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Joint Convention
on the Safety of Spent Fuel Management and
on the Safety of Radioactive Waste Management

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Division RS III 3
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AGO	Arbeitsgruppe Option - Rückholung *(Working group option – retrieval)*
AKR	Ausbildungskernreaktor *(Training reactor)*
ALG	Abfalllager Gorleben *(Gorleben waste storage facility)*
ALfR	Aktives Lager für feste und flüssige radioaktive Reststoffe, Rheinsberg *(Active storage facility for solid and liquid residues, Rheinsberg)*
AREVA NC	AREVA Nuclear Cycle (formerly COGEMA)
AtAV	Atomrechtliche Abfallverbringungsverordnung *(Nuclear Waste Shipment Ordinance)*
AtG	Atomgesetz *(Atomic Energy Act)*
AtSMV	Atomrechtliche Sicherheitsbeauftragten- und Meldeverordnung *(Nuclear Safety Officer and Reporting Ordinance)*
AtVfV	Atomrechtliche Verfahrensverordnung *(Nuclear Licencing Procedure Ordinance)*
AtZüV	Atomrechtliche Zuverlässigkeitsüberprüfungsverordnung *(Nuclear Reliability Assessment Ordinance)*
AVK	Abfallfluss-, Verfolgungs- und Produkt-Kontrollsystem *(Waste Flow Tracking and Product Control System)*
AVR	Arbeitsgemeinschaft Versuchsreaktor GmbH *(Experimental nuclear power plant at Jülich)*
AVV	Allgemeine Verwaltungsvorschrift *(General Administrative Regulation)*
BAFA	Bundesamt für Wirtschaft und Ausfuhrkontrolle *(Federal Office of Economics and Export Control)*
BAM	Bundesanstalt für Materialforschung und –prüfung *(Federal Institute for Materials Research and Testing)*
BE	Brennelement(e) *(Fuel assembly (FA)/fuel assemblies (FAs))*
BER II	Berliner Experimentier-Reaktor II *(Berlin experimental reactor II)*
BfE	Bundesamt für kerntechnische Entsorgung *(Federal Office for Nuclear Waste Management)*
BfS	Bundesamt für Strahlenschutz *(Federal Office for Radiation Protection)*
BGBl.	Bundesgesetzblatt *(Federal Law Gazette)*
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe *(Federal Institute for Geosciences and Natural Resources)*
BMBF	Bundesministerium für Bildung und Forschung *(Federal Ministry of Education and Research)*
BMU	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (bis 17.12.2013) *(Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (until 17.12.2013)*

BMUB	Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (ehem. BMU) *(Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (formerly BMU))*
BMWi	Bundesministerium für Wirtschaft und Energie *(Federal Ministry for Economic Affairs and Energy)*
BNFL	British Nuclear Fuels plc
BOR-60	Bystrij Opytnyj Reaktor *(Fast experimental reactor)*
BWR	Boiling Water Reactor
BZA	Brennelement-Zwischenlager Ahaus GmbH *(Fuel assembly storage facility at Ahaus)*
CASTOR	Cask for Storage and Transport of Radioactive Material
CEA	Commissariat à l'Energie Atomique et aux énergies alternatives
COGEMA	Compagnie Générale des Matières Nucléaires
CSD-B	Colis Standard de Déchets Boues *(Standard package for intermediate-level vitrified waste)*
CSD-C	Colis Standard de Déchets Compactés *(Standard package for waste compacted under high pressure)*
CSD-V	Conteneur de Standard de Déchets Vitrifiés) *(Standard container for high-level vitrified waste)*
DAEF	Deutsche Arbeitsgemeinschaft Endlagerforschung *(German Association of Repository Research)*
DBE	Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH *(German Service Company for the Construction and Operation of Waste Repositories)*
DESY	Deutsches Elektronen-Synchrotron *(German electron synchrotron at Hamburg)*
DIN	Deutsches Institut für Normung e. V. *(German Institute for Standardization)*
DIZ	Daten- und Informationszentrum *(Data and Information Centre)*
EAN	European Article Numbering
EBA	Eisenbahn-Bundesamt *(Federal Office for Railways)*
EPRI	Electric Power Research Institute
ERAM	Endlager für radioaktive Abfälle Morsleben *(Morsleben repository for radioactive waste)*
ESK	Entsorgungskommission *(Nuclear Waste Management Commission)*
ETSON	European Technical Safety Organizations Network
EU	European Union
EURATOM	European Atomic Energy Community
EUROCHEMIC	European Company for the Chemical Processing of Irradiated Fuels
EVU	Energieversorgungsunternehmen *(Electric power utility/utilities)*
EW	Exempt Waste
EWN	Energiewerke Nord GmbH
FA/FAs	Fuel assembly / fuel assemblies
FBR	Fast Breeder Reactor

FbU	Fachinformationssystem bergbaubedingte Umweltradioaktivität *(Technical information system on environmental radioactivity caused by mining)*
FH	Fachhochschule *(University of applied sciences)*
FINAS	Fuel Incident Notification and Analysis System
FR-2	Forschungsreaktor 2, Karlsruhe *(Research Reactor 2, Karlsruhe)*
FRG	Forschungsreaktor Geesthacht *(Geesthacht research reactor)*
FRJ	Forschungsreaktor Jülich *(Jülich research reactor)*
FRM	Forschungsreaktor München, Garching *(Munich research reactor, Garching)*
FRMZ	TRIGA-Forschungsreaktor Mainz *(TRIGA research reactor Mainz)*
FZJ	Forschungszentrum Jülich GmbH (früher KFA) *(Jülich research centre (formerly KFA))*
FZK	Forschungszentrum Karlsruhe GmbH (früher KfK, heute KIT) *(Karlsruhe research centre (formerly KFK, now KIT))*
GDR	German Democratic Republic
GG	Grundgesetz *(Basic Law for the Federal Republic of German)*
GKN	Kernkraftwerk Neckarwestheim *(Neckarwestheim nuclear power plant)*
GKSS	Forschungszentrum Geesthacht GmbH (ehemals Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt mbH) *(Geesthacht research centre (formerly GNS)*
GMBl.	Gemeinsames Ministerialblatt *(Joint Ministerial Gazette)*
GNS	Gesellschaft für Nuklear-Service mbH
GorlebenVSpV	Gorleben-Veränderungssperren-Verordnung *(Gorleben Development Freeze Ordinance)*
GSF	Gesellschaft für Strahlenforschung (now HMGU)
GSI	Gesellschaft für Schwerionenforschung mbH
HASS	High-Activity Sealed Radioactive Sources
HAW	High-Active Waste
HAWC	High-Active Waste Concentrate
HDB	Hauptabteilung Dekontaminationsbetriebe der WAK GmbH (ehemals des Forschungszentrums Karlsruhe) *(Central Decontamination Department of the WAK GmbH (formerly of the Karlsruhe research centre))*
HDR	Heißdampfreaktor, Großwelzheim *(Superheated steam reactor, Großwelzheim)*
HGF	Hermann von Helmholtz-Gemeinschaft Deutscher Forschungszentren *(Hermann von Helmholtz Association of National Research Centres)*
HKG	Hochtemperatur-Kernkraftwerk GmbH
HM	Heavy Metal
HMGU	Helmholtz Zentrum München – Deutsches Forschungszentrum für Gesundheit und Umwelt GmbH (früher GSF) *(Helmholtz Zentrum München - German Research Center for Environmental Health (formerly GFS))*
HMI	Hahn-Meitner-Institut Berlin GmbH (now Helmholtz-Zentrum Berlin)

HTGR	High-Temperature Gas-Cooled Reactor
HTR	High-Temperature Reactor
HWGCR	Heavy-Water Gas-Cooled Reactor
HZB	Helmholtz-Zentrum Berlin
HZDR	Helmholtz-Zentrum Dresden-Rossendorf
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IEC	International Electrotechnical Commission
IGD-TP	Implementing Geological Disposal of Radioactive Waste – Technology Platform
IGSC	Integration Group for the Safety Case
ILW	Intermediate Level Waste
IMIS	Integriertes Mess- und Informationssystem zur Überwachung der Umweltradioaktivität *(Integrated Measurement and Information System for monitoring environmental radioactivity)*
INES	International Nuclear Event Scale
INEX	International Nuclear Emergency Exercise
IRS	Incident Reporting System
IRSN	Institut de Radioprotection et de Sûreté Nucléaire, France
ISO	International Organization for Standardization
ITU	Institute für Transuranium Elements, Karlsruhe
KBR	Kernkraftwerk Brokdorf *(Brokdorf nuclear power plant)*
KFA	Kernforschungsanlage Jülich (now FZJ)
KfK	Kernforschungszentrum Karlsruhe (now KIT)
KGR	Kernkraftwerk Greifswald *(Greifswald nuclear power plant)*
KIT	Karlsruher Institut für Technologie *(Karlsruhe Institute of Technology)*
KKB	Kernkraftwerk Brunsbüttel *(Brunsbüttel nuclear power plant)*
KKE	Kernkraftwerk Emsland *(Emsland nuclear power plant)*
KKG	Kernkraftwerk Grafenrheinfeld *(Grafenrheinfeld nuclear power plant)*
KKI	Kernkraftwerk Isar *(Isar nuclear power plant)*
KKK	Kernkraftwerk Krümmel *(Krümmel nuclear power plant)*
KKN	Kernkraftwerk Niederaichbach *(Niederaichbach nuclear power plant)*
KKP	Kernkraftwerk Philippsburg *(Philippsburg nuclear power plant)*
KKR	Kernkraftwerk Rheinsberg *(Rheinsberg nuclear power plant)*
KKS	Kernkraftwerk Stade *(Stade nuclear power plant)*
KKU	Kernkraftwerk Unterweser *(Unterweser nuclear power plant)*
KMK	Kernkraftwerk Mülheim-Kärlich (heute Anlage Mülheim-Kärlich) *(Mülheim-Kärlich nuclear power plant (now Mülheim-Kärlich plant))*

KNK II	Kompakte Natriumgekühlte Kernreaktoranlage, Karlsruhe *(Compact sodium-cooled nuclear reactor plant, Karlsruhe)*
KRB	Kernkraftwerk Gundremmingen *(Grundremmingen nuclear power plant)*
KTA	Kerntechnischer Ausschuss *(Nuclear Safety Standards Commission)*
KWB	Kernkraftwerk Biblis *(Biblis nuclear power plant)*
KWG	Kernkraftwerk Grohnde *(Grohnde nuclear power plant)*
KWL	Kernkraftwerk Lingen *(Lingen nuclear power plant)*
KWO	Kernkraftwerk Obrigheim *(Obrigheim nuclear power plant)*
KWU	Kraftwerk Union AG
KWW	Kernkraftwerk Würgassen *(Würgassen nuclear power plant)*
LAA	Länderausschuss für Atomkernenergie *(Länder Committee for Nuclear Energy)*
LAVA	Lagerungs- und Verdampfungsanlage in der Wiederaufarbeitungsanlage Karlsruhe *(Storage and evaporation facility in the Karlsruhe reprocessing plant (WAK))*
LAW	Low-Active Waste
LWR	Light-Water Reactor
MAW	Medium-Active Waste
MLU	Ministerium für Landwirtschaft und Umwelt (Sachsen-Anhalt) *(Ministry of Agriculture and the Environment of Saxony-Anhalt)*
MOX	Mixed Oxide
MTR	Materialtestreaktor *(Material testing reactor)*
MWe	Megawatts elektrical
MZFR	Mehrzweckforschungsreaktor, Karlsruhe *(Multi-purpose research reactor, Karlsruhe)*
NCS	Nuclear Cargo + Service GmbH
NDA	Nuclear Decommissioning Authority
NEA	Nuclear Energy Agency
NEZ	Nukleares Entsorgungszentrum *(Nuclear waste management centre)*
NLWKN	Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz *(Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency)*
NMU	Niedersächsisches Ministerium für Umwelt und Klimaschutz (heute: Niedersächsisches Ministerium für Umwelt, Energie und Klimaschutz) *(Lower Saxony Ministry for the Environment and Climate Protection (now Lower Saxony Ministry for the Environment, Energy and Climate Protection)*
NORM	Naturally Occurring Radioactive Material
NPP	Nuclear Power Plant
OECD	Organisation for Economic Co-operation and Development
PETRA	Pellet-Trocknungsanlage *(Pellet drying facility)*

PFB	Planfeststellungsbeschluss *(Plan approval notice)*
PKA	Pilot-Konditionierungsanlage, Gorleben *(Pilot conditioning plant, Gorleben)*
PKS	Produktkontrollstelle *(Product control group)*
PSR	Periodic safety review
PSÜ	Periodische Sicherheitsüberprüfung *(Periodic safety review)*
PUREX	Plutonium-Uranium Recovery by Extraction
PWR	Pressurised Water Reactor
QSK	Qualitätsverbund Strahlenschutzkursstätten *(Quality association of radiation protection course providers)*
RANET	Response and Assistance Network
REI	Richtlinie zur Emissions- und Immissionsüberwachung kerntechnischer Anlagen *(Guideline concerning Emission and Immission Monitoring of Nuclear Installations)*
ReVK	Reststofffluss-Verfolgungs- und Kontrollsystem *(Software system for the documentation, methodical tracking and management of radioactive materials and waste)*
RFR	Rossendorfer Forschungsreaktor *(Rossendorf research reactor)*
RöV	Röntgenverordnung *(X-Ray Ordinance)*
RPV	Reactor pressure vessel
RSK	Reaktor-Sicherheitskommission *(Reactor Safety Commission)*
RWTH	Rheinisch-Westfälische Technische Hochschule Aachen
SKB	Svensk Kärnbränslehantering AB (Swedish Nuclear Fuel and Waste Management Company)
SSK	Strahlenschutzkommission *(Commission on Radiological Protection)*
SSR	Superheated Steam Cooled Reactor
StandAG	Standortauswahlgesetz *(Site Selection Act)*
STEAG	Steinkohlen-Elektrizität AG
StrlSchV	Strahlenschutzverordnung *(Radiation Protection Ordinance)*
StrVG	Strahlenschutzvorsorgegesetz *(Precautionary Radiation Protection Act)*
SUR	Siemens-Unterrichtsreaktor *(Siemens research reactor designed for training purposes)*
TBL	Transportbehälterlager *(Transport cask storage facility)*
TBL-A	Transportbehälterlager Ahaus *(Ahaus transport cask storage facility)*
TBL-G	Transportbehälterlager Gorleben *(Gorleben transport cask storage facility)*
TH	Technische Hochschule *(Technical institution of higher education)*
THTR	Thorium-Hochtemperaturreaktor, Hamm-Uentrop *(Thorium high-temperature reactor, Hamm-Uentrop)*

TRIGA	Training, Research and Isotope Production Facility of General Atomic (Reactor)
TSO	Technical Safety Organisation
TU	Technical University
TWh	Terawatt-hour
UBA	Ummantelte Betonabschirmung *(Encased concrete shielding)*
US-DOE	United States Department of Energy
US-NRC	United States Nuclear Regulatory Commission
USSR	Union of Soviet Socialist Republics
UVPG	Gesetz über die Umweltverträglichkeitsprüfung *(Environmental Impact Assessment Act)*
VAK	Versuchsatomkraftwerk Kahl *(Kahl experimental nuclear power plant)*
VBA	Verlorene Betonabschirmung *(Lost concrete shielding)*
VEK	Verglasungseinrichtung Karlsruhe *(Karlsruhe vitrification plant)*
VIBS	Vorfälle im Brennstoffkreislauf (Datenbank) *(Events in nuclear fuel cycle facilities (database))*
VKTA	Verein für Kernverfahrenstechnik und Analytik Rossendorf e. V. *(Nuclear Engineering and Analytics Rossendorf Inc.)*
VLLW	Very Low-Level Waste
VOAS	Verordnung über die Gewährleistung von Atomsicherheit und Strahlenschutz *(Ordinance on the Guarantee of Nuclear Safety and Radiation Protection)*
VSLW	Very Short-Lived Waste
WAK	Wiederaufarbeitungsanlage Karlsruhe *(Karlsruhe reprocessing plant)*
WENRA	Western European Nuclear Regulators' Association
WGWD	WENRA Working Group on Waste and Decommissioning
WHG	Wasserhaushaltsgesetz *(Federal Water Act)*
WTI	Wissenschaftlich-Technische Ingenieurberatung GmbH
WWER	Water-cooled and water-moderated energy reactor (Soviet design)
ZAW	Zentrale Aktive Werkstatt, Greifswald *(Central active workshop, Greifswald)*
ZDW	Zentrale Dekontaminations- und Wasseraufbereitungsanlage, Greifswald *(Central decontamination and water treatment plant, Greifswald)*
ZfK	Zentralinstitut für Kernforschung, Rossendorf *(Central Institute for Nuclear Research, Rossendorf)*
ZLN	Zwischenlager Nord, Rubenow *(Rubenow storage facility)*
ZLR	Zwischenlager Rossendorf *(Rossendorf interim storage facility)*

Summary

Status of power and research reactors in Germany

There are currently nine power reactors in operation in Germany. These are exclusively light-water reactors (seven pressurised water reactors and two boiling water reactors) whose fuel assemblies are composed of low-enriched uranium oxide or uranium/plutonium mixed oxide (MOX). With the 13th amendment to the Atomic Energy Act of 6 August 2011 as a consequence of the events in Japan, the licences to generate electricity at the Biblis A and B, Neckarwestheim 1, Brunsbüttel, Isar 1, Unterweser, Philippsburg 1 and Krümmel plants expired. By October 2013, applications for decommissioning and dismantling were filed by seven of the eight nuclear power plants that were shut down in 2011. These nuclear power plants are in the post-operational phase until a decommissioning licence will be granted. The utilities E.ON, RWE and Vattenfall appealed to the constitutional court against the amendment of the Atomic Energy Act. For the remaining nine nuclear power plants, the operating licences will expire progressively between the end of 2015 and the end of 2022. Another 16 reactors (including experimental and demonstration reactors) are in the process of being decommissioned.

There are at present three research reactors (MTR facility BER-II at Berlin; high-flux reactor FRM II at Garching; TRIGA reactor at Mainz), three teaching reactors and one training reactor in operation in Germany. Six research reactors are in the process of being decommissioned and four research reactors have been permanently shut down. For 28 research reactors decommissioning has been completed.

Spent fuel management facilities

Facilities for the management of spent fuel in terms of this Convention are:

- the interim storage facilities at the nuclear power plant sites,
- the storage facilities at Ahaus and Gorleben,
- the storage facilities at Rubenow and Jülich, and
- the pilot conditioning plant at Gorleben.

(1) On-site storage facilities

Decentralised storage facilities for spent fuel have been licensed under atomic law and constructed and commissioned at twelve sites with nuclear power plants. They are designed as dry storage facilities in which transport and storage casks loaded with spent fuel are emplaced.

The storage facilities are cooled by passive air convection which removes the heat from the casks without any active technical systems. The leak-proof and accident-resistant casks ensure safe enclosure as well as the necessary degree of radiation shielding and criticality safety during both normal operation and in the case of incidents. Protection against external hazards, such as earthquakes, blast waves and aircraft crashes, is ensured by the thick walls of the casks. It was demonstrated and confirmed in the licensing procedure that the casks are suitable for at least 40 years of storage. Thus, the licences limit the storage period to 40 years, starting with the emplacement of the first cask. An extension of the storage period is subject to licensing. According to § 6, par. 5 Atomic Energy Act (AtG), licences may only be renewed for irrefutable reasons and after prior referral to the German *Bundestag*.

(2) Storage facilities at Ahaus and Gorleben

Licences were granted for storage facilities in Ahaus and Gorleben for the storage of spent fuel from various German nuclear power plants. The facilities are designed as dry storage facilities. The Ahaus facility has been additionally licensed for the storage of transport and storage casks of the CASTOR® THTR/AVR and MTR 2 types in which spent fuel from experimental, demonstration and research reactors is stored.

It is intended to use the Ahaus cask storage facility (TBL-A) also for the storage of further spent fuel from research reactors (the BER II of the Helmholtz-Zentrum Berlin, the TRIGA reactor of the Technical University Mainz, and the *Forschungs-Neutronenquelle Heinz Maier-Leibnitz* (FRM II) of the Technische Universität München) in casks of the CASTOR® MTR 3 type. A decision about this possibility has not been made yet. Currently, it is not possible to make a prognosis about these planned storage options in the TBL-A as this depends on the potential use of other disposal paths by the operators of the research reactors (e.g. return to the USA).

With letter of 24 September 2009, the *Brennelement-Zwischenlager Ahaus GmbH* (BZA) and the GNS have filed an application at the Federal Office for Radiation Protection (BfS), according to § 6 AtG for the storage of nuclear fuel in the form of spent fuel assemblies and other radioactive material in the form of operational elements (absorber and graphite assemblies with no fissile material content) from the former AVR experimental reactor at Jülich, in a total of 152 transport and storage casks of the CASTOR® THTR/AVR type in the eastern part of the two storage areas (storage area II). This application has been suspended.

Furthermore, they applied for the storage of high-pressure compacted radioactive waste (the CSD-C from reprocessing at La Hague). Currently, a cask concept for the return and storage of the waste is under development.

On 9 November 2009, the competent district government of Münster granted a licence according to § 7 Radiation Protection Ordinance (StrlSchV) [1A-8] for the temporary storage of operational and decommissioning waste in the western part of the two storage areas (storage area I). The storage period is limited to 10 years. On 21 July 2010, the first waste packages were emplaced.

The Gorleben transport cask storage facility has been additionally licensed for HAW glass canisters. In January 2010, a licence was granted for the storage of the CASTOR® HAW 28M type. Since the end of 2012, 108 casks have been stored there with vitrified waste. After the entry into force of the Site Selection Act (StandAG), the remaining HAW from the reprocessing of German spent fuel abroad must be stored in local storage facilities. For conditioned non-heat-generating waste which is currently stored in the Gorleben waste storage facility, storage in a separate section within the transport cask storage facility was applied for in December 2013.

(3) Storage facilities at Rubenow and Jülich

In addition to spent fuel from the Soviet-type reactors at Rheinsberg and Greifswald, spent and fresh fuel from the compact sodium-cooled nuclear reactor plant (KNK II), from the nuclear ship Otto Hahn as well as HAW glass canisters from the Karlsruhe reprocessing plant (WAK) are currently stored in the dry storage facility *Zwischenlager Nord* (ZLN) in Rubenow. The KNK fuel rods were emplaced in 2010, the HAW glass canisters in 2011. The Jülich storage facility contains fuel pebbles from the operation of the experimental nuclear power plant at Jülich (AVR). It is considered to deliver the 152 transport and storage casks of the CASTOR® THTR/AVR type stored there to the USA.

On 26 June 2007 and with a more precise letter of 29 April 2009, the Jülich research centre (FZJ) applied for the storage of AVR fuel at the Jülich storage facility for another three years, starting on 1 July 2013. After the FZJ had asked on 16 July 2010 to suspend the licensing procedure, the BfS resumed the procedure on 16 May 2012 upon request of the FZJ and, since then, has been continuing it.

Since the licence applied for could not be granted by the BfS until 1 July 2013, the Ministry of Economic Affairs of the *Land* of North Rhine-Westphalia, as the competent nuclear supervisory authority, ordered the further storage of the AVR fuel at the Jülich storage facility until 31 December 2013.

Since the applicant didn’t submit all evidences even by 31 December 2013, a new order by the supervisory authority became necessary.

With the new order, the FZJ is authorised to continue to possess the nuclear fuel. It entered into force on 1 January 2014 and was limited for seven months until 31 July 2014.

Since the verification of fulfilment of the licensing requirements could not be completed until 31 July 2014, an order entered into force again on 2 July 2014.

(4) Gorleben pilot conditioning plant (PKA)

The reference concept for direct disposal of spent fuel in a salt dome pursued until entry into force of the StandAG envisaged the removal of the fuel rods from the fuel assemblies in an above-ground facility, the packaging of the fuel rods in self-shielding and sealed thick-walled casks and their emplacement in deep geological formations for disposal. In accordance with the type of cask used, it is also referred to as the POLLUX reference concept. In order to demonstrate the conditioning technique, a pilot conditioning plant was completed in Gorleben in 2000. The plant is licensed for a throughput of 35 Mg HM/a. According to the agreement between the Federal Government and the utilities of 11 June 2001, the use of the plant is licensed only for the repair of defective casks for spent fuel from light-water reactors and for vitrified HAW from reprocessing as well as for the handling of other radioactive material.

Spent fuel management policy and practices

Germany's objective regarding the management of spent fuel has changed. Until 1994, the Atomic Energy Act included the requirement of reusing the fissile material in the spent fuel. This requirement changed in 1994, and the operators of nuclear power stations then had the option of either reuse by means of reprocessing, or else of direct disposal.

Since 1 July 2005, delivery of spent fuel from commercial electricity production for the purposes of reprocessing has been prohibited in accordance with an amendment of the Atomic Energy Act to this effect of 22 April 2002 [1A-2]. The last spent fuel to be delivered for reprocessing was dispatched from the Stade nuclear power plant in May 2005. Now, only the direct disposal of the spent fuel existing and being generated in future in Germany as radioactive waste is permissible.

For the spent fuel which had been delivered for reprocessing until 30 June 2005, the proof of reuse of the recycled plutonium separated during reprocessing must be kept. This is designed to ensure that throughout the remaining residual operating lives of the nuclear power plants, all separated plutonium will be processed in the fabrication of MOX fuel and thus be reused.

As there is as yet no repository available for the spent fuel, it will generally be stored at the sites where it was generated until such time as a repository is commissioned; corresponding storage capacities exist as needed.

Usually, the spent fuel from research reactors will be returned to its country of origin. If this is not possible, it will be stored until its final transportation to a repository.

As at 31 December 2013, there was a total of about 14,886 Mg HM in the form of spent fuel. Of these, a total of 8,215 Mg HM are in stored at the NPP sites, i.e. in the fuel pools, or in the centralised and local dry storage facilities. 6,343 Mg HM were reprocessed mostly in other European countries, and 327 Mg HM were otherwise disposed of.

Radioactive waste management policy and practices

In Germany, disposal in deep geological formations is intended for all types of radioactive waste.

On 28 June 2013, the German Bundestag passed, the Act on the search for and selection of a site for a repository for heat-generating radioactive waste and for the amendment of other laws (*Gesetz zur Suche und Auswahl eines Standortes für ein Endlager für Wärme entwickelnde radioaktive Abfälle und zur Änderung anderer Gesetze*, Site Selection Act – StandAG) [1A-7]. The site selection act for a repository in particular for heat-generating radioactive entered into force on 27 July 2013. The site selection procedure for a repository in particular for high-level radioactive waste in deep geological formations is to be concluded by 2031. The objective is to find a disposal site for the domestic in particular high-level radioactive waste, on the German territory by means of a science-based and transparent process according to § 9a, para. 3 sentence 1 of the Atomic Energy Act. This site shall assure the best possible safety for a period of one million years. The actual procedure for site selection is preceded by the work of a "Commission on Storage of High-Level Radioactive Waste" (Commission), whose task it is to examine and assess the relevant fundamental issues for the selection procedure with regard to radioactive waste management and to develop proposals for decision making and for a policy recommendation for the German *Bundestag* and the *Bundesrat*. The results of the Commission will be submitted until 31 December 2015 (which may be extended once for further six months) in the form of a report. In this report, it should take a position on decisions taken so far and predefinitions as regards the issue of disposal. The Commission is to evaluate the StandAG [1A-7] and, where appropriate, make proposals for further development.

To demonstrate the safety of a repository, the German concept of disposal of radioactive waste with negligible heat generation in deep geological formations provides evidence for the backfilling of cavities and the sealing of drifts and shafts. Measures for retrieval after sealing of a repository are not part of this concept.

