Radioactive Waste Policy in the Netherlands

Ministry of Housing, Physical Planning and Environment

RADIOACTIVE WASTE POLICY

IN

THE NETHERLANDS

AN OUTLINE OF THE GOVERNMENT'S POSITION

Ministry of Housing, Physical Planning and Environment
September 1984

CONTENTS

SUMMARY

This report outlines the Government's position on the management of radioactive waste. The primary objective in this area must be radiation protection, and the three principal features of policy are isolation, control and surveillance.

What is required in the Dutch situation is an approach which is capable of dealing with all categories of radioactive waste over a period of several decades. Economic considerations among others indicate land-based storage as the preferred option at present. This option is environmentally acceptable and feasible. A site will need to be found which is suitable both for the processing and storage of low- and intermediate-level waste and for the storage of high level waste and/or irradiated fuel elements.

A committee is to consider possible sites, devoting particular attention in its deliberations to the administrative factors involved, and a decision on the choice of site will be reached on the basis of the committee's findings. Every effort will be made to communicate that decision to the Lower House of Parliament not later than 1 January 1986.

INTRODUCTION

This report sets out radioactive waste policy for the coming decades on the basis of current understanding of the questions involved. All the various types of waste produced in the Netherlands are discussed, including both low- and intermediate-level waste (which was considered by the committee – Commissie HVRA – set up to reexamine the question of the disposal of radioactive waste) and high-level waste and fission products.

Chapter 7 details the categories and quantities of waste which are produced in the Netherlands. The disposal policies followed in certain other industrialized countries are outlined in an annex. The bibliography lists parliamentary documents and some other publications relating to radioactive waste management.

1. OBJECTIVES OF RADIOACTIVE WASTE POLICY

Radioactive waste policy forms one aspect among others of overall radiation protection policy, the object of which is to ensure that human beings and their environment are protected from the harmful effects of exposure to radiation. It must therefore satisfy the following requirements (64):

a. any individual exposure must be as low as is reasonably achievable;
b. the total doses received must not exceed established limits.

Radioactive waste must be managed in such a way that these requirements are observed at all times: in particular, uncontrolled discharge of radioactive materials into the environment must be prevented. This objective can be achieved if the waste is adequately isolated, if the types and quantities of waste are tightly controlled and if the disposal process is carefully surveyed at all stages.

2. ISOLATION, CONTROL AND SURVEILLANCE

The main components of radioactive waste policy are the isolation, control and surveillance of waste material either until it is no longer radioactive or until it has been disposed of in such a way that the likelihood of an unacceptable amount of radioactivity finding its way into the biosphere is negligible.

One important element in isolation and control is the limitation of the quantity of waste in terms of both activity and volume: the smaller the volume of waste involved, the easier it is to control. Every application of radioactive materials in the Netherlands requires a licence, and the manner in which the licensing system is operated puts a brake on the use of such materials and hence contributes to limiting the quantity of waste.

Moreover in recent years technical progress has contributed to limiting the radioactivity contents of the waste in two ways: the increasing sensitivity and accuracy of measurement techniques has made it possible to use lower activity levels in many applications, while advances in the technology of radionuclide production have made many short-lived radionuclides available.

Research into the scope for further reducing the quantity of waste (16) has shown that while no substantial additional reduction in activity levels appears feasible some reduction in the physical volume of waste could be achieved by separating it into its active and inactive components. Hitherto the term "radioactive waste" has been interpreted to include not only radioactive substances which are no longer of use and objects which have been contaminated by radioactivity but also any materials or objects which may have been in contact with radioactive substances, and this has meant that the volume of what is regarded as radioactive waste is greater than is strictly necessary. While separation would bring with it a very slight risk of radioactive substances finding their way into other waste streams, research (60,61,62) has shown that thanks to improvements in measurement techniques separation into active and inactive waste could be carried out with an acceptable level of safety. It is considered that this would bring about a significant reduction in waste volume.

In addition to the limitation of the quantity of waste the processes of isolation, control and surveillance would also be facilitated by a policy of centralized collection. The central collection, processing and storage of radioactive waste presents advantages in three major areas, namely environmental protection, cost reduction and employee safety.

a. Environmental protection

The designation of a single centralized collection service to which waste could be surrendered and which would be required to accept any waste offered to it would greatly facilitate control of the waste stream. A central approach would provide greater safeguards for surveillance and management and thus ensure that there was no uncontrolled discharge of waste into the environment.

b. Cost reduction

While the output of radioactive waste in the Netherlands is small (some 1000 cubic metres per year) it comes from a large number of sources, and a central organization would help to keep unit processing and storage costs relatively low – an important consideration, particularly for smaller producers. In addition the financial resources needed for the exploitation of advanced processing techniques would be available on a sufficiently large scale only if the collection and processing services were centralized.

c. Employee safety

In general a central organization would be better able to assemble staff with specific expertise in the fields of waste treatment and radiation protection, and this expertise – combined with the use of advanced processing techniques – would help keep the radiation doses to which employees were exposed as low as is reasonably achievable.

Finally it should be noted that the Nuclear Energy Act (65) provides an adequate foundation for a radioactive waste policy within the limits set by overall radiation protection policy.

3. THE IMPLEMENTATION OF RADIOACTIVE WASTE POLICY

The subject of the implementation of radioactive waste policy has been raised in Parliament on numerous occasions in recent years; the relevant parliamentary documents are listed in the bibliography attached to this report.

