COMMISSION OF THE EUROPEAN COMMUNITIES

COM(93) 88 final

Brussels, 1 April 1993

COMMUNICATION AND THIRD REPORT FROM THE COMMISSION

on the present situation and prospects for radioactive waste management in the European Community

----

COMMUNICATION FROM THE COMMISSION

on the present situation and prospects for radioactive waste management in the European Community

----

I- INTRODUCTION

In its resolution of February, the 18th, 1980[1], the Council approved a Community Action Plan for 1980-1992 in the field of radioactive waste. This plan deals with problems due to radioactive waste from nuclear facilities and more especially those concerning management and disposal of high level and/or long-lived waste.

Under Point 1, the plan provides for continuous analysis of the situation regarding radioactive waste management in the Community with a view to adopting the necessary solutions. This analysis must deal with:

- the available techniques, the existing facilities and those planned by the Member States in order to ensure the different stages of radioactive waste management which include the processes and procedures enabling final disposal;

- the research and technological development works planned by the Member States and the Community;

- the management practices of the different waste types in the Member States, defined or to be defined;

- the implementation previsions and their timetable.

Information and results obtained during these studies must be exploited "with a view to continuously provide the Community and the Member States with an inventory of results and achievements in the field of radioactive waste management and storage, taking into consideration the needs of nuclear programmes".

The Commission forwarded to the Council in 1983 and 1987[2] two reports concerning the situation and the prospects for nuclear waste management in the Community Member States until the end of the century.

The Commission forwards as appendix its third report based on the 1990-1991 situation and compiled as were the previous ones from information provided by the Member States.

The Council has recently approved the renewal of the Plan[3] for the period 1993-1999. This renewal should in particular allow the Commission to continue periodically to inform the Council by other reports.

---

1 *see O.J. N°C51/1-2-3 of 29.02.1980*

2 *Communications from the Commission to the Council "First report on present situation and outlook for radioactive waste management in the Community", doc. COM (83) 262 of 16.05.1983 and "Second report", doc. COM (87) 312 of 29.07.1987.*

3 *Council Resolution of 15.06.1992*

II- PRESENT SITUATION AND PROSPECTS OF RADIOACTIVE WASTE MANAGEMENT

The report appended outlines the following points:

II.A. Waste generation

The high level of development of the Member States implies the production of many different types of radioactive waste with various origins in the Community; the amount of waste generation varies considerably from one Community State to the other; however every State is concerned by this problem.

- The first production source is the use of radioisotopes and some irradiation devices in industry, medicine and non nuclear research. It exists in all Member States. This waste is low level with the exception of used radiation sources. Although the national data concerning this waste are difficult to compare, it appears that the volumes involved cannot be neglected and require careful management.

- The second production source is the processing of ores or raw materials containing naturally occurring radionuclides by various industries; it exists in States with or without nuclear power programmes, which have industrial activities such as uranium mining and milling , phosphate fertilizer production and oil and gas extraction; this waste contains only natural radionuclides and is mainly only slightly radioactive. With the exception of those dealing with the uranium mine working, the data concerning this last waste type are not systematically available.

- The development of nuclear power programmes including the associated research and the decommissioning of obsolete facilities represents the third production source[4]. The waste arising from nuclear power stations and from associated fuel cycle installations represents the main part in terms of radioactivity contained. This waste belongs to all types (low, intermediate and high activity; short-and long-lived). It exists in Member States which are, or have been, involved with nuclear power programmes. In terms of volume, the annual production of this waste is in line with the previsions of the previous report and should remain more or less constant during the decade, depending on various factors (evolution of national nuclear programmes, technological progress in the field of waste processing, management optimisation, etc).

Although the report covers the period 1990-2020, the estimates beyond 2000 are highly speculative, taking into account the uncertainties related to the national policies as far as nuclear plant building and dismantling are concerned.

---

[4] *Military wastes do not come within the scope of this report.*

II.B. *Management of short lived waste*

Management and disposal of low and medium level activity (short-lived) waste, which represent 90% of the volume produced in the nuclear power industry, benefit from effective and well-tested technical solutions.

The processing methods clearly satisfy, in general, the present needs of industry and the requirements of the Community safety authorities; although these operations have been carried out for several decades, they continuously benefit from technological progress and management optimisation, in particular with regard to the reduction of generated waste volumes and of radioactive releases into the environment.

Near-surface disposal in engineered structures is most particularly developed and is increasingly practised in the Community for this waste type[5]. The capabilities of the national facilities recently brought into operation should accommodate the needs of the Member States concerned until about 2020/2030.
The other Member States' needs should be covered by an alternative option, disposal in deep repositories (see Section C below), which is being carried out or waiting for operation license, or long term storage (case for one Member State).

II.C. *State of deep disposal*

There is no doubt that deep disposal[6] of all types of radioactive waste is technically feasible and safe in principle after two decades of research programmes, development and demonstration at international, Community and national levels. Methods exist to estimate its safety as a function of the sites considered.

This kind of disposal has so far never been practised for the waste types, for which it is imperative, i.e. for long-lived waste: intermediate level waste contaminated by alpha emitters or high activity waste[7] producing heat by radioactive decay. This situation is not peculiar to the Community. It is not worrying from the radiation protection point of view since these waste types can be safely stored temporarily in appropriate facilities.

As far as high level waste is concerned, it is indeed advisable to let it "cool down" during a few decades for technical and safety reasons. Moreover, solutions and long term storage facilities exist or are being developed.

This situation is, on the other hand, unfortunate for alpha emitter contaminated waste, which does not present "cooling" requirements and has a volume to be stored which is becoming substantial - 8% of the total volume of generated waste per year. The projects in progress in some Member States then take on a greater importance.

---

5 *About 1,400,000 m^3 have already been disposed of, embedding materials and packages included.*

6 *Also named "geological" disposal.*

7 *Vitrified waste generated during reprocessing of spent fuel or spent fuel itself when it is not planned to reprocess it.*

II.D. Achievements and unsolved questions

Generally speaking, the safety of management of radioactive waste produced by the nuclear industry and the reduction of its impact on the environment appear to have significantly progressed during the last few years owing to the combination of technological progress, high effective investment, management improvement, structures put into position in the various Member States and to improving statutory regulations.

Waste coming from hospitals, industry and research laboratories is dealt with by efforts aiming at maintaining and improving its production and management control.

Some questions of a statutory or strategic nature still remain to be resolved and deserve a special attention, in particular the management of very slightly radioactive materials of various origins, the equivalence between radioactive waste coming from different sources and public information and consultation.

III- COMMISSION ACTION

From the report attached to this communication, Commission action seems to have responded well to the Community's needs in the scope of R&D both in the field of regulations and in providing incentives to cooperation and harmonization between the Member States.

- In the scope of R&D, the 1985-1989 programme has been carried through[8] and the 1990-1994 programme is being carried out with the support of the Advisory Management and Coordination Comittee.

- In the field of regulation, the measures taken to avoid uncontrolled transfers of radioactive waste from one country to the other have to be particularly noted[9]. Likewise, the Community has prohibited all direct and indirect export of hazardous waste and radioactive waste to the 68 ACP States[10]

- In the field of cooperation and harmonization, the still wider opening of national underground disposal experimental facilities to scientific teams from other member countries and the development of a Community laboratory network aiming at optimizing and harmonizing the quality control of waste packages are two outstanding examples.

---

8 *See evaluation of Community Research in the field of Radioactive Waste Management and Storage (1985-1989) - EUR report N°12264 EN.*

9 *Council Directive of February 3, 1992 on the supervision and control of shipments of radioactive waste between Member States and into and out of the Community - O.J. L35 - 12/02/92 p.24.*

10 *According to the article 39 of the fourth ACP-CEE Convention, signed in Lomé on 15 December 1989*

- In order to follow up the commitments made in the Community 5th action programme on the environment, the Commission intends to come forward shortly with a Community strategy on radioactive waste. This would complement the Community strategy on waste (which excludes radioactive waste) set out in the Council resolution of 7 May 1990.

IV- *RECOMMENDATIONS*

According to the analysis carried out in the attached report and summarized in Section II above, the Commission draws the attention of the Council to the following points:

- radioactive waste management is an important element as far as safety and environment protection are concerned; it must be developed and structured for all waste, whatever the origin of its production, in order to ensure the respect of safety and radiological protection requirements;

- the study, the choice and the opening of disposal sites are priorities and must be continued;

- the efforts of technological development and optimization must be carried on, in particular in the field of management of waste containing long lived radionuclides (e.g. volume reduction, waste decontamination and reduction of long term radiotoxicity).

- radioactive waste management and particularly its final stage, disposal, requires intensive public information and consultation.

THIRD REPORT FROM THE COMMISSION

on the present situation and prospects for radioactive waste management in the European Community

----

TABLE OF CONTENTS

ABBREVIATIONS

AEA	Atomic Energy Authority
ANDRA	Agence Nationale pour la gestion des Déchets RAdioactifs
BfS	Bundesamt für Strahlenschutz
BNFL	British Nuclear Fuels plc
CEA	Commissariat à l'Energie Atomique
CEC	Commission of the European Communities
CEN/SCK	Centre d'Etude de l'énergie Nucléaire/Studie Centrum voor Kernenergie
CIEMAT	Centro de Investigaciones Energeticas, Medio Ambientales y Technologicas
COVRA	Centrale Organisatie Voor Radioactief Afval
DBE	Deutsche Gesellschaft zum Bau und Betriebe von Endlagern für Abfallstoffe
EC	European Community
ENEA	Ente per le Nuove technologie, l'Energia e l'Ambiente
ENEL	Ente Nazionale dell'Energia ELettrica
ENRESA	Empresa Nacional de RESiduos rAdioactivos
HLW	High Level Waste
IAEA	International Atomic Energy Agency
LLW	Low Level Waste
MLW	Medium Level Waste
NE	Nuclear Electric
NEA	Nuclear Energy Agency
NIREX	Nuclear Industry Radioactive waste EXecutive
NUCLECO	NUCLeare-ECOlogia
ONDRAF/ NIRAS	Organisme National des Déchets Radioactifs et des matières Fissiles/Nationale Instelling voor het Beheer van Radioactief Afval en Splijstoffen

OECD	Organisation for Economic Co-operation and Development
OPLA	OPslag op LAnd
SN	Southern Network
WAK	WiederaufArbeitungsanlage Karlsruhe
WHO	World Health Organisation

PREFACE

The Community Plan of Action in the field of radioactive waste for 1980-92, approved by the Council of Ministers of the European Communities in February 1980[1], provides under point 1 for continuous analysis by the Commission of the situation regarding radioactive waste management in the Community.

To enable the Community and the Member States to make use of the results of such an analysis, the Commission periodically reports to the Council of Ministers.

Reports were forwarded to the Council in 1983 and 1987[2]. The present report is thus the third of its kind; it updates and supplements the information presented in the previous reports and for the first time provides information on the situation in the new States ("Länder") of the Federal Republic of Germany. The evaluation of radioactive waste arising in the Community has tentatively been extended up to 2020.

The present report is based on information from national sources supplied by Member States' delegates on the Commission's Advisory Committee for the Community Plan of Action in the field of radioactive waste.

General background information on radioactive waste has been set out in the previous reports, to which the reader will hence have to refer when the need arises.

* *

*

1.) Council Resolution of 18 February 1980, O.J. No C 51, 29.2.1980, p. 1

2.) Communications from the Commission to the Council of Ministers of the European Communities, Doc. COM (83) 262 of 16 May 1983 "Analysis of the present situation and prospects in the field of radioactive waste management in the Community" and Doc. COM (87) 312 of 29 July 1987, idem.

CHAPTER I

WASTE MANAGEMENT IN PERSPECTIVE

During the last decade the management of waste of any kind (domestic, industrial toxic and non toxic, nuclear) has been the subject of increased attention and concern in the European Community.

As far as domestic and industrial wastes are concerned, first estimates of arisings have been produced at national and Community levels. The annual production of solid waste (all categories together) is roughly of 2,200 million tons for the Community as a whole of which 20 million tons are industrial toxic waste. Provisional lists are being made of the harmful products which may be contained in these wastes and broad categories are being set up with a view to make easier the safe management and disposal of these wastes. Disposal options for toxic waste, mainly underground, are being reviewed in some countries, like the Federal Republic of Germany, as well as appropriate waste forms, according to the "system approach" already developed for nuclear waste (see Chapter III).
In parallel, the regulatory framework is being strongly developed at national and Community levels, notably the relevant EC legislation.
An EC waste strategy has been adopted at the end of 1989. In addition, appropriate national structures for this type of waste, have been recently created in several Member States.

As far as radioactive waste is concerned, estimates of past and future production according to categories have been made country by country and for the European Community as a whole. In the latter case an annual arising amounts to approximately 80,000 m^3, out of which some 150 m^3 are highly radioactive. Practices and trends in waste processing and disposal, national management strategies, regulatory developments and national structures (i.e. national agencies, waste operators, safety authorities) have been the subject of Commission's reports to the Council of Ministers in 1983 and 1987. In addition, since 1980, the Community Plan of Action in the field of radioactive waste has provided a suitable framework for concerting the national policies and regulatories practices in the field of waste management.

Since then, an increased awareness of the plant operators and the public has developed worldwide about additional aspects of radioactive management, like:

- the need for waste minimisation, in terms of volume, radioactivity and chemical toxicity, which calls for an optimal management procedure;

- the rules for the transport and international transfer of radioactive waste;

- the recycling and disposal of waste resulting from the dismantling of old nuclear facilities; today more than hundred major nuclear installations have been closed all over the world; this number will increase with the aging of existing plants;

- the management and disposal of radioactive waste arising outside the nuclear fuel cycle and resulting from research, industrial and medical activities involving the use of radionuclides;

- the restoration of sites used in the early years of nuclear energy;

The conditions of radioactive waste disposal and its acceptance by the public remains however today a major question in the EC and elsewhere.

