PNL-SA-17770

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PNL-SA--17770

DE90 009455

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April 1990

Presented at the
First International High-Level Management
Conference
Las Vegas, Nevada
April 8-12, 1990

Work supported by
the U. S. Department of Energy
under Contract DE-AC06-76RLO 1830

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ABSTRACT

This paper contains descriptions of the major parameters and plans for management of spent nuclear fuel and high-level radioactive wastes in Belgium, Canada, France, the Federal Republic of Germany, Japan, Sweden, Switzerland, the United Kingdom, and the United States. All nine countries are planning on disposal of spent fuel and/or high-level wastes in deep geologic repositories, although some have indicated an interest in alternatives such as seabed disposal and partitioning/transmutation. Most countries are planning on decades of interim waste storage, and are not planning to implement disposal until the year 2020 or later. Most countries plan to reprocess their spent fuel and vitrify the resulting high-level waste for disposal. Most disposal concepts utilize numerous engineered barriers that include overpacks and buffer materials. No country has finalized its repository site or concept, and only two have selected a candidate site for detailed evaluation.

INTRODUCTION

Radioactive waste disposal is a sensitive issue in many areas of the world. Management of spent nuclear fuel and high-level wastes, especially the disposal of these wastes, is particularly sensitive. Most countries with nuclear generation of electric power, including the nine countries discussed in this paper, are pursuing programs leading to eventual disposal of these wastes.

National policies, strategies, institutional structures, political situations, public reactions as well as technical considerations in any country can affect waste management programs in other countries through public and scientific pressures. The technical consensus in most countries with nuclear power, and of multinational organizations, is one of confidence in deep geologic disposal as the preferred method for the permanent disposal of spent nuclear fuel (SNF) and high-level radioactive wastes (HLW). A number of countries are now developing and/or implementing strategies based on deep geologic disposal. Although an international consensus exists for use of geologic disposal, there are differences in the general approaches among the various countries in managing and disposing of spent fuel and high-level radioactive wastes.

This paper summarizes the trends of current plans and developments of spent fuel and high-level waste management in Belgium, Canada, France, Federal Republic of Germany, Japan, Sweden, Switzerland, United Kingdom, and the United States. The strategies in these countries, which typify the range of strategies being pursued, are given to identify the trends, and the differences and similarities.

INSTITUTIONAL STRUCTURES

About one half of the countries discussed in this paper have a national law that mandates plans for waste management as a stipulation in granting licenses for operation of nuclear power reactors. Those in Germany and Japan relate only to the future reprocessing of their spent fuel; those in Sweden and Switzerland relate to disposal of the spent fuel or high-level waste. For implementation of waste management programs, most of the national laws are relatively simple, and provide much flexibility to the implementing institutions. The U.S. Nuclear Waste Policy Act and its Amendment Act are the most detailed with respect to specifying needs, responsibilities, and schedules.

As seen in Table 1, most of the countries have assigned responsibility to federal government agencies for implementing the high-level waste management system. In Sweden the responsibility is with a private entity set up among the utilities. In Switzerland the responsibility is with a private entity set up among the waste producers. In all nine countries, the "waste producer pays" is the principle for funding the waste management activities. The funding for the national waste management programs

TABLE 1 INSTITUTIONAL ASPECTS OF SPENT FUEL AND HIGH-LEVEL WASTE MANAGEMENT

Country	Nuclear Power Waste Stipulation Law	HLW Management Organization	State/Local Role In Repository Development
Belgium	No	Government (ONDRAF)	Review only and opinions
Canada	No	Government (AECL)	Review only and opinion (AECL)
France	No	Government (ANDRA)	Public inquiry and opinions
Fed. Republic of Germany	Yes[a]	Government (Bfs)	Public hearing; local approval; state-licensing decision
Japan	Yes[a]	Government (STA)	Public hearing; consensus approach
Sweden	Yes	Industry (SKB)	County siting veto; public comments
Switzerland	Yes	Industry (NAGRA)	Consultative only
United Kingdom	No	Government-policy; Industry-Implementation	Public inquiry; local veto (can be overridden)
United States	No	Government (DOE)	State siting veto; public comments and hearings; state monitors programs; review committees

[a] Only for spent fuel storage or reprocessing.

are typically managed by the respective federal government except in Switzerland, where it is managed by the nuclear industry. In France, the French national utility produces the waste, and waste program funding is provided from government funds.

