WASTE MANAGEMENT IN CHILE

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Abstract

The main radioactive waste management issues to be faced by the Chilean Nuclear Energy Commission (CCHEN) are discussed herein. Research reactor spent fuel management is the most outstanding challenge at the beginning of the 21st century. Interim storage appears to be the most promising alternative, allowing fuel safekeeping until a definitive step is taken. The situation regarding radioactive waste resulting from radioisotope applications in Chile will not undergo considerable change in the near future. Low and intermediate level radioactive waste management is being safely performed followed by interim storage of conditioned wastes. The strategy in the radioactive waste management plan, to be described as well, is meant to ensure the safe storage of radioactive wastes produced in Chile.

1. INTRODUCTION

The Chilean nuclear energy program, which is solely for peaceful purposes, has been widely applied in the fields of industry, health, and research in several universities and in nuclear research centres. There are two nuclear research centres: CEN La Reina (CEN LR) and CEN Lo Aguirre (CEN LA). They produce various kinds of low and intermediate level radioactive waste. Since RECH-1 research reactor started to operate under the control of the Chilean Nuclear Energy Commission (CCHEN) some twenty five years ago, these nuclear applications have gradually increased, with corresponding increase in the resulting waste.

CCHEN's goals are established in the Nuclear Safety Law No. 18.302. They include proposing to the Supreme Government the necessary laws regulating a wide scope of activities so as to keep the environment free from radiological damages and risks derived from nuclear energy applications and radiation use, as well as ensuring public safety. With time the radioactive waste generation issues undertaken by the commission have been increasing.

To achieve the basic waste management objectives, a national radioactive waste management plan (RWMP) for the near future is being developed for discussion. This plan covers the spent fuel from research reactors and is one of the main tasks that CCHEN, the regulatory authority on nuclear and radioactive matters, has assigned to the radioactive waste management unit (UGDR).

2. RESEARCH REACTORS AND NUCLEAR FUEL

Chile has two research reactors. One of them, the operating RECH-1, is located at CEN LR (8 km east of Santiago, at the foot of Los Andes range of mountains). The other one, RECH-2, is located at CEN LA (28 km west of Santiago, Chile's capital city). RECH-1 is a 5 MW nominal power pool-type reactor that uses light water as coolant and moderator, and Beryllium as reflector [1]. The maximum thermal neutron flux is 6.8 × 10E03 n/cm^2·s. It has facilities for physics beam experiments, in-core experiments, neutron irradiation, radioisotope production and activation analysis.

CEN LR research activities are based on RECH-1 radioisotope production. Radioactive wastes containing short lived radionuclides are typically generated at this nuclear research centre. These wastes are stored for decay and released after being monitored to certify that radioactivity levels are as low as the background levels.

RECH-2 is not operating at present. It is a 10 MW nominal power pool-type reactor [2] already licensed for operation. Some interest in the boron neutron capture therapy (BNCT) application was expressed in the last few years, but no definite conclusion has been reached yet.

Radioactive wastes generated at CEN LA are those produced from uranium mining activities and uranium recovery as by-product from other domestic minerals (i.e. copper). Research work done at bench scale in the 80's decade did not produce large quantitites of wastes. The main waste arisings from that research were wastes from hydrometallurgy of uranium. They are composed of a very acid solutions bearing uranium at PPM levels. As an option, they could be managed as lixiviation solution if more minerals were going to be studied; but these acid solutions were delivered to UGDR as radioactive waste. An ion-exchange resin plant to reduce liquid waste volume and precipitate acid effluents (free of radioactivity) constitutes the treatment for liquid waste from uranium hydrometallurgy work. There is no research going on at present on uranium recovery from minerals.

The manufacturing of fuel elements with nuclear fuel bought from Russia is another activity developed at CEN LA. The fuel elements plant (PEC) fabricatess the fuel elements for RECH-1 operation. A total amount of 50 low enriched uranium (LEU) fuel elements is programmed to be fabricated. They are expected to be ready by the year 2000. After being used in the RECH-1, they will become spent fuel to be managed in the country.

