MANAGEMENT OF RADIOACTIVE WASTE IN THE FEDERAL REPUBLIC OF GERMANY - ASPECTS OF FUTURE STRATEGY

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ABSTRACT

In September 1978, the Heads of Government of the Federation and the Länder of the Federal Republic of Germany agreed on a radioactive waste management concept, based on the interim storage of spent fuel elements, the conditioning and interim storage of radioactive waste, the reprocessing of spent fuel elements and the ultimate disposal of radioactive waste. This waste management concept, incorporating reprocessing - the so-called integrated waste management concept - puts the provision of the Atomic Energy Act, which gives priority to the safe reprocessing of residual radioactive matter over its controlled disposal as waste, into concrete terms. This concept has proved itself to be effective and continues to be used as a basic tool by the competent public and private institutions.

INTRODUCTION

The so-called integrated waste management concept of the Federal Government in the FRG puts the legal provisions of the atomic energy law into concrete terms. Today these terms are more important than ever due to the expected arising of nuclear wastes and spent fuel.

ARISING OF SPENT FUEL AND RADIOACTIVE WASTE-SPENT FUEL

The arising of spent fuel is directly connected with the amount of nuclear energy to the total energy supply. A breakdown of the energy supply in the FRG is given in Table I. In 1988, nuclear energy supplied more than 37,2 % of the total electricity demand.

TABLE I
Breakdown of the Energy Supply in the Federal Republic of Germany (%)

	Year		
Source	1973	1985	1988
Oil	55	42	42
Coal	22	20	19
Natural gas	10	15	16
Nuclear energy	1	11	12
Brown coal/Lignite	9	9	8
Others	3	3	3

Currently, 21 nuclear power plants are in operation, with a total capacity of about 23.920 ME(e); one is under construction (SNR- 300 Kalkar, 327 MW(e)) and 7 plants with a total capacity of 740 MW(e) have been decommissioned or are being decommissioned.

As to the amount of spent fuel we can not preclude construction of another one or two nuclear power plants until the year 2005.

Thus, two scenarios have to be considered, one relating to about 24.000 MW(e) and one relating to 27.500 MW(e). Table II shows the relevant arisings of spent fuel.

The figures indicate that by 2005 the expected arising of spent fuel amounts to roughly 13.000 t U.

TABLE II
Two Scenarios Of The Quantities Of Spent Fuel FROM LWRs Until the Year 2005

	Scenario A		Scenario B	
Until the end of year	Estimated installed nuclear power (MW(e))	Quantities of spent fuel (MW(e))	Estimated installed nuclear power (MW(e))	Quantities of spent fuel (MW(e))
1990	23 600	4 100	23 600	4 100
1995	23 600	6 700	23 600	6 700
2000	23 600	9 400	27 500	9 600
2005	23 600	12 050	27 500	12 800

RADIOACTIVE WASTES

Besides nuclear power plants several different nuclear facilities and laboratories, medical uses, small scale industry produce nuclear wastes. Since 1985, on behalf of the Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, the Physikalisch-Technische Bundesanstalt or now the Bundesamt für Strahlenschutz has been carrying out a survey on the amount of radioactive

waste produced in the FRG and the expected quantities of radioactive waste that will arise in the future.

On December 31, 1988, the unconditioned radioactive waste with negligible heat generation amounted to about 11.600 m^3, the volume of the conditioned radioactive waste with negligible heat generation to about 40.200 m^3. Up to the year 2000 the cumulated waste package volume is estimated to be about 173.400 m^3.

Table III shows a breakdown of the given quantities. The so called state collection facilities store the radioactive waste produced by medical uses, laboratories and small scale industry.

A comparison of estimated figures in the last years reveals a decrease of the waste package volume to be expected by 2000. This effect owes to the extended application of waste volume diminishing techniques like compaction and incineration.

MANAGEMENT OF SPENT FUEL AND RADIOACTIVE WASTE-LEGAL PRINCIPLES

The principles and basic requirements mandatory for the use of ionizing radiation, for operators of nuclear facilities as well as for the authorities, are laid down in the Atomic Energy Act and the Radiation Protection Ordinance (referred to hereafter as the Act and the Ordinance, respectively). A guideline adopted by the competent authorities in the FRG regulates the control and supervision of radioactive waste with negligible heat generation as far as they are produced by nuclear power plants, industry and research centers.