The implication of the components of radioactive waste policy referred to in chapter 2 is that implementation should be in the hands of a single central organization: the Government has accordingly initiated the establishment of the Central Organization for Radioactive Waste (COVRA), which will be responsible for the management of all radioactive waste in accordance with the policy which the Government has laid down (see also chapter 6).

Various methods have been developed for dealing with radioactive waste. Low- and intermediate-level waste on the one hand and high-level waste on the other must be considered. Detailed information on these categories is given in chapter 7.

Low- and intermediate-level waste

In the Netherlands low- and intermediate-level waste is produced in various forms in hospitals, research institutions and industry and at the nuclear power stations at Dodewaard and Borssele. Until May 1982 this waste was mainly disposed of by dumping in the Atlantic Ocean. On 21 March 1983 the committee appointed to reexamine the question of alternative disposal methods (Commissie HVRA) submitted a report to the Lower House of Parliament. From the many possible options the committee selected six for detailed comparison with ocean dumping; having considered the advantages and disadvantages of each it came to the conclusion that at least four of the methods examined were feasible alternatives to dumping in the Atlantic Ocean for at least some of the waste in question. There were (1) storage in structures on the land surface, (2) storage in structures beneath the land surface, (3) emplacement in geological formations deep beneath the land surface, and (4) incineration. The committee also considered that some degree of segregation of the different types of waste could prove a valuable element in the process of dealing with low- and intermediate-level waste.

This brief summary of the committee's conclusions does not of course do justice to the detailed arguments involved, and reference should therefore be made to the report itself (47).

There is in fact no difference of principle between the first two methods listed above, and in the rest of this report both are referred to as land-based storage.

As a disposal method incineration is suitable for only a small part of the waste produced, namely that which contains only carbon-14 and tritium as radioactive elements. The discharge of radioactive carbon dioxide and water resulting from incineration can be justified on the grounds that these substances occur naturally in the atmosphere and their dispersion in the environment would not cause any significant increase in background radiation levels. Besides, incineration is in principle environmentally acceptable as a volume reduction technique for low- and intermediate-level waste (49,66). Any radioactive substances other than carbon-14 and tritium will be collected in the ash residues or trapped in the filter systems (see also chapter 7).

High-level waste

A very small quantity of high-level waste is produced by research institutions and hospitals and in industry. It is currently stored at the Energy Research Foundation at Petten. However, by far the largest proportion of high-level waste is made up of irradiated fuel elements from the nuclear power stations at Dodewaard and Borssele (see also chapter 7), which are sent for reprocessing to France and the United Kingdom. Reprocessing produces a quantity of high level waste including vitrified fission products. The reprocessing plants have reserved the right to return the waste to its country of origin, but this is not expected to occur until the mid-1990s. There is also a possibility of spent fuel being sent back in unreprocessed form (63).

Following the report of the committee appointed to consider the position of the existing nuclear power stations at Dodewaard and Borssele (44,45,46) the Government decided that the two stations should remain operational, a view which was endorsed by a majority in the Lower House. Radioactive waste policy must therefore include provision for the high-level reprocessing waste, vitrified fission products and/or irradiated fuel elements of these two power stations. In the rest of this report these types of waste are referred to collectively as high-level fission waste.

International research (51,52,53,55,58) has demonstrated that both land-based storage for a long period of years and geological disposal are environmentally acceptable as methods of dealing with high-level waste. Further international research, in which the Netherlands is taking part, is investigating the possibility of deep seabed disposal.

Land-based storage

By land-based storage is meant the storage of waste in structures on or a few metres beneath the land surface. Many methods are technically feasible. The structure itself and where applicable a layer of ground material serve as barriers to radiation and to the transfer of material to the biosphere (isolation). The advantage of this form of storage is that it facilitates control and surveillance: a monitoring programme can be set up to ensure the early detection of any leakage. Furthermore some of the stored waste will eventually decay to the point that it can be regarded as inactive and disposed of accordingly; the time span involved is of the order of 100 years. Depending on the processing method used and the nature of the resulting product such waste can then be classified as either domestic of chemical; it is even possible that some use will be found for it.

Since high-level fission waste generates heat there are technical advantages in storing it for a period of several decades in a manner which permits heat removal. The Committee set up to look into the interim storage in the Netherlands of irradiated fuel elements and fission waste (Commissie MINSK) is studying the technical aspects of such storage in the framework of the comprehensive national study of nuclear waste (ILONA).

Land-based storage of both high-level fission waste and low- and intermediate-level waste containing long-lived radionuclides is of a temporary nature.

One major advantage of land-based storage is that it leaves open the possibility of using other disposal methods at a later date.

Geological disposal

Geological disposal in the Netherlands would imply emplacement in rock-salt formations, the salt itself and the surrounding strata forming a complete barrier to radiation and preventing any transfer of radioactive material to the biosphere. Extensive research has been carried out, both nationally and internationally, on the subject of geological disposal – notably in the context of the research programme of the European Communities (51) and the activities of the IAEA (56,57,58,59) and the OECD/NEA (53,54,55) – and the general conclusion is that disposal in certain geological formations is an environmentally acceptable method. However, while the United States has already decided to implement geological disposal, other countries – notably France and the United Kingdom – do not want to take this step on economic/political grounds or consider that it would be premature to reach a final decision at this time. In both France and the UK it is considered that high-level fission on waste must be stored for several decades before there can be question of geological disposal (see annex).

