

THE CONTROL OF SAFETY OF RADIOACTIVE WASTE MANAGEMENT AND DECOMMISSIONING IN GERMANY

1. NATIONAL FRAMEWORK FOR MANAGEMENT AND REGULATION OF RADIOACTIVE WASTE AND DECOMMISSIONING

1.1 National framework

1.1.1 Overview of National policy

The safety policy of the German Federal Government with respect to nuclear technology and radioactive waste management (RWM) was always given utmost priority to the protection of man and the environment.

In the Federal Republic of Germany, the latest federal elections took place on 18 September 2005. As a result, a Grand Coalition of the Christian Democratic-/ Christian Social Party (CDU/CSU) and the Social Democratic Party (SPD) came into power. The political aims of the Federal Government are given in the coalition agreement dated 11 November 2005. Pursuant to this document, the safe operation of nuclear power plants has the highest priority for the Grand Coalition. In connection with this priority, research activities into the safe operation of nuclear power plants will continue and be expanded. Furthermore, the coalition partners acknowledge their national responsibility for the safe disposal of radioactive waste. According to the coalition agreement they will work to come to a decision on how to progress in radioactive waste disposal within this legislative period which ends in 2009.

The basic document on the use of nuclear energy for electricity production in Germany was initialled on 14 June 2000, and signed on 11 June 2001. According to this document, the former Federal government and the utilities agreed to limit the future utilisation of the existing nuclear power plants. The most important agreements refer to operational restrictions. For each installation the

amount of energy it may produce is calculated from 1 January 2000 until its decommissioning. In total, about 2,620 TWh (net) can be produced. According to this, the time of operation of a nuclear power plant amounts to 32 calendar years on average, starting at the beginning of commercial operation.

The new policy was enforced by the latest amendment of the Atomic Energy Act which became effective on 27 April 2002. With respect to the coalition agreement dated 11 November 2005 the present Federal Government continues the policy to phase out nuclear energy use for electricity generation.

The management of spent nuclear fuel is restricted to direct disposal. Only that spent fuel which was shipped to foreign reprocessing facilities in France and Great Britain until 30 June 2005 can be reprocessed. Subsequent to 01 July 2005 shipments of spent nuclear fuel elements to reprocessing facilities are legally prohibited. As a consequence, the utilities construct and operate new engineered storage facilities at the sites of the nuclear power plants or near them (decentralised storage).

Nuclear facilities have to be decommissioned and dismantled at the end of their useful lifetime, i. e. decommissioning is required for all nuclear facilities and installations in Germany. According to the above-mentioned basic document a power reactor will be shut down when the respective amount of energy has been generated. Therefore, it is foreseeable that the 17 nuclear power plants being in operation will become decommissioning projects according to current estimates within the next 15 years and that the last nuclear power plant will be shut down by the year 2021. As there might be a transfer of net capacities from one nuclear power plant to another the shut-down schedule may vary.

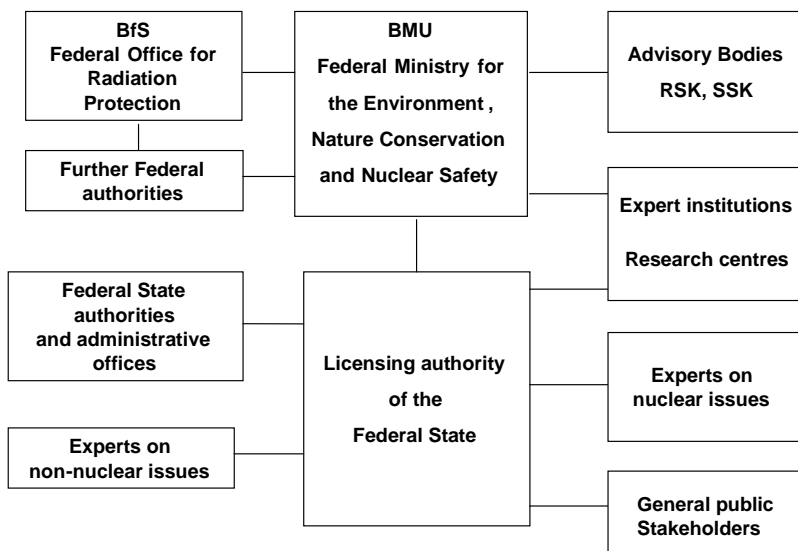
Since the early sixties, i. e. from its very beginning, radioactive waste disposal in Germany is based on the Federal Government decision that all types of radioactive waste (short-lived and long-lived) are to be disposed of in deep geological formations within the country. Only solid or solidified waste is accepted for disposal; liquid and gaseous wastes are excluded from the emplacement in a geological repository.

The intention to dispose of all types of radioactive waste in deep geological formations also makes it unnecessary to differentiate between waste containing radionuclides with comparatively short half-lives and waste containing radionuclides with comparatively long half-lives. As such, there are no measures or precautions required in Germany in order to separate radioactive waste in this way.

1.1.2 Overview of Relevant Institutions

An overview of the authorities involved in licensing and supervision of nuclear facilities as well as advisory commissions and consulting expert organisations is given in Figure 1 .

Figure 1. **Authorities, advisory committees and experts concerned with nuclear safety and radiation protection**



1.1.2.1 Federal Authorities

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU)

The Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU; Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) is responsible for nuclear safety and radiation protection. In this field it has the competence to issue directives and to supervise the legality and expediency of the acts of authorities responsible for enforcing the Atomic Energy Act and the Radiation Protection Ordinance. Under the Act on the Precautionary Protection of the Population against Radiation Exposure the BMU has the power to fix dose levels, which may be implemented by ordinances jointly issued with other interested federal ministries. The

BMU has also exclusive power to issue recommendations to the public as to the conduct they should adopt following a nuclear incident, but must do so in close contact with other competent authorities of the Bund (Federal Republic of Germany) or Länder (Federal States).

1.1.2.2 Other federal authorities

Apart from the BMU, the following federal ministries take part in RWM according to their specific responsibilities:

- Bundesministerium für Bildung und Forschung (BMBF; Federal Ministry of Education and Research).
- Bundesministerium für Wirtschaft (BMWi; Federal Ministry of Economics).
- Bundesministerium der Finanzen (BMF; Federal Ministry of Finance).
- Bundesministerium für Verkehr, Bau und Wohnungswesen (BMVBS; Federal Ministry of Transport, Building and Housing).

1.1.2.3 Federal offices

Bundesamt für Strahlenschutz (BfS)

The Bundesamt für Strahlenschutz (BfS; Federal Office for Radiation Protection) is a federal office in the portfolio of the BMU. BfS implements in particular federal administrative tasks in the field of radiation protection including radiation protection precaution as well as nuclear safety, the storage of spent nuclear fuel, government custody, the transport of radioactive material and the management of radioactive waste regarding in particular the construction and operation of federal installations for disposal. It supports BMU on technical and scientific matters in these fields.

BfS also performs scientific research in the fields of radiation protection, nuclear safety, transport of radioactive material and radioactive waste management and disposal.

