RADIOACTIVE WASTE MANAGEMENT PROGRAMMES IN OECD/NEA MEMBER COUNTRIES

GERMANY
[2005]

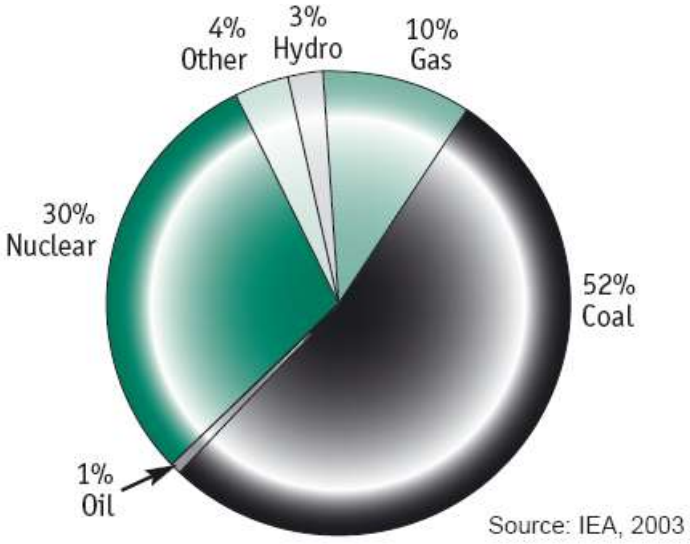
NATIONAL NUCLEAR ENERGY CONTEXT

Commercial utilisation of nuclear power in Germany started in 1961 and by 2002 there were 19 nuclear power units connected to the electricity grid. In 2002 they generated 164.8 TWh of electricity, 29.5% of the total electricity for public use generated in that year.

Also in 2002, the capacity for nuclear fuel fabrication was 650 tonnes heavy metal per year (HM/year) of uranium fuel for light water reactors. Spent fuel storage capacity was 15 350 tonnes HM, and the amount of spent fuel arising in 2002 was 410 tonnes HM.

The commitment to phase out nuclear energy production in Germany was made by law in 2002. Among the reasons for this were lack of public acceptance of nuclear energy in Germany, and the view that the residual risk associated with its use in electricity production is no longer tolerable. This phase-out is based on an agreement between the federal government and the electricity utilities, initialled on 14 June 2000 and signed on 11 June 2001. The agreement to phase out the use of nuclear power for electricity production therefore limits the standard lifetime of nuclear power plants to about 32 years from the date of commissioning.

Breakdown of electricity sources (in %)



SOURCES, TYPES AND QUANTITIES OF WASTE

An annual survey of the volume of radioactive waste produced in Germany is carried out by the Federal Office for Radiation Protection (BfS) on behalf of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

The main sources of radioactive waste are nuclear fuel cycle activities, including power production, related research and development and the decommissioning and dismantling of nuclear facilities, the use of radioisotopes in medical, research, and industrial applications, and the activities of other bodies associated with transfer and removal of such wastes.

The waste is classified into two categories according to the requirements for its disposal. These categories are:

- Radioactive waste with negligible heat generation
- Heat-generating radioactive waste

Radioactive waste with negligible heat generation includes metals and non-metals, filters and filter elements, combustible substances, carcasses, chemical fluids, sludge, slurries and biological fluids as well as oil, solvents and emulsions.

Heat-generating radioactive waste includes those wastes that arise from the reprocessing of spent nuclear fuel elements for recovery of reusable materials. These wastes include fission-product

concentrates, fuel-element cladding and related materials. Spent nuclear fuel that is not reprocessed, but is destined instead for direct disposal as radioactive waste, also falls within this category.