Storage in salt formations could involve the use either of a dumping pit or chamber or of a mine. Pit dumping would be suitable only for low- and intermediate-level waste. However this process is in principle irreversible and therefore does not fully meet the requirements of isolation, control and surveillance. Both low- and intermediate-level waste and high level fission waste could be stored in a mine furnished with bore holes from galleries or in bore holes directly dug from the earth's surface. Were salt mines to be used for disposal of waste, control and surveillance would remain feasible for as long as the facility was operational.

A programme of research into geological storage in the Netherlands is being drawn up in the framework of the comprehensive national study on nuclear waste. It will include a survey of the current state of knowledge in this area and an indication will be given of any additional work which needs to be undertaken before a final decision can be reached. In the course of this year the Government intends issuing a paper setting out its position following the public debate on energy policy; it will deal among other things with this and any other relevant research programmes.

The choice of disposal method

In the view of the Government it is essential to adopt a disposal method which can be used for all categories of radioactive waste for a period of at least several decades. Given (a) the recommendations of the committee set up to reexamine the question of the disposal of low- and intermediate-level waste, (b) the widespread opposition to the dumping of such waste in the ocean, and (c) the high cost of preparing a salt mine for disposal purposes, storage in structures on or just beneath the earth's surface is at present choosen as disposal method for low- and intermediate-level waste.

If at some future date high-level fission waste from Dutch nuclear power stations is returned to this country or spent fuel is no longer sent abroad for reprocessing, this waste could also be stored in land-based facilities pending definitive disposal. A site must therefore be found in the Netherlands which is suitable for the storage of all categories of radioactive waste. During the storage period further considerations can be given to definitive disposal options and developments in other countries can be studied. A possibility even is the use of an international storage or disposal facility were one to be established: exchanges of views on this matter regularly take place in international organizations concerned with radioactive waste management, and a first step has recently been taken by the OECD/NEA towards the identification and study of factors relevant to the establishment of such a facility. It is likely that in the course of the storage period geological disposal facilities will become operational in a number of countries.

The next chapter, which deals with the problems and practicalities of land-based storage as the Government sees them, is concerned in particular with the procedure to be followed with a view to ensuring (a) that a decision regarding the storage site is reached before 1 January 1986 and (b) that a land-based storage facility becomes operational before 1 January 1989, in accordance with the undertaking given to the municipal authority of Zijpe (34) (see also section "Location", p. 8).

4. LAND-BASED STORAGE

Environmental protection considerations

From the extensive experience which has been built up, both nationally and internationally, of various processing and storage methods it is clear that the processing and storage of low- and intermediate-level waste need present no danger to human beings or the environment. A number of recently completed Dutch investigations (50,60,61,62) of possible storage methods and techniques for the segregation of waste have shown that in normal operation the radiation exposure of the environment would remain far below the statutory limits. These limits would not be exceeded even following operational incidents or incidents due to external factors (48, 49,50).

A storage facility for low- and intermediate-level waste could take one of several forms, among them a repository building, a surface or underground bunker or deep lined trenches. The greater the shielding provided by the structure itself the less shielding capacity would need to be incorporated in the actual waste containers. In the case of subsurface storage the geohydrological characteristics of the site would need to be taken into consideration; however, the technical means exist to prevent any contact with ground water. Regular monitoring of the surrounding area could remain necessary until all the waste had sufficiently decayed.

A report is shortly to be issued regarding the technicalities of the interim storage of high-level fission waste in the Netherlands. It will include an examination of ways of ensuring that any storage facility meets requirements relating to the discharge of radioactivity, the exposure to radiation of staff and the surrounding area and the effects of external influences. Since preliminary findings indicate that the interim storage of this waste would present no danger to human beings or the environment, no technical criteria based purely on safety considerations need to be set for the location of a storage facility suitable for all types of waste.

Planning and land use considerations

In view of the preceding section it is evident that there are many potential storage sites in the Netherlands to which there would be no objection on environmental protection grounds. Assuming that no provision is made for an eventual combination of land-based storage with a geological disposal facility, this means that the only criterion for inclusion in the initial list of possible sites is the availability of sufficient space. If it is decided to use one location only for the storage of all categories of waste for perhaps 100 years the site will clearly have to be a large one. It is virtually impossible to predict future waste output over such a long period. And while it is essential to ensure that no second site is needed in a few decades's time, it is necessary to find a site with an area of some 20 hectares (or alternatively a smaller site with scope for expansion at a later date).

Final site selections can involve comparing potential locations in respect of various planning and land-use considerations. Relevant factors could include the transport infrastructure and traffic routes, local and structure plans, the features of the surrounding area, land costs, the degree of urbanization, proximity to residential and recreational areas, the site's location relative to water sources and areas of natural beauty or importance and any local risk-enhancing factors (such as the proximity of pollution sources or activities involving a danger of explosions).

Legal and administrative considerations

Under section 15 and 29 of the Nuclear Energy Act any storage site for radioactive waste will have to be licensed. Requirements under the Nuisance Act will be incorporated in the licence issued under the Nuclear Energy Act, while the requirements for public consultation laid down in the Environmental Protection (General Provisions) Act will have to be observed as part of the procedure leading to the granting of a licence. The Nuclear Energy Act procedure relating to the storage facility will include the preparation of an environmental impact statement, given that such statements are to be made a statutory requirement for such a storage-facility. In addition the relevant procedures will have to be observed in respect of construction work and any other work needed to provide access to the site.