For the construction and operation of repositories BfS may make use of “third parties” (i.e., contractors) according to section 9a para. (3) Atomic Energy Act. In 1979, the Deutsche Gesellschaft zum Bau und Betrieb von Endlagern (DBE), a company for the construction and operation of waste repositories, was founded as such a third party. DBE is the main contractor of BfS with regard to construction and operation of repositories.

Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAWA)

This body being an authority within the portfolio of the Federal Ministry of Economics is responsible for the issue of import and export licences of nuclear material. In carrying out this function, it is bound by the technical instructions issued by the BMU.

1.1.2.4 Länder (Federal States)

On behalf of the Federal Government the Länder (Federal States) execute administrative duties (licensing and supervision) under nuclear and radiation protection law as delegated by the federal authorities. Thus, the Federal States are the competent licensing authorities for all nuclear installations within their territory, except centralised and decentralised interim storage facilities for spent nuclear fuel. They supervise all nuclear facilities, repositories excluded. To ensure the uniform implementation of the Atomic Energy Act, the Federal States are subject to federal supervision by the BMU. The BMU has the right to issue directives to the competent nuclear authority of the respective Federal State, particularly in order to get consistent and suitable regulatory decisions. Federal supervision covers both legality and expediency of the Federal States' way of proceeding.

The Länder have to operate Landessammelstellen (regional collecting depots), i.e., interim storage facilities for radioactive waste originating in particular from isotope application in industry, universities and medicine.

1.1.2.5 Advisory Bodies

Federal supervision is supported by advisory bodies set up by the BMU. The offices of the advisory bodies are run by BfS.

The Reaktor-Sicherheitskommission (RSK; Reactor Safety Commission) is responsible for advising BMU on all major issues concerning the safety of nuclear reactors and the nuclear fuel cycle.

The Strahlenschutzkommission (SSK; Radiation Protection Commission) is responsible for advising BMU on all major issues concerning radiation protection and radiation protection precaution.

The Kerntechnische Ausschuss (KTA; Nuclear Safety Standards Commission) was set up by BMU. The commission consists of members of the licensing and supervisory authorities, expert organisations for safety assess-

ment and the industry and utilities involved in design and operation of nuclear facilities. The Nuclear Safety Standards Commission is responsible for the establishment of safety standards and promotes their application in all those fields of nuclear technology where a common opinion of experts can be achieved.

1.1.2.6 Expert institutions and research centres

The regulatory authorities are assisted by technical safety organisations such as the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS; Company for Industry and Reactor Safety), the Öko-Institut, research centres (e.g., FZJ Jülich Research Centre, GSF Research Centre Munich, GKSS Research Centre Geesthacht, FZK Karlsruhe Research Centre) and a variety of other institutions and experts.

1.2 National, technical regulatory organisation(s)

1.2.1 Regulatory function

The BMU is responsible for the preparation and further development of the legal framework as to the peaceful use of atomic energy. The proposals are eventually discussed and ratified by the Parliament.

1.2.1.1 Radioactive waste disposal

Pursuant to section 23 of the Atomic Energy Act, the Bundesamt für Strahlenschutz (BfS; Federal Office for Radiation Protection) is the competent authority for the licensing of the transport of nuclear fuel and large radiation sources as well as for the licensing of the storage of nuclear fuel outside government custody and the withdrawal or revocation of such licences. All other licensing activities regarding radioactive waste management are executed by the Federal States on behalf and under supervision of the Federal Government. These licenses include shipments, conditioning, interim storage and disposal of radioactive waste. In compliance with national legal regulations, the competent licensing authority for the transport of radioactive waste by rail is the Eisenbahnbundesamt (EBA; Federal Office for Railways) whereas the transport of radioactive waste by road is authorised by the competent authorities of the Federal States.

The disposal of radioactive waste in a repository is in particular governed by the following specific acts and regulations: Atomgesetz (Atomic Energy Act), Strahlenschutzverordnung (Radiation Protection Ordinance), and Bundes-

berggesetz (Federal Mining Act). The protection objectives of radioactive waste disposal in a repository are prescribed by the Atomic Energy Act and the Radiation Protection Ordinance. The Federal Mining Act regulates all aspects concerning the operation of a disposal mine.

According to section 9a of the Atomic Energy Act, the Federal Government has to establish installations for the disposal of radioactive waste, i.e., disposal of radioactive waste is assigned to the Federal Government as a sovereign task. On 1 November 1989, this competency was assigned to the BfS. Accordingly, the BfS is responsible for the construction and operation of those federal installations, acting on behalf of the Federal Government.

For the establishment of a repository, pursuant to section 9b of the Atomic Energy Act, a plan-approval procedure, i.e., a special kind of a licensing procedure, has to be initiated and conducted. BfS is the authorised applicant; the competent licensing authority of the respective Federal State is responsible for issuing the license. It is the objective of the plan-approval procedure to examine a project which is important for the region concerned, weighing and balancing the interests of the body responsible for the project and public and private interests affected by the planning in one procedure and to reach a decision which is legally binding in relation to third parties. The plan-approval procedure includes, among other things, the participation of all authorities concerned.

An important factor in the licensing procedure is public participation: the project is made available to the members of the public, who can express their objections to it, and these are then discussed at a non-public hearing, which involves the applicant, the licensing authority and the objectors.

The procedure is terminated by the plan-approval decision, i.e., the license. This decision embraces the so-called concentration effect, whereby it replaces all other approvals except that required by the Federal Mining Act. Thus, the legal competencies for the licensing of the construction and operation of a repository are regulated in such a way that only two procedures must be performed: the procedure under atomic law on the one hand and the procedure under mining law on the other.

Supervision on compliance to the issued licences regarding RWM activities is generally executed by the Federal State where the activity takes place. Again, the Federal States thereby act on behalf and under the supervision of BMU. There are two exceptions to this general State's responsibility for nu-

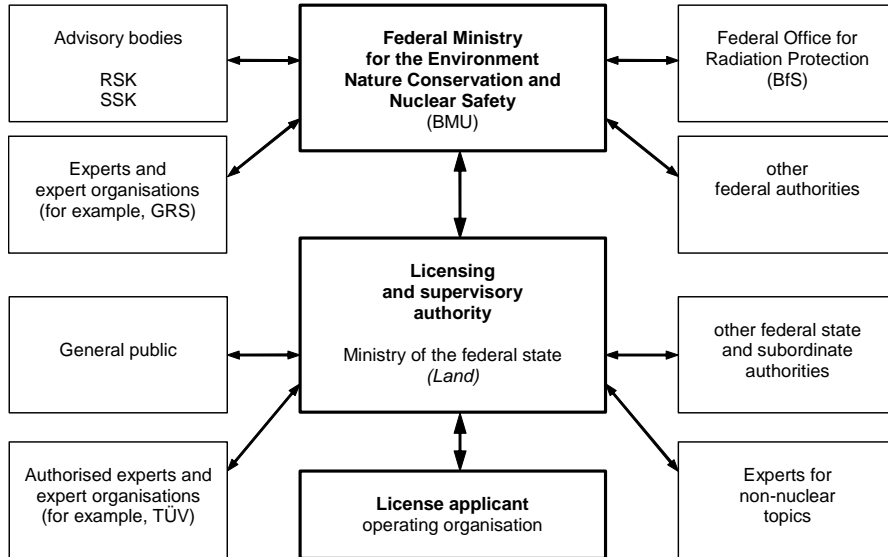
clear supervision: transport of radioactive material on public railroads and facilities for the disposal of radioactive waste. Supervision over the former is executed by EBA and on the latter by an independent organisational unit within BfS, being directly supervised by BMU.

