INTERNATIONAL PERSPECTIVES ON LOW-LEVEL RADIOACTIVE WASTE DISPOSAL

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ABSTRACT

The purpose of this review paper is to briefly describe the low-level radioactive waste disposal plans and practices in a number of western countries. The objective is not to provide detailed overviews but rather to highlight some of the key aspects so that the various national waste disposal practices can be compared to each other and to those being followed in the US The objective is to gain fresh insights and different perspectives on the programs in the USA. Six countries have been selected to provide a cross-section of approaches: Canada, (West) Germany, France, Sweden, Switzerland and the United Kingdom.

After brief summaries of the developments in each country are presented, the various programs will be compared to each other and to those in the US Differences in approaches are discussed with particular reference to those approaches which are yielding a good degree of success either in public acceptance, safety or general progress. Lessons which might be learned in the US programs are highlighted.

NATIONAL OVERVIEWS

The countries reviewed in this paper are western countries with similar standards of living and free democratic governments. Table I lists some of their demographic (population, land area) and nuclear statistics (number of reactors, total capacity). It is interesting to note that although the actual size of each nuclear program varies widely, on a per capita basis, all the countries have relatively similar sized nuclear programs. In general, it would be expected that factors such as the size of the nuclear program should have an impact on the commitment to developing disposal programs. Similarly, it would be expected that factors such as availability of land and low population density would assist in the progress of facility siting and implementation. From Table I, it is seen that the US has by far the largest nuclear program, combined with the greatest land area (effectively tied with Canada) and a reasonably low population density. This has not led to the best progress in LLRW disposal relative to the countries reviewed herein.

CANADA

Definition of LLRW

There is no official definition. However, LLRW is generally accepted as being that radioactive waste which is not high-level waste (HLW, that is, spent fuel) nor uranium tailings.

RESPONSIBILITY

The responsibility for the management of wastes being produced on an on-going basis lies with the generators. Nuclear utilities, primarily Ontario Hydro, are each developing their own facilities whereas hospitals, universities and industrial users are shipping their waste to Atomic Energy of Canada Limited (AECL) who is developing national disposal facilities at their Chalk River Nuclear Laboratories in Ontario.

The responsibility for historic wastes (whose owners are no longer in business or cannot be held responsible) is with the federal government, through their LLRW Management Office, managed by AECL.

Regulatory responsibility for virtually all aspects of LLRW management lies with the federal Atomic Energy Control Board.

Regulatory

Canadian regulations have the objectives of minimizing the burden placed on future generations and protecting the environment and human health. The risk to individuals from a waste disposal facility shall not exceed 10-6 serious health effects in a year (2). The doses that would accrue to critical groups must be calculated as well as the probability of their occurrence. The proponent is free to select suitable technologies and is given considerable flexibility in demonstrating that the above regulatory limit will be met.

Technologies and Progress

At this time, there are no licensed LLRW disposal sites in Canada, only storage is implemented (3). Ontario Hydro, Canada's major nuclear utility, is using storage buildings, concrete trenches, cylindrical holes and above-ground vaults with a design life of 50 years. AECL is using trenches and vaults.

AECL is developing technologies for disposal which aim to match the technology to the hazardous lifetime of the waste. Trenches will be used for wastes with a hazardous life of less than 150 years; concrete below-ground vaults for hazardous lifetimes of up to 500 years; and below-ground caverns for those wastes with longer hazardous lives (4).

TABLE I
Demographic and Nuclear Statistics by Country

	Population (millions)	Land Area x 1000 (ml^2)	No. of Reactors (1)	No. of Gigawatts (1)	Population Density (people/ml^2)	Watts/Person
Canada	24.2	3,560	18	12.6	7	521
Federal Republic of Germany	61.7	96	23	22.6	643	366
France	54.0	213	55	54.3	254	1,006
Sweden	8.3	159	12	10.0	52	1,205
Switzerland	6.5	15	5	3.1	433	477
United Kingdom	55.8	93	41	14.8	600	265
USA	229.0	3,541	110	101.9	65	445

Efforts have focused on the development of the vault concept which is estimated to be operational by 1992.

FEDERAL REPUBLIC OF GERMANY

Definition of LLRW

Low-level radioactive wastes are defined as those which are neither high-level waste nor uranium tailings.

Responsibility

The responsibility for siting, construction and operation of installations for the long-term storage and disposal of LLRW lies with the federal government. In 1989, this responsibility a transferred from the Federal Institute for Science and Technology to the Federal Office for Radiation Protection (5).