Nuclear fuel has been acquired from different countries: one charge was bought from United Kingdom (employing fuel from USA); another charge made of British fuel which is being used now, was acquired from the United Kingdom; and yet another charge made from French fuel, was bought from Spain to operate RECH-2. As mentioned earlier, Chile is manufacturing its own fuel elements with nuclear fuel bought from Russia. Table I summarizes the MTR type nuclear fuel elements to be used in research reactors in Chile and their situation.

TABLE I. INVENTORY OF NUCLEAR FUEL FOR CHILEAN RESEARCH REACTORS

Nuclear fuel originally from	Reactor	Acquired through	Enrichment level	Fuel Elements made in	Qty.	Current status
United States of America	RECH-1	United Kingdom	HEU 80%	United Kingdom	58	28: returned back to USA 30: to be returned back to USA
United Kingdom	RECH-1	United Kingdom	MEU 45%	United Kingdom	40	30: at CEN LR 4: certain spent 6: fresh in storage
Russia	RECH-1	Russia	LEU <20%	Chile	40	4: at CEN LR 1: experimental[c] 45: to be manufactured
France	RECH-2	Spain	HEU 90%	France	31	29: at CEN LA 2: fresh in storage

c: experimental element which has only 1 nuclear fuel plate (Source: Reactors Unit/Nuclear Application Department)

Current operation of RECH-1 gives rise to 4 spent fuel elements per year (50% burnup), which should be managed in the country. This accumulating spent fuel will change the radioactive waste management concept in Chile, since it is classified as high level radioactive waste. Different available options for temporary storage are being considered due to the need from the very beginning to establish a safe place to store and manage the spent fuel elements.

3. RADIOACTIVE WASTE CURRENT SITUATION

3.1. Low and intermediate activity waste

An average of 20 to 25 m^3 of radioactive waste, whose characteristics are shown in Table II, is processed annually by UGDR in its facilities of CEN LA. The wastes are principally comprised of spent sealed sources, compactible material, heterogeneous solid waste, which includes ion exchange resins (from research reactor RECH-1), and a minor quantity of liquid radioactive waste in both aqueous and organic phases. As a result of the treatment and conditioning, an average rate of 2 m^3/year of conditioned waste is temporarily stored, awaiting final disposal.

All these steps have been developed through technical assistance from the International Atomic Energy Agency (IAEA) which has played an important role in providing technical support for the acquisition of human and material resources necessary to develop a minimum infrastructure for radioactive waste management. This infrastructure currently includes the technical facilities to manage the different kinds of radioactive waste produced in the whole country, namely facilities for storage and decay, a waste treatment and conditioning plant, and an interim storage facility for the subsequent storage of the conditioned wastes that belong to and operate under the responsibility of the UGDR, in CCHEN.

TABLE II. AVERAGE QUANTITY PER YEAR OF LOW AND MEDIUM ACTIVITY WASTE ARISING IN CHILE

Radioactive waste production source	Type of facility	Volume (m^3)	Radioisotope	Composition
Nuclear Research Centers	CEN La Reina	12	^{35}S ^{125}I ^{131}I ^{99}Mo ^{53}Sm ^{32}P ^{60}Co ^{59}Fe ^{90}Sr ^{137}Cs	Heterogeneous Non-compactible Ion exchange resin, Compactible,
	CEN Lo Aguirre	5	^{238}U ^{137}Cs	Aq. & Org. liquid
Nuclear Applications	Hospitals	1 u[a]	^{60}Co	
	Industries	25 u[b]	^{137}Cs ^{60}Co ^{241}Am ^{226}Ra ^{90}Sr ^{85}Kr	Spent radiation sealed sources (SSS)
	Universities	2	^{3}H ^{14}C ^{22}Na ^{32}P ^{125}I	Compactible & Scintillation liquids
Decontamination & Closure	Research laboratories	1	^{238}U ^{137}Cs	Heterogeneous NC, Compactible solids, Aq. & Org. liquids