1.2.1.2 Decommissioning

The Atomic Energy Act is the key regulation for all nuclear regulatory activities with respect to decommissioning of nuclear facilities. It includes the provision that decommissioning of nuclear facilities needs to be licensed by the respective regulatory body. The regulatory body has to ensure that the requirements and conditions stated in the decommissioning licence are met by the operator. It has also to decide on the termination of a licence and the respective release of an operator from its obligations. In order to fulfil its duties, the regulatory body involves experts or expert organisations which are independent of the operator.

Licensing and inspection of nuclear facilities and related activities, including decommissioning of nuclear facilities, are within the responsibility of the Federal States. The BMU supervises the activities of the Federal States and harmonises the application of the legal framework. If necessary, the BMU may give directives to the regulatory body of the respective Federal State. The licensing procedure includes the participation of the public. Figure 2 provides an overview over the relations among the parties involved in the licensing of the decommissioning of nuclear facilities.

Figure 2. Participants in the Nuclear Licensing and Supervisory Procedure for the Decommissioning of Nuclear Facilities



The Atomic Energy Act is supplemented by several ordinances, in particular the Radiation Protection Ordinance and the Nuclear Licensing Procedure Ordinance. The Radiation Protection Ordinance lays down, for example, the radiation protection principles and the permissible occupational and public radiation exposures. The Nuclear Licensing Procedure Ordinance provides guidance, for example, on the licensing procedure, the involvement of the public and how to carry out an environmental impact assessment.

In accordance with legal requirements, the operators of private nuclear facilities have to cover the costs for the decommissioning of their nuclear facilities and the disposal of the resulting radioactive waste. They have to accumulate the respective funds during operation. Based on generic studies the German utilities estimate costs for the decommissioning of a 1,200 MW pressurised water reactor (PWR) to be in the order of about 300 million EUR. The respective costs for a 800 MW boiling water reactor (BWR) are about 350 million EUR. The higher costs of the BWR are pertinent to the BWR design which is associated with a larger controlled area.

Nuclear research facilities (including research reactors, critical assemblies and reprocessing plants) and nuclear facilities of the former GDR are basi-

cally in public hands (Federal and State Government) and the costs for their decommissioning and the disposal of the associated waste are borne by the respective public funds within the annual budget.

1.2.2 Organisation and resources

The BMU has a total staff about 800 people. About 1 % of this staff is concerned with regulatory tasks of radioactive waste management. About 18% of BfS staff (in total about 700 people) is concerned with regulatory tasks relevant to radioactive waste management. The staff of the Federal State authorities concerned with regulating RWM differs from Land to Land. Generally, it can be stated that the respective staff only comprises a few people. RSK and SSK commissions comprise 14 members each. Pursuant to actual activities and demands, BMU and the Federal States receive in particular technical support from the expert organisations such as GRS or Technische Überwachungsvereine (TÜV; Technical Inspection Agencies). Total staff of GRS is about 400 people. About 15% of the staff is concerned with RWM.

2. REGULATORY ARRANGEMENTS

In Germany the regulatory framework for RWM is based on a hierarchy of acts, ordinances, safety rules and guidelines. It provides the basis for the decommissioning and dismantling of nuclear facilities as well as the management and future disposal of radioactive waste in such a way that human health and the environment are protected now and in the future without imposing undue burdens on future generations.

Nuclear energy law in Germany is influenced by, and in part directly subject to, international treaties, as well as by EURATOM, OECD/NEA and the IAEA and ICRP recommendations. Thus, the German legal framework is in compliance with internationally accepted safety principles as, in particular, specified in the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. In addition, as far as transport regulations are concerned, the national regulations correspond to the recommendations of the International Atomic Energy Agency (Regulations for the Safe Transport of Radioactive Materials, IAEA Safety Standards Series No. TS-R-1 (ST-1, Revised)) as well as to RID, ADR, IMDG-CODE, ICAO-TI and ADNR. For construction and operation of RWM facilities European and German industrial standards, e.g., DIN/ISO requirements have to be applied.

2.1. Primary Legislation and General Regulation

German legislation most relevant to RWM includes the acts enlisted in Table 1. Due to the concentration effect of the plan-approval procedure (i.e., the licensing procedure – cf. section 1.2.1) for radioactive waste disposal many other acts and ordinances must be considered, too, e.g., the Naturschutzgesetz (NatSchG; Act on Nature Conservation and Landscape Cultivation) or the Wasserhaushaltsgesetz (WHG; Act on Water Resources Management Act). These non-nuclear acts will not be treated in the following.

Table 1. Acts relevant to RWM

German abbreviation	Act	Item
AtG	Act on the Peaceful Utilisation of Atomic Energy and the Protection against its Hazards – Atomic Energy Act	<ul style="list-style-type: none"> • Waste disposal and handling of radioactive material • Waste repository construction and operation • Storage of nuclear fuel • Carriage of nuclear fuel
UVPG	Act on the Assessment of Environmental Impact – Environmental Impact Assessment Act	<ul style="list-style-type: none"> • Environmental impact assessment for RWM facilities
BBergG	Federal Mining Act	<ul style="list-style-type: none"> • Construction and operation of waste repositories in deep geological formations
StrVG	Act on the Precautionary Protection of the Population against Radiation Exposure – Precautionary Radiation Protection Act	<ul style="list-style-type: none"> • Supervision of radiation
GGBefG	Act on the Transport of Dangerous Goods –Dangerous Goods Transport Act	<ul style="list-style-type: none"> • Transport
	Act on Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management – Act on the Joint Convention about Waste Management?	<ul style="list-style-type: none"> • Safety of Spent Fuel and Radioactive Waste Management

Most relevant ordinances with respect to RWM are given in Table 2.

