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Status of Proposed Repository for Latin American Spent Fuel

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ACRONYMS

AEC	Atomic Energy Corporation
ARIUS	Association for Regional and International Underground Storage
AVLIS	atomic vapor laser isotope separation
BNFL	British Nuclear Fuels, Ltd.
BWR	boiling water reactor
CCHEN	Nuclear Energy Chilean Commission
CNEA	Argentinean National Atomic Energy Commission
DOE	U.S. Department of Energy
EHL	Enterra Holdings, Ltd.
FLIP	fuel life improvement program
GNS	Gesellschaft für Nuklear-Service
HEU	high-enriched uranium
HM	heavy metal
IAEA	International Atomic Energy Agency
LEU	low-enriched uranium
ONDRAF	The National Agency for the Management of Radioactive Waste (Belgium)
ORNL	Oak Ridge National Laboratory
PURAM	Public Agency for Radioactive Waste Management (Hungary)
RERTR	Reduced Enrichment for Research and Test Reactors
SFE	spent-fuel elements
SWU	separative work unit
WAMAP	Waste Management Advisory Program

EXECUTIVE SUMMARY

This report compiles preliminary information that supports the premise that a repository is needed in Latin America and analyzes the nuclear situation (mainly in Argentina and Brazil) in terms of nuclear capabilities, inventories, and regional spent-fuel repositories. The report is based on several sources and summarizes (1) the nuclear capabilities in Latin America and establishes the framework for the need of a permanent repository, (2) the International Atomic Energy Agency (IAEA) approach for a regional spent-fuel repository and describes the support that international institutions are lending to this issue, (3) the current situation in Argentina in order to analyze the Argentinean willingness to find a location for a deep geological repository, and (4) the issues involved in selecting a location for the repository and identifies a potential location. This report then draws conclusions based on an analysis of this information. The focus of this report is mainly on spent fuel and does not elaborate on other radiological waste sources.

Several research reactors from Latin American countries have been in operation since the late 1950s with a gradual accumulation of a significant amount of spent fuel. The IAEA has listened to and consequently analyzed spent-fuel storage concerns in Argentina, Brazil, Chile, Mexico, and Peru. Most of these countries have returned part of their spent fuel to the United States. These countries were concerned because under the Nuclear Weapons Non-Proliferation Policy Concerning Foreign Research Reactors, the United States will receive no spent fuel discharged from the reactors of these Latin American countries after May 13, 2006, and because national solutions for countries without strong nuclear power programs will be very difficult to implement. In addition to the needs of research reactor spent-fuel storage, some Latin American countries have also developed nuclear power. Argentina has two state-owned nuclear plants in operation (Atucha-1 and Embalse), with a third reactor under construction (Atucha-2) as of December 31, 2003. Brazil has two working nuclear plants (Angra-1 and Angra-2). A third unit, Angra-3, is under consideration. The spent fuel coming from these nuclear reactors will certainly add to the inventory of nuclear material that requires permanent storage in these countries. However, to date, no permanent nuclear waste disposal programs exist in Latin America. Waste from these nuclear programs is currently stored onsite at the plants.

The U.S. Department of Energy (DOE) Energy Information Administration has indicated that Argentina may accumulate up to 4000 metric tons of heavy metals by 2020; Brazil may have 800 metric tons; and Mexico may have 700 metric tons by the same time. By 2007, Peru will join the group of countries that have power nuclear reactors.

All this information indicates that the potential for spent-fuel accumulation is growing in Latin America and that the pressing need to permanently store this material is increasing as well. The creation of a new repository in Latin America, whether it is developed by an individual country or under the umbrella of a regional effort, is inevitable. Furthermore, the international community should collaborate to make this repository compliant with the IAEA safeguards as well as to ensure that it is free from terrorism and proliferation concerns. The IAEA Regional Project is attempting to provide the basic conditions to define a regional strategy for managing spent fuel and to provide solutions that are consistent with the economic and technological realities of the countries involved. The IAEA Regional Project has demonstrated the feasibility of such an endeavor by showing accomplishments in the following related areas: (1) spent-fuel characterization, (2) safety and regulation, (3) options of spent fuel storage and disposal, and (4) public information and communication.

An expression of interest in international repositories came in a speech by the IAEA Director General Hans Blix in June 1997 about the concept of regional repositories developed within the IAEA. A white paper produced by the IAEA proposed that South Africa should be approached with a view to disposing of nuclear waste, either in a borehole or in association with spent-fuel wastes. The South African government studied the idea but later rejected it.

An ad hoc group sponsored by the Atomic Energy Corporation (AEC) of South Africa and Germany's Gesellschaft für Nuklear-Service (GNS), created in 1995, has continued working in this area by developing some basic criteria for identifying potential host countries for an international repository: (1) the country must have an established nuclear and radioactive waste management infrastructure; (2) the country must have existing technical and regulatory infrastructures for handling radioactive waste; and (3) the country must have a suitable land mass (which indicates a preference for a large continental country). The group has published a list of countries it believes would be prime locations in which to seek a home for spent-fuel inventories: Pakistan, Armenia, Slovenia, Netherlands, Brazil, Argentina, South Africa, and the Czech Republic.

Pangea Resources International was created specifically to explore the concept of a global nuclear repository by British Nuclear Fuels, Ltd. (BNFL); the Swiss radwaste agency Nagra; and Enterra Holdings, Ltd. (EHL) in Canada. The global search for a geologically "superior" site that was conducted by Pangea Resources International produced four groups of candidate sites in Australia, Argentina, China, and western South Africa. Sites in China and South Africa were eliminated because they did not have the right mix of good geology, strict regulatory regime, and solid democratic politics. Because initial and informal interest centered on Australia, the Argentine site was not actively pursued.

The Association for Regional and International Underground Storage (ARIUS), a new association promoting regional and international storage and disposal of radioactive waste, was created on February 22, 2002. The founding members are from Belgium (ONDRAF Waste Agency), Bulgaria (Kozloduy Power Plant), Hungary (PURAM Waste Agency), Japan (Obayashi Corporation), and Switzerland (Colenco Power Engineering, backed by two of the Swiss nuclear power utilities). One key objective of this association is to explore ways of making provisions for shared storage and disposal facilities for smaller users, who may not wish to — or may not have the resources to — develop facilities of their own. The association is open to all organizations sharing its goals; discussions with a range of additional potential members are already under way.