The EC Commission is giving due attention to these questions by means of its research programmes and of its regulatory activities as defined in Chapter III "Health and Safety" of the Euratom Treaty. A directive on radioactive waste transfers has just been adopted by the Council of Ministers. The Council also recently drew conclusions[3.] on future priorities, notably as far as the establishment of common principles for the siting of disposal facilities is concerned.

The present report, like the two previous ones, deals with the overall situation in the EC Member States; it updates the information given in the previous reports and complements it with the questions mentioned above.

3.) Press release of December 18, 1990, N° 10871-90 - press 232

CHAPTER II

RADIOACTIVE WASTE ARISINGS IN THE EC COUNTRIES

II.1. SOURCES OF RADIOACTIVE WASTE PRODUCTION

Three types of activity which generate radioactive waste can be considered within the European Community[4.)]:

- utilisation of radioisotopes and certain types of irradiation in industry, medicine and research;
- processing by various industries of raw materials containing natural radionuclides;
- nuclear power programmes, including related research and the decommissioning of obsolete plants.

The relative importance of these sources considerably varies from one Community country to another one; all Community countries commonly use radionuclides for research, industrial and medical purposes. Those countries with nuclear power programmes generate most of the radioactivity contained in the waste and the greatest part of the radioactive waste arising in the Community as a whole. A few countries having or not having a nuclear energy programme, are operating uranium mines and mills which generate large volumes of slightly radioactive materials, containing natural radionuclides.

For several years, it has also been recognised that other industrial activities may generate similar materials. This is the case in industrial activities where raw materials containing natural occurring radionuclides at low concentrations are processed on a large scale, such as the production of artificial phosphate fertilizers and the extraction of oil and gas. In these processes, the natural radionuclides present in the raw material are concentrated either in the products or in the different waste streams. Today an overview of amounts, compositions, radioactivity levels, etc, of these wastes is however not available[5.)]

II.2. RADIOACTIVE WASTE CATEGORIES

Radioactive waste comprises a great variety of materials. These materials can have different physical/chemical forms, can emit several types of radiation[6.)]

4.) Military activities do not come within the scope of this report.

5.) The report EUR 13262 EN, 1991 "Study of the radionuclides contained in waste produced by the phosphate industry and their impact on the environment" gives datas concerning a specific case. See also section V.1. of this report for the related safety aspects.

6.) Mainly alpha, beta and gamma radiations and can contain widely different amounts of radioactivity.

Clearly, this diversity results in widely differing potential hazards and therefore necessitates different types of management. Radioactive waste must hence be classified by categories. The classification described below has already been used in the previous reports (1983 and 1987) and was chosen because it is the best way of presenting, in the case of the Community, quantitative data on treated and conditioned radioactive waste produced in the Member States. It also possesses the advantage of grouping the radioactive waste into categories which correspond to a certain extent to the disposal options applied at present or contemplated in the Member States (see Chapter III).

Four main waste categories are distinguished:

- low level waste,
- medium level waste,
- alpha waste,
- high level waste from reprocessing and spent fuel (if declared as a waste).

These categories, and the inclusion of a "type" of waste in one category rather than in another one, are not of a regulatory or normative nature. Moreover, the management practices in some Member States may be such that categories or types of waste identical to those considered in this report may not exist at national level.

(a) The low level waste category covers waste (mainly technological [7.]) containing or suspected of containing beta-gamma emitters and mainly naturally occurring alpha emitters in low concentrations (and therefore of low activity) produced by research centres and arising from industrial and medical uses of radionuclides and from the operations conducted in various installations involved in the nuclear fuel cycle. The concentration of the other alpha emitters (plutonium, americium, etc.) in this waste category is very low and is very strictly monitored. The radioactivity of such wastes becomes negligible through natural decay after several centuries at most. The waste produces only negligible amounts of heat.

(b) The medium level waste category[8.] comprises waste containing mainly beta-gamma emitters in relatively high concentrations. This waste originates,for the most part, from operation of nuclear power plants (ion-exchange resins, filter cartridges, evaporator concentrates, ...). The

---

7.) Technological wastes are generated during maintenance operations.

8.) In the Federal Republic of Germany, medium level waste and alpha waste which produce only negligible amounts of heat are combined with waste in the low level category in view of the fact that deep-lying geological formations will be used for the disposal of all categories of waste.

alpha emitters concentration in waste of this category is extremely low, as in the case of low level waste. Only negligible amounts of heat are generated.

(c) The waste in the alpha waste category[9.)] comprises technological and process wastes from nuclear laboratories conducting research on transuranics, plants fabricating uranium/plutonium mixed-oxide fuel elements and spent fuel reprocessing plants. Some of this waste is low level waste containing only alpha emitters. The remainder is medium level waste containing alpha, beta and gamma emitters which arises at reprocessing plants and includes hulls, caps and fines from fuel elements. The radioactivity in such wastes persists for very long periods because long-lived alpha emitters are present. Only small amounts of heat are generated.

(d) The high level waste category[10.)] comprises, for the purposes of this report, mainly vitrified waste containing the "ashes" arising from nuclear combustion (fission products and minor actinides which are alpha and beta-gamma emitters). These ashes are separated from the unburnt nuclear fuel (uranium and plutonium) in radiochemical installations (reprocessing plants) which treat the spent fuel discharged from the nuclear power plants. Such a waste contains the greatest part of the radioactivity; it remains dangerous for very long periods and emits an appreciable amount of heat for several centuries.

(e) If the decision is taken not to undertake reprocessing of the spent fuel discharged from the nuclear power plants, it is declared to be waste and constitutes a category separate and distinct from high level waste. The spent fuel from the THTR reactor[11.)] in the Federal Republic of Germany and that from the light water reactors in Spain are examples of such wastes.

Some very low level waste may be exempted from regulatory control by the competent authorities, and therefore should not be considered any more as radioactive waste. This question will be looked into in chapter V.

Discharges of liquid and gaseous effluents into surface waters and the atmosphere - which take place with due regard to the radiation protection regulations in force and are adequately monitored - are communicated to the Commission of the European Communities and form the subject of periodic Commission reports; they are not dealt with in this report.

9.) Idem 8.)

10.) In the Federal Republic of Germany, this category is defined as a waste producing a significant amount of heat.

11.) THTR: Thorium Hochtemperaturreaktor in Hamm/Uentrop

II.3. RADIOACTIVE WASTE ARISINGS

The estimates refer to radioactive waste treated and conditioned as appropriate by means of current methods.

II.3.1. Radioactive waste arising from use of isotopes in industry, medicine and from general research

It should be pointed out that this question is of relevance to all the Community Member States. The production of this waste and its growth is not governed by electro-nuclear power programmes, but by the state and rate of industrial, economic and social development of the countries under concern and by their population number and future growth.

These wastes are generally of the low level type and very short lived. Exceptions are spent sealed radiation sources, some of which can be highly active and long-lived. The potential danger of such sources, in case of mismanagement, should not be underestimated as shown by the accident which occurred at Goiania (Brazil) in 1987. Approximately 200 persons were irradiated.

Measures have been taken at national level and efforts continue to maintain and improve control on production and management.

Illustrative estimates of the waste volumes shipped annually to the collecting agencies for interim storage are given in Table I.

As a result of differences occurring in the management routes being practised before interim storage (e.g. in matter of waste tracking, decaying, treatment and conditioning), these datas are not easily comparable from one country to another one. In spite of this fact, an average figure of 10-15 m^3 per million inhabitants per annum may be deduced.

II.3.2. Waste resulting from the processing of raw materials containing natural radionuclides

Uranium milling activities produce a special category of waste materials called tailings, containing very low concentrations of natural radionuclides some of which are long-lived. Uranium mining and milling in the EC are relatively modest and limited to France, Spain, Portugal and the Federal Republic of Germany.

Uranium ores in the mentioned countries are generally low grade. The recovery of uranium is based on hydrometallurgical extraction. Due to the low uranium content, mill tailings contain more than 99% of the treated ore mass and retain 75 - 80% of the natural radioactivity present in the ore in form of radioisotopes from the decay chain of uranium 238. One of the natural radionuclides associated with these tailings is radon gas (Radon 222). Tailings retain also a fraction of the chemical agents (e.g.residual acidity) used in the extraction process.

If uranium extraction is performed by heap leaching (lower grade ores), the depleted ore piles remain in place. For this reason the ground on which the piles are built is previously rendered impermeable, in order to achieve a good leaching yield and to prevent later on uncontrolled leaks of contaminated water into the ground.

Tailings from dynamic leaching (higher grade ores) are disposed of, together with slurries from the neutralisation or treatment of liquid plant effluents, in especially conditioned piles or dykes, in order to reduce the radiological risk to man and environment.

In the case of tailings left from older milling operations, remedial actions may have to be undertaken. The operations may vary considerably, depending on the specific conditions of the site.

As in any other mining activity, and especially in open pit mining, the disposal and conditioning of mill tailings is a part of an integrated process of rehabilitation of the site, tending to restore or recover the original landscape.

Liquid effluents are kept to a minimum through recirculation and before their controlled releases, subject to treatment consisting in neutralisation, precipitation and natural evaporation.

The amount of uranium milling waste produced until the end of 1990 is as follows :

	Slurries (tailings) (10^6 t)	Heap leach (depleted) (10^6 t)
Federal Republic of Germany	54.00	-
France	30.49*	18.05
Portugal	2.38	0.04
Spain	1.75	6.20

** Humid Weight; dry weight is 27.72*

II.3.3. Waste arising from nuclear power programmes

The production of radioactive waste associated with nuclear power programmes (including directly related research) is roughly proportional to the scale of those programmes. However, it also depends on the type[12.)] and situation (in

12.) As an example, the GGR (Gas-Graphite Reactor) type and its associated fuel cycle installations (reprocessing plants, etc.) which is not developed anymore but which is still part of the United Kingdom programme, produce almost four times as much waste per unit as the LWR reactor type with its fuel cycle installations.

operation, shut down, under dismantling) of the nuclear installations involved in each programme.

Several Community countries have installed nuclear power plants of various types since the late 1950s. The installed nuclear power capacity in the Community gradually rose to reach about 111.8 GWe in 1990 (1.8 GWe due to the addition of East German plants). This figure has to be compared with the end of 1985 figure of 77.5 GWe used for waste arising estimates in the 1987 report. Most of this increase is due to new French and German plants, and to a smaller degree, to new British and Spanish plants. Italian power plants stopped operation in 1987. A definitive shut down was decided in July 1990.

a. Radioactive waste from nuclear power programmes produced before 1991

This waste is either awaiting conditioning or has been conditioned and stored in a monitored interim storage facility, or has already been definitely disposed of.

Interim storage
Part of the existing low and medium level waste is in interim storage (see table II) either because no disposal facility has been provided up to now in the countries of concern (Belgium, Federal Republic of Germany, Italy, Spain) or because interim storage is the country's present policy (The Netherlands) or because it represents a normal buffer in the management of existing disposal facilities (France, United Kingdom). All alpha waste, high level waste, and unreprocessed spent fuel are in interim storage.

Disposal
Low and medium level wastes (see Table III) have been disposed in the past by :

- sea dumping (many countries, up to the setting up of a moratorium within the framework of the London International Convention on the prevention of marine pollution in 1983);
- deep disposal (Federal Republic of Germany, up to 1978);
- near surface disposal (France, United Kingdom)[13.)]

Near surface disposal has been subject to great improvements[14.)] and is being pursued by France at the "Centre de la Manche" and "Centre de l'Aube" and by the United Kingdom at Drigg. 464,500 m^3 of low and medium level waste have been disposed up to now at the "Centre de La Manche"

13.) For details, see 2nd report COM (87) 312 of 1987

14.) See chapter III.6.3.1

and 775,000 m³ of low level waste at Drigg[15.)]. In addition 14,000 m³ of low level waste have been disposed at Dounreay (United Kingdom).

The former Democratic Republic of Germany disposed of 14,300 m³ of mostly low level radioactive waste (part of them being liquid waste disposed of by in situ solidification) in the salt mine of Morsleben and of 5,800 encapsulated radioactive sources from 1978 till 1990. Since then, upon request of the competent safety authority ("Bundesamt für Strahlenschutz"), liquid waste, unconditioned combustible waste and radioactive sources have not been disposed of anymore.
A safety analysis of the Morsleben facility is currently being carried out. Since February 1991, the local authorities have decided to suspend the disposal of the waste, taking into account legal objections.

No alpha waste, high level waste, or spent fuel has been disposed of up to now within the European Community.

b. Future radioactive waste arising from nuclear power programmes

As regard the future of nuclear power (table IV), estimates possess in most cases a satisfactory degree of accuracy for the very short term only. It is therefore not possible to give a firm estimate of the installed nuclear capacity for the European Community as a whole in 2000, and, *a fortiori*, in 2020. The reason is mainly political uncertainties concerning the long term share of nuclear energy in each national energy balance.

Due to this situation and for the sake of homogeneity, radioactive waste estimates given in the present report for the European Community as a whole refer to waste produced by existing nuclear plants[16.)] (shut down or in operation) or committed. This may lead to unrealistic figures at national level. This is the case for France, where the working group for the Energy Plan forecasts the addition of new nuclear power plants during the period 2000-2020 (see Table IV, footnote 7).

Nuclear power estimates in table IV are therefore leading to a level of waste production which could only be decreased by unexpected major political decisions on national energy policies on the one hand, and by the technological and management progresses expected to result from research and development work and from experience on the other hand.

