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COMMUNICATION FROM THE COMMISSION TO THE COUNCIL

First report on the present situation and prospects in the management of radioactive waste in the Community

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REPORT FROM THE COMMISSION TO THE COUNCIL

Analysis of the present situation and prospects in the field of radioactive waste management in the Community

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# COMMUNICATION FROM THE COMMISSION TO THE COUNCIL

SUBJECT: First report on the present situation and prospects in the management of radioactive waste in the Community.

## I. INTRODUCTION

In its resolution of 18 February 1980 (*), the Council approved a Community plan of action in the field of radioactive waste. This plan refers to the problems posed by radioactive waste from nuclear installations and in particular those concerning the management and storage of high level and/or long-lived waste. It runs from 1980 to 1992 and is reviewable every three years (**).

Point 1 of the plan provides for a continuous analysis of the radioactive waste management situation in the Community with a view to adoption of the necessary solutions. This analysis must cover:

- the techniques available and installations already in existence or planned by the Member States for the various stage of radioactive waste management, including processes and practices for final disposal;

- technological research and development work which the Member States and the Community intend to carry out;

- management practices for various categories of waste which have been or are to be defined in the Member States;

- the estimated implementation dates and schedules.

The information and results obtained from this work are to be used "to keep the Community and the Member States constantly up to date on work and achievements in the management and storage of radioactive waste, having regard to nuclear programme requirements".

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(*) O.J. No C 51 of 29 February 1980

(**) In the light of the situation described here after and according to the opinion of the competent Advisory Committee on programme management (O.J. No C 51 of 29 February 1980) given on 5 November 1982, the Commission considers that there are no reasons to modify the plan of action for the time being. This Commission's decision will be the subject of another communication.

Consequently the Commission is transmitting to the Council, together with its comments, the annexed report drawn up on the basis of information supplied by the Member States; this report reflects the situation in 1981-82 and gives the prospects in the management of radioactive waste in the Community member States up to the end of the century. The Commission intends to follow up this report, the first of its type, with others in order to keep the Council regularly informed throughout the duration of the plan.

II. The Commission draws the Council's attention to the following points:

a) Because of the high level of development in the Member States, radioactive waste of many different categories and origins is produced in the Community (see chapter I of the report).

In terms of contained radioactivity, waste from nuclear power stations and associated fuel cycle plants accounts for the majority of the waste produced. This applies only to States having nuclear power programme. As several Member States have developed the fuel cycle in its various stages, the ensuing waste differs very greatly in type, volume, radioactivity level, life, etc.
In volume terms, a considerable proportion consists of waste from medical uses, non nuclear industry and research. This applies to all the Member States (see chapter I.4).

b) The radioactive waste situation therefore has to be analysed by categories of similar waste. According to the report, the present situation in the Community is as follows (see chapter II):

- There is some 30 years of experience in low and medium level waste management, which appears to meet the current requirements of nuclear power programmes in the Member States and also safety requirements, as regards both past achievements and future developments. It is of course essential to ensure that technological progress is continually applied (see chapter IV, point 6).

- There should not be any major problems in disposing of low and medium level waste in so far as existing methods (sea dumping and land disposal) will continue to be used. This calls for rapid necessary decisions on the identification and opening up of new sites (see chapter IV, point 7).

- The basic technologies for the management of long-lived waste contaminated by alpha emitters and high level waste are available. Some are coming on to the market place (waste vitrification) (see chapter III). However current development efforts must be continued. A special effort must be payed for adapting treatment and conditioning processes for waste contaminated by alpha emitters to the conditions required by disposal in geological formations (see chapter IV, point 8).

- So far these types of waste have been stored pending final disposal. Disposal facilities for alpha waste should come into service in the Member States concerned in the early 1990s (see chapter IV, point 9).

- High level waste disposal is being studied by the Member States and the Community from several angles: disposal in deep continental geological formations such as salt, clay, crystalline rocks available in the Community and the feasibility of which appears to have been proved, and in the ocean bed (see chapter IV, point 12).

III. From this analysis it results:

- Solutions which over long years of experience have been physically demonstrated to be feasible have therefore been found to many of the radioactive waste problems, especially for the medium and short term management stages, such as treatment, conditioning and temporary storage.

- Disposal, which is the ultimate long-term stage of management, has not yet been successfully demonstrated for long-lived and high level waste categories.
  A solution to this problem is regarded as an important factor for the public acceptance of nuclear development and that is why the Commission considers that a convincing demonstration must be given, even if:

  - disposal does not readily lend itself to direct demonstration since it needs safety assessments covering the very long term, which of necessity have to be based either on accelerated tests or on indirect evaluations;

  - the need to allow highly active waste to "cool" for several decades rules out any industrial disposal before the end of the century.

IV. In the light of what has been said above, the Commission considers it essential vigorously to pursue the Community activities that have been successfully conducted over the past few years and are recognized by the Community institutions.

In addition, special attention should be paid to the implementation of the measures described in point 2 of the Community plan of action (*).

Consequently the Commission has adopted the following course of action:

- Presentation to the Council in 1983 / 1984 - and in conformity with the objectives of the scientific and technical activities of the framework programme - of new R&D programmes which will be carried out by the Joint Research Center (programme 1984 - 1987) and by cost shared actions (programme 1985 - 1989). These programmes will focus on all aspects of the waste disposal problem: prior waste conditioning, specifications for disposal, quality control, disposal in geological formations, administrative, legal and financial aspects.

- Encouragement of technical cooperation between Member States either at the level of licensing Authorities or in the context of the R&D effort especially by suitable measures to facilitate:

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(*) Examination at Community level of measures which could ensure the long-term or permanent storage of radioactive waste under optimum conditions" (Plan of action, point 2). Note: the terms "permanent storage" and "disposal" are synonymous.

a) staff mobility and exchanges between public or private bodies taking part in the Community R&D programme mentioned above.

b) the negotiation of suitable methods for the subsequent phases of the programme; this should involve reciprocal commitments between the participants in the programme since up to now they have legal ties only with the Commission.

- In the context of the Community plan of action, examination of the development status, feasibility, cost and possible timetable for the various stages in the implementation of disposal options for long-lived and high level waste ranging from conditioning to the disposal facility pilot project; continuation of the safety studies already started. The corresponding proposals for projects will be presented at the same time as the proposal for the 1985 - 1989 R and D programme.

- Promotion of a demonstration - within the meaning of Section III above - of one or more radioactive waste management plans, including disposal in geological formations. The plan concerned could cover several sites or institutions, with each of the sites providing specific services. Cooperation extended to the outside of the Community should help to improve the standard of the demonstration and avoid costly duplication.

- The Commission invites the member States to communicate, as from now, their possible projects concerning the above actions and in particular the study and realisation of experimental or demonstration disposal installations.

- Community aid going beyond the budget allocated to the R&D programmes could be requested to help finance the above projects. The Commission will make concrete proposals in order to meet any requests for financing, provided the corresponding projects are in line with the interests of several Member States.

COMMISSION
OF THE
EUROPEAN COMMUNITIES

Directorate-General
for Science, Research and Development
Joint Research Centre

# Analysis of the present situation and prospects in the field of radioactive waste management in the Community

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# CHAPTER I

## Present situation and prospects concerning radioactive waste production in the Member States of the Community.

### I.1. Sources of radioactive waste production

All human activities inevitably produce waste. In particular, the use of radioactive materials of natural or artificial origin gives rise to the production of radioactive waste requiring treatment, conditioning and disposal to make it safe for man and his environment for as long as necessary.

This use also generates liquid and gaseous effluents which are discharged into surface water and the atmosphere in conformity with the radiation protection regulations in force and subject to adequate control. These discharges are communicated to the Commission of the European Communities and appear in periodic reports by the Commission; they do not constitute radioactive waste as such and do not come within the scope of this report.

Three types of activities generating radioactive waste can be considered within the European Community (military activities do not come within the scope of this report) :

- nuclear power production,
- research activities,
- industrial and medical activities involving the use of radioelements.

Sources of waste may be nuclear power stations and the associated fuel cycle facilities, laboratories and research centres, factories and hospitals. The relative importance of these sources varies considerably from one country to another within the Community; all these countries commonly utilise radioelements for research, industrial and therapeutic purposes, but to date only some of them have undertaken nuclear power programmes, which generate waste containing most of the radioactivity.

The activities linked to the nuclear power programmes entail the following waste production :

a) Production of low level waste during the successive steps of the fuel cycle upstream from the nuclear reactor, namely the mining and processing of uranium ores containing alpha-emitting radioisotopes of natural origin (such as radium-226), conversion into uranium hexafluoride, uranium enrichment in the uranium-235 fissile isotope and the fabrication of fuel elements. This technological and process waste (x) contains materials contaminated by uranium isotopes.

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(x) Technological waste is made up, for example, of non-reusable clothes, rags, papers, plastic sheets, etc., whereas process waste consists of materials specific to the process used.

b) Production of low and medium level waste during the operation of the reactors of nuclear power plants and of the associated fuel cycle plants. As far as reactors are concerned, a major part of this waste consists of evaporator concentrates, ion exchange resins, filter cartridges of coolant loops and off-gas cleaning devices, decontamination solutions, etc. This waste essentially contains activation products and traces of fission products, which, in the event of the failure of fuel element cladding, can be present in the primary coolant loop of the reactor.

c) Production of low, medium and high level waste in the part of the fuel cycle downstream from the nuclear reactor, essentially during the reprocessing of the spent fuel (x); this waste contains the fission products, transuranic elements such as americium and curium, and traces of plutonium (these various radioelements are produced in the reactor and are set free during the dissolution of the fuel in the reprocessing phase).

It is worth pointing out that the reprocessing of spent fuel does not constitute an additional source of radioactivity as the radionuclides are already present in the spent fuel.

Activities not connected with nuclear power programmes are essentially sources of low level waste :

a) In research, waste from nuclear research centres is the most abundant and resembles that produced under nuclear power programmes.

b) In industry and medicine, waste comes from the production and utilization of radioisotopes. Examples include non-destructive testing in industry by means of gamma radiation or neutron sources, radio-sterilization of food, surgical and other products, cobalt used in cancer treatment, etc...

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(x) These operations separate unburnt uranium and plutonium from the "ash" of nuclear combustion. The uranium and plutonium recovered can then be recycled.

## I.2. Radioactive waste categories

Radioactive waste comprises a large variety of materials. These materials can have different physico-chemical states, can emit several types of radiation (x) and can have radioactivities ranging over several orders of magnitude.

This diversity results in extremely different hazard potentials and necessitates therefore different types of management. Radioactive waste should therefore be classified by categories. No classification is accepted today as an international or Community standard, although the classification of untreated waste proposed by the IAEA (xx) constitutes a sort of reference for numerous laboratories and nuclear installations (1).

Most of the existing classifications comply with operational requirements; consequently, the utilization of some of them is limited to the internal needs of certain organizations, while others are established for regional and possibly national use. Some classifications are used for theoretical purposes, in particular for global and safety studies.

In these circumstances it is possible to ensure pragmatically proper waste management and the protection of man and his environment. On the other hand, overall evaluations are difficult, in particular when they have to cover several countries, as is the case for an evaluation concerning the European Community.

The classification used in this report and described below has been chosen because it was the best way of presenting for the Community, the quantitative data on treated and conditioned radioactive waste produced in the Member States (and by the Community's Joint Research Centre). It also offers the advantage of grouping the radioactive waste into categories which correspond to the disposal options at present applied or envisaged by the Member States (cfr. chap. II and III).

Four main categories are considered:

- low level waste,
- medium level waste,
- alpha waste,
- high level waste.

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

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(x) They are essentially alpha, beta and gamma radiation.