Table 2 summarizes the regulatory aspects of spent fuel and high-level waste management facilities. In all the nine countries, the primary regulatory safety requirements are set by the federal government. Licensing authorities for long-term waste management are generally with the respective national government, although some local licenses are also required. In all of the countries reviewed, public hearings or consultations are held for waste management facilities. In all cases, the public can express opinions that are taken into consideration; in other cases the public or local entities can have greater authority (e.g., in Germany, the State has licensing authority in practice, but this can be appealed; in Sweden, the local government can veto the facility siting; in Japan, the federal government can overrule local vetoes, but so far has preferred to receive local agreement). General safety performance requirements of the repositories are defined in the national regulations in all but two of the countries, and specific repository performance requirements are established only in the U.S. Most of the countries currently do not plan to have detailed and prescriptive regulations, but will require the repository license applicant to prove that the proposed facility will meet the overall performance requirements.

WASTE TYPES AND QUANTITIES

Five of the nine countries currently plan to reprocess or buy reprocessing services from other countries for all their spent nuclear fuel. Where spent fuel is reprocessed in another country, the high-level waste will be returned to the country of origin as a canisterized, solidified form. The Federal Republic of Germany (F.R.G.) plans to have most of their spent fuel reprocessed in France and the U.K.; however the F.R.G. also plans to dispose of some SNF directly without reprocessing, (i.e., SNF that is difficult to reprocess, e.g., HTGR fuels, second cycle MOX fuels, and perhaps some high-burnup LWR fuels). Canada is currently planning to dispose of spent nuclear fuel directly without reprocessing, but has not yet ruled out reprocessing. Sweden is the only foreign country in this paper that has firmly ruled out SNF reprocessing. Countries that are reprocessing are doing so primarily to conserve the remaining energy resources in the spent

TABLE 2 REGULATORY ASPECTS OF SPENT FUEL AND HIGH-LEVEL WASTE MANAGEMENT FACILITIES

Country	Public Role in Licensing	Repository Performance Requirements	Status of Regulations
Belgium	Review and comment only	General only	Details to be developed
Canada	Review and comment only	General only	Under development
France	Public inquiry; local veto (may be overruled)	General only	Under development
Fed. Republic of Germany	Public hearing; local veto	General for total system	General complete
Japan	Public hearing; local consensus desired	Not yet established	Not yet established
Sweden	Public hearing; local veto	General for total system	General complete
Switzerland	Consultative	Total system objectives	Complete
United Kingdom	Local veto on siting (government can override)	General only	Defined for spent fuel management; deferred for repository
United States States	Public hearings; state veto on siting; regulatory advisory committee	Specific for system and individual components	Complete, although some are undergoing revision

nuclear fuel over the long term. All countries that are reprocessing are planning to convert their HLW to monolithic borosilicate glass in metallic canisters for interim storage and disposal.

As shown in Table 3, by the year 2000, these nine countries will have accumulated about 180,000 MTIHM (metric tons of heavy metal [i.e., uranium and plutonium] present in the initial, unirradiated spent fuel) of SNF or equivalent of HLW. The largest quantities will be in the U.K. and the U.S. (about 40,000 MTIHM each), and the smallest quantities will be in Belgium (about 3,000 MTIHM) and Switzerland (about 2,000 MTIHM).

INTERIM STORAGE

Because most of the countries are planning on disposal after the year 2010, they are planning on extended interim storage of SNF or HLW for about 30 to 75 years. In most cases, wet (i.e., in-pool) storage is planned to be used for SNF that is less than about 10 years old, followed by dry storage (i.e., in dry storage casks or in air-cooled vaults). Belgium and Canada have not committed to central storage of their wastes, but the other six foreign countries in this review plan to use central storage. Sweden currently plans to store SNF in water pools at the reactors and at an existing central storage facility until disposal. Belgium will store SNF until it is reprocessed abroad. The vitrified HLW will be placed in dry interim storage in all the countries with reprocessed wastes. France, the only one of the nine countries to have vitrified HLW on an industrial scale, is already storing these wastes in air-cooled storage systems. This information is summarized in Table 4.

GEOLOGIC DISPOSAL

Most of the countries in this paper are planning to start disposing of their SNF and HLW between the years 2010 and 2030. The earliest schedules are in the F.R.G. (2008), and the U.S. and France (2010). Canada, Japan, and the U.K. do not have estimated schedules, and their likely dates will be after 2030. The schedules of most of the countries are based on their respective needs, on the estimated time to implement a repository system, and on a technical approach of conservative design of the repository tc handle wastes with lower heat loads.