Only stable (or fixed) radioactive waste will be accepted for disposal in deep geological formations; liquid and gaseous waste is excluded from acceptance. The controlled, safe disposal of radioactive waste therefore requires its conditioning.

Conditioning comprises several stages, depending on the quality and nature of the raw waste. After targeted collection or grading (where necessary), the raw waste may first be pretreated and then be either processed into interim products or directly into packages suitable for storage or disposal.

Proven methods and reliable mobile or stationary installations already exist for the pretreatment and conditioning of radioactive waste. Mobile conditioning installations are the preferred choice for the treatment and packaging of operational waste from nuclear power plants. Stationary installations which are capable of conditioning various different types of raw waste tend to be used primarily at the major research centres; there are also a number of other stationary conditioning installations which are operated on site by the respective waste generators.

In addition to German facilities, facilities in other European foreign countries are also utilised for waste management. Radioactive waste generated from the operation of nuclear facilities is delivered to Sweden for conditioning and subsequently returned to Germany.

Both central and decentralised storage facilities are available for the interim storage of radioactive waste with negligible heat generation from nuclear power plants and the nuclear industry. For waste generated from the use and handling of radioisotopes in research, industry and medicine, *Land* collecting facilities operated by the *Länder* are available for storage.

On the basis of the current licensing situation, heat-generating radioactive waste may be kept in storage in decentralised and central storage facilities. Waste from the reprocessing of spent fuel from German power reactors is conditioned in France and the United Kingdom (e.g. vitrification of the high-level fission product solutions) and is then returned to Germany. Until the end of 2013, the Gorleben storage facility was provided for the storage of vitrified waste. For the return of the CSD-B waste from France and HAW waste from the United Kingdom still to be performed, the Site Selection Act (StandAG) requires the establishment of on-site storage facilities. According to § 6, para. 5 AtG, the storage of nuclear fuel in nuclear plants shall not exceed 40 years starting at the first emplacement of a cask.

The compliance of the packages with the requirements set out in the acceptance criteria of the repository is reviewed within the scope of a product control. For this, the acceptance criteria of the Konrad repository, which has been plan-approved and is under construction, are relevant. The product control measures relate both to radioactive waste that has already been conditioned and to radioactive waste that will be conditioned in future. They assure a reliable identification of waste packages that do not conform to the specifications.

At the end of 2013, a total of 113,885 m³ (gross volume) of radioactive waste with negligible heat generation in containers was stored in Germany. The waste originated primarily from research institutions, nuclear power plants and the nuclear industry including reprocessing as well as from medical applications and the non-nuclear industry. In addition to the spent fuel, a total of 721 m³ of heat-generating radioactive waste was stored, which mainly consists of vitrified HAW from reprocessing. From 1967 to 1978, a total of 124,494 packages were emplaced in the mine as low-level radioactive waste, including also, in the case of higher activities, those with so-called lost concrete shieldings. In addition, 1,293 drums and packages with intermediate-level radioactive waste were emplaced. The gross volume of the packages is about 47,000 m³. From 1971 to 1998, a total of 36,753 m³ of solid low- and intermediate-level radioactive waste and 6,617 sealed sources were emplaced in the ERAM.

Criteria for the registration and classification of radioactive waste

The intention to dispose of all types of radioactive waste in deep geological formations 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 order to separate the radioactive waste generated in this way.

In order to meet the requirements concerning the registration and categorisation of radioactive waste from the point of view of disposal, it has been decided to refrain from using the terms LAW, MAW and HAW and to choose instead a new classification, which was made under particular consideration of aspects relevant for disposal and is based on the intention to dispose of all types of radioactive waste in deep geological formations. Accordingly, waste is initially subjected to a basic subdivision into

- heat-generating waste and
- waste with negligible heat generation

followed by a detailed classification according to the categorisation scheme established for this purpose.

In connection with the presentation of the national waste management programme required by Council Directive 2011/70/EURATOM of 19 July 2011, information and data on the quantity of radioactive waste and spent fuel are also submitted to the EU Commission according to a classification of the IAEA [IAEA 09a].

Heat-generating radioactive waste is characterised by high activity concentrations and thus by a high decay heat; this type of waste includes, in particular, the fission product concentrate, hulls, structural components and feed sludge from the reprocessing of spent fuel, and the spent fuel itself if it is to be disposed of directly as radioactive waste.

Wastes with clearly lower activity concentrations from the operation, decommissioning and dismantling of nuclear facilities as well as from the application of radioisotopes are classified among the radioactive waste with negligible heat generation. This encompasses e.g. disused plant components and defective components such as pumps or piping, ion exchange resins and air filters from waste water and exhaust air decontamination, contaminated tools, protective clothing, decontamination and cleaning agents, laboratory waste, sealed radiation sources, sludges, suspensions, oils as well as contaminated and activated concrete structures and debris. This classification makes it possible, in particular, to register the data for waste/waste packages required for description and characterisation, and therefore ensures the necessary degree of flexibility with respect to the many different types of waste as well as any changes/new developments in conditioning. It subdivides the different waste streams according to origin, waste container, immobilisation and waste type. With regard to the origin of the radioactive waste, a distinction is generally made between different parties obliged to deliver/hand over waste. Cast-iron containers, concrete containers or box-shaped containers are predominantly used for packaging radioactive waste, whilst cement and concrete are widely used for the purposes of immobilisation. This categorisation scheme allows the description of radioactive waste to be systematised in a way which fulfils the requirements for proper registration and description of the waste arising to be disposed of.

Responsibilities in the area of spent fuel and radioactive waste management

According to § 9a, para. 2 AtG, anyone possessing radioactive waste must deliver it to a repository or to a *Land* collecting facility. With the delivery of radioactive waste to a *Land* collecting facility, the ownership is transferred to this facility. Thus, the responsibility for conditioning is assumed by the operator of the *Land* collecting facility. According to § 9a, para. 3 AtG, the *Länder* shall establish *Land* collecting facilities for the storage of radioactive waste arising within their territory. Radioactive waste with negligible heat generation from research, medicine and industry is delivered to these facilities. The producers of radioactive waste arising from the use of nuclear energy are responsible for its storage and conditioning. According to § 9a, para. 3 AtG, the Federation shall establish facilities for the disposal of radioactive waste. According to § 23, para. 1, subpara. 2 AtG, the Federal Office for Radiation Protection (BfS) shall be responsible for the construction and operation of repositories as well as for the compliance with the legal requirements and the requirements stipulated in the approval. Third parties act on behalf of the BfS. In case of the Asse II mine, this is the federally owned *Asse-GmbH*. In the case of the Konrad mine, the ERAM and the Gorleben mine, the *Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH* (DBE) acts as a third party. In addition, the BfS is the project executing organisation for the site selection of a repository in particular for heat-generating radioactive waste.

Storage facilities for the safe-keeping of nuclear fuel are operated by the utilities, supervised by the Länder and licensed by the BfS. The Federal Office for Nuclear Waste Management (BfE) is to be responsible for the plan approval or licensing of repositories. Transitional arrangements apply to the Konrad repository and the ERAM; they stipulate that for the time being, licensing shall remain with the *Länder*. According to § 24 AtG, the *Länder* are responsible for the licensing and supervision of the other waste management facilities.

Funding of spent fuel and radioactive waste management

The polluter-pays principle also generally applies to the financing of spent fuel and radioactive waste management activities. Exceptions are the ERAM and the Asse mine whose costs are paid by the Federation. The Federation refinances the necessary expenses for the planning and construction of repositories at the parties' obliged to deliver material by means of advance payments on contributions. The site selection procedure is financed through cost allocations to the waste producers according to §§ 21 et seq. StandAG [1A-7]. The use of repositories and *Land* collecting facilities is refinanced by costs (fees and expenses) or charges that are payable by the party delivering radioactive waste.

As the surveillance of a repository after its sealing is a governmental task, the necessary financial means are provided by the Federation.

Legislative and regulatory framework in the area of spent fuel and radioactive waste management

The Federal Republic of Germany is a Federal State. The responsibilities for law-making and law enforcement are assigned differently to the organs of the Federation and the *Länder* according to the respective regulatory duties. Specifications are regulated by the provisions in the Basic Law of the Federal Republic of Germany.

The legislative competence for the use of nuclear energy for peaceful purposes lies with the Federal Government. The further development of nuclear law is also a task of the Federal Government. The *Länder* will be involved in the procedure dependent on the subject matter.

The Atomic Energy and the statutory ordinances based thereon are implemented by authorities of the Federation and the *Länder*, with many tasks related to the execution performed by the *Länder* on behalf of the Federal Government. With respect to the lawfulness and appropriateness of their action, the competent *Land* authorities are subject to the oversight by the Federal Government.

Assurance of the safe handling of disused sealed sources

Nearly 100,000 sealed sources are used in research, trade, industry, medicine and agriculture in Germany. The most common fields of application for radioactive sources in the industry are calibration of measuring devices, materials testing, irradiation and sterilisation of products, as well as level and density measurements. In medicine, radioactive sources are mostly used for radiotherapy and for irradiation of blood. The most frequently used radionuclides in radioactive sources are Co-60, Ir-192, Cs-137, Sr-90 and Am-241 whose activity is in the range of some kBq for test and calibration emitters and up to some 10^{12} Bq for radioactive sources for irradiation facilities. In Germany, the safety and security of disused sealed sources has long been ensured by a legal framework in accordance with European and international standards and by an extensive system of licensing and supervision. In the vast majority of the very rare cases of so-called "orphan sources" in Germany, radioactive sources of low activity are concerned. Loss and discovery of radioactive materials are regularly recorded and assessed in the annual reports of the BfS.

The working lives of the sources used are very different, in particular due to the strongly varying half-lives of the radionuclides used. In most cases, the devices operated on the basis of a licence for handling are returned to the equipment manufacturer by the operator after end of use together with the source remaining in the device. The manufacturer may check further use of the sources or returns them to the source manufacturer who may reuse parts of them. The sources that cannot be reused are delivered to the *Land* collecting facilities where they are stored until delivery to the Konrad repository.

Disused sealed sources may only be returned to Germany as other radioactive material if the delivery is exclusively to the manufacturer of supplier who fulfils the above-mentioned requirements or if the recipient can demonstrate that he will either continue to use them as licenced radiation sources or recycle them.

Shipment within the EU is not subject to licensing requirements. Transboundary movement inside the EU is regulated by Council Regulation No. 1493/93 [1F-34]. With respect to sealed sources, the prior notice of the competent authority based on a declaration of the addressee is essential (in Germany: the Federal Office of Economics and Export Control (BAFA). The competent authority of the country of destination must also be notified of the completion of the shipment. As far as a transboundary movement is subject to legal requirements for licensing or notification, e.g. for re-entry of a radioactive source from a non-EU country, the competent authority according to § 22 AtG [1A-3] is the BAFA.

Main developments in Germany since the Fourth Review Meeting

The return of high-active vitrified waste from reprocessing in France (CSD-V) was concluded with the final transport in November 2011. The waste is stored in the Gorleben transport cask storage facility.

On 25 April 2013, the Act to speed up the retrieval of radioactive waste and the closure of the Asse mine (*Gesetz zur Beschleunigung der Rückholung radioaktiver Abfälle und der Stilllegung der Schachtanlage Asse* ("Lex Asse") of 20 April 2013 [1A-26] entered into force. The Act included a revised version of § 57b AtG. Closure, already provided in the old version, shall take place after retrieval of the radioactive waste. However, retrieval shall be discontinued if its performance is not acceptable for the population and the employees for radiological or other safety-relevant reasons. This is particularly the case when mining safety can no longer be ensured. For further operation, including retrieval and related measures, plan approval according to § 9b AtG is not required.

On 27 July 2013, the Act on the search for and selection of a site for a repository for heat-generating radioactive waste and for the amendment of other laws, the Site Selection Act (*Gesetz zur Suche und Auswahl eines Standortes für ein Endlager für Wärme entwickelnde radioaktive Abfälle und zur Änderung anderer Gesetze, Standortauswahlgesetz* – StandAG) of 23 July 2013 [1A-7]) entered into force. Some of its provisions entered into force on 1 January 2014. A Commission has been set up to prepare the site selection procedure whose task is, in particular, to examine and assess the relevant fundamental issues for the selection procedure with regard to nuclear waste management. Among other things, the Commission will review the StandAG and prepare a report addressing all relevant issues for a decision. Furthermore, the Commission will submit a policy recommendation for the German Federal Parliament (*Bundestag*) and the German Federal Council (*Bundesrat*). The Commission started its work in May 2014.

The objective of the site selection procedure is to find a site in Germany for a disposal facility in accordance with § 9, para. 3, sentence 3 AtG for radioactive waste, in particular for high-level radioactive waste, produced in Germany, in a transparent procedure on the basis of scientific criteria that ensures best possible safety for a period of one million years.

It is intended to establish a Federal Office for Nuclear Waste Management (BfE) as an independent higher federal authority within the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). The tasks of the BfE, assigned to it by the Atomic Energy Act (AtG), the Site Selection Act (StandAG) or other federal laws, will include administrative tasks of the Federation in the field of licensing of federal facilities for the safekeeping and disposal of radioactive waste.

In addition, the StandAG contains further amendments to other laws, in particular consequential amendments to the AtG Act resulting from the site selection procedure.

As a consequence of the events in Japan in March 2011, the Nuclear Waste Management Commission (ESK) conducted a stress test for nuclear fuel cycle facilities in Germany carried out (see Chapter G.5.3 for details). The results of the stress tests are documented in two ESK statements [4-11].

In the spring of 2010, WENRA issued a revised "Waste and Spent Fuel Storage Safety Reference Levels Report" (Version 2.0). The action plan for Germany that resulted from the benchmarking of the national regulations has been largely implemented by the ESK's guidelines for the dry cask storage of spent fuel [4-2] and the ESK guidelines for the performance of periodic safety reviews and on technical ageing management for storage facilities for spent fuel and heat-generating radioactive waste [4-5a].

A Introduction

A.1 Structure and content of the report

The Federal Government will continue to meet Germany´s existing international obligations, particularly with regard to the fulfilment of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. In submitting this report, Germany is demonstrating its compliance with the Joint Convention and how it ensures the safe operation of facilities for the management of spent fuel and radioactive waste, including the decommissioning of nuclear facilities. At the same time, there is also still a need for future action in order to continue maintaining the required high standards of safety and ensure disposal.

The report to the Joint Convention follows the guidelines on form and structure of national reports. As such, it is divided into sections which address the individual Articles of the Joint Convention as prescribed in the guidelines. An introduction considering the historical and political development of nuclear power use is followed by a comment on each individual obligation. Statements made in the report tend to be of a generic nature, although plant-specific details are given wherever necessary in order to illustrate compliance with the requirements of the Convention.

In order to demonstrate compliance with the obligations, explanatory comments are given on the pertinent national laws, ordinances and standards, and descriptions are provided of the manner in which essential safety requirements are met. In the current national report, special emphasis is placed on describing the licensing procedure and state supervision, as well as the measures applied by the operators at their own responsibility for maintaining an appropriate standard of safety.

The annexes to the report contain a list of nuclear facilities currently in operation as defined by this Convention with their safety-relevant design characteristics, a list of installations in the process of decommissioning and dismantled installations, plus a comprehensive list of the legal and administrative provisions, statutory regulations and guidelines in the field of nuclear power which are relevant to the safety of the facilities as defined by this Convention and which are referred to in this report.

The fifth German national report does not merely include modifications of the previous reports but provides an integrated overall description. Any major amendments since the report for the Fourth Review Meeting in May 2012 are summarised at the beginning of the respective sections in an info box (Developments since the Fourth Review Meeting).

All information and data provided by the report apply as at the deadline of 31 March 2014 unless expressly specified otherwise.

The fifth German report under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was jointly revised and updated by organisations dealing with the safe disposal of spent fuel and radioactive waste in Germany. These are the nuclear regulatory authorities of the Federation and the *Länder*, supported by expert organisations, as well as the energy utilities as important waste generators, involved by a representative of their joint most important service provider, the *Gesellschaft für Nuklear-Service* (GNS) *mbH*. The report was approved by the Federal Cabinet at its meeting on 27 August 2014.

According to the national regulations of the Federal Republic of Germany, which are in line with the international requirements, the residual materials generated from former uranium ore mining are not counted among the radioactive waste, which is why these activities are – as in the National Reports since the second Review Meeting – presented in a separately annexed report describing the status of the ecological restoration as at 31 March 2014.

A.2 Historical development and current status of utilisation of nuclear energy

Research and development

In the Federal Republic of Germany, research and development in the field of the civil use of nuclear energy began in 1955 after the Federal Republic of Germany had officially renounced the development and possession of nuclear weapons. The research and development programme was based on intensive international co-operation and included the construction of several experimental and demonstration reactors, as well as the elaboration of concepts for a closed nuclear fuel cycle and for disposal of radioactive waste in deep geological formations.

In 1955, the Federal Government established the Federal Ministry for Nuclear Affairs and Germany became a founder member of the European Atomic Energy Community (EURATOM) and the Nuclear Energy Agency (NEA) of the OECD. German and US power plant manufacturers jointly began to develop commercial nuclear power plants for the German market: Siemens and Westinghouse developed pressurised water reactors (PWRs), AEG and General Electric boiling water reactors (BWRs).

In subsequent years, the following nuclear research centres were founded in West Germany:

1956	in Karlsruhe (*Kernforschungszentrum Karlsruhe*, KfK, now Karlsruhe Institute of Technology (KIT)) in Jülich (*Kernforschungsanlage Jülich*, KFA, now *Forschungszentrum Jülich*, FZJ), in Geesthacht (*Gesellschaft für Kernenergieverwertung in Schiffbau und Schifffahrt*, GKSS, now *Helmholtz-Zentrum Geesthacht* Centre for Materials and Coastal Research)
1959	in Berlin (*Hahn-Meitner-Institut für Kernforschung*, HMI, now *Helmholtz-Zentrum Berlin*), in Hamburg (*Deutsches Elektronen-Synchrotron*, DESY)
1964	in Neuherberg near Munich (*Gesellschaft für Strahlenforschung*, GSF, now *Helmholtz Zentrum München* – German Research Center for Environmental Health)
1969	in Darmstadt (*Gesellschaft für Schwerionenforschung*, GSI)

Many universities were equipped with research reactors. The FRM research reactor at Garching was the first to go critical on 31 October 1957, and the most recent operating licence was granted on 2 May 2003 for the FRM II research reactor at the same site. The operation was started in the year 2004.

In the former German Democratic Republic (GDR), the peaceful use of nuclear energy began with the development of a nuclear programme for nuclear research and nuclear technology in 1955. The offer of the USSR to the states within their sphere of influence to support the establishment of their own nuclear research institutions with the provision of research reactors and large-scale nuclear equipment was accepted by the former political leadership of the GDR. The establishment of the Central Institute for Nuclear Research (ZfK) in Rossendorf near Dresden took place in 1956; a research reactor supplied by the USSR went into operation here in 1957. In parallel, new chairs were set up at the institutions of higher education and universities in the fields of nuclear engineering and nuclear physics. In this way, a broad research and development base was created in the GDR for basic research in nuclear physics, radiochemistry and isotope production as well as for research work on the scientific and technical basis of the use of nuclear energy. At the turn of 1991/1992, the former facilities were taken over by Rossendorf research centre FZR (now *Helmholtz-Zentrum Dresden-Rossendorf* (HZDR) for the research tasks and by the Nuclear Engineering and Analytics Rossendorf Inc. (VKTA) for the operation of the nuclear facilities.

Development of nuclear reactors in the Federal Republic of Germany

In 1958, the first German nuclear power plant, the 16 MWe experimental nuclear power plant (VAK) in Kahl, was ordered from General Electric and AEG, and became operational in 1960.

Commercial power reactors with 250 to 350 MWe and 600 to 700 MWe respectively were ordered between 1965 and 1970. In 1966, the first commercial boiling water reactor was taken into operation in Gundremmingen with the KRB-A (250 MWe), and the first commercial pressurised water reactor 1968 in Obrigheim with the KWO (350 MWe). From 1970, larger power reactors (PWRs and BWRs) of the 1,300 MWe class were built. In 1975, the first of this class went into operation in Biblis with the KWB-A (1,225 MWe), the last in 1989. All nine power reactors still in operation have a gross capacity between 1,344 and 1,485 MWe.

In the 1950s, the independent development of a series of experimental and demonstration reactors began in close co-operation between the nuclear research centres and the industry. This led to the construction of a number of experimental and demonstration reactors. Worth mentioning in this connection are the 15 MWe high temperature pebble-bed reactor AVR (*Arbeitsgemeinschaft Versuchsreaktor GmbH*) at the former Jülich Nuclear Research Facility ordered in 1958, and the 57 MWe heavy-water PWR MZFR (multi-purpose research reactor) in the former Karlsruhe nuclear research centre ordered in 1961. Here, in the early 1960s, the development of a fast breeder reactor (FBR) began. This was later followed by the construction of a high-temperature reactor as a pebble-bed reactor based on thorium (THTR 300) in Hamm-Uentrop and a fast breeder reactor (SNR 300) in Kalkar as prototypes. The THTR was in operation between 1983 and1989 and is in safe enclosure now; the spent fuel is stored in the Ahaus transport cask storage facility. Although the SNR 300 was completed, it was never loaded with fuel assemblies. The SNR 300 fuel that had been already produced was processed in France into mixed-oxide (MOX) fuel for light water reactors.

Construction of nuclear reactors in the former GDR

Since the GDR did not have its own development programmes for nuclear power plants, nuclear power plants should be imported from the USSR as turnkey facilities. The first commercial power reactor in the GDR – a 70 MWe pressurised water reactor of Soviet design – was built in Rheinsberg and commissioned in 1966. From 1973 to 1989, five pressurised water reactors – four of the WWER-440/230 type and one of the WWER-440/W-213 type – started operation in Greifswald.

With the accession of the GDR to the Federal Republic of Germany in accordance with Article 23 of the Basic Law (*Grundgesetz* – GG) (in the version applicable until 1990), the Atomic Energy Act (AtG) [1A–3] applies for the territory of the former GDR. In the course of German reunification, the five reactors in Greifswald were shut down in 1989/1990 and the reactor in Rheinsberg in 1990. They are now being dismantled. Work already under way for the construction of three additional WWER-440 reactors in Greifswald and two WWER-1000 reactors at the first construction stage in Stendal was terminated.

Termination of the commercial production of electricity from nuclear energy

In 1998, the Federal Government decided to phase out the use of nuclear energy for commercial production of electricity in a carefully co-ordinated process. This decision applies in principle until today. In 2000, a consensus was reached with the power plant operators and fixed by contract.

The Act on the structured phase-out of the utilisation of nuclear energy for the commercial generation of electricity of 22 April 2002 [1A–2] established new boundary conditions for the use of nuclear energy in Germany. The phase-out in a controlled manner was formulated as one of the purposes of the Atomic Energy Act (AtG) [1A–3]. The starting point for a gradual phase-out of the operation of the nuclear power plants was an average operating lifetime of 32 years. On this basis, the KKS nuclear power plant in Stade was decommissioned in 2003 and the KWO nuclear power plant in Obrigheim in 2005 (see Table L-14).

In 2010, the Federal Government decided to extend the lifetimes of the nuclear power plants still in operation, but the events in Japan in March 2011 led to a reassessment of the risks associated with the use of nuclear energy. As a consequence, the authorisation for power operation expired for the eight plants Biblis A, Neckarwestheim 1, Biblis B, Brunsbüttel, Isar 1, Unterweser, Philippsburg 1 and Krümmel with the 13th amendment to the Atomic Energy Act of 6 August 2011 [1A-25]. For the nine nuclear power plants still in operation, the authorisation for power operation will expire successively between the end of 2015 and the end of 2022, or earlier if reaching the electricity volumes listed in Table A-1.

Table A-1: Electricity volumes and expiry of authorisation for power operation according to the 13th amendment to the Atomic Energy Act

Plant	Electricity volumes as from 1 January 2000 [TWh net]	Start of commercial power operation	Expiry of authorisation for power operation
Obrigheim	8.70	01.04.1969	-
Stade	23.18	19.05.1972	-
Biblis A	62.00	26.02.1975	06.08.2011
Neckarwestheim 1	57.35	01.12.1976	06.08.2011
Biblis B	81.46	31.01.1977	06.08.2011
Brunsbüttel	47.67	09.02.1977	06.08.2011
Isar 1	78.35	21.03.1979	06.08.2011
Unterweser	117.98	06.09.1979	06.08.2011
Philippsburg 1	87.14	26.03.1980	06.08.2011
Grafenrheinfeld	150.03	17.06.1982	31.12.2015
Krümmel	158.22	28.03.1984	06.08.2011
Gundremmingen B	160.92	19.07.1984	31.12.2017
Philippsburg 2	198.61	18.04.1985	31.12.2019
Grohnde	200.90	01.02.1985	31.12.2021
Gundremmingen C	168.35	18.01.1985	31.12.2021
Brokdorf	217.88	22.12.1986	31.12.2021
Isar 2	231.21	09.04.1988	31.12.2022
Emsland	230.07	20.06.1988	31.12.2022
Neckarwestheim 2	236.04	15.04.1989	31.12.2022
Subtotal	2,516.06		
Mülheim-Kärlich	107.25		
Total	**2,623.31**		

Note: The electricity volume of 107.25 TWh for the Mülheim-Kärlich nuclear power plant can be transferred to the nuclear power plants Emsland, Neckarwestheim 2, Isar 2, Brokdorf, Gundremmingen B and C

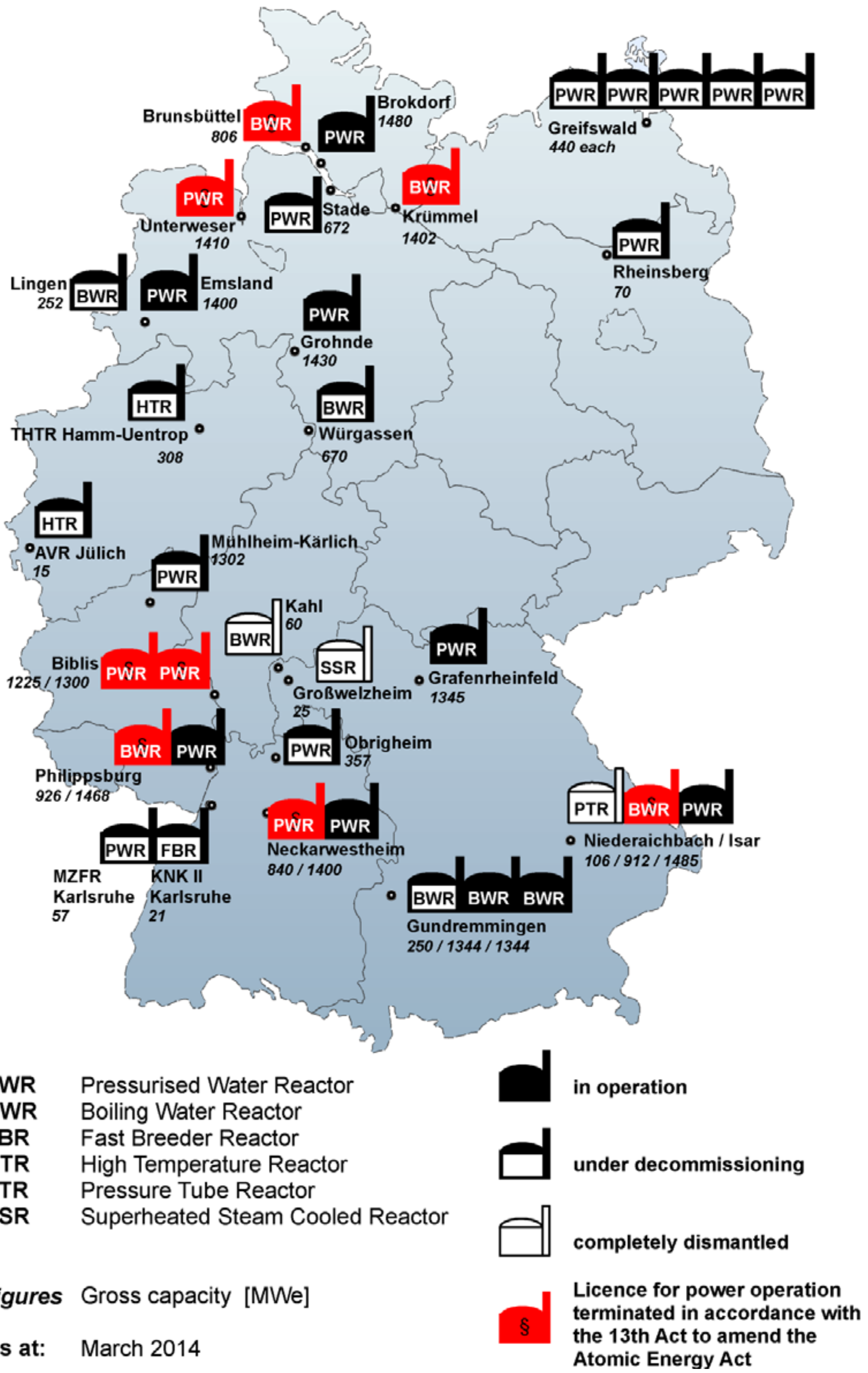
In March 2014, E.ON Kernkraft GmbH announced to permanently shut down the Grafenrheinfeld nuclear power plant already on 31 May 2015 for economic reasons – and thus seven months before expiry of the authorisation for power operation. The application for decommissioning and dismantling of the Grafenrheinfeld nuclear power plant was filed on 28 March 2014.