(xx) International Atomic Energy Agency.

a) The category of low level waste includes waste (mainly technological) containing or suspected of containing beta-gamma emitters and essentially naturally occurring alpha emitters in low concentrations (and therefore of low activity) coming from research centres, the industrial and medical utilization of radioelements and various installations in the nuclear fuel cycle. The concentration of the other alpha emitters (plutonium, americum, etc.) in this waste category is practically nil and is the subject of very strict controls (x).

b) The category of medium level waste comprises process waste containing principally beta-gamma emitters in relatively large concentrations. The waste in this category originates, for the most part, from nuclear power plants (ion exchange resins, filter cartridges, evaporator concentrates, etc..). The concentration of the alpha emitters in waste of this category is the same as in low activity waste. (x)

c) The waste in the alpha waste category (x) comprises technological and process waste from nuclear laboratories where research is carried out on transuranics, from plants fabricating uranium-plutonium mixed oxide fuel elements and from spent fuel reprocessing plants. Some is low-level waste essentially containing alpha emitters. The rest is medium-level waste containing alpha, beta and gamma emitters from reprocessing plants, such as fuel cladding and hulls and shearings from decanned fuel elements.

d) The category of high level waste consists, for the purpose of this report, solely of vitrified waste containing nuclear combustion ashes (fission products and transplutonium elements which are alpha, beta and gamma emitters).

(x) For the Federal Republic of Germany alpha waste is included in the low and medium level categories in view of the fact that deep geological formations will be used for the disposal of all categories of waste.

## I.3. Nuclear power programmes

The production of radioactive waste associated with power programmes is directly proportional to the scale of these programmes. It is therefore appropriate to recall their development and to assess future prospects.

Several Community countries have installed nuclear power plants since the end of the 1950s. For the 10 countries of the present Community, installed nuclear power rose gradually from 0.48 GWe in 1960 to 7.5 GWe in 1970, and was about 28 GWe in 1980.

As far as the future is concerned, the forecasts at the end of 1980 on the development of nuclear power programmes up to the year 2000 are summarized in Table I.1 which shows, country by country and for some key years, the net-nuclear power installed, committed and/or planned at the end of the year. (x)

The limitations relating to forecasts on nuclear power programmes are directly applicable to those relating to the production of radioactive waste linked to these programmes. They will be recalled in the following paragraph.

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(x) This table essentially takes up the data given in the report of the "ad hoc" Advisory Committee for the reprocessing of irradiated nuclear fuels (CORECOM) (2). However, the data on the French, Netherlands and British programmes have been revised to take into consideration :
- recent modifications in the programme for the installation of nuclear power plants in France;
- the existing Netherlands policy on nuclear energy.
- natural uranium nuclear power plants (Magnox reactors) already in operation in the United Kingdom whose installed power did not figure in the CORECOM report.

Table I.1 : Nuclear power programmes of the Community Member States.

| COUNTRY | | Net power installed at the end of the year (GWe)<br>a) = power stations in operation, committed & planned<br>b) = only power stations in operation and committed | | | | |
|---|---|---|---|---|---|---|
| | | 1980 | 1985 | 1990 | 1995 | 2000 |
| BELGIUM (1) | a) | 1.65 | 5.5 | 5.5 | 5.5 | 5.5 |
| | b) | 1.65 | 5.5 | 5.5 | 5.5 | 5.5 |
| DENMARK (2) | a) | 0 | 0 | 0 | (1.3) | (2.6) |
| | b) | 0 | 0 | 0 | 0 | 0 |
| GERMANY F.R. | a) | 8.95 | 18.2 | 29.6 | 40 | 53 |
| | b) | 8.95 | 18.2 | 29.6 | 29.6 | 29.6 |
| FRANCE | a) | 10 | 39 | 58 | 75 | 90 |
| | b) | 10 | 39 | 44 | 44 | 39 |
| IRELAND (3) | a) | 0 | 0 | 0 | 0.6 | 2 |
| | b) | 0 | 0 | 0 | 0 | 0 |
| ITALY (4) | a) | 1.24 | 1.24 | 7.2 | 13.2 | 21 |
| | b) | 1.24 | 1.24 | 3.2 | 3.2 | 3.1 |
| NETHERLANDS | a) | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 |
| | b) | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 |
| UNITED KINGDOM | a) | 6 | 10 | 11 | 15 | 20 |
| | b) | 6 | 10 | 10 | 9 | 8 |

(1) No decision has been taken on the development of the nuclear power programme after 1985.
(2) These are mean values in a range of forecasts, the lower limit of which is zero.
(3) Very tentative figures.
(4) The installed power of 21 GWe in 2000 is derived from an extrapolation no yet endorsed by the government authorities.

N.B. Luxembourg still has nos plans to construct nuclear power stations; information on any nuclear programme that might be considered in Greece was not submitted to the Commission in due time.

I.4. Prospects for the production of waste in the Community Member States

The estimates given below refer to the annual production of treated and conditioned radioactive waste linked to nuclear power programmes and associated fuel cycle installations (x) and to radioactive waste resulting from research and the production and utilization of radioelements in industry, medicine, etc.. They are based on information from national sources supplied by Member State delegates to the Commission's Advisory Committee on Programme Management for the management and storage of radioactive waste.

The estimates cover a period of 20 years, from 1981 to 2000. They are more reliable for the first than the second decade for the following reasons :

- the estimates concerning nuclear power programmes are affected by the same uncertainties as the programmes themselves and in the more distant future these programmes are very uncertain;
- to judge from technological progress in general and the research and development efforts of some Member States, of waste treatment and conditioning processes giving better volume reduction factors will be available in the years to come; any progress here will result in smaller volumes of waste than given in the following tables;
- the choice of the nature and scope of the treatment and conditioning to be applied to waste depends, to a large extent, upon the disposal options selected and must be optimized in that light; some Member States have not yet made final choices, there are uncertainties about the volumes of treated and conditioned waste.

Finally the estimates given also encompass materials which are only suspected of radioactive contamination. The future introduction of minimum values ("de minimis" values) , which are now being discussed internationally, will make it possible to define thresholds below which these materials do not require any special precautions. The introduction of these values would significantly reduce the volume of low level waste shown in the following tables.

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(x) With the exception of low level waste from the mining and treatment of uranium ore and the decommissioning of nuclear power plants and other nuclear installations.
For waste from the decommissioning of nuclear power plants, it should be noted that even if some nuclear power plants are definitively shut down before the end of the century, the decommissioning operations will not begin immediately and the resulting waste will be treated and conditioned (at least for the major part) after the year 2000. Estimates of the quantities of this waste are being made for the Community under the Commission's research and development programme on the decommissioning of nuclear power plants (O.J. n°L 83/19 of April 4, 1979). They are likely to be available towards the end of the programme (1983).

For each Member State, the estimates have been split up into the four waste categories discussed in paragraph I.2 and presented by periods of five years. They are set out in Tables I.2, I.3, I.4 and I.5 below, for low, medium, alpha and high level waste respectively. Furthermore, the data have been cumulated, category by category, and are shown in Fig. I.1. for the Community as a whole.

The data on waste associated with nuclear power programmes relate to the net power, installed at the end of the year, resulting from nuclear power plants in operation, committed and planned, given in item a) of Table I.1. However, account has been taken in some cases of a certain time lag to allow for the treatment and conditioning of the waste.

The production of waste from nuclear research activities and industrial and medical utilization of radioelements, the quantities of which are already included in the data in the preceding tables, has been assumed to be constant over the four five-year periods considered in this report (x). The percentage of the waste quantities coming from these activities in the total quantity of waste produced will without doubt decrease with time (see table page 14), as its rate of increase will be lower thant that of other waste. Nevertheless, this waste represents, for the time being, a considerable fraction of the total waste production in each Member State of the Community. This is particularly valid for Member States which, at present, have little or no-installed nuclear power capacity, such as Denmark, Italy and the Netherlands. However, at the end of the century, the real quantity of this waste will represent only a low percentage of the total quantity of waste produced in France, the Federal Republic of Germany and the United Kingdom.

From the analysis of the above-mentioned tables and diagram it appears that :

a) The largest quantity of waste belongs to the low level category (more than 77 % of the total volume of treated and conditioned waste arising up to the end of the century). Nevertheless this waste contains only a very small fraction of the total radioactivity of all the waste.

b) Medium level and alpha waste represent about 17 % and 5 % respectively of this total volume.

c) The amount of treated and conditioned high level waste produced up to the year 2000 represents less than 0.3 % of the total volume of waste produced in the Community. Waste of this category contains almost all the radioactivity of all the waste.

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(x) It is to be expected that the production of this waste will increase during these four periods; it is, however, very difficult to make reliable estimates. Moreover, better volume reduction factors can be expected in this field too.

Table I.2. : Amounts of treated and conditioned low-level waste from all sources, produced in various Community Member States (power stations in operation, committed and planned - hypothesis a) of Table I.1)

| Country | Total quantities of waste per five-year period (m3) | | | | | Remarks |
|---|---|---|---|---|---|---|
| | 1981-1985 | 1986-1990 | 1991-1995 | 1996-2000 | Total | |
| Belgium | 7,000 | 11,000 | 13,000* | 12,000* | 43,000* | * These amounts also include waste originating from fuel reprocessed abroad. |
| Denmark | 100 | 100 | 100 | 700 | 1,000 | |
| Germany | 31,000 | 41,000 | 57,000* | 64,000* | 193,000 | The amounts include a part of the alpha waste. * These amounts also comprise waste originating from fuel reprocessed abroad. |
| France | 101,000 | 118,000 | 129,000 | 140,000 | 488,000 | |
| Italy | 5,000 | 5,000 | 12,000 | 18,000 | 40,000 | |
| Netherlands | 4,500 | 4,500 | 4,500 | 4,500 | 18,000 | |
| United Kingdom | 120,000 | 120,000 | 120,000 | 120,000 | 480,000 | |
| Grand Total | 268,600 | 299,600 | 335,600 | 359,200 | 1,263,000 | |

N.B. The Commission did not receive in time information on waste produced in Greece, Ireland and Luxembourg.

Table I.3 : Amounts of treated and conditioned medium level waste produced in various Community Member States (power stations in operation, committed and planned - hypothesis a) of Table I.1)

| Country | Total quantities of waste per five-year period (m3) | | | | | Remarks |
|---|---|---|---|---|---|---|
| | 1981-1985 | 1986-1990 | 1991-1995 | 1996-2000 | Total | |
| Belgium | - | - | 800 * | 100 * | 900 | * Waste originating solely from fuel reprocessed abroad. According to management practices in Belgium, waste of this category is included in low-level waste. |
| Denmark | * | * | * | 200 | 200 | * The real amount is less than 1 $m^3$/y and is not included in this table |
| Germany | 600 | 1,000 | 16,000 * | 25,000 * | 42,600 | The amounts include a part of alpha waste. * These amounts also comprise waste originating from the fuel reprocessed abroad. |
| France | 31,000 | 45,000 | 51,000 | 58,000 | 185,000 | |
| Italy | 1,500 | 1,500 | 7,000 | 13,000 | 23,000 | |
| Netherlands | 250 | 250 | 250 | 250 | 1,000 | |
| United Kingdom | 10,000 * | 10,000 * | 11,000 * | 12,000 * | 43,000 | * These amounts include waste that is not treated and conditioned converted into the equivalent of treated waste. |
| Grand Total | 43,350 | 57,750 | 86,050 | 108,550 | 295,700 | |

N.B. The Commission did not receive in time information on waste produced in Greece, Ireland and Luxembourg.