Regulatory

In June 1988, the Reactor Safety Commission and the Radiation Protection Commission recommended that, in licensing nuclear waste repositories, long-term safety assessments should be limited to 10,000 years. For this time period, the calculated individual dose should remain below a specified limit which is related to the variation of the natural background radiation. Analyses for time periods following 10,000 years may be used to demonstrate the isolation capacity of the host rock and geosphere at a specific site, and to demonstrate the safety margins. They may also be used to optimize the repository.

Technologies and Progress

Sixty-two thousand containers of LLRW were disposed in the Asse salt mine between 1967 and 1976, after which the practice was discontinued and the mine was converted to a research facility. Presently, the disused Konrad iron mine in Lower Saxony with workings between 800 and 1,300 m is being investigated and may begin receiving wastes in the next year. The mine, which is very dry due to 800 - 1,000 m of overlying argillaceous (clay) rock, will accept about a million cubic meters of (non heat-generating) LLRW over a 40-year life span. The high-level waste repository being constructed in a salt dome at Gorleben will also receive LLRW, starting about the year 2000 (6).

FRANCE

Definition of LLRW

Radioactive wastes are classified into three categories. Category A includes short-lived wastes of low- and medium-level radioactivity. These wastes contain almost exclusively radionuclides with a half-life of less than 30 years. After a period of 300 years, the potential hazards associated with these wastes are negligible. Their cumulative volume attains 30,000 m^3 per year. Category B contains a certain proportion of long-lived wastes that emit alpha radiation. These wastes are temporarily stored and monitored in cement or asphalt matrices pending burial in deep geological formations. In France, their total volume will reach 80,000 m^3 by the year 2000. Category C includes high-level wastes. They will be placed in a deep underground repository (7).

Responsibility

The National Agency for the Management of Radioactive Wastes (Agence Nationale pour la Gestion des Dechets Radioactifs, ANDRA) was created within the Commission on Atomic Energy in 1979 and is responsible for the design,

siting, construction and operation of the disposal centers for every kind of radioactive waste produced in the country.

Waste management policy and the regulations and licensing of nuclear installations are the responsibility of the Central Service for Nuclear Installation Safety under the Ministry of Industry (8).

In addition, the Central Service for Protection Against Ionizing Radiation under the Ministry of Health and Labor plays a specialized role. This agency is responsible for monitoring and controlling releases to the environment from radioactive sources.

Regulatory

[No reference found; however, it is probable that a maximum individual dose limit of 10 millirem/year is applied.]

Technologies and Progress

Since 1969, all short-lived low- and intermediate-level wastes have been disposed of at the Centre de la Manche facilities adjacent to the LaHague reprocessing plant near Cherbourg, northern France. Their tumulus concept consists of concrete vaults below ground level which contain higher activity waste and disposal units located above ground on top of the vaults, which contain lower activity wastes. The use of engineered barriers, particularly concrete, is an important part of the facility design which is intended to provide integrity for a period of 300 years. Capacity at la Manche will be reached in about 1991, at which time a new facility, Centre de l'Aube, at Soulaines in central France, will commence operations. Exploration of several areas in France led to the selection of the Soulaines site which is on a small hill where the hydrogeological system is simple to study and control and augments the engineered barrier system. The Centre de l'Aube facility will have a capacity of 1,000,000 m^3 (8).

SWEDEN

Definition of LLRW

Low-level radioactive wastes are divided into a short-lived category (hazardous life of less than 500 years) and a longer-lived component. The former will be disposed as soon as feasible, as described below, while the longer-lived wastes will undergo interim storage of 30 - 40 years prior to final disposal deep underground in the HLW repository.

Responsibility

The prime responsibility for disposing of nuclear waste lies with the nuclear utilities who have formed a company, the Swedish Nuclear Fuel and Waste Management Company, to perform these duties on a national basis and by coordinating and integrating all components of the back end of the fuel cycle (i.e., low-level waste, high-level waste, transportation, interim storage, etc.).

Regulatory responsibility is shared between the National Institute of Radiation Protection, which regulates and monitors release of radioactivity, and the Swedish Nuclear Power Inspectorate, which issues licenses.

Regulatory

The design and location of a disposal facility should ensure the isolation of the waste from the biosphere so that the dose effects will not exceed 10 millirem/yr in the immediate vicinity of the facility (10). Long-term calculations are limited to 10,000 years. Regulations require a LLRW disposal facility to be sited near existing nuclear facilities (9).