The United States is highly interested in seeing that the Latin American countries initiate talks conducive to finding options for spent-fuel storage and the management of research reactor fuel in the region. The United States recognizes that although Latin American countries have promised that they would at least discuss the possibility of a regional repository, the efforts have been hindered by political problems. These problems arise mainly in Argentina, where the government does not want to stir up public feelings about the fuel they have pledged to condition from the new reactor Argentineans are building in Australia. However, in 2002 and 2003, the Argentinean National Atomic Energy Commission (CNEA) prepared reports on radioactive residues and spent fuels for the Argentinean Republic that were presented to the National Congress. The reports indicated that final disposal of conditioned wastes in deep geological structures with known characteristics was a solution that represents for present and future generations risks similar to those usually accepted in ordinary life. CNEA indicated that studies were made for the construction of a deep geological repository in Argentina. A search was conducted for a place with low seismic activity and low hydraulic conductivity as the location of the repository. A place with these characteristics was found in the area of Sierra del Medio, close to Gastre in the province of Chubut. The study was presented to Congress, but due to public pressure, further studies were suspended. However, CNEA continues to search for other possible locations for the repository.

Studies will have to be performed to determine precisely where and when this repository will be built. Certainly, these issues will be discussed at international forums. It will be important to have a U.S. presence at these international conferences, whether as observers or as presenters of papers.

1. INTRODUCTION

Several research reactors from Latin American countries have been in operation since the late 1950s, and they have gradually accumulated a significant amount of spent fuel. A published table from the International Atomic Energy Agency (IAEA) Research Reactor Database, included in Table A.1, Appendix A, indicates the countries that have research reactors.[1] This publication also analyzes spent-fuel storage concerns in Argentina, Brazil, Chile, Mexico, and Peru. Most of these countries have returned part of their spent fuel to the United States. Their concerns were based on the fact that under the Nuclear Weapons Non-Proliferation Policy Concerning Foreign Research Reactors, the United States will not receive spent fuel discharged from the reactors of these Latin American countries after May 13, 2006, and that national solutions for countries without nuclear power programs will be very difficult to implement.

In addition to the needs for research reactor spent-fuel storage, some Latin American countries have also developed nuclear power. Argentina's nuclear electric power makes up 5% of the nation's total electric power. Argentina has two state-owned nuclear plants in operation (Atucha-1 and Embalse), with a third reactor under construction (Atucha-2) as of December 31, 2001. Brazil has two working nuclear plants, (Angra-1 and Angra-2) generating about 1% of the nation's total electric power. A third unit, Angra-3, is under consideration. The spent fuel coming from these nuclear reactors will certainly add to the inventory of nuclear material that requires permanent storage in these countries.[1,2]

However, to date, no permanent nuclear waste disposal programs exist in Latin America, as only three countries in this region —Argentina, Brazil, and Mexico?   have small nuclear power programs. Waste from these nuclear programs is currently stored onsite at the plants, an approach that is less costly than funding research for a permanent waste depository.

Through the IAEA Regional Project, the IAEA is trying to (1) make available the basic conditions to define a regional strategy for managing spent fuel and (2) provide solutions that are consistent with the economic and technological realities of the countries involved. In addition, some of the nuclear regulatory institutions from countries in Latin America have informed their respective Congresses of the plans to study deep geological repositories for permanent storage of spent fuel.

The U.S. Department of Energy (DOE) Energy Information Administration has indicated that Argentina may accumulate up to 4000 metric tons of heavy metals by 2020, while Brazil may have 800 metric tons, and Mexico may have 700 metric tons in the same timeframe.[3] By 2007, Peru will join the group of countries that have nuclear power reactors.[3,4]

All this information indicates that the potential for spent-fuel accumulation is growing in Latin America and that the pressing need to store this material permanently is increasing as well. The creation of a new repository in Latin America, whether it is developed by an individual country or under the umbrella of a regional effort, is inevitable. Furthermore, the international community should collaborate to make this repository compliant with the IAEA safeguards as well as to ensure that it is free from terrorism and proliferation concerns.

This report provides a compilation of preliminary information from a variety of sources that supports the premise that a repository is needed in Latin America and analyzes the nuclear situation (mainly in Argentina and Brazil) in terms of nuclear capabilities, inventories, and regional spent-fuel repositories. Section 2 summarizes the nuclear capabilities in Latin America and establishes the framework for the need of a permanent repository. Section 3 summarizes the IAEA approach for a regional spent-fuel repository and describes the support that international institutions are lending to this issue. Section 4 analyzes the current situation in Argentina in order to analyze the Argentinean willingness to find a location for a deep geological repository. Section 5 analyzes the potential location for a permanent repository. Finally, Section 6 draws some conclusions from this analysis. Appendix A compiles some background information in tables, and Appendix B presents extracts in Spanish of presentations of the Argentinean National Atomic Energy Commission (CNEA) to the Argentinean Congress and provides a translation of an important paragraph for this report. This report focuses mainly on spent fuel and does not elaborate on other radiological waste sources.

2. NUCLEAR CAPABILITIES IN LATIN AMERICA

2.1 ARGENTINA

Argentina has one of the two largest nuclear programs in Latin America (the other program belonging to Brazil). Argentina has facilities for mining, refining and conversion, enrichment, fuel fabrication, power reactors, research reactors, reprocessing, interim storage, and other miscellaneous smaller facilities.

2.1.1 Mining

Argentina has one uranium mining facility (San Rafael) currently functioning in the province of Mendoza. There is one new uranium mining prospect, the Cerro Solo deposit in the Chubut Province that has the potential to produce 4600 tons of recoverable uranium ore.[5] Six other mine sites have been operated in the past, as observed in Table A.2, Appendix A.[6, 5, 7]

2.1.2 Refining and Conversion

Argentina has a UO_2 conversion plant in Córdoba and a UF_6 production facility in Pilcaniyeu, as indicated in Table A.2, Appendix A.[6, 7]

2.1.3 Enrichment Plants

Argentina has the Pilcaniyeu gaseous diffusion enrichment plant in the province of Rio Negro. In addition, there is a heavy-water production facility in the province of Neuque (see Table A.2, Appendix A).[6, 7]

2.1.4 Fuel Fabrication

Argentina has a fuel fabrication facility located in the province of Ezeiza. In addition, Argentina has a zirconium alloy manufacturing facility and a zirconium tubing manufacturing facility (see Table A.2, Appendix A).[7]

2.1.5 Reprocessing Plants

Argentina has a spent-fuel reprocessing pilot plant in Ezeiza. The IAEA has reported that the construction of this facility has been delayed. The construction of a second Ezeiza reprocessing facility was halted in 1990.[6, 7]

2.1.6 Storage Facilities

The main storage facility for the Argentinean nuclear infrastructure is Atucha Pool 2. In addition, Argentina has central storage facilities, located in Ezeiza and Constituyentes, and the Nuclear Material Store, located in Constituyentes. Figure 1 shows the Argentinean Central Storage Facility for spent-fuel elements at Ezeiza Nuclear Center.[6, 7]