Financial aspects

The costs incurred by producers in respect of the low- and intermediate-level waste they generate fall roughly into two groups, namely collection and processing costs and storage and disposal costs. The decision to abandon ocean dumping in favour of interim storage at Zijpe had brought with it a change in the second category of costs, but as yet there have been no substantial technical changes in the area of collection and processing. The studies of radioactive waste processing may lead to a change in processing methods; the choice of method will also be determined partly by financial and economic considerations (see also chapter 7).

The cost of interim storage at Zijpe – which can continue for from five to at the most ten years – is about 600 guilders per tonne of processed waste. The cost of longterm land-based storage of low- and intermediate-level waste will depend very much on the method chosen, but it is expected to be of the same order of magnitude (see table 4.1). The cost of storing high-level fission waste will also depend on the method chosen. Finally it must be remembered that costs would also be incurred from the geological disposal of high-level fission waste and low- and intermediate-level waste containing long-lived radionuclides.

COVRA – the Central Organization for Radioactive Waste – will be required to conduct its financial affairs in such a way as to cover the cost of collection, processing, storage and disposal (see also the letter of 27 March 1984 and the accompanying draft shareholders' agreement), and will build up a fund to meet the cost – which cannot yet be estimated with any accuracy – of final disposal for those types of waste for which this is necessary.

The Government's financial involvement will take the form of participation in COVRA's share capital and the provision of advance investment funds for the final storage facility if no other source can be found. The relevant information has already been given to the Lower House of Parliament (consultation with the standing Committee for Environment on 7 December 1983, letter of 27 March 1984).

Table 4.1 Estimated long-term storage costs

Size of site	about 20 hectares
Total site investment cost	about 10 M guilders
Cost of building (low- and intermediate level waste; storage capacity of five years' waste output; modular construction)	about 5 M guilders
Cost of building (high-level fission waste)	p.m.

Site-selection procedure

A small committee is to be appointed to advise the Government on the final choice of a site for the storage of all categories of radioactive waste. The committee, whose members will possess extensive administrative experience, will devote particular attention to the administrative feasibility of its recommendations.

Starting from an inventory of all sufficiently large sites in the Netherlands the committee will make an initial selection of perhaps ten on the basis of a technical evaluation in the light of e.g. the factors listed in section "Planning and land use consideration" (p. 6); thereby discussions will be held with the relevant provincial and municipal authorities. An evaluation of the administrative feasibility of the selected locations is likely to reduce their number to three or four. Having consulted the provincial and municipal authorities concerned the Government will reach a decision and inform Parliament accordingly.

The work of the committee, the selection procedure and the Government's eventual decision will need to be accompanied by an intensive programme of public information. The various aspects of radioactive waste processing and storage will also need to be covered.

5. PROGRESS ON INTERIM STORAGE ARRANGEMENTS

Location

In the course of the studies and administrative consultations conducted regarding potential locations in the Netherlands for an interim storage facility for low- and intermediate-level radioactive waste the site of the Energy Research Foundation (ECN) in the municipality of Zijpe emerged as being open to the fewest objections. It was the option preferred by COVRA, the provincial authority in North Holland and the Government (35) and was approved by a majority in the Lower House (27). On 31 March 1983 the Zijpe municipal council approved a preparatory decision on the development of the facility on the ECN site (35).

In the course of the administrative consultations which led up to this decision a number of undertakings were given to the municipal executive (letter of 15 March 1983) (34), the most important of which were that the Government would announce its position on measures for the disposal of Low- and intermediate-level waste by 1 January 1986, that disposal arrangements would be in operation by 1 January 1989 if at all possible and by 1 January 1994 in any event, and that regular consultations would be held regarding the interim storage facility and the details and implications of the undertakings given. The Interim Storage Coordination Committee, which includes representatives of the municipality of Zijpe, the province of North Holland, COVRA and the Government, was set up to implement this last undertaking.

Implementation

COVRA was given permission on 17 June 1983 for the temporary establishment of an interim storage facility on the ECN site and construction work began on 1 November 1983.

The facility will be ready for use in May 1984 (42). The structure plan for the area which was adopted in 1967 has now been revised to accommodate the facility.

After the interim policy

In view of the agreements mentioned in the first section of this chapter and the Government's preferences regarding the disposal of radioactive waste over the next few decades, the procedure outlined under "Site-selection procedure" is to be implemented at an early date.

6. CENTRAL ORGANIZATION FOR RADIOACTIVE WASTE (COVRA)

The elements of radioactive waste policy discussed in chapter 2 point to the conclusion that its implementation should be in the hands of a single central body, and the Government has therefore initiated the establishment of the Central Organization for Radioactive Waste (COVRA). Preliminary funding of COVRA by the Government proved necessary for the implementation of the interim policy (storage at Zijpe). COVRA will take responsibility for radioactive waste management on the basis of the policy formulated by the Government.

The Government's involvement in the implementation of radioactive waste policy by COVRA will be assured (a) through the inclusion of at least one government representative in COVRA's board of directors, (b) through appropriate provisions in the COVRA statutes, and (c) through provisions in the COVRA shareholders' agreement in which the principal shareholders give relevant undertakings.