For seven of the eight nuclear power plants shut down in 2011, applications for decommissioning and dismantling were filed by spring 2013 (see Table L-20 in Annnex L-(d)). For all plans, immediate dismantling has been applied for, a previous phase of safe enclosure is not provided. Until granting of the decommissioning licence, the plants are operated on the basis of the existing operating licence. In this phase, the fuel assemblies should, as far as possible, already be removed from the plants.

With the successive phase-out of the use of nuclear energy, the share of nuclear energy in the gross electricity production in Germany decreased from 28.2 % in 2002 to 15.4 % in 2013.

The geographical locations of the operating and decommissioned German nuclear power plants are shown in Figure A-1.

Figure A-1: Nuclear power plants, experimental and demonstration reactors in Germany



Facilities of the nuclear fuel cycle

With the commercial use of nuclear energy in Germany, facilities of the nuclear industry emerged in the western *Länder* in addition to the power reactors as well as facilities for treatment or storage of the resulting radioactive waste.

In the past, facilities for the fabrication of uranium, HTR and MOX fuel were operated at the Hanau site. However, these have meanwhile been decommissioned and dismantled; only facilities for groundwater remediation remained in operation.

One uranium enrichment plant at Gronau and one fuel fabrication plant at Lingen are in operation.

In Karlsruhe, the Karlsruhe Reprocessing Plant (WAK) was built under the leadership of the local research centre, and put into operation in 1971. As a pilot plant, it had the task to gain experience for planning, construction and operation of a larger German reprocessing plant. In addition, methods for reprocessing and waste treatment were to be further developed. The technical scale was chosen such that direct application of operating experience to a large industrial plant was possible.

In the 1970s, the German utilities planned the so-called nuclear disposal centre (*Nukleares Entsorgungszentrum* – NEZ), consisting of a reprocessing plant, fuel fabrication plants for uranium and MOX fuel, waste management facilities for all types of waste and a repository for all this waste. The NEZ was to be constructed at the site of Gorleben in Lower Saxony (see Chapter H.3.2 for details). With the exception of the repository project, plans for the centre were later shelved in 1979, whereupon the utilities turned instead to plans for a scaled-down project which would be confined to the reprocessing, the fabrication of MOX fuel and the treatment of radioactive waste at the site of Wackersdorf in Bavaria. In 1989, this project was also abandoned and the on-going licensing procedure was cancelled. From then onwards, the utilities exclusively turned their attention instead to reprocessing in other European countries.

The reprocessing plant at Karlsruhe was decommissioned in 1990 and is currently in the process of being dismantled. The approximately 60 m³ of highly radioactive solutions of fission products from operation were vitrified at the Karlsruhe Vitrification Plant (VEK) in the period from September 2009 to June 2010. Five casks of type CASTOR® HAW 20/28 CG filled with the 140 canisters produced were transferred to the storage facility *Zwischenlager Nord* (ZLN) of the EWN GmbH in Rubenow near Greifswald.

Although in the former GDR there were large uranium deposits in the Erzgebirge, no nuclear facilities of the nuclear fuel cycle have been constructed or operated on an industrial scale. The fuel assemblies for reactors in Rheinsberg and Greifswald were fabricated in the USSR and delivered, spent fuel was taken back. In 1968, the GDR abandoned breeder research due to safety concerns. In the same year, planning began for a plant for "refabrication of fuel assemblies", called "Komplex 04" for reprocessing of spent fuel for the fast experimental reactor BOR-60 in the USSR. In 1977, the plant went into operation in the USSR. In 1975, the construction of a plant for industrial fabrication of fuel assemblies for the USSR, called “Komplex 05”, was commissioned by the GDR Council of Ministers, but execution was rejected in 1979 by the USSR and then terminated by the GDR [ABE 00, LIE 00].

Spent fuel and radioactive waste management

Initial considerations

A memorandum of the German Atomic Commission, an advisory body of the former Ministry for Atomic Issues, of 9 December 1957 already pointed out the need for comprehensive development in the field of radioactive waste management. Since 1976, the Atomic Energy Act (AtG) [1A-3] contains the requirement of proper disposal of radioactive waste by the introduction of § 9a. Furthermore, the Principles Relating to the Provision to be Made for the Handling and Disposal of Spent Fuel of Nuclear Power Plants, which were amended by decision of the heads of government of the Federation and the *Länder* on 28 September 1979 (printed paper of the German Bundestag 11/1632) stipulated as a prerequisite for licences to commission and operate the nuclear power plants that the guaranteed safekeeping of the spent fuel had to be demonstrated six years in advance.

In the GDR, the office for radioactive residues and wastes (*Zentrale für radioaktive Rückstände und Abfälle*) was established in Lohmen, municipality of Sebnitz with effect from 1 April 1959 with the tasks of registration, transportation, treatment and concentration as well as the emplacement of radioactive residues and wastes [DDR 59]. For centralised registration of radioactive waste, appropriate guidelines were adopted [SZS 65]. The decision made about 10 years later to establish and operate a central repository for low- and intermediate-level radioactive waste led to the closure of the Lohmen site; from 1971, the radioactive waste temporarily stored here were transferred to the Bartensleben salt mine in Morsleben (the later Morsleben repository for radioactive waste, ERAM). In 1983, the Lohmen site was finally closed down.

The sites of today's disposal facilities – as far as they have not been constructed at the sites of nuclear power plants (see Figure A-1) – are shown in Figure D-1.

Reprocessing of spent fuel in other European countries

Until June 2005, spent fuel was transported to France and the United Kingdom for reprocessing. With the German phase-out decision and the amendment to the Atomic Energy Act in 2002 [1A-2], the transfer of spent fuel from power reactors for the purpose of reprocessing has been prohibited with effect from 1 July 2005 and was replaced by the disposal objective of direct disposal of spent fuel.

The separated plutonium from reprocessing is used for the fabrication of MOX fuel and will be completely recycled in German light water reactors. To date (as at 31 December 2013), about 94 % of the plutonium reprocessed before 1 July 2005 was recycled.

Storage of spent fuel

In the 1980s, two central storage facilities were built in Ahaus and Gorleben for the storage of spent fuel but also for radioactive waste from reprocessing. The storage licence according to § 6 AtG was granted for Gorleben in 1995, that for Ahaus in 1997. Another storage facility for the fuel of the decommissioned nuclear power plants Greifswald and Rheinsberg was built near Rubenow and put into operation in 1999. For the fuel pebbles of the AVR, a cask storage facility was built in the Jülich research centre. The storage licence was granted on 17 June 1993 and expired on 30 June 2013. At present, there is no regular licence in place. The storage of radioactive waste is currently based on orders issued by the competent supervisory authority of North Rhine-Westphalia.

Since according to § 9a AtG the transfer of spent fuel to facilities for reprocessing has been prohibited with effect from 1 July 2005, the operators of nuclear power plants are required to furnish proof that provisions for the handling and disposal of the spent fuel and the radioactive waste to be taken back from abroad have been made by the provision of adequate storage possibilities with the objective of disposal. This requirement has been met with the construction and operation of on-site storage facilities for spent fuel storage until delivery to a facility of the Federation for disposal.

On-site storage facilities for spent fuel in transport and storage casks were built and put into operation at twelve nuclear power plant sites (see Table L-4). An exception is the decommissioned Obrigheim nuclear power plant for which it is intended to transfer the spent fuel to the on-site storage facility of the Neckarwestheim nuclear power plant. An application for the corresponding change of the licence of the Neckarwestheim on-site storage facility has been filed. The spent fuel is currently stored in a wet storage facility at the Obrigheim site.

Conditioning of spent fuel

The licensing procedure for the Gorleben pilot conditioning plant (PKA), which has been designed for the conditioning of spent fuel for direct disposal, was concluded in December 2000 with the granting of the third partial construction licence. According to a collateral clause in the licensing decision, its operation is currently limited to the possibly required repair of defective transport and storage casks for spent fuel and HAW glass canisters.

Pretreatment, conditioning and storage of radioactive waste

By means of conditioning of the radioactive waste, intermediate or final products shall be produced which fulfil the requirements on safe handling, storage and transport also for the period of a longer-term storage.

Waste that cannot be stored in the long term for safety reasons is to be conditioned without any delay. The conditioning of the raw waste of the nuclear facilities and facilities in compliance with the requirements for disposal is the responsibility of waste producers.

Conditioning comprises the treatment and/or packaging of radioactive waste. Depending on the composition and condition of the radioactive waste, methods and equipment proven to be appropriate over many years are used. Some conditioning procedures are performed in mobile or stationary facilities at the power plant site, for other procedures, the raw waste is transferred to external stationary facilities and the conditioned waste produced returned.

Disposal

In the Federal Republic of Germany, disposal began with the rededication of the former salt mine **Asse II** in 1965. Between 1967 and the end of 1978, about 47,000 m³ of low- and intermediate-level radioactive waste were emplaced here in different types of packages. Since 1988, there has been a continuous inflow of groundwater from the overburden into the mine. At the same time, the stability of the mine started to deteriorate successively due to the pressure of the overlying overburden and the decreasing load-carrying capacity of the mine workings.

According to § 57b AtG [1A-3], the Asse II mine must therefore be decommissioned immediately. The Federal Office for Radiation Protection (BfS), as the responsible operator of the facility, applied for the initiation of a plan approval procedure under nuclear law at the Lower Saxony Ministry for the Environment and Climate Protection (NMU) in written form on 11 February 2009.

The BfS has examined how the Asse II mine can be shut down safely in the context of a comparison of three closure options. The possibilities of retrieval, internal relocation of the waste and complete backfilling of the mine were considered. On 15 January 2010, the BfS announced that, taking the present state of knowledge into account, the complete retrieval of all waste would be the best closure option. On 20 April 2013, the Atomic Energy Act was amended by the Act to speed up the retrieval of radioactive waste and the closure of the Asse II (*Gesetz zur Beschleunigung der Rückholung radioaktiver Abfälle und der Stilllegung der Schachtanlage Asse II*, “Lex Asse“) [1A-26]. Thereby the retrieval of the nuclear waste from the Asse II mine is legally laid down as the closure option to be pursued as long as this is justifiable for the employees and the public regarding radiological and safety-relevant reasons. Furthermore, legal provisions are created to speed up the retrieval. § 57b AtG has been revised. Accordingly, closure shall take place after retrieval of the radioactive waste. Retrieval shall be discontinued if its performance is not acceptable for the population and the employees for radiological or other safety-relevant (e.g. mining-related) reasons. If the retrieval and any other option for closure are only possible with deviation from the legal requirements, a decision is taken on the best possible closure option with the participation of the German Bundestag and the public after weighing up the advantages and disadvantages.

In order to ensure the safety of the employees and the public in case of waste retrieval and to be able to draw up concrete plans, more detailed knowledge of the boundary conditions is required. First step of the fact finding provided for this is the drilling into two emplacement chambers for investigating the condition of the chambers and of the waste packages.

Furthermore, retrieval requires sinking of a new shaft (Asse V shaft). The first exploratory drilling for it started on 5 June 2013. With the help of the drilling, the geology of the rock formations will be explored up to a depth of around 790 metres. The objective is to determine the suitability of the planned shaft location and to obtain additional data on the geological structure of the Asse. Should the exploratory drillings show positive results, this location is intended for the construction of the recovery shaft and new underground infrastructure areas.

To gain time for the implementation of retrieval, comprehensive stabilisation measures are currently being performed in the mine workings.

The concept for the retrieval of the radioactive waste provides for recovering all the waste, to transport it above ground in transport casks and to condition it there. For this purpose, a sufficiently large storage facility with conditioning plant needs to be planned and built. As a planning basis, the BfS assumes that all waste and an additional amount of contaminated crushed salt have to be conditioned and stored. The BfS has proposed criteria [BfS 12] on the basis of which a selection and evaluation of potential sites is possible. First of all, according to a BfS proposal, sites shall be investigated that can be connected to the premises of the Asse II.

For the **Konrad mine**, a former iron ore mine, plan approval regarding the construction and operation of a repository for radioactive waste with negligible heat generation was granted in May 2002. The complaints raised against the decision were rejected so that the decision has thereby become definitive. With letter dated 30 May 2007, the BfS was commissioned by the BMU with the conversion of the Konrad mine.

After having adapted the planning to the advanced state of the rules and regulations and other provisions of the Federation, conversion work was started. The Federation commissioned the company DBE with the conversion of the Konrad mine into a repository. The new date given by the DBE in the draft framework schedule for commissioning of the Konrad mine repository is the year 2022. However, the BfS holds the view that the date given by the DBE is subject to uncertainties that, according to the current state, are not quantifiable in detail and also have not been finally evaluated by the Federal Government yet.

Since 1979, the salt dome located at the **Gorleben site** has been investigated geoscientifically for its suitability as a host rock for a repository, in particular for heat-generating radioactive waste. Against the background of the agreement on ending the use of nuclear energy, the work for exploration of the Gorleben salt dome was suspended from October 2000 to September 2010 to clarify conceptual and safety-related issues in the context. At the end of 2005, the BfS presented the results of the related investigations with respect to the disposal in salt rock compared to other host rocks. In October 2010, the exploration of the Gorleben salt dome was resumed. On the basis of the new "Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste" [BMU 10] work to carry out a preliminary safety analysis for a possible repository in Gorleben was carried out in 2010. On 31 March 2013, the work was concluded without the originally planned explicitly preliminary suitability forecast for the Gorleben site. The underground exploration at the Gorleben site was discontinued in November 2012. With entry into force of the Site Selection Act (StandAG) on 27 July 2013, the mining activities for exploration at the Gorleben site were completed. In the new selection procedure, the Gorleben site will receive equal consideration. Exploration can be resumed only in the context of the site selection procedure as far as the site will not be excluded from the selection procedure. Meanwhile, the mine is kept open in such a way to ensure that all legal requirements are complied with and that it is maintained as necessary.

A decision by law on a repository site in particular for heat-generating radioactive waste in Germany is expected by 2031. This will be followed by a licensing procedure and the construction of the repository.

In the former GDR, the search for a central repository for low- and intermediate-level radioactive waste began in the late 1960s. The choice fell on the salt mine Bartensleben in Morsleben. After investigations and first trial emplacements of radioactive waste from the Lohmen storage facility, a temporary licence was initially granted for the **Morsleben repository for radioactive waste (ERAM)** for 5 years in 1981. This was followed by a permanent operating licence of unlimited validity granted on 22 April 1986. After German reunification, the ERAM was operated by the BfS and used for the emplacement of low-and intermediate-level radioactive waste from all over Germany until September 1998. In the period from 1971 to 1998, about 36,800 m³ of radioactive waste and about 6,600 disused sealed radiation sources were disposed of in this facility with a total activity of around 10^{14} Bq. In response to a technical re-evaluation, the BfS irrevocably waived further emplacement operation in Morsleben in 2001, as this was deemed no longer justifiable from the safety point of view. Since the end of emplacement operations, the plan approval procedure for backfilling and sealing of the ERAM has been pursued which the BfS had already applied for on 9 May 1993.

New legislation on the issue of disposal in particular for heat-generating radioactive waste

In April 2013, the Federation, the *Länder* and the political parties agreed on establishing new regulations on the issue of disposal in particular of heat-generating radioactive waste. The Act on the search for and selection of a site for a repository for heat-generating radioactive waste and for the amendment of other laws (*Gesetz zur Suche und Auswahl eines Standortes für ein Endlager für Wärme entwickelnde radioaktive Abfälle und zur Änderung anderer Gesetze*, Site Selection Act – StandAG) entered into force on 27 July 2013 [1A-7].

This Act regulates the new nationwide search for a suitable repository site in particular for heat-generating radioactive waste in a multi-step process. In preparation of the site selection procedure, a "Commission on Storage of High-Level Radioactive Waste" (Commission) was established to discuss the relevant fundamental issues for the selection procedure and to develop proposals for decision making. Further, its task is to evaluate the contents of the Act and to involve the public in its work.

Furthermore, a new regulatory authority is to be established for the site selection procedure with the Federal Office for Nuclear Waste Management (BfE).

A pluralistic committee to represent public interests is to accompany the selection process oriented towards the common good. An essential element of the new Act is a comprehensive and systematic participation of the public by, among others, public meetings, offers of dialogue, opportunities to take a stand and making use of diverse media.

The objective of the site selection procedure is to develop a proposal for a repository site via several steps, including

- the definition of requirements and criteria, decided on by the German Bundestag (Federal Parliament) by law,
- identification of potential site regions and exclusion of areas with unfavourable conditions, decided on by the German Bundestag by law,
- selection of sites for above-ground exploration,
- specification of site-related exploration programmes and examination criteria as well as the performance of above-ground exploration,
- selection of sites for underground exploration, decided on by the German Bundestag by law,
- specification of in-depth geological exploration programmes and site-specific examination criteria as well as the performance of underground exploration, and
- a final site comparison.

This site proposal will be decided on by the German *Bundestag* by federal law. The decision on the site will be followed by the licensing procedure according to § 9b, para. 1a AtG [1A-3].

Tailings from uranium mining

In 1946, a Soviet owned stock company began mining uranium ore on the territory of was later to become the GDR, as from 1954 these operations were continued by the Soviet-German Wismut joint-stock company. The mining of uranium ore was discontinued at the end of 1990 following German reunification. Uranium ore mining has left considerable environmental damage which since then has been remediated by the federally-owned company Wismut GmbH. The residues left over from the former uranium ore mining do not count as radioactive waste but, due to the great interest in this issue, details on the related activities are given in a report attached separately.

A.3 Overview

Table A-2 below has been added according to a decision of the second Review Meeting and provides an overview of the situation regarding the treatment of spent fuel and radioactive waste in Germany. The Morsleben repository for radioactive waste (ERAM) is regarded to be a completed waste management path.

Table A-2: Treatment of spent fuel and radioactive waste in Germany

Waste management task	Long term strategy	Financing	Current practice/ facilities	Planned facilities
Spent fuel	Interim storage in casks; subsequently conditioning and possibly direct disposal in deep geological formations; in the case of spent fuel for research reactors transport to the country of origin or disposal	Setting aside provisions for nuclear asset retirement by installations owned by the utilities for the future costs of waste conditioning and for construction, operation and closure of a repository; refunding as adequate for the generator of the costs incurred by the Federation; financing from public funds in the case of state-owned installations (polluter-pays principle)	Four central dry storage facilities, 12 dry storage facilities at the nuclear power plant sites, one wet storage facility (Obrigheim)	Repository planned; site selection procedure according to the Site Selection Act (StandAG)
Radioactive waste from the nuclear fuel cycle and the operation of the nuclear power plants	Interim storage at the site of origin or centrally with the aim of disposal in deep geological formations	See “Spent fuel” (polluter-pays principle)	Conditioning and interim storage (at the site of origin or centrally)	Waste with negligible heat generation: Konrad repository licensed; in the process of refitting; commissioning not before 2022 Heat-generating waste: one repository planned; site selection procedure according to Site Selection Act (StandAG)
Other radioactive waste	Interim storage at central sites with the aim of disposal in deep geological formations	Waste generators pay fees to the *Land* collecting facilities (polluter-pays principle); *Land* collecting facilities pay repository cost portion to the Federation	Conditioning and interim storage (*Land* collecting facilities)	Konrad repository licensed; in the process of refitting; commissioning not before 2022
	Retrieval of the waste from the Asse mine	Federation	Fact finding and planning of conditioning and storage as well as stabilisation of the mine workings	Decision on the future repository not taken yet
Decommissioning of nuclear facilities	Dismantling of the facility and release of all buildings and land areas from the obligations under the Atomic Energy Act	Setting aside provisions for nuclear asset retirement by installations owned by the utilities and in the case of nuclear fuel cycle installations; financing from public funds in the case of state-owned installations (polluter-pays principle)	Immediate dismantling or safe enclosure	If required, storage capacities for waste from decommissioning
Disused radiation sources	Transfer to the manufacturer, carrier or dispatch to a *Land* collecting facility with the objective of disposal in a deep geological formation	Waste generators pay fees to the *Land* collecting facilities (polluter-pays principle); *Land* collecting facilities pay repository cost portion to the Federation	Repackaging by the manufacturer or conditioning and storage as radioactive waste (*Land* collecting facilities)	Konrad repository licensed; in the process of refitting; commissioning not before 2022

B Policies and practices

This section deals with the obligations under Article 32 (1) of the Convention.

> *Article 32 (1): Reporting*
>
> *(1) In accordance with the provisions of Article 30, each Contracting Party shall submit a national report to each review meeting of Contracting Parties. This report shall address the measures taken to implement each of the obligations of the Convention. For each Contracting Party the report shall also address its*
>
> *i) spent fuel management policy;*
>
> *ii) spent fuel management practices;*
>
> *iii) radioactive waste management policy;*
>
> *iv) radioactive waste management practices;*
>
> *v) criteria used to define and categorise radioactive waste.*

B.1 Reporting

The report explains the situation regarding the safe management of spent fuel in Germany. In Germany, the reprocessing of spent fuel would be classified under “management” in terms of this Convention. However, as Germany has delivered spent fuel to France and the United Kingdom for reprocessing, it will not be reported here on the reprocessing of German spent fuel. There is no spent fuel used in the military sector in Germany, and hence there is also no need to report on this aspect.

The report also explains the situation regarding the safe management of radioactive waste in Germany in the scope of this Convention. Waste with increased proportions of naturally occurring radioactive material (NORM) (see reporting on Article 3 (2)) is included in the scope of application. Waste assigned to the military sector is excluded from reporting, since management of the latter does not fall within the scope of civil supervision.

The reporting relating to Article 6 deals exclusively with general issues of decommissioning. Details on the facilities currently in the process of decommissioning can be found in the reporting related to Article 32 (2) v).

In Germany, disposal in deep geological formations is intended for all types of radioactive waste.

B.1.1 Spent fuel management policy

Germany's objective regarding the management of spent fuel has changed. Until 1994, the Atomic Energy Act (AtG) [1A-3] included the requirement of reusing the fissile material in the spent fuel. This requirement changed in 1994, and the operators of nuclear power stations then had the option of either reuse by means of reprocessing, or else of direct disposal.

Since 1 July 2005, delivery of spent fuel from commercial electricity production for the purposes of reprocessing has been prohibited in accordance with an amendment of the Atomic Energy Act to this effect of 22 April 2002 [1A-2]. The last spent fuel to be delivered for reprocessing was dispatched from the Stade nuclear power plant in May 2005. Now, only the direct disposal of the spent fuel existing and being generated in future in Germany as radioactive waste is permissible.

For the spent fuel which had been delivered for reprocessing until 30 June 2005, the proof of reuse of the recycled plutonium separated during reprocessing must be kept. This is designed to ensure that throughout the remaining residual operating lives of the nuclear power plants, all separated plutonium will be processed in the fabrication of MOX fuel and thus be reused.

As there is as yet no repository available for the spent fuel, it will generally be stored at the sites where it was generated until such time as a repository is commissioned; corresponding storage capacities exist as needed.

Usually, the spent fuel from research reactors will be returned to its country of origin. If this is not possible, it will be stored until its final transportation to a repository.

B.1.2 Spent fuel management practices

The reprocessing of the spent nuclear fuel delivered to France and the United Kingdom until 30 June 2005 has been completed. During the period since the last report, the operators of the nuclear power plants have provided evidence of the safe reuse of all plutonium generated by means of its reuse as MOX fuel in reactors, and the safe storage of all uranium.

All other types of spent fuel remaining in Germany, and those which will continue to be generated will be stored until their final transportation to a repository. For this purpose, interim storage facilities have been constructed at the sites of the nuclear power plants. The spent fuel is stored dry in casks licenced for transport and storage. Spent fuel from decommissioned power reactors of Soviet design at Greifswald and Rheinsberg are likewise stored dry in casks at a central storage facility (*Zwischenlager Nord* - ZLN) in Rubenow.

For the shut-down Obrigheim nuclear power plant, which currently operates a wet storage facility, transport of casks with spent fuel to the Neckarwestheim on-site storage facility for dry storage is planned. An application for the corresponding change of the licence of the Neckarwestheim on-site storage facility has been filed.

B.1.3 Radioactive waste management policy

On 28 June 2013, the German Bundestag passed, the Act on the search for and selection of a site for a repository for heat-generating radioactive waste and for the amendment of other laws (*Gesetz zur Suche und Auswahl eines Standortes für ein Endlager für Wärme entwickelnde radioaktive Abfälle und zur Änderung anderer Gesetze*, Site Selection Act – StandAG) [1A-7]. The site selection act entered into force on 27 July 2013. The objective is to find a site for a repository in particular for high-level radioactive waste which ensures the best possible safety for a period of one million years. The site selection procedure is to be concluded by 2031. The actual procedure for site selection is preceded by the work of a "Commission on Storage of High-Level Radioactive Waste" (Commission), whose task it is to examine and assess the relevant fundamental issues for the selection procedure with regard to radioactive waste management and to develop proposals for decision making and for a policy recommendation for the German *Bundestag* and the *Bundesrat*. The results of the Commission, which met for the first time on 22 May 2014, will be submitted until 31 December 2015 (which may be extended once for further six months) in the form of a report. In this report, it should take a position on decisions taken so far and predefinitions as regards the issue of disposal. The Commission is to evaluate the StandAG [1A-7] and, where appropriate, make proposals for further development.

The legal requirement is that prior to disposal, all steps of treatment of the radioactive waste are subjected to the polluter-pays principle. Disposal itself is the responsibility of the Federal Government.

In accordance with this principle, the state obligates the producers of waste by law to ensure the controlled and safe management of radioactive waste generated during the operation and decommissioning of nuclear facilities (such as nuclear power plants and research centres). As such, they operate or order facilities in which the radioactive waste incurred may be treated and stored until its disposal; this may take place either in decentralised or centralised facilities.