2.1.7 Other Facilities

Argentina has other facilities where basic and applied research is performed. Within these facilities, there are nuclear-related activities such as laboratory testing, studies in radiation protection, and nuclear engineering. These facilities include the Alpha Facility (Centro Atómica de Constituyentes), the Experimental UO_2 Plant (Córdoba), the Enriched Uranium Laboratory (Centro Atómica Ezeiza), the Fission Products Division (Centro Atómica Ezeiza), the Fuel Fabrication Plant (Centro Atómica Ezeiza), the Liquid Fuel Reactor (Buenos Aires), the Uranium Powder Fabrication Plant (Constituyentes), the

Triple Altura Laboratory (Ezeiza), and the Centro Atómica Bariloche (which conducts basic research on nuclear engineering and related physics aspects).[6]

Fig. 1. Argentinean Central Storage Facility at Ezeiza Nuclear Center. *(Source: J. R. Maiorino et al., "Management of Spent Fuel from Research Reactors in Latin America: A Regional Approach," RERTR 2002, November 3–8, 2002, San Carlos de Bariloche, Argentina.)*

2.1.8 Power Reactors

Argentine has two power reactors: Atucha 1, located in Lima, and Embalse, located in Córdoba. Their combined power capacity is 935 net MW(e). A third reactor, Atucha 2, located in Lima, is under construction as indicated in Table A.4, Appendix A.[6]

2.1.9 Research Reactors

Argentina has five research reactors of which three are in operation: RA-1 (100 kW), located in the Constituyentes Atomic Center; RA-3 (5 MW, being upgraded to 10 MW), located in the Ezeiza Atomic Center; and RA-6 (500 kW), located in the Bariloche Atomic Center. Reactor RA-1 is used mostly for research on radiation material damage. RA-3 is dedicated mostly to the production of radioisotopes for medicine and industry and for material testing and fuel element prototyping. Reactor RA-6 is used for teaching and research[8] (see Table A.1, Appendix A). The other two research reactors that are not operating are the RA-2, a critical assembly located in Constituyentes, and the RA-9, a research reactor/pool located in Córdoba.[6]

In addition, there are three critical assemblies: RA-0, located at the University of Córdoba; RA-4, located at the University of Rosario; and RA-8, located at the Pilcaniyeu Atomic Center. RA-8 is empty and, consequently, is currently not in operation.[8]

The Argentinean strategy for spent-fuel management is to (1) centralize the interim storage of research reactor spent fuel, (2) develop a complementary wet cooling facility for medium-range storage, (3) build a dry interim facility for long-range storage, and (4) condition the spent fuel for final disposal.[1]

2.2 BRAZIL

Brazil has facilities for mining, refining and conversion, enrichment, fuel fabrication, power reactors, research reactors, reprocessing, interim storage, and other miscellaneous smaller facilities.

2.2.1 Mining

Brazil has one uranium mining facility currently functioning (Lagoa Real) in the state of Bahia. The Pocos de Calda mine, located in the state of Caldas, is currently shutdown, and the start-up date for the Itataia mine in the state of Ceara has been deferred (see Table A.3, Appendix A).[6, 7]

2.2.2 Refining and Conversion

Brazil has one UO_2 conversion plant in operation in Rio de Janeiro and one UF_6 plant in São Paulo. Another UF_6 conversion plant in Rio de Janeiro has been proposed and is supposedly built but is not currently in operation as observed in Table A.3, Appendix A. [6, 7]

2.2.3 Enrichment Plants

Brazil has a small laboratory-scale enrichment plant at Aramar designed as a centrifuge facility, which actually has performed most of the research to build the Resende enrichment facility. The Resende facility is under construction. There is a uranium-enrichment pilot plant in Bello Horizonte, which is currently shutdown, and the Institute of Advanced Studies in São Paulo, where the atomic vapor laser isotope separation (AVLIS) research activities took place, as indicated in Table A.3, Appendix A.[6]

2.2.4 Fuel Fabrication

Brazil has one operational fuel fabrication plant (Resende, Unit 1), located in Rio de Janeiro as noted in Table A.3, Appendix A.[6, 7]

2.2.5 Reprocessing Plants

According to the IAEA, Brazil has a spent-fuel reprocessing laboratory at São Paulo, which is currently on standby as observed in Table A.3, Appendix A.[6, 7]

2.2.6 Storage Facilities

Brazil has storage facilities at the IEA-R1 reactor. These facilities consist of racks located in the reactor pool with a capacity of 156 assemblies.[1] Figure 2 shows the IEA-R1 wet storage**.**

2.2.7 Other Facilities

Brazil has other nuclear facilities, including the Fuel Technology Coordination Unit (São Paulo), the Isotope Laboratory (São Paulo), the Metallurgy Uranium Project (São Paulo), the Nuclear Material Laboratory (Ipero), the Nuclear Fuel and Instrument Development Laboratory (São Paulo, Belo Horizonte), the Reconversion Project (São Paulo), the Universidade Federal do Rio de Janeiro, the Universidade Federal do Para, the Instituto de Radioprotecao e Dosimetria (Radiation Protection and Dosimetry Institute) in Rio de Janeiro, the Center of Nuclear Energy in Agriculture (São Paulo), the National Council of Scientific and Technological Development (Brasilia), and the Nuclear Engineering Institute of Rio de Janeiro.[6]

2.2.8 Power Reactors

Brazil has two nuclear plants in operation, Angra-1 and Angra-2, located in Angra dos Rios. These plants provide about 1% of Brazil's electric power, with a joint capacity of approximately 1856 MW(e) as indicated in Table A.5, Appendix A.[6, 7]

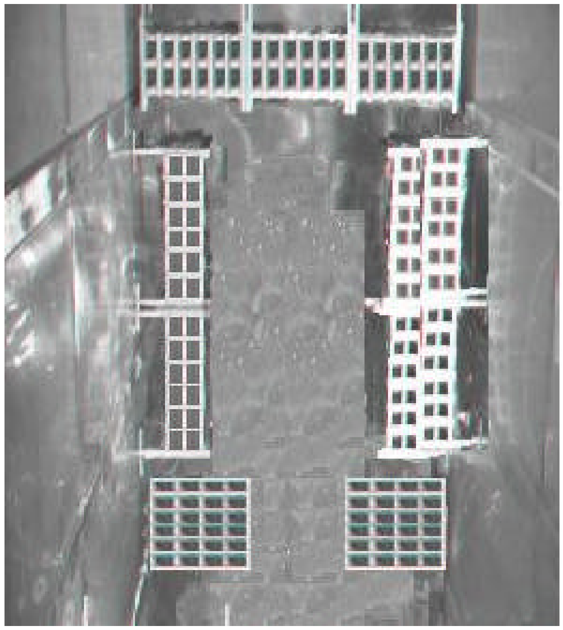

Fig. 2. Wet storage at the IEA-R1 reactor.
(Source: J. R. Maiorino et al., "Management of Spent Fuel from Research Reactors in Latin America: A Regional Approach," RERTR 2002, November 3–8, 2002, San Carlos de Bariloche, Argentina.)