Under the Nuclear Energy Act COVRA requires a licence, to which particular requirements may be attached, for all activities involving radioactive waste. In addition requirements will be attached to the designation of COVRA as a collection service with a view to ensuring observance of radiation protection standards at all times. The appropriate public bodies, notably the Health Inspectorate and the Factories Inspectorate, will be responsible for enforcing the licensing requirements.

Further details of the structure of COVRA and the participation of the principal producers were given in the discussions with the Lower House Standing Committee for Environment held on 7 December 1983 and in the letter of 27 March 1984.

7. RADIOACTIVE WASTE: QUANTITIES AND TREATMENT

Low- and intermediate-level radioactive waste

Table 7.1 (p. 12) lists the various types of low- and intermediate-level waste, annual output volumes, current processing methods and the volumes resulting after processing. The processing methods used are determined by the types of processing plants currently in existence, and since until 1983 waste was dumped in the Atlantic Ocean, treatment is still very much geared to producing a product suitable for ocean dumping. The change to land-based disposal may lead to a change in processing methods. The Ministry of Housing, Physical Planning and Environment has commissioned research into ways of treating low- and intermediate-level waste and separating it into its active and inactive components and a classification of waste by type of radioactivity has been produced (16,50,60,61,62). Possible methods of treating the five categories of waste distinguished (see table 7.2, p. 13) have been studied. It was concluded that waste in category 1 would have to be stored in unprocessed form; however, since the initial activity level of this material is generally quite low it can be disposed of as inactive waste once it has been allowed to decay for a period of two years. To a large extent this is what happens already: less than 10% of the waste in this category is presented for treatment, the rest being stored by the producers themselves until it has decayed sufficiently.

Waste in categories 2-5 can be treated by compression, incineration or acid-digestion. While the nature of the acid digestion process is such that it is not really practical for large quantities of waste. it is potentially of value for the treatment of liquid and solid waste from nuclear power stations (group e. in table 7.1). However it would have to be carried out on a decentralized basis, i.e. at the power stations themselves. This leaves only compression and incineration as treatment processes which could be carried out centrally. The two options are set out in table 7.3 (p. 13). Large items unsuitable for compression or incineration and solid/liquid waste (groups d., e. and f. in table 7.1) can be treated only by incorporation in concrete. The different options produce different volumes of processed waste (see table 7.4, p. 14). Option 1 approximates more closely to the existing situation, the difference being the separation of category 1 waste and the incineration of cadavers and organic liquids. While a comparison of the option on the basis of the final volumes of waste produced would favour option 2, economic and operational factors must also be taken into consideration; a study of these factors is due to be completed within the next few months.

Treatment of low- and intermediate-level waste

A distinction must be made between treatment during the interim storage stage at Zijpe and treatment thereafter.

Processing at the interim storage stage

The only method of processing low- and intermediate-level waste currently available in the Netherlands is compression followed by incorporation in concrete. However, waste in category 1 could be stored for a short time by the producers or by COVRA until its activity level has fallen below the threshold specified in the Nuclear Energy Act, when it could be disposed of as conventional waste. Consideration could be given to the construction of a facility for the incineration of cadavers and organic liquids at the ECN site. The Health Council has produced a report on the environmental aspects of this option (66). Alternatively those cadavers and organic liquid waste which come into category 4 or whose activity levels are below the threshold set in the Nuclear Energy Act could be taken directly to a conventional incineration facility for disposal, the remaining cadavers and liquid waste being incorporated into concrete or respectively stored in unprocessed form.

Processing after the interim storage stage

If incineration proves to be economically and operationally feasible, all low- and intermediate-level waste in categories 2-5 could be treated in this way. The ash would need to be conditioned in such a way that the product could be stored for long periods. At the collection stage only categories 1 and 5 would need to be kept separate. Category 5 waste would have to be collected separately so that any necessary additional safety measures could be taken during handling and processing.

Radiation sources; high-level waste

Relatively powerful radiation sources such as those used in cancer therapy, food irradiation and sterilization also eventually become waste material, and in general they are then returned to the manufacturer in the country of origin. However, such sources also have to be disposed of in the Netherlands from time to time: they are treated in the same way as high-level waste produced in the course of scientific research, i.e. they are packed in 50-litre steel containers and stored in underground concrete pipes at the ECN-site until radioactivity levels have decayed to the point that they can be regarded as low- and intermediate-level radioactive waste (usually after a period of some 25 years). The output of this type of waste is small (around one cubic metre per year).

High-level fission waste

Spent fuel from the nuclear power stations at Borssele and Dodewaard is sent to reprocessing plants in other countries (63).

This produces a quantity of reprocessing waste. Assuming that the power stations have an operational life of about thirty years the total number of irradiated fuel elements produced will be about 2500, giving rise after reprocessing to some 400 cylinders of vitrified waste and a quantity of high-level solid waste (casings, metal remains of fuel elements etc.) with a total volume of about 700 cubic metres.

