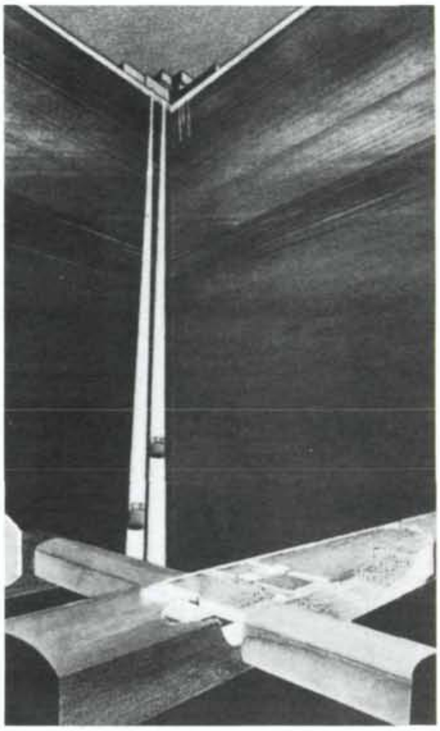
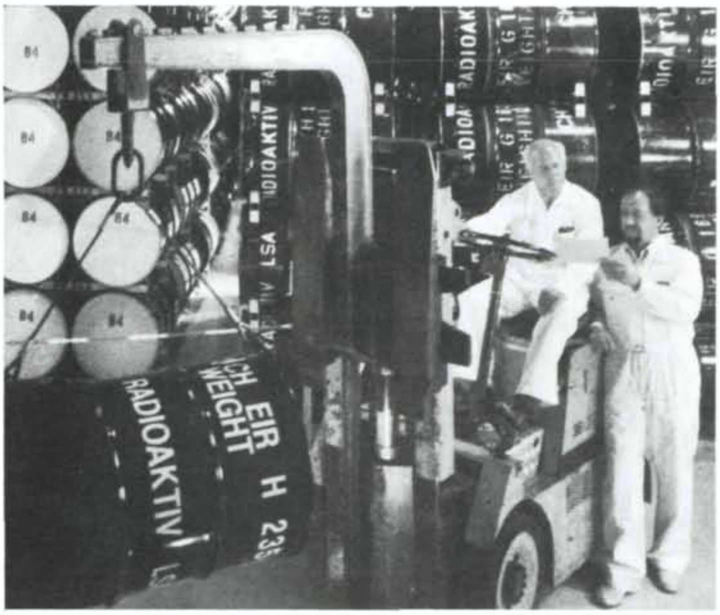


Geological disposal of highly radioactive waste is based on a multi-barrier approach to safely isolate the waste from the environment. In a number of countries, research is being done at underground laboratories. (Credits: SKB, ANDRA)

A storage building for low-level radioactive wastes in the USA. (Credit: USDOE)



At the Institute of Reactor Research in Switzerland, some low-level radioactive wastes are stored on site. (Credit: UNIPEDE)

Radioactive waste management: World overview

An update of trends and developments

by J.L. Zhu and C.Y. Chan

With a history of over 40 years of development, the use of the atom can be classified as a maturing technology. However, the benefits that result from the use of the atom are not without concerns. Few topics have commanded as much attention from scientists, governments, and the general public over the past 30 years as the subject of "nuclear waste" (radioactive waste) and what to do with it. In many countries, the future and continued use of nuclear power is contingent on acceptable solutions for waste management and disposal.

Almost every one of the IAEA's 113 Member States generates some radioactive wastes. These wastes have various forms and characteristics and they arise from nuclear generation of electricity, nuclear fuel cycle activities, industrial application, and work at research centres and hospitals, for example. The actual volumes of wastes from nuclear electricity generation and other nuclear applications are small compared to those of other technologies or industries (i.e. coal-burning power stations). However, a major concern is that some radioactive wastes can pose a threat to man and the environment for long periods of time.

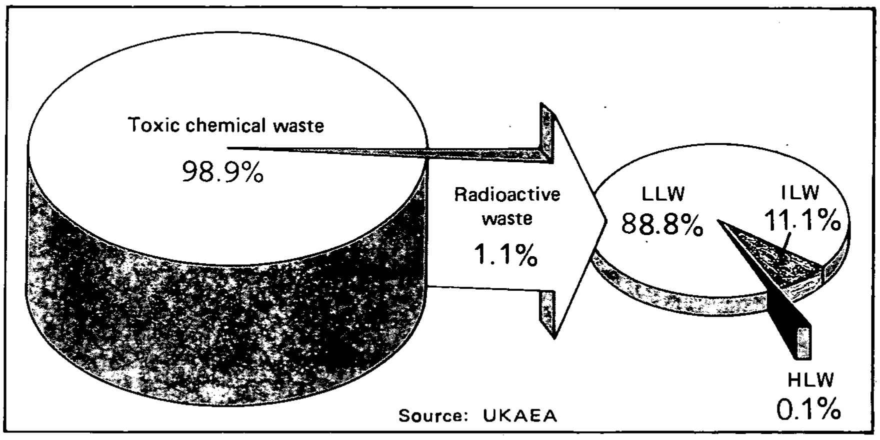
This report summarizes the national trends and strategies for radioactive waste management and disposal, and what is being done on an international basis in this field. The perspective of this summary is primarily from civilian nuclear power programmes.