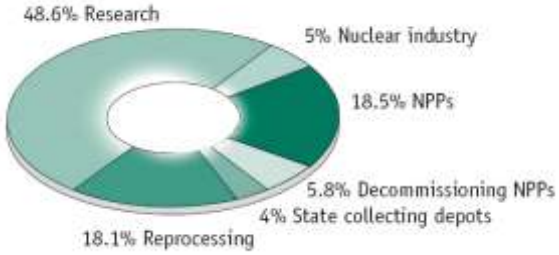
The main operations involved in preparing waste for interim storage and/or disposal include the following:

- Compaction, which is a treatment method where the bulk volume of a compressible material is reduced by the application of high external pressure.
- Immobilisation, which consists of converting waste into solid form by embedding or encapsulating it in materials such as cement, concrete, bitumen or glass.
- Incineration, which is a waste treatment process consisting of burning combustible waste to reduce its volume.
- Solidification, which is the conversion of gaseous, liquid or liquid-like materials into a solid waste form in order to produce a physically stable material. Typical processes include calcination, drying, evaporation, cementation, bituminisation or vitrification.

Collectively, these processes are termed "conditioning", and "conditioned waste" refers to processed and/or packaged radioactive waste ready for interim storage and/or disposal.

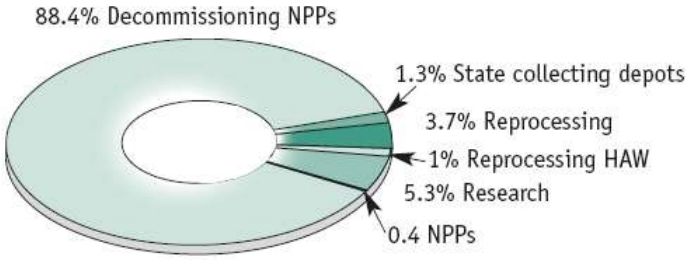
The total volume of conditioned radioactive waste with negligible heat generation, accumulated by the end of 2000, was 67 220 m^3. The percentage breakdown of this stock, by source, is shown in the figure below.

Percentage breakdown of conditioned radioactive waste
with negligible heat generation



The total volume of conditioned heat-generating radioactive waste, accumulated by the end of 2000, was 1 494 m^3. The percentage breakdown of this stock, by source, is shown in the figure below.

Percentage breakdown of conditioned heat-generating radioactive waste



The accumulation of conditioned radioactive waste in Germany has been forecast up to 2080, on the basis of waste surveys and disposal plans submitted by the utilities. The figures are as follows:

- Conditioned radioactive waste with negligible heat generation: 280 000 m^3 (approx.).
- Conditioned heat-generating radioactive waste: 24 000 m^3 (approx.).

RADIOACTIVE WASTE MANAGEMENT POLICIES AND PROGRAMMES

Policy

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

As a result of the 1998 Federal election a coalition of the Social Democrats and Alliance´90/The Greens came into power. The political aims of the Federal Government are given in the coalition agreement dated October 20, 1998. Since 1998, the Federal Government has made a pronounced change compared to the previous energy policy. It is intended to irreversibly phase out nuclear energy use for electricity generation.

The basic document on the future 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 Federal Government and the utility companies agree to limit 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 starting 01 January 2000, until its decommissioning. In total, about 2 620 TWh (net) may 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 is enforced by the latest amendment of the Atomic Energy Act which became effective on 27 April 2002. In particular, this act contains the following provisions:

- The purpose of the Atomic Energy Act is not (as before) to promote nuclear energy, but to phase it out in a structured manner, and to ensure on-going operation up until the date of the plant's discontinuation.

- No further licenses will be issued for commercial nuclear power plants. The authorization to operate a commercial nuclear power plant shall expire once the specific electricity volume fixed for this nuclear power plant has been produced. The electricity volumes of older nuclear power plants can be transferred to newer plants.

- All spent fuel elements from nuclear power plants are to be disposed of directly, with the exception of those delivered to a reprocessing plant until 30 June 2005. From 01 July 2005 onwards, the transportation of fuel elements from nuclear power plants for reprocessing is legally prohibited.

- Operators of commercial nuclear power plants are required to ensure that a local interim storage facility is constructed to reduce transports to the central storage in Ahaus or Gorleben and that the irradiated nuclear fuel incurred is stored until release to a final disposal site for radioactive waste.

- The required financial security for nuclear power plants has been increased tenfold to a maximum of 2.5 billion Euros. This security includes the security for interim storage facilities for spent fuel rods within the enclosed site of the respective nuclear power plants.

- The disposal of radioactive waste into Morsleben will not be resumed. The licensing procedure remains restricted to decommissioning.