The rationale behind the legislation passed by the constitutional bodies of the FRG is:

1. To reuse residues arising from the peaceful use of nuclear energy
2. To diminish the production of radioactive waste by avoiding wastes where possible
3. To safeguard appropriate disposal, or as long as final disposal is not feasible, to provide interim storage facilities
4. To pursue the "polluter pays principle"
5. To assign responsibility for the construction and operation of final repositories for radioactive waste to the Federal Government
6. To protect both the personnel and the public, to prevent any unnecessary radiation exposure and to keep any inevitable radiation as low as possible

Whoever applies radioisotopes and nuclear materials has to examine whether residues (e.g. dismantled components, spent fuel, radioactive substances) can be reused without harmful effects, in line with the safety objectives of the Act and the Ordinance. They have to appropriately dispose of residues as radioactive waste if reuse is not feasible because of the state of the art or if it is not reasonable from an economic point of view. The operators of nuclear power plants and other commercial nuclear facili-

TABLE III
QUANTITIES OF RADIOACTIVE WASTE IN THE FEDERAL REPUBLIC OF GERMANY (CONDITIONED WASTE, NEGLIGIBLE HEAT GENERATION) (1988)

	Waste producer						Total	
	Nuclear Power Plants (%)	Reprocessing (%)	Research Centers (%)	Nuclear Industry (%)	State Collection Facilities (%)	Others (%)	(%)	(m^3)
Amount by 31 Dec. 1988	32.0	19.9	40.3	3.7	3.9	0.2	100	40.200
Annual arisings in 1988	26.8	22.5	40.1	8.4	2.8	0.2	100	3.400
Estimated amount by the year 2000	29.7	28.8	26.2	4.7	2.1	0.5	100	173.400

ties have to establish their own interim storage capacities. Regarding the final disposal of radioactive waste, the Act places the responsibility for establishing and operating facilities for the disposal of radioactive waste on the Federal Government. In line with the Ordinance concerning the financial contribution of waste producers, prepayments are levied for the construction of disposal repositories by the Federal Government. Unlike several countries in which waste producers pay into a fund for financing R&D work and the planning and construction of a repository-to be, in the Federal Republic of Germany prepayments are levied on the waste producers according to the actual expenditure in each fiscal year. The apportionment of expenditures, i.e. the fee levied, amounts to:

a. 75.5% to German reprocessing plants with a throughput of more than 50 t/a

b. 17.5% to nuclear power plants of more than 200 MW(e)

c. 4% to reprocessing plants with a capacity of up to 50 t/a

d. 3% to others (fuel element manufacturers, research facilities, etc.).

Prepayments will be reimbursed to the extent they will appear to be inequitable once the repositories are in operation and a different apportionment of the costs would appear to be more appropriate.

In the past, the legal provisions have proved to be effective. Hence, in the course of amendment of the Ordinance, the Federal Government is basically proposing to retain the regulations, although it wants to improve on wording and logical sequence of the terms. The amendment has to take account of the change from basically domestic reprocessing to reprocessing in France and Great Britain and, thus, a new apportionment of costs.

BASIC POLITICAL DECISIONS

Since 1973, the concept of reprocessing being one constituent of the back end of the fuel cycle has repeatedly been confirmed by politicians. Hence, in principle, this concept still applies. In 1979, the heads of the Federal and State Governments confirmed that a reliable back end is an indispensable prerequisite for the utilization of nuclear energy. They emphasized the need to enlarge interim storage capacities, to expeditiously construct a reprocessing plant, and to characterize the site of the repository at Gorleben.

Simultaneously, investigation of alternative disposal techniques, such as direct disposal of spent fuel without reprocessing, was requested to enable a decision to be made as to whether decisive safety related advantages would result form direct disposal. In 1985, on the basis of an evaluation of the scientific findings, the Federal Govern ment found that there were no decisive reasons for dispensing with reprocessing.