2.2.9 Research Reactors

Brazil has four research reactors: Argonauta, located in Rio de Janeiro; IEA-R1, located in São Paulo; IPR-R1, located in Bello Horizonte; and IPEN-MB-01, located in São Paulo as observed in Table A.1, Appendix A.[1, 6, 7] A subcritical assembly at Recife has also been reported. A research reactor from the Navy is not currently in operation, and a subcritical assembly from the Army is not operating.[6, 7]

Brazil has not yet defined a policy regarding spent fuel or high-level-waste disposal. However, because the Brazilian legal framework regarding waste disposal is still being defined and a national low-and medium-level waste disposal facility must be constructed first, this issue will be discussed at the national level.[1]

2.3 CHILE

Chile has two research nuclear reactors: RECH-1 [5 MW, high-enriched uranium (HEU): 45%, low-enriched uranium (LEU): 19.75%] and RECH-2 (2 MW, HEU: 90%) as observed in Table A.1, Appendix A.[1]

In terms of storage, RECH-1 has 90 rack positions inside the reactor pool to store LEU and HEU spent-fuel elements (SFE). Natural convection provides the cooling needs. RECH-2 has an independent pool for storage that can store 224 elements and 3 racks in the reactor pool that can accommodate 30 elements.[1]

Projections from the Nuclear Energy Chilean Commission (CCHEN) indicate that RECH-1 will generate 91 SFE and RECH-2, 29 SFE. Furthermore, it is safe to say that there is enough storage in Chile for at least 30–35 years and that dry interim storage or the need to send SFE for final disposal would not be necessary until ~2040.[1]

2.4 Colombia

Colombia has one research reactor, IAN-R1 (100 kW, Pool Fe TRIGA), that is operable, but it is presently shutdown (see Table A.1, Appendix A).[1]

2.5 Mexico

Mexico has one nuclear research reactor (TRIGA MARK III, 1000 kW, HEU: 70%, LEU: 20%) and two subcritical assemblies (CHI-Mod9000 and CHI-Mod2000) that are operable (see Table A.1, Appendix A).[1] Mexico has 2 boiling water reactors (BWRs) at Laguna Verde, but they are not part of this study because the emphasis of this report is on research reactors from South America.

In terms of storage, the TRIGA MARK III can store an additional 56 fuel rods because 64 positions are already occupied (total storage capacity is 120 fuel rods). Also, Mexico has 3 storage wells with 19 positions each. Besides spent-fuel storage space, there are spaces for storing new fuel elements. In each of these fuel elements are 4 standard rods (LEU), 22 fuel life improvement program (FLIP) fuel assemblies (HEU), and 3 instrumented FLIP assemblies. It is forecasted that at the present rate of operation, Mexico has sufficient storage capacity for many years.[1]

2.6 Peru

Peru has two research reactors: RP-0 and RP-10 (10 MW) (see Table A.1, Appendix A). The RP-10 reactor has a temporary storage capacity of 120 positions in racks located in the main pool and connected auxiliary pool. Current levels of operation of the reactor (7.5 MW, 16 h/week) indicate that Peru has SFE storage space for the next 40 years. Peru has considered the possibility of (1) doubling the time of operation (to 32 h/week) or (2) using a cycle of 16 days of continuous operation at 10 MW. In these cases, the current SFE storage space would be sufficient for 20 years and 5 years, respectively.[1]

Even though Peru does not presently have a nuclear power program and the Peruvian authorities have not decided on a spent-fuel policy, their participation in the IAEA Regional Project (Sect. 3.1) project is considered to be an opportunity to ensure their awareness of the problem of SFE storage from the very beginning. The RP-10 is the most powerful research reactor in Latin America, and it is underutilized; furthermore, the scenario of maximum utilization could become a reality depending on the economy, the lifetime of other research reactors in Latin America, and the growth in nuclear medicine in the region.[1]

3. International Interest in a Regional Spent-Fuel Repository

3.1 IAEA Approach

Latin American countries like Argentina, Brazil, Chile, Peru, and Mexico have expressed their concerns about the fact that after 2006 the United States will not receive the spent fuel discharged from their research reactors. These concerns have driven IAEA to initiate the IAEA Regional Technical Corporation Project, “Management of Spent Fuel from Research Reactors in Latin America,” to provide the basic conditions to define a regional strategy for managing spent fuel and to provide solutions that consider the economic and technological realities of the countries involved. In particular, the IAEA Regional Project has the objectives of determining the basic conditions for managing spent fuel from research reactors during operation and interim storage as well as final disposal and of establishing forms of regional cooperation for spent-fuel characterization, safety, regulation, and public communication.

The IAEA Regional Project was divided into four subprojects or macroactivities: (1) spent-fuel characterization, (2) safety and regulation, (3) options for spent-fuel storage and disposal, and (4) public information and communication. A summary of accomplishments for each subproject is presented in the following sections.[1]

3.1.1 Spent-Fuel Characterization

- Preparation of a complete database of spent fuel in the region that can be used to make projections and serve as a resource for decision makers has been created, with database maintenance ongoing.

- A protocol for corrosion monitoring and surveillance activities has been implemented to ensure that current wet storage is under optimum conditions and that each country has the tools and know-how to characterize the extent of corrosion of its spent fuel.

- Provisions are being made for sampling and visual inspections to determine cladding failure in spent fuel.

- Effective burn-up measurement and determination activities to allow consistent assessments of burn-up determinations in the region.

3.1.2 Safety and Regulation

- Steps were taken toward harmonization of nuclear safety rules and regulations involved in activities related to the back end of the research reactor fuel cycle.

- The IAEA Joint Convention on Spent-Fuel Management Safety and Radioactive Waste Management (IAEA-INFCIRC/546) was recognized as a base document to be followed by the countries involved.

- In the Latin American region, Argentina signed and ratified the Joint Convention; Brazil and Peru signed, but did not ratify it; and the other countries are still analyzing it internally to decide whether to sign it.