Mr Zhu is Director of the IAEA Division of Nuclear Fuel Cycle and Waste Management and Ms Chan is a staff member of the Division.

Trends and strategies

As countries pursue, plan, and implement national programmes to manage various types of radioactive waste, there are similar issues and some apparent trends in the approaches and strategies. In summary:

● ***Emphasis is being placed upon demonstrating that all radioactive wastes, even the most highly radioactive wastes, can be safely isolated for the required time period from man and the environment.*** Most countries with nuclear power have programmes to study, develop, and demonstrate technical solutions to safely manage radioactive waste. The purpose of many projects for research and development and demonstration is to show that acceptable methods exist for long-term safe disposal of such wastes. These developments and continued studies are important for several reasons: they will test the latest conceptual solutions and options for waste management and disposal; they will yield further test data that will help to improve computerized mathematical models used to make safety assessments and evaluations of potential geological disposal conditions; and they will help assess, through analytical modelling and



In the United Kingdom each year, more than 4 million cubic metres of toxic waste are produced. Only 1.1% of this amount is radioactive waste. Of this small fraction, most of the waste contains low levels of radioactivity.

Radioactive waste terms

For safety and technical reasons, the various forms of nuclear wastes are usually categorized by their levels of radioactivity, heat content, and potential hazard. The IAEA has established definitions describing the technical features of radioactive wastes that are applied to their management in many countries. For general purposes, however, more simplified descriptions and explanations of important terms may be useful to a basic understanding:

- ***Half-life.*** This term refers to the time it takes for any given radionuclide to lose half of its radioactivity. Most significant fission products, which are highly radioactive, have half-lives of about 30 years or less; for example, caesium-137. A few, such as iodine-129, have half-lives in the thousands of years. For perspective, natural uranium has a half-life of about 4500 million years, or roughly the age of the earth.
- ***Short-lived and long-lived wastes.*** These terms refer to a given radioactive element's half-life. Those with half-lives longer than approximately 30 years are generally considered long-lived.
- ***Low-level wastes (LLW)*** contain a negligible amount of long-lived radionuclides. Produced by peaceful nuclear activities in industry, medicine, research, and by nuclear power operations, such wastes may include items such as packaged gloves, rags, glass, small tools, paper, and filters which have been contaminated by radioactive material.
- ***Intermediate-level wastes (ILW)*** contain lower levels of radioactivity and heat content than high-level wastes, but they still must be shielded during handling and transport. Such wastes may include resins from reactor operations or solidified chemical sludges, as well as pieces of equipment or metal fragments. Commercial engineering processes are being used to treat and immobilize these wastes; *disposal in surface structures or shallow burial* is practiced widely. Some countries have built or plan to build shallow repositories in rock formations on land or under the sea.
- ***High-level wastes (HLW)*** arise from the reprocessing of spent fuel from nuclear power reactors through which uranium and plutonium can be recovered for re-use. These wastes contain transuranic elements, and fission products that are highly radioactive, heat-generating, and long-lived. Liquid HLW has been effectively stored in tanks at specially constructed facilities. Before final disposal and isolation from the biosphere, they require treatment and solidification. Spent fuel that is not reprocessed may be considered a high-level waste.
- ***Alpha-bearing wastes*** (also called transuranic, plutonium-contaminated material, or alpha wastes) include wastes that are contaminated with enough long-lived, alpha-emitting nuclides to make disposal at a shallow land burial site unacceptable. They arise principally from spent fuel reprocessing and mixed-oxide fuel fabrication. The wastes may be disposed of in a similar manner to HLW.

Environmental assessment

Following the recommendations of the Post-Accident Review Meeting on the Chernobyl Accident in 1986, the IAEA established an international study aimed at utilizing the environmental data which exist as a result of the fallout from the Chernobyl release. This study, known as the Validation of Model Predictions (VAMP), seeks to take the advantage of the "natural laboratory" for validating environmental transfer models. Such models find application in assessing the radiological impacts in all parts of the nuclear fuel cycle. It operates with four separate working groups of experts from research institutions in more than 20 Member States and has attracted co-sponsorship from the Commission of the European Communities (CEC). VAMP is scheduled to continue until 1992.