Table I.4. : Amounts of treated and conditioned alpha waste produced in various Community Member States (power stations in operation, committed and planned - hypothesis a) of Table I.1)

| Country | Total quantities of waste per five-year period (m3) | | | | | Remarks |
|---|---|---|---|---|---|---|
| | 1981-1985 | 1986-1990 | 1991-1995 | 1996-2000 | Total | |
| Belgium | * 2,300 | 450 | + 1,350 | + 700 | 4,800 | * Stocks of waste produced previously which will be conditioned during this period.<br>+ These amounts also include waste originating from fuel reprocessed abroad. |
| Denmark | - | - | - | - | - | |
| Germany | - | - | - | - | - | The amounts of alpha waste are included in low and medium level categories. |
| France | * 7,000 | * 10,000 | * 13,000 | * 15,500 | 45,500 | * These amounts also include waste produced before the period concerned which is treated and conditioned during that period. |
| Italy | 600 | 850 | * 850 | * 200 | 2,500 | * These amounts also include waste originating from fuel reprocessed abroad. |
| Netherlands | - | - | * 50 | * 50 | 100 | * Waste originating from fuel reprocessed abroad. |
| United Kingdom | * 5,500 | * 5,500 | * 7,500 | * 7,500 | 26,000 | * These amounts include waste that is not treated and conditioned converted into the equivalent of treated waste. |
| Grand Total | 15,400 | 16,800 | 22,750 | 23,950 | 78,900 | |

N.B. The Commission did not receive in time information on waste produced in Greece, Ireland and Luxembourg.

Table I.5 : Amounts of treated and conditioned high level waste produced in various Community Member States (power stations in operation, committed and planned - hypothesis a) of Table I.1)

| Country | Total quantities of waste per five-year period (m3) | | | | | Remarks |
|---|---|---|---|---|---|---|
| | 1981-1985 | 1986-1990 | 1991-1995 | 1996-2000 | Total | |
| Belgium | - | - | * 70 | * 75 | 145 | * These amounts also include waste originating from fuel reprocessed abroad. |
| Denmark | - | - | - | - | - | |
| Germany | - | - | * 250 | * 375 | 625 | * These amounts also include waste originating from fuel reprocessed abroad. |
| France | 190 | 580 | 850 | 1,230 | 2,850 | Waste originating solely from the reprocessing of domestic fuel. |
| Italy | - | - | * 125 | * 135 | 260 | * These amounts also include waste originating from fuel reprocessed abroad |
| Netherlands | - | - | * 5 | * 15 | 20 | * Waste originating from fuel reprocessed abroad |
| United Kingdom | - | - | 400 | 400 | 800 | Waste originating solely from the reprocessing of domestic fuel |
| Grand Total | 190 | 580 | 1,700 | 2,230 | 4,700 | |

N.B. The Commission did not receive in time information on waste produced in Greece, Ireland and Luxembourg.

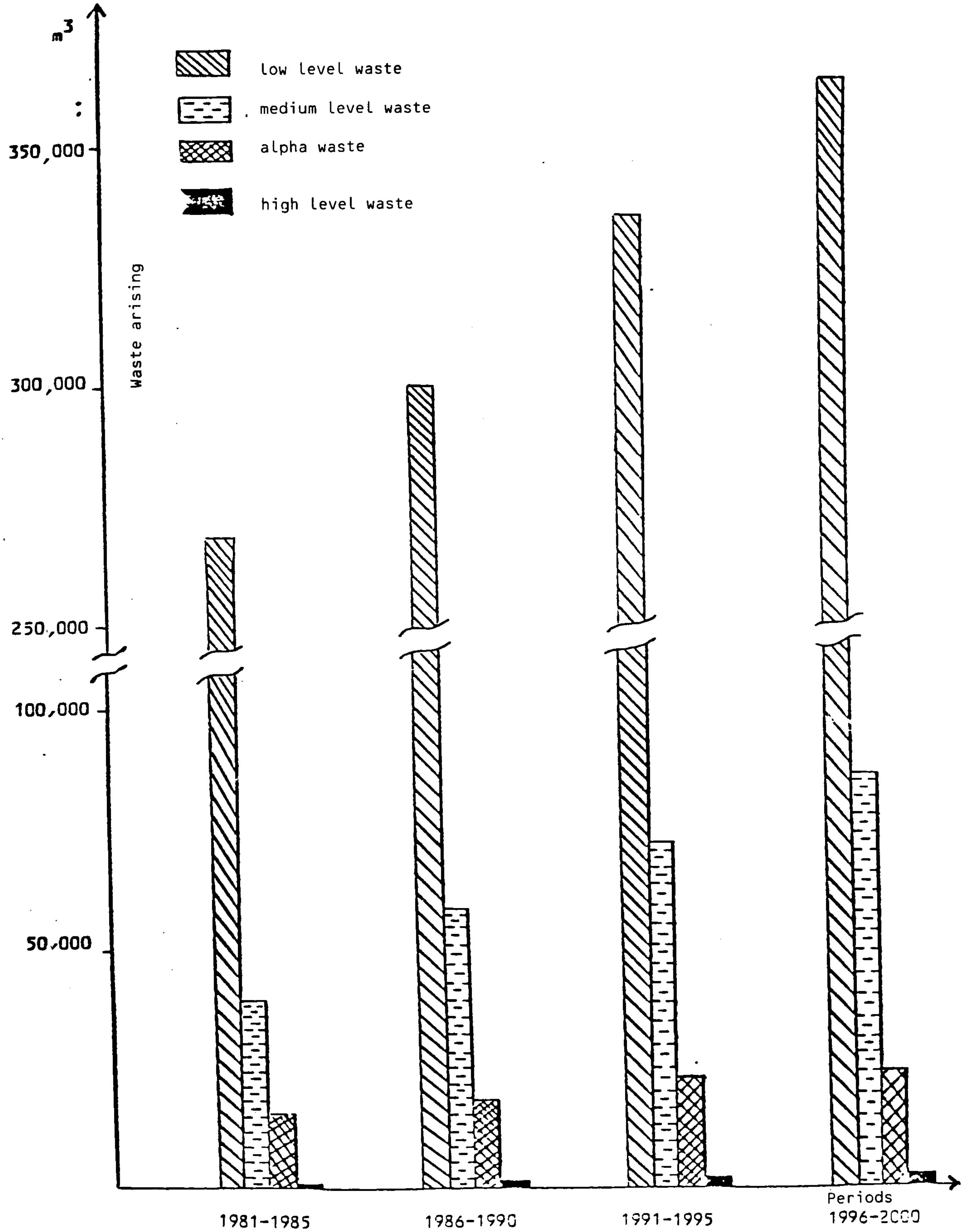


Fig. I.1. : Radioactive waste arisings from all sources within the Community (cumulated over five-year periods)

| Country | Percentage by volume of waste coming from research activities and the utilization of radioelements compared to total waste arisings. | |
|---|---|---|
| | 1981-1985 | 1995-2000 |
| Belgium | 30 | 20 |
| Denmark | 100 | 40 |
| Germany | 30 | 10 |
| France | 20 | 6 |
| Italy | 50 | 12 |
| Netherlands | 40 | 20 |
| United Kingdom | 15 | 10 |

d) The increase in the production of low and medium level waste is more or less linear during the period under review. The rate of increase is lower than that of installed nuclear power. This is mainly due to the hypothesis made earlier that new treatment and conditioning techniques allowing further reductions in volume will be applied in the years to come.

e) The non linear growth rate shown by the volume of alpha waste is due to the fact that a large part of this waste consists of waste from spent fuel reprocessing plants. The spent fuel will be reprocessed in ever increasing quantities as from the end of the 1980s.

Finally it should be pointed out that the volume of waste indicated in the preceding tables comprises the actual volume both of the radioactive materials constituting the waste and of various inert materials (cement, bitumen, polymers, glass, etc..) necessary for waste conditioning. This latter volume represents an important fraction of the final volume of conditioned waste. Furthermore, the numerical values in the tables also take into account the volume of the containers (metallic drums, concrete containers, etc..) into which the conditioned waste is put (*). In the case of vitrified high level waste, the volume of the container is 1.25-1.3 larger than the volume of the block of glass containing the actual waste.

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(*) The figures for Germany do not include the volume of concrete containers.

## CHAPTER II

### Present situation of radioactive waste management in the Member States of the Community.

### II.1. Radioactive waste management schemes

The main objective of waste management is to ensure the safety and protection of present and future generations and their environment until such time as the radioactive substances in the waste reach harmless levels by radioactive decay.

To this end, it must, in particular, conform to the general principles of radiological protection.

Management includes the gathering, sorting, treatment, conditioning, transport, storage and finally disposal of waste. These different activities are closely linked by numerous interactions. However, for the sake of simplicity, two main groups of activity can be distinguished : (*)

a) treatment and conditioning are industrial processing operations designed to put the waste in a suitable form for handling, storage and disposal.

b) disposal may be either land disposal (shallow burial, disposal in continental geological formations) or sea disposal (dumping in the ocean or burial in the ocean bed).

Management also encompasses the choice of techniques and the design of the installations involved; technical, social and economic factors play a considerable role.

Finally, management must be carried out in the framework of rules allowing adequate implementation and control.

The radioactive waste management schemes adopted or being developed by the Member States of the Community try to take these various considerations into account; they involve public and private organizations and industrial and regulatory bodies.

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(*) Transport operations constitute a particular case of the transport of nuclear materials in general and do not specifically come under the heading of radioactive waste management.

## II.2. Management and structures established in the Member States (*)

In the majority of Member States, waste management activities in the first group, i.e. treatment and conditioning, are carried out directly by the waste producers themselves on the waste production site (operators of industrial plants in the nuclear fuel cycle, nuclear research centres, etc..),with the exception of waste resulting from the medical and industrial use of radioisotopes, whose treatment and conditioning are, in certain cases, centralized. However, responsibility for disposal activities (the second group) lies with national organizations or the national authorities themselves.

It is advisable briefly to recall the essential management structure and administrative principles as they stand today in the various Member States, as the above outline of radioactive waste management is a general one which can vary from one country to another.

In Belgium, the storage, discharge and disposal of radioactive waste is reglemented by the provisions of the Royal Decree of February 1963 on the protection of the population and workers against the hazards of ionizing radiation. This Decree also lays down a system for the inspection and authorization of various nuclear operations, including those on radioactive waste. A National Agency for radioactive waste and fissile materials ONDRAF/NIRAS was set up by the law of August 1980 and confirmed by the Royal Decree of March 1981 which constitutes the Agency statute. The Agency's powers extend to the transport (organization, co-ordination and registration) of radioactive waste, the interim storage (responsibility), outside production plants, of untreated and unconditioned waste and all waste disposal operations, whether or not preceded by interim storage for which it is responsible. In the domain of waste conditioning, the Agency has a role complementary to that of the operators of major fuel cycle plants. Furthermore, the Agency is responsible for the definition of quality criteria for conditioned waste, the acceptance of conditioning methods and the quality control of conditioned waste.

In accordance with an agreement between the National Health Service of Denmark and the Risø National Laboratory, the latter is the only organization in Denmark which provides services in the field of waste management for users of radioactive materials (hospitals, industry, etc..). The system for the management of this waste and the waste produced at Risø itself is operated in accordance with the principles laid down in the Danish atomic laws (**). The system is supervised by the Danish nuclear regulatory authority. No decision has been taken on the disposal of the waste stored at Risø.

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(*) All the countries having nuclear activities guarantee that the exposure to radiation associated with these activities, and consequently with radioactive waste management, remains within fixed limits. Community and national rules established in this field do not come within the specific scope of this report.

(**) Lov om nukleare anlaeg (atomanlaeg) n°170, 16 May 1962 and part of Lov om sikkerhedsmaessige og miliømaessige forhold ved atomanlaey m.v. n° 244 of 12 May 1976.

Although no nuclear power plants are at present operating in Denmark, the aspects associated with high activity waste management are being studied by the Danish Agency for the Protection of the Environment. The purpose is to evaluate the investigation by the electricity companies of the feasibility of high level waste disposal in salt geological formations.