u[a]: Cobalt therapy unit
u[b]: Industrial sealed radiation sources

As mentioned above, the management of the radioactive waste arising from nuclear applications in the country ends with the interim storage of conditioned waste. UGDR has been operating these facilities since the year 1990. A good performance level has been reached, which has been recognized by the IAEA, by considering the facility as a 'Demonstration Center for Latin America and El Caribe for the procedures and methods before disposal [3]. Within the country, radioactive waste management has become a service to the national radioactive waste producers.

3.2. High level waste (HLW)

At present, the spent fuel elements from research reactor RECH-1 are the only waste in the country that could be classified as HLW. The spent fuel elements from the material testing reactor

RECH-1, are not being addressed by UGDR, as the pool has a capacity to store them for at least 20 years. The fact that the nuclear fuel was originally from the USA is an additional consideration, so that up to now, radioactive waste management was focussed mainly on those wastes arising from the radioisotope applications.

3.3. Spent fuel

The spent fuel that RECH-1 has discharged until now is being returned to the USA. A total of 28 high enrichment uranium (HEU) fuel elements fabricated by the United Kingdom Atomic Energy Authority (UKAEA) at Dounreay, Scotland, using uranium enriched in the USA, have already been transferred to Savannah River Site in South Carolina [4] in accordance with the Research Reactor Spent Fuel Acceptance Program of the US. Another charge of 30 HEU spent fuel elements is planned to be returned to the USA in the year 2001.

A charge of 40 fuel element units were bought from the UKAEA, and they are being used now. These fuel elements are of medium enrichment in ^{235}U (45%) and their management as radioactive waste or final destination is not yet defined.

Since 1995, the Fuel Elements Plant (PEC) of CCHEN, that is located in CEN LA, supplies the nuclear fuel elements to be used in RECH-1. PEC manufactures the fuel elements with a low enrichment uranium (LEU) acquired from Russia. Their final storage will be in Chile as there will not be any reprocessing of spent fuel in Chile.

3 RADIOACTIVE WASTE MANAGEMENT PLAN

An important milestone for 1999 in CCHEN was to have a 'plan' for radioactive waste management in which the projected inventory of waste is one of the most significant items to be considered. Based on its own experience, UGDR works in collaboration with radioactive waste producers in the country to develop the needs for the near future. In answer to a questionnaire, waste producers have indicated that the characterisitics and projections for the next 15 years will be the same as in Table II, with minor changes in waste to be produced due to the introduction of some research. The spent fuel from research reactors can be kept at the reactor pool for the next 20 years. Looking at the international experience, [5, 6, 7] a storage facility for spent fuel will provide a solution, unless the nuclear plan for the country changes considerably.

Another important item to be considered for the radioactive waste management plan is that in a country where hydroelectricity is the main source of energy, difficulties arise when natural waters are reduced due to weather changes. Further, when fossil resources are almost spent, the energy plan for the country calls for nuclear generated electrical energy, which needs to be planned. Since nuclear power generation of electricity has not been introduced as a matter for political discussion in the country, this item will remain open in the radioactive waste management plan.

The items to be developed for the radioactive waste management plan (RWMP) in Chile are:

- Legal framework;
- Domestic inventory of radioactive wastes;
- Infrastructure;
- Social and public aspects.

4.1. Legal framework

The legal framework for radioactive materials is determined by the safety law and its associated regulations to control matters related to radioactive materials. These regulations have been proposed by CCHEN and approved by the Supreme Government. They are:

- Transport of radioactive materials,
- Authorization for facilities and operators to manage radioactive materials,
- Radiological protection, and
- The physical protection for nuclear facilities.

Radioactive waste management is associated with legislation in force for radiation and environmental matters. CCHEN is working to propose specific regulations for radioactive waste management that will serve to complement the environmental framework related to dangerous waste.

