR) project (*www.arius-world.org, www.sapierr.net*; see Box 1). The following stages can be envisioned for a partnering scenario; it is interesting that these stages do not differ greatly from steps taken within a federally organized state to seek a national disposal solution.

Pilot feasibility studies: A sufficient number of interested national organizations cooperate to organize and fund pilot studies aimed at establishing the basic technical, legal, economic, and political feasibility of multinational repositories.

A formalized study consortium: To progress to the detailed level of study needed, a structured project team must be created, staffed, and funded at the appropriate level. At this stage, participating countries can still choose to leave open the question of whether all partners are potential hosts or whether some, perhaps with small areas or with no nuclear power production, can choose to enter only as potential users of a shared repository. The study consortium must agree on the level of funding needed, on the distribution of costs among partners, and, very importantly, on an organizational structure and medium-term (multiyear) program.

A dedicated regional repository project team: The project team must cover the same key aspects of repository planning that also affect national repositories. Of course, some tasks are more challenging in a multinational context than in national programs. A sensible option would be to recruit core team members by delegation of appropriate staff from the national programs involved.

Siting studies leading to candidate siting areas in different partner countries: The siting study is clearly the most sensitive work area. Optimally, it should involve working in parallel on a volunteer strategy and on a technical/societal study aimed at ranking options and keeping multiple options open. At this stage the project is coming close to moving into the phase of on-site investigations at potential sites. Reorganization and further formalization of the cooperation may be appropriate, in order to handle the growing political and technical challenges and the increased financing.

Establishment of a business consortium or joint venture: The purpose of this organization is to organize and fund characterization of the sites, finalize agreements on the key issue of compensation for host communities and countries, select a short list of preferred sites, and interact with political and regulatory bodies in the candidate countries. At this stage, at the very latest, it is imperative to assure involvement of and cooperation with relevant international bodies, in particular the EC (for a European venture) and the IAEA.

Establish a construction and operation company: It may be necessary to reorganize the existing joint venture in order to take account of specific wishes of the host country or countries with respect to legal structures, shared liabilities, funding mechanisms, and so forth.

Repository operation: During the decades for which the repository will operate, the relationships between the partners can be of various types. In all cases it is expected that the user countries will require sufficient insight into operations to enable them to reassure their national publics that required safety standards are being adhered to at the repository. Given the nature of the facility, international oversight by the IAEA will be a necessity (and the EC for a European repository).

Closure and postclosure: At some time in the far future, the regional repository will be closed and possibly monitored for some long time. As with the shared benefits, agreements for sharing liabilities must be agreed upon long before this final stage is reached. On the liabilities side, the question is how much and for how long partner countries may continue to be liable should any remediation work be required. On the benefits side, one issue is whether partner countries retain any claim to spent fuel should this ever be deliberately recovered from the repository because of the high energy content of the residual fissile materials it contains.

The scenario sketched above is one of many possible variants. At the heart of a successful project lies the siting issue. However, this is a difficult problem even in national programs—but this has not prevented local communities in some countries from agreeing to host repositories. The MNA group of the IAEA also recommends an initial cooperation phase, with participating countries working on a siteless pilot project—which is, of course, the precise course taken by the European SAPIERR project.

THE FIVE APPROACHES OF THE MNA GROUP AND THEIR IMPLICATIONS FOR STORAGE/ DISPOSAL OF SPENT NUCLEAR FUEL

It is emphasized correctly by the MNA group that disposal and storage of SNF/HLW should not be looked at in isolation but instead as part of a broader nuclear strategy. Nevertheless, it is interesting to examine the five suggested approaches for encouraging multinational initiatives and to consider specifically their implications for these two activities.

Approach 1: Reinforcing existing commercial market mechanisms on a case-by-case basis through long-term contracts and transparent suppliers' arrangements with government backing. Examples: commercial fuel banks, fuel leasing, and fuel take-back and commercial offers to store and dispose of spent fuel.

Commercial market mechanisms in the past have made possible the transfer of SNF with no return of wastes, for example, to reprocessing plants in France, the United Kingdom, and Russia. Increasing public and political pressures on the organizations involved led to these services being withdrawn. Russia is currently reopening the door for accepting fuel from nuclear power plants in other countries—but only for take-back of fuel elements supplied by Russia. Both Russia and the United States have implemented processes for taking back spent research reactor fuel—for purely nonproliferation reasons. Although initially also restricted to fuel supplied by themselves, this could change. The United States is already negotiating taking non-U.S. fuel from the new Australian OPAL (open pool Australian light water) research reactor. In practice, the only commercial offer currently being made for SNF is by Russia—and this is at present restricted to storage, with possible later reprocessing and return of HLW.

The potential acceptability, both within Russia and in a potential customer country, of including disposal in this arrangement, could be greatly enhanced by IAEA support and by an IAEA commitment to rigorously oversee, or even co-manage, the facilities. If the Russian approach achieves global acceptance, it is even possible that competition could arise, as other nations realize the commercial opportunity and receive international encouragement to provide such a service.

Approach 2: Developing and implementing international supply guarantees with IAEA participation. Different models should be investigated, notably the IAEA as guarantor, that is, as administrator of a fuel bank.

Supply guarantees for a storage or disposal service are important to any customer country. Withdrawal of the services could lead to shortage of storage capacity, which could impact continued reactor operation or could put the country back into its original position of having to implement an expensive geological repository. The latter potential problem will, fortunately, never be an urgent timing issue since disposal is easily postponed. Nevertheless, an IAEA initiative to organize for a group of service providers jointly to guarantee the continued availability of storage/disposal facilities would be of value.

Approach 3: Promoting voluntary conversion of existing facilities to MNAs, and pursuing them as confidence-building measures, with the participation of NPT (nonproliferation treaty) nonnuclear weapons states and nuclear weapons states, and non-NPT states.

Conversion of existing facilities is currently conceivable only for storage of spent fuel, since no geological repositories for SNF are in operation. For storage it has generally been found, even for small nuclear countries, that implementation of national facilities is affordable and politically feasible, especially if the stores are at existing nuclear plants. In fact, shortage of national storage capacity has threatened progress only in the large nuclear programs of Taiwan and Japan (and, to some extent, the United States). In the United States a private commercial initiative has been launched to fulfill the growing need for away-from-reactor storage, but it is not at present conceivable that this could be used for storing foreign fuel. For Japan and Taiwan the possibility of storing SNF for some decades in another country, such as Russia, could be of interest because of the difficulties in siting new storage facilities.

In the case of geological repositories, although none is operating, several countries have advanced projects leading to implementation—in particular Finland, the United States, Sweden, and France. All of these, however, have made it very clear that the repositories are purely national and will not accept foreign fuel or waste. The general consensus in the waste disposal community is that success in these programs will help the cause of geological disposal worldwide. If this success is currently more assured by purely national approaches, then these should continue, but this should not be interpreted as evidence that only national programs can succeed.

Approach 4: Creating, through voluntary agreements and contracts, multinational, and in particular regional, MNAs for new facilities based on joint ownership, drawing rights, or co-management for front-end and back-end nuclear facilities, such as uranium enrichment, fuel reprocessing, or disposal and storage of spent fuel (and combinations thereof). Integrated nuclear power parks would also serve this objective.

For geological disposal the creation in the future of new multinational and/or regional repositories is the most promising approach. Interest in the partnering scenario that could lead to these is clearly evidenced by recent developments, in particular in Europe. The Arius Association, founded in 2002, pursues this concept as its main activity. Organizations from eight countries are currently involved. The EC has promoted the concept of regional repositories in Europe in its council directive on the management of spent nuclear fuel and radioactive waste. The commission is also funding the SAPIERR project, which is studying the necessary boundary conditions for regional repositories in Europe (see Table 1). Organizations from 14 European countries participate in SAPIERR. The key question of siting is deliberately not addressed in the current phase. Consistent with the remarks made above on avoiding monopolies, it may be advisable ultimately to seek more than one site (see Tables 2 and 3).

Of course, new multinational facilities might also be constructed in the "add-on" scenario. Again, Russian possibilities have as yet been discussed the most. In 2003, and again this year, delegations have visited the Krasnokamensk site in eastern Siberia, where the local population is in favor of implementation of a repository for spent nuclear fuel from other countries (Laverov et al. 2004).

Approach 5: The scenario of a further expansion of nuclear energy around the world might call for the development of a nuclear fuel cycle with strong multilat-

TABLE 1 European Perspectives

A—The 14 SAPIERR Working Group members: (not all are EU member states—e.g., Bulgaria, Croatia, Romania); does NOT imply that they have chosen a disposal strategy	B—National Only: Major EU countries where implementer has taken definite position that waste disposal programs will be purely national	C—No nuclear power plants but some waste for deep disposal: Some Group C are also in the SAPIERR Working Group (e.g., Lithuania, Austria, Croatia)	Groups A and C	Undecided
Belgium	Finland	Cyprus	Austria	United Kingdom
Bulgaria	France	Denmark	Croatia	
Czech Republic	Germany	Estonia	Latvia	
Hungary	Sweden	Greece		
Italy		Ireland		
Lithuania		Luxembourg		
Netherlands		Malta		
Romania		Poland		
Slovakia		Portugal		
Slovenia				
Switzerland				

TABLE 2 SAPIERR Working Group: Spent Fuel Locations

Purpose Built Storage Facilities	Storage in Reactor Pools
Ignalina, Lithuania	Krsko, Slovenia
Doel, Belgium	Trino Vercellese, Italy
SCK·CEN Mol, Belgium	Saluggia, Italy
Tihange, Belgium	Caorso, Italy
Temelin, Czech Republic	Dodewaard, Netherlands
Dukovany, Czech Republic	Borselle, Netherlands
Bohunice, Slovakia	
Mochovce, Slovakia	
Paks, Hungary	
Gösgen, Switzerland	
ZWILAG, Switzerland	
SCN Pitesti, Romania	
Cernavoda, Romania	
Kozloduy, Bulgaria	
NRC Sofia, Bulgaria	

TABLE 3 Number of Nuclear Power Reactors in Operation

SAPIERR	37
France	59
United Kingdom	23
Germany	18
Sweden	11
Spain	9
Finland	4

eral arrangements—by region or by continent—and broader cooperation involving the IAEA and the international community.

This conclusion of the MNA group is very relevant now that interest in increased use of nuclear power is higher than it has been for decades. On the topic of multinational geological disposal, unfortunately, there has been controversy as well as cooperation between IAEA member states. However, the advanced national disposal programs are becoming more confident of success and subsequently feel less threatened by multinational initiatives, and the active support of the IAEA and the EC has become stronger. There should, therefore, be little difficulty in the international community in further supporting broader cooperation on multinational approaches and no obstacles in the way of intensive IAEA involvement.

CONCLUSIONS

There is clear recognition internationally that multinational approaches in the overall nuclear fuel cycle can enhance security and help hinder proliferation. Despite earlier controversies, the potential advantages are also recognized for multinational storage and disposal facilities. What concrete steps can be taken to move beyond empty expressions of support toward specific practical initiatives?

Specific repository projects involving technical and societal efforts toward siting and constructing a shared repository will need closer coordination, direct involvement of the interested countries and the international agencies, and significantly increased resources. Most of the small countries that could benefit most directly from shared repositories have not yet accumulated sufficient funds to implement a national repository. However, there are certainly sufficient resources available in these countries, if pooled, to support a serious joint waste disposal program. Initially, this would be aimed at clarifying the options for a shared regional facility. However, more support for back-end studies on storage and disposal is needed. The relatively large funding that is proposed for tackling security issues at the front end could be complemented by increased—although still comparatively modest—financial support for progressing shared repository projects for commercial reactor fuels (see Box 2). The “partnering” scenario outlined earlier in this paper exemplifies one possible practical approach. Box 3 shows a proposal for a second phase of activity under SAPIERR along these lines.

In addition to implementing comprehensive multinational disposal projects that closely parallel national projects in their structure, siting strategies, and timescales, the international community could support more specific, limited initiatives, for example, strengthening of ongoing efforts to secure all spent sealed

Box 2
Prerequisites to Identification of Potential Host Sites or Countries

1. Recognition of a common need for a repository
2. Transparent specification of all requirements to be fulfilled
3. Establish, document, and discuss pros and cons of hosting a facility
4. Establish trust in the potential implementing organization

Siting an international repository will entail the same problems as a national repository—in both cases it is not something that is done at the start of a program.