Furthermore, they are also responsible for the safe management of the radioactive waste resulting from the reprocessing of German spent fuel in France and the United Kingdom following its return, which Germany is under obligation to accept.

Where not stored by the producer, radioactive waste from research, industry and medicine must be deposited in *Land* collecting facilities provided by the *Länder*. The Federation is obliged to accept the waste from these storage facilities for disposal if it cannot be cleared after the radioactivity has decayed.

To demonstrate the safety of a repository, the German concept of disposal of radioactive waste with negligible heat generation in deep geological formations provides evidence for the backfilling of cavities and the sealing of drifts and shafts. Measures for retrieval after sealing of a repository are not part of this concept.

B.1.4 Radioactive waste management practices

Only stable (or fixed) radioactive waste will be accepted for disposal in deep geological formations; liquid and gaseous waste is excluded from acceptance. The controlled, safe disposal of radioactive waste therefore requires its conditioning.

Conditioning comprises several stages, depending on the quality and nature of the raw waste. After targeted collection or grading (where necessary), the raw waste may first be pretreated and then be either processed into interim products or directly into packages suitable for storage or disposal.

Proven methods and reliable mobile or stationary installations already exist for the pretreatment and conditioning of radioactive waste. Mobile conditioning installations are the preferred choice for the treatment and packaging of operational waste from nuclear power plants. Stationary installations which are capable of conditioning various different types of raw waste tend to be used primarily at the major research centres; there are also a number of other stationary conditioning installations which are operated on site by the respective waste generators.

In addition to German facilities, facilities in other European foreign countries are also utilised for waste management. Radioactive waste generated from the operation of nuclear facilities is delivered to Sweden for conditioning and subsequently returned to Germany.

Both central and decentralised storage facilities are available for the interim storage of radioactive waste with negligible heat generation from nuclear power plants and the nuclear industry. For waste generated from the use and handling of radioisotopes in research, industry and medicine (see reporting on Article 32 (1) iii), *Land* collecting facilities operated by the *Länder* are available for storage.

On the basis of the current licensing situation, heat-generating radioactive waste may be kept in storage in decentralised and central storage facilities. Waste from the reprocessing of spent fuel from German power reactors is conditioned in France and the United Kingdom (e.g. vitrification of the high-level fission product solutions) and is then returned to Germany. Until the end of 2013, the Gorleben storage facility was provided for the storage of vitrified waste. For the return of the CSD-B waste from France and HAW waste from the United Kingdom still to be performed, the Site Selection Act (StandAG) requires the establishment of on-site storage facilities. According to § 6, para. 5 AtG, the storage of nuclear fuel in nuclear plants shall not exceed 40 years starting at the first emplacement of a cask.

B.1.5 Criteria used to define and categorise radioactive waste

Radioactive residues are produced during the operation of nuclear facilities and installations, as well as during the decommissioning or dismantling of such facilities. These residues are composed of reusable or recyclable materials and radioactive waste. Radioactive waste refers to materials that cannot be safely reused and which must therefore be disposed of in a controlled way (see definitions in § 2 AtG and DIN 25401 [DIN 25401], regulations governing recycling and disposal in § 9a AtG and § 29 of the Radiation Protection Ordinance (StrlSchV) (StrlSchV) [1A-8]). The aforementioned activities may also generate material which is only marginally contaminated or activated.

Provided such material is proven to comply with the clearance levels stated in Appendix III, Table 1 to § 29 StrlSchV, it may be released and utilised, removed, owned or forwarded to third parties as non-radioactive materials (see reporting on Article 24 (2) I and ii). The compliance with the release limits ensures that during the reuse or the disposal of radioactive waste any noticeable exposure of the general public is precluded. There is a range of possibilities for the reuse of radioactive waste. Released tools and installations from decommissioned plants may be used e.g. in other nuclear power plants or in conventional plants. Metals may be recycled by melting them down. Rubble may be used as raw material in road-building, for backfilling of landfill or for the production of concrete. For electronic scrap, conventional recycling is applied, too.

In Germany, disposal in deep geological formations is intended for all types of radioactive waste. This 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 order to separate the radioactive waste generated in this way.

The proper registration and description of waste is an essential prerequisite of radioactive waste management. In accordance with the German approach to disposal, the definition and categorisation of radioactive waste (i. e. its classification) must therefore comply with the requirements for safety assessment of an underground repository. In this respect, the effects of heat generation from radioactive waste on the design and evaluation of a repository system are particularly important, since the natural temperature conditions may be significantly altered by the deposited waste. In order to meet the requirements concerning the registration and categorisation of radioactive waste from the point of view of disposal, it has been decided to refrain from using the terms LAW, MAW and HAW and to choose instead a new classification, which was made under particular consideration of aspects relevant for disposal and is based on the intention to dispose of all types of radioactive waste in deep geological formations. Accordingly, waste is initially subjected to a basic subdivision into

- heat-generating waste and
- waste with negligible heat generation

followed by a detailed classification according to the categorisation scheme established for this purpose.

This basic subdivision into heat-generating waste and waste with negligible heat generation will also be made if the waste packages to be disposed of are kept in long-term surface storage prior to transportation to a repository. Irrespective of this, the terms "low-active waste" (LAW) or "medium-active waste" (MAW) are used in exceptional cases for historical reasons. This is due to the fact that for the emplacement of radioactive waste in the Asse II mine and in the ERAM repository the waste was classified according to different criteria and the waste categories LAW and MAW were used during the operational phase.

In connection with the presentation of the national waste management programme required by Council Directive 2011/70/EURATOM of 19 July 2011, information and data on the quantity of radioactive waste and spent fuel are also submitted to the EU Commission according to a classification of the IAEA [IAEA 09a].

Heat-generating radioactive waste is characterised by high activity concentrations and thus by a high decay heat; this waste places special demands on the design and operation of a repository in deep geological formations (use of special emplacement techniques, thermal design of the repository mine). This type of waste includes, in particular, the fission product concentrate, hulls, structural components and feed sludge from the reprocessing of spent fuel, and the spent fuel itself if it is to be disposed of directly as radioactive waste.

Wastes with clearly lower activity concentrations from the operation, decommissioning and dismantling of nuclear facilities and facilities as well as from the application of radioisotopes are classified among the radioactive waste with negligible heat generation. This encompasses e.g. disused plant components and defective components such as pumps or piping, ion exchange resins and air filters from waste water and exhaust air decontamination, contaminated tools, protective clothing, decontamination, cleaning agents, laboratory waste, sealed radiation sources, sludges, suspensions, oils as well as contaminated and activated concrete structures and debris.

The term “radioactive waste with negligible heat generation” was quantified within the scope of the planning work for the Konrad repository. The objective of the related work was that the temperature conditions prevailing underground will only be influenced by the waste packages emplaced to a negligible extent. The realisation of this planning requirement eventually led to the quantitative stipulation that the increase in temperature at the wall of the disposal chamber caused by decay heat from the radionuclides contained in the waste packages must not exceed 3 K on average. This value is roughly equivalent to the temperature difference which occurs with a difference in depth of 100 m in the natural temperature environment, and is low compared to the change of temperature caused by ventilation. Compliance with the 3 Kelvin criterion was taken into account in connection with the safety-related analyses regarding the thermal influence on the host rock and is ensured by the limitation of the radionuclide-specific activity per waste package. These limits are laid down in the plan approval notice for the Konrad repository of 22 May 2002.

This classification makes it possible, in particular, to register the data for waste/waste packages required for description and characterisation, and therefore ensures the necessary degree of flexibility with respect to the many different types of waste as well as any changes/new developments in conditioning. It subdivides the different waste streams according to origin, waste container, immobilisation and waste type. With regard to the origin of the radioactive waste, a distinction is generally made between different parties obliged to deliver/hand over waste. Cast-iron containers, concrete containers or box-shaped containers are predominantly used for packaging radioactive waste, whilst cement and concrete are widely used for the purposes of immobilisation. Regarding waste type, it would seem appropriate to use a standardised nomenclature (see Appendix X of the Radiation Protection Ordinance (StrlSchV) [1A-8]). A more precise grouping can be achieved by further subdividing or supplementing this rough categorisation. This categorisation scheme allows the description of radioactive waste to be systematised in a way which fulfils the requirements for proper registration and description of the waste arising to be disposed of.

On this basis, further elaboration, including a site-specific safety assessment for a repository in deep geological formations, eventually leads to facility-related waste acceptance requirements, stipulating quantitative requirements governing radioactive waste which is intended for disposal. The requirements governing the acceptance of radioactive waste for disposal" (*Endlagerungsbed-ingungen*, last edited: October 2010, Konrad Mine) [BfS 10] is one such example. These requirements specify the final description or categorisation of waste from a repository-specific point of view.

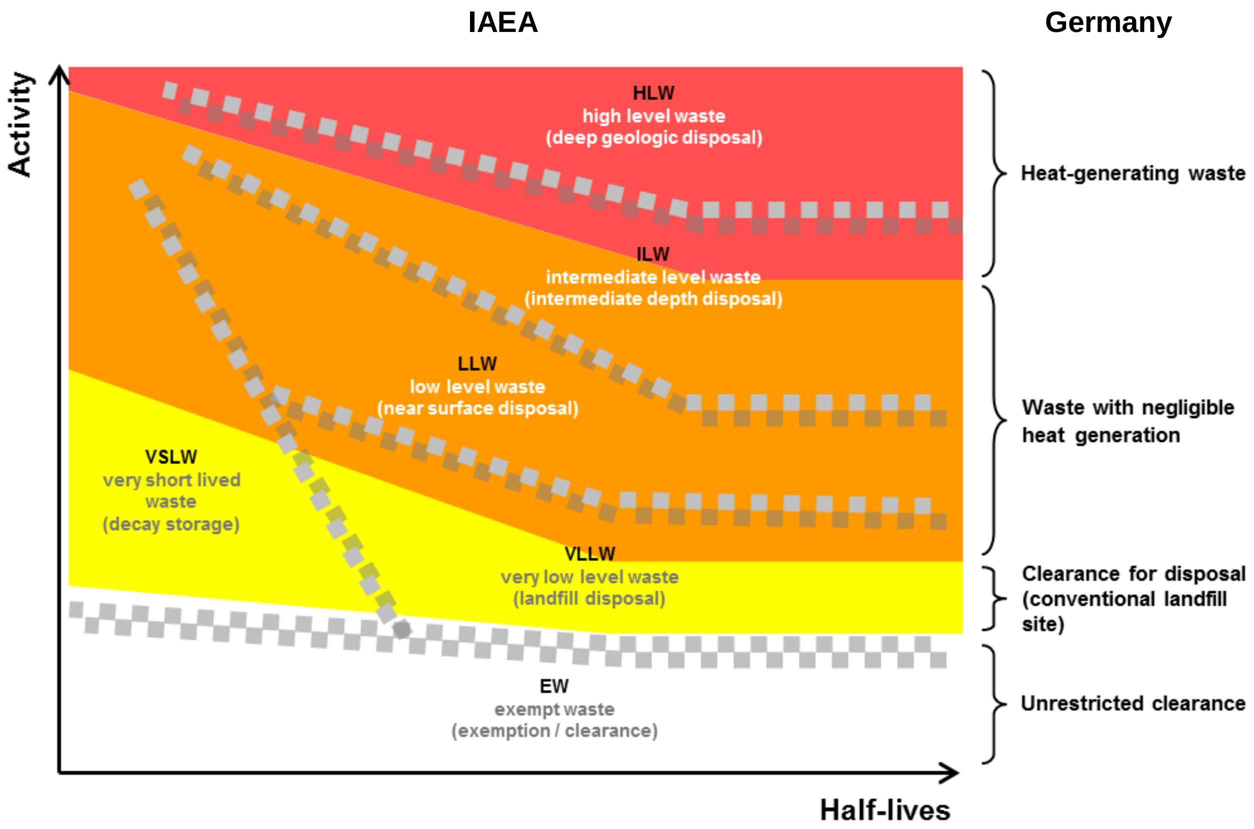
The waste categorisation according to heat-generating waste and waste with negligible heat generation has proven expedient. It is compatible with the IAEA proposal for classification [IAEA 09a] which additionally permits a further subdivision into short-lived and long-lived waste, thus allowing waste to be assigned to near-surface repositories and geological repositories.

In its General Safety Guide No. GSG-1 "Classification of Radioactive Waste" [IAEA 09a], the IAEA has recommended a classification scheme according to the following waste types:

- Exempt Waste (EW), no longer subject to regulatory control,
- Very Low-Level Waste (VLLW), disposal in special landfill type facilities,
- Very Short-Lived Waste (VSLW), decay storage,
- Low-Level Waste (LLW), disposal in a near-surface repository,
- Intermediate-Level Waste (ILW), disposal at intermediate depth, and
- High-Level Waste (HLW), disposal in deep geological formations.

Figure B-1 provides a comparison of the IAEA waste classification and the German classification. The figure shows that the waste which according to the German classification is referred to as heat-generating waste (red area) yet reaches into the area of ILW and that certain waste referred to as VLLW according to the IAEA already exceeds the current German clearance levels for management as conventional waste and therefore has to be disposed of in the Konrad repository. In general, it can be stated that the German classification blends in with the international classification with only slight deviations.

Figure B-1: Comparison of the IAEA waste classification and the German classification



C Scope of application

This section deals with the obligations under Article 3 of the Convention.

Article 3: Scope of application

(1) This Convention shall apply to the safety of spent fuel management when the spent fuel results from the operation of civilian nuclear reactors. Spent fuel held at reprocessing facilities as part of a reprocessing activity is not covered in the scope of this Convention unless the Contracting Party declares reprocessing to be part of spent fuel management.

(2) This Convention shall also apply to the safety of radioactive waste management when the radioactive waste results from civilian applications. However, this Convention shall not apply to waste that contains only naturally occurring radioactive materials and that does not originate from the nuclear fuel cycle, unless it constitutes a disused sealed source or it is declared as radioactive waste for the purposes of this Convention by the Contracting Party.

(3) This Convention shall not apply to the safety of management of spent fuel or radioactive waste within military or defence programmes, unless declared as spent fuel or radioactive waste for the purposes of this Convention by the Contracting Party. However, this Convention shall apply to the safety of management of spent fuel and radioactive waste from military or defence programmes if and when such materials are transferred permanently to and managed within exclusively civilian programmes.

(4) This Convention shall also apply to discharges as provided for in Articles 4, 7, 11, 14, 24 and 26.

C.1 Reprocessing of spent fuel

The scope of this Article and therefore the obligation of reporting encompasses the safety of the management of the spent fuel from German nuclear power plants and research reactors which is stored with the intention of disposal. German spent fuel which was delivered to France or the United Kingdom for reprocessing does not fall within the scope of this Article, and is therefore not subject to reporting.

Spent fuel from research reactors which is returned to its country of origin is also outside the scope of this Convention and is therefore exempt from reporting in this report.

C.2 Distinction between NORM and radioactive waste

The European Council Directive 96/29/EURATOM on basic radiation protection standards was revised and replaced by Council Directive 2013/59/EURATOM [1F-24] of 5 December 2013 (publication in the Official Journal of the European Union on 17 January 2014). The transposition of the new Directive into national radiation protection legislation of the member countries must be made by 6 February 2018. The following still refers to the current legal situation, which is based on the earlier Council Directive 96/29/EURATOM. Accordingly, a distinction is drawn between regulations for radioactive material from nuclear facilities and other handling licensed according to radiation protection legislation on the one hand, and waste that contains only naturally occurring radioactive material (NORM). For NORM, some of the applicable requirements (e.g. with regard to exemption provisions) are principally different from requirements applicable to radioactive material from nuclear facilities and other handling, which is licensed according to nuclear or radiation protection legislation. In keeping with the Basic Safety Standards of the European Union applicable so far, the German Radiation Protection Ordinance (StrlSchV) [1A-8] makes a distinction between

- practices, which are regulated in Part 2 StrlSchV and which refer to the use of radioactive material and ionising radiation, and
- work activities, which are regulated in Part 3 StrlSchV and which refer to natural sources of radiation.

The distinction between these two terms is explained in the following on the basis of the definitions provided in § 3 StrlSchV.

C.2.1 Practices

The term "practices" refers to the use of a material's radioactive properties. This may include, for example, the operation of nuclear facilities, spent fuel production, isotope production, and applications of radioactive material, especially radiation sources, e.g. in industry and research. The safety of radioactive waste management as defined by this Article of the Convention encompasses all radioactive waste from practices. This is further dealt with in this national report.

C.2.2 Work activities

The term "work activities" refers to actions involving materials which, although containing naturally occurring radionuclides, are not used for their radioactive properties. Of importance for the protection of the population is the recycling or removal of residues from certain industrial processes with elevated contents of naturally occurring radionuclides of the U-238, U-235 and Th-232 decay chains. Examples include excavated materials from mining activities, fly ashes from combustion processes, residues from flue-gas purification of coal-fired power plants and slag from ore smelting. So, among other things, their use as construction aggregate is to be limited. Until now, no radioactive wastes in terms of this Convention have originated from work activities. In the following, an overview is given of the fields of work and the related residues with increased natural radioactivity.

Overview

In its Part 3, the Radiation Protection Ordinance (StrlSchV) regulates the protection of man and the environment against natural radioactivity in connection with work activities (§§ 93 to 103 StrlSchV [1A-8]). The regulations referring to residues and other materials from work activities are found in §§ 97 to 102 StrlSchV. The radiological protection goal for individuals of the population is set to 1 mSv per calendar year by § 97, para. 1 StrlSchV.

According to § 97, para. 1 StrlSchV, anyone engaged or permitting engagement on his own responsibility in work activities where residues requiring surveillance accumulate and where the utilisation or disposal thereof may cause the effective dose reference criterion for the general public of 1 mSv per calendar year to be exceeded shall take measures for the protection of the general public. The requirement for surveillance of these residues is regulated in § 97, para. 2 in conjunction with Part A StrlSchV. Appendix XII, Part A includes the list of residues which have to be taken into account with specification of the application areas and branches in which such residues may arise and which may, in principal, lead to exceeding the 1 mSv/a dose criterion. The list includes the following materials:

1. Sludge and sediments from the recovery of oil and natural gas;
2. Unconditioned phosphoric plasters, sludge from their preparation as well as dust and cinder from the processing of raw phosphate (phosphorite);
3. a) country rock, sludge, sand, cinder and dust
   - from the extraction and preparation of bauxite, columbite, pyrochlore, microlyth, euxenite, copper shale, tin, rare earths and uranium ores,
   - from the processing of concentrates and residues that occur with the extraction and preparation of these ores and minerals, as well as

   b) minerals corresponding to the above specified ores that occur with the extraction and preparation of other raw materials.
4. Dust and sludge from the smoke gas filtering with the primary metallurgic processes in the raw iron and non-ferrous metallurgy.

Residues according to § 97 StrlSchV [1A-8] are also

a) materials in accordance with the subparas. 1 ff., when the occurrence of these materials is deliberately produced,

b) castings from the materials specified in subparas. 1 ff., as well as

c) excavated or cleared ground and demolition waste from the dismantling of buildings or other structures when these contain residues in accordance with the subparas. 1 ff. and are removed in accordance with § 101 StrlSchV after completion of the work activities or in accordance with § 118, para. 5 StrlSchV or from properties.

The possibility of exceeding the 1 mSv/a dose criterion has been carefully checked for each of the listed residues by extensive studies during the development phase of these regulations. These studies have been based on the actual material streams in Germany and have taken account of exposure conditions which would be typical for Germany.

Release from surveillance

Residues from the list given above are initially assumed to require surveillance. However, if the specific activity of those residues is lower than the surveillance limits provided in Appendix XII, Part B StrlSchV [1A-8], surveillance is not required according to § 97, para. 2 StrlSchV. If the surveillance limits are exceeded and it can be demonstrated in a case-specific evaluation according to § 98, para. 1 StrlSchV that the 1 mSv/a dose criterion is not exceeded, the competent authorities of the respective Federal State may release the residues from surveillance. The criteria listed in Appendix XII, Part C StrlSchV can be applied in this procedure.

The surveillance limits provided in Appendix XII, Part B StrlSchV have been derived on the basis of extensive radiological studies. If they are complied with, it is at the same time assured that the 1 mSv/a dose criterion will not be exceeded. The surveillance limits are a tiered set of specific activity values (in Bq/g) referring to the greatest values of any nuclide in the decay chains of U-238sec and Th-232sec. The limit values range from 0.2 Bq/g to 5 Bq/g, depending on the kind of intended use or disposal. When applying the surveillance limits, a summation rule has to be observed.

Residues remaining under surveillance

If it is not possible to release a specific kind of residues from surveillance, it has to remain in surveillance. The corresponding procedure is laid down in § 99 StrlSchV [1A-8]. It prescribes that the person who is responsible according to § 97, para. 1 StrlSchV must declare to the competent authority within one month the type, mass and specific activity of the residues requiring surveillance as well as any intended disposal or utilisation of these residues or delivery. The competent authority may rule that protective measures are to be taken and may specify the manner in which the residues are to be disposed of.

In those cases where a disposal of the residues remaining under surveillance is required, means for storage of the residues, if necessary under institutional control, have to be generated in order to comply with the protection targets.

In order to cover unforeseen cases or potential incompleteness of the regulations in Appendix XII, Part A StrlSchV, § 102 StrlSchV has been introduced to provide a rule for such cases where due to work with materials that are not residues according to Appendix XII, Part A StrlSchV or due to the execution of work where such materials accumulate, the radiation exposure of members of the public is increased so significantly that radiation protection activities are necessary. In such cases, the competent authority takes the appropriate measures, in particular by prescribing that certain protective measures are to be taken, that the materials are to be kept or stored at a site designated by it, or that and how the materials are to be disposed of.

Experience from application of the regulations

Compliance with the surveillance limits or the dose criterion with respect to the residues has been verified for a large number of companies using higher level NORM on the basis of the regulations described above. Various material streams have been investigated. In all cases which have been dealt with so far it was found that the surveillance limits were not exceeded or that compliance with the dose reference level on the basis of case specific evaluations could be demonstrated. Incrustations from the oil and gas industry, for which compliance with the dose reference level cannot be demonstrated, could have been handed over to *Land* collecting facilities so far due to their low total amount. However, two main problems with the disposal of NORM residues arise for the future. On the one hand, the number of landfills where NORM residues can principally be disposed of decreases and, on the other hand, the readiness to accept these NORM residues at the still existing landfills continues to decline. One possibility is the establishment of a landfill specifically for NORM residues.

The list of residues classified as requiring surveillance (Appendix XII, Part A StrlSchV) is continuously reviewed. So, for example, the use of geothermal energy for the production of energy (electricity, district heating) has been increasing in recent years. The depositions removed during the regularly scheduled cleaning of circuits and heat exchangers are no residues requiring surveillance according to Appendix XII, Part A StrlSchV but, depending on the site, they contain activity of nuclides of the U and Th decay series that are not insignificant. The management of such residues takes currently place on the basis of the provisions of § 102 StrlSchV and it is checked whether they require surveillance. The same applies to filter residues from water treatment if uranium or radium is removed from the water.

C.3 Spent fuel and radioactive waste from the military sector

There is no spent fuel from military or defence programmes in Germany.

The treatment and storage of radioactive waste from military or defence programmes remains the responsibility of the armed forces and is not transferred to civil responsibility until the waste is delivered to a repository. Until then, it is stored in a central collecting facility. If necessary, the waste will previously be conditioned according to the acceptance criteria of the particular repository for disposal. All these waste management stages are subject to the same safety provisions as those applicable in the civil sector.

D Inventories and lists

This section deals with the obligations under Article 32 (2) of the Convention.

Developments since the Fourth Review Meeting:

The return of the high-level vitrified waste from reprocessing in France was completed with the last transport in November 2011.

The Gorleben transport cask storage facility (TBL-G) is no longer available for future emplacements of vitrified radioactive waste from reprocessing. According to the Site Selection Act (StandAG), this waste must be stored in a local storage facility until delivery to a facility for disposal of radioactive waste.

At the site of the Konrad repository, the construction work has been continued. The underground construction work concentrates on the renovation and refurbishment of the side walls in the shafts Konrad 1 and 2, on the driving of transport galleries and chambers for emplacement, as well as on cable routing and cable laying. Above ground at the Konrad 1 site, the construction of the southern winding engine house has been completed and the construction work for the switchgear building and the shaft hall is in progress. The building site preparation at the site of the Konrad 2 shaft has been completed.

Article 32 (2): Reporting

(2) This report shall also include

i) a list of the spent fuel management facilities subject to this Convention, their location, main purpose and essential features;

ii) an inventory of spent fuel that is subject to this Convention and that is being held in storage and of that which has been disposed of. This inventory shall contain a description of the material and, if available, give information on its mass and its total activity;

iii) a list of the radioactive waste management facilities subject to this Convention, their location, main purpose and essential features;

iv) an inventory of radioactive waste that is subject to this Convention that:

a) is being held in storage at radioactive waste management and nuclear fuel cycle facilities;

b) has been disposed of; or

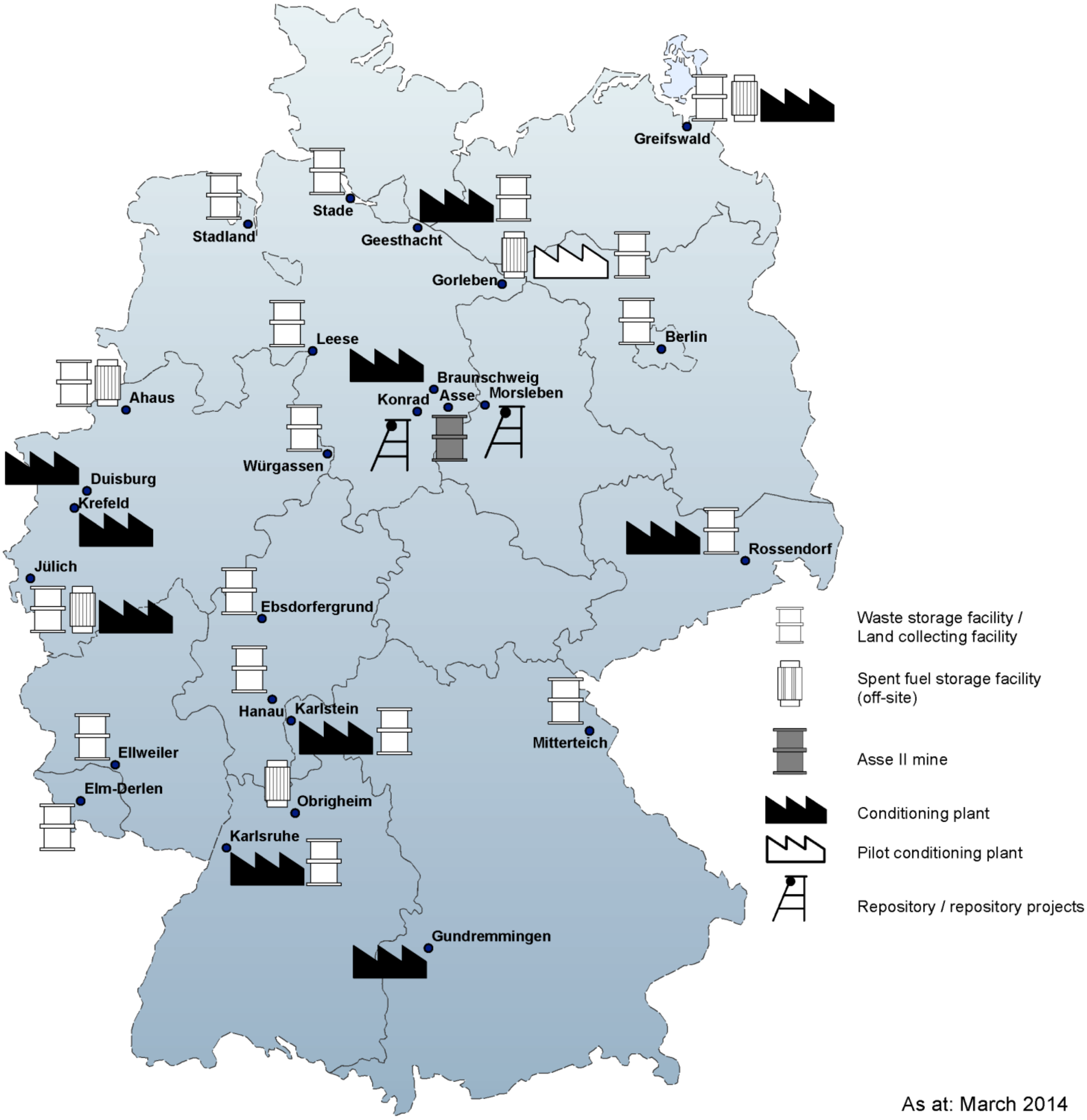
c) has resulted from past practices.