- The participant countries agreed to produce drafting guidelines of five documents: (1) safety guidance documents on transportation of spent fuel from research reactors, (2) safety guidance document on storage of spent fuel from research reactors, (3) safety evaluation document on storage of spent fuel from research reactors, (4) requirements document for interim storage of spent fuel from research reactors, and (5) requirements document for final storage of spent fuel from research reactors.

3.1.3 Analysis of Options for Research Reactor Spent-Fuel Storage

- All the possible options for the back end of the research reactors fuel cycle were identified and assessed.

- In early 2003, a Regional Workshop was held in Córdoba, Argentina, which discussed all known options (dry and wet interim storage, repository, reprocessing, conditioning, etc.). Although there are differences among the countries in the region, there is consensus regarding dry interim storage as a medium-range option

- Since the HALOX [1] process for conditioning SFE is being developed in Argentina, one possible option could be to send the SFE to Argentina for conditioning and then return the waste to the country of origin for interim storage. The final storage will depend on international, regional, and national policies. Presently, the legal framework in the region does not allow the receipt of radioactive waste from foreign countries. Therefore, a regional repository is presently out of the question, although technically it is a viable solution.

- Consensus was achieved among the countries about the possible need in the longer term for transport of research reactor spent fuel or its derivatives. Since Brazil has facilities for testing and qualification of Type-B casks, a subproject was initiated to develop a concept for a Type-B cask that could be used by all the reactors of the region and that could be licensed by the region's regulatory bodies for transport of research reactor SFE. If it is accepted, during 2003–2004, the conceptual design, testing of prototypes, and preliminary safety analysis will be conducted (results of this effort have not been published). It is hoped that in 2005–2006, a new regional project will be established with construction and licensing of a regional transport cask as the main objective.

- The harmonization of computational tools for safe spent-fuel management in the region was implemented, choosing the Oak Ridge National Laboratory (ORNL) package, SCALE[1], as the calculation tool and providing two training courses. This is considered one of the most significant achievements of the project to date.

3.1.4 Public Information and Communication

- The project has developed and will continuously implement effective public information and communication strategies about nuclear activities in the countries of the region, with particular emphasis on the benefits of research reactor activities and the consequent necessity to solve the problem of disposition of spent fuel safely and economically.

- The project has paved the way for public acceptance of the options chosen for the back end of the research reactor fuel cycle, when such a decision is eventually made.

3.2 Additional International Interest for a Regional Spent-Fuel Repository

Over the past 8 years, the IAEA has expressed interest in the concept of international or regional repositories within Latin America. In late 1994, a small group of experts met in Vienna to consider the technical, economic, and safety aspects of this concept. Following a series of Waste Management Advisory Program (WAMAP) missions to countries in southern Africa, an expression of interest in international repositories came in a speech by the IAEA Director General Hans Blix in June 1997 about the concept of regional repositories developed within the IAEA.

A white paper prepared by the IAEA proposed that South Africa could be approached to dispose of existing radium needle wastes (from cancer treatments) from neighboring countries because the country has enough infrastructure to handle them whether the disposal is in a borehole or they are disposed of with spent-fuel wastes. The South African government studied the idea but later rejected it.[9]

The IAEA's group of expert was disbanded in 1995, but work has continued in an ad hoc group sponsored by the Atomic Energy Corporation (AEC) of South Africa and Germany's Gesellschaft für Nuklear-Service (GNS). This group has had a wider scope and aims to produce a "platform document," which can be used by national governments in their own considerations of proposals for regional repositories. Statements from this group coincide with the IAEA's previous assessments that, for example, industrialized countries with large nuclear programs should manage their own radioactive wastes and that states with small nuclear programs and weak infrastructures for radioactive waste are legitimate parties for international repositories. The host country will be, then, the one with stronger infrastructure for dealing with nuclear waste and spent fuel. The regional repository concept assumes that existing waste management companies and organizations will handle these wastes and that the creation of new international entities is not necessary. The basic criteria for determining host countries were defined as follows:

- The country must have an established nuclear and radioactive waste management infrastructure.
- The country must have existing technical and regulatory infrastructures for handling radioactive waste.
- The country must have a suitable landmass (which indicates a preference for a large continental country).

The group has published a list of countries it believes would be prime locations in which to house spent-fuel inventories: Pakistan, Armenia, Slovenia, Netherlands, Brazil, Argentina, South Africa, and the Czech Republic.[9]

Pangea Resources International, created specifically to explore the concept of a global nuclear repository, is a spin-off of the international geotechnical company Golder Associates, based in Toronto, Canada. Investors include British Nuclear Fuels, Ltd. (BNFL); the Swiss radwaste agency, Nagra; and Canadian-based Enterra Holdings, Ltd. (EHL), Golder's parent holding company. The concept of an international nuclear repository is not new. Australia, which does not have any nuclear power plants but is a major source of uranium, suggested the idea in 1992. German and Swiss industries investigated the possibility of locating one in China's Gobi Desert in the 1980s. The global search for a geologically "superior" site conducted by Pangea Resources International produced four groups of candidate sites in Australia, Argentina, China, and western South Africa. Sites in China and South Africa were eliminated because they did not have the right combination of good geology, strict regulatory regime, and solid democratic politics. Because initial and informal interest centered on Australia, the Argentine site was not actively pursued.[10]

The Association for Regional and International Underground Storage (ARIUS) promotes regional and international storage and disposal of radioactive waste. It is a new organization created on February 22, 2002, and founded by Belgium (ONDRAF Waste Agency), Bulgaria (Kozloduy Power Plant), Hungary (PURAM Waste Agency), Japan (Obayashi Corporation), and Switzerland (Colenco Power Engineering, backed by two of the Swiss nuclear power utilities). The association promotes concepts for socially acceptable international and regional solutions for environmentally safe, secure, and economic storage and disposal of long-lived radioactive wastes. One of their main objectives is to find mechanisms to make possible shared storage and disposal facilities for smaller users, who may not be in a position to develop facilities of their own. The initial membership of ARIUS comes predominantly from countries with smaller nuclear programs. However, some industrial organizations are included because of their interest in promoting the concept of international disposal. The association is open to all organizations sharing its goals.[11] Charles McCombie, Executive Director, and Neil Chapman, Program Director, are the principal managers of ARIUS. Both executives have worked with Pangea Resources International.[11]

Through the combined efforts of the United States and many other nations participating in the Reduced Enrichment for Research and Test Reactors (RERTR) program, much progress has been made in reducing the amount of HEU in international commerce. In 1996, the DOE adopted a new 10-year policy to accept spent nuclear fuel from research reactors into the United States from other nations. The policy supports U.S. nuclear weapons nonproliferation objectives and demonstrates the continued commitment of the United States to the RERTR program.[12]

The United States is highly interested in seeing that the Latin American countries initialize talks conducive to finding options for spent-fuel storage and the management of research reactor fuel in the region. The United States recognizes that although Latin American countries have promised that they would at least discuss the possibility of a regional repository, the efforts have been hindered by political problems. These problems arise mainly in Argentina, where the government does not want to stir up public feelings about the fuel they have pledged to condition from the new reactor Argentineans are building in Australia. Except for the safeguards agreements between Argentina and Brazil, the United States does not foresee a specific agreement among the Latin American countries that have nuclear capabilities (Argentina, Brazil, Chile, Peru, and Mexico) in the very near future.