The estimates relating to each Member State have been divided among the four waste categories described in section II.2 and are presented, accumulated per five-year or ten-year periods, in tables V, VI, VII and VIII for low level, medium level, alpha and high level wastes, respectively.

The global evolution of the waste arising in the future is resulting from a combination of various causes, sometimes contradictory in their effects :

15.) 1986 figures were 278,000 m³ for La Manche and 630,000 m³ for Drigg.

16.)Power plants and the associated fuel cycle installations.

- The production of electricity of nuclear origin;

- The volume reduction allowed for in anticipation of the gradual introduction of new treatment and conditioning techniques and of the optimisation of waste management at the sources of production;

- The timing of spent fuel reprocessing and of the treatment and conditioning of the resulting waste;

- The improvement of reactor operating modes, the fuel loading/unloading patterns and the burn up rates being regularly adjusted with a view to more effective economic optimisation, and *inter alia*, to a reduction of the waste arising;

- And last but not least the shut down of several power plants and the dismantling of obsolete nuclear facilities;

As the medium or long term future of nuclear power plants in operation today is not known in several countries; it has been arbitrarily supposed that they will be operated till the end of their technological life, taken as of 30 years (see table IV).

From the data shown in the various tables, it appears that, all in all, the conclusions of the 1987 report are still valid for the next years. More precisely, the 1987 forecasts for low and medium level waste have been revised slightly downwards for the period 1996-2000, while the 1987 forecasts for alpha waste arisings have been revised upwards, mainly as a consequence of the operation of the British and French reprocessing plants. The total production rate of conditioned low level, medium level and alpha waste is estimated at present to about 80,000 m^3/year for the Community as a whole and should remain approximately the same till the end of the century. The alpha waste accounts for 8% of that total, the medium level and low level waste for nearly all the remainder, or 92%. Under the assumptions made above concerning the future of the nuclear power programmes, the annual waste production will slowly decrease after 2000.

However, the low level/medium level waste arisings may increase sharply after 1995/2000 from the decommissioning of obsolete nuclear plants. Numerical figures are given in tables V and VI; they are based on strategies currently under study in various Member States. Several national authorities consider it difficult to make meaningful forecasts about the time schedule as well as about the amounts of decommissioning waste, for the following reasons :

- a power plant's life may be stretched for an additional decade, according to on-going studies ;

- national decommissioning policies are not decided yet; many electronuclear power plants may be shut down for long periods of time at the end of their life without being dismantled partially or totally.

- how much radioactive waste will come out of the 12,000 to 15,000 tons of materials (concrete, metals) resulting from the dismantling of the nuclear island of a 1,000 MWe power plant is not well known. On the one hand technological progress, notably on decontamination processes, will reduce the amount of waste to be disposed of; on the other hand, the rules for exempting some slightly contaminated dismantling materials from regulatory control are only under development at national and Community levels.

As far as the spent fuel discharged from the power stations is concerned, almost all of the radioactivity generated by the use of nuclear energy is concentrated in it; the production rate amounts to about 3,400 MTHM [17.)] per year at present and will decrease to about 3,000 MTHM per year by 2000 in the Community as a whole (table IX). These figures are a direct consequence of the slowing down or stopping of nuclear power programmes notably in the United Kingdom and Italy, and of the limitation of the present evaluation to nuclear plants shut down, in operation or committed, planned facilities being excluded.
A major part of this spent fuel will be reprocessed during the present decade; as a result several hundred m^3/year of vitrified high level waste will be produced for the Community as a whole.

The spent fuel of research reactors amounts to a very limited quantity of highly enriched material and is mostly under interim storage; this and the variety of fuel elements to be dealt with, make their reprocessing difficult in large industrial facilities.

17.) MTHM = Metric Ton of Heavy Metal.

CHAPTER III

PRESENT SITUATION AND PROSPECTS OF THE RADIOACTIVE WASTE MANAGEMENT PRACTICES AND POLICIES IN THE COMMUNITY

Radioactive waste management consists of implementing a set of co-ordinated actions (waste sorting, treatment, conditioning, packaging, transport, storage) from the wastes production at the source up to their final disposal. A typical radioactive waste management scheme is reported in Fig. 1.

III.1 ORGANISATION AND STRUCTURE OF RADIOACTIVE WASTE MANAGEMENT IN THE EC COUNTRIES

The four main parties involved in waste management at national level may be identified as follows :

- the radioactive waste producers;

- the executive bodies responsible for all or part of waste management in each country;

- the regulatory authorities;

- the government.

Radioactive waste producers are registered by the regulatory authorities in each country. The producers are generally responsible for the waste conditioning and packaging up to the package delivery to the disposal site. From this point, the responsibility of the packages is taken over by the disposal operator. However :

- in The Netherlands the waste producer is only responsible for certifying that the waste's nature, properties, radioactivity content, etc., are in agreement with the acceptance criteria and specifications for central treatment and interim storage;

- the general rule for responsibility mentioned above may also not apply to the producers of small waste quantities, the so-called "small producers". In this case, waste conditioning is taken in charge by a competent body at national level or at the "land level" in a Federal State like Germany (collecting stations in the "Länder").

Within the national regulatory framework, the disposal of wastes, and to a variable extent, their management is entrusted to executive bodies or national agencies for waste management; they have been in existence for a number of

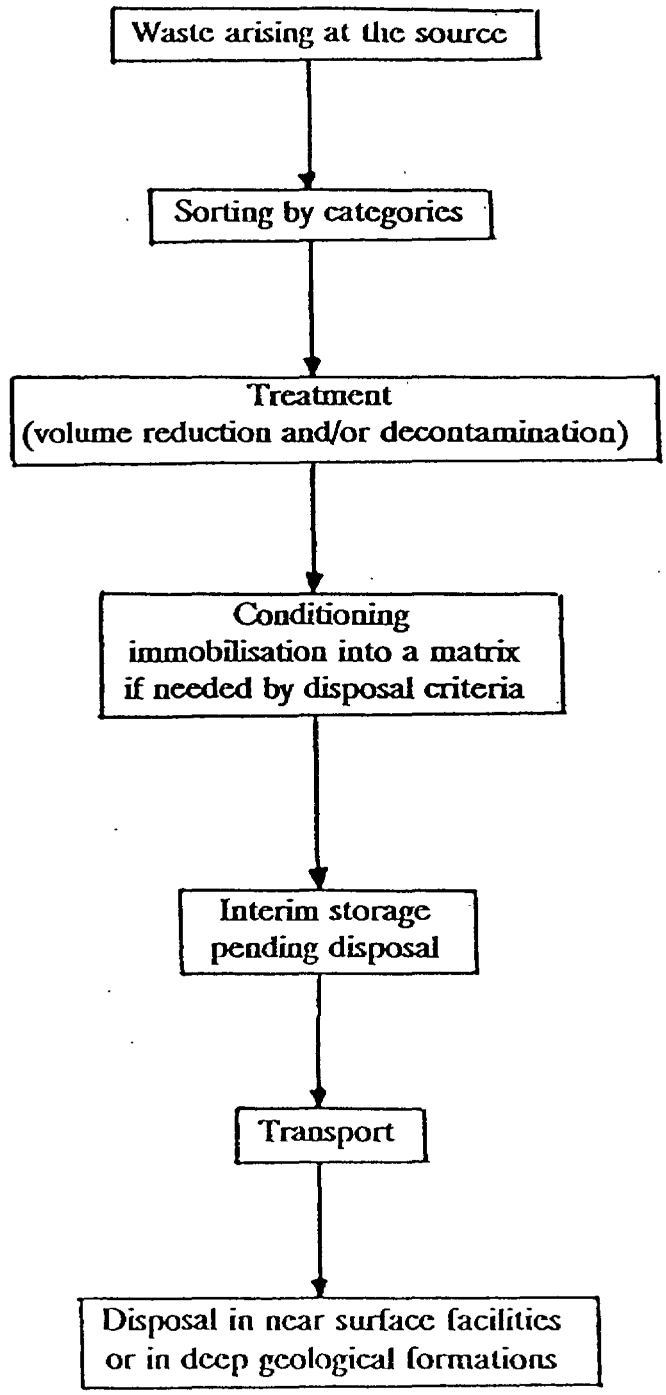

Fig. 1. TYPICAL RADIOACTIVE WASTE MANAGEMENT SCHEME

years in all Member States having nuclear power programmes.
Their various tasks and competences have been described in some details in the previous report of 1987. Table X summarises the present situation, updated as of 1991. The executive bodies accept the waste packages delivered to them by the waste producers for interim storage and disposal if these packages meet acceptance criteria. These criteria are consistent with the general radiological protection and nuclear safety objectives. Quality assurance and control procedures ensure compliance with the acceptance criteria.

Since the publication of the last report, one should note :

- the independence given to the French national agency ANDRA, which before depended on the French "Commissariat à l'Energie Atomique (CEA)";

- the broadening of the competence of the Belgian national agency ONDRAF/NIRAS to encompass decommissioning activities;

- the transfer of the relevant department of the "Physikalisch Technische Bundesanstalt (PTB)" to the "Bundesamt für Strahlenschutz (BfS)" in the Federal Republic of Germany;

- the transfer of responsibility for regulating waste disposal in the United Kingdom to Her Majesty's Inspectorates of Pollution (HMIP and HMIPI).

These governmental decisions reflect national consensus to optimise the already existing organisational and operational structures devoted to radioactive waste management.

The regulatory authorities are responsible for the development of the regulatory framework, the control of its implementation and for the licensing of nuclear facilities, including radioactive waste management and disposal facilities.

Finally, the governments are responsible for the national radioactive waste management policies and are ultimately responsible for the long term safety of disposal. The three other parties act in this context.

III.2. RESEARCH AND DEVELOPMENT PROGRAMMES.

III.2.1 Programmes and budgets

Important research and development programmes on radioactive waste management and disposal have been carried out at national and Community levels for many years. The amount of knowledge accumulated is considerable[18] and gives no ground for doubting that waste could be managed and disposed of safely on an industrial scale. Programmes are therefore more and more of a research development and demonstration character and oriented toward the optimisation of the waste management and the validation of the deep underground disposal concept already under development (see chapter III.6.3)

A special emphasis is being given to the following topics :

- minimization of the waste volumes to be disposed of, especially those containing long-lived radionuclides (alpha waste);

- reduction of releases of radioactivity into the environment well below existing discharge limits;

- Development of deep underground repositories; safety of disposal.

Table XI gives an overview of the budgets allocated by Member States and by the Commission of the European Communities for research and development in the field of radioactive waste management. One should observe that the general trend during the last three years has been to maintain the level of the research financial effort or even to increase it.

It must be underlined that international cooperation is exceptionally strong in this particular area. Regarding this, the Commission of the European Communities has been and is still very active to promote and coordinate such a cooperation among the Member States notably by means of its R&D programme and the EC Plan of Action in the field of radioactive waste[19]

III.2.2. Advanced Research/Transmutation

Some research programmes have been recently started to look into the technical feasibility and various implications of developing an advanced management strategy for radioactive waste - i.e. the possibility of transmuting long lived radionuclides into short lived ones. Such a strategy supposes, among others, the use of special reprocessing facilities for the partitioning of the relevant radionuclides and special "burners" for transmuting them (e.g. fast breeders reactors, accelerators, etc.). The strategy might increase the safety of geological disposal. Social considerations and political requests are therefore also prompting an effort in this area. This is reflected at national level in the recent French law on radioactive waste management research[20] and at Community level in the contents of the present CEC R&D programme on radioactive waste management.

18.) See, as an example, the proceedings of the 3rd European Community Conference on Radioactive Waste Management and Disposal, Luxembourg, 17-21 September 1990, report EUR 13389 EN (1991).

19.) Council resolution of 18/02/1980 - O.J. C51/1 and Commission's communication to Council COM(92)22 of 31/01/92 on the renewal of the Plan.

20.) Law N° 91-1381 of December 30,1991

The transmutation research effort is currently very limited in terms of budget; EC countries involvement mainly concerns France (a 30 man/year effort) and to a lesser extent The Netherlands, the Federal Republic of Germany and possibly Italy. Outside the Community only Japan (OMEGA project) and the former USSR have significant programmes.

III.3 SYSTEM APPROACH AND PRINCIPLES

The management of radioactive waste comprises the collection, sorting, treatment, conditioning, transport, storage and, finally, disposal operations. These activities are closely linked through numerous interactions between them. They have to be seen as a system and to be dealt with accordingly.

A "system approach" is presently being used worldwide to identify the many interactions between the system's components: waste package, transportation means, storage facility or repository, disposal site and its environment.

Delays in the definition of one component of the system may therefore have consequences on the development of the other ones. As an example, if the disposal option is being kept open, the right waste form or package may be difficult to select and specific packages, only adequate for interim storage purposes, may have to be fabricated.
The system approach is being taken into account in the waste management policies of the Member States.

General principles, the subject of an international consensus, provide the framework for waste management and its safety. They apply to radiation protection, ethical and sociological questions, environmental and natural resources protection, and nuclear safeguards. They are listed hereafter.

Community regulations provide common guidelines and requirements from which a large proportion of national measures are derived. National measures therefore share several common features, mainly in the field of radiological protection (see Chapter V). However, policies and strategies for carrying out the management of radioactive waste are matters of national competences, as are the ways and means of ensuring technological safety.

As a result, some differences in waste management practices exist from one EC country to another one, as it will be seen from the following.