In particluar, the Federal Government decided:

1. That it would stand by its judgement on the need for fast implementation of a reprocessing plant since there was no rational motive to change the concept or the principle of spent fuel reprocessing; this decision has been extended in June 1989. In June 89 the Federal Government decided that reprocessing abroad may substitute the domestic reprocessing plant.
2. That the question posed by the heads of the State and Federal Government in 1979 as to whether decisive safety related advantages could result from direct disposal of spent fuel elements rather than reprocessing had to be answered with "no".
3. That, in the light of today's state of the art, it would not permit employment of direct disposal techniques to demonstrate the required evidence of back end provisions for LWRs; that, in principle, direct disposal was technically feasible but that it needs further R&D work; that it would continue to develop direct disposal techniques in addition to implementation of the back end with reprocessing, taking into conside- ration international developments.
4. That it would continue to apply direct disposal techniques for spent fuel where reprocessing is not reasonable from an economic point of view.

In line with the legal requirements, political decisions and current status, the concept comprises treatment of spent fuel and disposal of radioactive waste. The time schedule for implementation of the Entsorgungskonzept is:

1. As soon as possible, enlargement of storage capacities for spent fuel in nuclear power plants, construction of AFR facilities, enlargement of interim storage capacities for radioactive waste, characterization of the salt dome at Gorleben and a positive report on its suitability as a repository.
2. At the beginning of the 1990s, startup of the Konrad repository for radioactive waste with negligible heat generation.
3. By the mid-1990s, startup of the pilot plant for conditioning and consolidating of radioactive waste and spent fuel at Gorleben.
4. By the end of the first decade of the next century startup of the repository at Gorleben for the disposal of all categories of radioactive waste.
5. Reprocessing of spent fuel.
6. Development of direct disposal techniques.

Until 1989 the reprocessing of spent fuel relied upon a domestic reprocessing plant. In 1989 negotiations between

the German Electricity Industry and the reprocessors in France and Great Britain led to the decision not to pursue a domestic large-scale reprocessing plant. The legal commitment as to reprocessing will be met by reprocessing abroad.

The German company VEBA, and the French company COGEMA habe agreed to sign a contract on closer cooperation from 1999, particularly in the field of reprocessing. Corresponding negotations between the British firm BNFL and German electricity supply companies are also underway.

The discussions between the German and French governments have paved the way for placing VEBA and COGEMA's joint declaration of intent in the much wider context of the peaceful use of nuclear energy: the fuel cycle (production, reprocessing, waste disposal), nuclear power stations, all aspects of energy policy, and possibilities for coordinating the political objectives of both countries as well as energy technologies. A high-ranking Working Party has been commissioned to study the joint declaration of intent of VEBA and COGEMA in this wider context and to elaborate first proposals for cooperation in the above-mentioned fields.

This has led to Joint Declarations on cooperation between France and the Federal Republic of Germany, and between Great Britain and the Federal Republic of Germany with regard to the peaceful use of nuclear energy. These Joint Declarations open the way to concrete cooperative projects particularly in the following are as:

- the reprocessing of spent fuel elements, inculuding further development of safety standards and reprocessing in general
- the manufacture of fuel elements
- uranium enrichment
- the exchange of all relevant monitoring data from nuclear installations.

Furthermore, a Franco-German group of experts has been established for the exchange of information and for discussion of safety objectives and technical features of comparable radioactive waste management plants in both countries.

The Joint Declarations create an international framework for realizing cooperative projects, and these should, as far as ne cessary, be further secured by means of individual agreements under international law.

Negotiations on cooperation in all aspects of energy policy and in the field of the energy technologies are now underway as part of the second stage in the cooperative programme of Great Britain and France. This is particularly important in view of the completion of the Single European Market in 1993.

The Act assigns the responsibility for construction and operation of the repositories to the Federal Government and the other constituents of the Entsorgungskonzept to the industry which operates the nuclear facilities and produces the radioactive waste. Hence, apart from the repositories, implementation of the concept is the responsibility of the waste producers. As a licence will only be granted if a reliable back end can be demonstrated, the nuclear industry is anxious to implement the Entsorungskonzept. Currently, operators of nuclear power plants are obliged to de monstrate 6 years in advance what they intend to do with their spent fuel. Thus, the quantities of spent fuel and radioactive waste have to be in balance with the requested capacities for residues and waste. In this context contracts between industry and reprocessors abroad will be accepted by the authorities as evidence as to appropriate treatment of spent fuel according to the Act.