Decommissioning waste

After the nuclear power stations have been decommissioned they will eventually have to be dismantled, and although complete dismantling immediately after closure is technically feasible it is generally envisaged that there will be a waiting time of several decades during which activity levels will fall rapidly owing to the decay of the shortlived radioisotopes. This will significantly reduce the radiation dose to which workers dismantling the stations will be exposed. Dismantling will not be necessary until well into the twenty-first century and will produce only low- and intermediate-level waste. A certain amount of waste will also be produced in the course of dismantling research reactors and laboratories. The dismantling of the nuclear installations now in existence will produce several thousand cubis metres of waste in total.

Table 7.1. Low- and Intermediate-level waste

Waste group	Annual output	Current treatment	Final volume
a. Solid	600-800 m^3	Compression + incorporation in concrete	300-400 m^3
b. Cadavers	4-5 m^3	Incorporation in concrete	10 m^3
c. Organic liquids	20-30 m^3	Storage pending incineration	------
d. Large items unsuitable for compression or incineration	10-15 m^3	Incorporation in concrete	20-30 m^3
e. Liquid/solid (power stations)	80 m^3	Binding with cement/ polyethylene and packaging in B-containers	480 m^3
f. Liquid/solid (other producers)	80 m^3	Incorporation in concrete	160 m^3

Table 7.2 Low- and intermediate-level waste classified by type of radioactivity

Category	Type of radioactivity
1	Beta/gamma emitters with a half-life of 61 days or less
2	Beta/gamma emitters with a half-life greater than 61 days but not exceeding 5.4 years
3	Beta/gamma emitters with a half-life greater than 5.4 years
4	Tritium and carbon-14
5	Alpha emitters

Table 7.3 Processing options for low- and intermediate-level waste

Option 1

- Compression of all compressible waste
- Incineration of organic liquid waste and cadavers
- Immediate packaging of remainder

Option 2

- Incineration of solid material, organic liquid and cadavers
- Packaging of remaining unflammable material, compressed where possible

Table 7.4 Volumes remaining after processing

Waste group	Final volume option 1	Final volume option 2
a. Solid	250-340 m^3	
b. Cadavers c. Organic liquids	) 0.6-0.9 m^3	24-32 m^3
d. Large items unsuitable for compression or incineration	20-30 m^3	20-30 m^3
e. Liquid/solid (power stations)	480 m^3	480 m^3
f. Liquid/solid (other producers)	160 m^3	160 m^3

BIBLIOGRAPHY

A. Parliamentary documents

1.	16400 XVII 36	Dumping operations report; remit of committee on disposal of radioactive waste (Commissie HVRA); study regarding new organization for radioactive waste.
2.	16400 XVII 43	Report on discussion with Standing Committee for Environment and Standing Committee for Nuclear Energy of Lower House on 3 December 1980 regarding dumping. Subjects: interim storage, quantities of radioactive waste.
3.	16400 XVII 61	Dumping licence 1981.
4.	17100 XVII 32	Letter from State Secretary Lambers of 13.11.1981 with request for consultation; note to Lower House of 1.12. 1981 concerning consultation; report on consultation; report on consultation of 9 december 1981. Subjects: waste disposal policy; policy intentions; proposed research; abandonment of dumping.
5.	17100 XVII 59	Second note on low- and intermediate-level waste; programme of requirements (ECN); licensing timetable.
6.	17100 XVII 64	Report on consultations on 16 February 1982 regarding dumping in 1982.
7.	17100 XVII 65	Letter concerning storage capacity.
8.	17100 XVII 68	Motion (Willems) on dumping in 1982.
9.	Proceedings	Discussion of Willems' motion (18 March 1982).
10.	Proceedings	Vote on Willems' motion (23 March 1982).
11.	17100 XVII 86	Dumping licence 1982.
12.	17100 XVII 88	Radioactive waste at the KEMA site.
13.	17100 XVII 95	Proposal of Den Helder as waste storage site.
14.	Annex to Proceedings (82-83) no. 9	Parliamentary questions (Lankhorst) regarding availability of sites for waste storage.
15.	Annex (82-83) no. 286	Parliamentary questions (Willems) regarding quantities of waste and storage capacity.
16.	17600 XVII 23	Twijnstra Gudde report on limiting quantities of waste; proposal for follow-up study.
17.	17600 XVII 24	Progress on interim storage; site selection; selection criteria; programme of requirements.
18.	Annex (82-83) no. 349	Parliamentary questions (Lankhorst) regarding waste storage and choice of site.
19.	17600 XVII 26	Announcement of acquisition of site in Velsen for interim storage; establishment of COVRA in hand.