GENERAL PRINCIPLES [21]

FIELD		PRINCIPLE
• **Radiation protection**		
a) System of dose limitation	→	JUSTIFICATION
	→	OPTIMISATION OF PROTECTION (ALARA)
	→	INDIVIDUAL DOSE LIMITATION
b) System of control	→	NOTIFICATION
	→	REGISTRATION
	→	LICENSING
• **Ethical and sociological questions**	→	CARE FOR OTHERS
	→	PUBLIC INVOLVEMENT
	→	POLLUTER SHOULD PAY
	→	COMPENSATION FOR DAMAGE (CIVIL LIABILITY)
• **Environmental and natural resources protection**	→	PREVENTION OF DAMAGE
	→	RECTIFICATION OF DAMAGE
	→	PROTECTION OF NATURAL RESOURCES
• **Nuclear safeguards**	→	PREVENTION OF NUCLEAR MATERIALS DIVERSION

III.4. TREATMENT AND CONDITIONING

After collection and proper sorting, wastes are treated and conditioned. These activities are industrial conversion operations intended to impart to the waste a form appropriate to handling, storage and disposal.

Low and medium level waste
Almost 92 % of the volume of radioactive waste currently produced in the

21.) "Objectives, Standards and Criteria for radioactive waste disposal in the European Community." Report EUR 12570 EN (1989).

Community are low and medium level waste (see Chapter II).

Processes for the treatment and conditioning of such wastes are available and industrial installations have been operated successfully since the early 1950s. A general description of these processes and installations was given in the 1983 and 1987 reports.

The treatment prepares the waste, as produced at source, for conditioning; it chiefly takes the form of:

- compaction or incineration in the case of solid waste;

- evaporation, ion-exchange and chemical precipitation followed by filtration in the case of aqueous waste.

As regards solid waste, the trends identified in the 1987 reports towards volume minimization by supercompaction and by incineration are confirmed.

Supercompaction is straight forward (based on established hydraulic press technology), is not environmentally intrusive, and is especially attractive when there is a limited availability of interim storage and/or disposal sites.
As an example, the use of supercompaction techniques at the Drigg low level waste disposal site (United Kingdom) will extend the life of that site until 2050. At the French low level waste disposal facility "Centre de l'Aube", a 1000 tons supercompactor will be operational in 1992. Several supercompactors have been sold or are planned in EC Member States (Belgium, Federal Republic of Germany, France, Italy, Spain, The Netherlands, United Kingdom).
In several cases supercompaction is performed in campaigns, using mobile commercial units. However, fixed supercompaction installations are used and planned to complement (or to take the place of) the mobile units. This is the case in Belgium where a large fixed facility with the necessary supplementary facilities (interim storage, pretreatment, cementation, control) should be operational before 1995. Volume reduction factors of up to 10 could be achieved provided that solid wastes are previously sorted out (see table XII).
In Italy, supercompaction of low level waste, with volume reduction factors ranging from 3 to 6, is currently performed in fixed and mobile units.

Incineration can produce much higher volume reduction factors[22.)], after adequate segregation of the combustible part of the waste. Despite this, large incinerators are developing at a lower rate than supercompactors, due to their high cost and their need for complex antipollution off-gas scrubbing and filtration when burning waste of relatively high specific activity or possibly contaminated with alpha emitters. In addition the adequate long term behaviour of matrices for embedding the incineration ashes has not been demonstrated yet and is subject of present research (see table XIII).

Finally, efforts done during the last few years by electricity producers with the

---

22.) 20 to 40

view to waste minimization by technological means and by a relevant training of the personnel, have significantly contributed to reduce the waste production at the source. As an example, in France the average ratio of solid waste production from the operation of nuclear power plants has decreased by about 8% per year, falling from 70 m^3/TWh in 1983 down to 40 m^3/TWh in 1990.

As regards liquid waste, numerous facilities designed to achieve high decontamination factors have recently been adopted for use in certain major nuclear installations; for example, the Site Ion eXchange Effluent Plant (SIXEP) which was brought into service in 1985 for the decontamination of low level liquid waste at the British reprocessing plant at Sellafield (United Kingdon). That very large installation makes use of an ion exchange process which now enables the amount of radioactivity discharged into the sea to be reduced to only a few per cent of that discharged in the 1970s. Flocculation/coprecipitation decontamination processes have been used for several years at the CEN/SCK Mol (Belgium). Other very effective processes are being developed, such as ultrafiltration (membrane separation processes) or processes which make use of complexing agents for the most important radionuclides. The introduction of these processes will make it possible to reduce the volume of the active sludges through improved separation and may also result in lower residual activity in the discharges.

Conditioning converts the treated waste into materials having low risk of dispersion of the radionuclides in the waste during handling and transport operations or by contact with water or other external agents after disposal. To that end, the treated waste is most frequently incorporated in matrices which solidify into blocks or structures possessing, with or without external containers, the requisite safety features (good mechanical strength, resistance to fire, a low leaching rate, satisfactory long term behaviour, etc.).

The matrices most often used in the Community are as follows:

- cements which have been employed since the 1950s mainly for low level waste;
- bitumens, which were introduced between 1960 and 1965, are used by some Member States (Belgium, France, Denmark);
- polymers which were more recently introduced.

Considerable efforts, including EC research projects, have been made to improve the characteristics of cement solidified waste materials, to ascertain their long term behaviour under storage or disposal conditions, and to enlarge their range of application. Positive results and simplicity of operation make them the most widely used matrices today for low and medium level waste.

The treatment methods for low and medium level waste would seem, on the whole, to meet satisfactorily the current requirements of the nuclear power industry and the safety requirements of the regulatory authorities. Although such operations have been carried out for several decades, they still benefit significantly from technological advances.

Alpha waste
Of the radioactive waste produced in the Community, approximately 8 % consists of products contaminated by long-lived radionuclides mainly alpha emitters such as plutonium, americium and neptunium. Despite considerable R&D efforts carried out on the development of improved treatment and conditioning processes, an important part of such wastes is still kept untreated in store mainly because definite waste acceptance criteria for disposal of alpha waste (high level waste excluded) in geological formations are lacking. This absence of criteria (which itself derives from the unavailability of underground disposal facilities for the near future) led to refocusing of current research programmes on the development of high performance decontamination processes capable of decategorising alpha waste in terms of disposal route. In other words, attempts have been made to reduce the alpha content of a number of waste types to such a level that these might subsequently comply with acceptance criteria associated with near surface disposal. In this respect, a number of advanced treatment processes dealing with liquid and solid alpha bearing wastes are under development. Some of them have reached the active pilot scale.

For those alpha wastes which - *a priori* - could not be decategorised with current technologies, the research efforts are being conducted towards the development of volume reduction techniques. In this respect, it is worth mentioning the melting process investigated by the CEN/Valrhô (France) for spent fuel hulls (inactive industrial prototype operating) and the approaching start up of active operation of the EARP (Enhanced Actinide Removal Plant) facility for the treatment of the Sellafield low and medium level liquid wastes (United Kingdom).

Finally, it must be stressed that significant improvements can be realised in the management of alpha wastes by implementing adapted technologies to reduce their arisings at the source. An illustration of this statement is given by the experience recently gained by Belgonucléaire (Belgium) in the operation of the mixed oxides fuel fabrication plant of Dessel where reduction of both plutonium content (by 80 %) and solid alpha bearing waste volumes (by 10-15 %) were recorded after the introduction of a fourth confinement barrier in the fuel fabrication line.

High level waste

Produced during reprocessing operations, this waste type contains almost all the radioactivity generated during operation of nuclear power plants. Conditioning of high level waste is usually performed in large commercial vitrification plants located in France and in the United Kingdom (Marcoule, La Hague and Sellafield). All the three plants are operating the same vitrification process relying on the use of a rotary kiln. In addition, a demonstration vitrification plant involving the use of a ceramic melter has been erected on the Dessel site (Belgium). First operated for conditioning the high level Eurochemic waste, this plant is intended to be next used for vitrifying the WAK high level liquid waste generated in the past at Karlsruhe (Federal Republic of Germany).

III.5 TRANSPORT OF RADIOACTIVE WASTE

III.5.1. Provisions governing the transport of nuclear materials in general

The transport of radioactive material has been governed for many years by the provisions of the International Atomic Energy Agency (IAEA) which have been taken into account in their national laws by all EC Member States.

Philosophy of the regulations and basic regulatory requirements
The prescriptions embodied in the IAEA regulations essentially aim to ensure that when any radioactive material is transported the following four basic safety requirements are met:

a. adequate *containment of the radioactive material*;

b. adequate *control of radiation* emitted from the material;

c. safe *dissipation of heat* generated in the process of absorbing the radiation;

d. *prevention of criticality*, if the material is fissile.

The IAEA regulations provide for each of these requirements by prescribing radiation level and release limits for both normal and accident conditions of transport. Rather than seeking to do this by controls such as special vehicles or routes, the regulations are directed towards ensuring that protection against the hazards of radioactive material in transport should be mainly provided by the packaging in which it is carried; safeguards appropriate to the nature and quantity of the radioactive material are "built-in" to the design of the package on the premise that there could be a severe accident in transport. The regulations specify design performance standards which are independent of the means of transport by which the package may be carried.
Where the radioactivity of the intended content exceeds specified levels, the standards include tests for demonstrating the ability to withstand conditions of transport, including accidents, and require independent assessment and certification of compliance by the competent authority. In addition, the regulations require that competent authorities should institute emergency response measures to be followed if an accident does occur during transport.

The primary responsibility for safety lies with the consignor of the radioactive material, who must declare in the transport documents that it is packed, marked and labelled in accordance with the applicable regulations. This ensures that the onus for providing safety in the transport of individual consignments falls mainly to the person most likely to have the necessary knowledge of the special hazards presented by the radioactive material, as well as having the resources to deal with them. A much lesser degree of responsibility is assigned to the carrier, who must take appropriate precautions to protect workers and the public during transit; for example, by ensuring that his load is correctly stowed.

The regulations also require stringent quality assurance measures to avoid inadvertent non-compliance with safety features, and appropriate emergency response arrangements to mitigate the consequences of accidents or incidents. The effective and comprehensive nature of the regulatory system recommended by the IAEA has been a significant factor in achieving its global implementation.

III.5.2. Transport of radioactive waste in practice

Radioactive waste transport and regulatory aspects

Most radioactive wastes are transported in solid form. However, specially designed and shielded containers are used in some EC countries for the transport of liquid waste.

Transport is mainly done from the producer to the centralised storage or disposal facility. Frequency of transport depends very much on the national situations. As an example, in Belgium about 200 shipments of non conditioned waste were made in 1989 and 1990 and 115 shipments of conditioned waste have been made in 1990, most of them from a nuclear power plant to the Belgoprocess storage plant. The record of radioactive waste transport in the EC Member States has been excellent through the years, showing that the technology is well in hand.

Like all other categories of radioactive material the transport of radioactive waste is governed by the provisions and regulations described above.

As far as the EC is concerned, Article 2 of the Euratom Treaty[23.)] includes transport of radioactive substances in the scope of its application. However, the corresponding directive on the uniform safety standards (article 30) only contains generic requirements applicable to any activity involving a hazard from ionising radiation.

Transfrontier shipments of radioactive waste

In January 1988 a number of allegations were made relating to the movement of radioactive waste, in particular between Belgium and the Federal Republic of Germany. The CEC noted that the physical arrangements for transporting low and medium level waste examined were found to be in conformity with the relevant IAEA requirements and provided an adequate level of safety at all times. However it appeared that the control of the waste movement by the regulatory authorities had to be improved in some cases.

Following a European Parliament's request, the CEC presented on 1 December 1989[24.)] to the EC Council of ministers a directive proposal adding shipment of radioactive waste to the activities for which prior authorisation is

23.) Article 2 (b) provides that the Community shall establish uniform safety standards to protect the health of the workers and of the general public and ensure that they are applied.

24.) O.J. No C5/7 of 10 January 1990.

required and lays down a common system of notification and consignment aimed at avoiding the risk associated with the competent national authorities losing control of radioactive waste. This directive has been adopted by Council on February 3rd 1992.

The international movement of radioactive waste has also been dealt with at EC level. The fourth ACP-CEE [25.] Convention, signed in Lomé on 15 December 1989, in its Article 39 deals with the international movements of hazardous waste and radioactive waste. The provisions include that "The Community shall prohibit all direct and indirect export of hazardous waste and radioactive waste to the 68 ACP States while at the same time the ACP States shall prohibit the direct or indirect import into their territory of such wastes from the Community or from any other country. These provisions do not prevent a Member State to which an ACP State has chosen to export waste for processing from returning the processed waste to the ACP State of origin."

The same question has also been dealt at worldwide level; an IAEA code of practice on the international transboundary movement of radioactive waste has been agreed upon in 1990 by the IAEA's 112 Member States. The code, which is not legally binding, affirms the sovereign right of every State to prohibit the movement of radioactive waste into, from, or through its territory. It further requires that transboundary movements of radioactive waste take place in accordance with internationally accepted safety standards, and respective national laws and regulations, and with prior notification and consent of the sending, receiving and transit States.

III.6 STORAGE AND DISPOSAL OF RADIOACTIVE WASTE AND SPENT FUEL

III.6.1. Introduction

With respect to disposal operations which constitute the key and final step of any management route for radioactive waste, the overall situation has not significantly changed since 1987. On the one hand, the moratorium on the sea-dumping of radioactive waste [26.] is still effective and sea-dumping is therefore not practised. On the other hand, only one land based disposal facility has been put into operation, namely the "Centre de l'Aube" (which should progressively be substituted for the "Centre de la Manche" nearly filled up) for the specific case of low and medium level wastes (France). Another near surface repository to be operational in early 1992 is under construction at "El Cabril" in Spain. A number of considerations and general principles governing the selection of interim storage and disposal facilities as well as some descriptions of operating installations were already outlined in the foregoing report. These will therefore not be repeated here.

25.) African, Caraibe and Pacific countries.