The IAEA is also participating in a similar international study, the Biospheric Model Validation Study (BIOMOVS), initiated in 1986 by the Swedish National Institute of Radiation Protection (SSI). This study, which began prior to the Chernobyl accident, tests models for ecological transfer and bioaccumulation of the radionuclides and other tracer substances. The study has changed its original schedule to consider post-Chernobyl accident data and will now continue until 1991. — *S. Hossain, Division of Nuclear Fuel Cycle and Waste Management*

validation and laboratory research, the capability of a waste repository to protect public health safely over the long-term. Additional assurance on the long-term behaviour of waste is being obtained from studies of natural radioactive conditions, including the behaviour of radionuclides from uranium ore bodies that have been present and undisturbed in the earth's crust for millions of years.

- ***Several countries are building or planning commercial-scale reprocessing and vitrification facilities.*** The reprocessing of spent fuel is planned or being implemented by almost one-half of the countries with nuclear power. France and the United Kingdom have had commercial reprocessing capabilities for nearly a decade. However, by the early 1990s, most of the other countries planning reprocessing will have operational facilities.

To improve vitrification technologies (the immobilization of waste into glass or glass-like form), some countries have built or plan to build small-scale pilot plants to demonstrate the technology at hand. A few full-scale vitrification plants are presently in operation and other plants are either in the planning or construction phase. The Australian Nuclear Science and Technology Organization (ANSTO) has recently started integrating its Synroc small-scale demonstration plant with a larger plant where alternative calcination methods will be developed and studied.

● ***Most countries with nuclear power programmes are developing technology for deep geologic disposal facilities for high-level radioactive waste (HLW).*** The factors influencing nuclear waste management depend on the country's policy and involvement in the various stages of the nuclear fuel cycle. However, there is international consensus, supported by technical basis, that deep geologic disposal of HLW and/or spent nuclear fuel is the preferred option at this time. However, some national programmes continue investigation of other disposal options, such as sub-seabed disposal. *(See accompanying tables.)*

● ***Countries continue to develop more efficient and effective treatment and conditioning, and disposal technology for low-level waste (LLW) and intermediate-level waste (ILW).*** Developments include new processes and techniques to reduce waste volumes at points of generation and after generation (i.e., incineration and compaction). Additionally, studies of different immobilization methods are receiving major emphasis. In the past, some LLW were disposed of with little or no treatment and/or conditioning. National programmes are being redefined and practices developed to eliminate negative environmental impacts of LLW disposal.

● ***A number of countries have established special methods of funding nuclear waste management and disposal programmes, and nuclear plant decommissioning.*** These methods include assessing nuclear electricity producers (or waste generators) a small fee per kilowatt-hour of electrical generation to cover current and expected costs to develop, operate, and close disposal projects. Because of the vast amounts of electricity produced, these small assessments are expected to adequately finance national nuclear waste management and disposal programmes. In absolute terms, total estimated costs vary considerably depending upon the size and requirements of a country's nuclear power and fuel-cycle programme. In context the costs are relatively low compared to the total value of electricity produced. On a percentage basis, they are generally expected to range from 2–6% of the total production costs of nuclear electricity, according to studies reported to the IAEA and Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (NEA/OECD).

● ***The volume of radioactive wastes will grow in the years ahead in developing and industrialized countries alike because of nuclear energy's continuing development, as well as from the decommissioning of old nuclear reactors that will have to be dismantled.*** Worldwide, 31 countries had 531 nuclear power reactors in operation or under construction as of October 1989, based on data reported to the IAEA. In 67 countries, 356 research reactors were in operation, under construction, or planned. Another 239 units were in shutdown status at year-end 1988. Additionally, nearly 100 nuclear facilities were in various stages of decommissioning in 17 countries.

Synthetic rock

At a demonstration plant at Lucas Heights in Australia, scientists are testing a product known as Synroc for immobilizing highly radioactive wastes. The synthetic rock formulations are made of three titanate minerals and a small amount of metal alloy. Plant operations will provide practical experience in fabricating Synroc at or near full-scale on a non-radioactive basis; there is no commitment to build a radioactive Synroc plant in Australia. The plant will also provide data for the design of a plant that would process radioactive wastes and allow preliminary estimates to be made of the cost of fabricating radioactive Synroc.

The Synroc strategy is based on the knowledge that certain natural minerals have survived extreme geological conditions for millions of years. All rocks contain small amounts of radioactive elements, such as uranium, thorium, and potassium, that become distributed among co-existing minerals as dilute solid solutions. Many of these minerals, such as zircon and feldspar, have demonstrated their ability to lock up small amounts of radioactive elements for millenia. In Synroc, the radioactive waste elements are likewise immobilized as solid solutions in the crystalline structures of their host minerals.*

In its development and testing, Australia is collaborating with the United Kingdom, Japan, and Italy. In the United Kingdom, small Synroc specimens containing highly active waste have been made and similar work is planned in Japan, where Synroc samples previously have been produced. Synroc properties and performance have also been studied in laboratories in Canada, the Federal Republic of Germany, and the United States. In Australia, main participants in research and development are the Australian Nuclear Science and Technology Organization (ANSTO) and the Australian National University (ANU), where the Synroc concept was invented by Prof. A. E. Ringwood and colleagues in the 1970s.