Box 3
SAPIERR-2 Proposal, Content, and Component Studies

Proposal

- Develop feasibility studies into practical implementation strategy and organizational structures
- Enable shared EU radioactive waste storage and disposal activities to begin in 2008
- Participating EU member states will be able to use these structures as, when, and if needed for the furtherance of their individual national policies

Content

- In-depth studies of key issues related to design, location, and safety of shared storage and disposal facilities
- A business framework and project plan to underpin the establishment of a self-sufficient European organization in late 2008

Component Studies

- Management study of legal and business options for establishing a European waste management sharing organization leading to a proposed framework for such an organization
- Study of legal liability issues of international waste transfer within Europe
- More detailed definition of the SAPIERR waste inventory, timescales of waste arisings, and local implications for waste storage and conditioning
- Study of thermal and container materials aspects of repository size and design and of alternative designs
- Assessment of broad geological environments potentially available for shared facilities in partner countries: act as boundary conditions for design studies
- Development of a project plan for initial stages of work of waste management sharing organization

sources worldwide or to repatriate research reactor fuel. Significant progress in these areas has been made in recent years.

However, the biggest, potentially fully international, storage/disposal initiative that could be grasped and developed immediately is that proposed by Russia. A combination of fuel leasing, allowing take-back of Russian-origin fuels, and acceptance of foreign fuels requiring U.S. consent under existing fuel-flagging rules would be a first step.

In our view, however, the Russian storage initiative will only be acceptable if the endpoint of disposal is available—this means actually available, or specifi-

Box 4
Getting Started and Ensuring Support

- A. National entities need to be convinced that it is politically feasible before they will provide full backing.
- B. Implementers need to convince themselves that it can work in order to divert funding from their own national programs.

— Consequence: research and development is done with limited resources.

- Action, not words: high-level external political and financial support would help achieve A and B.

— Many stakeholders will not be convinced unless international bodies like the EC-EP and the IAEA give concrete support or take a leading role.
— Both add-on and partnering scenarios could be immensely strengthened by considering a measure of external control (supranational scenario).

cally planned and financed, rather than held out as a vague future prospect. If the international community thus wants to make a really useful contribution to global security and safety, this is where it could direct its resources. Specifically, we propose that the IAEA offer to assist Russia to move forward by assembling both the funding and the enormous expertise that exists internationally to develop, in a timely fashion, a state-of-the-art international deep geological repository. Currently, some movement in this direction is taking place, as evidenced by this workshop and by the Conference on Multilateral Technical and Organizational Approaches to the Nuclear Fuel Cycle Aimed at Strengthening the Non-proliferation Regime held in Moscow, July 13-15, 2005. In return for this offer, Russia should agree to a new level of transparency and international oversight in the development work. Only in this way can the trust of the international community be enhanced to a level needed for other countries to enter into long-term commitments to transfer fuel to the Russian Federation (see Box 4). This would be a truly worthy project with truly global benefits; it is surely to promote solutions such as this that the IAEA was founded and exists today.

Of course, as emphasized above, a single supplier of disposal services could present strategic and economic risks for potential customer countries. Global waste inventories easily justify multiple international repositories, and commercial competition could conceivably encourage this. If the international community acknowledges the global value of having international repositories available and is prepared to support their development, it is not unlikely that other candidates could appear. These might be other large countries or they might be smaller countries willing to consider hosting a facility implemented with partners.

We need bold initiatives for global solutions if we are to achieve multinational goals. These solutions need not only the strongest of support from the United Nations and its member states but also to be championed by the major countries, working together.

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8

Interim Storage of Spent Nuclear Fuel in Japan

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INTRODUCTION

About one-third of Japan's electricity is supplied by nuclear power plants. As of January 2005, the total number and capacity of nuclear power plants were 53 and 47 GWe, respectively. Since the first commercial operation of a nuclear power plant in 1966, about 17,000 metric tons of uranium (MTU) of spent fuel has been produced, including fuel in the reactors, and 10,000 MTU of this fuel is stored in nuclear power plants.

Based on Japanese policy, the spent nuclear fuel is reprocessed and plutonium and recovered uranium are recycled. From 1973 to 1998, 5,610 MTU of spent fuel was reprocessed in plants in France and the United Kingdom. The Tokai Reprocessing Plant began operation in 1997, and 1,029 MTU of spent nuclear fuel was reprocessed by February 2004. Japan Nuclear Fuel Limited is constructing a commercial reprocessing plant at Rokkasho-mura, which will begin operation in 2008 and reprocess 800 MTU annually. It is planned that the reprocessed spent nuclear fuel will be stored at a vitrified waste storage center in the plant until the final disposal site is constructed.

Annual production of spent nuclear fuel from all nuclear power plants in Japan was 900 MTU in 2003 and will increase to 1,100 MTU by 2010. The estimated total production of spent fuel from 1997 to 2010 is 14,000 MTU. Of the 14,000 MTU, 6,700 MTU will be shipped to the Rokkasho-mura reprocessing plant and 70 MTU has already been shipped overseas for reprocessing. The amount of spent nuclear fuel from power plants exceeds the current reprocessing capacity plant at Rokkasho-mura, which can reprocess about 800 MTU per year. Of the excess spent fuel, 2,900 MTU will be stored at nuclear power plants.

Consequently, 4,400 MTU of spent nuclear fuel must be stored outside the power plants. For this spent fuel, an interim storage facility should be prepared. Based on the estimation by the Ministry of Economy Trade and Industry (METI), the required capacity of the facility is 4,400 MTU by 2010 and 7,100 MTU by 2020.

MEASURES FOR SPENT NUCLEAR FUEL INTERIM STORAGE

The policy for the interim storage of spent fuel was discussed by the METI council. The council advised in 1998 that the interim storage facility should be prepared before 2010 within Japanese territory. Based on this advice, METI issued a technical report for safety assessment of the temporary storage site in 2000. Guidelines for safety assessment of the temporary storage site using metallic casks were issued by the Nuclear Safety Commission of Japan in 2002. Based on the guidelines, the Nuclear and Industrial Safety Agency will act as a regulator.

Tokyo Electric Power Company searched all over Japan for an appropriate site. The local government of Mutsu City in Aomori Prefecture showed a keen interest in the matter and in 2000 asked Tokyo Electric Company to evaluate the possibility of constructing interim storage at Sekinehama, once the home of the nuclear-powered ship Mutsu. The company issued a technical assessment report in 2003. Based on the report, local governments are examining the plan for approval. According to the Tokyo Electric Company's plan, the facility will begin operation before 2010, and the spent fuel will be stored for 50 years in metallic casks kept in a building. During the first stage of construction, a facility with 3,000 MTU storage capacity will be built, and after its completion another facility will be built. The total storage capacity planned by the Tokyo Electric Company is 5,000 to 6,000 MTU. Fifty years after the completion of these facilities, all remaining stored fuel will be removed from them based on an agreement with the local government.

The amount of spent nuclear fuel from power plants exceeds the capacity of the reprocessing plant at Rokkasho-mura, which can reprocess about 800 MTU per year. The spent fuel in the temporary storage facility will fill rapidly even though the reprocessing plant is operating at full capacity. Capacity calculations should be made around 2010.

Our government policy is that all nuclear waste should be disposed of within Japanese territory. Current circumstances do not provide for a change in policy in the near future, but Japanese experts are carefully studying the information and international discussions about multinational storage.

9

Methods for VVER-1000 Fuel Testing Under Dry Storage Conditions

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In order to guarantee safe long storage of spent nuclear fuel, it is necessary to develop a model of spent nuclear fuel behavior under different storage conditions in order to select safe conditions for its dry storage. Conditions include transient conditions (vacuum dehydration), standard storage conditions, abnormal events, and design-basis accidents. It is necessary to test the irradiated fuel at different temperatures, which simulate possible storage conditions in order to develop an appropriate model. Preservation of cladding integrity during the entire period of fuel rod storage is one of the main factors that ensures the dry storage safety of spent nuclear fuel.

The following activities help ensure safe storage:

- Certification of fuel rods using nondestructive examination techniques
- Thermal testing of fuel rods
- Intermediate nondestructive examinations of fuel rods between several successive tests (if they are performed)
- Material science examinations of fuel rods after testing

Figure 1 depicts the equipment for testing under dry storage conditions. Using this equipment, after visual examination fuel rods are subjected to eddy-current testing and measurements of diameter and length between tests. Refabricated fuel rods are subjected to additional measurements of volume. Gamma-scanning and cladding puncture followed by analysis of gas quantity and composition under the cladding are performed after the fuel rods are tested.

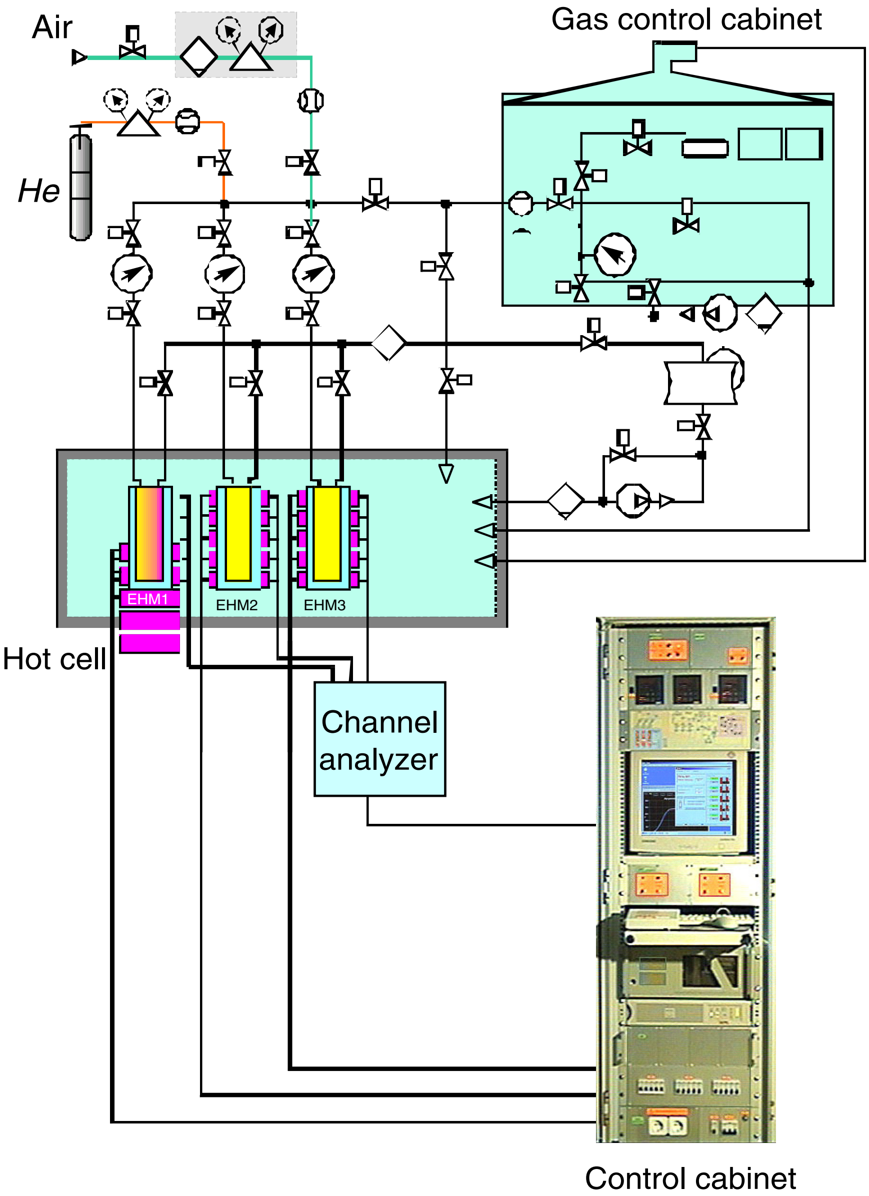

FIGURE 1 Structural schematic of dry storage testing equipment.

Three independent electric modules, which are located inside the hot cell, and systems of gaseous medium preparation and gas sampling from the modules and from the module operation and control system are used. Fuel rods under examination are inserted into a leak-tight capsule that is placed in the module.