This inventory shall contain a description of the material and other appropriate information available, such as volume or mass, activity and specific radionuclides;

v) a list of nuclear facilities in the process of being decommissioned and the status of decommissioning activities at those facilities.

The sites of storage facilities for spent fuel and radioactive waste, as far as they have not been constructed at the locations of nuclear power plants that were in operation at the time of the construction of the storage facilities, as well as of facilities for conditioning and disposal are shown in Figure D-1.

Figure D-1: Sites of facilities of spent fuel and radioactive waste management (without on-site storage facilities)



D.1 Spent fuel management facilities

An overview of spent fuel management facilities is given in Table D-1. More detailed information on existing and planned facilities can be found in Annex L-(a). The overviews given there also include the spent fuel pools within the reactor buildings.

The following facilities are classified as spent fuel management facilities within the meaning of the Joint Convention:

- The on-site storage facilities of nuclear power plants,
- the Ahaus and Gorleben storage facilities,
- the storage facilities in Rubenow and Jülich, and
- the Gorleben pilot conditioning plant.

The decommissioned spent fuel reprocessing plant at Karlsruhe (WAK) is dealt with within the reporting on Article 32 (2) v.

D.1.1 Spent fuel pools within reactor buildings

The spent fuel unloaded from the reactor core is first placed in fuel pools within the reactor building for several years. These pools allow the required decay of activity and heat generation until the fuel is placed in a cask for storage, and provides the operator with sufficient flexibility to operate the facility. The additional wet storage facility outside the reactor building in Obrigheim is an exceptional case. As this facility, like the spent fuel pools inside the reactor buildings, is regarded to be part of the power plant operation from a licensing point of view, it will not be dealt with further in this report. It is, however, included in Table D-1, Table L-1 and Chapter D.1.2 for the sake of completeness.

D.1.2 On-site storage facilities of nuclear power plants

The concept of the Federal Republic of Germany envisages that the spent fuel will be stored at the sites of the nuclear power plants. It should generally remain at the sites where it is produced until it can be conditioned to meet the requirements for disposal and be disposed of. On-site storage means that spent fuel transports will be avoided until disposal of the fuel with prior conditioning.

Decentralised storage facilities for spent fuel have been licensed under atomic law and constructed and commissioned at twelve sites with nuclear power plants. They are designed as dry storage facilities in which transport and storage casks loaded with spent fuel are emplaced.

The storage facilities are cooled by passive air convection which removes the heat from the casks without any active technical systems. The leak-proof and accident-resistant casks ensure safe enclosure as well as the necessary degree of radiation shielding and criticality safety during both normal operation and in the case of incidents. Protection against external hazards, such as earthquakes, blast waves and aircraft crashes, is ensured by the thick walls of the casks. It was demonstrated and confirmed in the licensing procedure that the casks are suitable for at least 40 years of storage. Thus, the licences limit the storage period to 40 years, starting with the emplacement of the first cask. An extension of the storage period is subject to licensing.

At the Obrigheim nuclear power plant, an extension of the wet storage capacity in a pool outside the reactor building was licensed in 1998. The spent fuel remaining in the plant since its shutdown in May 2005 is stored in the on-site wet storage facility for the time being. It is planned to deliver it to the Neckarwestheim on-site storage facility.

D.1.3 Ahaus and Gorleben storage facilities

Licences were granted for storage facilities in Gorleben (see Figure D-2 and Figure D-3) and Ahaus for the storage of spent fuel from various German nuclear power plants. The facilities are designed as dry storage facilities. The Ahaus facility has been additionally licensed for the storage of transport and storage casks of the CASTOR® THTR/AVR and MTR 2 types in which spent fuel from experimental, demonstration and research reactors is stored (see Figure D-4 and Figure D-5).

It is intended to use the Ahaus cask storage facility (TBL-A) also for the storage of further spent fuel from research reactors (the BER II of the Helmholtz-Zentrum Berlin, the TRIGA reactor of the Technical University Mainz, and the *Forschungs-Neutronenquelle Heinz Maier-Leibnitz* (FRM II) of the Technische Universität München) in casks of the CASTOR® MTR 3 type. A decision about this possibility has not been made yet. Currently, it is not possible to make a prognosis about these planned storage options in the TBL-A as this depends on the potential use of other disposal paths by the operators of the research reactors (e.g. return to the USA).

With letter of 24 September 2009, the *Brennelement-Zwischenlager Ahaus GmbH* and the GNS have filed an application at the Federal Office for Radiation Protection (BfS), according to § 6 AtG for the storage of nuclear fuel in the form of spent fuel assemblies and other radioactive material in the form of operational elements (absorber and graphite assemblies with no fissile material content) from the former AVR experimental reactor of the AVR GmbH Jülich, in a total of 152 transport and storage casks of the CASTOR® THTR/AVR type in the eastern part of the two storage areas (storage area II). This application has been suspended. Furthermore, they applied for the storage of high-pressure compacted radioactive waste (the CSD-C from reprocessing at La Hague). Currently, a cask concept for 27 canisters is under development.

On 9 November 2009, the competent district government of Münster granted a licence according to § 7 of the Radiation Protection Ordinance (StrlSchV) [1A-8] for the temporary storage of operational and decommissioning waste in the western part of the two storage areas (storage area I). The storage period is limited to 10 years. On 21 July 2010, the first waste packages were emplaced.

The Gorleben transport cask storage facility has been additionally licensed for HAW glass canisters. In January 2010, a licence was granted for the storage of the CASTOR® HAW 28M type. Since the end of 2012, 108 casks have been stored there with vitrified waste. After the entry into force of the Site Selection Act (StandAG), the remaining HAW from the reprocessing of German spent fuel abroad must be stored in local storage facilities. For conditioned non-heat-generating waste which is currently stored in the Gorleben waste storage facility, storage in a separate section within the transport cask storage facility was applied for in December 2013.

Further information on the Ahaus and Gorleben storage facilities is given in Table L-2 of the annex.

Figure D-2: Pilot conditioning plant (PKA), Gorleben transport cask storage facility (TBL-G) and the Gorleben waste storage facility (ALG) of the *Brennelemente-Lager Gorleben GmbH* (BLG) (Copyright: GNS)

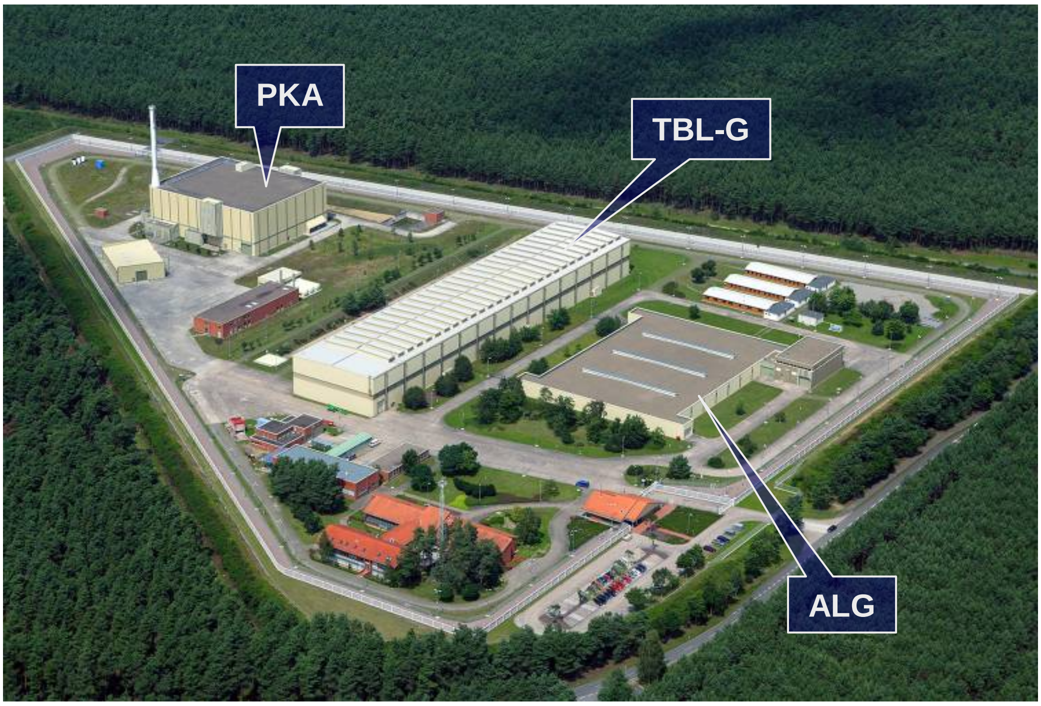
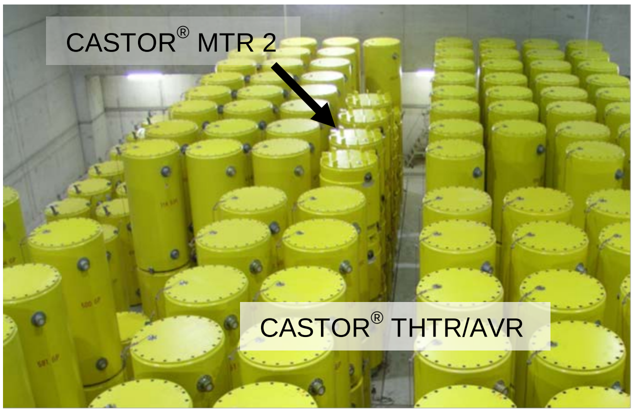


Figure D-3: Transport and storage casks in the Gorleben transport cask storage facility (TBL-G) (Copyright: GNS)

Figure D-4: Ahaus transport cask storage facility (TBL-A) for spent fuel and radioactive waste (Copyright: GNS)

Figure D-5: Ahaus transport cask storage facility (TBL-A) (Copyright: GNS)
left: CASTOR® V and CASTOR® THTR/AVR
right: CASTOR® MTR 2 between CASTOR® THTR/AVR



D.1.4 Storage facilities in Rubenow and Jülich

In addition to spent fuel from the Soviet-type reactors at Rheinsberg and Greifswald, spent and fresh fuel from the compact sodium-cooled nuclear reactor plant (KNK II), from the nuclear ship Otto Hahn as well as HAW glass canisters from the Karlsruhe reprocessing plant (WAK) are currently stored in the dry storage facility *Zwischenlager Nord* (ZLN) in Rubenow. The KNK fuel rods were emplaced in 2010, the HAW glass canisters in 2011.

The Jülich storage facility contains fuel pebbles from the operation of the experimental nuclear power plant at Jülich (AVR). It is planned to deliver the 152 transport and storage casks of the CASTOR® THTR/AVR type stored there to the USA.

On 26 June 2007 and with a more precise letter of 29 April 2009, the Jülich research centre (FZJ) applied for the storage of AVR fuel at the Jülich storage facility for another three years, starting on 1 July 2013. After the FZJ had asked on 16 July 2010 to suspend the licensing procedure, the BfS resumed the procedure on 16 May 2012 upon request of the FZJ and, since then, has been continuing it.

Since the licence applied for could not be granted by the BfS until 1 July 2013, the Ministry of Economic Affairs of the *Land* of North Rhine-Westphalia, as the competent nuclear supervisory authority, ordered the further storage of the AVR fuel at the Jülich storage facility until 31 December 2013.

After issuance of this order on 28 June 2013, it turned out that the verification of requirements from the licensing procedure at the BfS was considerably more time-consuming than assumed. Therefore, a new order by the nuclear supervisory authority was required.

With the new order, the FZJ is authorised to continue to possess the nuclear fuel. It entered into force on 1 January 2014 and was limited for seven months until 31 July 2014.

Since the verification of fulfilment of the licensing requirements could not be completed until 31 July 2014, an order entered into force again on 2 July 2014.

Further information on the storage facilities in Rubenow and Jülich is given in Table L-2 of the annex.

D.1.5 Pilot conditioning plant

The reference concept for direct disposal of spent fuel in a salt dome pursued until entry into force of the StandAG envisaged the removal of the fuel rods from the fuel assemblies in an above-ground facility, the packaging of the fuel rods in self-shielding and sealed thick-walled casks and their emplacement in deep geological formations for disposal. In accordance with the type of cask used, it is also referred to as the POLLUX reference concept. In order to demonstrate the conditioning technique, a pilot conditioning plant was completed in Gorleben in 2000. The plant is licensed for a throughput of 35 Mg HM/a. According to the agreement between the Federal Government and the utilities of 11 June 2001, the use of the plant is licensed only for the repair of defective casks for spent fuel from light-water reactors and for vitrified HAW from reprocessing as well as for the handling of other radioactive material.

The reference concept for the direct disposal of spent fuel was developed to a stage of technical maturity. According to this concept, it was intended to emplace the casks in drifts. The alternative BSK3 concept (BSK = German acronym for *Brennstabkokille* – fuel rod canister; suitable for fuel rods from three PWR fuel assemblies) is based on the emplacement of the unshielded fuel rod canister in a borehole. For handling of the BSK3 and transfer from the above-ground conditioning plant to the repository, a transfer cask is used into which the BSK3 loaded with the fuel rods is inserted and which provides shielding.

In addition, concepts were investigated for the disposal of fuel assemblies not disassembled in order to reduce handling effort above ground with its special requirements as regards radiation protection. Against the background of the new boundary conditions defined by the StandAG [1A-7], the concepts for conditioning and emplacement have to be adapted or newly developed depending on the future repository formation.

Table D-1: a) Spent fuel storage facilities (as at 31 December 2013);
b) Conditioning plant

Site	Storage capacity		Status		Emplaced
	Positions for casks / fuel assemblies	[Mg HM]	Licensed	Applied for	[Mg HM]
Fuel pools inside reactor buildings					
Nuclear power plants in total	19,523 FA positions[1)]	Approx. 6,044[1)]	x		4,024
Fuel pools outside reactor buildings					
Obrigheim (KWO)	980 FA positions[3)]	286	x		100
On-site storage facility (dry storage)					
Biblis (KWB)	135 cask positions	1,400	until 2046		519
Brokdorf (KBR)	100 cask positions	1,000	until 2047		216
Brunsbüttel (KKB)	80 cask positions	450	until 2046		78
Grafenrheinfeld (KKG)	88 cask positions	800	until 2046		214
Grohnde (KWG)	100 cask positions	1,000	until 2046		228
Gundremmingen (KRB)	192 cask positions	1,850	until 2046		371
Isar (KKI)	152 cask positions	1,500	until 2047		305
Krümmel (KKK)	80 cask positions	775	until 2046		175
Lingen/Emsland (KKE)	130 cask positions[2)]	1,250	until 2042		327
Neckarwestheim (GKN)	151 cask positions	1,600	until 2046		377
Philippsburg (KKP)	152 cask positions	1,600	until 2047		357
Unterweser (KKU)	80 cask positions	800	until 2047		82
Obrigheim (KWO)	15 cask positions	100		2005	
Central storage facility (dry storage)					
Gorleben	420 cask positions[4)]	3,800	until 2034		37[6)]
Ahaus	420 cask positions[5)]	3,960	until 2036		55[7)]
Decentralised storage facility (dry storage)					
Rubenow	80 cask positions	585	until 2039		583
Jülich	158 casks	0.225[8)]	until 30.06.2013[9)]	extended until 30.06.2016	0.086

1) Part of the storage capacity has to be kept free for unloaded cores.
2) Licensed for 125 cask positions for loaded casks and 5 casks positions for empty casks.
3) The Obrigheim nuclear power plant has a wet storage facility outside of the reactor building that was commissioned in 1999. Delivery of the fuel assemblies to a near on-site storage facility is planned.
4) Including the positions for HAW canisters.
5) Including cask positions in the storage area I, for which a licence for storage of operational and decommissioning waste was granted according to § 7 StrlSchV on 26 May 2010 for a maximum of 10 years.
6) An additional 2 Mg HM in the HAW canisters.
7) Total amount from power reactors; an additional approx. 6 Mg HM from the THTR and 2 Mg HM from the Rossendorf research reactor (RFR).
8) Thermally fissile isotopes (U-233, U-235, Pu-239, Pu-241).
9) Since the licence extension for another three years has not been issued yet by the BfS, the nuclear supervisory authority has ordered further storage until 31 July 2014.

b) Conditioning plant

Plant	Site	Purpose	Maximum throughput	Status
PKA	Gorleben	Conditioning of spent fuel for direct disposal and for the treatment of radioactive waste; presently only repair of damaged casks	35 Mg HM/a (conditioning)	Licensed and constructed but not yet in nuclear operation

Further information on the pilot conditioning plant in Gorleben is given in Table L-3 of the annex.

D.2 Spent fuel inventory

An overview of the spent fuel assemblies from German power reactors until the end of 2013 is given in Table D-2 (classified according to place of origin) and Table D-3 (classified according to destination). Table D-4 lists the destinations of the spent fuel from prototype reactors.

D.2.1 Spent fuel quantities

Power reactors

In the spent fuel pools of the power plants (including Obrigheim on-site storage facility designed for wet storage) and in the core of the decommissioned Brunsbüttel nuclear power plant, there is a total 4,292 Mg HM of spent fuel assemblies (as at 31 December 2013).

The on-site storage facilities, which are designed for dry storage, hold 3,249 Mg HM, and the central storage facilities at Ahaus and Gorleben hold 92 Mg HM. The inventory is in the form of LWR spent fuel assemblies which are stored in storage casks. 583 Mg HM WWER fuel assemblies from Rheinsberg and Greifswald are stored in transport and storage casks in the storage facility *Zwischenlager Nord* (ZLN) in Rubenow near Greifswald. A total of 6,670 Mg HM spent fuel assemblies from the nuclear power plants have already been shipped abroad either for reprocessing or for permanent storage there. The major part was sent to the La Hague and Sellafield reprocessing plants. Table D-3 gives an overview of the destinations of the spent fuel.

As at 31 December 2013, there was a total of about 14,886 Mg HM in the form of spent fuel from the operation of the German light water reactors still in operation and shut down with capacities > 50 MW, around 202 Mg HM of which had been produced in 2013 (see Table D-2). A part of the spent fuel assemblies in the fuel pools have not yet reached their final burn-up and are therefore intended for reuse in the reactors at a later point in time. However, as the Joint Convention makes no distinction in this respect, the spent fuel intended for reuse has been considered in the spent fuel quantities given in this report (e.g. in Table D-2 and Table D-3).

Table D-2: Quantities of spent fuel produced in light water reactors (capacity > 50 MW) in the Federal Republic of Germany as at 31 December 2013

Type	Abbr.	Power plant, site	Total quantity	
			Number FAs	[Mg HM]
Plants in operation				
PWR	KBR	Brokdorf	1,272	688
PWR	KWG	Grohnde	1,420	770
PWR	KKE	Emsland	1,284	691
PWR	KKP 2	Philippsburg 2	1,371	740
PWR	GKN 2	Neckarwestheim 2	1,149	615
BWR	KRB-B	Gundremmingen B	4,448	775
BWR	KRB-C	Gundremmingen C	4,289	746
PWR	KKI 2	Isar 2	1,208	646
PWR	KKG	Grafenrheinfeld	1,532	823
Subtotal			**17,973**	**6,494**
Authorisation for power operation for electricity production expired in 2011				
BWR	KKB	Brunsbüttel	2,664	464
BWR	KKK	Krümmel	3,909	692
PWR	KKU	Unterweser	1,717	922
PWR	KWB A	Biblis A	1,676	897
PWR	KWB B	Biblis B	1,824	976
BWR	KKP 1	Philippsburg 1	3,632	646
PWR	GKN 1	Neckarwestheim 1	1,830	655
BWR	KKI 1	Isar 1	4,072	723
Subtotal:			**21,324**	**5,975**
Plants under decommissioning				
BWR	KWL	Lingen	586	66
BWR	KRB-A	Gundremmingen A	1,028	125
BWR	KWW	Würgassen	1,989	346
PWR	KMK	Mülheim-Kärlich	209	96
PWR	KWO	Obrigheim	1,235	352
PWR	KKS	Stade	1,517	539
PWR	KKR	Rheinsberg	918	106
PWR	KGR 1-5	Greifswald 1-5	6,813	787
Subtotal			**14,295**	**2,417**
Total:			**53,592**	**14,886**

Note: The quantities given in Mg HM have been rounded to the nearest integers. This may result in minor differences in the total compared to other figures published.

Table D-3: Overview of total quantities of spent fuel assemblies from German light water reactors (capacity > 50 MW) as at 31 December 2013

Place of storage / whereabouts	Quantity [Mg HM]
Spent LWR fuel in NPP spent fuel pools (incl. wet storage facility outside the KWO reactor building)	4,292
Dry storage of spent WWER fuel in casks at ZLN	583
On-site dry cask storage	3,249
Dry cask storage at the Ahaus and Gorleben storage facilities	92
Shipped to La Hague (France) for reprocessing	5,393
Shipped to Sellafield (United Kingdom) for reprocessing	851
Reprocessed at the WAK reprocessing plant in Karlsruhe	85
Reprocessed at the EUROCHEMIC reprocessing plant (Belgium)	14
Returned to the former USSR (WWER fuel)	283
Shipped to Sweden without return (CLAB)	17
Reuse of WWER fuel at Paks (Hungary)	27
Total	**14,886**

Note: The quantities given in Mg HM have been rounded to the nearest integers. This may result in minor differences in the total compared to other figures published.

Experimental and demonstration reactors

Apart from the above-mentioned reactors, eight experimental and demonstration reactors were operated in the Federal Republic of Germany, which are all under decommissioning or have already completely been dismantled. These are:

- AVR, Jülich,
- THTR-300, Hamm,
- MZFR, Karlsruhe,
- KNK II, Karlsruhe,
- VAK, Kahl,
- KKN, Niederaichbach,
- HDR, Großwelzheim,
- nuclear ship Otto Hahn, Geesthacht.

More details on these reactors are given in Table L-17 in Annex L-(c). The destinations and corresponding quantities of heavy metals for storage or management of the accumulated 190 Mg HM spent fuel assemblies are summarised in Table D-4.

Table D-4: Management of spent fuel from experimental and demonstration reactors

Reactor	Quantities stored or disposed of in Mg HM at									Total
	WAK	BNFL	SKB	CEA	EURO-CHEMIC	FZ Jülich	TBL Ahaus	ZLN	Others	
VAK	7.9	0.1	6.5		7.4				0.1	22.0
MZFR	89.6	10.6	0.4							100.6
KKN				46.3						46.3
KNK II				1.4				0.5	0.2	2.1
AVR						1.9				1.9
THTR							6.9			6.9
HDR	6.9									6.9
Otto Hahn	2.9							«0.1		2.9
Total	**107.3**	**10.7**	**6.9**	**47.7**	**7.4**	**1.9**	**6.9**	**0.5**	**0.3**	**189.6**

Most of the spent fuel listed in Table D-4 was reprocessed at the WAK Karlsruhe, at BNFL or at EUROCHEMIC in Belgium. A smaller part was shipped to SKB in Sweden and to CEA in France and will remain there. The THTR fuel pebbles are stored at the TBL-A. They have been reported so far as an intermediate and not as spent fuel. The AVR fuel pebbles are stored at the Jülich research centre (FZJ). 152 casks contain 290,000 fuel pebbles with 1.9 Mg HM (including thorium). Proper management of the spent fuel from experimental and demonstration reactors has thereby been ensured.

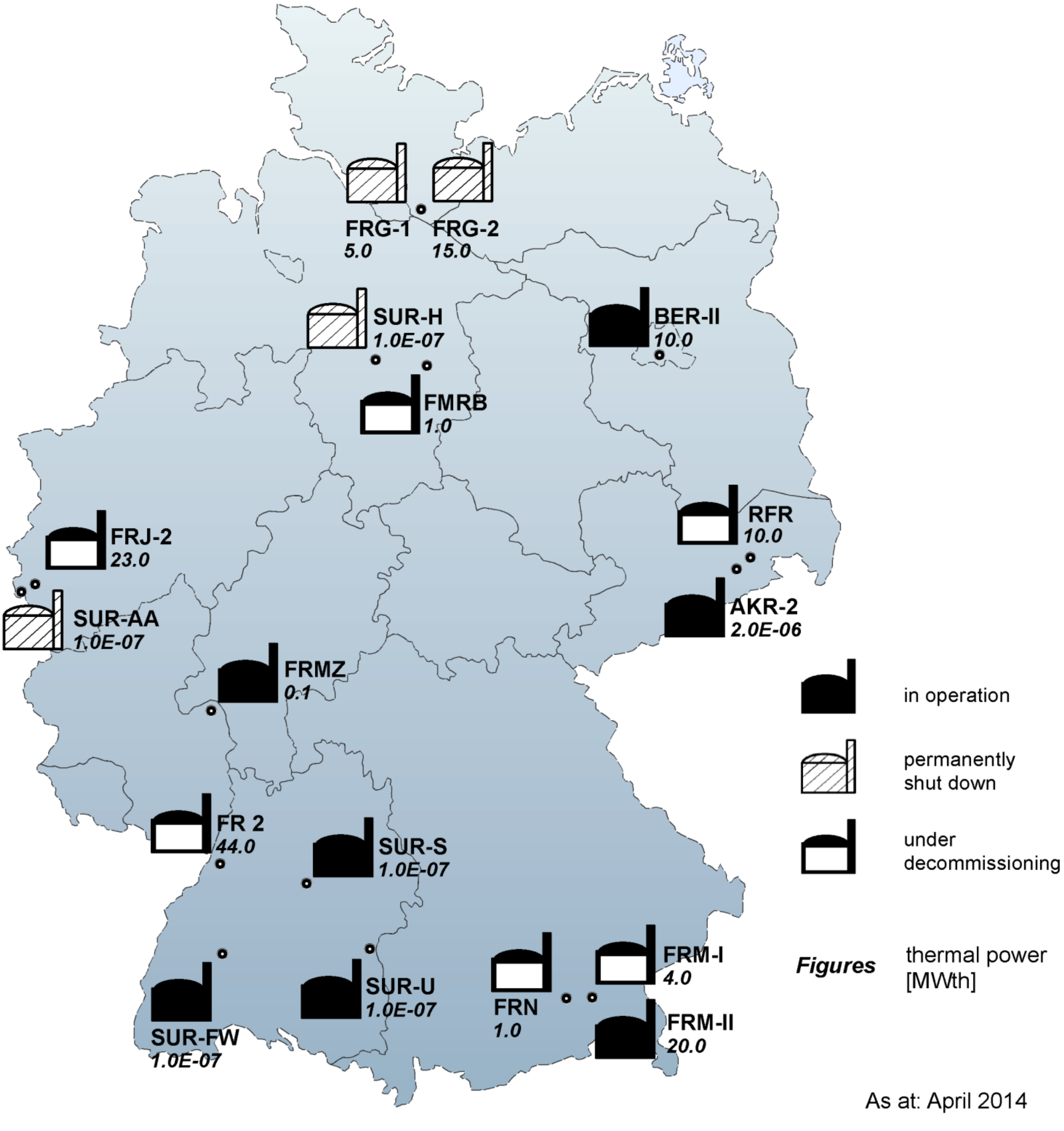
Research and training reactors

Seven training and research reactors are in operation in Germany. These are

- one material test reactor (BER II, Berlin),
- one high-flux reactor (FRM II, Munich),
- one TRIGA reactor in Mainz, and
- three Siemens reactors for training purposes (SURs) and the AKR-2 reactor for educational purposes.