As part of national activities, ANU has prepared Synroc containing radioactive uranium and technetium and tested its properties. ANU researchers also have carried out geological, crystallographic, and isotopic studies of naturally occurring minerals that have been exposed to large cumulative doses of radiation over geological time and that have quantitatively retained radioactive elements. ANSTO has prepared and leach-tested radioactive Synroc containing actinide elements and, separately, fission products that are a by-product of medical isotope production at its Lucas Heights research reactor. Excellent results were reported. Synroc has also been subjected to fast neutron irradiation at the research reactor. In tests lasting up to 6 months, Synroc has withstood a simulated 100 000 years of high-level waste containment without experiencing any significant physical damage or loss of resistance to leaching, ANSTO reports.

* "Synroc", by A. E. Ringwood and S. E. Kesson, *Radioactive Waste Forms for the Future,* Elsevier Science Publishers B.V. (1988).

Low- and intermediate level waste: Handling and disposal strategies

	Handling strategies	Type of disposal (actual and/or proposed)
Argentina	some incineration	shallow land
Belgium	treated, packed and stored	repository
Brazil	treated, packed and stored; some incineration	shallow land or sea coast facility
Bulgaria	treated/untreated, packed and stored	surface land/landfill
Canada	treated/untreated, packed and stored	shallow land; repository
China	treated/untreated, packed and stored; some incineration	shallow land
Cuba	treated, packed and stored; some incineration	surface land/landfill
Czechoslovakia	treated, packed and stored; some incineration	shallow land; repository
Finland	treated, packed and stored	repository
France	treated, packed and stored; some incineration	shallow land; surface land/landfill
German Dem. Rep.	untreated, packed and stored; packaged and buried	repository
Germany, Fed. Rep. of	treated, packed and stored; some incineration	repository
Hungary	treated, packed and stored	shallow land
India	treated, packed and stored; some incineration	surface land/landfill
Italy	untreated, packed and stored	shallow land
Japan	treated, packed and stored	shallow land; seabed studies
Korea, Rep. of	treated, packed and stored	shallow land; repository
Netherlands	treated, packed and stored; some incineration	repository
Romania	treated, packed and stored; some incineration	
Spain	treated, packed and stored	shallow land
Sweden	treated, packed and stored; packaged and buried	sea coast facility
Switzerland	treated, packed and stored; some incineration	repository
United Kingdom	treated, packed and stored; some incineration	shallow land; repository; seabed studies
United States	treated/untreated, packed and stored; some incineration	shallow land; surface land/landfill
USSR	treated, packed and stored; some incineration	surface land/landfill
Yugoslavia		repository; surface land/landfill

High-level waste/spent fuel disposal: Research and development programmes

			Underground research laboratory		
	Site investigation	Site selection	Construction	Investigation	Repository operation (projected)
Argentina	■				
Belgium	■	■	■	■	
Brazil	■				
Canada	■		■	■	>2020
China	■				
Finland	■				
France	■	■			2009
Germany, Fed. Rep. of	■	■	■	■	>2000
India	■		■	■	
Japan	■	■			>2020
Netherlands	■				
Spain	■				2005–10
Sweden	■	■			>2020
Switzerland	■	■	■	■	>2020
United Kingdom	■				
United States	■	■	■		2003
USSR	■				

Notes: In Bulgaria, Cuba, Czechoslovakia, German Democratic Republic, Hungary, Poland, and Romania, spent fuel is to be returned to the foreign supplier.