26.) This moratorium has been agreed on a voluntary basis by the parties to the Convention on the prevention of marine pollution by dumping of waste and other matters (the so-called London Convention) in 1983, and is still in force pending on the completion of various studies which are expected to be finished in 1993.

However, it must be mentioned that the public unease concerning the nuclear industry in general already noticeable in 1987 has continued during the last few years, leading to the development of strong local oppositions against the installation of radioactive waste disposal facilities. This resulted in the multiplication of actions at law and moratoria which considerably delayed the construction and/or operation of radioactive waste repositories or experimental and pilot underground installations. In certain cases (like in The Netherlands), public opposition even delayed the operation of a centralised interim storage facility.
Even if distinct differences exist between the Member States, one of the consequences of this situation is increase of on-site storage of nuclear spent fuels or radioactive waste. This also contributed to the development of very effective volume reduction techniques (e.g. incineration, supercompaction) to save room for storage.

Other consequences are more research for improved information to the public concerning the potential risks associated with disposal sites, additional efforts to increase the safety, as well as the quality of the documentation of safety, of the repositories and also the study of advanced management strategies enabling a reduction of the inventory of long-lived radionuclides to be disposed of in the far future (see section III.2.2).

Finally, it is worth mentioning that direct disposal of spent fuels - especially the off-standard types - is being looked at with an increasing attention in most Member States.

III.6.2. Interim storage

III.6.2.1. Low and medium level radioactive waste packages

Basically, there are two main approaches to the storage of low and medium level radioactive waste packages, either on the site of production or in a centralised interim storage facility. Both approaches are followed within the European Community. As quoted in table XIV, Member States having only a limited installed nuclear power seem to prefer centralised interim storage.

Spain
The centralised storage facility of "El Cabril" is composed of modules which, at the end of 1990, have received some 2,900 m^3 of conditioned waste, mainly waste packages arising from small producers and CIEMAT activities. Waste packages from some nuclear power plants are being stored since 1988. Some 12,000 m^3 are still stored at the reactor sites.

The Netherlands
Since 1984, the option of a centralised long term (100 years) interim storage for all kinds of radioactive waste has been adopted by the government. To this purpose, a facility was erected first provisional at Petten and then near Borsele by COVRA. However, due to the local opposition, the starting of storage operations at Borsele was somewhat delayed. Following a positive decision from the Council of States, the storage operation of radioactive packages started from late 1991 onwards.

Belgium
All waste types (nuclear power plants, mixed oxides fuel fabrication, medicine... wastes) are currently stored at Mol/Dessel in a centralised storage facility. At present time, 8,300 m³ of low level waste are in store. Conditioned medium level waste (2,750 m³) resulting from the reprocessing of spent fuel by EUROCHEMIC are stored in a building called "Eurostorage". The available remaining storage capacity of this building (more than 1,000 m³) is now used for medium level waste arising from reactor operation.
An additional interim storage facility specifically devoted to reprocessing wastes coming from abroad is being constructed in Dessel. This should be operational in 1993.

The United Kingdom
Except for low level solid wastes which comply with the acceptance criteria set-up for the BNFL owned Drigg near surface disposal site, all waste types are currently stored on-site. A deep geological disposal facility is however being planned to take both low and intermediate level wastes.

France
On account of current operation of two near surface disposal sites for low and medium level wastes ("Centre de la Manche" and "Centre de l'Aube"), interim storage mainly concerns alpha bearing wastes and part of the low level waste arising from small producers where decay and sorting are needed before release or treatment. In this latter case, two centralised interim storage sites are available (CEN/Saclay and Tricastin).

Federal Republic of Germany
Pending the availability of the Konrad mine or the re-opening of the Morsleben disposal site, several interim storage facilities for low and medium level wastes are in operation at different sites. Part of the reactor waste packages are stored on-site, another part is stored in the Gorleben and Mitterteich facilities. The existing capacities are sufficient to cover the needs for the next few years.

Italy
All radioactive waste packages generated during past operation of nuclear facilities are stored on-site.

Denmark, Portugal, Greece
Interim storage is practised in centralised facilities (Riso, Sacavém and Demokritos).

III.6.2.2. Vitrified high level waste

Since the issuing of the 1987 report, the available reprocessing capacities for light water reactor fuels within the European Community increased by approximately 1,000 t per annum (mainly thanks to the operation of the UP2 400 at its normal capacity and the recent starting of the UP3 reprocessing facility in La Hague in France). Accordingly, increased amounts of vitrified high level waste, which contains most of the fission products and long-lived radionuclides, are currently produced and stored (see Table VIII).
In order to allow much of the heat and radioactivity to decay, this waste type has to be stored for several decades either on-site (i.e. Sellafield in the United Kingdom, Dessel in Belgium, La Hague and Marcoule in France) or in suitable facilities located in the Member States owning the spent fuel reprocessed abroad (see Table XV).
In most cases, the general concept for interim storage of vitrified high level waste is based on the emplacement of glass blocks in double steel tubes cooled by natural air circulation.
Stores are being built on a modular design that can be easily extended to meet future needs.

III.6.2.3. Spent fuel

The general policies of the Member States concerning management of spent fuel have not significantly changed since 1987 in the sense that no further country joined Spain and the Federal Republic of Germany in their decision not to reprocess most or specific categories of spent fuels respectively. On the other hand, the early reprocessing of spent fuels did not gain additional supporters. A number of countries opted for the "wait and see" option which consists of storing spent fuel for at least a few decades.
Interim storage of spent fuel is mostly performed in ponds on reactor sites for several months or years, in order to allow the fuel to cool down before it can be transferred to another storage facility.
However, even with appropriate control of storage conditions, i.e. pondwater chemistry and other physical aspects of containment, Magnox fuel (produced in the United Kingdom) can only be stored for about three years due to the particular type of fuel can and the uranium metal itself. Further storage of this kind of fuel can be implemented in dry conditions.
There is greater interest in dry storage of light water reactor spent fuels which is gaining interest especially when long interim storage periods (exceeding a few decades) are aimed at. In this respect, some applications are expected to be made in the United Kingdom for the interim storage of advanced gas-cooled reactor fuels [27.)].

Also the Federal Republic of Germany is looking at this interim storage option. However, due to local opposition which led to actions at law, the storage facilities constructed at Gorleben and Ahaus do not yet accommodate spent fuels.

27.) Magnox fuels from Wylfa are already stored in a gaseous environment.

In Spain, the process of designing and licensing a dual purpose metal cask (storage/transport) has been undertaken. These casks could be used for interim storage of spent fuel either at or away the reactor site.

The total storage capacities (i.e. on-site and in centralised facilities) for spent fuel currently available within the Member States are reported in Table XVI.

III.6.3. Disposal of radioactive waste

III.6.3.1. Near surface disposal sites

France

This disposal option was subject to important developments since 1987. First, due to the phasing out of the "Centre de la Manche" in which approximately half a million of m^3 of radioactive waste products containing short-lived radionuclides will finally be disposed of, a new near surface disposal site for the accommodation of the same kind of radioactive waste products has been constructed. This site - named "Centre de l'Aube" - should receive up to 1 million m^3 of radioactive waste packages. Operation of the "Centre de l'Aube" disposal site started in early 1992.

Spain

A similar concept, incorporating some specific design variations, has been undertaken in Spain at the "El Cabril" site, where a near surface repository is in an advanced stage of construction. The possibility of retrieving the waste packages, in case of necessity, is one of the main specific features included in the design of this installation. It will have a capacity equivalent to some 50,000 m^3 of radioactive waste packages, and its operation is scheduled to start by mid 1992.

United Kingdom

In the United Kingdom, the Drigg disposal facility has continued to receive low level radioactive waste packages (since 1987). However, it is worth noting that new specific activity limits were set in 1988 with respect to individual waste consignments (4 GBq alpha/ton and 12 GBq beta-gamma/ton) and to the total quantities of groups of radionuclides disposed at the site in any one year. In addition, the Drigg facility is being upgraded in the sense that trenches have been replaced by a system of concrete vaults aiming at improving the overall safety of the disposal operations. The first concrete trench came into use in January 1989.
Finally, it must be pointed out that investigations on additional near surface disposal sites for low level radioactive waste in the UK stopped in 1987 following a government decision considering that after the allowed quantities for disposal at the Drigg site are reached, arisings of low level radioactive waste should be disposed of in a deep repository along with medium level and alpha wastes.

Belgium

Near surface disposal options for conditioned low level waste are being investigated. The final decision concerning the disposal system is expected to be taken at the earliest by the end of 1992, with the view to begin the operation of a repository by the turn of the century.
Studies are being performed in Belgium in order to determine the design basis to which a possible site must obey including preliminary limits for the waste characteristics.
On the basis of a preliminary safety review, a first site selection could be done leading, after approval of the safety report of the site by the authorities, to the construction and the start up of a disposal facility around end of the nineties.

III.6.3.2. Deep geological repositories

Basically, one can distinguish two kinds of deep repositories; those which are devoted to disposal of non-heat generating wastes and those which should accommodate all waste categories including vitrified high level waste and spent fuel. Although no deep repository is currently operational within the European Community, there are some prospects that the disposal facilities installed in disused mines (in the Federal Republic of Germany) for non-heat generating wastes can start or re-start their operation by the turn of the century provided that political issues do not further delay the delivery of operation licences. However, for the deep repositories to be excavated from geological formations (salt dome, clay, shale, granite formations), investigations are progressing within the framework of the construction and/or operation of underground laboratories which are expected to last several lustra still. It is worth mentioning that under the sponsorship of the Commission of the European Communities a close and fruitful co-operation between the agencies in charge of operating the underground laboratories has been established and that the Commission's R & D programme supports financially research in underground pilot installations.
The situation within each individual Member State concerning construction of deep repositories is outlined hereafter.

Federal Republic of Germany
As a result of successive actions at law taken by the government of Lower Saxony, the progress of the administrative procedure for opening the Konrad mine repository has been considerably delayed. The legal procedure ("Planfeststellungsverfahren") is now at a point where after opening of the planning documents to the public (between 16 May and 15 July 1991) comments and questions are studied. The public discussion of all arguments will probably take place in 1992. Therefore, operation of this deep repository for non-heat generating wastes is not expected to begin before the mid nineties. The disposal capacity of the Konrad mine amounts to approximately 1 million m^3 of radioactive waste packages. This disused mine will comprise six different emplacement fields, each of them being subdivided in several disposal rooms with a mean cross section of 40 m^2 and a length up to 1,000 m.

For the Gorleben site which should accommodate all kinds of waste including heat generating wastes, above ground investigations are nearly completed. The underground exploration of the Gorleben salt dome is in progress. Two access shafts are being sunk. The end of underground investigations is planned for the late nineties, together with a general assessment of the Gorleben salt dome performances for radioactive waste disposal. The operation of the facility should not start before 2008. However, it must be pointed out that as for the Konrad mine the progress of the investigations and the licensing procedure are strongly dependent on political issues which might give rise to further delays.

The disused Morsleben salt mine - which was operated as a deep repository for low and medium level waste in the former German Democratic Republic (14,300 m^3 of solid and liquid radioactive wastes as well as about 5,800 radioactive sources were already disposed of in it) - was shut down further to a decision of the Magdeburg Court of Justice taken in February 1991. In addition, the competent Federal German Minister ordered to stop any further disposal operations until a positive recommendation of the Reactor Safety Commission is provided.

Finally, it is worth mentioning that as a support to experimental investigations being performed at Gorleben, an important R&D programme is being carried out in the Asse salt mine.
This concerns :

- the development and testing of the emplacement techniques for medium level waste packages (containing dissolution residues as well as hulls and caps) and for spent high temperature reactor fuel elements (MAW project);

- disposal tests of 30 simulated high level waste glass blocks spiked with caesium and strontium for which considerable delays have occurred: five years now, due to licensing problems (HAW project);

- a demonstration experiment for direct disposal of spent fuel elements (TSS test);

- the development of a multicomponent dam for use as an engineered barrier in galleries.

Belgium

Construction and operation of an underground laboratory (67 m long test drift with an internal diameter of 3.5 m) in the clay layer under the Mol site at a depth of 225 meters is underway since 1984 (HADES project). With this respect, several research areas have been subject to investigations, namely:

- monitoring of long-term stress experienced by the lining of a disposal gallery;

- Control Experiment with Radiation for the Belgian Repository (CERBERUS project) which consists of monitoring the in-site response of the clay mass to the controlled exposure of combined heat and radiation;

- heating tests (only with electrical heaters) in order to determine the effects of heat sources on the surrounding clay and in the backfill materials in a disposal gallery (PRACLAY and CACTUS projects).

In 1989, the SAFIR (Safety Assessment and Feasibility Interim Report) report was issued by ONDRAF/NIRAS about the characteristics of the Boom clay as host for disposal of high active and/or long-lived isotopes. An evaluation commission has approved the report and issued recommendations in the examined field. The research programme has been defined with as objective a PSAR (Preliminary Safety Analysis Report) in 1997. After a period for the feasibility demonstration, a definitive site election will then become necessary. Emplacement of the first fully active package is not expected to take place before 2030.

France
As a first step to select an appropriate host geological formation for the disposal of long-lived radioactive wastes, preliminary field investigations in four sites started in 1987.
Drilling tests for seismic calibration and hydrologic purposes were accomplished in a clay formation (Aisne department). The launching of a new campaign of drilling tests in a shale formation (Maine et Loire department) gave rise to a strong local opposition which led the Prime Minister to call for a moratorium on field works until a law on research on radioactive waste disposal is discussed and approved by the Parliament. This law has been approved by the Parliament in late 1991. Two of the main features of the law are that several underground laboratories will be constructed in France and that no definite decision concerning the location of the deep repository will be taken before a full assessment of the performances of the different laboratories is completed (at the latest in 2007).