The United States has supported initiatives to have Latin American countries work on harmonization of safety rules and regulations for the management, storage, and transportation of fuels in their countries as well as cooperation on the design and construction of a transport container. This effort also includes a public outreach effort tailor made for the Latin American public and the characterization of their current inventories of spent fuel. The issue of the final disposition of spent fuel has not yet been addressed, mainly for political reasons. However, the United States supported the presentation of papers on these matters at the RERTR meeting in Bariloche, Argentina, November 2002.[13]

4. Analysis of Activities in Argentina

Argentina, as mentioned earlier, is one of the two Latin American countries with the largest nuclear programs in the region. Studies done by the IAEA and other international parties concur in pointing to Argentina as a likely country for the development of a deep geological repository to store spent nuclear fuel. This section is devoted to an analysis of the current political, social, and technical climate in Argentina, which may indicate how feasible it would be to develop a deep geological repository in this country for a local solution to the problem of spent-fuel storage.

The Argentinean National Atomic Energy Commission (CNEA) prepared a report on radioactive residues and spent fuels for the Argentinean Republic that was presented to the National Congress (see Appendix B and C).[14] The report indicates that Argentina has decided to store the spent fuel temporarily in installations designed for this purpose until a decision on its reprocessing or final direct disposal is made. The report also mentioned that in 1980, CNEA started a Feasibility Study and Engineering Preliminary Design for the Construction of a High Level Waste Repository that would (1) demonstrate that wastes could be disposed of safely within the current available technological framework, (2) identify an acceptable geological structure to dispose of high-level wastes, and (3) identify future developments and cost impacts of waste disposal. The study concluded that the final disposal of conditioned wastes in deep geological structures was a solution involving risks similar to those usually accepted in ordinary life.[14]

The report to the Argentinean Congress continues by indicating that regarding the "high-level and long-lived radioactive waste generated in the last part of the nuclear fuel cycle, Argentina has decided to store the spent fuel temporarily until a decision is made" [on whether to reprocess spent fuel or use direct geological disposal]. Notwithstanding, the studies for the siting, location, and operation of a deep geological repository will be made. If the option adopted for high-level radioactive waste generated from the last part of the fuel cycle is reprocessing (closed cycle), high-level waste segregated there shall be conditioned by immobilizing it in specially designed glass matrixes and containers and the final disposal shall be in the deep geological repository."[15] In the section about research and development activities to improve management technologies, the report states that the objectives of a deep geologic final disposal are to make and/or complete studies concerning deep geologic final disposal, monitoring kinetics of backfill material, and mechanisms of radiation damage to materials used in high-level waste containers located in a deep geologic repository.[15]

During its 2003 presentation to the Argentinean Congress, the CNEA indicated that studies have been made for the construction of a deep geological repository in Argentina. A search was conducted for a location with low seismic activity and low hydraulic conductivity. A place with these characteristics was found in the area of Sierra del Medio, close to Gastre in the province of Chubut. The study was presented to Congress, but due to public pressure, further studies were suspended. However, CNEA continues to search for other possible areas for the repository (see Appendix B).[14]

The strategic plan for the management of radioactive wastes produced by CNEA in connection with National Law 25018 proposes the year 2030 as the final date to assess and decide the reutilization of the fissionable material contained in the spent fuels. This plan establishes the need to have a deep geologic repository for the final disposal of the high-level disposable wastes from spent-fuel processing and/or conditioning.

A paper presented at the 24th International Meeting RERTR2002 stated that according to the current planning, a deep geological repository would be operational in 2050.[8]

Because the Argentinean company, INVAP, has won the bid for the sale of a research reactor in Australia, under the condition of accepting the returned spent fuel from this reactor, the project is likely to surface again. Environmentalist associations maintain that new legislation, which will update the provincial laws, leaves open the possibility of new nuclear locations and the construction of a nuclear waste repository.[16]

In June 1996, the then-president of the CNEA, Eduardo Holy, said that within 5 years he would have to rely on a “nuclear wastebasket” to store the radioactive remainders. Since then, environmentalist organizations have denounced the selection of southern Argentina as the site to construct a repository for radioactive wastes. Thousands of demonstrators in different localities from the south to Buenos Aires protested against the waste repository, which ultimately resulted in the cancellation of the project.

5. Analysis of Potential Locations

Since 1996, CNEA has recognized publicly that a nuclear repository is absolutely required to store nuclear residues.[13] CNEA has made annual presentations to the Argentinean Congress on the country’s nuclear activities and has stated the activities conducive to a deep geological repository.[14, 15] According to these reports, CNEA has made studies that indicated that the repository would be located in an area where the geology has been stable for several hundred million years; hence, total reliance on a robust engineered barrier system would not be required to keep the waste securely isolated for thousands of years. As mentioned earlier, CNEA recognized that studies were being made to install a nuclear waste repository in Argentina for the final elimination of high-quality radioactive remainders. Of 198 sites, 4 were considered the most appropriate: Esperanza and Chasicó, both in River Negro, and Calcatapul and Means Mountain ranges (both in Chubut). It is in this last area, located within 60 kilometers of the locality of Gastre (Chubut), where the geologic studies began (core samples were taken and analyzed).[14] Figure 3 shows the general location of Chubut region in Argentina.