In the Federal Republic of Germany, with the aim of "closing the nuclear fuel cycle", the governement has developed an "integral concept for the back end of the fuel cycle" (*). This system includes all back end activities and installations, i.e. the management of irradiated fuel and radioactive waste. The 1976 4th Amendment to the German "atomic law" (**) defines and distributes the responsibilities between the government and the industry concerned. The Federal Government is responsible for securing and finally disposing of radioactive waste. This task was conferred on the federal agency "Physikalish - Technische Bundesanstalt (PTB)" which has to develop, build and operate the installations for waste confinement and final disposal. The industry, on the other hand, is responsible for development construction and operation of all other back-end installations including those for the treatment and conditioning of waste. The industry concerned here consists of all utilities which operate nuclear power reactors, and for the purpose of accomplishing the task imposed by the law, these have established the "German Company for Reprocessing of Nuclear Fuel" (***).

According to the atomic law, the radioactive waste coming from the medical, industrial and research use of radioisotopes has to be delivered to central storage installations built by the Federal Länder (****). The final disposal of these waste categories is also the responsibility of the Federal Agency PTB.

Work on radioactive waste management has been carried out in France for about 30 years by the scientists of the Atomic Energy Commission (CEA) who have gradually been confronted with all the aspects of waste management including disposal since the establishment of the La Manche disposal centre in 1969 fo low/medium level waste. This centre has been operated for ten years by a private company on the CEA's behalf.

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(*) "Integrietes Entsorgungskonzept"
(**) "Deutsches Atom-Gesetz"
(***)"Deutsche Gesellschaft für Wiederaufarbeitung von Kernbrennstoffen mbH" (DWK)
(****) "Landessammelstellen".

More recently, the development of the French nuclear reactor programme has prompted the authorities to step up the waste disposal effort and give it an industrial character.

As a result, a central organization, the national Agency for radioactive waste management (ANDRA), was established on the 7 November 1979.

The legislative and regulatory provisions make ANDRA responsible for :

- the long-term management of disposal centres, either directly, or through third parties acting on its behalf;
- designing, installing and establishing new disposal centres, and carrying out all the necessary studies to this end, especially the forecasting of waste production;
- promoting, jointly with waste producers, specifications for conditioning and storage of radioactive waste before removal to disposal centres;
- contributing towards research, studies and work concerning long-term management processes for radioactive waste and their future development.

The CEA is the organization which carries out basic research and the development of waste conditioning processes. The plant operators producing radioactive waste are responsible for waste conditioning in conformity with the specifications issued by ANDRA so that the waste can be accepted in a disposal centre.

In Italy, the treatment and conditioning of waste and the interim storage of conditioned waste (on production or "ad hoc" sites) is the responsibility of the nuclear plant operators and of the users of radioisotopes (including hospitals). This applies to all categories of waste including high level waste category. It is foreseen that the Italian State will be responsible for the disposal of all categories of conditioned waste. Disposal will be carried out after prior authorization by the Industry, Commerce and Handicraft Ministry.

The NUCLECO Company was set up by ENEA and Agip Nucleare to manage low and medium level waste (*).

ENEA (National Committee for research and development on nuclear energy and alternative energies) was given the following tasks:

- to carry out and promote, partly by means of appropriate international cooperation, studies and R & D work on waste management (development of treatment and conditioning processes, studies and experiments on techniques for disposal in geological formations, studies to select geological formations most suitable for disposal);

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(*) This Company was established in 1981 by AGIP Nucleare and ENEA. Its activities consist of :
- the collection, transport, storage and conditioning of low and medium level waste;
- the decontamination of plants and facilities;
- the decommissioning of nuclear plants;
- the design, construction, delivery and operation of plants for the treatment and conditioning of low and medium level waste.

- to ensure that a suitable publicly-owned site is available for the disposal of high level and/or alpha waste in geological formations;

- to contribute, in its capacity as a technical State body, to the definition of criteria and management practices for each category of waste and, in particular, of the characteristics of conditioned waste.

In addition, ENEA, as a producer of waste in its own facilities, has the same responsabilities as any ordinary operator.

Pursuant to the law on nuclear energy in the Netherlands, the Energy Research Centre of the Netherlands (ECN) (*) is the central department for the collection of radioactive waste. The Centre also treats and conditions waste for interim storage and disposal.

In the United Kingdom, the Environment Departments are responsible for nuclear waste management policy. This includes the establishment of an overall long-term strategy. The bodies responsible for the regulation of radioactive waste management are the Environment Departments, the Ministry of Agriculture, Fisheries and Food, the Nuclear Installations Inspectorate and the Department of Transport.

The treatment, conditioning, storage, transport and disposal of waste are the responsibilities of individual waste producers. In July 1982, the electricity generating boards (CEGB and SSEB), BNFL and UKAEA set up the Nuclear Industry Radioactive Waste Executive (NIREX) to coordinate the nuclear industry's requirements for disposal, to establish the necessary disposal facilities and to take over responsibility for the operation of sea disposal from UKAEA (**).

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(*) Energieonderzoek Centrum Netherlands

(**) CEGB : Central Electricity Generating Board
SSEB : South of Scotland Generating Board
BNFL : British Nuclear Fuel Limited
UKAEA : United Kingdom Atomic Energy Authority
NIREX : Nuclear Industry Radioactive Waste Executive.

## II.3. Available techniques and facilities for waste treatment and conditioning

As already pointed out, treatment and conditioning are supplementary processes designed to put waste into a form suitable for safe handling, storage and disposal. In accordance with the ALARA (*) principle, the techniques and processes used are chosen in such a way that workers are not exposed to significant radiation doses.

According to the nature and the activity level of the contained radioactive materials, the treatment may be preceded by some months or even years of storage of raw waste for radioactive decay and cooling purposes.

The treatment prepares the waste, as generated at the production source, for conditioning by mechanical, physical, and/or chemical processes which are basically designed to reduce the volume of raw waste and change its composition. Some of these processes are (**):

for solid waste:
- cutting, shearing, shredding;
- compaction;
- incineration, calcination;

for liquid waste:
- evaporation;
- insolubilization;
- chemical precipitation, neutralization and filtration;
- etc..

Some of these processes have been successfully applied to low-level waste in the Community for 20 to 30 years.

Conditioning transforms treated waste into forms that reduce to a minimum the risk of releasing the contained radionuclides during the handling and transport operations and/or during attack by external agents (essentially water) when waste is stored and or disposed of. The treated waste is frequently embedded in matrices which solidify into blocks or structures offering, with or without the help of external metallic containers, the required safety characteristics (good mechanical resistance to impacts, resistance to fire, a low leaching rate, etc...).

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(*) As Low as Reasonably Achievable.

(**) Most gaseous waste is today released as effluent (cfr. I.1.). Such releases may become inacceptable in the long term. Therefore R & D work is being carried out with a view to developing adequate treatment processes and immobilization in solid matrices.

The choice of matrix depends on many factors, the main ones being the type of waste, the type and level of the contained radioactivity, cost and the safety given by the conditioning.

The current situation in the Community may be outlined as follows:

- Cements have been used since the 1950s and are still in general usage, essentially for low level waste,

- Bitumens introduced around 1960-1965 can embed higher activities per unit volume than cements. They are used in only some Member States.

- Polymers have recently been introduced and are used primarily for conditioning of power plant waste.

- Glass, studied for about 25 years for the conditioning of high level and long-lived waste from the reprocessing of irradiated fuel, can now be used industrially and commercially in the process recently put on the market by France.

The description of the different techniques used is beyond the scope of this document. Recent reports (3) (4) (5) give, if need be, the state of the art for the countries of the Community and also full technical details (*).

Nevertheless, Table II.1. gives an overview, country by country, of the main techniques for treatment of solid waste and embedding matrices currently used. It should be pointed out that evaporation and filtration techniques are widely used in all the Member States for the treatment of liquid waste.

Obviously the treatment and conditioning techniques described are making progress, and improvements are being studied (improved cements and bitumens, thermosetting resins, vitroceramics, etc..). These activities and prospects, together with the development of new techniques, are under the heading of Research and Development and are dealt with in Chapter III.

The main treatment and conditioning facilities for solid wastes now in operation in the different Community countries are shown in Table II.2, while Table II.3 lists facilities for the treatment and conditioning of liquid wastes.

After treatment and conditioning, waste is confined in containers specially designed for waste disposal. In particular, these containers meet the specifications issued by national bodies responsible for radioactive waste management (cf. II.2).

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(*) these reports are the outcome of studies in the Community's first R & D programme (1975-1979) on the management and storage of radioactive waste (see III.1.)

Table II.1. : Main techniques for the treatment of solid waste and main embedding matrices used in the Community Member States.

| COUNTRY | Treatment techniques | | Embedding matrices for waste conditioning | | |
|---|---|---|---|---|---|
| | Compaction | Incineration | Cements | Bitumen | Polymers |
| BELGIUM | + | + | + | + | + |
| DENMARK | + | | + | + | |
| GERMANY | + | + | + | | + |
| FRANCE | + | + | + | + | + |
| ITALY | + | | + | | + |
| THE NETHERLANDS | + | | + | | + |
| UNITED KINGDOM | + | + | + | | + |

TABLE II.2.

Available installations for treatment and conditioning of solid waste in various Community countries.

| COUNTRY | NATURE OF WASTE | MANAGEMENT STEP | INSTALLATION | CAPACITY AND CHARACTERISTICS | REMARKS |
|---|---|---|---|---|---|
| Belgium | combustible | treatment | Low-temperature incinerator type (700-800°C) installed at the CEN/SCK - Mol | 100-150 Kg/h volume reduction factor 60 including compaction of ashes | the incinerator does not allow treatment of plutonium-bearing waste |
| | compactable | treatment | 300-tonne press installed at CEN/SCK Mol | volume red.f.3 | alpha-tight installation |
| | combustible compactable non-compactable | conditioning | Facilities for incorporation of waste in cement and bitumen are available at CEN/SCK Mol | | conditioned waste is packed in 220l metal drums or 400 l concrete containers |
| Denmark | compactable | treatment | Balling press available at Risø | | waste is compacted into metal drums and stored without conditioning |

TABLE II.2.

Available installations for treatment and conditioning of solid waste in various Community countries.

| COUNTRY | NATURE OF WASTE | MANAGEMENT STEP | INSTALLATION | CAPACITY AND CHARACTERISTICS | REMARKS |
|---|---|---|---|---|---|
| Germany | combustible | treatment | Incinerators for low and medium level waste are in operation in the following nuclear research centres :<br>- Karlsruhe | 70 Kg/h | also for liquid waste |
| | | | - Jülich | 100 Kg/h | |
| | compactable | treatment | Waste compaction facilities are in operation in several nuclear power plants and in the following nuclear research centres :<br>- Karlsruhe | 1000 $m^3$/y volume reduction factor 5 | |
| | | | - Jülich | | 16-tonne press |
| | | | - HMI, Berlin | volume reduction factor 2 | |
| | | | - GKSS, Geesthacht | | |

TABLE II.2.

Available installations for treatment and conditioning of solid waste in various Community countries.

| COUNTRY | NATURE OF WASTE | MANAGEMENT STEP | INSTALLATION | CAPACITY AND CHARACTERISTICS | REMARKS |
|---|---|---|---|---|---|
| Germany (cont.) | non-compactable | treatment | Shearing facilities are available in the following research centres : | | |
| | | | - Karlsruhe | 400 $m^3/y$ | for low level waste |
| | | | - Karlsruhe | 70 $m^3/y$ | for medium level waste |
| | | | - Jülich | | |
| | | | - HMI, Berlin | | |
| | combustible compactable non-compactable | conditioning | Facilities for embedding waste in cement are available in several nuclear power plants and in the following nuclear research centres : | | |
| | | | - Karlsruhe | 2 drums/h (200 l) | for ash, ion exchange resins and evaporator concentrates |
| | | | - Jülich | 150-200 drums per year (200 l) | for ash and dried evaporation sludges |
| | | | - HMI, Berlin | | for solids and evaporator concentrates |
| | | | - GSF | | |
| | | | - GKSS, Geesthacht | | |
| | compactable non-compactable | conditioning | Mobile plant for immobilization of ion exchange resins in styrene mixed with a catalyst | | the resins are conditioned in 200 l drums |

TABLE II.2.