Programmes and projects

In Germany, the handling of radioactive materials and the disposal of radioactive waste are governed by the *Atomic Energy Act*. According to this act, radioactive residues must be properly disposed of as radioactive waste. Also, after waste conditioning by a method that depends on the characteristics of the waste, packaged wastes are to be placed in interim storage facilities that ensure their proper storage until disposal.

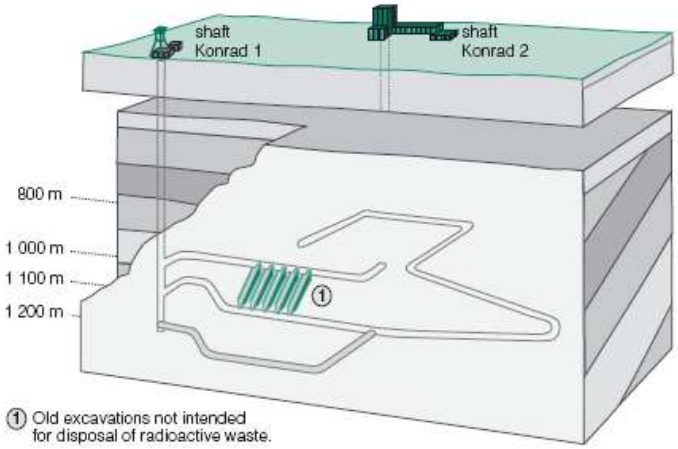
In the direct disposal concept, spent fuel elements will be packaged in containers suitable for disposal and then stored for several decades. Approval has already been given for a period of 40 years of interim storage, and it is currently envisaged that these containers will then be disposed of by emplacement in galleries or boreholes in deep geological formations. Since no repository is in operation being capable of accepting spent fuel elements, there are only conceptual considerations available on the design of such a facility.

The Bartensleben rock-salt mine near Morsleben, in Saxony-Anhalt, was chosen by the former German Democratic Republic in 1970 for disposal of low and medium-level radioactive waste with rather low concentrations of alpha-emitting radionuclides. After German re-unification in 1990 it became a Federal repository. Experimental disposal operations had started in 1971 with the first delivery of low-level radioactive waste. Following further development and licensing, the actual emplacement of radioactive waste started in 1981 in the existing rock-salt cuttings and galleries in the deepest part of the mine. By September of 1998, when disposal was stopped, a total volume of 36 753 m^3 of solid and solidified waste, and 6 617 sealed radiation sources had been disposed of in the Morsleben repository.

In addition to the above disposals, certain other items were placed in deep boreholes in the Morsleben facility for interim storage. These included sealed cobalt radiation sources, some sealed caesium radiation sources, small quantities of solid, medium-level radioactive waste containing europium and packaged in

seven special steel cylinders with a volume of 4 litres each, and one 280 litre drum containing radium-226 waste. An application for disposal of these wastes has been filed within the scope of the licensing procedure for decommissioning of the Morsleben repository.

Two sites have been considered to date with respect to their suitability as disposal facilities. The abandoned Konrad iron-ore mine in Lower Saxony has been investigated for the disposal of radioactive waste with negligible heat generation, i.e. waste packages that do not increase the host rock temperature by more than 3°K on average. The licensing procedure started in August 1982 and the plan approval was issued by the licensing authority in May 2002. However, under an agreement between the Federal Government and the electricity utilities, an application for immediate enforcement of the licence was withdrawn. This withdrawal means, in effect, that conversion of the Konrad mine into a repository for all types of radioactive waste with negligible heat generation will be possible only after a final court decision referring to the licence. The court cases are expected to take about four years, then further decisions on the Konrad project will have to be taken. The general scheme for a disposal repository in the Konrad mine, as currently conceived, is shown in the diagram below. The salt dome at Gorleben, which is located in Lower Saxony, has been investigated for its suitability as a site of a repository for all types of radioactive waste, but primarily for the heat generating radioactive waste arising from reprocessing and spent fuel elements.