20.	17600 XVII 31	Rijnconsult's report and recommendations on the structure of a new organization for radioactive waste.
21.	17600 XVII 35	Establishment of COVRA; statutes.
22.	17600 XVII 36	Storage capacity, origins of waste.
23.	17600 XI 24	Report on consultations with Lower House Standing Committee for Environment on Velsen, 14.12.1982.
24.	17600 XI 25	Progress report for use in consultation with Lower House Standing Committee for Environment (27January 1983).
25.	17600 XI 35	Corrections to table (see no. 22).
26.	17600 XI 44	Report on consultations of 27 January 1983.
27.	Proceedings	Consultations with Lower House of 10 February 1983.
28.	17600 XI 48	Motion on separation of nuclear power station waste (Alders, Lankhorst and Zijlstra).
29.	17600 XI 49	Motion on Kiribati resolution on London Dumping Convention (Willems).
30.	17600 XI 90	Netherlands' position on London Dumping Convention.
31.	17600 XI 71	Motion on Norwegian proposals regarding London Dumping Convention (Alders, Lankhorst and Lambers).
32.	17600 XI 75	Implementation of motion with proviso.
33.	17600 XI 88	Telephone survey concerning Velsen.
34.	17600 XI 94	Progress report on interim storage.
35.	17600 XI 97	Agreement of Zijpe regarding interim storage.
36.	17600 XI 98	Minister's position on recommendations of committee on radioactive waste (Commissie HVRA).
37.	Proceedings	Oral answers (24 March 1983) to Willem's questions regarding administrative agreements.
38.	Annex (82-83) no. 876	Parliamentary questions (Alders) regarding COVRA of 19 May 1983, replies.
39.	17600 XI 118	Written consultations with Lower House Standing Committee for Environment (35 questions).
40.	Annex (83-84) no. 7	Parliamentary questions (Zijlstra, Alders) regarding separation of radioactive waste (2.9.1983).
41.	Annex (82-83) no. 176	Parliamentary questions (Zijlstra, van den Bergh) regarding artillery tests at Breezanddijk.
42.	1 December 1983	Letter on current situation regarding COVRA and interim storage facility for use in oral consultation on 7 December 1983.
43.	Annex (83-84) no. 7	Questions (Zijlstra and Alders) on separation of radioactive waste.
44.	17740 no. 1	Report of committee on existing nuclear power stations.

45. 17600 XIII 79 — Government's position regarding report on existing nuclear power stations.

46. Proceedings — Discussion of 19 December 1983 on Government's position regarding existing nuclear power stations.

B. Other literature

47. Study of alternatives to dumping in the Atlantic Ocean for the disposal of low- and intermediate-level radioactive waste produced in the Netherlands; Commissie HVRA; March 1983; Government Publishing House (in Dutch).

48. Interim storage facility for low- and intermediate-level waste; ECN-NUCON; January 1983 (in Dutch).

49. Report on the use of incineration in the treatment of low- and intermediate-level radioactive waste; Health Council, February 1982 (in Dutch).

50. Treatment of low- and intermediate-level waste; ECN-NUCON; February 1984 (in Dutch).

51. Evaluation of the Community's indirect action programme on management and storage of radioactive waste; EC Commission, 1981 ISBN 92-825-2786-7.

52. Research and development on radioactive waste management and storage; EC Commission, 1982, ISBN 3-7186 0115-X.

53. Geological disposal of radioactive waste, research in the OECD area; OECD/NEA, May 1982.

54. NEA activities in 1982, eleventh activity report of the OECD/NEA (1983).

55. Disposal of radioactive waste, an overview of the principles involved (OECD/NEA, 1982).

56. Underground disposal of radioactive waste, basic guidance (1981), IAEA Safety Series no. 54 (recommendations), IAEA STI/Pub/579; ISBN 92-0-123381-7.

57. Safety assessment for the underground disposal of radioactive waste (1981), IAEA Safety Series no. 56 (procedures and data), IAEA STI/Pub:590; ISBN 92-0-6233181-2.

58. Concepts and examples of safety analyses for radioactive waste repositories in continental geologic formations (1983), IAEA Safety Series no. 58 (procedures and data), IAEA STI/Pub/632; ISBN 92-0-123383-3.

59. Criteria for underground disposal of solid radioactive waste (1983), IAEA Safety Series no. 60 (recommendations), IAEA STI/Pub/612; ISBN 92-0-123583-6.

60. Inventory of laboratory waste resulting from the use of radioactive substances in the form of open sources, Eindhoven Technical University, annex to no. 60.

61. Canberra Positronika measurement report, annex to no. 60.

62. Act approving exchange of notes concerning reprocessing contracts, Bulletin of Acts, Orders and Decrees no. 347 (1981).

63. Euratom Basic Standards, Journal of the European Communities, 17 September 1980, L246.

64. Nuclear Energy Act, Bulletin of Acts, Orders and Decrees no. 82 (1983).

65. First interim report on an incinerator for radioactive waste, Health Council, no. 17 (1977) (in Dutch).

ANNEX

RADIOACTIVE WASTE POLICY IN SOME INDUSTRIALIZED COUNTRIES

The underground storage on an industrial scale of low- and intermediate-level radioactive waste has been practised in various countries for a number of years (burial at shallow depths in France and the United Kingdom and at great depths in West Germany) and is subject to national statutory regulation. Certain countries dump such waste in the Atlantic Ocean, while others employ only temporary storage with a view to permanent disposal at a later date.

In general the countries of Western Europe have not yet determined their final position on the various options. Brief descriptions are given below of the current situation in various countries as regards storage and disposal, including the interim storage arrangements which are an essential part of the waste management process; interim storage is practised in all the countries concerned.

In the 1960's Belgium opted for dumping as a means of disposing of conditioned low-level waste. Pending dumping the conditioned waste is stored in the open-air facility at the SCK site at Mol, where additional covered capacity of 10,000 tonnes is now under construction. Conditioned waste from the Eurochemic reprocessing plant is stored along with other solid waste at the Eurostorage installation, which consists of surface bunkers and is designed for storage for a period of 50 years. Research is being carried out into the possibility of disposing of high-level waste in clay formations at a depth of some 250 metres. Waste management is the responsibility of a statutory public body, the Nationale Instelling voor Radioactief Afval en Splijtstoffen (NIRAS).