National plans for disposal of high-level waste and/or spent fuel

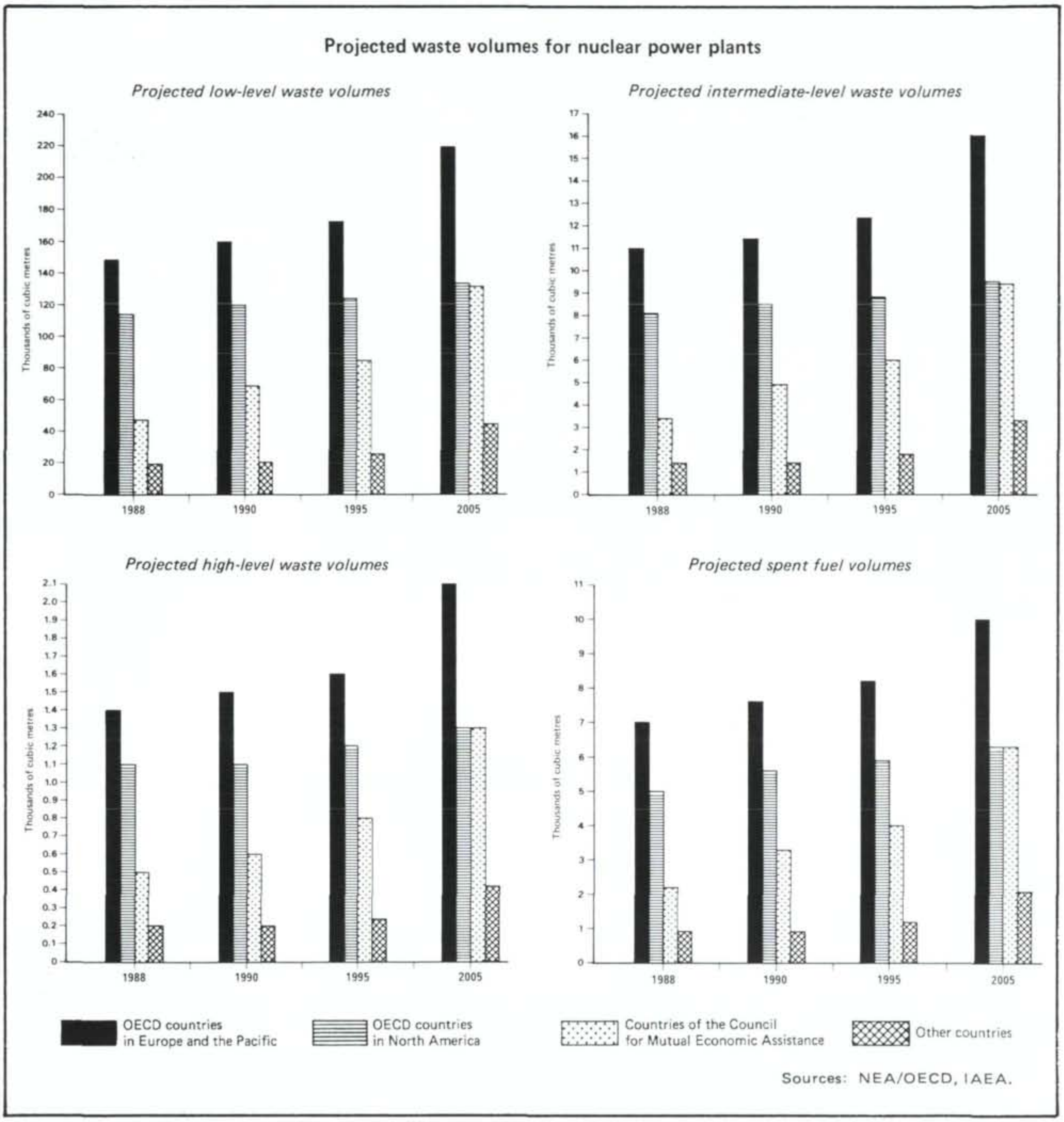
	Geological disposal	Rock media	Reprocessing Domestic	Reprocessing Foreign	Final waste form
Argentina	■	Granite	■		Glass blocks
Belgium	■	Clay		■	Glass blocks
Bulgaria				■	
Canada	■	Granite			Spent fuel in casks
China	■		■		Glass blocks
Cuba				■	
Czechoslovakia				■	
Finland	■	Granite		■	Glass blocks
France	■	Clay, salt, granite, schist	■	■	Glass blocks
German Dem. Rep.				■	
Germany, Fed. Rep. of	■	Salt		■	Glass blocks
Hungary				■	
India	■	Granite	■		Glass blocks
Italy	■	Clay or crystalline		■	Glass blocks
Japan	■	Granite, schist, tuff	(1992) ■	■	Glass blocks
Netherlands	■	Salt, clay		■	Glass blocks
Poland				■	
Romania				■	
Spain	■	Salt, clay, crystalline		■	Glass blocks and spent fuel in casks
Sweden	■	Granite			Spent fuel in casks
Switzerland	■	Granite, sedimentary rock		■	Glass blocks and spent fuel in casks
United Kingdom	■		■	■	Glass blocks
United States	■	Tuff			Spent fuel in casks
USSR	■	Salt, crystalline	■	■	Glass blocks

Notes: No Member State has made a final selection of a repository site for disposal of HLW or spent fuel. The identified rock media are those under consideration and/or the subject of site characterization studies. In Bulgaria, Cuba, Czechoslovakia, German Democratic Republic, Hungary, Poland, and Romania, spent fuel is to be returned to the foreign supplier.