Table 2. Ordinances relevant to RWM

German abbreviation	Ordinance	Item
AtVfV	Ordinance on the Procedure for Licensing Facilities under Section 7 of the Atomic Energy Act – Nuclear Licensing Procedure Ordinance	<ul style="list-style-type: none"> • Licensing procedure for nuclear facilities
StrlSchV	Ordinance on the Protection against Damage and Injuries caused by Ionising Radiation – Radiological Protection Ordinance	<ul style="list-style-type: none"> • Radiation protection
AtDeckV	Ordinance Concerning the Financial Security Pursuant to the Atomic Energy Act – Nuclear Financial Security Ordinance	<ul style="list-style-type: none"> • Financial security
AtKostV	Cost Ordinance under the Atomic Energy Act – Atomic Energy Act Cost Ordinance	<ul style="list-style-type: none"> • Costs of licensing
Endlager VIV	Ordinance on Advance Payments for the Establishment of Federal Facilities for Safe Custody and Disposal of Radioactive Waste – Disposal Advance Payments Ordinance	<ul style="list-style-type: none"> • Costs of radioactive waste disposal
	Ordinance on the Protection of Groundwater against Pollution Caused by certain Dangerous Substances – Groundwater Ordinance	<ul style="list-style-type: none"> • Groundwater protection
UVP-V Bergbau	Ordinance on Assessment of Environmental Impact for Mining Projects	<ul style="list-style-type: none"> • Environmental impact assessment for federal waste repositories
GGVSE	Ordinance on the Internal and the Cross-border Transport of Dangerous Goods by Road and Rail (Dangerous Goods Ordinance Road and Rail)	<ul style="list-style-type: none"> • Transport
GGVSEE	Ordinance on the Transport of Dangerous Goods by Sea (Dangerous Goods Ordinance Sea)	<ul style="list-style-type: none"> • Transport

The acts and ordinances listed, except for those exclusively devoted to mining and radioactive waste disposal, also contain the most relevant aspects for the legislation related to the decommissioning of nuclear facilities. Similar to the above mentioned plan-approval procedure non-nuclear acts shall be taken into account during the licensing of a decommissioning project. Some of the related requirements, e.g. from building lease or laws pertaining to water and waterways, are subject to non-nuclear licenses which have to be applied for by the operator in parallel to the nuclear license.

2.2 Regulations concerning specific activities or facilities

2.2.1. Radioactive waste management

Site specific regulations do not exist in Germany.

2.2.2. Decommissioning

Facility specific regulations do not exist in Germany.

2.3. Guidance on implementation

2.3.1. Radioactive waste management

In 1989, a guideline for the control of radioactive waste with negligible heat generation has been published (Richtlinie für die Kontrolle radioaktiver Abfälle mit vernachlässigbarer Wärmeentwicklung, die nicht an eine Landessammelstelle abgeliefert werden). Its purpose is to guarantee more clarity in radioactive waste management and to ensure better supervision of the various waste management steps by the responsible authorities. The guideline gives guidance to the control of waste and facilitates supervision. It is being revised in order to comply with the regulations given in the 2001 amendment of the Radiation Protection Ordinance. At present, a draft version as of September 2005 is discussed.

In April 2001 the RSK passed the recommendation “Safety-Related Guidelines for the Dry Interim Storage of Spent Fuel Elements in Storage Casks”, which has to be followed in the authorisation procedure for interim storage of irradiated nuclear fuel.

In December 2002 the RSK passed the recommendation “Safety-related Requirements on the Long-term Interim Storage for Low-level and Intermediate-level Radioactive Waste”. This guideline was amended in October 2003 with respect to seismic design aspects.

The basic aspects which must be taken into account to achieve the objective of disposal are compiled in the “Safety Criteria for the Disposal Radioactive Waste in a Mine” issued in 1983. They qualitatively specify the measures to be taken in order to achieve the protection objective of disposal and define the principles by which it must be demonstrated that this objective has been

reached. These criteria are at present revised on behalf of BMU in order to account for the progress in safety-related developments and procedures.

2.3.2. Decommissioning

A supplemental guideline (Guide to the Decommissioning of Facilities as defined in section 7 of the Atomic Energy Act) was prepared for the decommissioning of nuclear facilities. This decommissioning guide as of 14 June 1996 includes proposals for an appropriate procedure for the decommissioning of facilities as defined in section 7 of the Atomic Energy Act in respect of the application of the technical rules for the planning and preparation of decommissioning work as well as for licensing and supervision. It refers to the need for an early planning for decommissioning and requires detailed data to be provided with the application for decommissioning such as a description of the decommissioning project (concept), a safety report, information on expected discharges, an estimate of the associated generation of radioactive waste and measures to avoid the generation of waste. These proposals are primarily aiming at the decommissioning of nuclear power plants.

The decommissioning guide is currently under revision in order to reflect recent amendments of the legal framework, in particular of the Atomic Energy Act and the Radiation Protection Ordinance, and to integrate recent best practice in Germany.

3. STATUS, STRATEGIES AND CURRENT ISSUES AT THE NATIONAL LEVEL

3.1 Status

Radioactive materials subject to regulatory control may be released from the radiological protection system if their use presents only a minor radiological risk. This procedure is called “clearance” and the corresponding levels of radioactivity concentration are called clearance levels. Details are given in section 29 of the Radiation Protection Ordinance. The clearance may be restricted to certain conditions or specific uses or management routes (conditional clearance) or may be without restrictions (unconditional clearance). The different options for the management of residues and waste from a licensed practice are summarised in Table 3.

Table 3. Management of residues and waste from a licensed practice

Under regulatory control			Conditional Clearance			Unconditional Clearance
Disposal	Recycling	Reuse	Disposal	Recycling	Reuse	
Deep geological disposal of radioactive waste	Production of waste containers and shielding plates used in the nuclear field	Equipment, tools and components in nuclear facilities	As conventional waste (incineration or municipal landfill disposal)	As secondary raw material (e.g., use of scrap for general melting or special products; recycling of building rubble)	Equipment, tools and components	No conditions on treatment or use after clearance (incl. reuse, recycling, disposal)

3.1.1 Waste classification and quantities

In the Federal Republic of Germany it is intended to dispose of all types of radioactive waste in deep geological formations. This approach comprises spent fuel elements, vitrified fission product solution, operational and decommissioning/dismantling waste of nuclear facilities and installations as well as spent sealed radiation sources and miscellaneous waste originating from small waste generators. According to this approach, essential disposal-related waste package characteristics must be considered when developing a waste classification system. As the decay heat per waste package and, thus, the thermal influence upon the host rock are of great importance, in particular with regard to waste disposal in deep geological formations, it was decided to introduce a basic classification making a subdivision into heat-generating radioactive waste (i. e., high level waste) and radioactive waste with negligible heat generation (i. e., low level and intermediate level waste). Waste with negligible heat generation consists of operational waste from nuclear power plants (e.g., filters, ion exchange resins, clothes or cleaning rags), decommissioning waste as well as radioactive waste from research, medicine and industry. Heat-generating waste are especially the vitrified fission product solution originating from reprocessing of spent fuel elements and spent fuel elements from power reactors envisaged for direct disposal.

This basic subdivision into heat-generating waste and waste with negligible heat generation has not only proven expedient at national level, but is also applied internationally, i. e., by the Commission of the European Union. It is also compatible with the IAEA recommendation for qualitative classification which additionally permits a further subdivision into short-lived and long-lived waste.

Furthermore, the basic subdivision is followed by a detailed categorisation scheme subdividing the different waste streams according to origin, waste container, immobilisation material and waste type. This categorisation scheme allows the description of radioactive waste to be systematised in a way which fulfills the requirements for proper registration and description of all existing waste and waste arising in the foreseeable future.