Available installations for treatment and conditioning of solid waste in various Community countries.

| COUNTRY | NATURE OF WASTE | MANAGEMENT STEP | INSTALLATION | CAPACITY AND CHARACTERISTICS | REMARKS |
|---|---|---|---|---|---|
| France | combustible | treatment | Incinerators of various types are in service at the following CEA nuclear research centres:<br>- Cadarache | 30 Kg/h | incineration of all types of solid radio-active waste including alpha-bearing |
| | | | - Cadarache | 50 Kg/h | incinerator for organic liquids |
| | | | - Marcoule | 100 Kg/h | the incinerator will also fire non-aqueous liquid waste. |
| | | | - Fontenay-aux-Roses | 50 Kg/h | |
| | | | - Grenoble | 20 Kg/h | for biological waste and contaminated plastic materials |
| | compactable | treatment | Presses of various forces are in service at :<br>- Cadarache<br>- Marcoule<br>- La Manche disposal site | <br><br>2500 KN<br>600 KN<br>4000 KN | |

(3)

TABLE II.2.

Available installations for treatment and conditioning of solid waste in various Community countries.

| COUNTRY | NATURE OF WASTE | MANAGEMENT STEP | INSTALLATION | CAPACITY AND CHARACTERISTICS | REMARKS |
|---|---|---|---|---|---|
| France (cont.) | non-compactable | treatment | Arc-cutting facilities available at Marcoule for waste of large dimensions. Other cutting facilities are in operation in research centres such as Saclay. | | |
| | combustible compactable non-compactable | conditioning | Waste cementation facilities are available at various nuclear power plants, at COGEMA and MARCOULE fuel reprocessing plants and at the La Manche disposal site. Cementation/bituminization facilities at Cadarache. Facilities for incorporation of ion exchange resins and filter cartridges in thermosetting resins are available at Chooz power plant; a facility of the same type is in operation at the CEN Grenoble. | | |
| Italy | compactable | treatment | various presses are available at : - CAMEN research centre | volume reduction factor 4 | |
| | | | - Ispra JRC | 750 KN | |
| | | | - Trino, Garigliano, Caorso and Latina nuclear power plants. | | Balling presses |

TABLE II.2.

Available installations for treatment and conditioning of solid waste in various Community countries.

| COUNTRY | NATURE OF WASTE | MANAGEMENT STEP | INSTALLATION | CAPACITY AND CHARACTERISTICS | REMARKS |
|---|---|---|---|---|---|
| Italy (cont.) | compactable non-compactable | conditioning | One facility for embedding in bitumen is in operation at<br>- Ispra JRC | | |
| | | | Facility for embedding ion exchange resins in formaldehyde is available at the Caorso nuclear power plant. | 500 drums of 200 l/y | |
| | | | Facility for embedding the fuel element splitters in resins available at the Latina nuclear power plant. | | |
| | | | Mobile unit for embedding ion exchange resins, evaporator concentrates etc.. in plastic materials or cement. | average capacity : 2000 drums of 220 l/y | |
| The Netherlands | compactable | treatment | 1500-tonne press in operation at Petten ECN | volume reduction factor 5 | |
| | | conditioning | A facility for embedding waste in cement is in operation at Petten ECN | 20-25 drums/h | |

TABLE II.2.

Available installations for treatment and conditioning of solid waste in various Community countries.

| COUNTRY | NATURE OF WASTE | MANAGEMENT STEP | INSTALLATION | CAPACITY AND CHARACTERISTICS | REMARKS |
| --- | --- | --- | --- | --- | --- |
| United Kingdom | combustible | treatment | Incinerators for low level waste are available at most nuclear power plants. | about 7,000 $m^3$/y | This type of incinerator has no filter in the stack. |
| | | | Incinerators for medium level waste are in operation at Berkeley, Hinkley Point, Bradwell and Wylfa nuclear power plants and at the Harwell research centre. | about 3,000 $m^3$/y | |
| | compactable | treatment | Presses are available in some nuclear power plants and at the Harwell research centre. | volume reduction factor 2 | |
| | various | conditioning | Facilities for embedding in cement are available at<br>- Hinkley Point and Trawsfynydd nuclear power plants. | 0.2 $m^3$/d | |
| | | | - Harwell and Winfrith research centres. | | conditioning for sea dumping |

TABLE II.3.

Major installations available for treatment and conditioning of liquid effluents in various Community countries.

| COUNTRY | NATURE OF WASTE | MANAGEMENT STEP | INSTALLATION | CAPACITY AND CHARACTERISTICS | REMARKS |
|---|---|---|---|---|---|
| Belgium | effluents from nuclear power plants | treatment | Facilities for filtration and evaporation of liquid effluents are available at Doel I, II and Tihange power plants | capacity of the filtration/evaporation circuits : 2 tonnes/h | processed liquids are discharged into rivers. |
| | effluents from Eurochemic fuel reprocessing plant | treatment | Two evaporators under vacuum for medium level liquid effluents. | 1.5 $m^3$/h concentration factor 30 | Hot waste concentrates are stored pending conditioning. |
| | | conditioning | Immobilization in bitumen of residues from the chemical decanning of fuel elements at the Eurobitume facility. | 650 $m^3$/year | Waste is conditioned in 220 l stainless steel drums. The drums are stored at the Eurostorage facility. |
| | effluents from various nuclear installations | treatment | Flocculation -coprecipitation facilities are available at the CEN/SCK Mol for treatment of liquid effluents from the nuclear laboratories at Mol and Geel (JRC), Eurochemic fuel reprocessing plant and Belgonucléaire (Dessel) : | | After treatment and control liquid effluents are discharged into a river. |
| | | | - effluents of category 1 * | 500 $m^3$/day | |
| | | | - effluents of categories 2 * and 3 * | 400-500 $m^3$/day. Concentration factor : 4000 - 5000 | * These are IAEA categories (see refer.1) |

TABLE II.3.

Major installations available for treatment and conditioning of liquid effluents in various Community countries.

| COUNTRY | NATURE OF WASTE | MANAGEMENT STEP | INSTALLATION | CAPACITY AND CHARACTERISTICS | REMARKS |
|---|---|---|---|---|---|
| Belgium (cont.) | effluents from various nuclear installations (cont.) | conditioning | Facility for direct immobilization of sludges in bitumen available at CEN/SCK Mol | 10 Kg of dried solid per hour | conditioned waste is stored pending sea dumping |
| Denmark | low level activity effluents from laboratories and nuclear research facilities | treatment | Evaporation plant (recompression plant with forced circulation) in operation at Risø | 2 $m^3/h$ | |
| | | conditioning | Facility for bituminization of evaporation concentrates | | waste is placed in 100 l drums which are put into 210 l drums. The annular space between drums is filled with cement |

TABLE II.3.

Major installations available for treatment and conditioning of liquid effluents in various Community countries.

| COUNTRY | NATURE OF WASTE | MANAGEMENT STEP | INSTALLATION | CAPACITY AND CHARACTERISTICS | REMARKS |
|---|---|---|---|---|---|
| Germany | effluents from nuclear research centres | treatment | Evaporation facilities are available at the following research centres :<br>- Karlsruhe | 4 $m^3$/h | two evaporators for low level effluents |
| | | | - Karlsruhe | 1 $m^3$/h | for medium level effluents |
| | | | - Jülich | 5 tonnes/h and 2 tonnes/h | for low level effluents |
| | | | - HMI, Berlin | 150 Kg/h | for low level effluents |
| | | | An incinerator for solvents is available at Karlsruhe | 20 Kg/h | Pilot facility |
| | | | A kerosene purification facility is available at Karlsruhe | 40 $m^3$/y | |
| | | | A decontamination facility (ion exchange resins) is available at Jülich. | | |
| | | conditioning | Evaporation concentrates are embedded in cement at the facilities mentioned in Table II.2. | | |

TABLE II.3.

Major installations available for treatment and conditioning of liquid effluents in various Community countries.

| COUNTRY | NATURE OF WASTE | MANAGEMENT STEP | INSTALLATION | CAPACITY AND CHARACTERISTICS | REMARKS |
|---|---|---|---|---|---|
| France | low and medium level effluents from the nuclear fuel cycle plants and research centres | treatment | Two installations available at Cadarache for treatment, by precipitation, of aqueous waste from the mixed-oxide fuel fabrication plant.<br>Other facilities of the same type are available at La Hague and Marcoule | $2\ m^3/h$<br>$6\ m^3/h$ | |
| | | | Evaporators are available in all the nuclear power plants and at :<br>- Saclay | $7{,}000\ m^3/year$ | |
| | | | - Cadarache | $10{,}000\ m^3/year$ | |
| | | | - Fontenay-aux-Roses | $2000-4000\ m^3/year$ | |
| | | | - Marcoule | 100 - 130 l/h | for carbonated liquids |
| | | conditioning | Facilities for immobilization of evaporator concentrates and sludges in cement are available in several nuclear power plants and research centres.<br>Facilities for immobilization of evaporator concentrates in bitumen are available at Saclay, Cadarache and Marcoule | | |
| | high level effluents from fuel reprocessing plants | treatment | Evaporators are in operation at La Hague and Marcoule | 500 l/h | |
| | | conditioning | A vitrification pilot workshop is in operation at Marcoule | | vitrified waste |

TABLE II.3.

Major installations available for treatment and conditioning of liquid effluents in various Community countries.

| COUNTRY | NATURE OF WASTE | MANAGEMENT STEP | INSTALLATION | CAPACITY AND CHARACTERISTICS | REMARKS |
|---|---|---|---|---|---|
| Italy | low level effluents from research centres and nuclear power plants | treatment | A precipitation/filtration installation for category 2 aqueous liquids is available at the Casaccia research centre. | 2.5 $m^3/h$ | |
| | | | Treatment facilities in operation at the JRC Ispra :<br>- combustion furnace for organic liquids.<br>- flocculation/centrifugation installation. | <br><br>25 l/h<br>5 $m^3/h$ | |
| | | | Evaporation installations are in operation at Latina, Trino, Garigliano and Caorso nuclear power plants | | |
| | | conditioning | Facility for immobilization of ion exchange resins in urea-formaldehyde in operation at Caorso nuclear power plant. | 500 drums of 220 l per year | |
| | low - medium high level effluents from pilot reprocessing plants | treatment | Evaporators are in operation at EUREX and ITREC pilot reprocessing plants. | | Evaporator concentrates are stored awaiting conditioning |

TABLE II.3.

Major installations available for treatment and conditioning of liquid effluents in various Community countries.

| COUNTRY | NATURE OF WASTE | MANAGEMENT STEP | INSTALLATION | CAPACITY AND CHARACTERISTICS | REMARKS |
|---|---|---|---|---|---|
| The Netherlands | low level effluents from research centres and nuclear power plants | treatment | Precipitation- centrifugation - filtration facility at Petten ECN | 2 $m^3$/h | |
| | | | Filtration and evaporation facilities are in operation at the following nuclear power plants :<br>- Dodewaard<br>- Borssele | <br><br><br>0.6 $m^3$/h<br>1 tonne/h | |
| | | conditioning | Facilities for waste immobilization are in operation at :<br>- Petten ECN (cement)<br>- Dodewaard (cement)<br>- Borssele (polyethylene) | <br><br><br>0.5 $m^3$/d<br>0.25 $m^3$/d | |
| United Kingdom | low - medium level effluents from nuclear fuel cycle plants | treatment | Filtration and/or ion exchange facilities are available in all the nuclear power plants and at the Windscale spent fuel reprocessing plant. | 4,000 $m^3$/d | |

II.4. Means available for waste storage and disposal

The disposal of radioactive waste in the Community is currently confined essentially to low and medium level waste. For the time being alpha and high level waste * are stored. Means of disposal are being studied or developed and will be dealt with in Chapter III.