According to calculations based on latest nuclear power plant capacity figures published by the NEA/OECD and the IAEA, waste inventories have been projected for the years 1988, 1990, 1995, and 2005. *(See figures on page 10.)* These estimates are based on a 30-year average life for nuclear power plants (actual figures may differ).

• ***Developing countries face different problems — and therefore have different immediate needs — than industrialized countries in the day-to-day safe handling and management of radioactive waste.*** Some reasons for this are that their nuclear power programmes are either in the early stages or just beginning. Therefore their total experience base is smaller and their overall industrial and regulatory infrastructures are frequently not as established. Many developing countries do not have nuclear power programmes but must manage wastes from the use of radioisotopes in industry, medicine, research, and other fields. To assist developing Member States with their specific waste management needs, the IAEA provides technical assistance by sponsoring technical projects, experts, training, and equipment. (See article in this edition: "Radioactive waste management in developing countries.")

• ***In many countries, public opinion has heavily influenced the progress of radioactive waste management and can be expected to do so in years ahead.*** Although scientists and engineers are confident that modern technology can ensure the safe disposal of nuclear wastes, the public is often not so sure. "What is needed in many countries is an effort to make the proposed techniques and their safety features more widely understood," IAEA Director General Hans Blix has said. "It is evident that this educational effort may be more difficult than the engineering effort that has been required." The number of national and international public information and education programmes has increased significantly in the past few years. Many organizations are identifying and preparing mechanisms to reach and educate the public. The IAEA is currently preparing an IAEA Source Book highlighting the main issues of public concern related to waste management and disposal. The book will provide an overview of how some countries are dealing with nuclear wastes, how they communicate with the public, and how policies are developed and implemented. Its purpose is to provide countries with a reference of issues, concerns, and possible solutions.



● ***International co-operation and exchange between national programmes and international organizations continue to be important and beneficial for all parties involved.*** Co-operative studies, special working groups, and joint projects sponsored by and between national and international organizations continue to increase as organizations recognize the importance and benefits of joint efforts. International organizations such as the Commission of the European Communities (CEC), IAEA, and the NEA/OECD have sponsored and participated in various technical and environmental studies related to waste management. Joint studies, such as the Stripa project in Sweden, continue to provide valuable data and experience for its participants. Several new environmental initiatives jointly sponsored by the three organizations are planned or under way.

Radioactive waste management strategies

Low-level and intermediate-level waste. Most national strategies include some treatment and conditioning of LLW and ILW. During the past several years, many national programmes have established active projects and studies to develop techniques and technology that would significantly reduce the amount of waste generated and to reduce the volume of waste "after generation''. After treatment and/or conditioning, the waste is usually packaged and stored or placed in an engineered disposal facility (i.e., in shallow ground and concrete trenches).

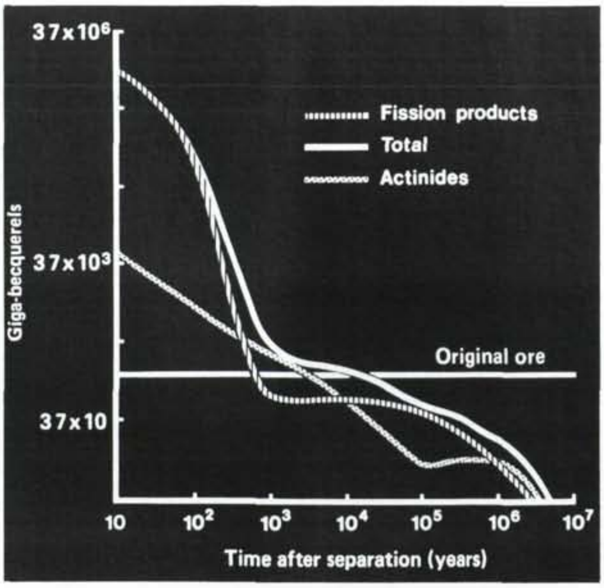
Repositories and shallow-ground disposal facilities for LLW and ILW already are operating in some countries. The German Democratic Republic, for example, has operated a repository for its reactor wastes since 1978. Sweden completed a repository (SFR) under the Baltic Sea near Forsmark in 1988. Other countries have facilities for surface storage or shallow-ground disposal of their LLW/ILW.