In the context of the continuing international debate, the German government considers it necessary to further develop the suitability criteria for a final repository, and to revise the concept for the final storage of radioactive wastes. In recent years, state-of-the-art science and technology and general risk assessment have developed considerably, and this has consequences for the further exploration of the salt dome in Gorleben. A number of conceptual and safety-related issues raise particular doubts. A further exploration of the Gorleben salt dome can contribute nothing to clarify these issues. Consequently, the investigation of the Gorleben site has been interrupted for a period lasting between 3 and 10 years, until 2010 at the latest, in order to allow sufficient time for the clarification of the conceptual and safety-related disposal issues. In addition, further sites in different host rock formations shall be explored. Potential sites will be identified based on site selection criteria.

In the year 1999, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety appointed the *"Arbeitskreis Auswahlverfahren Endlagerstandorte"* (Committee on a site selection procedure for repository sites) in order to develop criteria for the identification of sites, that are both suitable for safe disposal and at the same time are accepted by the general public. In December 2002, the committee made recommendations for a comprehensive and systematic and stepwise approach to a selection of disposal sites including societal and stakeholder involvement. For reasons of public acceptance and procedural fairness, the procedure is designed to include the entire territory of Germany from the

beginning. No area will be selected or precluded prior to the start of the procedure; all areas are to be evaluated using the same criteria.

During the planned legal implementation, a wide scope of public participation is envisioned to assure, that the public may deliver its suggestions on the procedure. It is the objective to have a procedure implemented by the year 2006, that leads to the identification of the safest possible site and which finds broad acceptance in the public. The selection procedure should begin shortly thereafter. The start of repository operations is scheduled approximately for the year 2030. It is intended to strengthen the polluter pays principle by transferring the disposal task to the waste producers. Consequently, disposal no longer would be a Federal task.

RESEARCH AND DEVELOPMENT

Organisation and funding

Research on radioactive waste management in Germany follows two distinct categories: (1) Research necessary for the construction of German waste disposal repositories. (2) Research that is independent of preparatory work on repositories, and comes under the general objective of continually improving the protection of man and his environment.

R&D on repository projects is carried out by the Federal Office for Radiation Protection (BfS) and costs are recovered from waste producers, primarily the electricity utilities.

Supplementary research is the responsibility of the Federal Ministry of Education, Science, Research and Technology (BMBF) and the Federal Ministry of Economics and Labour (BMWA). It is conducted and financed under the Energy Research Programme and consists of: (a) the long-term safety assessment of repositories in rock-salt; (b) the assessment of the suitability of geological formations, other than rock-salt, for the disposal of high-level, heat-generating radioactive waste; (c) the domestic plan for the back-end of the nuclear fuel cycle; (d) the concepts, measurement techniques, and data-recording and processing for the monitoring of fissile material.

Research projects in both of these categories are carried out mainly by the major research centres at Karlsruhe and Jülich, and by the Company for Plant and Reactor Safety (GRS), the Federal Institute for Geosciences and Natural Resources (BGR), the German Company for the Construction and Operation of Final Repositories for Waste Materials (DBE), and by universities and other bodies.

Underground laboratory studies

Between 1965 and 1978, the former Asse salt mine, near Remlingen in the Wolfenbüttel district, was used by the Environment and Health Research Centre (GSF) as an experimental repository for low and medium-level radioactive waste. The purpose of this research was to solve technical and scientific problems connected with the construction and operation of a repository for radioactive waste of all kinds. When the radioactive waste storage permit expired in 1978, about 124 500 waste drums of low-level waste and 1 300 waste drums of medium-level waste had been emplaced in the Asse facility.

Since then, R&D has continued on a salt concrete barrier system. When the Asse sealing system was designed, it was planned to erect different components serving as seal and abutment. The salt concrete plug was intended primarily as an abutment and secondarily as a seal.