BALANCE OF ARISING AND REMOVAL SPENT FUEL

The strategy for pursuing the concept of spent fuel management and management of radioactive waste can be summed up as follows:

1. interim storage of spent fuel;
2. reprocessing of fuel;
3. interim storage of radioactive waste as long as necessary; and
4. final disposal in a repository.

The word "necessary" reflects both the need for interim storage until a final repository is available and the appropriateness of interim storage prior to disposal of heat generating waste, especially high level waste.

Table IV describes the overall balance between the quantities produced and the removal of spent fuel at a

presumable power rate of 23.600 MW(e) until the year 2000. The balance relies on:

1. The on-site storage capacity in nuclear power plants
2. The AFR storage capacity in the interim storage facilities at Gorleben and Ahaus, with a capacity of 1.500 t U each.
3. Reprocessing contracts with the Compagnie generale des matieres nucleaires (Cogema) and British Nuclear Fuels (BNFL).

The sum of the last three columns shows that capacities have been provided to store or reprocess spent fuel. Table IV answers the question, what happens with the spent fuel.

RADIOACTIVE WASTE

Table V describes the current situation of storage of radioactive waste.

Until the operation of an ultimate repository radioactive waste is being stored in interim storage facilities. Currently, about 122.600 m^3 storage capacity is available. It is planned to increase this capacity by about 5.700 m^3. The average occupation of the storage facilities is about 36 o/o. Taking into account the amount of radioactive waste in the next future, a sufficient capacity for radioactive waste has been calculated from 1989 onwards for 8 years. Nevertheless, individual nuclear facilities can run short of storage capacity, since only a limited balancing of storage capacity between different facilities could be performed.

DISPOSAL OF RADIOACTIVE WASTE

If we want to avoid the construction of new storage facilities, the implementation of an ultimate repository is undispensable, i.e. a repository has to be in operation by the mid-nineties.

In the Federal Republic of Germany the former iron ore mine Konrad in Salzgitter / Lower Saxony is planned for the final disposal of radioactive waste with negligible heat generation. This kind of waste comprises about 95% of all radioactive waste produced in the Federal Republic of Germany. On the basis of a suitability study the Physikalisch-Technische Bundesanstalt (PTB) submitted an application for the issue of a plan-approval. This licensing procedure is going on. The capacity of this repository-to-be amounts to roughly 500.000 m^3 of radioactive waste. The main effort is to start the operation of this repository by the mid-nineties.

A second final disposal facility - the Gorleben salt mine - is in the phase of reconnaisance. Currently, two shafts are being sunk to start the exploration below ground. According to the time schedule the start up of this repository for all kinds of radioactive waste - including high radioactive waste - should commence by 2008.

TABLE IV
BALANCE BETWEEN PRODUCED SPENT FUEL AND ITS TREATMENT

1 Until the End of Year	2 Estimated Installed Nuclear Power (MW(e))	3 Quantities of spent fuel (t U)	4 Storage capacity inside nuclear power plants	5 Away from Reactor (AFR) storage capacity	6 Eurochemic Cogema BNFL SKB
1988	22.248	3229	4065	1500	2356
1990	23.600	4070	4380	3000	3050
1995	23.600	6700	4380	3000	4180
2000	23.600	9370	4380	3000	4460

TABLE V
INTERIM STORAGE CAPACITY FOR RADIOACTIVE WASTE FROM THE NUCLEAR FUEL CYCLE AND IN STATE COLLECTION FACILITIES (negligible heat generation)

Interim storage	Storage Capacity (m^3)	Degree of Occupation in 1986 (%)	Planned Enlargement (m^3)	Still available (m^3) (including planned enlargement)
Nuclear power plants	26837	41,9	-	15592
Research centers	54304	51,4	-	26392
Reprocessing WAK	120	6,8	-	88
Other nuclear industries (enrichment, fuel element manufacture)	1402	85	135	345
Others	500	61,3	-	
Interim storage facilities for nuclear power plant radioactive waste	ca.			
Gorleben				
Mitterteich	10577	8,8	-	9646
	21600	1,2	-	21341
State collection facilities	7241	39,4	730	5118