Geologic repositories are expected to isolate the wastes to the extent that future releases of radionuclides from the repository

TABLE 3 ESTIMATED QUANTITIES OF SPENT FUEL AND HIGH-LEVEL WASTES FROM NUCLEAR POWER

Country	Waste Form	Cumulative Quantity, MTIHM[a] 1986	2000
Belgium	Vitrified HLW	700	3,000
Canada	Spent fuel	9,500	33,900
France	Vitrified HLW	2,900	20,000
Federal Republic of Germany	Vitrified HLW and spent fuel	2,600	11,000
Japan	Vitrified HLW	3,700	19,600
Sweden	Spent fuel	1,330 (1985)	7,800 (2010)
Switzerland	Vitrified HLW	650 (1985)	2,000
United Kingdom	Vitrified HLW	26,000	44,000
United States	Spent fuel/ Vitrified HLW	14,000/640	40,000/640
TOTALS		62,000	182,000

[a] Metric tons of initial heavy metal in spent nuclear fuel.

will represent acceptable radiological risks to man and his environment. Each of the national disposal programs includes the following major phases:

- screening and selection of potential repository sites
- detailed characterization of the proposed final candidate site(s)
- development of the repository design
- underground testing to support development of the repository concept
- assessment of performance of the proposed repository
- preparation of and application for obtaining a license for repository
- construction and testing of the repository
- emplacement of wastes
- closure and post-closure of repository for maintenance and monitoring

None of the countries has confirmed a final site for geologic disposal of spent fuel and high-level wastes. To date, only Germany and the U.S. have identified a proposed final candidate site for detailed characterization and confirmation. Most of the other countries are in the screening phase for potential host repository sites. All countries plan on carrying out a detailed site characterization program at their proposed final candidate repository site to allow for evaluation and confirmation (or rejection) of the site for use as a repository. Each of the nine countries is planning to construct an underground test facility (called "Exploratory Shaft Facility," or ESF, in the U.S.) at the candidate repository site or in a geologic formation similar to that of the candidate site. The underground test facilities will provide detailed information on the geohydrology and geochemistry of the site for evaluation of site suitability.

A variety of disposal media is being pursued by other countries as the host rock for a repository. Domal salt, clay, schist, granite, gabbro and sedimentary formations are under review. The U.S. is the only country that is presently pursuing the use of tuff as a host formation for a deep geological repository.

All other countries are planning to locate their repository below the water table in saturated or dry strata having an expected long groundwater travel time. Only the U.S. has identified a potentially suitable rock formation at an appropriate depth above the water table to be considered as the host rock formation.

Although each of the countries except the United Kingdom is working on its repository concept, none of the nine countries has

TABLE 4 OVERALL SPENT FUEL AND HIGH-LEVEL WASTE MANAGEMENT SYSTEMS

Country	Interim Storage of Spent Fuel	Extended Interim Storage HLW or Spent Fuel	Transport to Repository	Geologic Disposal and Waste Age at Disposal
Belgium	AR only until reprocessing	HLW 30-50 yr in dry AFR	Rail offsite; truck onsite	Yes, HLW; ~50 yr
Canada	AR only until disposal	Spent fuel in water and air ~50 yr	Truck	Yes, spent fuel; ~50 yr
France	1 yr AR/2-3 yr at reprocessing plant	HLW 20-30 yr in dry AFR or at disposal site	Rail; truck for short hauls	Yes, HLW; ~30 yr
Fed. Republic of Germany	1-10 yr AR; AFR planned	Spent fuel-wet AR, dry AFR; HLW-dry AFR	Rail; truck	Yes, HLW and spent fuel; ~20 yr
Japan	2-3 yr AR	HLW 30-50 yr in dry at reprocessing plants	Ship; truck over land	Yes, HLW; 30-50 yr
Sweden	1-5 yr AR; 30-40 yr AFR	Spent fuel wet AR and AFR	Ship; truck over land	Yes, spent fuel; ~40 yr
Switzerland	~10 yr AR; dry AFR planned	HLW 40 yr in dry AFR	Rail; truck	Yes, spent fuel; ~40 yr
United Kingdom	Wet AR and dry AFR for Magnox and AGR -short term; LWR-up to 18 yr AR	HLW-dry AFR; LWR spent fuel-18 yr AR	Rail, truck-U.K. fuel; Ship-foreign fuel	Yes, HLW; 50-100 yr
United States	AR (wet) and extended AR (dry); one small wet AFR until disposal; dry federal AFR proposed	Spent fuel up to ~30 yr AR; Some dry storage AR and at proposed federal AFR; small amount of HLW in dry AFR	Rail and truck; possibly some barge	Yes, spent fuel and HLW; 5-40 yr