DECOMMISSIONING AND DISMANTLING POLICIES AND PROJECTS

In Germany, 18 nuclear power reactors and prototype reactors, 32 research reactors and critical assemblies, and 10 fuel cycle facilities have been permanently shut down. Two of the power reactors, 21 of the research reactors and critical assemblies, and five of the fuel cycle facilities have already been dismantled. The sites of two power reactors, KKN in Niederaichbach and HDR in Großwelzheim, were restored to "green-field conditions" and released from regulatory control. Dismantling is in progress for other power reactors, and restoration to "green-field conditions" is the plan in most cases. Deferred dismantling has been chosen for two power reactors, KWL in Lingen and THTR-300 in Hamm-Uentrop, where a system of safe enclosure has been licensed. Deferred dismantling has also been selected for four research reactors, which are also in safe enclosure mode. According to the respective licenses, the concept for completing all decommissioning steps has to be submitted to the regulatory body, and no license for deferred dismantling will be granted without this.

The operator of a nuclear facility may choose between dismantling and deferred dismantling after a safe enclosure period. Recent decisions by operators of power reactors have been in favor of immediate dismantling, mainly because of cost considerations, societal aspects and the availability of qualified and trained staff.

An important aspect of nuclear facility decommissioning is disposal of the radioactive wastes generated and re-use of residual substances. Future decommissioning of nuclear power plants in Germany is expected to generate a total of about 150 000 tonnes of radioactive waste. The rate at which it is generated is expected to increase gradually over the years and to peak in about 2025. These wastes will be managed in accordance with the provisions of the *Atomic Energy Act* and the *Radiological Protection Ordinance*. The conditions for the release of materials, buildings and sites from nuclear regulatory control, the respective monitoring of such materials and the systematic approach to the management of radioactive wastes are regulated in the legal framework. Further information on decommissioning of nuclear facilities in Germany can be found via:

http:\www.nea.fr(html)rwm/wpdd/welcome.html.

TRANSPORT

Transport of radioactive waste and spent fuel elements from nuclear power plants involves: untreated waste for conditioning; conditioned waste to central interim storage facilities; spent fuel elements for

reprocessing in France and the United Kingdom until 30 June 2005; and vitrified high-level reprocessing waste from La Hague, in France, to the Gorleben interim storage facility.

The safety regulations for these transport opera tions are prescribed by the *Atomic Energy Act* and the regulations on the transportation of dangerous goods, primarily the Dangerous Goods Ordinances concerning Road and Rail Transport. A transport licence has to be obtained from the Federal Office for Radiation Protection for the transport of nuclear fuels and large radioactive sources. Nuclear fuels include enriched uranium, plutonium, new fuel elements. Large radioactive sources have an activity of more than 1 000 TBq and include, for example, cobalt-60 radiation sources which are used in the medical field. The Federal State (Länder) Authorities, the Federal Railway Authority and the Federal Air Transport Authority are responsible for supervising transport operations.

COMPETENT AUTHORITIES

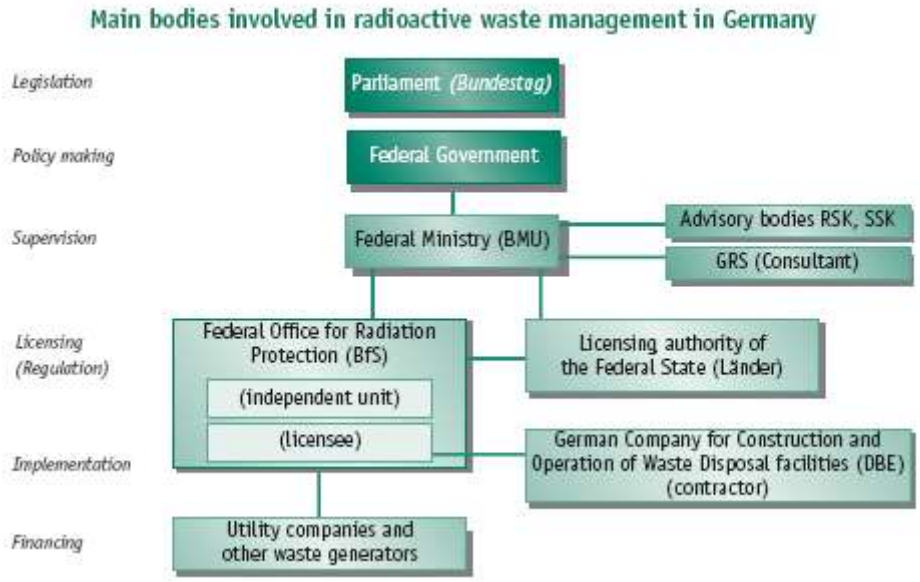
Responsibility for take-over and disposal of radioactive waste