The performance capabilities of the equipment are as follows:

- Test temperature range of 300 to 600°C
- Remote loading and unloading of fuel rods
- Simultaneous testing of up to 18 irradiated full-size fuel rods from VVER-1000 reactors in three independent modules
- Concurrent simulation of several storage conditions for spent nuclear fuel both in gaseous media and temperature
- Recurrent gas sampling in any module
- Profiling of the temperature field throughout the height of the fuel rod
- Temperature cycling (simulation of daily or seasonal variations in ambient temperature)
- Nonuniformity of axial temperature distribution along the height of no more than ±3 percent, and nonuniformity of radial temperature distribution in the capsule of no more than ±2°C.

Figure 2 depicts cycling of test and ambient temperatures.

In Russia, equipment is available for testing VVER-1000 irradiated fuel rods to predict their behavior during long-term storage. Such investigations must be executed for all kinds of spent fuel before designing and commissioning a suitable storage facility.

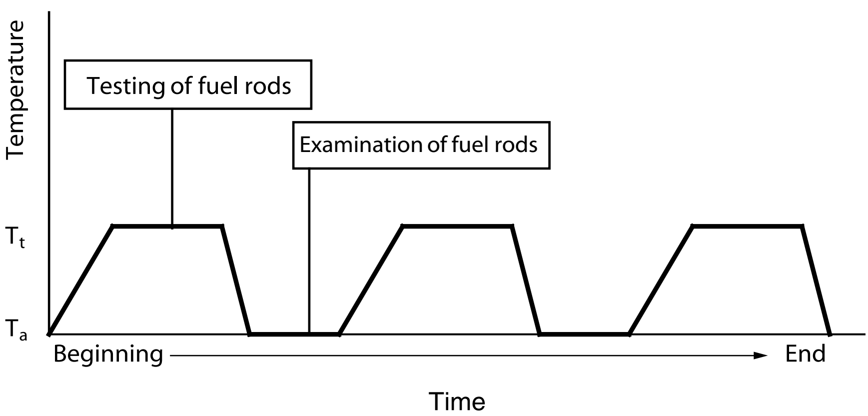

FIGURE 2 Schematic representation of test conditions for fuel rods: $\mathbf{T_t}$ and $\mathbf{T_a}$—test temperature and ambient temperature, respectively.

10

U.S. Nuclear Power Industry Trends in Spent Fuel Management

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INTRODUCTION

At present, nuclear power supplies approximately 20 percent of the electricity needs in the United States. There are 103 nuclear power plants in 31 states. Of these, 34 are boiling water reactors (BWRs) and 69 are pressurized water reactors (PWRs).

In the past few years the U.S. nuclear power industry has undergone a few changes. There has been significant consolidation of the industry. Utilities with only one plant or a handful have sold their plants to other utilities, such that today the 103 plants are in the hands of fewer individual utilities than a decade ago. Furthermore, improvements in operations and safety have increased the average capacity factor from approximately 50 percent to over 90 percent in the past decade.[1]

Several other advances in the U.S. nuclear power industry will result in more nuclear-generated electricity for a longer period. Power upgrades at existing plants have added more than 2,000 MWe over approximately the past four years. However, a major step that the current U.S. nuclear power plant owners have taken is to seek and, increasingly, obtain license extensions to operate plants for many years longer than their initial license periods—typically an additional 20 years. At present, 30 plants have received such extensions, with another 48 pending. While the 1990s saw the shutdown of a few nuclear power plants, no additional plants have been shut down since 1998. In addition, one reactor that had previously been shut down is now back in operation.

[1]See Nuclear Energy Institute's web site: *www.nei.org*.

The idea of building new nuclear power plants in the United States has become more of a reality over the past few years. There is a joint U.S. Department of Energy (DOE)/industry initiative to license and construct new plants. Several utilities are considering building a new plant—either as a consortium or on their own. In all cases the utilities are considering building an additional plant at an existing nuclear site. Several utilities have applied for early site permits—essentially requesting the Nuclear Regulatory Commission (NRC) to approve the suitability of the site chosen for locating a new plant. Furthermore, recent energy legislation provides a few incentives to U.S. utilities to build new nuclear power plants. At present, however, no U.S. utility has yet announced plans to actually proceed with a license application to build a new plant.

All of the above means that there will be continued production of used commercial nuclear fuel at present rates (or higher) for at least several more decades. Hence, there is a growing need to manage the increasing inventory of used nuclear fuel. Projections of that inventory in the United States are given in Figure 1. This figure shows how much of the commercial used nuclear fuel is currently in spent fuel pools or dry storage—both at reactor sites. The figure also shows that spent fuel pools are nearing their capacity, such that the rate of dry storage capacity must rival or exceed the rate of used fuel production in the near future.

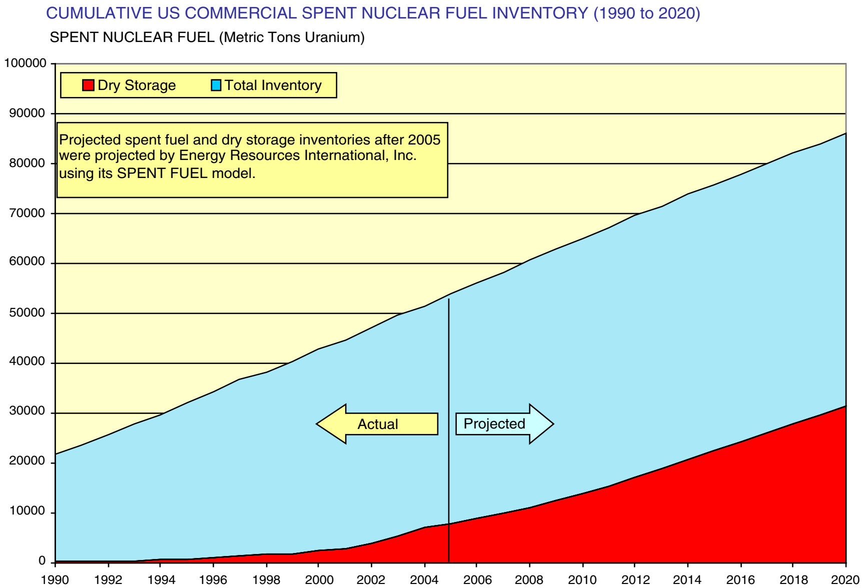

FIGURE 1 Cumulative U.S. commercial used nuclear fuel production. Source: Energy Resources International, Inc.

U.S. LAWS AND REGULATIONS GOVERNING THE NUCLEAR POWER INDUSTRY'S USED FUEL/ HIGH-LEVEL WASTE MANAGEMENT

There are three main U.S. laws that govern the way used nuclear fuel is to be managed and paid for. The 1982 Nuclear Waste Policy Act (NWPA) and the subsequent 1987 Nuclear Waste Policy Amendments Act (NWPAA) require DOE to be responsible for managing both commercial and defense high-level waste (HLW), including commercial used nuclear fuel. To pay for this responsibility, the U.S. nuclear power utilities must pay a tax of $0.001 per kilowatt-hour of electricity generated. The money is to go into a Nuclear Waste Fund (NWF) that is managed by the U.S. Congress. At present, the U.S. nuclear utilities pay on the order of $700 million per year into the NWF. As of December 2004, the NWF had received a total of approximately $26 billion. The NWPA and NWPAA require that DOE and the U.S. nuclear power utilities enter into contracts for the receipt of used nuclear fuel from the utilities. Per the above laws, and entered into the contracts, was an obligation by DOE to begin accepting used nuclear fuel from the utilities by January 31, 1998. DOE also sets the waste acceptance criteria in the contracts, which relates to the properties of the used fuel itself.

The 1992 Energy Policy Act, the third law, governs the regulations specifically for Yucca Mountain. Along with the NWPA, this act requires the U.S. Environmental Protection Agency (EPA) to promulgate a regulation based on and consistent with recommendations made by the National Academy of Sciences. The NRC is to implement the EPA regulation and will be responsible for receiving and reviewing any license application from DOE for Yucca Mountain. In 2005, the EPA issued a revised Yucca Mountain regulation for public comment.

In addition to the Yucca Mountain–specific EPA and NRC regulations, there are a few other NRC regulations of note: 10 Code of Federal Regulations (CFR) Part 72 sets out requirements for dry used fuel storage systems; 10 CFR Part 71 provides requirements for used fuel transportation systems.

The third NRC regulation, 10 CFR Part 51, has what is called a waste confidence provision. For U.S. nuclear reactors to keep operating, the NRC requires reasonable assurance

- that geological disposal is technically feasible,
- that a repository will be available in the first quarter of the 21st century,
- that used fuel will be managed safely until sufficient repository capacity is available to dispose of all of it,
- of safe on-site storage for the life of the nuclear power plant plus the period of the plant's license extension plus an additional 30 years, and
- that sufficient on-site storage capacity will be made available if needed.

This implies that it is not enough to have a national program with just long-term storage of used nuclear fuel; an active, credible program for the development and implementation of a geological disposal facility also is needed.

DOE ACTIVITY REGARDING COMMERCIAL USED FUEL MANAGEMENT—A BRIEF HISTORY

DOE has been exploring options for managing used nuclear fuel and HLW for many decades. In the 1980s, DOE actively pursued locating a monitored retrievable storage (MRS) site. The MRS was, in concept, to be a centralized surface facility for the storage of used nuclear fuel and HLW for many decades, perhaps longer. The MRS requires, however, a willing host community and cooperative state and local governments. Unfortunately, DOE found no volunteers.

DOE has been pursuing permanent geological disposal for many decades. The intent of the NWPA (1982) was for DOE to identify and explore two different sites. Initially, nine different sites were explored, after which the list was narrowed down to three. The NWPAA (1987) narrowed the focus to one site—Yucca Mountain—for further development, mostly due to rising costs. DOE has been actively exploring the Yucca Mountain site ever since. The current disposal limit at Yucca Mountain is 70,000 metric tons of uranium (MTU), or its equivalent for HLW. Of that 70,000 MTU total, 63,000 MTU is reserved for commercial used nuclear fuel. Figure 1 suggests that the U.S. inventory of used nuclear fuel will reach 63,000 MTU in approximately 2010. It should be noted, however, that this limit is a legal rather than a technical limit. DOE officials have suggested that approximately twice the current 70,000 MTU limit could likely be disposed of at Yucca Mountain.

There have been continual delays in the development of Yucca Mountain as a repository for used nuclear fuel and HLW. While much has been accomplished at Yucca Mountain over approximately two decades, the scope of the project has changed, and DOE funding requests to the U.S. Congress have almost never been fully granted. Before 1987 and enactment of the NWPAA, DOE expected that Yucca Mountain would be open and accepting waste by 1998. However, in 1987, DOE moved the opening date back to 2003. Two years later in 1989, DOE moved the date to 2010. As of late 2004, DOE stated that the 2010 date was unlikely. At this time DOE has not announced its new estimated date for Yucca Mountain availability.

U.S. NUCLEAR PLANTS' REACTION TO DOE DELAYS AND NRC'S WASTE CONFIDENCE REQUIREMENT

When most U.S. reactors were designed in the 1960s and 1970s, used nuclear fuel was expected to be shipped off-site after approximately five years of cooling in spent fuel pools. The intent at the time was to reprocess the majority of the used fuel. However, reprocessing was halted in the earliest stages of implementation in the United States and has not yet been revived. Therefore, the U.S. nuclear power utilities were forced to manage their growing inventories of used nuclear fuel. Most utilities started by reracking their pools to accommodate a higher density of used fuel assemblies. Almost all plants are now fully reracked. Starting in the early 1980s, some plants needed to move some of their used fuel out of the pools. In 1986 the first on-site dry storage of used nuclear fuel was licensed and implemented.

As of today the U.S. utilities are still managing essentially 100 percent of their used fuel at their own reactor sites. Nearly one-half of all reactor sites have or will soon have on-site dry storage systems. Almost all nuclear power plants will require on-site dry storage by 2010 if no off-site solution becomes available. The on-site dry storage systems have an initial license period of 20 years. A few dry storage system owners have applied to the NRC for license extensions. The first few extensions have now been granted, in one case for an additional 40 years of storage.

Separately, a consortium of U.S. utilities has been actively seeking its own private MRS (that is, developed without the assistance of DOE). Three industry initiatives for such an MRS have been undertaken. The private MRS that is farthest along is located at the Goshute Reservation in Utah. This site is known by the abbreviation PFS (Private Fuel Storage) for the name of the utility consortium. After a seven-year licensing process, PFS has received regulatory approval to proceed with construction. The PFS site capacity is to be 40,000 MTU of used nuclear fuel for a licensing period of 40 years. Construction has not yet begun.