In meeting the objective of the radioactive waste management regulation, earliest tasks of the national plan, are directed to:

- Determine responsibilities with regard to waste producers, waste managers, regulatory body and the government,
- Define concepts and terminology in a manner which can be understood by all the radioactive waste producers and the regulatory body in the country and abroad,
- Promote waste minimization by controlling the steps from the initiation of a project involving radioisotopes and by defining clearance levels.

4.2. Domestic inventory of radioactive waste

One of the most relevant process of information for planning of the RWMP is the inventory of radioactive waste to be generated in the next 15 years. The development of this item is undertaken by UGDR which has made a questionnaire for users. The first results indicate that radioactive waste that will arise from radioisotopes users are not so different from those that we have now, and for which CCHEN already has the main management infrastructure.

According to the data obtained until now, the only different waste that will be generated is the spent fuel from research reactors for which CCHEN has the management responsibility within the country.

4.3. Infrastructure

For the wastes that are currently produced now, Chile has the technical infrastructure to manage them. With regard to human resources, the main concerns are to provide satisfactory training and to develop the capacities for meeting the needs for operators. Some improvements in the facilities have to be made, which are covered in the CCHEN's budget.

The storage requirements that ensure the maintenance of spent fuel in a safe stable state until a final decision is adopted is one of the most important items in the RWMP. Characterization and storage of spent fuel are the main new tasks to be introduced in this plan. Resources and effort have to be focussed on these items to achieve the infrastructure consistent with the national economy and competing demands on resources.

For the time being, waste management in Chile ends with the interim storage of conditioned waste for low and intermediate activity. The actual surface storage building, with a sixty cubic meters capacity for this kind of waste, can be improved to provide another sixty cubic meters, which will cover storage requirements for at least the next two decades, according to the actual development level. In the meantime, while spent fuel is stored at the reactor pool, temporary away from reactor (AFR) storage should be considered and defined.

The temporary AFR storage should be an independent interim storage facility at the reactor site. Financial and safety studies should be done to converge to support a final decision on whether the storage should continue to be at the reactor site (the preferred option from the technical, safety and

social points of view), or off the reactor site. This last option should be very carefully examined in depth, due to the existence of 2 research reactors in different locations.

4.4. Social aspects and public information

Social aspects and public information in the nuclear field have been very significant items developed in CCHEN and considerable resources have been invested. These efforts have been sustained over a long period of time. For CCHEN, the social aspects include, in addition to discussion and incentives at young students level, activities involving radiotransmitted and newspaper interviews, and TV discussion programs showing the benefits of nuclear applications and their development in Chile.

With regard to radioactive waste management, information discussion addresses the correlation between environmental protection and waste management. The RWMP will take this into consideration within the CCHEN public information program as is being done now. According to development level achieved in the technical issues, the social aspects and public information will also be considered, so that the public will be informed of the benefits accruing as a consequence of such achievements.

5. CONCLUSIONS

The radioactive waste management projections in Chile will change in the future due to the accumulation of spent nuclear fuel from research reactors.

To temporarily store the spent fuel waste safely until a final decision is adopted is the objective. Characterization and storage of spent fuel are the main new tasks to be introduced in the national radioactive waste management plan (RWMP). Resources and efforts have to be focussed on these items to establish and maintain the waste management infrastructure consistent with the national economy and competing priorities.

With regard to radioactive waste arising from nuclear applications, small changes are expected: small increases in the quantities of waste, but not very much in the radioactivity, which is an advantage since technological infrastructure for this kind of waste is available.

Though radioactive waste management has been carried out in a safe way, an elaboration of the legal framework should be done in the aspects involving responsibilities, authority and definition of exempted wastes.

Finally, spent fuel from research reactors is the most relevant radioactive waste to be considered in the future in the RWMP. The RWMP should periodically be opened for discussion and subjected to review of those aspects where external situations or new nuclear developments occur.

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