As to waste production, BfS carries out an annual inquiry into the amounts of unconditioned and conditioned radioactive waste in Germany. According to the results of the 2004 inquiry, about 37,700 m³ of radioactive residues and preconditioned waste and about 82,600 m³ of conditioned waste with negligible heat generation had been accumulated in Germany by the end of 2004 (radioactive waste originating from operation as well as from decommissioning and dismantling). Main contributors are: nuclear power plants, research establishments and reprocessing facilities. The amount of unconditioned and conditioned heat generating waste accumulated to about 60 m³ and 1,700 m³, respectively (without spent nuclear fuel elements). Due to a forecast of waste amounts to be expected in the future, approximately 290,000 m³ of conditioned waste with negligible heat generation and approximately 24,000 m³ (i. e., about 17,400 tons Heavy Metal) of conditioned heat-generating waste will be accumulated by the year 2080.

3.1.2 Installations in a decommissioning phase

Germany already gained a substantial amount of experience in the decommissioning and dismantling of nuclear facilities of different type and size. The decommissioning projects comprise:

- 19 power and prototype reactors;
- 33 research reactors; and
- 9 fuel cycle facilities

which are being or have been decommissioned or for which a license for decommissioning has been applied for.

Among the 19 power and prototype reactors there are six prototype reactors and 13 power reactors. Amongst the prototype reactor projects there are two which were completely dismantled and their sites were unrestrictedly released from nuclear regulatory control. 12 of the power reactors currently are under dismantling:

- the 670 MW boiling water reactor (BWR) at Würgassen, which is planned to be completely dismantled and the site being released from nuclear regulatory control;
- the five 440 MW pressurised water reactor units of soviet design (VVER) reactors at Greifswald, supposedly the largest decommissioning project in the world;
- the 1,300 MW pressurised water reactor (PWR) at Mülheim-Kärlich which was shut down for legal reasons after a short operational period; and
- the 670 MW PWR at Stade which was shut down in 2003 after more than 30 years of full operation.

Additionally to these 12 units, the 357 MW PWR at Obrigheim was shut down on 11 May 2005 and a license for decommissioning and dismantling has been applied for, which currently is under preparation..

The 9 nuclear fuel cycle facilities comprises of 3 prototype facilities, which completely were dismantled and 6 commercial facilities, of which 4 are completely dismantled and 2 (Siemens Brennelementwerk Betriebsteil MOX Hanau, WAK Wiederaufbereitungsanlage Karlsruhe) are still under dismantling. With respect to the dismantling of WAK the activities are associated with the vitrification of the existing high level liquid waste solution, including the construction of a vitrification plant .

Up to now 21 research/training reactors of different types and sizes have also been completely dismantled. The buildings / sites were cleared and often reused for non-nuclear purposes.

3.2 National strategies

3.2.1 Waste management

Radioactive waste disposal policy in Germany is based on the decision that all types of radioactive waste are to be disposed of in deep geological for-

mations. The Atomic Energy Act gives the responsibility for the disposal of radioactive waste to the Federal Government with BfS as the responsible authority. All other waste management procedures, i.e., spent fuel storage, reprocessing, conditioning, transportation and interim storage is within the responsibility of the waste generators. The Federal States must construct and operate regional collecting depots for the interim storage of radioactive waste originating in particular from radioisotope application in industry, universities and medicine.

3.2.1.1 Spent fuel management

According to the agreement between the Federal Government and the utilities and to the April 2002 amendment of the Atomic Energy Act, the management of spent fuel is restricted to direct disposal. The nuclear power plant operators must provide interim storage facilities on-site. Since 01 July 2005, spent nuclear fuel may only be transported if no licensed interim storage capacity exists at the nuclear power plant site and if the operator of this site is not responsible for this situation.

As a consequence the utilities construct and operate new engineered storage facilities at the sites of the nuclear power plants or near them. As a result of the termination of spent fuel shipments to foreign reprocessing facilities as well as the construction and operation of dry spent fuel interim storage facilities on-site, the number of shipments of spent fuel elements within Germany is considerably reduced to the indispensable quantity. In addition, the period of time until the start of operation of a geological repository to host all types of radioactive waste (including spent fuel) is bridged.

Decentralised on-site facilities may either be interim storage facilities (operational lifetime: 40 years) or interim storage areas (operational lifetime: 5 years). The latter are necessary for nuclear power plants with limited fuel element pool capacity in order to bridge the time gap until the proper on-site storage facilities will become operable.

The construction and operation of such decentralized facilities require a license for the interim storage of nuclear material according to the Atomic Energy Act and a construction license for the erection of the storage building according to the respective Federal State building regulations. The license according to nuclear law is issued by BfS, the construction license by the respective local building authority.

Starting at the end of 1998 until February 2002 the utilities filed 18 applications for dry on-site interim storage of spent fuel in decentralized facilities to BfS (the application for the Stade facility was withdrawn in August 2001 due to the final shut down of the Stade nuclear power plant in autumn 2003). In April 2005 Obrigheim made an application for dry on-site interim storage facility of spent fuel.

As to the interim storage areas the mass of heavy metal applied for varies between 120 Mg and 200 Mg and the activity between $7.6 \cdot 10^{18}$ Bq and $2.8 \cdot 10^{19}$ Bq. The respective numbers for the interim storage facilities are 450 Mg to 2,250 Mg and $4.4 \cdot 10^{19}$ Bq to $2.7 \cdot 10^{20}$ Bq.

When filing the applications the applicants ask for a stepwise licensing of parts of an application in order to expedite the issuing of a license. The excluded parts of the applications remain to be pursued later on and are presently be examined. Thus, BfS issued the licenses for the interim storage areas from April 2001 to June 2003 and the licenses for the interim storage facilities from November 2002 to December 2003 in the first licensing step. Thus, the first licensing step for all interim storage facilities was successfully completed.

As part of the examinations performed within the licensing procedure BfS decided to include an assessment of a terrorist attack using an aircraft and to investigate if the necessary protection has been provided against disruptive action or other interference by third parties. As a consequence, the assessment of a forced airplane crash including big commercial airplanes such as Boeing 747 and Airbus 340 were taken into account. As a result the required safety could clearly be demonstrated.

In the meantime all construction licenses were granted by the respective local building authorities. Thus, up to now (as of September 2005), three interim storage areas and six interim storage facilities are in operation.

Current activities of BfS are focussed on a continuation of the licensing procedures, i. e., the second licensing step. In addition, a new application for the Obrigheim nuclear power plant was filed in April 2005.

3.2.1.2 Disposal-related aspects

In the past one site was used and two sites have been explored to be considered for disposal.