U.S. NUCLEAR POWER INDUSTRY'S GUIDING PRINCIPLES AND THOUGHTS GOING FORWARD

The U.S. nuclear power industry is driven by a few guiding principles regarding used nuclear fuel management:

- Ensure that used nuclear fuel storage and/or disposal does not result in plant shutdowns, jeopardize license renewal, affect economic competition, or affect new plant construction.
- Ensure that DOE meets its contractual obligation to remove used nuclear fuel from power plant sites at the earliest opportunity.
- Set the fee at $0.001 per kilowatt-hour and ensure that all funds are used for the Yucca Mountain program.
- Focus maximum efforts to keep the Yucca Mountain program on schedule and within budget.
- Develop political and policymaker support for nuclear energy to provide a strong impetus for solving the used fuel issue.

The U.S. nuclear power industry recognizes that a spent fuel and HLW repository is an essential part of the industry under all waste policy scenarios. The industry thinks that Yucca Mountain is technologically sound as a geological repository and can meet appropriate regulations. Finally, the industry is counting on the current administration to file a Yucca Mountain license application at the earliest possible time.

There has generally been consistent support by the nuclear power industry for Congress to adequately fund DOE to develop and license Yucca Mountain. However, as shown in Figure 2, DOE has never received from Congress all that it has requested. This is partly responsible for the delays in the current Yucca Mountain schedule.

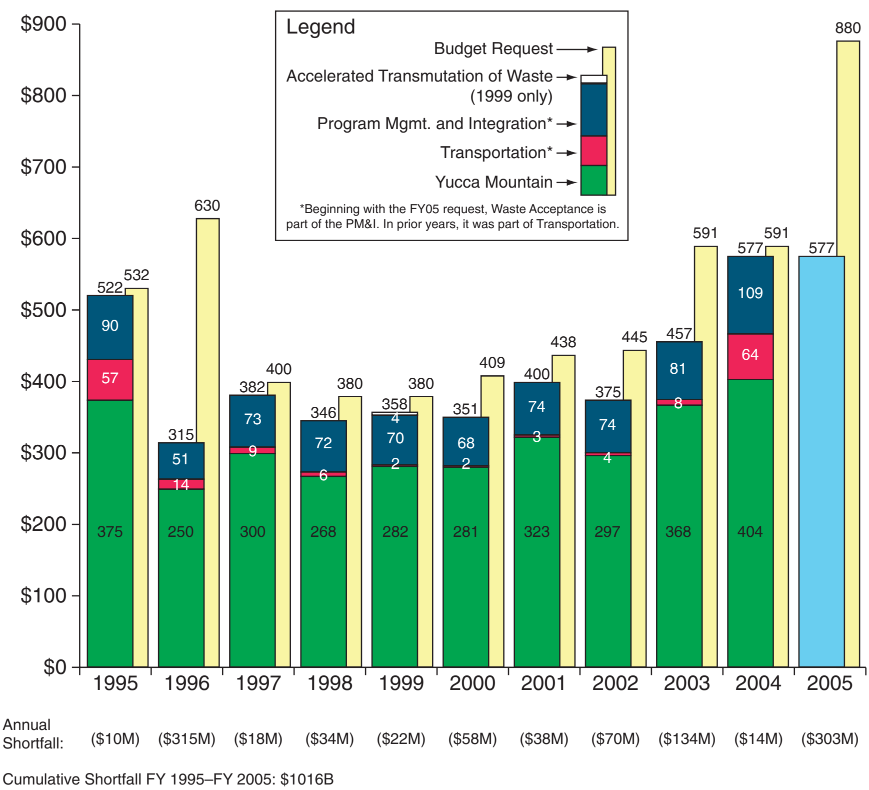

FIGURE 2 DOE Yucca Mountain funding requests versus allocated amounts by Congress.

After January 31, 1998, the date in the DOE/utility contracts when DOE was to begin accepting used nuclear fuel from the utilities, the utilities sued DOE for breach of contract. The utilities are seeking compensation for their expenses related to having to manage the used nuclear fuel on their own, along with other related expenses. At present, only one of these lawsuits has been partially settled and the rest are still pending.

However, this does not mean that industry is not supportive of DOE's efforts to open Yucca Mountain. Quite the contrary, as indicated by some of the principles above and the industry's actions. For example, the industry was heavily involved in the site recommendation process. A formal site recommendation for Yucca Mountain was required by law. The site recommendation requires that DOE recommend Yucca Mountain to the President and that the President approve the recommendation and send it to Congress for possible action. The host state, Nevada, has the opportunity to veto the recommendation. If vetoed, both houses of Congress would have to override the veto with a simple majority vote. The site recommendation process took place during the first half of 2002. In February 2002 the Secretary of Energy recommended the site to the President, who then immediately recommended it to Congress. As expected, Nevada vetoed the site recommendation, which meant that Congress had to vote to override the veto. Industry was actively involved in providing technical information to the public and members of Congress,[2] along with lobbying Congress. In July 2002 the Nevada veto was overridden by a vote of 306 to 117 in the House of Representatives and by a vote of 60 to 38 in the Senate.

IS THERE A NEED FOR A SECOND REPOSITORY IN THE UNITED STATES?

The NWPA requires DOE and Congress to report on the need for a second repository between 2007 and 2010. Issues likely to be factored into that report are the current legal limit on Yucca Mountain capacity versus the higher technical limit and the potential for expanded use of nuclear power in the United States in the future.

At present, the U.S. nuclear power industry has not yet developed a formal position on the need for a second repository. The industry notes, however, that it is DOE that is responsible for managing used nuclear fuel. DOE assumes ownership of the fuel as soon as it leaves the nuclear power plant. Nuclear utilities will continue to be obligated to pay the $0.001 per kilowatt-hour for DOE's management responsibilities.

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[2]For example, the nuclear power industry has regularly funded the Electric Power Research Institute to conduct used fuel storage, transportation, and disposal research for over two decades.

SUMMARY

Confidence in the handling of waste, discussed above, is essential for the continued use of nuclear power. Hence, the U.S. nuclear power industry has every reason to support solutions to long-term used fuel management and disposal. There has generally been strong industry support for Yucca Mountain, both technical and political. Finally, there is, at present, a high interest in future expansion of nuclear power in the United States, leading to further strengthening of support for progress on Yucca Mountain. Industry notes, however, that it is DOE's responsibility to develop storage and disposal solutions.

In the meantime the U.S. nuclear power industry is committed to safely managing its used fuel inventory.

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Comments of Particular Interest During the Workshop Discussions

Glenn E. Schweitzer
The National Academies

The questions and discussions during the workshop clearly indicated that the workshop achieved its primary objective of helping to clarify for specialists interested in the disposition of spent nuclear fuel many of the legal, regulatory, technical, and financial aspects of developing and operating international facilities for storing spent nuclear fuel. A number of the issues that were raised had been considered at previous meetings of the International Atomic Energy Agency (IAEA) and in Europe, Asia, and the United States. All of the issues will undoubtedly be considered again in the future as many countries seek solutions to the problems associated with the disposition of spent nuclear fuel—including interim storage, recycling, and permanent disposal.

This workshop has made a unique and timely contribution to international deliberations by focusing sharply on the Russian experience within the context of more general considerations and relevant ongoing activities in a number of countries. It is important to consider generic issues as has been done before, particularly by the IAEA, but discussions of the specific steps taken by Russia and of the impediments in moving forward to transform its commitment to establishing a facility into reality were very informative. Details are important, and many details can best be considered when specific proposals are on the table.

THE RUSSIAN EXPERIENCE

Russian legislation authorizes the importation and storage of spent nuclear fuel. But it does not permit the importation of waste, and Russia distinguishes sharply between spent fuel that has intrinsic value and waste that has no recoverable value. It authorizes the reprocessing of imported spent fuel. If the original fuel was manufactured in Russia or the former Soviet Union, the wastes associated with reprocessing may be retained in Russia. If the original fuel was manufactured elsewhere, the waste cannot be retained in Russia. Of course, in time the legislation could be modified, but at present the focus is on interim storage and that was the theme of this workshop.

Russian specialists have in mind another scenario for the future in addition to (a) import, store, and return to the sender and (b) import and reprocess either for use in Russia or return to the sender. That option is to use breeder reactors, which reduce the cleanup requirements. Russian specialists claim they have the technology in hand to do this, but this topic should be the subject of another workshop.

Russian specialists have carried out many investigations of sites that might be considered for an interim storage facility. Much of the attention has been directed toward uranium mining areas at Krasnokamensk and to areas where Russian spent fuel is already stored at Krasnoyarsk. The investigations have included consideration of the general characteristics of the locations, including earthquake frequency and intensity and the likelihood of flooding. Also, more detailed studies have been directed to the geological/geophysical conditions of the immediate area under consideration. Russian specialists believe that the costs of above-ground and subsurface interim storage at Krasnokamensk would be about the same, although they do not have authoritative data in this regard.

Turning to packaging, shipping, and handling of international spent fuel, since 1994 Russia has been developing a legal structure that is consistent with requirements embodied in international law. In March 2005 Russia signed the 1963 Vienna Convention on responsibility for nuclear damage as nuclear material changes hands, and this action has alleviated many concerns in Russia and abroad about the commitment of the nation to undertake international spent fuel activities. Also, in recent years an insurance industry has emerged in Russia with a number of small companies slowly supplementing the capabilities of the one major company that in the past provided most of the insurance coverage for nuclear-related activities.

Russia also has considerable technological capabilities to carry out activities in compliance with these legal requirements and acceptable international practices. As to technological aspects, Russian companies have considerable experience in transporting spent fuel—internationally and within Russia. Of particular importance has been the transportation of spent fuel for research reactors located in the former Soviet Union and Eastern Europe and the shipment of spent fuel from both neighboring countries and internally to Mayak and Krasnoyarsk. Russian specialists have also been actively exploring models for predicting spent fuel behavior under different storage conditions in order to assist in selecting safe conditions for dry storage.

ACTIVITIES IN ASIA

Both Japan and Taiwan have ambitious nuclear programs and plans. They will generate considerable spent fuel. Both countries have populations concentrated in confined geographical areas with limited available territory for spent fuel storage or disposal sites.

In Japan, plans are being developed to establish an interim dry storage facility by 2010. Meanwhile, a reprocessing facility is operating with plans to provide plutonium for light water reactors. A range of technical codes and standards, as well as laws and regulations, relevant to these activities are well developed. A related development is the effort of the government to encourage municipalities to consider hosting a high-level radioactive waste site.

Turning to Taiwan, the government has plans for dry storage for spent fuel, which is currently stored in water at the reactor sites. The concept calls for eventually commissioning a deep geological repository by 2050. In the immediate future, dry storage will be employed at NPP 1. But a multilateral spent fuel storage facility is also an attractive option.

FINAL OBSERVATIONS

The theme of the workshop was consolidation of spent fuel at international storage facilities. Indeed, consolidation of all types of nuclear material—internationally, nationally, and at facilities—is an important approach both for safety and security. While different types of nuclear material—from highly enriched uranium no longer needed at research reactors to radioactive waste—pose different types of threats and challenges, consolidation is an important crosscutting concept that deserves the strong support of governments and nuclear operators. In both the short and long terms, aggressive consolidation programs are important in countering both proliferation and terrorism threats. Such an approach responds directly to some of the principal observations on nuclear security made during the Putin-Bush summit in Bratislava in May 2005.

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Summary Remarks

David N. McNelis
University of North Carolina, Chapel Hill

This was the second interacademy workshop addressing the proposed Russia-based international spent nuclear fuel (SNF) storage site. Although the plans for this site are in an early stage of formulation, these workshops have provided a forum for the international community to exchange ideas and engage in informative discussion regarding international storage sites in general, the Russian site in particular, and directly related issues.

Both of these interacademy workshops were sponsored by the Russell Family Foundation. Its cofounder, George Russell, is primarily interested in the waste component of the nuclear fuel cycle and specifically the burn-up and/or transmutation of residual fissile materials and the long-lived, radiotoxic actinides and fission products in the SNF. He wants to mitigate the potentially damaging legacy from these materials by ensuring that fissionable materials are destroyed or, at a minimum, safely and securely stored. His interests include exploring how an international body, presumably the International Atomic Energy Agency (IAEA), could assure transparency and provide applicable standards for siting, safety, transportation, and safeguards as well as monitoring for such a site. He hopes to advance the concept of multilateral cooperation and ultimately reduce the number of sites around the world where SNF and high-level radioactive waste (HLRW) are stored, reprocessed/recycled, or placed in geological repositories.