The activity of low and medium level waste will, by radioactive decay, decline to that of natural radioactivity in a few hundred years. For disposal of this waste, the Member States use either land disposal (shallow or in depth) or sea dumping or both.

The optimization procedure needed for the application of radiological protection principles helps to determine the relative importance to be attributed to these two options in each particular case.

Land disposal is or has been practised industrially in several Member States for many years (shallow land burial in France and the United Kingdom, disposal in depth in the Federal Republic of Germany) and is governed by national regulations.

Other Member States (Belgium, the Netherlands, the United Kingdom) have been dumping waste in the sea for many years under the multilateral consultation and surveillance mechanism for sea dumping of radioactive waste introduced in 1977 within NEA ** in order to promote the objectives of the London Convention *** among the member countries of the OECD (of which they are also members).

This convention attributes to the competent international body, currently the IAEA, the task of:

- defining "highly active waste and other highly active materials ... not suitable for dumping owing to their consequences on human health, biology, and other fields";

- establishing recommendations which the contracting parties, i.e., the States, must take into account when issuing permits for the dumping of other waste and radioactive materials.

On this basis, the competent national authorities must also make a detailed examination of the consequences of dumping.

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* As defined in Chapter I for the purposes of this report.

** In view of the 1960 IAEA-NEA agreement on cooperation on matters of common interest.

*** February 1972 convention on the prevention of marine pollution by dumping of wastes and other matter.

The IAEA has established activity limits (expressed in curies of certain isotopes/tonne of waste) which are subject to periodic revision.

Under Article 37 of the Treaty establishing the European Atomic Energy Community (Euratom), the Member States have to provide the Commission with general data on any new sea dumping site they select. After a panel of Community experts has examined the data on the site and the waste to be dumped there, the Commission has to deliver an opinion.

The European Parliament, for its part, adopted on 16 September 1982 a resolution which, amongst other things, called on the Commission "to prepare a directive which will in future ensure the sea is not polluted by radioactive waste from the European Community".

Finally, some Member States practise only storage, i.e. temporary storage allowing the subsequent recuperation of waste with a view to its disposal.

Generally the attitudes of the Member States to these various approaches are not definitive. The storage and disposal methods currently used in the Community are briefly described below, country by country. They include buffer storage necessary for the proper staggering of the various phases of waste management. Buffer storage is practised by all the Member States.

Owing to its high population density and geographical and geological limitations, Belgium has chosen sea dumping for the disposal of low level conditioned waste since the beginning of the 1960s. Disposal operations, organized nationally and coordinated by multilateral consultations in NEA/OECD, are carried out in partnership with the Netherlands and Switzerland.

Conditioned waste avaiting dumping is stored at the CEN/SCK storage site in Mol which for the time being is in the open air. This site is being enlarged and will have an additional storage capacityof 10 000 tonnes in sheltered areas.

The waste disposed of by Belgium includes :

- all low level solid waste treated and conditioned in Mol;

- bitumized sludges from the Mol central facility for the treatment of low level liquid effluents;

- the evaporation concentrates conditioned on the sites of nuclear power plants.

Conditioned waste from the Eurochemic reprocessing plant (alpha waste referred to in Table I.4) and other solid waste are stored in the Eurostorage facility, which has some surface bunkers and is equipped to provide storage for 50 years.

No waste disposal option is currently practised in Denmark. However, for some fifteen years temporary storage facilities have been available at the Risø research centre for low and medium level conditioned waste. Waste of the latter category is stored in an underground facility.

In the Federal Republic of Germany, low and medium level waste has, since 1967, been disposed of in a disused salt mine at Asse, excavated in a salt geological formation, the stability and confinement capability of which go very much beyond the required durations. About 25 000 $m^3$ of low level waste, embedded in bitumen or in concrete, containing no more than five Ci per container and not exceeding 200 millirem at the surface of the container, have been placed in large rooms at a depth of between 490 and 715 m. About 250 m3 of waste containing a few hundred curies per 200 litre drum (medium level waste requiring remote handling) have been lowered by cable and stored in a closed room at a depth of 511 m. No high level waste has been disposed of in this mine. All disposal operations have been suspended in the Federal Republic of Germany since the licence expired in 1978. No other disposal option is authorized in that country.

Reauthorization of disposal in the Asse mine is currently under consideration, together with procedures to authorize the use of the "Konrad" disused iron mine. The R & D done since 1977 has shown that this mine has an adequate confinement capability for the disposal of low level waste.

In addition, facilities for the temporary storage of conditioned waste awaiting disposal are available in most of the nuclear research centres, fuel cycle facilities and nuclear power plants.

In France, low and medium level waste has been disposed of by shallow land burial at a centre in La Manche since 1969.

Two types of manmade structures are used for the disposal of conditioned waste :

- monoliths,located below the original ground level, for waste whose initial conditioning has to be completed by immobilization in a concrete structure;

- tumuli, above the original ground level, for waste whose initial conditioning does not necessitate any supplementary immobilization.

The whole is covered with a thick layer of clay to protect both structures and waste packages from rain water.

The disposal centre occupies an area of 12 hectares and has a disposal capacity for about 400 000 m3 of conditioned waste. About 200 000 m3 of waste has already been disposed of.

Long-lived waste (alpha and high level waste) are stored in specific facilities located in various research centres or nuclear plants, pending the preparation of deep disposal centres in suitable geological formations. For example, the Marcoule centre has since 1978 been storing the output of the Marcoule vitrification plant consisting of 750 stainless steel drums each containing 150 litres of vitrified waste.

As there are no disposal sites available in Italy, low and medium level conditioned waste is stored temporarily in facilities designed for this purpose. As in other countries, these facilities are attached to the centres producing the waste (mainly nuclear research centres and nuclear power plants). The first sea dumping exercise for low and medium level waste is planned for 1984.

In the Netherlands low and medium level conditioned waste has been dumped in the sea for some years now (see Belgium). The current policy consists of storing conditioned waste temporarily as an alternative to dumping.

In the United Kingdom low level waste is disposed of by the routes outlined below; they include, where appropriate, disposal with ordinary household refuse,on-site burial, and disposal at a land-fill tip for non-radioactive waste.

The main disposal routes are as follows :

(a) Burial at Drigg where waste principally from BNFL but also from UKAEA and the generating boards is disposed of by shallow land burial. This site of approximately 300 acres is owned and operated by BNFL. Waste is disposed of in trenches which are 700 m long, 15 m wide and 4.5 m deep and is covered with at least 1 m of soil. It is estimated that approximately 150 000 m3 of waste have been buried at this site since it started operation in 1971.

(b) The UKAEA has also been exploiting a burial site at Dounray since 1972. There 200 l steel drums containing conditioned waste are piled up in pits which are 7 m deep. Six pits exist at present. The first four have a volume of 3 500 m3 each, while pits 5 and 6 have a volume of 6000 and 14 000 m3 respectively. The empty space between the drums inside the pits is filled with polythene materials. The pits are then covered with earth.

(c) Sea dumping has been going on since 1949. Up to now it has been organized by UKAEA but will shortly be taken over by NIREX. This disposal route is used for waste from nuclear and non-nuclear applications and in 1981 some 2 500 tonnes of waste (including packaging) containing approximately 2 000 alpha curies and 100 000 beta-gamma curies were disposed of.

The disposal routes described above cope with most of the waste arising from non-nuclear applications and the low-level waste from nuclear plants.

Waste which cannot be disposed of by these routes is stored where it is produced, generally in the form in which it is generated.

# CHAPTER III

## Prospects for the management of radioactive waste in the Community Member States

### III.1. R&D in the Community

All human activities involving the use of any techniques and practices, whether or not of an industrial nature, start and are perfected as a result of R&D work. This ongoing R&D first demonstrates feasability and then makes the activity itself more reliable, safer and even more economical by improving and optimizing the basic processes and techniques. This general observation is equally applicable to the management of radioactive waste.

In some Community countries research on radioactive waste management started in the early 1950s. The aim was to develop treatment and conditioning methods for the waste existing at that time, i.e. mainly low and medium level waste from nuclear research. Alongside this research effort, later expanded to cover waste from the first nuclear power stations to be commissioned, studies on the disposal of these categories of waste were started.

In this way treatment and conditioning techniques and processes and also the two disposal routes for low and medium level waste have gradually been developed since the 1960s. Today these are industrial operations and they have been discussed in the previous chapter.

With the entry into operation of the first spent fuel reprocessing plants (towards the beginning of the 1960s), research on the treatment and conditioning of high level waste was started, especially in France and the United Kingdom. The research work, which in the United Kingdom was suspended for some years, resulted in the commissioning in France, in 1969, of the first facility for waste solidification in glass (Piver facility) *.

Later several Member States embarked on studies and research on waste disposal in suitable geological formations at depths of up to several hundred metres. A major R&D effort was also launched on alpha-contaminated waste.

* This facility operated up to 1973. It was followed in 1978 by the present vitrification plant at Marcoule (AVM) already mentioned in Chapter II.

From the beginning of the 1970s, with the launching of these numerous national programmes or projects, the large number of possible options, and the need in the medium term to select and optimize methods and processes, Community cooperation became essential.

In 1973, the Council of Ministers of the European Communities established the principle of Commission competence for environmental protection and in particular nuclear and non-nuclear waste.

That same year a modest initial multiannual R&D programme on radioactive waste was started at the JRC. In 1975 it was supplemented by a wider five-year programme comprising shared-cost projects with laboratories in the Member States (6).

This programme, the main results of which were described in 1980 at the first European Community conference on radioactive waste (7), covered activities designed to solve certain technological problems arising from the treatment, storage and disposal of waste of all categories and to help towards the definition of a legal, administrative and financial framework for waste management activities.

Considering that this first programme "has yielded positive results and opened up encouraging prospects" on the one hand and that "the particular nature of the waste is such as to require monitoring of its potential effect and reinforcement of projects and research activities undertaken to ensure the protection of the environment" on the other, the Council adopted, in 1980, a second five-year programme (1980-84) which is a logical follow-up to the first programme (8). This programme, the nature and scope of which, together with the initial (partial) results already obtained are described in the first two annual reports (9), is closely coordinated with the activities of the JRC in the same sector. Some of the research now being carried out under the Member State national programmes is supported by this programme which also makes it possible to coordinate at Community level some specific activities such as the evaluation of the performance of various geological systems for high-level waste confinement or the characterization and definition of acceptance criteria for the disposal of various forms of conditioned waste.

R&D is still going on at both national and Community level, stimulated by the results already obtained.

The prospects, together with the installations and facilities that will exist in a few years time, are examined country by country in the next two sections.

## III.2. Prospects and plans for treatment and conditioning techniques and facilities.

The purpose of the research currently under way is :

- to improve and optimize the existing techniques which are only concerned with low and medium level waste. Improvement and optimization have become necessary to cope with the ever-increasing quantities of waste resulting from the expansion of nuclear power generating programmes.
  The improvements concern in particular volume reduction factors, the decontamination factors necessary to meet the ever more stringent authorized limits for radioactive discharges and the increase in the long-term resistance of conditioned radioactive products to ensure greater safety in disposal;

- to perfect certain processes now under development or being tested on a pilot plant scale so that they will be industrially and commercially available in the Community when they are needed in a few years time; this applies essentially to :

  1. treatment processes for medium level liquid waste and solid waste contaminated by alpha emitters.
  2. conditioning of fuel element hulls (alpha waste)
  3. conditioning of high level waste; in this field, however the French AVM process is already in commercial use.

Finally, systematic evaluation of the characteristics of the different forms of conditioned waste will help to define acceptance criteria for their disposal. This problem is already being discussed between reprocessors and their customers and studied by various national safety authorities, while a coordinated research effort is under way at Community level.

The main programmes in the Member States and some future prospects are outlined below.