3.2.1.2.1 Morsleben repository

Since 1971, low and intermediate level radioactive waste with mainly short-lived radionuclides and an alpha emitter concentration of up to $4.0 \text{ E}+11 \text{ Bq/m}^3$ originating from the operation of nuclear power plants and the application of radioisotopes in research, medicine and industry in the former German Democratic Republic was disposed of in the Endlager für radioaktive Abfälle Morsleben (ERAM; Morsleben repository), an abandoned salt mine re-used for radioactive waste disposal. Since German unity on 03 October 1990, this facility has the status of a federal repository. Operated by BfS as licensee the Morsleben facility received radioactive waste from a broad range of origins and/or sources, in particular from nuclear power plants, research establishments and from smaller waste generators. Nuclear power plant waste comprises operational and decommissioning waste. Large amounts of decommissioning waste originate from the dismantlement of the Greifswald, Rheinsberg and Niederaichbach plants. Thus, during a five year period of time, BfS gathered comprehensive experience and specific knowledge in the operation of a repository in geological formations serving for disposal of low and intermediate level waste. From 1971 through 1998 radioactive waste with a total volume of about $36,800 \text{ m}^3$ including about 6,600 spent sealed radiation sources was disposed of. The total activity of beta/gamma emitters amounts to about $5 \text{ E}+14 \text{ Bq}$ (relating to 2005), that of alpha emitters to about $7.5 \text{ E}+11 \text{ Bq}$. According to a 25 September 1998 court order BfS had to immediately stop further radioactive waste disposal in the so-called eastern emplacement field. Thus, last waste emplacement operations were carried out on 28 September 1998.

The Morsleben repository will not resume emplacement operations. BfS stated on 12 April 2001 that this facility will definitely never again be used for radioactive waste disposal (renunciation of those parts of the Morsleben repository operation license dealing with the emplacement of radioactive waste). An application for the licensing procedure for decommissioning and closure was filed on 13 October 1992. On 09 May 1997 BfS renewed this application. The main licensing document, the so-called Plan, has been provided – together with the Environmental Impact Assessment and further important documents – to the competent regulatory body (licensing authority) on 13 September 2005. The licensing procedure is in progress and present activities are particularly focussed on the final preparation of further documents for the licensing authority.

The latest important measure is the backfilling of the central part of the Morsleben repository. The backfilling of selected rooms of this part, which has not been used for radioactive waste disposal, is being undertaken in order to enhance geomechanical stability and integrity. Thus, an important safety-related prerequisite with respect to the future backfilling and sealing of the Morsleben repository will be provided by this action. The backfilling measures started on 08 October 2003. In total, 20 rooms with a volume of approx. 730,000 m³ will be backfilled up to the year 2009.

3.2.1.2.2 Konrad repository

The abandoned Konrad iron ore mine was investigated for the disposal of all types of short-lived and long-lived radioactive waste with negligible heat generation, i.e. waste packages which do not increase the host rock temperature by more than 3 K on an average on an overage (low and intermediate level waste). The most essential waste-related planning data comprise an emplacement of up to 650,000 m³ waste package volume with a total beta/gamma activity of about 1 E + 18 Bq and an alpha emitter activity of about 1 E + 17 Bq. Planning work and site-specific safety assessments include the emplacement of decommissioning and dismantling waste from various types of nuclear facilities, too. Waste packages are intended to be emplaced at a depth of 800 m to 1,300 m in disposal rooms with a cross-section of 40 m² and a length of up to 1,000 m using the stacking technique.

The licensing procedure for the Konrad repository was started on 31 August 1982. The license was issued on 22 May 2002 for the emplacement of up to 303,000 m³ waste package volume. Of this, approx. 150,000 m³ will originate from decommissioning and dismantling of nuclear facilities. The license was immediately sued at court. In accordance with the agreement between the Federal Government and the utilities dated 14 June 2000, BfS withdrew the application for immediate enforcement of the license on 17 July 2000, thus enabling court examination of the license. This withdrawal means that the re-construction of the Konrad mine into a repository for all types of radioactive waste with negligible heat generation will only be possible after the court decision. The Lower Saxonian Higher Administrative Tribunal pronounced its judgement on the four court cases on 08 March 2006 rejecting all suits without the admittance of revision. Nevertheless, up to now, the judgements do not become effective and it is presently still open in which way the Federal Administrative Court will decide. BfS will not start preparations for radioactive waste emplacement unless the judicial decision has become effective.

3.2.1.2.3 Gorleben repository project

Since the end of the seventies the Gorleben salt dome was investigated for its suitability to host a repository at depths between 840 m and 1 200 m for all types of radioactive waste, in particular for heat-generating waste originating from reprocessing and for spent nuclear fuel elements (direct disposal). The accumulated inventory of beta/gamma and alpha emitters is planned to be in the order of magnitude of $1 \text{ E}+21 \text{ Bq}$ and $1\text{E}+19 \text{ Bq}$, respectively. Site-specific investigations were started in 1979. The above-ground investigation programme was finished and two shafts were completed. The underground investigation of the Gorleben salt dome was in progress.

Since 1998 the German radioactive waste management concept is being reviewed. With respect to disposal, due to the new approach, further sites with various host rocks are intended to be investigated according to the view of the responsible Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Accordingly, sites should be selected that offer particularly favourable conditions for a suitability demonstration as a repository site and to confirm this suitability within a future licensing procedure.

Though the Federal Government expressed doubts with respect to the suitability of the Gorleben site, it is not considered to be unsuitable as a repository site by the Federal Government. Thus, the Gorleben site will be included in a future site selection procedure. In accordance with the agreement between the Federal Government and the utilities dated 14 June 2000 further underground exploration of the Gorleben salt dome would contribute nothing to help clarify the doubts of the Federal Government. For this reason the underground investigation would remain suspended for at most 10 years (Gorleben moratorium). The moratorium became effective on 01 October 2000. During this period the operation of the Gorleben exploration mine will be restricted to maintenance work necessary to keep the mine in a safe state.

A rapid clarification of the doubts was initiated aiming at the clarification of conceptual and safety-related issues irrespective of the type of host rock. Twelve crucial topics were identified. Work was finished in autumn 2005 and documented in twelve reports. In order to ensure that the results achieved document the state-of-the-art these reports were reviewed by independent experts and the results were discussed by a pluralistic group of about 80 scientists during a workshop organised by BfS in September 2005.

BfS summarised the work in a synthesis report comparing the different types of host rock being available in Germany based on the reports, the reviews, and the results of the workshop. This report summarises important results and shows the limitations of generic studies. The investigations indicate that no type of host rock provides a priori the highest level of repository safety. A comparison of different options is only possible through a comparison of concrete sites and repository concepts. Adjusted repository designs could be developed for all potential German host rocks.

In September 2006 the RSK issued a positive evaluation of BfS' synthesis report.

3.2.2 Decommissioning

The time frame for the shut-down of commercial nuclear power plants is set by the 14 June 2000 agreement, which states a total energy production permissibility for each nuclear power plant individually. If this is used up, the plant has to be shut down. Up to date one facility has been shut down for this reason. Other facilities have been shut down mainly for financial reasons, e.g. if continued operation would have required major backfitting activities.