Although not directly connected with field investigations, an in-situ research programme in a 1,885 m long tunnel at Tournemire in the south of France was launched in late 1990. This tunnel crosses a thick clay formation (overlying limestone layers are 270 m thick) for which the geotechnical and hydrogeological conditions appeared to be representative to those of a deep repository.

The United Kingdom
UK NIREX Ltd. is currently investigating the possibilities for the development of a deep underground facility for low and medium level wastes. To this end, geological investigations involving drilling and geophysical

surveys have been performed at Sellafield and Dounreay. At both sites suitable hard rock formations have been found, but Sellafield has been chosen for detailed underground investigations and measurements during the excavation phase. The repository will consist of a series of underground caverns in deep rock. Construction of the caverns will be phased and will continue during the operational period. The preferred location is close to the reprocessing site at Sellafield.
According to the current schedule (subject to the necessary permission and consents to be granted), construction of a deep repository for low and medium level waste should commence in the late nineties, leading to a possible operation around the year 2005.
As far as the disposal of high level waste is concerned, the Department of the Environment is maintaining a watching brief on research carried out abroad. Neither specific concepts nor location for the disposal of high level waste has yet been chosen.

Spain

Concerning disposal of spent light water reactor fuels and vitrified high level waste, as well as all those waste packages which will not comply with the "El Cabril" acceptance criteria, preliminary investigations aiming at identifying potential deep repository sites are under way since 1986.
In parallel, projects dealing with the preliminary conceptual design of a deep repository in two geological media : salt and granite, have been undertaken in 1990. A similar project for clay is contemplated to start at a later date. The main purpose of these projects is to provide sufficient results as to select reference concepts, as well as important data to the siting process and the associated R & D programme. Operation of the geological repository is not expected to take place before the second decade of 2000.

The Netherlands

Although the policy of The Netherlands is based on long term interim storage (for 100 years) of all kinds of radioactive waste (see section III.6.2.1.), the OPLA research programme on final disposal options in salt is still going on. The generic nature of this research programme did not yet include the identification of potential sites for deep repositories. Possible preliminary field research near sites (comprising seismic surveys and other non-destructive field research as well as geohydrological drillings) are not expected to start before the mid nineties.

Italy, Portugal, Greece, Ireland, Denmark

No further developments on disposal of radioactive waste have taken place since 1987.

CHAPTER IV

NUCLEAR SAFETY IN RADIOACTIVE WASTE MANAGEMENT

IV.1. PREDISPOSAL ACTIVITIES

Nuclear safety must be assured in all sectors of human activities involving the movements of radioactive materials and the construction, operation and closure of nuclear facilities. Radioactive waste management and its different steps make no exception.
Facilities and plants for the treatment and conditioning of radioactive waste are operated under the same general safety requirements as other nuclear plants. Three types of important steps forward deserve however to be mentioned :

- The reduction of the environmental impact by the commissioning of new treatment plants has drastically reduced radioactive releases to the environment; examples are the British achievements at Sellafield and the French programme underway at la Hague;

- The continuous development of technologies and processes for the characterisation, quality control, identification and tracking of the waste forms or packages produced by the plant. This does not pertain to the safety of the plants of concern themselves, but is an important contribution to the safety of the operations following in the waste management sequence (i.e. transport, storage, disposal);

- The constant decreasing of the occupational exposure resulting from all individual operations entering radioactive waste management (waste sorting, treatment, conditioning, handling of waste packages...).

The present situation concerning the transport of radioactive waste has been reported above (see chapter III.5). The recent developments of a regulatory nature, the technological achievements, notably for a spent fuel transportation and the large experience acquired with good records give confidence that safety is well in hand in this sector.

The safety of new storage facilities like the Borsele facility (The Netherlands), the "El Cabril" facility (Spain), or the Dessel facility (Belgium) is assured by appropriate designs to further minimize the risks such as flooding, fire, etc. When heat generating wastes, like vitrified high level wastes are stored, appropriate and reliable cooling is provided minimizing the risk of mechanical troubles. As an example, passive systems have given the Marcoule facility a satisfactory experience over the last twenty years and forced convection has been chosen for the La Hague facility (France).

IV.2. DISPOSAL

IV.2.1. Near surface disposal

For safety reasons, near surface disposal is limited to low and medium level wastes (as defined in section II.2). It has been practised in some countries from the earliest days of nuclear energy.
At the outset, wastes were buried in shallow trenches, with or without having been previously conditioned and/or packaged. This early concept is now generally considered obsolete.

As a result of progress in technology, engineering and operating experience, more advanced concepts have been investigated and/or implemented. The concept of near surface disposal in engineered structures, first demonstrated in France ("Centre de la Manche") in the early seventies for low and medium level, short-lived, radioactive waste, is now included in the radioactive waste management strategies of all countries practising or considering near surface disposal.

The principle underlying the concept is to isolate the waste from the human environment under controlled conditions and for a period of time long enough to allow the radioactivity to decay naturally, and to return the site to unrestricted access afterwards.

In reality, such a principle is applicable only insofar as the length of the institutional control period (operating period of the facility plus post-closure period) is acceptable on a human scale, i.e. a maximum of a few hundred years.

The application of the principle relies on the use of a system of multiple barriers between the radioactivity and the human environment. This system is generally divided into three main components, as follows:

- the waste package, including the physico-chemical properties of the waste, the characteristics of the embedding material, if any, and the performance of the container;

- the repository, i.e. the structures built at the disposal facility to protect the waste package: disposal cap, concrete pad, other concrete structures, etc.;

- the geology of the site itself.

It is the combined efficiency of these three barriers that provides containment of the radioactivity in normal operating and postclosure conditions, and ensures that the consequences of any reasonable foreseeable incident are acceptably low.
Several national safety authorities have accordingly given their approval during the recent years to the practice of near surface disposal of low and

medium level wastes in engineered structures.

Within the European Community[28)], this applies to :

a. the Drigg facility in the United Kingdom, following the review of its authorisation in 1987 by the authorising Departments;
b. the Dounreay facility in the United Kingdom, which has been used almost exclusively for low level waste arising at the Dounreay site;
c. the existing low/medium level waste disposal centre in France "Centre de la Manche", following its review in 1971;
d. the new low/medium level waste disposal centre "Centre de l'Aube" licensed for operation by the French safety authorities in December 1991;
e. the new low/medium level waste repository of "El Cabril", licensed for construction by the Spanish safety authorities in beginning 1990 and expected to be licensed for operation in Spring 1992.

In addition, the option is under consideration in Belgium (see section III. 6.3.1).

IV.2.2. Deep disposal in geological formations

In contrast to engineered barriers which are unlikely to remain unalterate for periods of time exceeding several centuries, some geological formations (e.g. clay, salt and granite) have proved to be stable for more than several millions of years and thereby could provide a safe long term solution for the disposal of radioactive waste containing long-lived radionuclides.Therefore the deep disposal in geological formations is being developed world-wide for alpha and high level radioactive wastes.
The safe disposal of these wastes, particularly as regards the need to protect humans and the environment in the far future, is a subject of broad concern in all countries engaged in nuclear energy production, notably in the European Community. It is also of concern in the other countries, making use of radioactive materials only for medical, industrial, or research purposes.
The safety of a disposal system for long-lived waste needs to be analysed and demonstrated over time scales far beyond the normal horizon of social and technical planning in order to obtain construction and operation licenses for a radioactive waste repository. Debate arises however on the feasibility of such an analysis and scepticism is often encountered about the validity of their results.

It is obvious that absolute proof of continuing safe behaviour is impossible for all technical systems. Accordingly what is expected and sought is a scientific and regulatory process that properly considers those factors that might significantly affect safety, and in that way provides the basis to decide if the proposed waste disposal system can be considered safe enough in the long term.

28.) The projected disposal facilities in North Carolina, Illinois and Pensylvania in the USA are examples of near surface disposal in engineered structures outside the European Community.

The following summarizes the progresses made in the EC in developing scientific ways and means to evaluate the long term safety of disposal and presents the results obtained so far, as well as the view of the EC experts and of the international scientific community.

The safety assessment

Safety assessment can be defined as an analysis of the future behaviour of the overall waste disposal system and of its potential impacts on humans and the environment, followed by comparison of the results with appropriate safety standards.
The range of possible futures to be considered is defined using scenarios, based upon human imagination and scientific judgment, coupled with existing knowledge of natural systems (see below natural analogues) and man-made barriers.
Then, predictive models are used to evaluate and quantify the effects of the key processes determining the performance of radioactive waste disposal systems, and to assess the possible radiological consequences with time. Adequate datas relevant to the system under evaluation and a sound basic understanding of the relevant physical and chemical properties of the system's constituents and their evolution remain a main prerequisite for successful modelling. This is one of the main objectives of the current research programme as indicated in section III.2.1.

The growth of the efforts to improve safety assessment has been impressive over the past years.
All countries having a relevant nuclear power programme, developed a competence in safety assessment and elaborated, or are elaborating, appropriate methodologies.
Within the European Community, the CEC launched in 1982 a large multinational project (PAGIS: Performance Assessment of Geological Isolation Systems), as part of its R&D programme on radioactive waste, to support such a development in the interested EC Member States, to harmonize the various methodological approaches and to allow the dissemination of the results.
All interested Member States participated or were associated to this project, which ended in 1989.
A methodology was elaborated with the involvement and consensus of a large majority of the scientists acting in the European Community in the various fields of this multidisciplinary activity and was applied to the case of deep repositories of high level waste.
With the assumptions made, the results reported at a CEC Conference in Madrid in 1989, show no radioactivity release at the surface of any of the sites investigated within 10 000 years at least and eventually insignificant releases in the very far future.
The methodology developed during the PAGIS project can be, and is already in some EC Member States, the basis for the performance assessment needed in the future, when it can be implemented with refined models and data as obtained from site specific investigations.

These achievements, together with those obtained outside of the EC led the international scientific community to express a collective opinion in 1990, which says[29.)] :
"safety assessment methods are available today to evaluate adequately the potential long-term radiological impacts of a carefully designed radioactive waste disposal system on humans and the environment";
"and appropriate use of safety assessment methods, coupled with sufficient information from proposed disposal sites, can provide the technical basis to decide whether specific disposal systems would offer to society a satisfactory level of safety for both current and future generations".

Work is continuing in this field to further develop the safety assessment methods and to collect and evaluate datas from proposed disposal sites.

Natural analogues : a supporting evidence of safety

As seen above, the central issue in assessing the long-term performance and safety of a radioactive waste disposal facility is the ability to predict confidently the nature and effect of processes and geological events far into the future.
Extrapolating laboratory data, generally obtained over months or at most a few years, out to realistic times into the future, is an obvious problem.

The processes being studied in the laboratory consider specific aspects of the mobilisation of radionuclides from the waste and their subsequent transport in groundwaters. Fortunately almost all of the processes of interest are also to be found operating in the natural environment, although different elements and different geochemical and hydrochemical regimes may be involved. There is thus an opportunity to use natural analogues to assess these processes over geological time scales.

Since many years already, Member States have been investigating natural systems (as well as archaeological and historical analogues) in and outside Europe. Some of them also participated to major projects, as for instance those at the Alligator River, Poços de Caldas and Cigar Lake uranium deposits in Australia, and Brazil and Canada respectively.

Since 1985 the Commission has supported the study of natural analogues through its R&D programme on radioactive waste and by providing an international forum (the Natural Analogues Working Group) where the experience gained worldwide in the field is presented and discussed.
Evidence of the segregation and retardation capabilities of natural systems is accumulating, contributing to build confidence in the deep geological disposal concept.
The Commission continues this effort within the framework of the fourth research programme on radioactive waste management and contributes financially to a number of studies in this area and in particular to the analysis

29.) A collective opinion on "Disposal of radioactive waste : can long term safety be evaluated" / NEA/CEC/IAEA Paris 1990.

of the natural reactor at Oklo (Gabon) led by the French "Commissariat à l'Energie Atomique" to which other Countries are being associated.

The regulatory process

For the selection of a site and up to the final licensing of a repository, the detailed procedure for demonstrating the safety of the system needs normally to be defined on a case by case basis: it may therefore differ in the various countries. In all cases it involves the responsibilities of various organisations which are outlined in section III.1. The agencies and executive bodies listed in Table X are responsible for providing all the elements needed to satisfy the competent safety authorities so that the facility matches a set of preestablished criteria.

CHAPTER V

ONGOING REGULATORY AND POLICY ISSUES

V.1 MATERIALS PRESENTING A VERY LOW RADIOACTIVITY

The existing regulatory measures at international, EC and national levels concerning the protection of the workers and of the public against the ionizing radiations, define very clearly the conditions under which the treatment, conditioning, storage, transport and disposal of radioactive materials must be done. The scope of these regulatory measures is defined according to the radioactivity of the materials under consideration.

In most regulatory regimes a grey area exists however where low level radioactive wastes approach levels of activity (and radiotoxicity) which are close to, or the same as, those existing in many naturally occurring substances. This is due to the fact that control activities are mostly concentrated in areas of higher risks, with a view to optimise the protection levels. The large number of practices involving very small quantities of radioactive materials and the great variety of industries which may be concerned, also explain this situation[30.)].

Many of these practices in medicine, research and industry have been regulated by the relevant national authorities; the radioactive wastes produced are exempted of regulatory control when they comply with the relevant exemption criteria. However, national regulations considerably differ from country to country.