In Belgium, the high temperature FLK-60 * incinerator, constructed in an alpha-tight cell at CEN/SCK in Mol, is currently in operation for the treatment of low-level beta-gamma waste, both solid and liquid (organic residues). As of 1983 this incinerator will also treat low-level alpha waste.

For fuel element hull conditioning, the CEN/SCK, which has concentrated its R&D work on a technique based on the mechanical compaction of the hulls followed by embedding in a lead alloy, is now engaged on designing a press capable of working in hot cells.

Towards the end of the 1980s, the Belgian vitrification plant (AVB) could enter into operation for the conditioning of high level waste.

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* This incinerator is being developed under the Community programme on radioactive waste management and storage.

The plant is based on the AVM process. However, construction depends on future spent fuel reprocessing activities in Belgium, on which no decision has as yet been taken.

Since the first nuclear power stations in Denmark will not be installed until toward the end of the 1990s at the earliest, there are no plans at present for the development of new waste treatment and conditioning facilities.

Nevertheless, basic research will be continued, especially in the field of waste treatment and characterization of waste forms.

In the Federal Republic of Germany high-level waste from the WAK reprocessing pilot plant, now stored in liquid form, are to be vitrified in a pilot plant. However, no definite decision has as yet been taken.

A combined facility for glass block and bead production is under construction at the Eurochemic site and should demonstrate the feasibility of the PAMELA process (*). It should enter into service in 1985 and will be managed by DWK jointly with BMFT(**) and Eurochemic.

In the coming years nuclear power plant operators who treat or store waste themselves will develop improved conditioning techniques, the ultimate aim being to reduce volume.

A new management system for medium level liquid waste is now being developed. The waste will be split into a small active fraction containing gamma and alpha emitters and a large low level fraction for direct immobilization in cement or bitumen. Much of the "lost" shielding required for transport and handling prior to disposal will be saved by this system.

The Karlsruhe nuclear research centre is developing :

- waste immobilization in cement, ceramics and glass
- an acid digestion process for combustible alpha waste with subsequent plutonium recovery (***)
- conditioning methods for fuel element dissolver sludges, hulls and structural materials.

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(*) This process was developed by a team of researchers from various German organizations, backed up by techniques developed by Eurochemic

(**) BMFT = Federal Ministry for Research and Technology

(***) The ALONA pilot plant based on this process will shortly start hot operation on the Eurochemic site at Mol.

Some of these projects are being developed in conjunction with Battelle Frankfurt.

The NUKEM company is developing a new incineration method for alpha waste, based on hydropyrolysis, and a method for the incineration of ion exchange resins and organic esters of phosphoric acid.

NUKEM is also developing a waste immobilization waste container system using natural graphite. It can immobilize any type of dried or calcined waste free from highly oxidizing material.

The Jülich nuclear research centre is continuing to operate its new FIPS II facility for vitrification of high-level waste.

The Karlsruhe and Jülich research centres are devoting special attention to the trapping and immobilization of gaseous waste in solids (silver-based adsorbants for iodine-129, zeolites or metal alloys for krypton).

A special containerless conditioning and disposal concept for low and medium level waste is now being developed. It consists of pregranulating the waste solutions, sludges or solids with cement and mixing the granules with a cement-based binder. The mixture can be injected into a cavern where it cures to form a monolith. No human intervention is required within the cavern.

This development is being sponsored by BMFT and developed by two research centres and two industrial companies.

In France, many studies and research projects are being carried out on waste treatment and conditioning and its characterization. The lines of research are as follows :

a) low and medium level waste, alpha waste

The processes developed for aqueous liquid waste have already been operational for a long time and, depending on the type of waste, produce either sludges, concentrates or various ion exchange resins.

At present an intensive effort is being made to facilitate final conditioning (e.g. reduction of the sodium content in concentrates, and of nitrates in sludges).

For organic liquid waste, incineration (already in operation for all types of organic waste) or distillation-mineralization processes for organic solvents (TBP) are being developed simultaneously.

For high alpha waste, recovery of alpha emitters is being developed as follows :

- a facility for the treatment of mixed oxide fuel fabrication waste is due to start operation in 1983 at Cadarache (cryogenic shredding, recovery of plutonium, acid digestion of cellulosic waste).

- a facility (LEDA) for waste from nuclear research centres is planned at Fontenay-aux-Roses (leaching of alpha waste up to 70-90 %).

For combustible waste, incineration is being studied from the technological, economic and safety aspects.

Some small-capacity facilities already exist in France. A few design studies are available, in particular for a 100 kg/h incinerator for low level waste. The use of this technique on an industrial scale will depend on later decisions.

Much research is being devoted to gaseous waste treatment, with priority for iodine and krypton, and this will be continued.

The most common conditioning processes for all treated waste make use of hydraulic binders, bitumens or thermosetting resins, in accordance with formulae and processes already available industrially, but substantial research and development work is being actively pursued in these fields. These conditioning processes have been selected for the new reprocessing units at La Hague (1987).

Mention should also be made of the extensive research on the development of alternative highly stable conditionings for alpha waste, the embedding matrix generally being a ceramic material, a generic term that covers ceramics, glass, porcelain, sandstone, etc...
Two main directions are being followed :

- processes as alternatives to bitumenization for aqueous waste from reprocessing plants,

- the self-crucible melting of fuel element hulls and end-fittings.

The characterization of conditioned waste is a fast developing basic research activity.

It involves :

- systematic tests on :

  . characteristics relating to fabrication (quality control)

  . characteristics relating to storage and disposal (resistance to shock, fire, weather conditions, etc..)

  . short-range chemical stability (full-scale leaching tests).

It is also planned :

. to set up a sample collection (conservation of representative samples)

. to set up a laboratory for destructive testing of old packages.

- basic studies on :

  . the phenomenology of possible long-range modifications (mechanism and physico-chemical nature of leaching, internal diffusion, thermal stability, alpha, beta and gamma radiolysis),

  . the composition in time of effects previously known as ageing (study currently limited to hydraulic binders).

The following large-scale development work cannot be omitted from a full analysis :

- studies on the conditioning of special waste, in particular tritium-bearing waste and decommissioning waste (decontamination processes, melting of metallic waste, etc..)

- development at all stages of processes for bulk and sample measurements (alpha, beta, gamma spectrometers, alpha counting by active and passive neutron methods),

- establishment of the fullest possible inventories of waste arisings.

b) High level waste

Vitrification, the basic process for the conditioning of high level waste, has now reached the industrial stage. Expected future developments are as follows :

The AVH (or R7) facility associated with the extensions at La Hague is expected to become operational in 1987. Following the pattern of AVM, it will be based on an inactive prototype now being constructed. In handling primary high level solutions, a maximum of liquid waste will be recycled and sent for vitrification, which will reduce the other activities for alpha waste.

PIVER II : an active pilot unit for continuous vitrification.

Intensive work is in progress on the characterization of glass :

. Analytical studies : leaching, exchange mechanisms in the surface layer, radiation stability (alpha-doped glass, ion implantation, etc..), physical stability (crystallization, effects of thermal and mechanical shocks), pressure and temperature effects.

These studies started more than 10 years ago are being intensively continued.

. Global study : simulation on active and inactive blocks of foreseeable storage conditions, with or without geochemical barriers, a programme to start in 1983.

Long-term plans include the development of a leaching model.

A number of studies and research projects are also being conducted in Italy on waste treatment, conditioning and characterization. They are carried out essentially by ENEA and to a lesser extent by AGIP Nucleare.

ENEA is mainly engaged on an R & D programme to acquire vitrification technology for high level waste. National work in this field is open to any possibility of Community cooperation.

A pot vitrification process is now being tested both cold and hot (the latter in a hot cell on a mini-pilot scale). At the same time an experimental set-up to study remote handling of the pot is being developed (PROTEO facility) and studies on the characterization of the glass produced are being continued.

There are plans to construct in the early 1990s a pilot vitrification unit attached to the EUREX pilot reprocessing plant.

Two pilot conditioning facilities are being developed for low and medium level liquid waste. They will be used to demonstrate the feasibility of two processes for embedding waste in polyester and in cement plus resin matrices, developed by ENEA.

It is planned to construct a conditioning facility based on one of these two processes in the early 1990s. It will be attached to the ITREC reprocessing plant. A compaction facility will be constructed for the treatment of solid waste currently stored in various nuclear research centres.

Studies and R & D work on the treatment of plutonium-contaminated liquid and solid waste (alpha waste) will be continued. In this field AGIP Nucleare has developed a molten salt oxidation process.

In the Netherlands, research is focussed mainly on the disposal of high level waste (vitrified waste from spent fuel processed abroad which will be returned to the Netherlands from the beginning of the 1990s). Tests and evaluations on ceramic materials for the immobilization of high level waste are also in process.

In the United Kingdom, a vitrification plant for high level waste will be constructed at Sellafield and should be operational by 1990. Although present indications are that vitrification using borosilicate glass will produce a waste form suitable for disposal, other processes based on ceramic and mineral matrices are being investigated for possible use in later plants.

A plant for the sorting, treatment and conditioning of alpha waste is also planned at Sellafield. The processes will probably include immobilization of the waste, when appropriate, in cement-based matrices for sea dumping.

The range of waste of other categories generated in the United Kingdom is wide both in terms of physical and chemical form and in the nature and quantity of associated radioactivity. Hence there is a wide range of potential processes for converting waste into forms suitable for disposal.

Examples of treatment processes currently being researched are as follows :

- for volume reduction : shredding, laser cutting, compaction, incineration, acid digestion and, in the case of wet waste, dewatering by filtration, evaporation, centrifugation and hydrocyclone drying;
- for decontamination : washing, ultrasonic cleaning, leaching, electropolishing for solid waste and floc precipitation, ultrafiltration, magnetic filtration, ion-exchange and electrochemical techniques for liquids;
- for inertness and/or compatibility with immobilization matrix : incineration or acid digestion for organic materials and conversion to inert oxide or hydroxide for reactive materials.

Conversion of waste into a form suitable for disposal may be achieved by incorporation, with or without pre-treatment, in a matrix such as cement, bitumen, organic polymers, polymer-impregnated cement or even metals. Alternatively, some materials such as metal oxides or salts may be suitable for direct conversion to a ceramic material by hot pressing and plastics might be converted directly to a solid block by melting and casting. These various processes are at different stages of technical development. They produce waste forms of different quality and suitability for disposal. Also, process costs and radiation exposure of operators may vary widely between options such as direct encapsulation in cement or bitumen and more complex treatment processes involving volume reduction and decontamination before immobilization.

In practice the final selection of a process will be made in the context of an optimized waste management scheme when the requirements of storage, transport and disposal have all been assessed with respect to environmental impact and cost. The Department of the Environment is now carrying out studies, in collaboration with other bodies and waste producers, to define and evaluate this scheme.

## III.3. Prospects and plans for waste storage and disposal

The prospects and plans for waste storage and disposal discussed in this section relate mainly to alpha and high level waste, since disposal of both low and medium level waste has already reached the industrial stage (see section II.4). Nevertheless some information on the installation of new facilities will be given country by country.

The option for disposal of alpha and high level waste that is now being studied most in the Member States and at Community level is the confinement of waste in deep geological formations (*).

The results obtained so far from research in this field seem to confirm the feasibility and merits of this disposal option. Also, the inventory of geological formations having the right technical characteristics for the installation of repositories in deep underground geological formations in the Community countries (10) shows that the authorities responsible for prospecting and studying possible disposal sites have a wide choice available to them.

Even though existing knowledge shows that it is possible to construct disposal facilities in any type of the geological formation studied (clay, granite, salt), the confinement performance of these different formations has nevertheless to be clarified.

Studies and research carried out by Member States in different geological formations, at both national and Community level (**), should make it possible to answer this question in the next few years.