The geographical location of the research reactors in Germany is shown in Figure D-6.

Figure D-6: Research and training reactors in Germany



The Jülich research reactor (FRJ-2) was permanently shut down on 2 May 2006 and the decommissioning licence was granted on 20 September 2012. For the FRG-1 research reactor in Geesthacht finally shut down on 28 June 2010 and free from fuel assemblies since end of July 2012, the operator has filed an application for decommissioning on 21 March 2013. Decommissioning is to take place together with the already partially dismantled FRG-2 (common reactor pool). On 3 April 2014, the licence for dismantling of the FRM research reactor in Garching was granted. Altogether, eight facilities with a thermal power > 1 MW have been shut down or are in various stages of decommissioning. Several reactors with smaller capacities have permanently been shut down or already been removed. An overview of research reactors permanently shut down or being under decommissioning is given in Annex L-(c) (see Table L-15 and Table L-16).

The amount of spent fuel from research reactors stored as at 31 December 2013 is several orders of magnitude less than the amount to be managed from power reactors. As at 31 December 2013, 57 fuel assemblies with approximately 77 kg of heavy metal were stored at the Berlin experimental reactor (BER II) in Berlin, and 34 spent fuel assemblies with approximately 237 kg of heavy metal were stored at the FRM II in Garching. Four disused fuel assemblies with 764 g of uranium were stored at the TRIGA research reactor Mainz (FRMZ). Approximately 2.3 Mg of spent fuel are stored at the VKTA Rossendorf in 18 CASTOR® MTR 2 casks in Ahaus.

All the fuel from the decommissioned MTRs in Geesthacht and Jülich was shipped into the USA and the United Kingdom. It is intended to ship also the fuel from the BER II and the FRMZ into the USA. However, according to current law, this path will only be open for fuel unloaded until May 2016. Should there be no further extension for shipments into the USA, the spent fuel produced after May 2016 will be stored centrally in Ahaus. For the spent fuel from the FRM II, shipment into the USA will not be possible according to current situation. The spent fuel will therefore also be stored in Ahaus with the aim of direct disposal. According to the current status, the conversion of the FRM II, currently operated with highly enriched uranium (93 % U-235), to to the use of fuel with lower enrichment is envisaged for 2018. The operator of the BER II, the Helmholtz-Zentrum Berlin, decided in June 2013 to decommission the reactor on 1 January 2020. According to current plans, the FRMZ will be operated at least until 2020.

In the 1960s and 1970s, 12 Siemens training reactors (SURs) were installed in the Federal Republic of Germany and, taking these as a model, one training reactor for educational purposes (AKR) in the former GDR. The SURs are so-called zero-power reactors (thermal output 100 mW), which are and were operated with < 20 % enriched uranium dioxide dispersed in polyethylene. A SUR core consists of 8 to 10 fuel plates. The SURs in Stuttgart, Ulm and Furtwangen as well as the training reactor in Dresden are to continue operation.

D.2.2 Activity inventory

The activity inventory of the spent fuel (as at 31 December 2013) at the reactor sites and in the cask storage facilities can be estimated based on the following assumptions:

In an initial approximation, only uranium dioxide fuel is considered. The spent fuel is divided according to different age categories: for the spent fuel assemblies unloaded prior to 1998, the assumed mean burn-up is 40 GWd/Mg HM, whilst for the spent fuel assemblies unloaded between 1999 and 2006, the mean burn-up is defined as 45 GWd/Mg HM. A mean burn-up of 50 GWd/Mg HM is assumed for the time after 2007. A minimum decay period of one year for the last unloading is assumed. The data taken as a basis are determined using an internationally recognised burn-up program.

Accordingly, the radioactive inventories as at 31 December 2013 are estimated as follows:

- Inventory of spent fuel stored in NPP fuel pools (corresponding to 4,292 Mg HM) — $2.3 \cdot 10^{20}$ Bq
- Spent fuel in casks and storage facilities (corresponding to 3,923 Mg HM) — $6.9 \cdot 10^{19}$ Bq

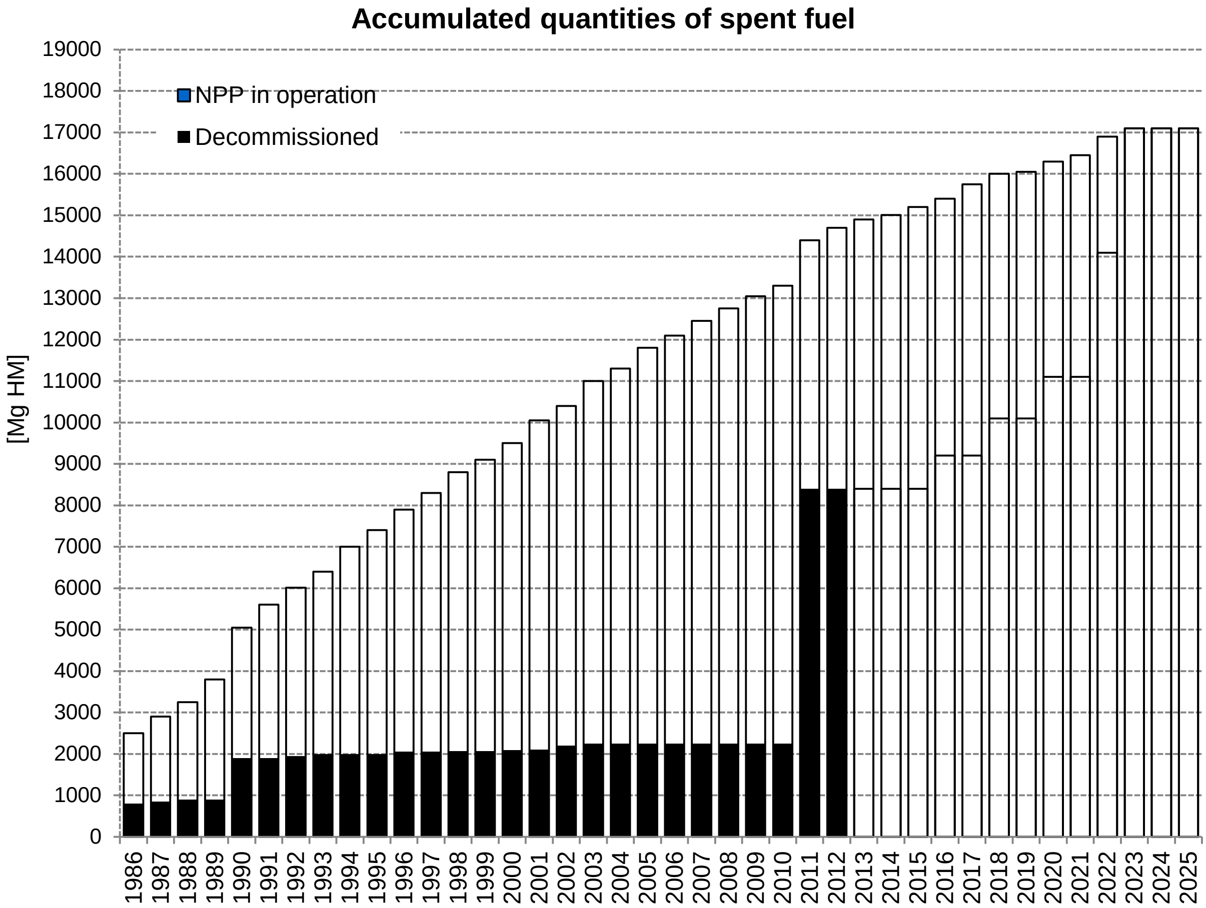
Thus, the total activity of all spent fuel in storage as per the reference date is approximately $3.0 \cdot 10^{20}$ Bq.

D.2.3 Predicted amounts

The utilities inform the competent supervisory authorities about the amounts of spent fuel probably produced at each nuclear power plant until their final shutdown at intervals of one year. Under defined boundary conditions of the 13th amendment to the Atomic Energy Act (AtG) of 30 June 2011 decided by the *Bundestag*, it follows that from 1 January 2014 until the final shutdown of all plants, about another 2,308 Mg HM (including residual cores) of spent fuel will be produced. Together with the spent fuel already produced until 31 December 2013, this amounts to a total of around 17,200 Mg HM, of which around 10,500 Mg HM have to be conditioned and disposed of. The remaining amount was disposed of via other paths, the large majority by reprocessing abroad.

The spent fuel produced over time including the predictions until 2025 is shown in Figure D-7.

Figure D-7: Accumulated quantities of spent fuel from power reactors until 2025 (light bars: prediction as from 2014)



D.3 Radioactive waste management facilities

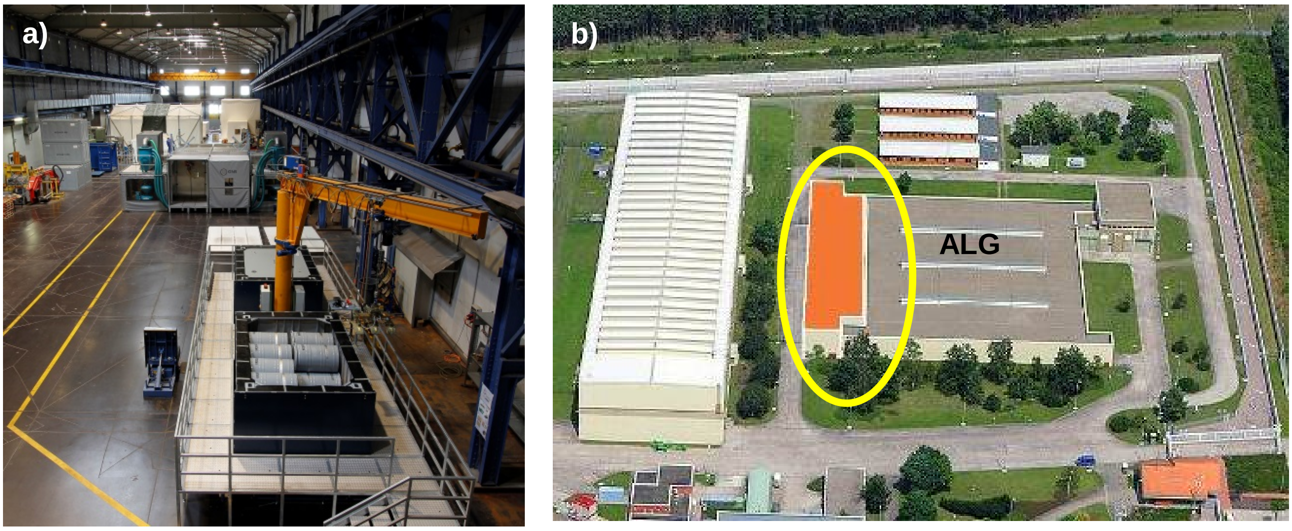
D.3.1 Conditioning plants

Due to the operation and decommissioning of nuclear facilities and the use of radioisotopes in research, trade, industry and medicine, radioactive waste is produced continuously in the Federal Republic of Germany which must be stored until commissioning of the Konrad repository.

The aim of waste conditioning is therefore to convert radioactive waste through treatment and/or packaging in a form suitable for disposal according to the waste acceptance requirements of the Konrad repository. In order to limit the volumes to be stored and disposed of, conditioning is also aimed at volume reduction. Depending on the composition (organic, metallic, mineral) and state (solid, liquid) of the waste, different conditioning methods are used. Whether solid waste will primarily be burnt, pyrolysed, compacted, melted or crushed and liquid waste primarily dried, cemented or vitrified also depends on the radiological properties of the waste. It may be necessary to use different conditioning methods in consecutive steps before raw waste is processed via one or several intermediates such to obtain a qualified waste product suitable for disposal from raw waste.

Conditioning of radioactive waste may take place in mobile or stationary facilities. Frequently used stationary waste conditioning facilities are decontamination and dismantling facilities, drying facilities, evaporator facilities, high-pressure compaction facilities, melting facilities and cementing facilities, which are located e.g. in Duisburg, Jülich, Karlsruhe, Krefeld and Rubenow near Greifswald and that are also available for the processing of waste from external waste producers. The facility in Duisburg (see Figure D-8a) with a controlled area of around 10,000 m^2 provides the opportunity for maintenance, and if required, for conversion of the conditioning facility.

Figure D-8: a) GNS facility Duisburg, loading station for Konrad containers (Copyright: GNS); b) Planned extension to the Gorleben waste storage facility (ALG) to accommodate the technical installations necessary for increasing the conditioning capacity (Copyright: GNS)



The aim is to continuously provide a waste package volume of approximately 10,000 m^3 annually meeting the requirements of the Konrad repository. For this purpose the conditioning and storage capacities will be increased if necessary. In Gorleben, for example, an extension to the existing Gorleben waste storage facility is planned (see Figure D-8b). At the TBL-A, additional storage capacity was provided for operational and decommissioning waste until its delivery to the Konrad repository.

D.3.2 Storage facilities

Until its delivery to a repository, radioactive waste from the operation and decommissioning of nuclear power plants are to be stored in facilities that have to be constructed and operated by the facility operator according to the polluter-pays principle.

In addition to the storage of radioactive waste, decay storage of radioactive residues is also pursued (for details see the comments in Chapter 0 on the Greifswald nuclear power plant (KGR) and the Rheinsberg nuclear power plant (KKR)) to facilitate processing at a later stage and, where intended, the clearance of the materials and thus to reduce the need for disposal volume (see Figure D-9).

Figure D-9: Decay storage of large components (steam generator, reactor pressure vessel) at the ZLN (Copyright: EWN)

Apart from the on-site facilities, facilities currently available for waste storage are the Unterweser off-site storage building, the Biblis on-site temporary storage facility (the duration of radioactive waste storage is limited to ten years from the first emplacement of a waste package), the Ahaus transport cask storage facility (TBL-A) (the duration of radioactive waste storage in the western part of the storage area is limited to ten years from the first emplacement of a waste package), the Gorleben waste storage facility (ALG), the storage building of the power utilities at Mitterteich, the storage facilities of the Nuclear + Cargo Service GmbH (NCS) in Hanau, the ZLN in Rubenow, the Rossendorf storage facility (ZLR), and the storage facility of the central decontamination department *Hauptabteilung Dekontaminationsbetriebe* (HDB) in Karlsruhe. The licences for these storage facilities contain restrictions regarding delivery. For example, only waste from Bavarian nuclear facilities may be delivered to Mitterteich, mainly waste from the Greifswald and Rheinsberg nuclear power plants under decommissioning to the ZLN, and mainly waste from the operation and decommissioning of the facilities at the Karlsruhe site to the HDB for storage. In addition, storage capacity is to be provided within the framework of a licensing procedure according to § 6 AtG [1A-3] with extension to the handling of other radioactive substances according to § 7 StrlSchV [1A-8] at the Gorleben transport cask storage facility (TBL-G). Radioactive waste from the reprocessing of German spent fuel abroad are stored at the TBL-G (HAW glass canisters from France) with the intention of future storage at the TBL-A (applied for, CSD-C from France) and according to § 9a, para. 2a AtG at storage facilities still to be selected (HAW glass canisters from the United Kingdom and CSD-B from France).

Radioactive waste from large research institutions is generally conditioned and stored at its place of origin. Waste from research, industry and medicine may be delivered to eleven regional *Land* collecting facilities. The waste is accepted for the most part as raw waste. Depending on the availability of technical installations it may be conditioned on site or by external service providers. In addition, there are private conditioning and waste management companies for waste from research, medicine and industry. Waste from the nuclear industry is conditioned on site such to meet the requirements for disposal and delivered to the ALG, the storage building of the power utilities at Mitterteich, or the storage facility of the NCS in Hanau for storage.

D.3.3 Repositories

All radioactive waste in storage which cannot be cleared by decay storage, is intended for subsequent disposal in deep geological formations.

Morsleben repository for radioactive waste (ERAM)

In the former GDR, the Morsleben repository (ERAM) in Saxony-Anhalt was available for the disposal of low- and intermediate-level radioactive waste since the first test emplacement in 1971 (see Figure D-10) which, after German reunification, was taken over by the BfS as the operator and was used, with some interruptions, until September 1998 for the emplacement of these wastes from Germany. In the ERAM (a former salt mine), waste of nuclear power plants and waste from research, industry and medicine was emplaced.

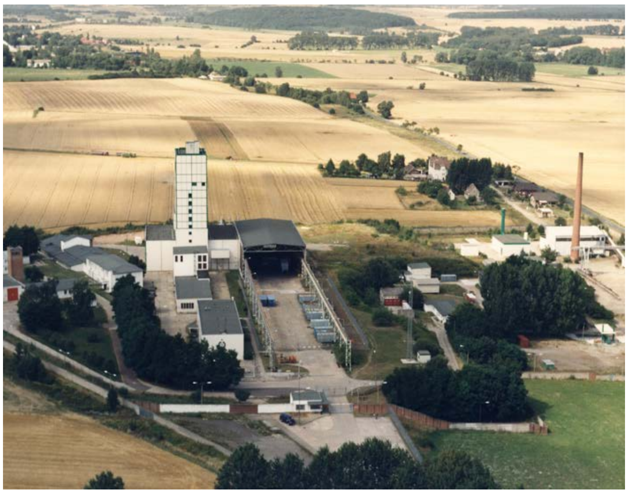
After the Higher Administrative Court of the *Land* of Saxony-Anhalt had prohibited further emplacement in the eastern field on 25 September 1998, the BfS stopped any further emplacement in the facility. In response to a re-evaluation, the BfS irrevocably waived further emplacement operation in Morsleben in 2001, as this was deemed no longer justifiable from the safety point of view. In 2005, the BfS submitted the application documents for closure of the facility to the licensing authority of Saxony-Anhalt.

Within the procedure for the planned closure of the repository for low- and intermediate-level radioactive waste at Morsleben, all citizens had the possibility to inspect the documents for the closure applied for from 22 October 2009 to 21 December 2009 and to raise objections at the Ministry of Agriculture and the Environment of Saxony-Anhalt (MLU), being the competent body for the licensing procedure.

After expiry of this period, the objections received were examined and then discussed in a public hearing from 13 October to 10 November 2011 conducted by the MLU. Currently, the MLU decides on the objections discussed; in parallel, the plan approval procedure is continued.

After the public hearing, the Federal Ministry for the Environment, Nature Conservation and Nuclear safety (BMU, now the BMUB) requested the Nuclear Waste Management Commission (ESK) to prepare a statement on the long-term safety case for the ERAM from the viewpoint of whether this safety case conducted by the BfS complies with the state of the art in science and technology regarding the methods applied. This statement [4-11a] was submitted in January 2013. It includes six recommendations that present supplementary measures and safety analyses which are required according to the ESK to complete the long-term safety case so that it complies with the state of the art in science and technology. The work needed to fulfil these requirements has been specified and commissioned.

Figure D-10: Repository for radioactive waste (ERAM) (left: aerial photograph, right: emplacement chamber with stacked low-level waste drums) (Copyright: BfS)



Konrad repository

In 1982, the application for a plan approval procedure to use the Konrad mine, a former iron ore mine in Lower Saxony, as a repository for radioactive waste with negligible heat generation was filed. This plan approval procedure for the Konrad repository has been concluded. The plan approval decision was issued on 22 May 2002.

The Konrad repository may only accept radioactive waste with negligible heat generation and a maximum waste package volume of 303,000 m^3.

With its ruling of 8 March 2006, the Lüneburg Higher Administrative Court rejected the complaints against the plan approval decision and refused to allow an appeal in front of the Federal Administrative Court. The complaints by the plaintiffs against the non-admission of an appeal were rejected by the Federal Administrative Court on 26 March 2007. There is thus a definitive and incontestable plan approval decision for the Konrad repository.

In a letter of the BMU dated 30 May 2007, the BfS was tasked with retrofitting the Konrad mine to convert it into a repository. The work started in 2007 has been continued.

About 500 ancillary provisions have to be observed and already existing design documents have to be revised for the retrofitting. Due to the advanced time since the plan approval decision was issued, further modification licences concerning conventional building permits also have to be obtained. On 15 January 2008, the main operating plan for the construction of the Konrad repository was approved by the Lower Saxony regional mining, energy and geology authority. The main operating plan allows the necessary mining and construction work to be carried out and is thus an important basis for the conversion of the former iron ore mine into a repository.

The company commissioned by the Federation with the conversion of the Konrad mine into a repository, the Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH (DBE), informed the BfS at the beginning of 2013 that it had noted that additional costs would incur for the remediation of at least one of the two old shafts of the mine. Whether this additional need for remediation is urgently required, what consequences it would probably have for the time the repository will be ready to use or whether the costs or time for the remediation can be reduced, cannot be quantified on the basis of the information available at present. The new date given by the DBE in the draft framework schedule for commissioning of the Konrad mine repository is the year 2022. However, the BfS holds the view that the date given by the DBE is subject to uncertainties that, according to the current state, are not quantifiable in detail and also have not been finally evaluated by the Federal Government yet.

The total costs for the Konrad repository so far comprise the costs for planning and exploration in the period from 1997 to 2008 to the amount of approximately € 930 million, and the project costs for the construction from 2008 to 2013 to the amount of approximately € 693 million. In the estimates of the 1980s and 1990s it was assumed that costs to the amount of € 900 million would be incurred for the construction of the Konrad repository from the start of the preparatory work for construction according to the plan approval decision until commissioning. The considerably higher costs of the project cost accounting in the meantime submitted by the DBE compared to prior estimates are particularly due to the changed market situation, the incorporation of the 500 ancillary provisions of the plan approval decision in the planning documents, changes in technical standards (DIN, energy saving regulation), general price, wage and salary increases, and the value added tax increase.

At the Konrad repository site preparatory measures like detection of explosive ordnance and removal of industrially contaminated soil were carried out. Construction site facilities were built and the planned demolition of old buildings was carried out. First buildings (underground media duct, switchgear building, shaft hall) were constructed (see Figure D-11). Fencing has largely been completed. Furthermore, there has been comprehensive security and corrosion protection work on the shaft head frame.

The necessary remediation of the shafts is continued. Work on the underground strengthening of galleries and the driving of emplacement chambers in the first planned emplacement field are currently underway. Two emplacement chambers have already been driven up to the planned final length. The driving of the return air collection roadway proceeds as scheduled.

Vehicles for underground works were procured and transported underground. Further, competitive tendering procedures were prepared and tenders invited (partly Europe-wide).

Figure D-11: Konrad repository in Salzgitter (Konrad 1: southern winding engine house) (Copyright: BfS)

With the plan approval decision for the Konrad repository of 22 May 2002, the Konrad waste acceptance requirements have been established as at December 1995, and waste-specific ancillary provisions stipulated in the legislative Part A III and in Annex 4. Thus, the decision to convert the Konrad mine into a repository for radioactive waste with negligible heat generation implies the adaptation and updating of the Konrad waste acceptance requirements. The updating of these requirements, which constitute the safety framework for the emplaced waste packages, will take place on a step-by-step basis.

The current version of the Konrad waste acceptance requirements is of October 2010 [BfS 10]. This version is currently being updated to Revision 2; here, a distinction is to be drawn between updating from the water law and nuclear law perspective.

With the intermediate permit under water law to dispose of radioactive waste in the Konrad repository (Annex 4 to the Konrad plan approval decision), the BfS has been authorised to dispose of radioactive waste in the Konrad repository with the contained non-radioactive harmful substances according to the restrictions stipulated and in compliance with two ancillary provisions.

The immediate implementation of the provisions as regards quantity and quality in the Konrad waste acceptance requirements or in corresponding waste-related requirements and necessary information for waste producers/*Land* collecting facilities has not been possible. This initially required the development of a concept that duly takes into account the provisions and stipulations of the qualified permission issued under water law and, in particular, the recording and balancing of non-radioactive harmful substances in the radioactive waste with negligible heat generation to be disposed of. The BfS developed such a concept and submitted it to the competent authority within the supervisory procedure unter water law for examination as a pre-empting measure. With its supervisory statement of 15 March 2011, the Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency (NLWKN) approved this concept for meeting the ancillary provisions under water law from the Konrad plan approval decision. The approval was granted subject to conditions.

The adaptation of the Konrad waste acceptance requirements according to water law provisions was concluded on 15 March 2012 under consideration of these conditions. In its final statement of 20 January 2013, the NLWKN confirmed compliance with its conditions with the further specification of the waste data sheet still to be performed.

In the framework of the updating of the Konrad waste acceptance requirements from the nuclear regulatory perspective, the BfS also sought statements from waste producers/*Land* collecting facilities. In consideration of the comments obtained, the ongoing work includes, in particular, the following issues:

- Clarification/illustration of various requirements by taking into account the comments in the statements of the waste producers/*Land* collecting facilities resulting from the previous long-standing application of the Konrad waste acceptance requirements in practice and help avoid misunderstandings.

- Clarification/illustration of individual requirements from the implementation of the ancillary provisions of the Konrad plan approval decision, such as the further specification of the ancillary provision "fissile material mass of more than one-twentieth of the smallest critical mass" by supplementing the smallest critical mass for selected radionuclides and isotopic mixtures.

- Consideration of the encased concrete shielding (UBA), which is a further development of the Type II cylindrical concrete container and which is covered by the Konrad waste acceptance requirements with the materials used for its manufacture, as well as with its external dimensions in height and diameter.

- Supplementation of further radionuclides with partly low activity from waste of the operation of nuclear power plants and waste from research/decommissioning and dismantling/*Land* collecting facilities that have previously not been covered by the Konrad waste acceptance requirements.

- Clarification of the requirement for compliance with the average activity concentrations (operational aspect which is to further specified and stipulated for the planning of emplacement campaigns).

The Konrad waste acceptance requirements are supplemented by the two complementary documents radioactive waste product control, radiological aspects and radioactive waste product control, material aspects. The adaptations and amendments made in the framework of the revision of the Konrad waste acceptance requirements are taken into account in Revision 2 of the radioactive waste product control, radiological aspects appropriately. Moreover, the eight ancillary provisions of the Konrad waste acceptance requirements for product control are implemented. The work for revision of the product control measures are partly performed in parallel to the updating of the Konrad waste management requirements and partly subsequent to it.

Regarding the radioactive waste product control, material aspects it should be noted that its update from water law point of view – as is the case for the Konrad waste acceptance requirements – was completed on schedule on 15 March 2012. No further aspects resulted from the final statement of the NLWKN of 20 January 2013 that would have to be considered.

Gorleben

In 1977, the Gorleben site (Lower Saxony) (see Figure D-12) was selected for a nuclear waste management centre (see Chapter A.2 for details) and later limited to the use as a possible repository site. Following a surface site exploration started in 1979, underground exploration of the salt dome was begun in 1986 with the sinking of the shafts. Until 1 October 2000, the beginning of the moratorium, drifts with a total length of approximately seven kilometres had been driven. In all, about € 1,700 million have been invested until the end of 2013 in exploring the Gorleben salt dome and keeping the mine open.