At Community level, exemption for reporting to competent national authorities and from prior authorisation for any practice involving radioactive substances, is defined in the Euratom Basic Safety Standards (Directive 80/836 as amended in 1984). This directive quantifies the limits for a given consignment of radioactive substances, which depend on the radiotoxicity of the substances. It also sets a general concentration limit of 100 Bq/g, which is increased to 500 Bq/g, for solid natural radioactive substances. Materials containing radioactive substances in quantities and concentrations exceeding these limits may be released only after having obtained the agreement of the authorities. However, these values should not be considered as allowable amounts for unrestricted disposal of waste.

As far as the nuclear sector is concerned, dismantling of obsolete nuclear installations is a practice under development which will produce large quantities of scrap, most of it materials of very low radioactivity (see section II.3.3b). At EC level, recommendations on "radiological protection criteria for the recycling

---

30.) Waste from medical analysis and treatment, research institute waste, discarded consumer products like smoke detectors and spent electronic valves, waste from luminous paint industry, etc...

of materials from the dismantling of nuclear installations[31.)] have been published under the umbrella of the EC group of experts as defined in Article 31 of the Euratom Treaty. These recommendations are presently under revision and are to be extended to include other material than steel, like copper and aluminium; at a later stage concrete is to be added. These recommendations are of a scientific character only. At the level of the EC Member States, most decisions on exemption of low level waste within the nuclear fuel cycle are taken by the competent authorities on a case by case basis.

All in all, the situation in respect of exemption from regulatory control of materials presenting a very low radioactivity is not satisfactory. For this reason, activities for setting up coherent and scientifically sound rules have been stepped up during the last decades; several national safety authorities and international organisations (IAEA, OECD/NEA, WHO)[32.)] are studying criteria for the exemption - partial or total - of radiation sources and practices from regulatory control. In the meantime, several EC Member States have prepared or are preparing legal measures. It should be underlined that harmonisation of national measures is highly recommended with a view to assure an equivalent level of protection within the Community. The coming single internal EC Market adds to the need for such an harmonisation.

Finally, one must note, as already done in Chapter II, that a number of industrial processes leading to a further concentration of naturally occurring isotopes (an example is the treatment of phosphate ores)[33.)] are usually exempted from reporting to the relevant national safety authorities, or are not listed as practices involving radioactive materials. There may be matter of concern in relation to the radiological consequences of disposal of some of these materials. Several countries are at different stages in developing inventories and management strategies for these wastes and appropriate measures will be taken, if necessary.

V.2 RADIOACTIVE WASTE EQUIVALENCE

A number of countries are processing or conditioning some foreign waste as a result of commercial arrangements or as a consequence of spent fuel reprocessing commitments.

Over and above any possible national policy of the receiving country regarding the disposal of foreign waste, a return of the precisely identical foreign waste in its totality to the country of origin after adequate treatment and conditioning, may be, in some cases, technically impossible, or counterproductive from a radiological safety point of view (unnecessary handling of radioactive materials as an example). In such a situation, one may consider, or indeed one may be compelled, to return an "equivalent waste".

31.) CEC radiological protection series, Publication N° 43, December 1988

32.) IAEA SAFETY SERIES N° 89 "Principles for the exemption of radiation sources and practices from regulatory control" (1988)

33.) See. Ref. 5.) page 6

This should be carried out within an adequate regulatory framework, to be agreed upon by the parties involved.
Radioactive waste equivalence has not been addressed up to now, neither in international nor in national regulations. The EC Council of Ministers noted in 1990[34.)] the need to set up appropriate guiding principles, as a conclusion to a Commission's report on the subject[35.)]

V.3 PUBLIC INFORMATION AND INVOLVEMENT

Great efforts have been made during the last years by the various national authorities and/or waste operators, and by the Commission of the European Communities within the limits of its competence :

- to provide information to the public about major nuclear sites and the related radioactive waste discharges;

- to involve the public in the decision making process with respect to the setting up of new installations for radioactive waste management and disposal.

As far as the European Community Institutions are concerned, a Directive asking, *interalia*, the Member States to take care that :

- every licensing request for a new project and the supporting information will be made available to the public;

- the public has the opportunity to make known its opinion before the project is begun,

entered into force in July 1988. The Commission shall send a report to the Council and the Parliament on the Directive's application and effectiveness in 1993.

In many cases the public is given access to any applications to set up such facilities (United Kingdom, etc) and, in the case of major projects, there is often a public inquiry which :

- gives the public access to information on the project under consideration;

- collects the comments and objections of the public for consideration by the competent national administration.

34.) Conclusions of the 1464th Council meeting of December 18,19, 1990, press release 10871/90 (presse 232).

35.) "Radioactive waste equivalence", Euradwaste series N° 3, report EUR 12879 - Office for EC Official Publications, Luxembourg 1990.

In most cases, the public inquiry procedure is legally based; it may be compulsory (Federal Republic of Germany, Spain, France, The Netherlands) or, as in the United Kingdom, for government to consider its use on a case by case basis. In addition, a recent French law[36] demands that a local information and oversight Committee, where all interested parties will be represented, will be established on the site of each underground disposal laboratory.

In addition to the information made available to the public by means of booklets (like the Dutch information campaign of 1987) or by giving access to official documents, several governments (Federal Republic of Germany, Spain, United Kingdom) report at various intervals of time, to the national Parliaments, about the arisings and/or about the management of radioactive waste in their country. These reports are publicly available. According to the recent law referred to above, the French government shall also submit an annual report to Parliament on research on high level and alpha waste management.

36.) Law N° 91-1381 of December 30,1991 on radioactive waste management research.

TABLE I

RADIOACTIVE WASTE ARISING FROM USE OF ISOTOPES IN MEDICINE, INDUSTRY AND GENERAL RESEARCH (m ³)

(liquid and solid waste shipped for centralized interim storage)

COUNTRY	1991-1995	1996-2000	2001-2010	2011-2020
BELGIUM	370	370	740	740
DENMARK	100	100	200	100
GERMANY	5,100	5,100	10,200[4]	10,200[4]
IRELAND	some tens[3]	some tens[3]		
SPAIN	210	210	420	420
FRANCE [1]	5,000	5,000	10,000	10,000
GREECE	100	some tens	some tens[5]	some tens[5]
ITALY	4,500	4,500	9,000	9,000
THE NETHERLANDS	1,600	1,600	3,200	3,200
PORTUGAL	20	30	80	100
UNITED KINGDOM [2]	4,960	3,030	5,610	5,610

1) Waste volumes before treatment and conditioning.
2) Periods resp. 1990-1994, 1995-1999, 2000-2009, 2010-2019.
3) Unconditioned and held at site of production.
4) Extrapolated from figures given for period up to 2000.
5) Per five-year period.

TABLE II

WASTE IN INTERIM STORAGE WHICH WAS PRODUCED BEFORE 1991, TREATED AND CONDITIONED OR PRESUMED TO HAVE BEEN CONDITIONED [1]

COUNTRY	Quantities of waste in interim storage (m³)				
	low level	medium level	alpha	high level	Remarks
Belgium	6,000	-	3,000	160	Data per 1.5.1990 Medium-level waste incl. in low-level waste
Germany	43,900	[2]	[2]	500	
Spain	15,000	-	-	-	Medium-level waste incl. in low-level waste
France	0	0	60,400	1,040	Medium-level waste incl. in low-level waste
Italy [3]	10,400	720	190	15	
The Netherlands	3,100				
United Kingdom	7,930	18,470	65,550	710	Alpha waste are those MLW with an alpha activity >10 GBq/m³ when in conditioned waste form
Denmark	700[4]	50[5]	-	-	Alpha-waste incl. in MLW
Portugal	50	-	-	-	
Greece	100	50	-	-	

1) Most of the alpha and high-activity waste (stored in liquid form) has not yet been conditioned. For uniformity of presentation, the volumes indicated in this table are those which could be obtained by conditioning the waste with the methods available at present.
2) Partially included in low level waste (as waste "without heat generation") and in high level waste (as "heat generation waste").
3) The unconditioned quantities in interim storage are: 12,195 m^3 LLW (11,620 m^3 solid and 575 m^3 liquid); 585 m^3 solid MLW; 356 m^3 alpha (346 m^3 solid and 10 m^3 liquid); 120 m^3 liquid HLW.
The conditioned quantities in interim storage are: 3,610 m^3 LLW and 345 m^3 MLW.
A volume reduction factor between 3 and 5 for solid waste to be compacted, and a reduction factor of 1/2 for liquid LLW is assumed.
Figures do not include about 5000-7000 m^3 of unconditioned waste coming from medical industrial and non-nuclear research.
4) Only half of the volume is actual waste, the rest is a surrounding concrete layer in the waste units.
5) Stored mostly without conditioning in stainless steel containers, drums or other types of package.

TABLE III

LOW AND MEDIUM LEVEL WASTE DISPOSED OF BEFORE 1991 WITH CONDITIONING PRODUCTS AND LOST PACKAGE INCLUDED

COUNTRY	Quantities of waste (m^3)			
	Low level	Medium level	Type of disposal	Site
Belgium	15,000		Sea dumping[1]	N. Atlantic Ocean
Germany	96		Sea dumping[1]	N. Atlantic Ocean
	42,000	260	Deep geological formation	Asse salt mine[2]
	14,300[3]		Deep geological formation	Morsleben salt mine
Spain	-	-		
France	9,900		Sea dumping[4]	N. Atlantic Ocean
	464,500		Near surface disposal	Centre de la Manche
Italy	23		Sea dumping[1]	N. Atlantic Ocean
The Netherlands	8,700		Sea dumping[1]	N. Atlantic Ocean
United Kingdom	26,000		Sea dumping[1]	N. Atlantic Ocean
	775,000	-	Shallow burial	Drigg
	14,000	-	Shallow burial	Dounreay

1) Moratorium on sea dumping since 1983

2) In operation between 1967 and 1978

3) Figures up to 1990

4) Experimental campaigns in 1967 and 1969

TABLE IV

NUCLEAR POWER PROGRAMMES IN THE MEMBER STATES OF THE EUROPEAN COMMUNITY

COUNTRY	Net power installed at the end of the year (GWe) (Only power stations in operation or committed)				
	1990	1995	2000	2010	2020
Belgium [1]	5.4	5.4	5.4	5.4	3.6
Germany	23.6	23.6	23.6	25.0[5] 17.5	25.0[5] 17.5
Spain [2]	7.1	7.1	7.1		
France [7]	62.7	62.2	[63.3]	[63.3]	[63.3]
Italy [3]	1.1				
The Netherlands [4]	0.5	0.5	0.5		
United Kingdom [6]	11.4	10.0	9.5	5.4	1.2

1) The general electricity plan applies until 2000 ; there are no estimates beyond this period.
2) The present nuclear programme only extends up to the year 2000. No provisions beyond this date are available.
3) 1.1 Gwe installed, but not in operation.
4) The development of nuclear power programmes has to be reviewed.
5) 1st line: power stations in operation and with substitution of old stations phased out
   2nd line: idem, without substitution
6) Will be reviewed in 1994.
7) Figures in brackets are given for the sake of homogeneity with similar figures in other countries. They do not take into account the planned power stations figuring in the French Energy Plan's forecast : 63.3 to 66.3 GWe in 2000/74.2 to 80.8 GWe in 2010/and 80 to 95 GWe in 2020.

TABLE V

PRODUCTION OF LOW LEVEL WASTE, TREATED AND CONDITIONED IN VARIOUS COMMUNITY MEMBER STATES
(Power stations in operation or committed - assumptions in Table IV, the associated fuel cycle facilities, nuclear energy research)

Country	Quantities of waste accumulated per indicated period (m^3)				
	1991-1995	1996-2000	2001-2010	2011-2020	Remarks
Belgium	3,130	4,230	15,785	15,060	
Germany[2]	35,000-50,000	50,000-71,000	97,000 (83,000+14,000)	97,000 (83,000+14,000)	include partially MLW and alpha waste
Spain[1]	11,000	10,000 (8,500+1,500)	17,000 (15,700+1,300)	40,000 (14,600+25,400)	incl MLW
France	160,000	160,000	300,000	300,000	incl MLW
Italy[1]	3,100 (3,100+0)	2,700 (1,900+800)	4,300 (3,500+800)	7,000 (500+6,500)	
The Netherlands	2,400	2,400	-[4]	-[4]	
United Kingdom[1]	137,530 (104,550+32,980)	106,230 (65,200+41,030)	256,730 (77,360+179,370)	143,330 (12,830+130,500)	periods 90-94, 95-99, etc
Denmark	-	-	-	1,500[3]	

[1] A breakdown between waste volume from operating plants (1st. figure) and waste volume from plant decommissioning (2nd fig.) is given in bracket.
[2] Upper and lower estimates.
[3] Possible decommissioning of DR3 research reactor.
[4] See footnote 4 to table IV

TABLE VI

PRODUCTION OF MEDIUM LEVEL WASTE OF ANY ORIGIN, TREATED AND CONDITIONED, IN VARIOUS COMMUNITY MEMBER STATES
(Power stations in operation or committed - assumptions in Table IV)

Country	Quantities of waste accumulated per indicated period (m^3)				
	1991-1995	1996-2000	2001-2010	2011-2020	Remarks
Belgium[3]	2500 (2450+50)	2754 (2704+50)	6724 (6624+100)	5730	
Germany	-	-			1)
Spain	-	-	-	-	1)
France	-	-	-	-	1)
Italy	205	120	275		4)
The Netherlands	-	250	250	-	2)
United[3] Kingdom	12240 (7240+5000)	11540 (6400+5140)	23010 (11560+11450)	18100 (6270+11830)	Periods: 90-94, 95/99 etc.
Denmark	100	5	5	-	incl. alpha waste

1) In accordance with management practices applied in this country, this waste is accounted for in other waste categories.

2) Waste originating from fuel reprocessed abroad from present power plants.