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(*) The transmutation of transuranic elements into short-lived elements by irradiation in nuclear reactors would reduce the problem of disposing of long-lived waste. Research carried out at JRC Ispra in cooperation with the international scientific community from 1973 to 1980 has shown that this strategy would have more drawbacks than advantages, at least in the current state of technology. This strategy is no longer being envisaged at present by the Member States and the Commission.

(**) Under the Community's R & D programme, clay formations are being studied mainly by Belgium and Italy, crystalline formations by France and the United Kingdom, salt domes by the Federal Republic of Germany and the Netherlands. Supporting studies on all formations are being carried out by Denmark. It should be noted that, except for the Federal Republic of Germany, these options do not in any way imply a definitive commitment to the type of formation being studied. These Member States and the JRC are also taking part in the Community programme to investigate the confinement performance of these geological formations and of deep marine sediments. However, the Community is doing less work on the last option.

Recently disposal in the sea bed has been considered as an alternative to disposal in continental geological formations. Studies and research in this field are much less advanced than those on continental formations. In particular, feasibility remains to be demonstrated.

At this stage it can be predicted that some Member States will by the early 1990s have facilities in continental geological formations for the disposal of alpha waste at depth.

Some Member States have planned or are constructing underground facilities to study the disposal system for high level waste. This could be followed towards the end of the century by operational facilities for the disposal of high level waste in the deep layers of continental geological formations.

The main plans of the Member States and some future prospects are given below :

In Belgium, sea dumping is still the disposal route used for low level waste, following technical and organizational efforts to reduce volume.

On the other hand, the possibility of creating a set of underground galleries for disposal of high and medium level and alpha waste in a layer of clay under the CEN/SCK territory at Mol (HADES project) has been under study for some years and still is.

The clay layer concerned (Boom clay) is 160 to 270 metres deep.

Geological and hydrogeological studies and investigations have already been carried out and the first aim of the current programme is to set up an experimental laboratory in the clay 225 m below ground. The work started in 1980 and will in principle be completed in 1983. This underground laboratory (the first of its kind in Europe) will provide additional hydrogeological, geomechanical and technological data and verify in situ aspects related amongst others to thermal exchange and corrosion.

The construction of a final underground facility for waste disposal will be subject to the authorization procedure. It is expected that all the data for the file will be available around 1987-1988.

According to an initial design study, the facility, situated in the middle of the layer, would comprise two vertical access shafts, two ventilation shafts, a main gallery 4.5 m in diameter and 550 m long for transport purposes and a set of secondary galleries 3.5 m in diameter for disposal. About 7 km of these galleries would be set aside for medium level and alpha waste.

Although the facility could become operational reasonably quickly for medium level and alpha waste, it is expected that at least a 50-year storage period on the surface will be necessary for high level waste.

After several decades during which a recovery option will be maintained, all the empty spaces will be rigidly backfilled and the shafts will be sealed with the clay extracted when drilling them. The sealing mode used will depend on experience gained during the reversible phase.

In Denmark, because nuclear electricity will only be subsequently introduced and because of the relatively small volume of low and medium level waste now stored at Risø national laboratory, geological disposal facilities will not be required this century. However, preliminary planning for waste disposal is necessary. Various possibilities are currently being investigated.

Given the conditions requested prior to the introduction of nuclear electricity in their country, the Danish electricity utilities have conducted a vast site investigation programme to demonstrate the feasibility of disposing of high-level waste in Danish salt domes. This is currently being evaluated by the authorities.

In the Federal Republic of Germany, the Asse mine could very probably be authorized again in the near future for the disposal of low and medium level waste. The Konrad mine could also be used for disposal of low level waste, probably from 1988.

At the present the Gorleben salt dome is the subject of a considerable R & D effort with a view to its future use as a disposal site for high level and other categories of waste.

The plans provide for the use of the waste emplacement methods developed since 1967 in the Asse mine and the high level waste emplacement methods now being developed in the same mine.

In France, the following are being considered under a general programme for the management of all radioactive waste :

- a second centre for the disposal of low and medium level waste of the same type as that now in operation should be constructed and should become operational around 1986,

- some categories of waste should be dumped in the ocean under the arrangements set up by OECD/NEA; this practice would be supplementary to land disposal,

- a disposal centre for alpha waste should come into operation early in the 1990s,

- an experimental disposal centre for vitrified high level waste should also be put into operation at about the same time,

- the first phase, which is considered as essential for the whole development of the programme, consists of making an inventory of potentially suitable sites and studying them so as to characterize and qualify the disposal site or sites where these centres would be located.

In the immediate future, pending the creation of these disposal centres, there are plans to construct the necessary storage facilities to cope with the waste generated, in particular alpha and vitrified waste from the reprocessing of spent fuel.

In Italy, underground caverns in disused mines are now being identified for the disposal of low and medium level waste.

Alpha and high level waste will be disposed of in suitable geological formations at depth. Disposal will be preceded by storage for some decades in artificial ad hoc structures to allow cooling and radioactive decay.

Work on the identification of sites for disposal facilities is concentrated on clay formations. However, other geological formations are being considered.

The construction of an experimental underground laboratory will start soon. A demonstration disposal facility could be available by the end of the century.

In the Netherlands, options for disposal of low and medium level waste as an alternative to sea dumping are being studied.

In the United Kingdom, a storage facility for high level vitrified waste will be constructed at Sellafield.

Since the feasibility of high level waste disposal deep underground has been established in principle, work is continuing on disposal under the ocean bed. Thus it will in due course be possible to make a comparative assessment of the different options.

Work is now in progress so as to bring into operation from 1990 land facilities for the disposal of most medium level and alpha waste. These facilities could consist of engineered trenches 20-30 m deep or a modified mine or purpose-built cavities at greater depths.

Investigations are under way to identify suitable sites. The types and quantities of waste that can be disposed of in a given facility will depend on the specific design of each facility and of the waste packages. Consequently it is not possible at this stage to evaluate the number of facilities required.

For low level waste, it is planned to continue using the existing disposal methods described in section II.4. However, there are also plans to identify suitable new sites for the shallow burial of the forms of waste that are currently disposed of at Drigg.

## CHAPTER IV

## CONCLUSIONS

1. At present radioactive waste is generated in the Community in three sectors of activity : production of nuclear electricity (including the associated fuel cycle *), research and the industrial and medical applications of radioisotopes.
The relative contribution of these three sectors varies in time and from one Member State to another, in particular depending on commitments and progress in nuclear electricity programmes.

2. Institutional provisions regulating radioactive waste management exist in all Member States. In recent years additional measures have been taken in the countries concerned to ensure the implementation of the disposal of radioactive waste. All these provisions are designed to keep man safe and to protect the environment; they are continuously monitored so that they can be supplemented whenever necessary.

3. The volume of essentially low level waste generated by research, medical and industrial activities today represents the total production of the Member States that do not have nuclear power programmes and a significant or major proportion of the total production of those that do.

4. About 95 % of the conditioned waste produced today in the Community consists of low and medium level activity waste which, by radioactive decay, will be reduced to the natural environment activity level in a few hundred years. This percentage will decline in the years ahead with the increased arisings of waste of other categories related to the development of the nuclear fuel cycle in the Community, but it will still remain very high (about 85 %) up to the end of the century.

The annual production rate in the Community is now some tens of thousands of m3 for all the three sectors mentioned above. It will approach the one hundred thousand m3 mark by the end of the century. By comparison, in 1982 the Community produced approwimately 40 million tonnes of chemical waste of varying degrees of toxicity.

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* In this report no account has been taken of low level waste from uranium ore mining and treatment and from the decommissioning of nuclear plant. Most fo the decommissioning waste will not be treated before the end of the century.

5. Products considered today as low level waste include materials that are only suspected of radioactive contamination.

A decrease in the volume of these products is to be expected in the future owing to :

- the completion of studies now in progress at international level to define thresholds below which materials do not call for any special precautions ("de minimis" values).
- the development of methods of determining low activities
- the improvement of the techniques described under 6.

6. Treatment and conditioning processes for low and medium level waste are available and the corresponding industrial facilities have been operating successfully since the early 1950s. R & D work is being continued, however, in many Community countries in order to improve existing processes and to develop, where necessary, new processes, products and packages that are more efficient and/or more economic and can be used on a vast industrial scale.

All this work is designed, amongst other things, to improve volume reduction factors and increase long-term integrity of conditioned products so as to ensure safer disposal. This part of waste management appears to satisfy quite adequately the existing requirements of the nuclear power programmes and as regards safety.

7. Two complementary methods are at present being used in combination or separately by the Member States to dispose of low and medium level waste : land disposal on the surface and sea dumping. Land disposal capacity is likely to prove insufficient in the near future if the establishment of new sites is not rapidly decided on in some Member States. The quantity and activity of waste dumped in the sea are limited by the international recommendations in force. At the moment these limits exceed the requirements of the Community.

8. Of the radioactive waste produced in the Community, 5 % consists of products contaminated by long-lived alpha emitters, the radioactivity of which will remain at significant levels over long periods of time. Most of this waste is as yet untreated. Basic technologies for the treatment and conditioning of this waste are available but the processes must be developed, improved and selected so as to ensure optimum disposal. Current R & D is concentrated on treatment techniques for alpha-contaminated liquid and solid waste and the conditioning of spent fuel element hulls. The aim is to find conditioning processes allowing safe storage and disposal over long periods of time. The separation of long-lived radioactive species (actinides) either for recycling of to downgrade the bulk of the waste to other waste categories is also being studied.

When these techniques are perfected in a few years time, the Community should be in a position to meet requirements in good time.

9. Alpha-contaminated waste is not yet disposed of. The Member States concerned have up to now been storing this waste in special facilities until they are in a position to condition and dispose of it. The first facilities for the disposal of alpha waste in geological formations at medium depth (around a few hundred metres) should enter into operation in some Member States at the beginning of the 1990s. If this is so, the disposal of alpha waste will not be a problem in the future; otherwise, the interim storage practices in use today will have to be continued. Thus the situation and prospects regarding alpha waste disposal do not appear to be a hindrance to the development of nuclear electricity programmes in the Member States having the greatest commitments to nuclear energy.

10. Of the volume of radioactive waste produced in the Community, 0.3 % consists of high level waste (also containing alpha emitters) that will be vitrified. This waste contains almost all the radioactivity generated by nuclear electricity programmes. Radioactive decay heat is therefore a major concern for waste management. Radioactivity and decay heat will reach similar levels to those of alpha waste after a few hundred years, and then high level waste may be treated in a similar way as alpha waste.

11. Most of this high level waste is today stored in liquid form in tanks with special cooling and safety arrangements. Treatment and conditioning processes are designed to immobilize this waste in long-term integrity solid matrices such as glass. Various conditioning processes are now being developed in the Community. The French vitrification process (AVM) is now commercially available.

12. The necessary cooling period, the availability of temporary storage facilities and the small volume of high level waste allow great flexibility in the defintion of a strategy and time schedule for the disposal of such waste. An enormous R & D effort both within and outside the Community is being devoted to disposal. Almost all the Member States and the Commission are contributing to this effort. The options under study are disposal at depth in various continental geological formations, well represented in Community territory, and disposal in sediment in the ocean bed. The results obtained so far confirm that disposal in suitable continental formations is feasible in the Community. The seabed disposal option helds out interesting prospects but its feasibility has not yet been demonstrated. Several Member States are constructing or planning underground laboratories in order to obtain further information on the waste/disposal facility system. This could be followed by operational facilities towards the end of the century.

13. In the final analysis, taking an overall view, the current situation and prospects in the field of radioactive waste management in the Community do not jeopardize the safety of man and his environment or offer a technical obstacle to development of nuclear power programmes in the Community. If this situation is to continue, it is essential to ensure that current predictions can actually come about by continuing national and Community R & D activities and starting work on additional facilities. Any obstacles to the implementation of this plan are not of a technical nature but could come from a lack of acceptance by the general public. Consequently clear political decisions on the implementation of this plan are necessary.

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