The handling of radioactive waste is regulated by the *Atomic Energy Act*. According to Section 9a of the Act, the Federal Government must set up facilities for taking over and ensuring the safe disposal of radioactive waste. The government has transferred this responsibility to the Federal Office for Radiation Protection (BfS), which is a superior federal authority under the Federal Ministry for the Environment (BMU). BfS may call on other bodies to carry out its legal tasks. The German Company for the Construction and Operation of Final Repositories for Waste Materials (DBE), which is based in Peine and was set up in 1979, acts on behalf of BfS as its main contractor. In this context, wastes from various sources, including medical establishments and universities, may be placed in interim storage at the sites belonging to research centres, nuclear fuel fabrication plants and the collection plants of regional authorities. In addition, there are central storage facilities at Gorleben, Ahaus and Mitterteich.

BMU works with the Federal Ministry of Education, Science, Research and Technology (BMBF) and the Federal Ministry of Economics and Labour (BMWA) on R&D concerned with the take-over and final storage of radioactive waste.

Licensing procedures

The *Atomic Energy Act* provides the legal framework for licensing of the construction and operation of a radioactive waste disposal site. BfS is the applicant and the licensing bodies are the regional authorities. In the case of the Konrad repository, the Lower Saxony Environment Ministry (NMU) is the licensing authority. Public participation is an important factor in the licensing procedure, and information about a project application is made available to members of the public, who may express objections. These objections are then discussed at a hearing involving the applicant and its experts, the licensing authority and its experts, and the objectors and their experts. In addition, all mining activities must also be approved by the competent mining authorities.



Institutional Framework

The Federal Government and the parliament are responsible for policy making and legislation, respectively. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety is responsible for nuclear safety, radiation protection, nuclear disposal and final storage. The Reactor Safety Commission (RSK) and Radiation Safety Commission (SSK) are responsible for advising BMU on all major issues concerning nuclear reactors, nuclear fuel cycle and radiation protection.

The regulatory authority is assisted by technical safety organisation such as the Company for Plant- and Reactor Safety (GRS).

The Federal Office for Radiation Protection (BfS) is afederal authority subject to supervision by BMU. BfS has its own integrated supervisory unit (independent unit). 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 nuclear fuel, government custody, the transport of radioactive substances and the management of radioactive waste including construction and operation of federal installations for safekeeping and final disposal. It supports BMU on a technical and scientific level in these fields.

On behalf of the Federal Government the Länder 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 *Landessam-melstellen* (regional collecting depots), i. e. interim storage facilities for radioactive waste originating in particular from isotope applications in industry, research and development as well as medicine.

For the construction and operation of repositories the BfS may make use of "third parties". In 1979, the German Company for the Construction and Operation of Final Repositories (DBE) was founded as

such a third party according to the Atomic Energy Act. DBE is the main contractor of BfS with regard to construction and operation of repositories.

FINANCING

The costs of conditioning, interim storage and disposal of radioactive waste from nuclear power plants, including the waste from reprocessing of spent fuel elements abroad, are met by the electricity utilities and are incorporated into the price of electricity. All waste producers including the electric utilities and the Federal Government, on behalf of its research centres, finance the planning and preparation for future German radioactive waste disposal, in accordance with the Prepayment Ordinance. The actual operation of the disposal facility will be financed by all waste producers according to the provisions of Article 21a of the *Atomic Energy Act*.

PUBLIC INFORMATION

In addition to the information available locally from individual companies and facilities, information is also provided by Federal Government agencies, federal authorities, individual federal state governments and their agencies, and by industry.

For more information, the websites of some relevant authorities and organisations are listed below.

Government

Bundesamt für Strahlenschutz (BfS) Salzgitter
E-mail: info@bfs.de
Website: http://www.bfs.de

Industry

GNS Gesellschaft für Nuklear-Service mbH Hollestraße 7 A, Essen
E-mail: info@gns-gnb.de
Website: www.gns.de