These workshops were different from the more typical intergovernmental or international meetings on the topic of the storage of SNF. For example,

1. the Russian proposal to host a storage site was placed in a broad international context;

2. the workshops were convened by nongovernmental entities and most of the participants represented nongovernmental organizations;
3. the workshops provided the nongovernmental organizations community with an opportunity to participate in serious deliberations on the Russian plans and directly related topics;
4. an objective of the workshops was to open a nongovernmental channel to encourage or advance international approaches to the consolidation, storage, and disposal of waste nuclear materials; and
5. as previously stated, the workshops were privately funded.

The first workshop was held in Moscow in May 2003. Relevant experiences in selecting and characterizing repository sites; in managing, handling, and transporting SNF; in developing policy options, policies, and infrastructure; and in regenerating fuels and stabilizing wastes—from Russia, the United States, Japan, South Korea, and Switzerland—were presented and discussed. As the intent was to illuminate, not resolve issues or even attain a consensus on an approach, the richness of the dialogue and the merits of the policy options that were suggested were particularly important.

A few observations and conclusions from the first workshop are described below.

- Although there are differing opinions as to the most appropriate endpoint, long-term storage, preferably centralized, is required in every case that was considered and should have high priority.
- Each government should have the right to establish its own policy for managing SNF while observing international norms for ensuring its safety and security.
- More than five decades of experience confirms that shipment of SNF and HLRW can be conducted safely. With the increase in terrorism, however, greater attention to transportation security is needed.
- Fifty years of experience in the storage of SNF has demonstrated conditions that appear to ensure that materials will remain stable. The materials in question may be stable over longer periods, but that assumption needs to be validated. Licensing of long-term storage facilities, perhaps for 100 years or beyond, may be necessary for heat and radiation dissipation, given the trend to higher burn-up and the incorporation of plutonium in mixed oxide fuels.
- Two of the sites under consideration in Russia for the International SNF Storage Site are Krasnoyarsk (currently the site for the national SNF storage program) and Krasnokamensk (a uranium mining area). There may be other possible sites as well.
- Issues associated with proliferation and terrorism were recognized but not directly addressed in detail at the Moscow workshop.

This second workshop, which was convened at the IAEA Conference Center in Vienna, was also an international gathering, with participants from Germany, France, Japan, Taiwan, Austria, and Switzerland, in addition to the IAEA, Russia, and the United States. This workshop also focused on the proposed International SNF Storage Site in Russia and its possible consideration as a pilot regional site—preferably one of a small number of sites worldwide that would store all materials.

While there are no international sites in operation for the storage of SNF that are not linked to a reprocessing plant, several countries have, or soon will have, national sites, for example, Switzerland's storage site and Finland's geological repository. In Finland the repository has particularly broad public and political support. Russia is the first country to propose hosting a site where SNF of international origin could be stored. Russia has in place the enabling legislation to establish such a storage site, but Russian law prohibits the import of radiological waste. Many of the potential international customers for the Russian site use U.S.-origin fuel, and U.S. law requires a consent agreement with the U.S. government for the import of such materials by a third party. The United States is opposed to the reprocessing of U.S.-origin fuel transferred under such a consent agreement.

The geological repository site in the United States at Yucca Mountain (Nevada) has not garnered the same level of public support as the analogous site in Finland. The U.S. nuclear industry supports Yucca Mountain as being a technologically sound geological repository that can meet regulatory requirements. While the goals of the U.S. Department of Energy (DOE) include demonstrating that the repository can be constructed, operated, and closed in a manner that protects the public, there is an unresolved issue with setting the radiation standard for the site. Court decisions in this regard along with past and projected financial appropriation shortfalls have resulted in DOE delaying its license application. As a result, SNF in the United States is stored in on-site pools with excess material going to on-site dry spent fuel storage locations. By 2010 it is expected that almost all utility sites in the United States will require dry cask storage.

Although U.S. government attempts to identify a state willing to host a monitored retrievable storage site have failed, there have been a few initiatives led by industrial consortia to develop their own centralized storage facilities. One of these is located on land of the Skull Valley Band of the Goshute people, a sovereign American Indian nation in Utah. It has recently received approval from the Nuclear Regulatory Commission for construction of a 40-year lifetime installation (40,000 MTU capacity). This initiative of eight utility companies was discussed at the first workshop. At present it does not have approval of the state of Utah or broad public support.

There appeared to be a consensus among workshop participants with respect to several aspects of SNF management, including the storage and final disposal aspects being prime candidates for multilateral approaches and international cooperation. The benefit of such collaboration seems obvious, although a host of legal and liability issues, in addition to the political and public acceptance concerns, need to be resolved. Potential customers for regional storage sites would presumably include countries that lack a suitable storage site, lack reprocessing facilities, or seek a more economical solution than building and managing their own facilities. It is my view that countries with well-developed nuclear energy programs and experience in the management and handling of spent fuel would seem to be the most appropriate hosts for SNF storage sites.

The Joint Convention on the Safety of Spent Fuel and Nuclear Waste Management and on the Safety of Radioactive Waste Management as well as a number of other international legal instruments allow for international solutions consistent with maintaining a high level of safety worldwide. In March 2004 the director general of the IAEA convened a group of experts to explore options and develop proposals for multinational nuclear approaches (MNAs) to the nuclear fuel cycle. The report of that group has just been published and includes a recommendation that attention be given by IAEA member states, by the IAEA itself, by the nuclear industry, and by other nuclear organizations to MNAs in general and to five specific approaches. They include "creating, through voluntary agreements and contracts, multinational, and in particular regional, MNAs for new facilities based on joint ownership, drawing rights or co-management for front-end and back-end nuclear facilities, such as uranium enrichment; fuel reprocessing; and disposal and storage of spent fuel (and combinations thereof)."[1]

In addition to its roles with respect to assuring transparency and establishing standards and safeguards, it would seem appropriate for the IAEA also to monitor regional storage sites for compliance with international design standards, safety, financial management, environmental compliance, and other security issues. Based on conversations with IAEA staff members, the IAEA would presumably use the experience of the United States, Russia, Finland, and other countries in developing standards for siting and site characterization for regional international SNF storage sites. The IAEA is authorized by statute to provide such services, although they would most likely be provided in response to requests from the contracting parties.

The IAEA has recently completed a revision (yet unpublished) of its standards for packaging and shipping of SNF. Topics included are packaging (casks), modes of transport, transport requirements, regulatory requirements (during package design and testing and during transport), radiological safety, and accident conditions and emergency response. The standards note a 10-year history of transport of radioactive materials in the United States with no accidents involving SNF casks (type B packages) that resulted in significant radioactive releases. The

[1]IAEA. 2005. Multilateral Approaches to the Nuclear Fuel Cycle: Expert Group Report Submitted to the Director General of the IAEA, INFCIRC/640, available online at *http://www.iaea.org/Publications/Documents/Infcircs/2005/infcirc640.pdf.*

IAEA has prepared many other highly relevant documents, many of which were mentioned at the workshop, on topics including, for example, safety, transport, economics, partitioning, and transmutation.

One of the stated goals of this workshop was to highlight international law and liability issues concerning the shipment of SNF packages. Nuclear facility operators and transport carriers could have significant and complex problems in the event of a nuclear incident or major accident occurring during the shipment of nuclear materials. The complexity of resolving the liability and financial aspects of the problem depends largely on the nuclear liability policies and practices of the states involved. States may be parties to one of the international nuclear liability conventions, may have enacted their own national nuclear liability legislation, or may be without specific nuclear liability legislation.

There are three international conventions on nuclear liability: the Vienna Convention on Civil Liability for Nuclear Damage: International Framework, the Paris Convention on Third Party Liability in the Field of Nuclear Energy, and the Convention on Supplementary Compensation for Nuclear Damage). Liability under these conventions is consistent and generally clear. It resides with the nuclear facility operator where the incident/accident occurred. Liability for accidents that occur during shipment between states without common treaty relations are more complex, with identifying the competent court and the applicable law(s) often difficult. Compensation as a result of such accidents would be subject to the general rules of international law covering commercial transactions in the private sector, and the outcomes would be difficult to predict.

It would be beneficial for partnering operators to be parties to the same international convention under which the competent court and applicable laws are clearly understood. However, bilateral arrangements or contracts for the shipment of nuclear materials have a long history and probably will continue for an extended period.

It is also important to review the policies of countries with respect to importing or exporting materials designated as radioactive waste. These policies or their underlying laws are, of course, subject to change. Within Europe slightly more than one-half of the 20 countries reporting would not permit the import of these materials, and there are conditions that would be imposed by those countries that would permit such imports. In contrast, almost all of the countries would permit, under certain conditions, the export of radiological waste. There are also, as could be expected, significant differences between what is permitted (or restricted) by law and the policies that are implemented.

The discussions at this interacademy workshop outside governmental channels were quite open and frank regarding the potential of the Russian site as the first commercial international storage site for SNF not associated with a reprocessing plant. They focused international scrutiny on the potential site at Krasnokamensk, whereas most of the attention previously has been devoted to the potential site at Krasnoyarsk. Regardless of the location, workshop participants noted that progress is being made in establishing a storage site in Russia.

Finally, the ideal solution to the fuel cycle and the associated high-level radioactive waste, whatever its composition and magnitude, is an international one. The consolidation of SNF at international storage sites would resolve only part of the problem. Ultimately, both the front and back ends of the fuel cycle must be designed so as to minimize the actinide and long-lived fission product generation and, at the same time, maximize the proliferation barriers for the fissile components. National and shared international engagement is needed in developing approaches that are responsive in providing for the energy needs of nuclear nations while at the same time ensuring the safe and secure management of SNF and its waste by-products.

In closing, it is important to continue to include both governmental and nongovernmental specialists in the debates about spent fuel.

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Welcoming Remarks, October 3, 2005

Milton Levenson
National Academy of Engineering

I would like to welcome you to this miniworkshop, a follow-on to the major workshops we held in Moscow and Vienna on the topic of an international storage site for spent nuclear fuel. This series of workshops has been conducted under the joint auspices of the Russian Academy of Sciences and the U.S. National Academies with financial support from George Russell. In past workshops we explored issues of technology, liability, law, and safeguards. While the overall topic is an international storage site, we have used a site in Russia as the first example of a site to host an international spent fuel storage operation not directly linked to a reprocessing plant. The issues have been identified, and in most cases the path forward to resolve the issues has been identified. The issue not resolved is the approval required from the United States by most potential user countries, an issue we will hear about here. We will also hear an update on activities in Russia. The Russian government has been taking this subject very seriously, as indicated by its announcement in Vienna that Russia would not put its fuel in the international storage facility. The result is to improve the robustness of International Atomic Energy Agency monitoring since without Russian fuel questions of sovereignty that often complicate inspection should be easily resolved. I think we all recognize the safety and security benefits of making sure that spent nuclear fuel, now literally scattered all over the world, be consolidated in secure and monitored storage. The challenge is how to do it and how to make it happen.

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On the Problem of Creating Regional International Storage Facilities for Spent Nuclear Fuel (Based on the Russian Example)*

Nikolay P. Laverov
Russian Academy of Sciences

WHY IS IT NECESSARY TO ACCELERATE THE CREATION OF AN INTERNATIONAL SPENT NUCLEAR FUEL STORAGE FACILITY?

Almost 170,000 metric tons of equivalent heavy metal from spent fuel from commercial reactors and more than 60,000 fuel assemblies from research reactors are currently being stored worldwide. Spent fuel is accumulating at a substantially faster rate than it is being reprocessed. An increasing number of countries have poorly developed industrial sectors and lack the necessary experience and personnel engaged in handling spent nuclear fuel. The world undoubtedly faces an increasing threat from radiation-related danger.

Recognizing the serious potential consequences of radiation terrorism, Russia's leaders and public have focused constant attention in recent years on the reliable long-term (50-100 years) storage of spent fuel as one of the most important elements of the fuel cycle. Important steps have been taken with regard to international efforts in the scientific-technical, socioeconomic, and legal sectors, including matters related to the creation of a regional international spent fuel storage facility in Russia.