After expiry of the moratorium, the underground exploration work at the Gorleben salt dome was resumed in October 2010. In parallel, a preliminary safety analysis for the salt dome was developed in application of the Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste of 30 September 2010. Initially, it was intended to subject the results of this preliminary safety analysis to an international peer review in 2013, but this was not pursued. The work for the preliminary safety analysis was completed in March 2013 without a preliminary suitability statement for the Gorleben site. The developed repository concepts for disposal in salt rock may be appropriate to meet the BMUB safety requirements for ensuring safety in the long term.

According to § 29 StandAG [1A-7], the mining exploration work at the Gorleben site were to end with the entry into force of this Act on 27 July 2013, but it was already discontinued in November 2012. Until decision on a site according to the StandAG, the mine is kept open while ensuring that all the legal requirements are met and the necessary maintenance work is performed as far as the salt dome will not be excluded from the selection procedure.

Figure D-12: Gorleben site; in the background TBL-G, ALG and PKA (Copyright: GNS)

D.3.4 Asse II mine

After mining operation from 1909 to 1964, the former salt mine Asse II was acquired by the *Gesellschaft für Strahlenforschung* (GSF), the later *Helmholtz Zentrum München* (HMGU), on behalf of the Federal Ministry for Scientific Research and Technology (now the Federal Ministry of Education and Research (BMBF)) as a research mine. From 1967 to 1978, a total of 124,494 drums and packages were emplaced in the mine as low-level radioactive waste, including also about 15,000 so-called lost concrete shieldings (VBA) with higher-active waste. 1,293 drums and packages with intermediate-level radioactive waste were emplaced, among other things, between 1972 and 1977. In parallel to the emplacement, tests with cobalt sources were performed to investigate the impacts of radioactive radiation on salt rock. Until 1985, there was research into the development and demonstration of techniques for the emplacement of radioactive waste.

On 4 September 2008, the then competent BMU, the BMBF and the Lower Saxony Ministry for the Environment and Climate Protection (NMU) agreed that the Asse II mine will be treated as a repository in the future according to the AtG. Therefore, the BfS, which is responsible for the disposal of radioactive waste, was to take over the operatorship of the facility on 1 January 2009 from the HMGU. For the operation of the facility, the BfS employs the services of the Asse-GmbH, a 100 % federally owned company.

According to the 10th amendment to the AtG of 24 March 2009 [1A-24], the operation and closure of the Asse II mine are subject to the requirements pursuant to the AtG, which requires the BfS to close the facility. This was preceded by the decision of the Federal Government of 5 November 2008 to transfer the Asse II mine, which had so far been operated according to mining law, to the area of application of nuclear law and to operate the mine in future as a radioactive waste repository according to § 9a AtG [1A-3].

In order to bundle regional interests in a safe closure, already in 2008, the *Begleitgruppe Asse-II* (Asse II advisory group) was established in Wolfenbüttel, which consists of representatives of the municipal representatives, local politics, environmental organisations and citizens' initiatives. The working group option – retrieval (AGO), which consists of the experts appointed experts by the *Begleitgruppe Asse-II* gives expert advice to the advisory group.

Since 1988, inflow of groundwater from the overburden into the mine has been observed (see Figure D-13 right). Collecting points were established to collect the influent solutions. Daily, about 12 m³ of NaCl saturated groundwater is collected in the mine before they can come into contact with the emplaced waste. It is not possible to predict the further development of the inflow at this stage.

The current main collecting point is located at the 658-m level. The uncontaminated solution collected there is pumped to the surface and used for controlled flooding of an old salt mine. This option will expire in a few years. The BfS aims at obtaining a water permit to discharge the uncontaminated solution into suitable surface waters.

About 0.8 m³ of influent solutions are collected per day at the 725-m level. These waters are partly contaminated with tritium. However, they are not utilised externally, but used in the production of special concrete (Sorel concrete) for backfilling of cavities. Saline solutions collected at the 750-m level are contaminated with tritium (H-3) below the exemption level and partially with caesium 137 (Cs-137) above the exemption level. The amendment to § 57b AtG of 25 April 2013 ("Lex Asse") [1A-26] makes it possible to use contaminated solutions (up to 10 times the exemption level) also for the production of Sorel concrete. Solutions with higher contamination levels must be delivered to the competent *Land* collecting facility.

For stabilisation of the mine, former mining chambers in the southern flank were backfilled with fine-grained crushed salt from August 1995 to December 2003. A total of approximately 2.1 million

Mg (corresponding to approximately 1.75 million m³) of backfill material was inserted into the southern flank of the Asse II mine. Subsequent to it, backfilling of shafts and drifts below the emplacement areas with rock salt and magnesium chloride solution started.

Due to the stabilisation material used, the high excavation degree in the southern flank of the salt structure, the nearness of the former mining chambers to adjoining rock and the entry of solution into the in the mine, the deformation rate of pillars and stopes can only be predicted to a limited extent. The rates of deformation of the remaining strongholds are still high. Therefore, after having taken over the operatorship, the BfS carried out further stabilisation measures with Sorel concrete to improve stability and precautionary measures regarding the influent solutions.

For this purpose, the complete backfilling of the residual cavities in the former mine workings of the southern flank where no radioactive waste had been emplaced was initiated (roof cleft backfilling). Emplacement chambers were not filled. The aim of the backfilling measure is to slow down the rock deformation and thus to improve the safety situation. As part of emergency preparedness, numerous residual cavities have already been filled with Sorel concrete at the 775-m level below the waste chambers. It is also planned to backfill cavities no longer needed in the surrounding of the emplacement chambers at the 725- and 750-m level. These measures are intended to counteract the progressive damage of the rock.

Backfilling of the emplacement chambers is only provided for the occurrence of an emergency (e.g. in case of a solution inflow found to be uncontrollable).

Moreover, for the case of an uncontrollable solution inflow, emergency planning was set up describing further emergency preparedness and response measures (enlargement of the capacity of the solution management, preventive removal of fittings and operating material no longer required as well as preparatory planning for evacuation, remaining backfill, shaft seals and controlled cross-flooding).

Since 8 July 2010, the Asse II mine has a licence for handling radioactive substances according to § 7 StrlSchV [1A-8] to keep the mine open.

Figure D-13: Asse II mine (left: waste package in an emplacement chamber (no more accessible today), right: dripping point) (Copyright: BfS)

With public participation and the involvement of various experts and the AGO a comparison of options was performed in 2009 to identify the safest closure strategy for the Asse II mine. Three possible closure options were described, analysed and evaluated. The options considered were:

- the retrieval of the radioactive waste,
- the relocation of the radioactive waste to a deeper part of the salt dome, and
- the complete backfilling of the mine without removal of the radioactive waste.

As a result of the comparison, the BfS, tasked with the closure, has identified the retrieval of all waste as the closure option by which long-term safety can be demonstrated with the highest probability through the controlled disposal of the waste in a plan-approved repository. The retrieval of all waste was therefore considered the preferred method for the closure of the Asse II.

The ESK points out that in the case of retrieval of the waste from the Asse II mine, it is currently not possible to make substantiated estimates of the radiation exposure of personnel and the public. During retrieval of the waste, additional radiation exposure for the operating personnel and the public would have to be accepted over the next decades. The conservatively calculated potential future doses in the case that the waste remains in the Asse II mine must be weighed against this.

On 28 February 2013, the German *Bundestag* adopted the Act to Speed up the Retrieval of Radioactive Waste and the Closure of the Asse II Mine ("Lex Asse") [1A-26]. This Act governs the closure of the Asse II mine following the retrieval of the radioactive waste.

Due to the limited knowledge about the condition of the waste and the emplacement chambers, the realisation of retrieval is fraught with uncertainties. For this reason, first a fact finding and trial phase will take place, divided into three steps:

- In a first step, there will be drillings into two emplacement chambers at the 750-m level to take gaseous, liquid and solid samples and the surrounding area of the emplacement chambers will be explored.
- In a second step, these emplacement chambers will be opened to assess their condition and the condition of the emplaced packages.
- In a third step, it is intended to recover first waste packages from the two emplacement chamber by way of trial.

All three steps must be carefully planned. In particular, the necessary technical and organisational safety measures have to be observed so that neither the staff in the mine nor the people above ground and the environment will be at risk.

On 21 April 2011, the Lower Saxony Ministry for the Environment and Climate Protection (NMU) granted a licence according to § 9, para. 1 AtG for the first step of fact finding, i.e. drilling into the emplacement chamber 7 and 12 at the 750-m level. The first drilling started on 1 June 2012, had a total length of 35 m and was above chamber 7/750 in the salt rock. To explore the chamber ceiling and possible cavities at the upper edge of the chamber, radar measurements were conducted from the borehole. Subsequently, the borehole was backfilled. A second borehole was drilled west to the sealing structure into emplacement chamber 7/750. At the beginning of June 2013, it reached a waste package at a depth of 23.20 m. First results were obtained on the radiological situation in the backfill material and its pore volume. Flammable or explosive gas mixtures were not found. Further drilling work is planned to investigate the rock condition of the stope above the chamber. Drilling into chamber 12/750 is currently being prepared.

The fact finding will take longer than planned. Contrary to initial expectations (3 years), it is assumed today that it will take about eight to ten years. The necessity of the individual steps within the fact finding is to be checked repeatedly in the course of further actions with the aim of acceleration.

Since January 2012, the BfS conducted three workshops also involving a large number of external experts and the general public with the following results.

- The duration of the retrieval is estimated to be about 35 to 40 years on average (according to the concept plans, 8 to 10 years were assumed). In addition, a new shaft for the recovery of waste is urgently required. The creation of new underground infrastructure rooms outside the current mine workings is obligatory. Prior to this, the emergency preparedness measures (particularly stabilisation and backfilling) need to be fully implemented.

- To speed up the start of retrieval, the new shaft and the storage facility should immediately be planned and also executed without the final examination of the feasibility of retrieval.

- In a third workshop in November 2012, boundary conditions and the necessity of emergency preparedness as well as the justification of retrieval in terms of radiation protection were discussed.

In April 2013, a revised framework schedule was presented. In addition to possible accelerations, time delays have meanwhile also been considered. The latter are due to the closure of infrastructure areas and driveways in 2012 necessary for safety reasons and their subsequent renovation as well as an increasing effort to maintain the usability of the mine workings. There is no experience as regards the retrieval of radioactive waste from a mine. Experience from other mining areas can only be used to a limited extent. Currently, there are no technical plans for the realisation so that the existing framework schedule only comprises the period until start of retrieval. Accordingly, retrieval starts in 2033. The framework schedule is updated annually.

However, the longer the mine will be kept open, the higher is the risk that the inflow of groundwater will shift to inaccessible areas and can no longer be collected there or increases. Through the amendment to § 57 AtG, the Act to Speed up the Retrieval of Radioactive Waste and the Closure of the Asse II Mine ("Lex Asse") [1A-26] defines the statutory objective of retrieval of radioactive waste as a preferred option with regard to the safe closure of the Asse II mine. With the amendment, procedural framework conditions for accelerating the work were created (i. a. the clarification that for retrieval plan approval is not required, a regulation on the admissibility of partial licences and premature start, introduction of licences with concentration effect). To avoid enforcement uncertainties it was clarified that, in the context of European law, regulatory exceptions to radiation protection regulations will be possible to the extent that radiation protection is ensured.

Acceleration potential exists, in particular, for the subprojects whose completion is a prerequisite for retrieval (construction of Shaft 5, planning and construction of the storage facility and development of recovery techniques) and those which can be started due to the "Lex Asse" before completion of the fact finding.

Should the waste remain in the mine completely or partially, the BfS will perform a long-term safety analysis on the long-term effects caused by it. For this purpose, more detailed knowledge of the geological conditions is required. For further exploration of the overburden in the area of the southern flank, further investigations are provided.

D.4 Inventory of radioactive waste

In the Federal Republic of Germany, radioactive waste originates from

- the operation of nuclear power plants and research reactors,
- the decommissioning of nuclear power plants, of experimental and demonstration reactors, research, as well as from research and training reactors for educational purposes, and other nuclear facilities,
- uranium enrichment and fuel fabrication (nuclear industry),
- basic and applied research,
- the use of radioisotopes in other research institutions, universities, trade and industry companies, hospitals and medical practices,
- other waste producers, such as the military sector,
- the future conditioning of spent fuel intended for direct disposal.

The Federal Republic of Germany accepts the return of the following radioactive waste:

- According to contractual agreements with the reprocessing companies AREVA-NC, formerly COGEMA (France), and Sellafield Ltd., held by NDA (United Kingdom), Germany must accept the return of an equivalent amount of radioactive waste obtained from the reprocessing of spent fuel from light water reactors. The return of the vitrified fission product concentrate from France started in May 1996 and was completed in November 2011 as scheduled. For the other radioactive waste from the United Kingdom and France, plans have been prepared.

In the following, an overview is given of the inventory of untreated radioactive residues, together with the inventory of intermediate waste products and conditioned waste as at 31 December 2013 as well as a forecast on the volume of waste expected to arise until the year 2080. An overview of the radioactive waste disposed of in the ERAM and the waste emplaced in the Asse II mine is also provided.

D.4.1 Inventory of radioactive waste and forecast

The inventory of radioactive waste is determined for radioactive waste with negligible heat generation as well as for heat-generating radioactive waste. The original category system for reporting with untreated raw waste, intermediate products and conditioned waste was replaced by the following system of categories. The assignment of the former to the new category system is shown in Table D-5.

Table D-5: Assignment of the former to the more recent category system

Waste	RA	VA	P1	P2	G1	G2
Untreated raw waste	X	X				
Intermediate products		X	X		X	
Conditioned waste			X	X	X	X

Waste with negligible heat generation

Due to Council Directive 2011/70/EURATOM and the report on the national waste management programme prepared in response to it, data collection was adapted particularly by having to specify whether the waste is intended for the Konrad repository. In addition, the waste producers obliged to deliver may specify the masses instead of volumes for waste that are not yet conditioned to meet the requirements for disposal. This will not be followed by a distinction according to the intended destination due to the small amounts currently intended to be disposed of in another repository.

According to its state of processing, the waste is divided into raw waste (*Rohabfälle* – RA), i.e. waste in its original form, and pretreated waste (*vorbehandelte Abfälle* – VA) which e.g. has undergone preconditioning for better handling. For storage, waste will generally be conditioned. The conditioning process generates waste products that are usually stored in drums (= waste in inner container (P1) or have already been inserted into Konrad containers (G1). If further treatment of the waste product before disposal is not intended, it can be determined through the product control of the BfS that the waste product is suitable for the Konrad repository if it meets the waste acceptance requirements. In this way, a product-controlled waste product (*produktkontrolliertes Abfallprodukt* – P2) is generated from the waste product of the P1 category The waste products of the P2 category will then be inserted into Konrad containers (G1) for disposal. If suitability of the waste package (G1) for disposal is confirmed by the BfS, it will be categorised as product-controlled waste package (*produktkontrolliertes Abfallgebinde* – G2) and can be disposed of on call by the repository.

Table D-6: Overview of masses and volumes of radioactive waste in storage facilities with negligible heat generation as at 31 December 2013

Category	Mass	Volume
	[Mg]	[m^3]
RA – raw waste	9,349	
VA – pretreated waste	13,946	
P1 – Waste in inner containers		15,235
P2 – Product-controlled waste products		1,231
G1 – Waste in Konrad containers		97,412
G2 – Product-controlled waste packages		7
Total	**23,295**	**113,885**

According to Table D-3, the raw and pretreated waste stored at the waste producers' sites amounted to 23,295 Mg. 16,466 m^3 of the 113,885 m^3 of waste stored in containers (gross volume) relate to waste in inner containers that still have to be packed in Konrad containers and 97,419 m^3 to waste already packed in Konrad containers. As at 31 December 2013, 7 m^3 of waste have been prepared for delivery to the Konrad repository (see Table D-6).

Table D-7 shows the inventory of waste with negligible heat generation for the different groups of waste producers.

Table D-7: Overview of the inventory of radioactive waste with negligible heat generation according to its state of processing as at 31 December 2013

Waste producer group	RA Mass [Mg]	VA Mass [Mg]	P1 Volume [m³]	P2 Volume [m³]	G1 Volume m³]	G2 Volume [m³]
Research institutions	2,298	6,083	1,769	41	40,122	0
Nuclear industry	225	172	330	100	10,220	0
Nuclear power plants	792	160	2,213	717	4,925	0
Decommissioned nuclear power plants*	5,368	6,517	8,130	308	26,768	7
Land collecting facilities	416	524	2,318	65	900	0
Reprocessing (WAK)	250	489	475	0	14,476	0
Total	**9,349**	**13,946**	**15,235**	**1,231**	**97,412**	**7**

* Decommissioned nuclear power plants including nuclear power plants permanently shut down.

Table D-8 gives an overview of the distribution of the inventory of conditioned waste with negligible heat generation to the different storage facilities.

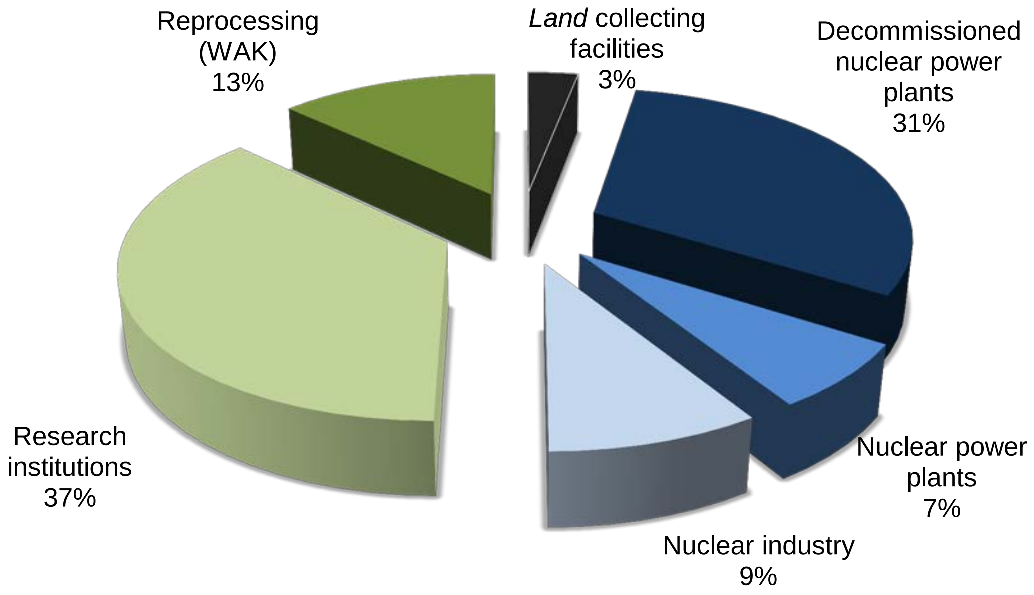
Table D-8: Storage of radioactive waste with negligible heat generation of categories P1 to G2 as at 31 December 2013

Storage facility	Waste volume [m³]
Research centres, including customers	59,251
Nuclear industry	2,513
Energiewerke Nord, ZLN storage facility	6,573
Nuclear power plants	12,777
Land collecting facilities	2,409
Storage facility at the Unterweser nuclear power plant	1,390
Storage facility of the utilities at Mitterteich	7,392
GNS Werk Gorleben	7,143
NCS storage facility	7,146
GNS and other storage facilities	2,174
Ahaus storage facility in the TBL-A	1,345
Storage facility at the Stade nuclear power plant	3,771
Total*	**113,885**

* Minor differences are due to rounding.

Figure D-14 shows the distribution of the radioactive waste inventory with negligible heat generation accumulated by the end of 2013 to the different waste producers.

Figure D-14: Distribution of the radioactive waste inventory with negligible heat generation of categories P1 to G2 according to waste producer groups as at 31 December 2013, total volume: 113,885 m³



Heat-generating radioactive waste

As at 31 December 2013, apart from spent fuel, 721 m³ of heat-generating radioactive waste were stored in the Federal Republic of Germany. The majority of the conditioned heat-generating waste comes from reprocessing. The conditioned waste from reprocessing is contained in 108 casks (one cask of the TS 28 V type, 74 casks of the CASTOR® HAW 20/28 CG type, 21 CASTOR® HAW 28M, 12 casks of the TN85 type) holding a total of 3,024 canisters with vitrified fission product concentrate from the reprocessing of spent fuel at AREVA NC. In the years 2009 and 2010, the liquid fission product concentrate was vitrified in the Karlsruhe vitrification plant (VEK). Since February 2011, the vitrified waste produced thereby is stored in five transport and storage casks of the CASTOR® HAW 20/28 CG type at the Rubenow storage facility (ZLN). The other heat-generating radioactive waste generally consists of activated components and spent fuel parts from the WAK, concentrate, and unsorted waste, e.g. from the dismantling of the WAK and the KNK II. The distribution of the inventory of heat-generating waste is shown in Table D-9.

Table D-9: Overview of the inventory of heat-generating radioactive waste as at 31 December 2013

Waste producer groups	Waste [m^3]
Research institutions	80
Nuclear industry	0
Nuclear power plants	0
Decommissioned nuclear power plants	0
Land collecting facilities	19
Others	0
Reprocessing (WAK and abroad)	622
Total	**721**

The conditioned radioactive waste, both the waste with negligible heat generation and heat-generating waste, is stored at the waste producers', as well as in internal and central storage facilities.

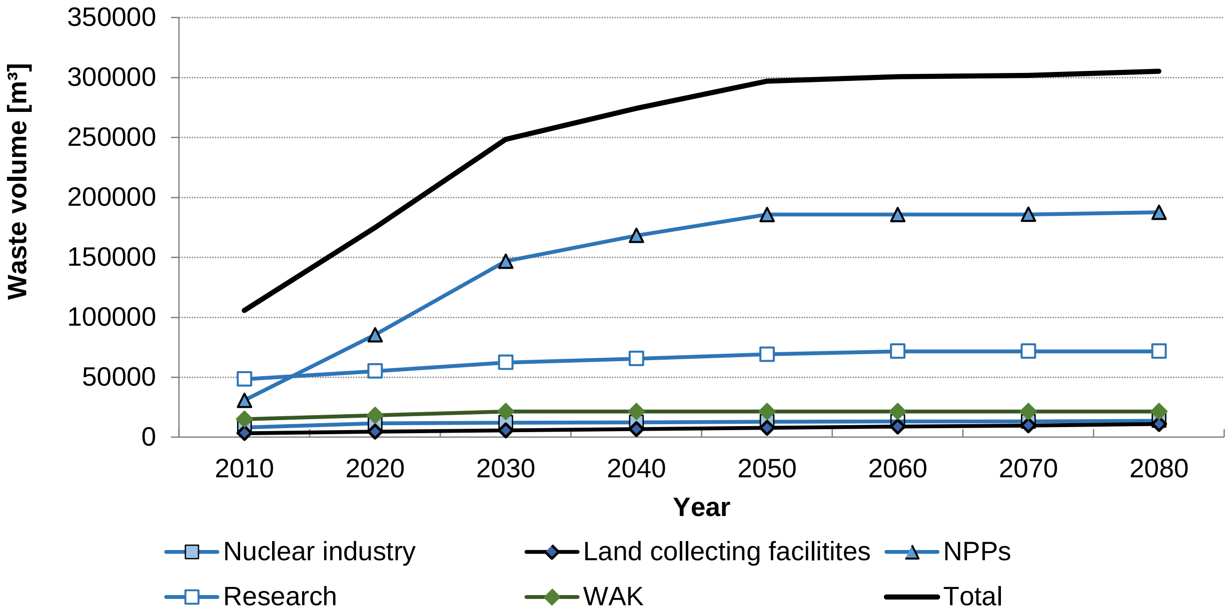
Forecasts

Regarding the work involved in planning a repository, it is necessary to make forecasts on the waste produced in future and to update these when boundary conditions change. The waste producers provide information about the expected waste volumes. This information also comprises the respective waste volumes expected in connection with the decommissioning and dismantling of nuclear facilities. The data provided represent planning values that are subject to uncertainties and which will have to be reviewed and adapted in the future.

For the forecast on the volumes of waste with negligible heat generation arising, the following boundary conditions were assumed: For each nuclear power plant unit, the operational waste is assumed to amount to a waste package volume of 45 m^3 (conditioned waste) per year. During a transitional phase of four years from operation until decommissioning, the licensing procedure for decommissioning of the installation is performed. During this period, there is further operational waste arising. For the decommissioning itself, an average of about 5,000 m^3 per light water reactor has been considered. The amount of decommissioning waste arising depends on when the decommissioning licence was granted and on the decommissioning concept (immediate dismantling or later dismantling after a period of safe enclosure). It is expected that the volume of decommissioning waste will be reduced further due to the progressing improvement of methods. Furthermore, it has to be taken into account that great efforts are undertaken to clear materials for release and that mainly only those materials will be counted among the radioactive waste which even after a longer decay period cannot be cleared for release (e.g. active components that used to be close to the core). It is expected that the largest waste stream volume will come from the decommissioning of the nuclear power plants.

The time-dependent accumulation of waste expected by the waste producers is modelled in Figure D-15 which shows that large amounts of waste are not to be expected after 2040.

Figure D-15: Time-dependent accumulation of radioactive waste with negligible heat generation as waste package volumes until 2080



The accumulated inventory of heat-generating waste in the year 2080, is estimated under the boundary conditions of the 13th amendment to the Atomic Energy Act adopted by the German *Bundestag* on 30 June 2011, taking the residual operating times into account. A volume of 27,000 m^3 is obtained for the following cask concept developed for disposal in a salt dome:

- approx. 20,400 m^3 of packaged fuel from light water reactors for direct disposal (this estimate is based on the assumption of disposal in POLLUX casks as present reference concept, which corresponds to 10,500 Mg HM),
- approx. 770 m^3 of vitrified waste (HAW from France, the United Kingdom and Karlsruhe as well as vitrified waste from liquid waste processing at the French La Hague reprocessing plant),
- approx. 820 m^3 of structural parts and sleeves (CSD-C) from the reprocessing of spent fuel in foreign reprocessing plants (France),
- approx. 1,340 m^3 packaged fuel from the THTR,
- approx. 180 m^3 of packaged fuel from the VKTA, HMI and FRM II (for the remaining fuel from research reactors, it is assumed in the context of this forecast that it will be shipped to the USA), and
- approx. 3,400 m^3 of waste packages with structural parts of the spent fuel for direct disposal.

D.4.2 Inventory of the Morsleben repository for radioactive waste

During the period from 1971 to 1991 and from 1994 to 1998, low- and intermediate-level radioactive waste with comparatively low concentrations of alpha emitters was emplaced in the Morsleben repository for radioactive waste (ERAM).

This waste originated from

- the operation of nuclear power plants,
- the decommissioning of nuclear facilities,
- the nuclear industry,
- research institutions,
- *Land* collecting facilities or directly from small waste producers, and
- the handling by other users.

In total, 36,753 m^3 of solid and solidified waste and 6,621 sealed radiation sources were emplaced in the repository. In general, the emplaced radioactive waste is packaged in standardised containers, such as 200- to 570-l drums and cylindrical concrete containers. The sealed radiation sources are not subjected to further treatment or only packaged in small containers. In addition to the disposed of radioactive waste, sealed cobalt radiation sources, some caesium radiation sources, and small quantities of solid intermediate-level radioactive waste (europium waste) in seven special containers (steel cylinders) with a volume of 4 l each and one 280-l drum containing Ra-226 waste are intermediately stored. Within the scope of the licensing procedure for the decommissioning, an application was submitted to dispose of this intermediately stored waste.