In Denmark temporary storage installations for conditioned low- and intermediate-level waste have been in operation for some 15 years at the research centre at Risø. Research has been carried out into the possibility of disposing of high-level waste in deep boreholes in the Mors salt dome, and a number of test drillings have been made.

In Sweden the application of nuclear power is subject to a statutory requirement that safe methods be shown to exist for the handling and storage of the waste produced. Great emphasis is placed in this connection on research, and in the late 1970's a theoretical study was carried out in fulfilment of a statutory obligation in which it was demonstrated that geological disposal was both feasible and acceptable. An underground interim storage facility for spent fuel elements is now in preparation. Low- and intermediate-level waste is to be placed in a granite formation situated under the seabed but accessible from the land. As part of an international project elements of the Swedish approach to disposal are being tested in an old mine at Stripa.

In West-Germany low- and intermediate-level waste has been stored in a disused salt mine, Asse II, since 1967. Some 25,000 cubic metres of low-level waste incorporated into concrete or bitumen have been deposited at depths varying between 500 and 700 metres, and some 250 cubic metres of intermediate-level waste have been placed in a closed vault at a depth of approximately 500 metres. This mine has not been used for the disposal of high-level waste. Following the expiry of the operating licence in 1978 the disposal of waste in West Germany was discontinued, no other disposal method being permitted in that country. The procedure for relicensing the use of the Asse II mine has been initiated.

Research and development work carried out since 1977 has shown that a disused iron-ore mine (Konrad) is suitable for the disposal of low-level waste, and this facility could become operational in 1988.

Research into the disposal of high-level waste is being carried out in the Gorleben salt dome. Permission has been granted for the boring of two mineshafts to enable a detailed underground survey to be carried out, and work is due to start in mid-1984. Permission has also been granted for the construction of an interim storage facility for irradiated fuel elements at Ahaus; it is expected to become operational in 1985.

In France a site in the department of La Manche has been in use since 1979 for the storage of low- and intermediate-level waste, both on the surface and at shallow depths.

The waste is covered by a thick layer of clay to protect it from rain-water. The area of the site, some 12 hectares, is sufficient to accomodate 400,000 cubic metres of conditioned waste; some 200,000 cubic metres have already been deposited.

High-level waste is stored in specially equiped repositories at the various nuclear installations pending the development of disposal facilities deep underground in suitable geological formations. The construction of an underground laboratory has been recommended as a preliminary to geological disposal. At Marcoule vitrified blocks of nuclear power station waste are stored in an underground system of air-cooled pipes.

ANDRA (Agence Nationale pour la gestion des Déchets Radioactifs), a subdivision of the Commissariat à l'Energie Atomique, was set up in 1979. Its principal functions are the management of the various storage and disposal facilities, participation in research activities and the promotion of coordinated national action in the field of radioactive waste disposal.

In Italy conditioned low- and intermediate-level waste is stored in special installations and, as in Belgium, the disposal of high-level waste in clay formations is under investigation. Nucleco, a company whose principal shareholders are ENEA (the State Energy Office) and AGIP Nucleaire (an organization concerned with energy matters), was established in 1981 to provide services covering all aspects of radioactive waste management.

In the United-Kingdom a number of methods are used for the disposal of low-level waste, namely burial at shallow depths at Drigg (a 120-hectare site where it is estimated some 150,000 cubic metres of waste have been buried since it became operational in 1971), burial at shallow depths at Dounreay (since 1972) and dumping in the Atlantic Ocean (since 1949). These methods are sufficient for the disposal of most of the waste deriving from non-nuclear applications and most of the low-level waste from nuclear installations. The possibility is being investigated of constructing a facility at Elstow for the storage of low-level and short-lived intermediate-level waste on or just beneath the land surface.

With regard to long-lived intermediate-level waste research is being carried out into the possibility of disposal in a disused anhydrite mine at Billingham, while emplacement in the seabed is being investigated as an option for the disposal of high-level waste. However, it is thought that it will be 50 years before the United Kingdom needs to make use of this method.

The Nuclear Industry Radioactive Waste Executive (NIREX), which was established in 1982, brings together the electricity authorities, the nuclear industry and other producers of radioactive waste. Its main functions are the exercises of joint responsibilities in the area of waste management and the development of a national strategy in this field.

In the past Switzerland has disposed of low- and intermediate-level waste by dumping in the Atlantic Ocean, but consideration is now being given to temporary land-based storage pending geological disposal. NAGRA (National Genossenschaft für die Lagerung radioaktiver Abfälle) is a cooperative organization under private law, set up in 1972 to bring together representatives of the nuclear power industry and of hospitals and laboratories. Its functions are to establish and maintain facilities for dealing with radioactive waste and to promote national cooperation in this field; it has also been given the job of determining, by 1985, whether the geological disposal of high-level waste in Switzerland is a viable proposition.

In the United-States low- and intermediate-level waste is buried at shallow depths at various publicly owned sites. With regard to high-level waste the President is required under the terms of the Nuclear Waste Policy Act 1982 to make a recommendation by 31 March 1987 regarding a suitable location for geological disposal; a second location must be annnounced by 31 March 1990, and the first facility must be operational by 31 January 1998.

The construction of the Waste Isolation Pilot Plant in a salt formation in New Mexico has now reached an advanced stage; it will be used for the disposal of waste which contains plutonium.