AF = At-reactor.
AFR = Away-from-reactor.

finalized their design concept. Most concepts involve emplacement in a mine-like facility, typically 300 to 1200 meters below grade. Most of the concepts involve emplacement of waste containers in holes in the floors or walls of mined out drifts; some involve emplacement directly in the drifts. All of the concepts include a major facility at the surface to receive and handle the wastes.

A summary of the information on the geologic disposal system for the nine countries is given in Table 5.

OTHER DISPOSAL CONSIDERATIONS

As in the U.S., all of the other countries in this paper are considering the disposal of alpha-containing wastes (called "transuranic" wastes in the U.S.) in deep geologic repositories. Several plan to emplace them in the same repository as high-level waste. Several of the countries are still hoping for an eventual multinational repository for SNF and HLW.

All nine countries discussed here are planning on geologic disposal of SNF and HLW. However, other disposal concepts are still being considered to some degree in several countries. For example, Canada, France, Japan, and the U.K. may be considering seabed disposal as an alternative. In addition, Japan has recently embarked on a major program to study partitioning/transmutation for ultimate management of at least some fractions in the HLW.

TABLE 5 GEOLOGIC DISPOSAL SYSTEMS

Country	Status	Repository Concept	Host Rock and Water Environment	Approximate Year of Repository Startup
Belgium	Conceptual	12 canisters in each borehole in floor of drifts; alternate is emplacement in drifts	Clay; dry	2030
Canada	Conceptual	1 canister of 72 assemblies in borehole in floor of drifts	Granite; saturated	2030
France	Pre-conceptual	18 canisters in cooled boreholes or 1 canister in uncooled hole	Granite, salt, clay or schist; TBD	2010
Fed. Republic of Germany	Reference concept	HLW stacked vertically in boreholes; SF horizontally in drifts	Salt dome; dry	2008
Japan	Pre-conceptual	No information	Crystalline or sedimentary; TBD	after 2030
Sweden	Reference concept; unchanged since 1983	Single packages in boreholes in floors of drifts	Granite, gneiss or gabbro; saturated	2020
Switzerland	Reference concept, may change	Single packages horizontal in drifts	Granite, anhydrite, saturated	2020
United Kingdom	Deferred disposal, interim storage	Preconceptual; packages in vertical boreholes or horizontal drifts	Granite preferred; TBD	2040
United States	Preliminary design	Single packages in boreholes in floors (or multiple packages in walls) of drifts	Tuff; unsaturated	2010

TBD = To be determined.

WASTE PACKAGE

The waste package design is a critical part of the repository system. In this paper, the waste package consists of the waste form (i.e., HLW or SNF), the canister immediately containing the waste form, any engineered outer container (called "disposal containers" or "overpacks") if any, and any buffer material surrounding the disposal container in the emplaced configuration in the repository. (In the U.S., this terminology applies to the waste package for high-level waste; for waste packages with spent nuclear fuel, the immediate container surrounding the spent fuel is called the "disposal container," and the "waste form" which is the spent nuclear fuel plus its immediate container.) Table 6 provides an overview of the status and characteristics of the waste package systems in the nine countries.

No country has yet selected its final waste package design, although the development of the waste package in about half the countries is well along. Borosilicate glass is the waste form of choice for the countries that are reprocessing, although some studies are still in progress on HLW forms with expected further reduction in water leachability. Spent fuel is planned to be disposed of in canisters as intact assemblies in Canada and Sweden, but consolidation is being considered in the F.R.G. (which is also considering chopping the spent fuel) and the U.S. Most of the nine countries plan to use canisters of stainless steel for the HLW and SNF. Canada, Sweden and the F.R.G. (for spent fuel) are considering the use of highly corrosion-resistant canisters made of thin-walled titanium, thick-walled copper, and a hastelloy coating, respectively. Although the Swedish conceptual canister is expected to have