Fig. 3. Geographical location of the region of Chubut. *[Source: World Sites Atlas @ www.sitesatlas.com (left) and www.expedia.com (right)]*

6. Analytical Steps Toward a Latin American Spent-Fuel Repository

The United States is very interested in seeing that the Latin American countries initialize talks conducive to finding options for spent-fuel storage and the management of research reactor fuel in the region. It has also supported initiatives to have Latin American countries work on the harmonization of safety rules and regulations for the management, storage, and transportation of fuels in their countries as well as cooperation on the design and construction of a transport container. This effort also includes a public outreach effort tailor made for the Latin American public and the characterization of their current inventories of spent fuel. The issue of the final disposition of spent fuel has not yet been addressed (mainly for political reasons). However, the United States has supported the presentation of papers on these matters at the RERTR meeting in Bariloche, Argentina, November 2002, and at later meetings.[13]

Argentina has plans to operate Atucha-1 until the year 2015. By that time, Argentina will need to have an operational repository, whether it is located in the country or in a regional site in a different country. In addition, Argentina has emerged as a country that can build research reactors and has already sold one such reactor to Australia. Debate has arisen over the possibility that, as a fall-back option, spent fuel could be sent back to Argentina for processing. Current regulations in Argentina forbid the importation of foreign nuclear spent fuel. However, Argentina is going through one of its worst economic and political crises in its history, and the public is likely to realize that stopping the technology transfer from Argentina will work against the economic survival of the country. With these elements in mind, it would not be premature to argue that during the next 5 years, the subject of a repository, whether local or regional, should be discussed among the involved countries. CNEA has continuously conveyed to the Argentinean Congress the needs for a deep geological repository for high-level waste and has informed the Argentinean public of the need for research in this area in order to offer the safest solution of securing the spent nuclear fuel in one place. Among the possibilities for spent fuel storage are dry storage facilities offered by vendors who are eager to sell their products to countries like Argentina. These types of facilities represent economic and political options that could be used before the country engages in the construction of a deep geological repository, thus adding to the existing controversy in Argentina.

Brazil may have the Angra-3 power reactor in operation by 2006, and Peru may have its first nuclear power reactor by 2007, creating an additional need for spent-fuel storage capacity by the end of this decade.

Studies will have to be performed to determine precisely where and when this repository will be built. Certainly, these issues will be discussed at international forums. It will be important to have a U.S. presence at these international conferences, whether as observers or as presenters of papers. CNEA has informed the Argentinean Congress of the studies that have already been made for determining a potential location for a deep geological repository.

The IAEA and the United States are eager to help the selected country build such a repository (within IAEA safeguards and controls) to keep these installations safe for the environment and impermeable to terrorist attacks and proliferation trends.

APPENDIX A

NUCLEAR REACTORS AND FUEL IN LATIN AMERICA

Table A.1. Research reactors in Latin America

Facility	Power (kW)	Type	Status
Argentina			
RA-0	0.01 (Critical assembly)	ZPR Tank	In operation
RA-1	100	Tank	In operation
RA-2	0.03	ZPR	Shutdown
RA-3	5,000	Pool	In operation
RA-4	0.00 (Critical assembly)	ZPR Homogeneous	In operation
RA-6	500	Pool	In operation
RA-8	0.01 (Critical assembly)	ZPR	Operable, but core is currently empty
Brazil			
ARG	0.20	Argonaut	In operation
IEA-R1	5,000	Pool	In operation
IPEN-MB 01	0.10	ZPR Tank	In operation
IPR-R1	100 (200)	TRIGA-Mark I	In operation
Chile			
RECH-1	5,000	Pool	In operation
RECH-2	2,000	Pool	*
Colombia			
IAN-R1	100	Pool FE TRIGA	*
Mexico			
CHI-Mod9000	0.00	Subcr.	In operation
CHI-mod2000	0.00	Subcr.	In operation
SUR-100	0.00	ZPR Homogeneous.	Decommissioned
TRIGA Mark III	1,000	TRIGA Mark III	In operation
Peru			
RP-0	0.00	ZPR Tank	In operation
RP-10	10,000	Pool	In operation
Uruguay			
RU-1	1	Pool	Shutdown
Venezuela			
RV-1	3,000	Pool	Shutdown

* IAN-R1 and RECH-2 although operable, presently are shutdown. *Source:* [1, 6, 7, 8]

Table A.2. Uranium ore processing and fuel production and processing facilities in Argentina

Facility	Location	Type	Startup–Shutdown	Capacity	Scale	Status
Mining						
Don Otto	Salta	Uranium ore processing	1964 - 1981	40 t U/yr	Commercial	Shutdown
La Estela	San Luis	Uranium ore processing	1985 - 1990	20 t U/yr	Commercial	Shutdown
Los Adobes	Chubut	Uranium ore processing	1977 - 1985	55 t U/yr	Commercial	Shutdown
Los Colorados	La Rioja	Uranium ore processing	1993 - 1995	30 t U/yr	Commercial	Shutdown
Los Gigantes	Córdoba	Uranium ore processing	1982 - 1989	45 t U/yr	Commercial	Shutdown
Malargue	Mendoza	Uranium ore processing	1954 - 1988	85 t U/yr	Commercial	Decommissioned
San Rafael	Mendoza	Uranium ore processing	1979 -	120 t U/yr	Commercial	In operation
Cerro Solo	Chubut	Uranium ore processing	NA	4600 t U reserves	Commercial	Feasibility analysis
Refining and conversion						
Pilcaniyeu - 1	Rio Negro	Conversion to UF6	1984 -	62 t U/yr	Commercial	In operation
Complejo Fabril Cordoba	Córdoba	Conversion to UO2	1982 -	150 t U/yr	Commercial	In operation
Enrichment						
Pilcaniyeu	Rio Negro	Uranium enrichment	1990 -	20,000 SWU/yr	Pilot plant	Standby
Arroyito	Neuque	Heavy water production	1993 -	200 t/yr	Commercial	In operation
Atucha		Heavy water production	1988 -	2 t/yr	Pilot plant	Shutdown
Fuel fabrication						
Nuclear fuel Manufacture plant	Ezeiza	Fuel fabrication	1982 -	160 t HM/yr	Commercial	In operation
Special alloy fabrication		Zirconium alloy	1987 -	10 t/yr	Commercial	In operation
Fabrication special alloy		Zircaloy tubing	1987 -	300 km/yr	Commercial	In operation
Reprocessing						
Ezeiza		Spent-fuel reprocessing	1973	5 t HM/yr	Pilot plant	Deferred
Ezeiza		Spent-fuel reprocessing	1978	10-20kg Pu/yr	Pilot plant	Halted construction (1990)
Storage						
Atucha Pool 2		AFR wet spent-fuel storage	1988 -	986 t HM	Commercial	In operation
Central store	Ezeiza	NA	NA	NA	NA	NA
Central store	Constituyentes	NA	NA	NA	NA	NA
Nuclear material store	Constituyentes	NA	NA	NA	NA	NA
Storage bunker	Ezeiza	NA	NA	NA	NA	NA

Source: [5, 6, 7, 17]

Table A.3. Uranium ore processing and fuel production and processing facilities in Brazil