In our opinion, multinational agreements on the creation of a spent fuel storage facility in Russia could be implemented under the aegis of the International Atomic Energy Agency (IAEA). Here we are counting on the fact that creation of such a facility will entail application of the world's best technologies for design and implementation of the storage process to ensure the safety of the population

*Translated from the Russian by Kelly Robbins.

and reliable physical protection of the materials, transportation, high-quality containers, methods for analyzing the condition of the fuel rods, licensing and guarantees, hiring and training of personnel, site selection, provision of accounting and control of operating status, and possibilities for professional exchanges with other similar facilities.

We proceed based on the belief that the creation of international regional spent fuel storage facilities will undoubtedly promote nonproliferation of nuclear materials and should be categorized as an antiterrorism measure.

WHAT PLACE MUST AN INTERNATIONAL SPENT FUEL STORAGE FACILITY HOLD IN THE FUEL-CYCLE SYSTEM?

This problem has been discussed frequently in recent years at scientific conferences, seminars, and councils to review problems of managing spent nuclear fuel and high-level wastes of civilian and military origin.

Russia adopted and until recently operated a system in which technological wastes from major radiochemical plants were stored in liquid form deep underground at facilities adjoining the plants where they were produced. These wastes were stored in the water-bearing sedimentary layers bounded at the top and bottom by poorly penetrable clay covers (similar to the formations in which oil and gas deposits are found). This prevented the wastes from having a substantial impact on the biosphere.

In Russia, spent nuclear fuel was never viewed as radioactive waste; therefore, its underground disposal was not considered in plans for the development of the nuclear power industry. An insignificant portion of Russia's spent fuel was reprocessed at the Mayak enterprise. Most spent fuel from nuclear power plants is today concentrated at the plants, whose storage potentials are already full to capacity. At Mayak, vitrified technical waste is kept in a surface facility on the grounds of the enterprise. Spent fuel planned for reprocessing is kept in a pool.

In selecting a site for an international spent fuel storage facility, Federal Atomic Energy Agency (Rosatom) personnel and Russian scientists considered several options within the fuel-cycle system:

- an underground storage facility for spent nuclear fuel and high-level waste not located on the premises of any of the fuel-cycle enterprises (Kola peninsula);
- an underground international spent fuel facility near the Krasnoyarsk enterprise (Siberia), where there is a Russian-built surface spent fuel storage facility and an underground liquid waste repository, with construction of a spent fuel reprocessing enterprise planned; and
- an underground international spent fuel storage facility on the grounds of a major natural uranium mining enterprise (Krasnokamensk, Siberia).

Geologists and specialists in the fields of mining and radioecology support the proposal for the Krasnokamensk site. A final decision has not yet been made. However, a number of foreign experts (especially in the United States) oppose the idea of having the reprocessing plant and the international spent fuel storage facility located at the same site.

International efforts under the patronage of the IAEA to develop optimal regional systems for spent fuel storage seem very much needed. Longstanding relations among countries that store spent fuel and those that supply it must be taken into account, as well as guarantees, controls, systems for managing the storage process, resolution of joint technological questions common to the fuel cycle, and guaranteed safety. Russia is prepared to participate actively in these efforts.

SPECIAL CHARACTERISTICS OF SPENT FUEL THAT DETERMINE THE CONDITIONS FOR ITS STORAGE

An analysis of underground spent fuel repositories that are currently operating or under construction shows that an assessment of the risk of container seal failure involves consideration of a wide range of natural catastrophic phenomena, particularly those associated with hydrogeological processes. The geochemical aspects have received intense study in Russia.

It is well known that nuclear fuel is based on the fuel element, a long, narrow tube made of corrosion-resistant zirconium alloy (or other metals) and filled with uranium dioxide (UO_2) tablets with a ^{235}U isotope content higher than that found in natural mixtures of uranium isotopes. The tablets in fuel elements are manufactured by pressing and have a density 94 to 95 percent of the theoretical density of uraninite. The size of the fuel grains does not exceed a few microns. During the irradiation process, numerous cracks form in the fuel tablets and the space between the grains expands, and this leads to an increase in the area of its interaction with underground water in the event that the seals on the spent fuel containers are broken.

Uranium dioxide is the conserving matrix for all elements formed in the nuclear reaction process. A number of elements such as Pu, Am, Cm, Np, Th, the rare earth elements, Nb, and Zr occur in the structural lattice of irradiated uranium dioxide, the stability of which prevents the leakage of these elements into underground water. Other elements such as Tc, Se, I, Cs, Sn, Sr, and products of their decay exist in the form of an unstructured mixture. They enrich the intergrain seams and microcracks in the uranium dioxide matrix. In the event of violation of the integrity of the fuel element coating, the gas-forming radionuclides (^{85}Kr, ^{3}H, and ^{14}C) will primarily be released into the environment, and in the event of contact with underground water, nonstructured easily soluble radionuclides will also be released. Here the cracks will promote the migration of radionuclides from the spent fuel. It is therefore obvious that safe underground storage of spent nuclear fuel requires favorable conditions ensuring a high level of stability of the uranium dioxide and lack of interaction with underground water.

The results of natural observations are undoubtedly key in ensuring the geochemical conditions for high stability of uranium dioxide in underground spent fuel storage facilities. These observations make it possible not only to characterize the behavior of actinides in a wide range of physical-chemical conditions but also to obtain information regarding slow-developing processes. Many researchers view deposits of uranium and thorium as natural analogs of spent fuel repositories. It has been established that the bulk of uranium in uranium ore deposits is concentrated in oxides. According to Russian experience, ore deposits are localized within the bounds of highly permeable zones in conditions of direct contact with underground water. Nevertheless, even in areas with increased water permeability, numerous cases have been noted in which deposits of uranium ore that have lain deep in the earth for hundreds of millions of years are found in practically ideal states of preservation. The reducing near-neutral properties of underground water are the main condition determining the high level of stability of uranium dioxide.

The fact that the equilibrium concentration of uranium in underground water in reducing hydrogeochemical conditions is very low and totals less than 10^{-8} mol per liter is of fundamental significance. Therefore, uranium ore deposits influenced by such water maintain high levels of stability.

Rich major ore deposits in Canada and Russia are often cited in the literature as natural analogs for spent fuel repositories. Despite long contacts between the ores in these deposits and underground water, the uraninite displays a high level of preservation, which is due to the reducing properties of underground water. The concentration of uranium in the water from the ore deposits containing up to 40 percent uranium is practically no different from background concentration levels, totaling 10^{-8} mol per liter.

However, a question arises: Will uranium dioxide irradiated in fuel elements behave in a geological environment similar to natural uraninite, given that the intensity of alpha-radiation on the surface of spent fuel is two to three orders of magnitude higher than that of uranium ores? To resolve this question, let us turn to the results of a study of the ore deposits of the Franceville uranium mining region in Gabon (West Africa). The best-known deposit in this region is Oklo, in the ores of which the existence of the natural nuclear reactor phenomenon was first established. Evidence of this is seen in the depletion of the isotope ^{235}U in certain ore deposits as well as the presence of radioisotopes or end products of their decay formed as a result of the nuclear reaction. The deposits of the Franceville region were formed about 2 billion years ago in sandstones containing an organic substance at a depth of 3,000 to 3,500 m. Calculations show that the content of ^{235}U in the uranium at that time totaled 3.25 percent by mass, which corresponds to the level in the nuclear fuel of modern power reactors. In the presence of water, which played the role of a neutron moderator, processes similar to those in nuclear reactors occurred in certain ore deposits in Oklo over the course of 500 million years.

A study of such ore deposits located at various depths from the current surface made it possible to assess how uranium dioxide and nuclear reaction products contained in it would behave in both reducing and acidic hydrogeochemical conditions. Thus, in an ore deposit at a depth of 250 meters in reducing conditions, uraninite is not affected by processes of secondary change.[1] A detailed study of element mixtures and their isotopic components in such ores has shown that all elements occurring in the crystalline lattice structure of uraninite are maintained in it right up until their complete decay.

The fact that Am, Pu, and Np behaved in just such a manner is shown by the end products of their decay, ^{209}Bi and ^{207}Pb, which, despite the substantial difference in their geochemical properties from those of uranium, were largely maintained in the composition of uraninite and only partially transferred in direct proximity to ore deposits. Such nonstructural elements as Rb, Cs, Sr, Mo, Cd, Xe, and I were almost completely transferred out of the ore deposits, while Ru and Sn were partially removed.

On the whole, the results of geochemical studies of natural reactor zones show that in reducing conditions uraninite is characterized by very high stability and not only reliably maintains actinides in its structure but also very powerfully limits the outward movement of elements not included in the uraninite structure. Thus, the results of studies of the ore deposits of Oklo support the conclusion that this geological environment is capable of ensuring the safe long-term storage of spent nuclear fuel.

ON SELECTING A SITE FOR AN INTERNATIONAL GEOLOGICAL SPENT FUEL STORAGE FACILITY IN RUSSIA

For the majority of countries, selecting a site for the construction of a spent fuel repository is an exceptionally complex problem. In the 1970s, IAEA and a number of countries developed rules for decision making on repository locations. These decisions are to be made taking geological, economic, legal, and socioeconomic factors into account. In the various countries that use nuclear power, each of these factors has widely varying significance. It is especially difficult to resolve the problem of selecting an underground spent fuel repository site in countries with high population density and unfavorable geological conditions. Russia is among those countries with a large land area, low population density, and an enormous diversity of geological conditions. For these reasons it is possible to

[1]Pourcelot, L., and F. Gauthier-Lafaye. 1998. Weathering conditions and behavior of fission products in Oklo reactors. Proceedings of the Symposium on Scientific Basis for Nuclear Waste Management XXI 506:1071-1072.

select spent fuel repository and storage facility sites in Russia with practically ideal geological conditions.

Intensive studies have been made of the geological-geochemical conditions of uranium migration in the Transbaikal (Krasnokamensk) region characterized by long stability and chemical destruction of uranium ores. The major uranium deposits here are located in the caldera of an ancient volcano. During the 30 years that the enterprise has operated here, unique research has been conducted regarding conditions of migration and transformation of uraninite at depths ranging from the surface to 1,500 m underground.

The primary uranium ore mineral here—pitchblende (mineral version close to uraninite)—is a natural analog of synthetic uranium dioxide, making up 96 percent of the volume of spent nuclear fuel. A study of U-Pb isotopic systems of unchanged pitchblende preserved in several parts of ore deposits has shown that these systems have remained completely closed over the course of the entire period (about 135 million years) since the deposit was formed. The majority of primary uranium ores have been subject in varying degrees to the effects of hydrothermal solutions, during the course of which in reducing conditions the pitchblende was replaced by a U-Si gel compound, which was also redeposited in the ore deposit veins.

In one ore deposit subjected to such hydrothermal changes, an original methodology was used to conduct a quantitative calculation of the uranium balance. This study showed a practically complete absence of uranium transfer outside the bounds of the ore body. The uranium freed up by the substitution of uraninite remained in practically the same spot in a newly formed U-Si gel as a result of the action of the effective geochemical barrier, preventing further uranium migration.

In addition to the assessment of the long-term safety of underground spent fuel storage, the results of this research study provide the basis for believing that the uranium dioxide in spent fuel, provided that it is preserved as a mineral phase, ensures the reliable long-term isolation of uranium and the transuranic and fission radionuclides "imprinted" in the uranium dioxide matrix. Under the influence of hydrothermal solutions, which could cause mineral transformations of the uranium dioxide matrix, the uranium will be effectively immobilized by the newly formed U-Si gel.

The large volume of data obtained as a result of lengthy systematic studies of the conditions for the placement of an underground storage facility in this region, the presence of highly qualified personnel, and the consent for the most part of the local population argue in favor of Krasnokamensk as an important site for the possible placement of an international spent fuel storage facility.

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International Storage of Commercial Spent Fuel and High-Level Waste: Considerations for U.S. Approval to Ship Spent Fuel with U.S.-Origin Uranium to Russia for Storage and Disposal

Alex R. Burkart and *Janet M. Gorn*
Office of Nuclear Energy Affairs, U.S. Department of State

Many steps have been taken over a period of years to work toward acceptable solutions for the safe disposal of spent fuel and radioactive waste, most recently through the first meeting of the parties to the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management. The U.S. government sees a continued high priority for these activities, as more countries make progress toward national geological disposal and enter active phases of decommissioning and dismantling.