TABLE 6 HIGH-LEVEL WASTE PACKAGE SYSTEMS

Country	Status	Waste Form	Matrix	Canisters	Disposal Container	Buffer (or (packing) Material
Belgium	Reference concept	Borosilicate glass	None	5 mm wall 215 CN 24-13 SS (French canister)	None	Possibly clay or cement
Canada	Reference concept	Intact spent fuel	Sand	4.76 mm wall titanium	None	Sand
France	Canisters in use; other components are conceptual	Borosilicate glass	None	5 mm wall cylinder 215 CN 24-13 SS	TBD	Possibly clay
Fed. Republic of Germany	Reference concept well-developed	Borosilicate glass; some spent fuel (may be consolidated, intact or chopped	None	French design for HLW (SS); Pollux for spent fuel (steel and hastelloy coating)	None for HLW; Pollux and overpack for spent fuel	None
Japan	Conceptual	Borosilicate glass	None	304 L SS	TBD	Possibly clay or cement
Sweden	Reference concept; others considered	Intact spent fuel	Lead or copper	10 cm-thick copper; provides long-life ~1,000,000 yr	None	Pressed bentonite
Switzerland	Reference concept	Borosilicate glass	None	5 mm wall 215 CN 24-13 SS (French and U.K. canisters)	Yes, cast steel	Compacted bentonite
United Kingdom	HLW glass in French-type canister; other components not yet studied	Borosilicate glass	None	Similar to French canister	Overpack of thin titanium or thick cast iron	Bentonite or cement backfill
United States	Preliminary design for site characterization; others considered	Intact or consolidated spent fuel	None	9.5 mm-thick SS	None for spent fuel; SS for HLW	None presently; considering clay

TBD = To be determined.
SS = Stainless steel.

a life expectancy in the order of one million years, most countries are expecting their canister to have a life expectancy of a few tens to about 1000 years. Most of the countries are considering the use of an overpack container to provide additional structural support or chemical durability to their waste package after emplacement in their repository, but few have made the final decision.

Most countries are considering the use of a clay-based buffer material around the waste canister or disposal container in the geologic repository as an additional barrier to retard migration of radionuclides away from the waste container. Canada and Sweden are also considering the use of filler materials in canisters containing spent fuel.

REPOSITORY PERFORMANCE ASSESSMENT AND SAFETY

All nine countries are placing significant emphasis on developing computerized models to mathematically predict the performance of a repository system for isolating the radionuclides from man and his environment. Results from safety analyses using these models will be used in all cases as part of the licensing process to judge the adequacy of the near-term and long-term radiological safety of a proposed repository. Most of the nine countries are using a combination of deterministic and stochastic models for repository performance assessment. Each country is developing its own or major variations of other models to carry out its own performance assessments. Differences arise in the level of detail in the models, in the number of models developed for analyses, and in the rigor of work on validating the models. All the countries are making some use of studies on natural analogues to provide data for their repository performance assessments. A summary of repository safety considerations is given in Table 7.

All nine countries are cooperating in international performance assessment initiatives and projects to improve performance assessment methods. These initiatives are facilitating comparison studies, verification and validation of mathematical models, development of scenarios, and analysis of sensitivities and uncertainties in results.

Growing reliance is being placed on multinational or foreign peer reviews to confirm policies, strategies, technical positions and approaches regarding safety. For example, the Swedish repository concept was reviewed by the International Atomic Energy Agency (IAEA), the U.K. low-level waste management system was reviewed by the IAEA, and The Netherlands concept was reviewed by the OECD/Nuclear Energy Agency (OECD/NEA). All of the nine countries depend on national advisors and reviewers of their programs.

The nine countries plan to depend to a significant degree on the host rock and geologic environment for the long-term safety of the repository. Some are also depending on the engineered barriers to a major degree. Sweden, for example, is expecting their waste canister to last up to one million years. There seems to be a recent trend of increasing dependence on redundant engineered barriers for assurance of long-term repository performance.

Most of the nine countries do not consider post-emplacement retrievability of the waste as a necessary safety feature of a repository, although some design concepts would accommodate retrievability. Most countries generally prefer to conduct immediate-to-near-term backfilling to entomb the waste, whereas some retrievability for a limited time period is a regulatory requirement in the U.S.