Spent fuel and HLW. Initially, spent fuel are stored underwater at reactor sites in specially constructed pools to allow much of the radioactivity to decay during interim storage. Many countries then store the spent fuel in centralized interim storage facilities or at reprocessing facilities. How long spent fuel remains in interim storage largely depends upon national policies. Spent fuel is usually stored 5–10 years prior to reprocessing. On the average, HLW and/or spent fuel will be stored for 20–50 years prior to disposal. From a technical viewpoint, radioactive decay during storage eases disposal and handling requirements; the decay is most rapid in earlier years. *(See accompanying graph.)*

Centralized storage centres (''away from reactor'' or AFR facilities), for spent fuel have been built or will be in some countries. In some cases, they are needed to better integrate the entire waste management system prior to reprocessing or disposal, or because of limited capacity at interim storage facilities at reactor sites. Serious storage problems are facing power plants in some countries. Studies by the IAEA and NEA/OECD have estimated that about 200 000 metric tonnes of spent fuel will accumulate by the year 2000 from light-water reactors worldwide.*

Currently, nine countries are operating or building reprocessing facilities for spent fuel, and 11 countries are or will be sending spent fuel abroad for reprocessing. At present, about half of the Member States with nuclear power plants plan to reprocess spent fuel, through which reusable uranium and plutonium is separated from fission products.

Deep geological disposal for HLW — concept and rational. Why deep geologic disposal? Many scientists agree that deep geologic disposal of HLW waste is the most preferred disposal option available today. It is also agreed that the objective of geological disposal is to isolate radioactive waste from the human environment for a period of time and in conditions such that any possible subsequent release of radionuclides from the repository will not result in unacceptable radiological risks, even in the long term.**



The radioactivity of high-level waste declines steadily over time, most dramatically over the first hundreds of years. Eventually the radioactivity level will be lower than that of the natural uranium ore from which the spent fuel originally came. The graph shows the levels of radioactivity in waste products for one tonne of fuel.

The becquerel is the international unit of measurement to indicate how fast a radioactive element spontaneously decays or disintegrates and releases its energy. One becquerel corresponds to the decay of one atom per second. The becquerel is a smaller unit than the curie, which also is sometimes used. One curie equals 37 giga-becquerels.

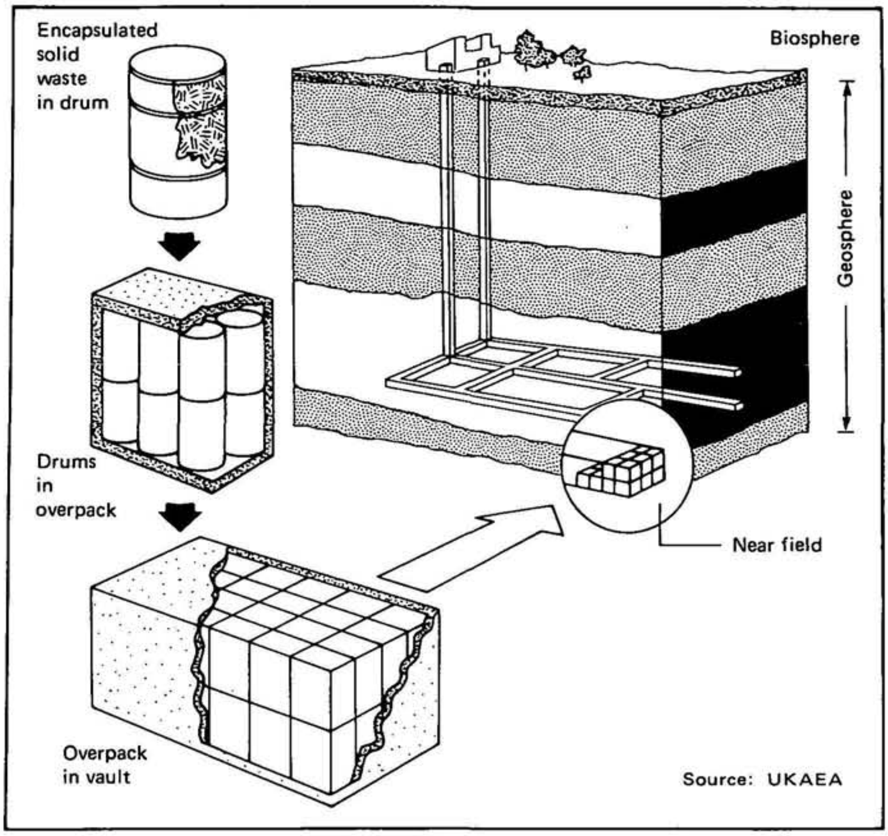
This objective can be achieved by designing multi-component systems, where the waste package (the waste form, canister, and overpack), the other engineered barriers, and the repository and specific characteristics of the geological system (e.g., geology, hydrogeology) provide multiple barriers to radionuclide release and transport. The emplacement of properly packaged long-lived waste at depth in stable geological formations can assure that the waste will remain immobilized and isolated while radioactive decay reduces radioactivity to low or negligible levels. It is agreed that radiological risks to present and future generations must be limited to very low levels compatible with relevant national and international safety requirements.

The first commercial demonstrations of final disposal for conditioned high-level waste and/or spent fuel are expected within the next 10–15 years. In the meantime, tests and analytical studies are intensifying to improve knowledge about long-term behaviour of the waste form, waste containment, and selection of suitable disposal sites.