For all other German facilities there are no criteria laid down, to force the shut down, i.e. the final termination of operation, of the facility (except for safety reasons as a measure of regulatory supervision). Thus for these facilities the responsibility for the decision on the final terminal of operation completely lies within the operator. It should be mentioned that operation licences remain valid even after shut down, until a decommissioning and dismantling license has been granted. Thus, the operator of any shut down facility is to apply for a decommissioning license, if he wants to reduce the regulatory burden.

In Germany it is the operator's responsibility to select an appropriate decommissioning strategy for the respective nuclear facility. The strategies valid according to the Atomic Energy Act are::

- immediate dismantling and
- deferred dismantling (after "Safe enclosure").

In the case of the safe enclosure option the facility is typically mothballed for a deferral period of 20 to 30years. It will be dismantled after the encl-

sure period. This strategy has been chosen so far only for a two nuclear power plants in Germany and for four research reactors, of which recently two have been resolved. It should be noted that in recent decommissioning projects (either on nuclear power plants and research reactors) the selected strategy is immediate dismantling.

From the viewpoint of the regulator, immediate dismantling is preferable. There are several aspects to be considered, e.g., decay of radionuclides / waste amounts, costs, funding, use of existing components, existence of an operator, qualified staff, social impacts, and public acceptance.

Most of these aspects are addressed in a more suitable way if immediate dismantling is chosen, from the viewpoint of the regulator. This may, at least, with regard to total cost (including storage of the remainder until the availability of a repository) not be the same for an operator.

Independent from the selected decommissioning strategy the proposed end-state of the facility will be greenfield or brownfield conditions, i.e. unrestricted or restricted release of the facility and the site, so that the regulatory control due to the Atomic Energy Act can be removed. Nevertheless, in cases of brownfield conditions a supervision in the regime of the radiation protection ordinance or other environmental acts and ordinances may become relevant.

3.3 Issues at national level

3.3.1 Waste management

In Germany there is at present no disposal facility for any type of radioactive waste in operation. Due to this fact, there are no legally binding waste acceptance requirements permitting final processing and packaging of radioactive waste.

According to this situation radioactive waste with negligible heat generation originating from all waste generators is mainly conditioned in compliance with the Konrad Waste Acceptance Requirements as of December 1995. Nevertheless, there is no guarantee that the waste will not have to be reconditioned. Therefore it is important that a flexibility in waste processing and packaging is taken into account in order to facilitate additional steps in conditioning (should this be needed) regarding compliance with future legally binding waste acceptance requirements.

3.3.2 Decommissioning

As a profound experience in decommissioning and dismantling for nearly various types of nuclear facilities has already been accumulated in Germany, there is no unknown major risk to be awaited from the dismantling of further facilities. A safety assessment must be carried out for the dismantling (or partial dismantling) of the respective facility prior to the application for a decommissioning license. The major risks have to be addressed and the release of radionuclides from normal operation as well as from incidents has to be evaluated.

In case of larger facilities as nuclear power plants or large research reactors decommissioning and dismantling are not performed in one phase but in several phases which are subject to individual, separate licenses which will be explicitly applied for by the operator. The decision on a multi-phase application or a single-phase application fully lies with the operator, not with the regulatory body. Unlike in the construction phase, these dismantling phase are not so closely interlinked with each other that one step must necessarily follow from the previous step. There is no linking function such as in the construction and operational phase requiring a prior positive overall assessment in the case of the individual partial licences. Documents for a prior positive overall assessment are therefore not required. It is, however, necessary to demonstrate for each applied for decommissioning and dismantling phase, especially for the first phase, that the proposed measures are compatible of the planned overall decommissioning measures to achieve the proposed end-state.

Dividing up the decommissioning sequence into phases ensures that new techniques can be introduced and experience which has been gained in the previously completed phases can be applied. Assessment of the next step can also take place in parallel to execution of the phase which has already been licensed. In certain circumstances these can also result in a time saving on the overall project.

With the individual licences defined in section 7 para. 3 of the Atomic Energy Act it is possible to establish conditions for releasing plant components or ancillary installations, which are no longer required during decommissioning, from nuclear supervision related to the facility under decommissioning and dismantling and thus re-defining the scope of the facility and

also the limits of the controlled area under the terms of the Radiation Protection Ordinance according to the conditions laid down in that license.

Thus, parts of the facility which are not required for safety purposes (buildings, systems, components), that is to say those parts which are not necessary for fulfilling the protection objectives defined in section 1 of the Atomic Energy Act for decommissioning itself and safe occupancy of the facility (e.g. "inactive parts of the plant", in terms of radioactivity), and which are subject to the license for construction and operation of the facility can only be dismantled and disposed of on receipt of corresponding decommissioning licences.

The safety of the plant is granted not only by the license but also by a meticulous control and supervision by the competent authorities. Section 19 para. 1 of the Atomic Energy Act stipulates, amongst other things, that the handling of radioactive substances and the ownership of facilities of the type designated in section 7 are subject to state supervision. Thus, the decommissioning of nuclear facilities and all other measures associated with safe enclosure or dismantling are subject to supervision under nuclear legislation, as was the operation of the facility before its decommissioning.

The nuclear supervisory authorities are also responsible for monitoring that the conditions of the licences for decommissioning and dismantling are observed by the operator. The objective of the licensing process was to make sure that the subject of the licence is adequately defined and the necessary precautions against damage are guaranteed during execution of the planned decommissioning work. Also, during the licensing process it is checked whether the planned procedures and sequences are appropriate and clearly enough defined and to what extent it is admissible to decide what methods to apply during the individual work steps in the context of the working permit system, if proposed by the operator.

The work permit system, which can be stipulated in the licence, does complement the system of licensing. While during authorization of a dismantling phase the frame will be defined and safety is assessed in detail, the detailed planning of individual dismantling steps is subject to the regulatory supervision. This allows a flexible work planning, taking into account individual conditions relevant for the individual dismantling step, without jeopardizing safety aspects as regulatory control is ensured. The work permit system covers among others the work planning, including the determination of protection measure against conventional and radiological hazards, the

way of participation of the regulatory authorities in an approval step (depending on the safety classification of the system / component under discussion), the preparation of the work, its execution and the post processing.

Usually, a work permit system was introduced already during power operation of the facility in accordance with the regulations laid down in the operating manual (maintenance order) and in accordance with the guideline on the radiological protection of personnel during the performance of maintenance work in nuclear power plants with light water reactors. Thus, after adaptation to the needs for decommissioning and dismantling activities, this system will be used further on.

As long as there is no inadmissible shifting of contents relevant for licensing into the supervisory procedure, i.e. to the work permit system, the licence can be based on work sequences which are subsequently detailed and clarified as part of the supervisory procedure. The work sequences must give details of the concrete work steps and auxiliary equipment, separation methods, devices which are to be used, decontamination techniques, measures for handling residues, preparation for transport, transport processes, radiological protection measures and radiological protection equipment, taking account of the activity concentration and nuclide distribution for each component.

It should be mentioned, that working procedures, work schedules, the working permit system, the clearance procedure for radioactive residues and documentation of decommissioning activities play a significant role in supervision (accompanying controls) of the decommissioning sequence, in particular for dismantling of the facility or parts of the facility.