Technologies and Progress

In 1988, Sweden commissioned the Swedish final repository for reactor wastes, a mined cavern which is located 50 m under the ocean near the Forsmark nuclear power plant. The facility consists of four tunnels for low activity wastes and a larger, silo-like cavern for higher-level wastes. The larger cavern includes additional barriers of cement grout and bentonite backfill. Planned for a capacity of 90,000 m^3, the facility can be expanded to also contain reactor decommissioning wastes (10). The facility is intended to provide containment for 1,000 years for wastes with half-lives predominantly less than 30 years.

Little site selection was involved and a key factor was the neighboring nuclear reactor installation.

SWITZERLAND

Definition of LLRW

Low-level radioactive wastes are divided into low- and intermediate-level categories as outlined by the International Atomic Energy Agency, with the former consisting primarily of short-lived radionuclides (half-lives of less than 30 years).

Responsibility

According to Swiss law, the producers of nuclear waste are responsible for waste management. In 1972, all generators of radioactive waste joined together to form NAGRA, Swiss National Cooperative for the Storage of Radioactive Waste, with the responsibility of designing, constructing and operating radioactive waste disposal facilities. Responsibilities for regulatory functions is shared by the Federal Com

mission for Safety in Nuclear Installation and the Nuclear Safety Department of the Federal Office of Energy (12).

Regulatory

Wastes need to be isolated from the biosphere in such a manner that dose effects will not exceed 10 millirem/yr to any individual and on-going maintenance is not required.

Technologies and Progress

In 1988, the Swiss government endorsed the concept that low- and intermediate-level wastes can be managed safely and instructed NAGRA to initiate site selection for a mined cavern repository. Four potential sites have been identified and fieldwork has been initiated at three of these sites. At the Wellenberg site, the federal government has authorized NAGRA to conduct detailed investigations including the construction of a 2,000-m exploratory tunnel and an underground rock laboratory. The laboratory would be used to conduct experiments specific to marl. It is intended to have a low- and intermediate-level waste (and possibly TRU waste) repository in operation by 1998 (1).

UNITED KINGDOM

Definition of LLRW

Those radioactive wastes which are not high-level wastes and are not uranium mine tailings, are divided into two categories. Low-level wastes are defined as having less than four gigaBequerals (about 110 millicuries)/tonne of beta activity and less than 12 gigaBequerals (about 325 millicuries/tonne of beta/gamma activity, and has a hazardous lifetime of 300 years. Intermediate-level wastes are defined as having greater activity than LLW and not generating any heat (13).

Responsibility

The responsibility for developing LLRW disposal capability in the UK lies with United Kingdom NIREX Ltd., a company whose shares are held by the component parts of the nuclear industry, including the Central Electricity Generating Board, British Nuclear Fuel Ltd., UK Atomic Energy Authority, the Department of Energy and the South of Scotland Electricity Board. NIREX, which stands for the Nuclear Industry Radioactive Waste Executive is developing plans on a national basis (14).

Regulatory

The regulatory limits for doses to individuals in the general population from a disposal facility are 10 millirem, which is felt to be equivalent to a risk of one in a million of an individual receiving a serious health effect (cancer or genetic defect).

Technologies and Progress

Currently, LLW is being disposed of at the Drigg site, but the facility is nearing full capacity and new sites are necessary. It is planned that the intermediate-level wastes will be emplaced into clay trenches of about 20 m depth, with the waste containers grouted with large masses of concrete. Three sites are being investigated with the objective of selecting one and commencing disposal operations by 1992. The intermediate-level wastes will be placed into a mined cavern facility at a depth of 200 to 1,000 m. The facility may be located under the sea as in the Swedish concept. The LLW repository is scheduled to come on-line early in the next decade.

DISCUSSION

Definition of LLRW

The five European countries have similar outlooks in a number of areas including waste categorization. They all define radioactive wastes by the IAEA-recommended categories of low-, intermediate- and high-level. The low-level wastes are felt to be those that have a radioactive, hazardous life of less than 300 to 500 years. In Canada the situation is also going in the same direction for research and hospital wastes (disposal decisions have not bee reached for utility wastes). The US LLRW classification of A, B and C is unique in the respect that it is the only one that has three categories instead of two. Actually, the US classification has four levels since the Greater than Class C (GTCC) wastes must also be included. It should be noted that no other country has the equivalent of the GTCC category.