Facility	Type	Startup–Shutdown	Capacity	Scale	Status
Mining					
Itataia	U recovery from phosphates	-	325 t U/yr	Commercial	Deferred
Pocos De Caldas	Uranium ore processing	1981 - 1997	360 t U/yr	Commercial	Shutdown
Lagoa Real	Uranium ore processing	2000-	250 t U/yr	Commercial	In operation
Refining and Conversion					
Resende	UF_6 conversion	-	500 t U/yr	Pilot plant	Deferred
Resende - Unit 2	Conversion to UO_2	2000 -	160 t HM/yr	Commercial	In operation
São Paulo - conversion unit	Conversion to UF_6	1984 -	90 t U/yr	Pilot plant	In operation
São Paulo – U reduction unit	Conversion to U metal	1986 -	30 t U/yr	Pilot plant	Standby
São Paulo - zirconium oxide	Conversion to U metal	1988 -	1 t ZrO_2/yr	Pilot plant	In operation
Enrichment					
Aramar, Ipero, São Paulo	Uranium enrichment	1987-	7000 SWU/yr	Ultra-centrifuge	Operating
Pilot uranium enrichment plant, Belo Horizonte	Uranium enrichment	1969 - 1989	NA	Pilot plant	Decommissioning
Resende	Uranium enrichment	2002	20,000 SWU/yr	Commercial	Under construction
Sao Jose dos Campos	Uranium enrichment, AVLIS research	1981 -	Research only	Laboratory	In operation
Fuel Fabrication					
Resende - Unit 1	Fuel fabrication (LWR)	1982 -	120 t HM/yr	Commercial	In operation
São Paulo - zirconium metal	Zirconium alloy	-	5 t/yr	Pilot plant	Under construction
Reprocessing					
São Paulo - reprocessing	Spent-fuel reprocessing	1982 -	0, research only	Laboratory	Standby
Storage					
Aramar Stores, Ipero	2 units	-	-	-	-
UF_6 production facility, São Paulo	-	-	-	-	-

Source: 6, 7, 17

Table A.4. Power reactors in Argentina

Facility name	Location	Capacity	Type	Start-up date	Current status	Manufacturer
Atucha-1	Lima	335 Net MWe	CANDU	May-74	Operating	Siemens
Atucha-2	Lima	692 Net MWe	CANDU	N/A	Under construction	Siemens
Embalse	Rio Tercero, Córdoba province	600 Net MWe	CANDU	Jan-84	Operating	

Source: [6, 7]

Table A.5. Power reactors in Brazil

Facility Name	Location	Capacity	Type	Start-up date	Current status	Manufacturer
Angra-1	Itaorna, Angra dos Rios, Brazil	626 Net MWe	PWR	Dec-84	Operable	Westinghouse
Angra-2	Itaorna, Angra dos Rios, Brazil	1275 Net MWe	PWR	Jul-00	Operable	Westinghouse
Angra-3	Itaorna, Angra dos Rios, Brazil	1275 Net MWe	PWR	Jul-00	Proposed	Westinghouse

Source: [6, 7, 18]

APPENDIX B

RADIOACTIVE WASTE AND NUCLEAR SPENT-FUEL MANAGEMENT IN THE REPUBLIC OF ARGENTINA—CLASSIFICATION AND MANAGEMENT OF RADIOACTIVE RESIDUES

This appendix contains an excerpt from Sect. 2, Classification and Management of Radioactive Residues, of the report, *Radioactive Waste and Nuclear Spent-Fuel Management in the Republic of Argentina,* presented by the Comision Nacional de Energia Atomica (CNEA) to the Honorable Argentinean Congress in March 15, 2003.[14]

This document deals with the management of radioactive waste and spent fuel in the Republic of Argentina. It defines the premises by which radioactive residues have been classified and, in particular, suggests disposition mechanisms. The following paragraph discusses CNEA plans for disposition of high-level wastes and the location of potential deep geological repositories. The original paragraph is given in Spanish, followed by an English translation.

Con respecto a la disposición final de los residuos de alta actividad, en la década de los 80 la CNEA inició un estudio de factibilidad y anteproyecto de ingeniería para la construcción de un repositorio geológico profundo. Se decidió buscar formaciones graníticas estables en zonas de baja sismicidad y con escasa conductividad hidráulica. Se determinó como una de las opciones posibles, la zona de Sierra del Medio, cercana a la localidad de Gastre, provincia del Chubut y se comenzaron los estudios de caracterización del lugar. El informe con los resultados obtenidos fue entregado oportunamente al Congreso Nacional. Posteriormente, debido a presiones de la opinión pública, a principios de la década de 1990 se tomó la decisión política de suspender los estudios. Actualmente la CNEA está llevando a cabo investigaciones geológicas con el objetivo de identificar otras posibles zonas favorables en el resto del país.

Translation:

During the 80s, CNEA initiated a feasibility analysis that included pre-engineering studies for the construction of a deep geological repository to permanently dispose of the high-level residues. It was decided then, to search for a stable granite zone of low seismic activity and low hydraulic conductivity. It was determined that the most likely area was at Sierra del Medio, close to the Gastre locality at the Chubut province. The studies began to fully characterize this area. The Argentinean Congress received the timely report; however, by the early 90s, due to public pressure, the political decision of suspending the studies was adopted. Currently, CNEA is performing geological studies in order to identify other possible areas of interest.

APPENDIX C

RADIOACTIVE WASTE AND NUCLEAR SPENT-FUEL MANAGEMENT IN THE REPUBLIC OF ARGENTINA—RESEARCH AND DEVELOPMENT PROJECTS

This appendix contains an excerpt from Sect. 6.2, Research and Development Projects, of the report, *Radioactive Waste and Nuclear Spent-Fuel Management in the Republic of Argentina*, presented by the Comision Nacional de Energia Atomica (CNEA) to the Honorable Argentinean Congress in March 15, 2003.[14]

This document deals with Argentinean research and development projects related to the nuclear industry. In particular, it describes research and development conducive to the search for the most appropriate geological formations for a deep geological repository. The following is a paragraph that discusses the CNEA research for finding deep geological repositories. The original paragraph is given in Spanish, followed by an English translation.

• **Elaboración del inventario a nivel nacional de las formaciones geológicas favorables para repositorios geológicos profundos. Este proyecto contó con el apoyo del OIEA, a través del Proyecto ARG/4/084. Incluye el desarrollo de un Sistema de Información Geográfica conteniendo la información geológica digitalizada de diversas regiones del país, e incorporando datos hidrogeológicos, de distribución de yacimientos de minerales, información sobre el volcanismo cuaternario y activo, ensayos de modelización espacial y aplicación de criterios de exclusión.**

Translation:
Perform a national inventory of the favorable geological formations that can be used in deep geological repositories. This project was supported by the OIEA through the Project ARG/4/084. The project included a Geological Information System with digital information on different regions around the country about hydro geological information, mineral sources, volcano information, special essays, and exclusion criteria.

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