As during decommissioning and dismantling a large volume of radioactive waste will be generated, the immediate conditioning of decommissioning waste and the subsequent transport of this waste to a repository is highly desirable for the operator of a facility. In the case that a repository is not available, a storage facility has to be constructed and operated until a repository will be available. Construction and operation of a waste storage facility is a significant cost factor and it is often questioned whether it is wise to dismantle immediately or bring the facility into safe enclosure until a repository will be available. For the German facilities recently under decommissioning this question has been answered positively in most cases, but this may change with changing boundary conditions.

4. CURRENT ISSUES AND PRIORITIES FOR THE REGULATOR

4.1 Waste Management

4.1.1 Issues and Priorities

An amendment of the Disposal Advance Payments Ordinance with regard to the financing of repository projects Konrad and Gorleben was made necessary by a court decision in the Isar-Amperwerke test case (Musterprozess Isar-Amperwerke). This amendment was implemented on 06 July 2004.

4.1.2 Developments in policy and regulation

According to the current approach to waste management and disposal, BMU intends to investigate further sites in various host rocks for their suitability. The final site shall be selected upon a subsequent comparison of potential sites, including the Gorleben site.

The primary objective of the site selection procedure is to identify – with public participation – potential disposal sites in a comprehensible and reliable way. In a step-by-step procedure potentially suited sites should be compared for selection. The selected site will finally be subjected to a future licensing procedure.

Decisions on this intended procedure are still to be made.

4.2 Decommissioning

4.2.1 Issues and priorities

Clearance

Clearance is an important issue in the German decommissioning scene.

Clearance levels have been subjected to meticulous investigations recently. These investigations examined the dose criteria against the background of recent changes in the conventional waste sector (this might have affected especially the incineration pathway) as well as against recently published criteria in other countries and from international organisations. None of the investigations showed an inescapable need to change clearance levels.

Further investigations checked whether the collective dose criterion will be met despite the increase in decommissioning activities through the phase-

out decision in Germany. The collective dose criterion will be met with a peak value of about 600 man mSv/a around 2030.

Safety Management Systems

Following international recommendations and reflecting the high importance of managing safety especially under rapidly changing conditions safety management systems shall be operated in NPP, which are under decommissioning and dismantling. Depending on its availability, such a system can be an adaptation of the system operated in the operational phase of the NPP or shall be introduced during decommissioning and dismantling, as is the case in a recent decommissioning and dismantling project.

4.2.2 Developments in policy and regulation

The Decommissioning Guideline is dating from 1996. Since then some laws and ordinances had been amended. A review and revision of the guideline is currently under way and is discussed between federal and state authorities.

5. RESEARCH AND DEVELOPMENT PROGRAMME BY THE REGULATOR FOR BOTH WASTE MANAGEMENT AND DE-COMMISSIONING

5.1 Functions

There are several institutions and organisations which promote R&D programmes in the frame of RWM. The main institutions are listed below:

- BMU,
- BMWi,
- BMBF,
- BfS, and
- Nuclear Industry.

Regarding waste disposal two kinds of research are to be distinguished:

- Research necessary for the construction of German repositories.
- Research which is independent of preparatory work on repositories, and falls under the general objective of continually improving the pro-

tection of man and the environment, independent of licensing and/or monitoring requirements.

Research and development (R&D) work for the construction of repository projects is initiated by BfS, the cost being reimbursed by the waste producers (mainly the utilities). BMU carries out research necessary for competent supervision of BfS and of Federal States authorities. Independent research is the responsibility of BMWi and BMBF. For both kinds of research, i.e., site-specific R&D and independent research, the projects are mainly carried out by the major research establishments at Karlsruhe and Jülich, the GRS, the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR; Federal Institute for Geosciences and Natural Resources), the Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe (DBE; German Company for the Construction and Operation of Repositories for Waste), universities and other bodies.

Several bilateral, multilateral and international co-operations on different aspects of repository development are in progress.

5.2 *Contents of R&D plans*

5.2.1 *Waste management*

The R&D Programmes cover, among other things, the development of concepts for disposal, safety aspects, improvement of instruments for safety assessments of repositories, and development of fission material monitoring.

5.2.2 *Decommissioning*

R&D-projects on nuclear safety are financed of the federal budget with about 33 Mio EUR, 5 Mio EUR thereof are used for R&D in the fields of decommissioning and radiation protection. Liabilities from former nuclear activities are financed up to 160 Mio EUR from the budget of the BMBF.

6. FINANCING OF RADIOACTIVE WASTE MANAGEMENT AND DECOMMISSIONING

The financial resources for facilities belonging to the privately owned power utilities, in particular nuclear power plants, are provided in the form of reserves built up during the operational phase. It should be noted that for commercial power plants, the main emphasis is on generating profits from

electricity production. The formation of reserves according to commercial law is based on the obligation under public law (German Commercial Code) to ultimately remove the radioactive part of the facility, which is derived from the Atomic Energy Act. The existence of reserves for decommissioning guarantees that financial provisions will be available for decommissioning and dismantling after electricity production has been terminated and there are no further revenues from electricity charges. At the same time, the formation of reserves serves to assign the costs for decommissioning and dismantling, which are ultimately caused by electricity production itself, to the operational phase. Separate reserves are formed for the disposal of the fuel assemblies.

The power utilities manage decommissioning and dismantling (with the exception of the disposal of radioactive waste) at their own responsibility, under the supervision of the competent authorities. The allocation of reserves for the decommissioning of nuclear power plants covers all costs associated with dismantling of the plant itself. This includes the costs of the post-operational phase in which the facility is prepared for dismantling after its final shut-down (including removal of fuel assemblies and operational wastes), the costs for the licensing procedure and supervision, the costs of dismantling (dismantling and interim storage of all components and all buildings of the controlled area), and the cost of the interim and final storage of all radioactive wastes from decommissioning. The total amount of costs is estimated from cost studies which are updated regularly by the power utilities, with due regard for technical advancements and general price trends. These cost estimates and the related obligations are checked by the fiscal authorities. Recently the provisions built up by the respective companies' amount to over 32 billion Euros.

The above remarks also apply analogously to commercially operated fuel cycle facilities and waste handling plants.

ACRONYMS AND ABBREVIATIONS

BGR	Federal Institute for Geosciences and Natural Resources
BMBF	Federal Ministry of Education and Research
BMF	Federal Ministry of Finance
BMU	Federal Ministry of Environment, Nature Conservation and

	Nuclear Safety
BMWi	Federal Ministry of Economics
BMVBW	Federal Ministry of Transport, Building and Housing
BfS	Federal Office for Radiation Protection
DBE	German Company for Construction and Operation of Re- positories for Waste
EBA	Federal Office for Railways
FZJ	Jülich Research Centre
FZK	Karlsruhe Research Centre
GKSS	Gesthacht Research Centre
GRS	Company for Facility and Nuclear Safety
KTA	Nuclear Safety Standards Commission
RSK	Reactor Safety Commission
SSK	Radiation Protection Commission