Regulatory

The European countries have adopted 10 millirem/year dose limit for an individual, which is based on International Commission Radiological Protection recommendations. In Canada, the regulatory limit is based on a risk of one in a million chance per year of a serious health effect (this is equivalent to a dose of about 5 millirem). These values are all lower than the NRC whole body limit of 25 millirem. The NRC also specifies a maximum allowable organ dose of 75 millirem to the thyroid. The US is the only country that specifies organ doses. It should also be noted that in all the countries reviewed the proponent has considerable latitude in demonstrating how the dose limits will be met; nowhere

are the regulatory requirements as prescriptive and detailed as those specified by the NRC.

Responsibility

In France and Germany, the responsibility for LLRW disposal lies with the federal government. In the remaining countries, the responsibility lies with the waste generators. In all the but Canada, the generators have combined forces so that the problem is being handled on a nationwide basis. The US is unique in that it is the only country which has made LLRW disposal a state responsibility, thereby encouraging the establishment of many regional repositories rather than promoting a national effort. In all cases, except for the US and Canada, definite long-range plans have been developed to handle these radioactive waste disposal problems on a nationwide basis.

Technologies

All countries except the US are pursuing a common objective in that intermediate-level wastes (ILW) will be placed into deep underground caverns instead of surface facilities. In some cases, the low-level wastes (less than 30-year half-lives) will also go underground (Sweden, Germany and Switzerland) and in others these wastes will be placed in near surface facilities (Canada, France and UK). Several countries (Sweden, Canada and Germany) are placing, or propose to place, their intermediate-level wastes into a dedicated facility, while in other countries (France, Switzerland and UK) it will be placed into the HLW repository. No country (other than the USA) is developing plans for more than one LLW and one ILW repository.

Based on this review of other countries' radioactive waste disposal programs, it appears clear that it has been found unacceptable to dispose of ILW (equivalent to NRC Class B and C) in near-surface facilities. Despite the fact that the US HLW program is actively pursuing a deep-mined repository, it is unclear as to why the NRC and Department of Energy (DOE) have not developed a coordinated radioactive waste disposal program as have other western countries. One reason may be that the NRC licensing regulations for LLRW were not developed until active commercial disposal, consisting of shallow land burial, had been underway for a number of years. As a result, the US regulations were developed "after the fact," based on prescriptive measures to meet better performance standards and operating procedures being used within the industry at the time. In addition, there appears to be a lack of coordination between the HLW and LLW programs in the US.

Different strategies for site selection have been adopted. Some countries are performing relatively comprehensive site selection processes (Switzerland, the UK and France) similar to what is being done by the various states and compacts in the US. In other cases, however, fairly limited site selection is being done (Sweden, Germany and Canada).

Progress

The two countries who have progressed the furthest in their radioactive waste programs are France and Sweden, both of whom have successfully operating repositories which are of state-of-the-art design. In both of these cases, the low- and high-level waste disposal programs are under the auspices of one organization which is providing a national, integrated program. Germany has made good progress in their program and should have the Konrad mine in operation by 1992. The Swiss program is well-organized and appears to be moving forward positively. The United Kingdom is struggling and is meeting continuing resistance in locating a site. Canada is making good progress on the non-utility side and will have a below ground vault operational by about 1992. However, disposal plans for the utility sector, and coordination with the non-utility sector, have yet to be developed.

The US program currently calls for the closing of the three existing commercial LLW disposal sites in 1993, at which time the various states and compacts must have their own facilities licensed and operational. Review of the various US programs indicates that only a few states will be able to meet this milestone, leaving the majority of states with no means of disposing of their wastes. There is considerable uncertainty as to how this problem will be resolved.

SUMMARY

The US LLRW disposal program is uniquely different from those of other countries in many aspects.

While other countries are integrating and centralizing their waste programs, the US, through the enacted Low-Level Radioactive Policy Amendment Act of 1985, has decentralized its waste program by placing the responsibility for disposal of LLRW squarely on individual states and compacts who, for the most part, have limited expertise, experience and resources in dealing with such a highly complex issue.

Secondly, in contrast with other countries' programs, the US has not addressed the use of mined caverns for their B and C wastes.

Thirdly, because of the method of waste classification in the US, the various states and compacts are faced with addressing such waste streams as "Greater than Class C" and mixed wastes.

Fourthly, the US NRC regulatory process is prescriptive in nature, thereby not allowing for the flexibility and

interpretation often needed in the siting and design of a LLRW disposal facility.

Lastly, the US radioactive program, in contrast to other western countries, does not provide a coordinated effort between the LLW and HLW disposal programs.

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ACKNOWLEDGEMENTS

The authors are grateful to many individuals for their discussions and input to the opinions expressed in this paper. We are particularly grateful to Mr. Richard Heystee, Ontario Hydro, who recently visited several European countries and shared with us his knowledge of their disposal programs.