Regulatory requirements are more flexible or not as fully developed in most other countries compared to those in the U.S. The foreign national requirements require proof of safety, but typically allow the implementing organization to prove the safety of disposal in their own way, given some general regulations. Regulations in most of the other countries are non-prescriptive, and do not specify the performance requirements of various parts of the waste disposal system.

TRANSPORTATION SYSTEM

Transportation of the spent nuclear fuel or high-level waste from its point of origin to the repository is a major part of the waste management system. All countries plan to use truck and/or rail shipments for land transport. Some countries are using ships for transport between facilities at or near the coast, and for transporting spent fuel to reprocessing facilities abroad and for return of the resultant high-level wastes. Germany is using "dual-purpose" casks for transport and interim storage of spent fuel for reprocessing, and is developing "triple-purpose" casks for transport and interim storage and disposal of spent fuel that is not to be reprocessed.

PUBLIC PERCEPTION

Public distrust of nuclear power and radioactive waste management is gaining momentum internationally. This is due in no small part to occurrences or revelations, primarily over the last five years, of some poor nuclear power and waste management practices. In general, these occurrences have reinforced and will continue to reinforce distrust of the viability of deep geologic disposal. The general political and regulatory trends internationally are making it more and more difficult to gain public acceptance of repository sites because of strong public pressure in several countries.

TABLE 7 REPOSITORY SAFETY CONSIDERATIONS

Country	Major Safety Barriers	Package Retrievability Planned	Post-Closure Monitoring	Proving Safety	Peer or Foreign Review of Progress
Belgium	Host rock	No	No	Deterministic and stochastic	Yes, indirectly
Canada	Host rock, canister	No	No	Deterministic and stochastic	Yes, indirectly
France	Host rock, waste form	TBD	About 300 yr	Deterministic	National advisors; no foreign reviews
Fed. Republic of Germany	Waste form, geologic formation	No	None identfied	Deterministic; conservative	None identified
Japan	Host rock and engineered barriers (waste form, canister)	TBD	TBD	Stochastic	No information
Sweden	Canister and matrix	None required but possible with concept	Not required technically but TBD	Conservative; deterministic some stochastic	National peers; IAEA and NEA
Switzerland	Host rock, bentonite overpack, waste form	No	No	Deterministic; conservative	None identified
United Kimgdom	Waste form, others TBD	Strong public support for retrievability	TBD	Conservative; deterministic; stochastic; time-dependent simulation modeling	None to date
United States	Canister, host rock	Retrievability for 50 yr after start of emplacement	None planned	Stochastic and deterministic; detailed; extensive model validation	Several national peer groups; no foreign reviews

TBD = To be determined.

Public pressures for information and participation in decisions affecting the public's own communities are rising in most countries. The public is participating in many of the decisions in most countries in various ways. All countries are searching for methods to maintain appropriate and constructive public participation without adding undue difficulties to the program.

SUMMARY AND CONCLUSIONS

All nine countries discussed in this paper are planning to implement geologic disposal of spent fuel and/or high-level radioactive wastes. These plans express the confidence of the technical community that such disposal can be done safely and effectively. However, this confidence is not always shared by the public as seen by their growing distrust, in all of the countries, of the national entities responsible for nuclear power and waste management.

No country is planning to have an operating repository until about the year 2010, and some are going to wait until near the middle of the 21st century. All are planning to utilize a combination of geologic and engineered barriers to isolate the wastes from man's environment. All are planning on extended interim storage of the spent fuel or high-level waste, either in water pools or in dry storage systems. Safe transportation of these wastes is proven from experience, and many of the nine countries are developing their system for transporting the wastes to their repository in the future. Most of the nine countries have set up their institutional structures for managing these wastes from generation through final disposal.

All nine of the countries plan to use similar overall strategies in their systems for managing spent nuclear fuel and high-level wastes. All are planning on geologic disposal in the next century after a time period of interim storage. All are using a similar approach in selecting, evaluating and confirming a repository site. Differences occur in some areas such as participating institutions and in legislative requirements, timing and type of interim storage, spent fuel reprocessing or direct disposal, candidate repository host rocks and surrounding geology, disposal facility concepts, waste package design and redundancy in engineered barriers, amount of conservatism in design, approach to proving repository safety, regulatory requirements, institutional structure, and public participation. However, the governments and scientific organizations in each of the countries are moving forward in a careful and well-planned manner to implement disposal in a geologic repository when it is needed.