Underground research sites. At underground research laboratories in Belgium, Canada, the Federal Republic of Germany, India, Sweden, Switzerland, and the United States, scientists and engineers are conducting detailed investigations of sites in salt, clay, crystalline, and other types of rock formations. At some of these test facilities, highly active elements have been

* *Nuclear power and fuel cycle: Status and trends,* Part C of the *IAEA Yearbook 1989,* Vienna (1989).

** *In-situ research and investigation in OECD countries,* NEA/OECD, Paris (1988).



For the deep geological disposal of low- and intermediate-level wastes, strategies in a number of countries call for a multi-barrier approach, similar to the one illustrated here.

emplaced inside boreholes in excavated vaults for periods of time to demonstrate the technology at hand. Several countries are planning or currently building underground test facilities at the potential repository site. Some of these countries participate in the world's first international underground research laboratory at the Stripa mine, which began in 1978. The Stripa project, now well into the second year of its third phase, will work on site investigation techniques, geophysics technique development, network modelling, channelling effects, and sealing of fractured rock.*

Analogues: natural laboratories. One of the most unique and scientifically complex aspects of predicting the safety of HLW repositories is the application of short-term laboratory data to long time periods. Studies of natural analogues may be the best way of obtaining evidence of the cumulative effect of the migration of radionuclides over tens of thousands of years.

Several national and international organizations have joined in co-operative natural analogue projects: scientists are studying several uranium ore deposits in the Alligator Rivers region in the Northern Territory of Australia; in northern Saskatchewan, Canada, researchers are studying the Cigar Lake uranium deposit, where they are especially interested to learn what influenced the migration of radionuclides in the host rock and why the uranium ore body has survived for 1300 million years in a relatively open system saturated with groundwater; detailed studies are being done of a thorium deposit near Poços de Caldas, Brazil; and, at the Oklo site, the natural laboratory located in Gabon, researchers have gathered valuable information related to the long-term storage of radioactive wastes.

Ocean disposal for LLW/ILW. Disposal of packaged, solid low-level radioactive waste into the sea is an alternative to land disposal for some waste types. Studied since 1949, and regularly practised by several countries in the past, ocean disposal of certain packaged radioactive wastes remains under consideration by some countries. However, under the *Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter* (known as the LDC or London Dumping Convention), signed in 1972, a non-binding moratorium on the sea-dumping of radioactive wastes was agreed to by LDC parties while certain issues are resolved. (See related article in this edition: "Ocean disposal of radioactive waste: Status Report".)

Within the framework of the LDC, the IAEA has defined HLW unsuitable for dumping at sea. It has also issued recommendations to parties on the quantities and the nature of material that may be dumped. The definition is continually reviewed to reflect changes in radiation protection philosophy, improvements in ocean

* *"Update on waste management policies and programmes", Nuclear Waste Bulletin No. 2,* NEA/OECD, Paris (1988).

Code of practice for international transactions involving radioactive waste

Following concerns that toxic wastes had been dumped in developing countries, a resolution to develop a code of practice for international transactions involving radioactive wastes was adopted by the IAEA's 32nd regular session of the General Conference in September 1988. The code of practice is meant to guide governments in the prevention of illicit transactions and dumping of radioactive wastes.

In response to this resolution, the first meeting of an expert group was convened at the IAEA in Vienna in May 1989. The experts represented 20 Member States and three international organizations. Some of the basic principles under discussion at the meeting were aimed at ensuring that all international radioactive waste transactions should take place with the express consent of the countries concerned in accordance with their laws and regulations and in conformity with internationally accepted safety standards; no radioactive wastes should be exported to any country that lacks the technical and/or administrative capacity to safely manage and dispose of such wastes; and wastes that are to be the subject of a transboundary movement should be transported in conformity with generally accepted international rules and standards.

The draft code of practice will be finalized at the next meeting of the expert group in January 1990, and submitted for approval to the IAEA Board of Governors and the General Conference in September 1990. — *P.L. De, Division of Nuclear Fuel Cycle and Waste Management*

modelling and in our understanding of the impact of sea disposal on marine species. Such reviews bring together international experts of various disciplines and views from many organizations.

The future

In summary, the time it has taken, and will still take, to prepare, implement, and demonstrate safe, permanent solutions to radioactive waste disposal reflects the political, economic, and environmental importance to public health and safety of the task at hand, and its technical challenges. However, it is not the technical challenges and issues that will stand in the way of progress. There is international consensus that the technical solutions for waste management and disposal exist and can be demonstrated. It is the institutional and socio-political issues that must be resolved for progress to continue. Therefore, national and international waste management programmes must continue to draw from a broad, common, technological, and institutional base available to meet the needs of their specific programmes. On all fronts, international co-operation will and must remain an active, and necessary, component of progress for all countries.