The subject is both national and global in character. For countries for which national disposal solutions are not feasible, developing and implementing multinational solutions is a possible alternative. However, it is important that the search for a multinational solution should not jeopardize any ongoing national programs.

In the United States there are requirements established by U.S. law and policy regarding any scheme for international storage and disposal of spent fuel containing U.S.-origin nuclear materials. Specifically, questions arise with regard to the opportunity created by the 2001 Russian legislation and numerous related proposals. These factors and others complicate the issue of international cooperation in the storage and disposal of spent fuel and high-level radioactive waste.

THE CURRENT SITUATION

Requirements of the Joint Convention

Ultimate responsibility for ensuring the safety of spent fuel and radioactive waste rests with the state. This is affirmed in the Preamble to the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management. The convention also recognizes the principle that responsibility for the safety of spent fuel and radioactive waste rests with the state that produced it. The convention entered into force on June 18, 2001. On September 29, 1997, the United States became the first signatory to the convention. On April 9, 2003, it became the 31st member to ratify the convention, becoming a full contracting party on July 14, 2003. The convention now has 42 signatories and 34 contracting parties.

The convention incorporates principles important to all states, which enhances and strengthens the world's safety culture. We look forward to the Russian Federation becoming a contracting party in the near future and to its participation in the second meeting of the parties in May 2006.

While giving primacy to the responsibility of the state that generates spent fuel and nuclear waste to dispose of it on its own territory, the joint convention recognizes that in certain circumstances safe and efficient management of spent fuel and radioactive waste might be fostered through agreements among contracting parties to use the facilities in one of them for the benefit of the other parties, particularly where the waste originates from joint programs.

Each proposal for international spent fuel or high-level waste storage or disposal must be evaluated individually on its merits. The International Atomic Energy Agency (IAEA) has developed a Code of Practice on the Transboundary Movement of Radioactive Waste. The most important provisions of the code found their way into the joint convention. This code and the convention provide some technical guidance for a state to use in determining whether or not to participate in an international repository or spent fuel or waste transfer. The overriding principle is that a sending state should ship waste or spent fuel only with the consent of the receiving state and only after satisfying itself that the receiving state has the administrative and technical capacity, as well as the regulatory structure, needed to manage the waste or spent fuel safely. Similarly, the receiving state should only consent to receiving the waste or spent fuel if it can satisfy itself that it can meet those requirements. This means that shipments of spent fuel and nuclear waste fall clearly under state jurisdiction and reflect a state's policy. While technical factors are important in evaluating a proposal, political factors always count in state decisions as well.

U.S. Waste Management Cooperation

In general, the United States favors the idea of states in a region getting together to solve their spent fuel and radioactive waste issues collectively. Conceptually, this is similar to the waste compact program in the United States in which several U.S. states join together in compacts to locate a low-level waste repository in one of them, rather than locate separate repositories in each. Some progress is already under way in moving in this direction.

One example is the agreement between Luxembourg and Belgium for Belgium to take Luxembourg's radioactive waste. Another example is the announcement by Slovenia, at the first meeting of the parties to the joint convention, that it had taken the first steps in support of a regional approach by hosting a meeting to begin discussion among the Newly Independent States (NIS). Subsequent annual meetings have taken place since this announcement. A third example is the announcement by the European Commission in March 2004 of its readiness to finance (50,000 euros) a European regional repository feasibility study to move the concept ahead. Where once a collective solution was regarded with deep suspicion or skepticism by many, today a shared solution is gaining momentum.

The United States has maintained a strong program of international cooperation in the area of radioactive waste management to assist other states in managing their own spent fuel and radioactive waste. For example, U.S. nuclear cooperation committee meetings with Taiwan and the Republic of Korea have been held for more than 15 and 25 years, respectively, and spent fuel and radioactive waste management have been on the agenda of most of those meetings. Many states have gained an understanding of the U.S. Department of Energy's (DOE) site evaluation methodology and repository science programs.

States, however, should not expect to see the United States giving consideration to taking irradiated U.S.-origin fuel supplied for electricity generation back for storage and/or disposal, in Yucca Mountain or elsewhere. The Nuclear Nonproliferation Act of 1978 makes any plan for the return of such fuel subject to stringent conditions, including submission to Congress, which has the option to reject it. Subsequently, Congress has prohibited the executive branch from even spending money to formulate or review such a plan.

Despite U.S. policy against taking back spent nuclear power reactor fuel, the United States has operated an international spent fuel disposal system of sorts, taking back spent U.S.-origin research reactor fuel for disposal. This is part of the effort to reduce worldwide use of highly enriched uranium, an effort that has been successful in encouraging the conversion of most research reactors to the use of low-enriched uranium fuels. The bulk of spent highly enriched uranium fuel will be repatriated before the U.S. program ends in 2009. The United States is also working with Russia and the IAEA on a similar program involving the return to Russia of highly enriched uranium fuel and spent fuel from exported Soviet-era research reactors.

Acceptance of Shared Repositories

The major problem facing any international storage or acceptance of a shared repositories disposal scheme is public acceptance. If it were an easy problem, there would be a regional spent fuel repository by now, because the concept has been around for at least 25 years. However, it seems inevitable that at least in some areas of the world, regional storage sites or repositories will be built.

There are presently 34 countries plus Taiwan that will have to dispose of spent fuel and/or high-level waste from reprocessing. It is hard to imagine 35 separate deep geological repositories or an indefinite continuation of the present situation where almost every nuclear reactor in the world constitutes a long-term spent fuel storage facility. It is particularly hard to imagine these outcomes in regions of closely grouped states, each with spent fuel from only a few nuclear power plants. These states might conclude that their environs would be better served by one storage site and/or repository rather than several.

GENERAL FACTORS AFFECTING U.S. POLICY

Over the past few years there have been numerous proposals for international spent fuel storage or disposal. The focus of this meeting is the possibilities presented by the new Russian legislation on the receipt of foreign spent fuel for interim storage or reprocessing. Before addressing that issue, a few remarks about general factors are in order.

An Agreement for Cooperation Required

Source and special nuclear material are exported from the United States pursuant to an agreement for cooperation negotiated according to the requirements of Section 123 of the Atomic Energy Act, as amended. These requirements apply to not just exported material but also the special nuclear material produced through its use or the use of certain U.S.-exported nuclear facilities and technology. This material is referred to here as U.S.-origin nuclear material. The requirements include the following:

1. provision for a peaceful use/no explosive use guarantee,
2. application of full-scope safeguards for nonnuclear weapons states,
3. maintenance of adequate physical protection,
4. a U.S. consent right over reprocessing or enrichment of the nuclear material and alteration in form or content of any irradiated fuel containing the material,
5. a U.S. right to require return of the material to the United States under certain conditions,
6. a U.S. approval right over any storage facility for separated plutonium or highly enriched uranium, and
7. a U.S. consent over retransfer to another country.

An agreement for cooperation is negotiated by the Secretary of State with the technical assistance and concurrence of the Secretary of Energy and in consultation with the Nuclear Regulatory Commission. The agreement is submitted by the secretaries of State and Energy to the President, who transmits it to Congress where it must lie for a period of 90 days of continuous session, after which it can enter into force unless disapproved by both houses of Congress. While the President may waive one or more of the above requirements for an agreement, any such agreement then requires an affirmative vote of Congress. No president has ever waived any of the required provisions. The United States currently has nuclear cooperation agreements with the European Atomic Energy Community (Euratom), the IAEA, Taiwan, and 22 countries.

U.S. Consent Rights Apply

There is nearly 33,000 metric tons of spent fuel outside the United States that contains U.S.-origin nuclear material and consequently is subject to U.S. consent rights. Among countries included in this estimate are the European Union member states, Brazil, the Czech Republic, India, Japan, the Republic of Korea, Mexico, Switzerland, and the former Yugoslavia, as well as Taiwan. The most frequently mentioned customers for any international repository are Taiwan and Korea, as both have large quantities of spent fuel to dispose of and the funding necessary to make a repository proposal attractive to a potential host. All the spent fuel in Taiwan and much of the spent fuel in Korea are subject to U.S. consent rights, making the exercise of these rights by the United States an important consideration in any proposal for international storage or disposal of spent fuel. It is worth noting that the high-level nuclear waste that comes from the reprocessing of spent fuel over which U.S. consent rights existed would generally not be subject to the same consent rights.

Under Section 131 of the Atomic Energy Act of 1954, as amended, U.S. consent rights over the retransfer of spent nuclear fuel are exercised according to legally established procedures and standards by the Secretary of Energy on a case-by-case basis through a process called a subsequent arrangement. In addition to obtaining the consent of the Secretary of State and consulting with the Department of Defense and the Nuclear Regulatory Commission, the Secretary of Energy must make a written determination that the subsequent arrangement will not be inimical to the common defense and security. A notice of the proposed subsequent arrangement and this determination must be published in the Federal Register for 15 days before the arrangement can take effect. If the retransfer of spent fuel is for the purpose of reprocessing, the subsequent arrangement must also lie before Congress for 15 days. Section 127 of the Atomic Energy Act requires that retransfers of U.S.-origin nuclear material can only be approved to recipient states that agree to the U.S. export control requirements.

POLICY FACTORS IMPORTANT

Disposal, Not Reprocessing

It is the policy of the Bush administration that the United States will continue to discourage the accumulation of separated plutonium worldwide. This policy and the requirements of the subsequent arrangement process mean that before approving new arrangements for the retransfer of any spent fuel containing U.S.-origin nuclear material, the United States would almost certainly need to be assured that the spent fuel was destined for eventual disposal and not reprocessing. A permanent repository need not be available at the time of the export, and long-term storage could be part of any scheme. But the scheme should also involve specific plans for, and the commitment of sufficient resources to, development of a geological repository. The United States would expect to use its consent rights to enforce the disposal, as opposed to reprocessing, of transferred spent fuel.

Facilities Must Be Safe and Environmentally Sound

In addition to gaining assurances about the ultimate disposition of the spent fuel, the United States would need to be assured that the interim storage facilities and the final repository facilities were safe and environmentally sound. The technology for storage of spent fuel is well established, as demonstrated, for example, at a large number of U.S. nuclear power plants as well as away from reactor storage facilities in Canada, Russia, and Sweden. The Nuclear Regulatory Commission has concluded that spent reactor fuel could be stored safely for at least 100 years, and commercial suppliers of the necessary technology are available. In any event, we would be likely to participate in the scientific evaluation of any facility storing and disposing of spent fuel containing U.S.-origin nuclear material to ensure it is constructed on an environmentally sound basis.

The DOE's recommendation for Yucca Mountain as a scientifically sound site for the disposal of nuclear wastes and the subsequent notification by the President to Congress that he considers the Yucca Mountain site to be qualified for a construction permit are evidence of a large body of work on geological containment of nuclear waste. The opening of the Waste Isolation Pilot Plant (WIPP) in New Mexico in 2000 marked the world's first geological repository and a giant step forward. Sweden and Finland are also well on the way toward development of a geological repository. The United States shared its experience with both WIPP and Yucca Mountain at the joint convention's first meeting of the parties. The United States is also making a broad range of efforts to share its experience with cooperating partners. While the events of 9/11 certainly raise concerns about the security of nuclear fuel and terrorism, DOE Secretary Spencer Abraham pointed out the benefits of safely locking away nuclear fuel forever rather than storing it at a large number of different sites.

Transport Must Be Safe

Prior to providing consent for retransfer, the United States would further have to be assured that the material would be handled safely in transit. Sea transport of radioactive materials is routinely carried out with an exceptionally high degree of safety and security, in compliance with stringent IAEA and International Maritime Organization standards. Nevertheless, such shipments are highly controversial, and some coastal and small island states are increasingly vocal in calling for greater regulation or an outright ban. Attempts to ship through international choke points, like the Panama Canal, the Straits of Malacca, or the Bosporus and the Dardanelles, could risk attempts to pose unilateral restrictions or even attempts at interception by protestors. Large-scale movement of nuclear material from a port to a repository, via road or rail, might prove to be a challenge for many nations' infrastructures and can be another focal point for protests. However, the technology for the transport casks is well established, and any foreseeable incidents are not likely to pose a safety risk.