3) See note 1) Table V

4) Waste originating from fuel reprocessed abroad from shut down power plants.

TABLE VII

PRODUCTION OF ALPHA WASTE TREATED AND CONDITIONED, IN VARIOUS COMMUNITY MEMBER STATES (Power stations in operation or committed - assumptions in Table IV)

Country	Quantities of waste accumulated per indicated period (m^3)				
	1991-1995	1996-2000	2001-2010	2011-2020	Remarks
Belgium	190	540	2890	2430	
Germany[3]	-	-	-		
Spain	-	-	-	40	
France	13640	14060	36110	36110	
Italy					[4]
The Netherlands	10	60	70	20	[1]
United Kingdom [2]	16350 (12000+4350)	18620 (14230+4390)	20470 (11960+8500)	9550 (1080+8470)	Periods: 90-94,95-94 etc.

1) Including waste originating from fuel reprocessed abroad from present power plants.

2) See note [1] table V

3) In accordance with waste management practices applied in this country, this waste is accounted for in other waste categories.

4) No noticeable amount is estimated to arise from nuclear energy research activity.

TABLE VIII

PRODUCTION OF HIGH LEVEL WASTE TREATED AND CONDITIONED IN VARIOUS COMMUNITY MEMBER STATES
(Power stations in operation or committed - assumptions in Table IV)

Country	Quantities of waste accumulated per indicated period (m^3)				
	1991-1995	1996-2000	2001-2010	2011-2020	Remarks
Belgium	45	54	180	180	
Germany [2]	1310-1510	1310-1510	2620-3020 [5]	2620-3020 [5]	
Spain	-	-	-	36	
France	510	540	1980	2190	
Italy [4]	10	5	25	-	
The Netherlands [1]	-	20	25	-	
United Kingdom [3]	170	260	130	-	Periods 1990-1994,1995-1999, etc.

1) Waste originating from fuel reprocessed abroad from present nuclear power plants.

2) Upper and lower estimates. This category includes partially medium level and alpha waste.

3) Solely from the reprocessing of UK fuel

4) Waste originating from fuel reprocessed abroad from shut down power plants.
5) Extrapolated from figures given for the period up to 2000.

TABLE IX

SPENT FUEL DISCHARGED IN THE MEMBER STATES OF THE EUROPEAN COMMUNITY

Country	Reactor type	Quantity of fuel discharged per indicated period (MTHM)[1] - Power stations in operation and/or committed (assumptions in Table IV)				
		up to end 1990	1991-1995	1996-2000	2001-2010	2011-2020
Belgium	LWR	850	550	550	1100	770
Germany	LWR	3865	2450	2215	4500[6] 4100	5500[6] 3200
Spain	LWR GGR	975 445	800 447	855 -	1510 -	1090 -
France	LWR GGR FBR	6650 4340 -	5120 1850 65	5330 - 72	10820 - 140[5]	11000 - 140[5]
Italy [2)4)]	LWR GGR	342 1353	137 73			
The Netherlands	LWR	75	75	75	[2)]	[2)]
United Kingdom	GGR AGR LWR FBR		4000 1100 -	4000 1200 150	2300[3] 1500[3] 150[3]	[3)]
Denmark		0.2	0	0	0	0

---

1) MTHM : Metric tons of heavy metal
2) See footnotes 3 and 4 to Table IV
3) Data is only available up to 2005
4) Discharge planned to be completed in 1991
5) These datas concern reactors in operation, and do not presume decisions on the future of FBR
6) First line : Power stations in operation, with substitution of old stations phased out;
   Second line: idem, without substitution

---

* LWR: Light Water Reactor
GGR: Gas-Graphite Reactor
AGR: Advanced Gas-cooled Reactor
FBR: Fast Breeder Reactor

TABLE X
EXECUTIVE BODIES RESPONSIBLE FOR ALL OR PART OF RADIOACTIVE WASTE MANAGEMENT
IN THE COMMUNITY MEMBER STATES
(see Annex for meaning of acronyms)

Country	Executive body	Waste conditioning	Laying-down of specifications and quality criteria	Quality control	Site studies, design, construction and management disposal centres	Studies on management strategies	Transport of waste	Interim storage away from the production installations
BELGIUM	ONDRAF/ NIRAS <u>public</u> set up 80-81	In parallel with the industrial operators	X	X	X	X	X	X
DENMARK	The RISO national laboratory, by agreement with the National Health Service, is responsible for collecting and storing radioactive waste from hospitals and industry.		Inspectorate of Nuclear Installations					
FEDERAL REPUBLIC OF GERMANY	BfS The "waste" task was assigned to this <u>Federal</u> body in 1976	- (Responsibility of the industry)	X BfS	X BfS	X (DBE acts on behalf of BfS)	X	Performed by industry after permit from BfS	By industry and/or federal centres (Landessammelst ellen)
FRANCE	ANDRA <u>public</u> set up on 07.11.79	- (Responsibility of the industry)	X	X	X	X	X (partially)	
SPAIN	ENRESA* <u>public</u> set in 1984	X (in particular cases and circumstances)	X	X	X	X	X	X
GREECE	The management and storage are the task of the ministries concerned in co-operation with the Atomic Energy Commission and the Demokritos Research Center.							

* including spent fuel

TABLE X (continued)
EXECUTIVE BODIES RESPONSIBLE FOR ALL OR PART OF RADIOACTIVE WASTE MANAGEMENT
IN THE COMMUNITY MEMBER STATES
(see Annex for meaning of acronyms)

Country	Executive body	Waste conditioning	Laying-down of specifications and quality criteria	Quality control	Site studies, design, construction and management of disposal centres	Studies on management strategies	Transport of waste	Interim storage away from the production installations
IRELAND	The nuclear Energy Board is responsible for the regulation of the storage and disposal of radioactive waste arising from industry, research laboratories and hospitals in accordance with Statutory Instrument 166/1977							
ITALY	NUCLECO* <u>Semi-public</u> set up in 1981	Waste producers (ENEA & ENEL) and NUCLECO	ENEA-DISP (Directorate for Nuclear Safety and Radiation Protection	ENEA-DISP	Site management	ENEA	Commercial operators (under ENEA-DISP control)	X (for waste from medical, industrial and research activities)
THE NETHERLANDS	COVRA <u>private</u> set up in Dec. 1982	X **	X	X			X**	X****
PORTUGAL	The collection, packaging and storage of radioactive waste from research laboratories, hospitals and industry are carried out by the Department of Radiological Protection and Safety of the Laboratory Nacional de Engenharia e Tecnologia Industrial (LNETI) in Sacavém. National competent Authorities are the General Directorate for Primary Health Care of the Ministry of Health (Decree-Law N° 348/89 of October 12, 1989) and the Nuclear Safety and Protection Office of the Ministry of Environment (Decree-Law N° 425/91 of October 30,1991).							
UNITED KINGDOM	UK NIREX Ltd set up in July 1982 and made into a limited company wholly owned by the Government in 1985	Waste producer	X***	X***	X***	waste producers	nuclear operators	BNFL, AEA NE, SN

* Solely in the case of low- and medium-level waste (waste operator for providing conditioning services).
** In the case of interim storage of low- and medium-level waste.
*** Solely in the case of low- and medium-level waste and alpha waste.
**** New facilities for interim storage and treatment of low- and medium-level wastes are under construction and should be completed in 1991 and 1992 respectively.
X Role covered by the Executive Body.

TABLE XI

ANNUAL EXPENDITURES INVOLVED IN RADIOACTIVE WASTE R&D ACTIVITIES

MECU

	1987[1]	1990
BELGIUM	9.5	11
DENMARK	0.6	0.3
FRANCE	48 (1)	85
FED. REP. OF GERMANY	55	57
GREECE	0.1	0.1
IRELAND	0	0
ITALY	10	5
LUXEMBOURG	0	0
THE NETHERLANDS	4.3	3.6
PORTUGAL	0.1	0.1
SPAIN	4.5	7.5
UNITED KINGDOM	56	63
CEC	15	20

(1) only CEA

[1] Ref : The nuclear fuel cycle : Review on R&D policies in the Member States of the European Community - EUR 12380 (1987)

TABLE XII

SUPERCOMPACTORS IN EC MEMBER STATES*
(in operation or committed)

COUNTRY AND LOCATION	TYPE	MAXIMUM FORCE	WASTE STREAM	TYPICAL VOLUME REDUCTION [1]
FRANCE				
Waste repository				
Centre de l'Aube	Fixed	1000T	Misc LLW	2-5
Reprocessing plants				
La Hague AD2	Fixed	1500T	Misc LLW	2-16
Nuclear Power Plant				
Bugey	Fixed	2000T		
GERMANY				
Power Plant				
Brunsbuttel	Mobile	2000T	Misc LLW (180 litre drums)	3-4
Research Centres				
Karlstein and Karlsruhe	Fixed	1500T	Misc LLW (180 litre drums)	3-10
Gesellschaft für Nukleare Service, Essen, various	Mobile	1500T	Misc LLW (220 litre drums)	3-10
ITALY				
Research Centre/ Waste Processor				
Casaccia	Fixed	1500T	Misc LLW	3-6
Nucleco, various	Mobile	2000T	Misc LLW (220 litre drums)	3-6
THE NETHERLANDS				
Research Centre/ Waste Processor				
Petten	Fixed	1500T	Misc LLW (100 litre drums)	5-10
SPAIN				
Various	Mobile	1200T	Misc LLW	3-6
UNITED KINGDOM				
Drigg	Fixed	-	Misc LLW	-
Dounreay	Mobile	2000T	Misc LLW	5-10
BELGIUM				
	Mobile	-	Misc LLW	-
	Fixed	Operational in 1995		

[1] Dependent on waste feed physical form. Lower range values refer to pre-compacted material.

TABLE XIII

LARGE SCALE INCINERATORS IN THE EC MEMBER STATES*
(in operation or committed)

COUNTRY AND LOCATION	STATUS	WASTE STREAM	DESIGN CAPACITY
BELGIUM Mol	In operation	Low level beta gamma solid waste +minor quantitities of liquids	80 kg/h
id	will substitute the previous one	Idem + limited quantities of very low level alpha waste	80 kg/h
FRANCE			
Marcoule	Committed	Misc solids	80 kg/h
Fontenay-aux-Roses	In operation	Animal carcasses	50 kg/h
Pierrelatte	"	Oil and solvents	70 kg/h
Cadarache	"	Spent solvents	30 kg/h
"	"	Pu contaminated solids	30 kg/h
Grenoble	"	Organic products	15 kg/h
FEDERAL REPUBLIC OF GERMANY	In operation	alpha-solids	50-60 kg/h
Karlsruhe	"	Misc solids (beta/gamma)	50 kg/h
"	"	liquids	50 kg/h
Jülich	"	Low level liquid wastes	20 kg/h
"	"	Low level solid wastes	50 kg/h
SPAIN El Cabril	Committed	Low level waste, mainly organic and biological wastes	50 kg/h
UNITED KINGDOM			
Hinkley Point	In operation	Misc solids	75 kg/h
and Weylfa		Contaminated oil	20/30 l/h
Harwell	"	Solid low level waste	136 kg/h
Dounreay	"	Mainly solid	3000 m^3/y

TABLE XIV

Interim storage of low and medium level radioactive waste packages within the European Community

COUNTRY	ON-SITE	CENTRALISED SITE	REMARKS
Spain	yes	yes	The El Cabril facility should progressively receive waste packages still stored on-site.
The Netherlands	yes (provisional)	yes	the Borsele interim storage facility is equipped for receiving reactor and reprocessing wastes as well.
Belgium	no	yes	All kinds of waste generated in Belgium are stored in Mol/Dessel. An extension of the buildings capacity for storing reprocessing wastes should be completed by 1993.
UK	yes	no	Interim storage only concerns those waste types which do not comply with the disposal criteria for the Drigg near surface site.
France	yes	yes (for LLW arising from small producers)	As in the UK case, interim storage only concerns those waste types which cannot be disposed of in a near surface site ("Centre de la Manche" and "Centre de l'Aube").
Federal Republic of Germany	yes	yes (Gorleben and Mitterteich facilities)	Once a disposal facility for L & MLW is available, only centralised interim storage sites will be operated.
Italy	yes	no	
Portugal	no	yes	
Greece	no	yes	
Denmark	no	yes	

TABLE XV

Interim storage of vitrified high level waste within the European Community

Country	Facilities	(available capacity in m³)	Duration of interim storage	Date of operation
France	Marcoule	440 160	30 y	1978 1996
	La Hague	900 720	30 y	June 1989 1996
UK	Sellafield	1200	at least 50 y	February 1991
Belgium	Dessel 1) Eurochemic 2) La Hague	 250 75	 at least 30 y at least 50 y	 1986 1993
The Netherlands	Borsele	60	100 y	2000
Federal Republic of Germany	Gorleben	to be defined	at least 15-20 y	still not defined
Spain	- [1]		40 y	- [2]
Italy	- [3]		-	1994

[1] Will be defined at the turn of the century.

[2] Vitrified waste will be returned after 2010.

[3] ENEL's vitrified wastes will probably be stored at a shut down power station.

TABLE XVI

STORAGE CAPACITIES FOR SPENT FUEL
(TONS OF HEAVY METAL)

Country	Year		
	1990	1995	2000
Belgium	1350	1350	1350*
Federal Republic of Germany	**** 3000	**** 3000	**** 3000
Spain***	1950	4030	4170
France*****	13000	20400	21000
Italy	590	590	580
The Netherlands	0	0	0
United Kingdom	8,300	8,300**	8,300**

* Extension of capacity is under study.
** Beyond this date, additional capacity will be provided as required.
*** Additional full core discharge capacity is available.
**** Away from reactor
***** Including reprocessing plants and power plants