Assurance of Needed Resources

The requirements for safety and security already identified will need to be implemented over a long period of time. Before granting its consent to a retransfer, the United States would want to be sure that institutional mechanisms, whether private or governmental, were in place to ensure that the safety and security requirements continue to be met over a very long period of time. In particular, these mechanisms include those for ensuring that the large amount of money that would change hands, much of it up front, was properly managed and accounted for and remained available to manage the spent fuel for the life of the disposition program. The obligations being undertaken may be longer than what a commercial entity might be able to guarantee.

RUSSIAN REPOSITORY OPPORTUNITIES

The United States is interested in the possibility of safe and secure storage in Russia of spent reactor fuel containing U.S.-origin nuclear material. Among the specific technical issues raised above, the DOE has already begun a cooperative program in geological repository science with Russia. This would be an excellent basis for ultimate cooperation in evaluation of a potential repository location.

Transport Issues

Western ports in Russia might be problematic as receiving stations for foreign spent fuel as they require access through politically sensitive sea lanes and choke points. If spent fuel were shipped to a Pacific port, there could be concerns about the ability of the old trans-Siberian rail lines to sustain traffic in heavy rail-mounted casks. However, a new rail line could easily be designed for such traffic.

Disposition Issue

Ultimate disposition of spent fuel provides greater difficulties. While the United States requires a clear path to disposal, Russian legislation requires that spent fuel be accepted only for interim storage or reprocessing and not for disposal. Interim storage, particularly if it is a long interim, would ease political problems arising from the exhaustion of on-site storage capacity that could prematurely shut down reactors. Interim storage can also make the scientific analyses and ultimately the construction of a final repository easier, for example, in thermal management and materials performance/corrosion. However, the disposal of spent fuel would still require construction of an expensive geological repository, reducing the value of such interim storage.

IAEA Safeguards

Another issue might be a potential requirement for IAEA safeguards on some of the spent fuel transferred to Russia. There is no requirement in U.S. law for safeguards on exports or retransfers of source or special nuclear material to Russia, since it is a nuclear weapons state. Furthermore, the United States believes that the discretionary application of safeguards to spent fuel in Russia should be a low priority for the IAEA, particularly given the already inadequate resources available to meet safeguards obligations in nonnuclear weapons states. The United States also doubts that the IAEA wants to spend its resources in this way. However, some nonnuclear weapons states might wish such safeguards applied to fuel they export and want it written in their own transfer agreement. The wording of the safeguards agreement applied in Taiwan may require safeguards on any spent fuel transferred from there.

Iran

Finally, while the concept of spent fuel storage in Russia has promise, it will not be possible for the United States to support practical steps in this direction until the problem of Russian cooperation with Iran is resolved. The United States does not authorize retransfer of nuclear material to countries to which it could not transfer nuclear material directly. Therefore, the United States and Russia must have an agreement for cooperation in force before any spent fuel with U.S.-origin nuclear material may be shipped to Russia. No such agreement is in force. The transmittal report to Congress for a proposed agreement for cooperation must include an assessment of the proliferation record of the other party. The United

States would only be in a position to negotiate such an agreement once Russia addressed U.S. concerns regarding Russian-Iranian nuclear, missile, chemical, biological, and advanced conventional weapons cooperation. The Bush administration has firmly linked the storage of spent fuel containing U.S.-origin nuclear material in Russia to resolution of this concern.

Appendix A

Agenda
Workshop on Setting the Stage for International Spent Nuclear Fuel Storage Facilities

Vienna
June 1-2, 2005

June 1, 2005

Opening Remarks
Milton Levenson, National Academy of Engineering (U.S.A.)
Nikolay Laverov, Russian Academy of Sciences
Yury Sokolov, International Atomic Energy Agency (IAEA)
David McNelis, University of North Carolina, The Russell Family Foundation (U.S.A.)

Discussion of Goals and Objectives

Technical Session 1: Monitoring and Security of a Repository
Chair: Milton Levenson, National Academy of Engineering (U.S.A.)

International Monitoring of Storage and Disposal Facilities: The Potential Role of the IAEA
Bruno Pellaud, Switzerland

The Russian Experience
Nikolay Laverov, Russian Academy of Sciences

General Discussion

Technical Session 2: Packaging and Shipping of Spent Fuel
Chair: Nikolay Laverov, Russian Academy of Sciences

IAEA Standards for Packaging and Shipping of Spent Nuclear Fuel
Michael Wangler, IAEA, Division of Radiation, Transport and Waste Safety

Experience of the Dimitrovgrad Scientific and Research Institute for Nuclear Reactors in Packaging and Shipping of Spent Nuclear Fuel
Valentin Ivanov, State Duma of the Russian Federation

General Discussion

Technical Session 3: Liability and Insurance during Shipping and Receiving at the Repository
Chair: Milton Levenson, National Academy of Engineering (U.S.A.)

Status of Liability and Insurance Laws for International Shipments of Spent Nuclear Fuel
Norbert Pelzer, Germany

Insurance and Liability During Shipping and When Received at the Repository
Nikolay Pronkin, Russian Scientific and Research Center for Nuclear and Radiation Safety

General Discussion

From the PNC Report: International Cooperation on High-Level Nuclear Waste and Spent Nuclear Fuel Management
Kazuaki Matsui, Institute of Applied Energy (Japan)

June 2, 2005

Technical Session 4: Adequacy of National Legislation
Chair: Nikolay Laverov, Russian Academy of Sciences

Overview of National Laws in Relation to a Regional Repository
Christina Boutellier, Arius (Switzerland)

Russian Legislation of Today as Regards Spent Nuclear Fuel Import and Storage
Valery Bezzubtsev, Rostekhnadzor (Russia)

General Discussion

Technical Session 5: Country Perspectives
Chair: Milton Levenson, National Academy of Engineering (U.S.A.)

Overview of the Yucca Mountain Repository
Margaret Chu, former director of U.S. Department of Energy Office of Civilian Radioactive Waste Management
Presented by John Kessler, Electric Power Research Institute (U.S.A.)

Perspective from Europe
Neil Chapman, Arius (Switzerland)

Radioactive Waste Management in Taiwan
Ying-Ming Tsai, Taipei Economic and Cultural Office

Interim Storage of Spent Nuclear Fuel in Japan
Kinichiro Kusunose, National Institute of Advanced Industrial Science and Technology

General Discussion
Chair: Nikolay Laverov, Russian Academy of Sciences

General Status and Perspectives Related to Nonproliferation
Valentin Ivanov (Russia)

U.S. Nuclear Power Industry Trends in Spent Fuel Management
John Kessler, Electric Power Research Institute (U.S.A.)

Final Session

Themes of the Workshop
Glenn Schweitzer, National Research Council (U.S.A.)
David McNelis, University of North Carolina, The Russell Family Foundation (U.S.A.)

Concluding Remarks
Nikolay Laverov, Russian Academy of Sciences
Milton Levenson, National Academy of Engineering (U.S.A.)
Yury Sokolov, IAEA

Appendix B

Agenda
Setting the Stage for International Spent Nuclear Fuel Storage Facilities: An Update

Washington, D.C.
October 3, 2005

Welcoming Remarks
Milton Levenson, National Academy of Engineering

Perspectives from Russia
Nikolay Laverov, Russian Academy of Sciences

Update on the International Spent Fuel Storage Facility in Russia
Alex Burkart, U.S. Department of State

Update on U.S. Nuclear Power Industry Trends in Spent Fuel Management
John Kessler, EPRI

Discussion of Presentations

Appendix C

Experience of Russian Companies in Transportation of Nuclear Materials

Valentin B. Ivanov
Institute of Ore Deposits, Petrography, Mineralogy, and Geochemistry, Russian Academy of Sciences

Russian companies offer a broad range of services in the area of transportation of nuclear materials (fissile materials, fresh fuel, or spent fuel for various reactors). The services include the following:

- preparation of necessary licensing documentation for transportation of the spent nuclear fuel from power and research reactors in Russia and abroad
- preparation of nuclear material for transportation; development and manufacturing of unique equipment and transportation of fuel from nuclear power plants in Russia and abroad for research, storage, or reprocessing
- analysis of technical parameters of containers produced in Russia and overseas to develop optimal variants for transportation that guarantee high-level security, including protection from fuel failure

Recent experience of Russian companies is set forth in Tables 1, 2, and 3.

TABLE 1 Detailed Information on Fresh Fuel Transportation for Research Reactors (High Level of Enrichment)

Supplier	Recipient	Date of Delivery	Load Weight (g)	Weight of Uranium Isotopes (g)	Weight of U-235 Isotopes (g)	Number of Units	Comments
Vinca Institute for Nuclear Sciences, Belgrade, Republic of Serbia	RIAR,[a] Russia	August 2002	817,452.00	48,441.60	38,854.20	5,046	TVR-S fuel assembly
Institute for Nuclear Research, Pitesti, Romania	Russia, Chemical Concentrates Plant, Novosibirsk	October 2003	189,842.10	14,166.58	9,703.04	200	50 IRT-2M fuel assemblies (36%); 150 S-36V fuel units (36%)
Institute for Nuclear Research and Nuclear Energy, Sofia, Bulgaria	RIAR, Russia	December 2003	9,896.00	16,913.09	6,110.80	28	28 IRT-2M fuel assemblies (36%)

Nuclear Research Center Tajura, Tripoli, Libya	RIAR, Russia	March 2004	261,665.00	16,465.29	13,209.30	88	88 IRT-2M fuel assemblies (36%)
Institute of Nuclear Physics of the Uzbekistan Academy of Sciences, Tashkent, Uzbekistan	RIAR, Russia	September 2004	45,609.10	10,170.51	1,752.64	23	1 S-90 fuel assembly (90%); 4 S-36 fuel assemblies (36%); 6 EK-10 fuel assemblies (10%); 3 S-90 fuel units (90%); 4 S-36 fuel units (36%), 5 EK-10 fuel units (10%)
Nuclear Research Institute Rez, Czech Republic	RIAR, Russia	December 2004	23,910.00	3,721.71	1,438.00	7	3 fuel assemblies with 3 units (36%); 3 fuel assemblies with 4 units (36%); 1 fuel assembly with 4 units (80%)
			2,528.20	2,193.59	1,925.54	—	UO_2 powder (87.7% enrichment)
Total			1,439,971.40	112,072.37	72,993.52	5,392	

[a]Research Institute for Atomic Reactors.

TABLE 2 Detailed Information on Completed Transportation of Spent Fuel for Various Reactors

Supplier	Fuel Assembly Type and ID Number	Transport Cask	Date of Delivery	Carrier	Comments
Beloyarsk NPP (Zarechny, Sverdlovsk region, Russia)	BN-600,[a] 505.020.01.02.99, 505.020.02.05.02	TUK-11BN	2005	Mayak	
Balakovo NPP (Balakovo, Saratov region, Russia)	VVER-1000,[b] SDR9610U	TUK-13/1V	2004	Mining and Chemical Complex	
Kola NPP (Polarnye Zori, Murmansk region, Russia)	VVER-440, 144-46879, 136-42198	TUK-6	2003	Mayak	Delivery with two different railroad cars
Kalinin NPP (Udomlya, Tver region, Russia)	VVER-1000, SVV0011, VB0017	TUK-13/1V	2003	Mining and Chemical Complex	
Khlopin Radium Institute (St. Petersburg, Russia)	Fuel swarf VVER-1000	TK-45	2003	RIAR	Transport by truck
Zaporizhzhe NPP (Energodar, Ukraine)	VVER-1000	TUK-13/1V		Mining and Chemical Complex	

[a] Fast neutron reactor (BN).
[b] Water-moderated water-cooled power reactors (VVER).

TABLE 3 Detailed Information on Planned Transportation of Spent Fuel for Various Reactors

Supplier	Fuel Assembly Type and ID Number	Transport Cask	Date of Delivery	Carrier	Comments
Leningrad NPP (Sosnovy Bor, Leningrad region, Russia)	RBMK-1000,[a] 1-24-20567-89 4-26-54361-96 4-24-55609-96 11-26-76676-01 10-26-70360-00	TUK-11R1	2005	Mayak	
Ignalina NPP, Lithuania	RBMK-1500, 6 26 50 78255 02, 5 24 58867 97 Э, 6 24 52086 95 Э, 6 24 51904 95 Э,	TUK-11R1	2005	Mayak	
Kalinin NPP (Udomlya, Tver region, Russia)	VVER-1000 SV0007	TUK-13/1V	2006	Mining and Chemical Complex	

[a] High-power channel reactor (RBMK).