Building rubble, contaminated soil, cemented mixed waste both compacted and uncompacted, metallic waste, combustion residues, contaminated laboratory waste, cemented rinse solutions and immobilised radiation sources were supplied to the ERAM repository as radioactive waste by research institutions and other waste producers. Most of the radioactive waste from these waste producers is packaged in 200-l drums.

Waste data on the emplaced radioactive waste is documented and archived. The total activity of all emplaced radioactive waste is in the order of magnitude of 10^{14} Bq, the activity of the alpha emitters about 10^{11} Bq. Table D-10 provides an overview of the activity of the relevant radionuclides contained in the waste disposed of in the ERAM repository. The activity data refer to 31 December 2013.

Table D-10: Radionuclide-specific activities of the waste disposed of in the ERAM (as at 31 December 2013)

Alpha emitters	Activity [Bq]
Am-241	$2,3 \cdot 10^{11}$
Am-243	$9,5 \cdot 10^{07}$
Cf-249	$5,8 \cdot 10^{05}$
Cf-251	$2,3 \cdot 10^{04}$
Cf-252	$9,2 \cdot 10^{03}$
Cm-243	$5,9 \cdot 10^{05}$
Cm-244	$4,8 \cdot 10^{09}$
Cm-245	$2,3 \cdot 10^{06}$
Cm-246	$2,6 \cdot 10^{06}$
Cm-247	$2,6 \cdot 10^{04}$
Cm-248	$2,2 \cdot 10^{07}$
Cm-250	$3,3 \cdot 10^{02}$
Np-237	$8,3 \cdot 10^{07}$
Pa-231	$1,7 \cdot 10^{06}$
Pu-238	$7,8 \cdot 10^{10}$
Pu-239	$6,9 \cdot 10^{10}$
Pu-240	$6,6 \cdot 10^{10}$
Pu-242	$9,9 \cdot 10^{07}$
Pu-244	$2,1 \cdot 10^{04}$
Ra-224	$5,4 \cdot 10^{08}$
Ra-226	$2,3 \cdot 10^{10}$
Th-228	$5,4 \cdot 10^{08}$
Th-229	$4,6 \cdot 10^{05}$
Th-230	$1,9 \cdot 10^{06}$
Th-232	$5,8 \cdot 10^{06}$
U-232	$4,4 \cdot 10^{07}$
U-233	$5,0 \cdot 10^{06}$
U-234	$1,1 \cdot 10^{09}$
U-235	$8,2 \cdot 10^{07}$
U-236	$4,8 \cdot 10^{07}$
U-238	$4,3 \cdot 10^{08}$

Beta emitters/gamma emitters	Activity [Bq]
Ac-227	$6.2 \cdot 10^{06}$
Ac-228	$3.6 \cdot 10^{08}$
Ag-108m	$6.5 \cdot 10^{10}$
Al-26	$8.6 \cdot 10^{05}$
Am-242m	$2.3 \cdot 10^{08}$
C-14	$3.2 \cdot 10^{12}$
Ca-41	$7.3 \cdot 10^{07}$
Cd-113m	$6.5 \cdot 10^{09}$
Cl-36	$3.9 \cdot 10^{09}$
Co-60	$5.4 \cdot 10^{12}$
Cs-134	$9.4 \cdot 10^{09}$
Cs-135	$3.7 \cdot 10^{08}$
Cs-137	$6.3 \cdot 10^{13}$
Eu-152	$2.1 \cdot 10^{11}$
Eu-154	$1.9 \cdot 10^{11}$
Eu-155	$2.1 \cdot 10^{10}$
Fe-55	$1.4 \cdot 10^{11}$
H-3	$2.0 \cdot 10^{12}$
Ho-166m	$3.3 \cdot 10^{04}$
I-129	$2.1 \cdot 10^{08}$
K-40	$2.3 \cdot 10^{10}$
Kr-85	$2.1 \cdot 10^{11}$
Mn-54	$1.1 \cdot 10^{05}$
Mo-93	$2.5 \cdot 10^{08}$
Na-22	$3.2 \cdot 10^{08}$
Nb-94	$2.7 \cdot 10^{10}$
Ni-59	$1.8 \cdot 10^{11}$
Ni-63	$1.4 \cdot 10^{13}$
Np-236	$4.5 \cdot 10^{03}$
Pb-210	$1.2 \cdot 10^{10}$
Pd-107	$6.7 \cdot 10^{07}$
Pm-147	$1.1 \cdot 10^{10}$
Pu-241	$9.0 \cdot 10^{11}$
Ra-228	$3.6 \cdot 10^{08}$
Rb-87	$2.8 \cdot 10^{07}$
Ru-106	$7.2 \cdot 10^{06}$
Sb-125	$8.5 \cdot 10^{09}$
Se-79	$1.9 \cdot 10^{08}$
Sm-151	$2.6 \cdot 10^{11}$
Sn-126	$2.4 \cdot 10^{08}$
Sr-90	$4.8 \cdot 10^{12}$
Tc-99	$1.0 \cdot 10^{11}$
Zr-93	$9.3 \cdot 10^{09}$

The bulk (about 90 %) of the emplaced waste volume originates from operational and decommissioned nuclear power plants. The remaining 10 % comes from research, industry, business, medicine and other delivering parties. As the limit for the activity of alpha emitters was very low at ERAM ($4 \cdot 10^8$ Bq/m³), the portion of the waste originating from the nuclear industry, research centres and reprocessing is low. Table D-11 shows the volume of waste emplaced in the ERAM repository, classified according to individual waste producer groups.

Table D-11: Volume emplaced in the ERAM according to individual waste producer groups

Waste producer	Volume [m³]
Nuclear power plant	23,816
Decommissioned nuclear power plants	6,528
Research	2,592
Nuclear industry	159
Land collecting facilities	3,090
Others	523
Reprocessing	45
Total	**36,753**

D.4.3 Inventory of the Asse II mine

The data on the inventory of the Asse II mine originate from a waste database established by the former operator GSF (later HMGU) in 2000. This waste database was last revised in 2010 to check the inventory.

The BfS has prompted a review of the waste database according to which comprehensive recommendations were made. Some of them refer to the raw data and some to the calculation modules of the waste database which are used to determine the inventories on a specific date. The following inventory data are based on a further development of the revised version of the waste database and are subject to the reservation that the majority of the recommendations has not been implemented yet. The revision of the calculation module is very complex and not yet completed. The inventory data will therefore still be subject to changes in the future.

For transport and storage of intermediate-level radioactive waste an additional shielded cask was needed. In 1978, the limited emplacement licences expired, and research and development in the field of disposal was continued without any further emplacement of radioactive waste. Until then, a total of 47,000 m^3 of radioactive waste from the delivering parties had been emplaced in various different waste package types:

In the Asse II, the emplacement of low-level radioactive waste, which was handled without additional shielding, began in 1967, and the emplacement of intermediate-level radioactive waste in 1972. For transport and storage of intermediate-level radioactive waste, an additional shielded cask was needed. In 1978, the limited emplacement licences expired. Until then, about 47,000 m^3 of radioactive waste (package gross volume) from the delivering parties had been emplaced in various different waste package types:

- 124,494 packages as low-level radioactive waste with a total activity of about $2.16 \cdot 10^{15}$ Bq (as at 31 December 2012). According to the current state of knowledge, 14,779 of them are so-called lost concrete shieldings (VBA) containing waste with higher activity. Altogether, the packages contain about 80 % of the total activity in the Asse II mine and are distributed over eleven chambers at the 750-m level and one chamber at the 725-m level.

- 1,293 drums holding intermediate-level radioactive waste with a total activity of about $5.5 \cdot 10^{14}$ Bq (as at 31 December 2012). These represent about 20 % of the total activity and are stored at the 511-m level. Additionally, eight drums with low-level radioactive waste are also stored there. The latter was emplaced for testing of a new shielded cask (E2).

Table D-12 gives an overview of the waste origin and the percentages of the total activity.

Table D-12: Percentages of the waste packages emplaced in the Asse II mine with regard to waste origin, number and activity

Delivering party (waste origin)	Waste packages [%]	Total activity [%]
Karlsruhe Institute for Technology (KIT)	49	93
Jülich Research Centre (FZJ)	10	1
Nuclear power plants	25	2
Other delivering parties	16	4
Total	**100**	**100**

The low-level radioactive waste was mainly emplaced in drums with volumes of between 200 and 400 l or in cylindrical concrete containers. For the emplacement of intermediate-level waste, only 200-l drums were used.

The low-level radioactive waste emplaced contains solidified or dried former aqueous waste, such as evaporator concentrates, filter residues, sludges, ion-exchanger resins, furthermore solid waste such as scrap, rubble and mixed waste. As regards the intermediate-level radioactive waste, metal scrap, filters and solidified former aqueous waste was emplaced. The percentages of the waste packages (number of packages) emplaced with regard to the different kinds of waste are given in Table D-13 for low-level radioactive waste (LLW) and intermediate-level radioactive waste (ILW). According to the current state of knowledge, no high-level radioactive waste was emplaced in the Asse II mine. Eight drums filled with intermediate level radioactive waste from FZJ contain parts of new and irradiated fuel rod segments or AVR fuel pebbles with, in some cases, enriched uranium.

Table D-13: Percentages of the waste packages with regard to the different types of waste for LAW and MAW

Type of waste	LLW packages [%]	ILW packages [%]
Filter, filter aids, sludges, evaporator concentrates, resins, etc.	30	35
Metal scrap (iron, steel metal, structural parts, pipes, etc.)	20	65
Rubble, gravel, floor coverings, etc.	10	-
Mixed waste, paper, film, overalls, galoshes, cleaning rags, wood, glass, etc.	40	-
Total	**100**	**100**

The 125,787 waste packages emplaced, which have a gross waste package volume of about 47,000 m³ and a total mass of about 89,000 Mg, had a total activity of about $1 \cdot 10^{16}$ Bq at the time of emplacement. Table D-14 gives an overview of the activities of the relevant radionuclides in the waste emplaced in the Asse II mine as at 31 December 2012. At that time, the total activity was about $2.8 \cdot 10^{15}$ Bq including an alpha activity of about $3.9 \cdot 10^{14}$ Bq.

Table D-14: Radionuclide inventory of relevant radionuclides in the Asse II mine as at 31 December 2013

Radionuclide	Activity [Bq]	Radionuclide	Activity [Bq]
H-3	$4.3 \cdot 10^{11}$	Ra-226	$2.0 \cdot 10^{11}$
C-14	$2.6 \cdot 10^{12}$	Th-232	$3.3 \cdot 10^{11}$
Cl-36	$7.2 \cdot 10^{09}$	U-234	$1.4 \cdot 10^{12}$
Co-60	$1.1 \cdot 10^{13}$	U-235	$5.3 \cdot 10^{10}$
Ni-59	$1.8 \cdot 10^{12}$	U-236	$2.4 \cdot 10^{10}$
Ni-63	$2.6 \cdot 10^{14}$	U-238	$1.3 \cdot 10^{12}$
Se-79	$3.4 \cdot 10^{09}$	Np-237	$3.7 \cdot 10^{09}$
Sr-90	$2.0 \cdot 10^{14}$	Pu-239	$4.5 \cdot 10^{13}$
Zr-93	$5.5 \cdot 10^{11}$	Pu-240	$5.1 \cdot 10^{13}$
Nb-94	$1.8 \cdot 10^{11}$	Pu-241	$1.3 \cdot 10^{15}$
Tc-99	$1.1 \cdot 10^{11}$	Pu-242	$9.1 \cdot 10^{10}$
Sn-126	$4.6 \cdot 10^{09}$	Am-241	$2.4 \cdot 10^{14}$
I-129	$2.7 \cdot 10^{08}$	Cm-244	$8.0 \cdot 10^{11}$
Cs-135	$3.2 \cdot 10^{09}$	Cm-245	$2.7 \cdot 10^{08}$
Cs-137	$3.6 \cdot 10^{14}$	Cm-246	$3.3 \cdot 10^{08}$
Sm-151	$3.4 \cdot 10^{12}$		

D.4.4 Inventory from former activities

Waste from former activities has been conditioned and either stored (see reporting on Article 32 (2) iv a)) or was disposed of (see reporting on Article 32 (2) iv b).

Reporting on measures related to former practices is contained in Chapter H.2.2.

D.5 List of decommissioned facilities

D.5.1 Overview

As part of this report for the Convention, an overview is given of nuclear facilities in Germany that have been permanently shut down and of nuclear facilities being under decommissioning (nuclear power plants, experimental and demonstration reactors, research reactors, nuclear fuel cycle facilities). In Germany, a nuclear facility is regarded as being "under decommissioning" only if a decommissioning licence was granted. The report also includes information on the status of decommissioning of nuclear facilities. Table D-15 gives an overview of the number of nuclear facilities permanently shut down, being under decommissioning and those for which decommissioning has been completed and which were released from regulatory control. Plant-specific lists can be found in Table L-14 to Table L-19 in Annex L-(c).

For seven of the eight nuclear power plants shut down by law in 2011, applications for a first decommissioning and dismantling licence according to § 7, para. 3 AtG have been filed until spring 2013 (see Table L-20 in Annex L-(d)). These nuclear power plants are in the post-operational phase (operational phase after expiry of the authorisation for power operation until granting of the decommissioning licence). In Germany, the eight shut down nuclear power plants are not yet considered as decommissioning projects. This would only be the case with the granting of a licence for decommissioning.

Over the past four decades, Germany has acquired considerable experience in the decommissioning of nuclear facilities. Many research reactors and all experimental and demonstration reactors but also a few larger nuclear power plants and nuclear fuel cycle facilities are currently at various stages of decommissioning. Some facilities have been fully removed and the site has been cleared for reuse.

Through courses for achieving and maintaining the required expert knowledge, as well as through research and education at universities and technical colleges, the high standards of education and qualification in the field of nuclear technology in Germany are maintained. Chapter F.2.1 of this report describes the measures for maintaining competence.

Table D-15: Overview of nuclear facilities permanently shut down, being under decommissioning and those for which decommissioning has been completed

Type of waste	Permanently shut down	Decommissioning	Decommissioning completed
Power reactors	8 reactors	12 reactors	-
Experimental and demonstration reactors	-	4 reactors (see explanation in D.5.3)	3 reactors and the nuclear ship Otto Hahn
Research reactors ≥ 1 MW thermal power	2 reactors	6 reactors (see explanation in D.5.4)	1 reactor
Research reactors < 1 MW thermal power	2 reactors	-	26 reactors 1 reactor rededicated
Nuclear fuel cycle facilities (primarily commercial fuel fabrication and reprocessing)	-	2 facilities	4 facilities
Research, experimental and demonstration facilities of the nuclear fuel cycle	-	-	3 facilities

D.5.2 Power reactors

With the entry into force of the 13th Act to amend the Atomic Energy Act on 6 August 2011 due to the events in Japan, the authorisation for power operation of eight nuclear power plants expired. Until October 2013, applications for decommissioning licences had been submitted for seven of the eight shut-down nuclear power plants. These nuclear power plants are in the post-operational phase until granting of a decommissioning licence.

The 12 nuclear power plants under decommissioning are located in Greifswald (KGR, five units), Rheinsberg (KKR), Würgassen (KWW), Mülheim-Kärlich (KMK), Stade (KKS), Lingen (KWL), Gundremmingen (KRB-A) and Obrigheim (KWO).

D.5.3 Experimental and demonstration reactors

Four experimental and demonstration facilities are in the decommissioning phase. The experimental and demonstration reactors at Niederaichbach (KKN) and Großwelzheim (HDR) as well as the Kahl experimental nuclear power plant (VAK) have been fully dismantled and released from regulatory control. The nuclear ship Otto Hahn has been released from regulatory control, the reactor pressures vessel (RPV) of the ship was removed and is stored at the Helmholtz-Zentrum Geesthacht.

D.5.4 Research reactors

Two research reactors with a thermal power of 1 MW and more have been permanently shut down, but do not have a decommissioning licence yet. Six research reactors with a thermal power of 1 MW and more are in various stages of decommissioning (including the FMRB Braunschweig, released from regulatory control except for one storage facility). One reactor (FRJ-1) has been fully dismantled and released from regulatory control.

26 research reactors no longer in operation with a thermal power of less than 1 MW, many of them zero power reactors for educational purposes, have already been fully removed. The AKR-1 was rededicated for a limited period of time according to § 57a AtG. In parallel, it was rebuilt as AKR-2 which commenced its operation in July 2005. The fuel core was removed from the training reactors in Aachen and Hanover decommissioning applied for.

D.5.5 Nuclear fuel cycle facilities

The six decommissioned or dismantled commercial facilities of the nuclear fuel cycle are the processing plant (WAK) together with the Karlsruhe vitrification plant (VEK) in Karlsruhe and five fuel fabrication plants at Hanau and Karlstein. Three of the five fuel fabrication plants have already been fully removed and released from regulatory control, a facility in Karlstein has been converted for conventional use. At the site of the removed NUKEM-A plant, groundwater remediation is still ongoing, which is the reason that the site has not yet been fully released from regulatory control.

In addition, the facility Siemens Power Generation Karlstein (SPGK) – a research facility with hot cells – and the facility for the production of Mo-99 (AMOR) in Rossendorf are under decommissioning, which, however, are not considered as commercial facilities of the nuclear fuel cycle in this report. For other non-commercial nuclear fuel cycle facilities, which were located in research centres, decommissioning has been completed.

An overview of commercial nuclear fuel cycle facilities being under decommissioning as well as those for which dismantling has been completed and which are released from regulatory control is given in Table L-18 of the annex.

D.5.6 Status of some current decommissioning projects

Greifswald nuclear power plant (KGR) and Rheinsberg nuclear power plant (KKR)

The dismantling of both the Greifswald nuclear power plant and the Rheinsberg nuclear power plant is managed by the federally owned company *Energiewerke Nord GmbH* (EWN GmbH).

Eight nuclear power plant units of Soviet design, each with an electrical output of 440 MWe, had been planned for the nuclear power plant complex at Rubenow near Greifswald (KGR). At the time of final shutdown in 1990, the first four units (WWER-440/W-230 type) had been in commercial operation since the 1970s (Unit 1 since 1974), whilst the fifth (WWER-440/W-213 type) had been in trial operation for a few months when it was shut down in 1989. Units 6 to 8 were still under construction. Apart from the reactor units, the complex also comprises the *Zentrale Aktive Werkstatt* (ZAW). The decision to shut down all existing units and to halt commissioning of the remainder was taken on the basis of financial considerations, because under federal atomic energy law, their continued operation would have required major structural conversions. Certain special features of the plant needed to be taken into account when preparing the concept for decommissioning and dismantling. Under § 57 AtG [1A-3], the operating licence from the former GDR remained valid until the decommissioning licence was granted on 30 June 1995. Since May 2006, there has been no more fuel in the Greifswald nuclear power plant. The dismantling of the KGR power plant units is well advanced. Parts of the plant buildings have already been put to industrial use and removed.

In October 2012, the EWN GmbH filed an application for approval for long-term storage of disused, contaminated buildings inside the KGR. The procedure described in the application is to provide an alternative to the immediate removal of buildings released for demolition. The application is being reviewed by the competent authority.

The Rheinsberg nuclear power plant (KKR) was the first nuclear power plant of the former GDR. It was equipped with a pressurised water reactor of the WWER type with 70 MWe (gross), which was in operation from 1966 to 1990. The former Ministry for the Environment, Nature Conservation and Regional Planning of Brandenburg, as the competent supreme *Land* authority, issued a licence for the decommissioning and partial dismantling of the KKR in April 1995. Decommissioning is carried out in several licensing steps. The scope of dismantling includes the active storage facility for solid and liquid radioactive residues (ALfR) at the KKR site where radioactive waste from the operational phase of the KKR was stored. Decommissioning of the KKR has to be seen in direct context with the KGR, since the radioactive waste, the reactor pressure vessel (RPV) and a part of the material eligible for clearance are treated or stored at the facilities at the KGR site, in particular the ZLN (see below), the ZAW and the clearance measurement facility. Transport of the material to Rubenow is mainly carried out in larger quantities with freight trains. So in October 2007, the RPV of the KKR was transported to the ZLN with a heavy freight train.

An essential part of the overall concept for decommissioning of the KGR and the KKR was the construction of ZLN storage facility at the KGR site. The spent fuel from the fuel pools in the reactor buildings and from the spent fuel storage facility as well as from the KKR is stored in the ZLN. In addition, the ZLN serves as a storage facility for radioactive waste from KGR and KKR until it can be delivered to a repository ready for operation, for storage of the RPVs from Units 1 to 5 of the KGR and from the KKR as well as for a part of the RPV internals and unsegmented steam generators, making use of radioactive decay for several decades, but no longer than until the end of the operating period of a repository (see Figure D-16). With their installations for conditioning and segmentation, the ZLN, the ZAW, the central decontamination and water treatment plant (ZDW) and the clearance measurement facility also significantly contribute to handling the large quantities of material from the decommissioning of the KGR, since the successive segmentation of large components, such as steam generators, can be decoupled from the dismantling of the rest of the plant with various sawing methods (see Figure D-16). In addition, there is the possibility to treat radioactive residues/waste from other nuclear facilities with a maximum activity of $1.4 \cdot 10^{16}$ Bq and a total weight of up to 15,000 Mg.

Since December 2007, the ZLN has a licence for the storage of radioactive residues from other nuclear facilities with light water reactor (only facilities for commercial production of electricity under decommissioning) five years prior and five years after treatment or conditioning at the Rubenow site.

Figure D-16: Segmentation of a steam generator by sawing procedures at ZLN (Copyright: EWN)

Obrigheim nuclear power plant (KWO)

The Obrigheim nuclear power plant (KWO), a pressurised water reactor with an electrical power rating of 357 MWe (gross), started operation in 1968. Since 1 January 2007, the KWO has been operated by *EnBW Kernkraft GmbH* (EnKK), like the two plants in Neckarwestheim and Philippsburg. The principal owner of the EnKK is the *EnBW Kraftwerke AG*.

This plant had produced its assigned electricity quantity as defined in the AtG in 2005, so that power operation was terminated on 11 May 2005. The decommissioning strategy chosen for the KWO is direct dismantling. Decommissioning and dismantling of the facility have to be carried out under four licences according to § 7, para. 3 AtG [1A-3]. The first decommissioning and dismantling licence for final and permanent cessation was granted on 28 August 2008. This allowed the dismantling of components in the supervised area. The second decommissioning and dismantling licence, which comprises the dismantling of components in the controlled area, was issued on 24 October 2011. After two steam generators that had been dismantled and stored on the premises of the Obrigheim nuclear power plant were already transported to Rubenow on waterways in 2008, two further steam generators were taken to the ZLN in 2012 after granting of the second dismantling licence (end of 2011) for plant components of the controlled area with the same objective of decontamination and disassembly.

On 30 April 2013, the third dismantling licence was granted for the dismantling of the lower part of the RPV with internals, the biological shield and other structural plant components in the reactor building. This work began in September 2013.

The scheduled work for decommissioning is influenced by several site-specific factors, of which the storage of the 342 spent fuel assemblies in parallel to the dismantling work is of particular importance. The fuel assemblies are located in the external fuel pool (wet storage facility) in the emergency building. Dry storage in CASTOR® casks at the KWO site was planned and applied for according to § 6 AtG on 22 April 2005 at the BfS. The licensing procedure has been suspended since a transport of the KWO fuel to the Neckarwestheim storage facility is being pursued as an alternative. The application for modification of the storage licence of the on-site storage facility was filed on 10 December 2013.

Würgassen nuclear power plant (KWW)

The Würgassen nuclear power plant (KWW), a boiling water reactor with an electrical output of 670 MWe (gross), was commissioned in 1971. The decision for decommissioning was taken at the end of May 1995 by the operator for economic reasons. Since October 1996, the plant has been free of nuclear fuel.

Direct dismantling was chosen as the decommissioning option. Dismantling was separated into six phases, where conventional demolition of the buildings at the site is the last phase. The licence for the first decommissioning phase was issued under atomic law on 14 April 1997; the fourth and thus last licence for the fourth and fifth dismantling phases was issued on 6 September 2002. With completion of dismantling of the RPV and concrete structures in the area of the containment, the relevant milestones regarding the full dismantling of the plant were as scheduled.

In all parts of the controlled area buildings, decontamination of building surfaces and clearance measurements are performed. At the same time, measurements are performed outside of buildings for the clearance of soil surfaces.

The dismantling measures according to the fourth decommissioning licence are scheduled for completion at the end of 2014. After that, low- and intermediate-level radioactive waste will remain at the site and stored in a rededicated building and a hall for keeping it ready for transport. The waste will not be removed from them before commissioning of the Konrad repository.

Stade nuclear power plant (KKS)

The Stade nuclear power plant (KKS) was equipped with a pressurised water reactor with an electrical output of 672 MWe (gross). The plant started operation in 1972 and was permanently shut down on 14 November 2003. Direct dismantling was chosen as decommissioning strategy. Dismantling of the plant was divided into five phases and applied for successively. The final dismantling phase comprises the conventional demolition of the buildings at the site.

The first licence under atomic law was issued on 7 September 2005 and referred to the decommissioning of the entire complex as well as the transition phase of the plant, the construction of an operational storage facility for radioactive waste, as well as the dismantling of first components and systems. The fourth dismantling phase relates to all residual dismantling measures in preparation for the conventional demolition. This licence was issued on 4 February 2011.

With the final removal of any residual fuel assemblies in April 2005, the absence of nuclear fuel was achieved. As part of the removal of large components, the four steam generators with a total mass of 660 Mg were shipped to Sweden in September 2007 for non-detrimental recycling. Dismantling of the reactor pressure vessel was completed in October 2010.

Currently, final dismantling measures are carried out in the KKS as well as decontamination and clearance of buildings. Radioactive waste from operation and decommissioning of the are stored in the on-site storage building constructed for this purpose until delivery to the Konrad repository.

Except for the storage facility for radioactive waste, completion of the dismantling licensed under atomic law for release from regulatory control is scheduled for 2015. This will be followed by conventional demolition of buildings of the KKS and return to a “greenfield” within the fifth phase.

Gundremmingen nuclear power plant; Unit A (KRB-A)

The Gundremmingen nuclear power plant, Unit A (KRB-A) has been the first commercial boiling water reactor in Germany. It had an electrical power of 250 MWe (gross) and was in operation between 1966 and 1977. Dismantling started in 1983. The decommissioning licence was granted on 26 May 1983. The decommissioning concept for KRB-A was divided into three phases. Phase 1 relates to the turbine hall internals, Phase 2 to the contaminated systems of the reactor building, and Phase 3 to the activated components in the reactor building, such as RPV and biological shield.

Dismantling is at an advanced stage. The components and systems in the turbine hall and reactor building no longer needed were dismantled. Segmentation of the RPV and the biological shield has been completed. The radioactive waste produced thereby was delivered to the Mitterteich storage facility in qualified packages. The reactor building has been decontaminated.

Since the Gundremmingen site comprises two other nuclear power plants (Unit B and Unit C) with boiling water reactors in operation, it has been decided to make use of the buildings of Unit A as a technology centre for the operational needs of the site. A licence for the operation of this technology centre was granted on 5 January 2006 and regulates the transition of these areas into the licence of the Units B and C.

Under certain conditions the licence permits the handling of radioactive waste with the aim of clearance, conditioning of waste, maintenance of components, manufacturing and storage of tools and equipment as well as the storage and preparation for transport of conditioned and unconditioned waste until processing or shipment.

Mülheim-Kärlich nuclear power plant (KMK)

The Mülheim-Kärlich nuclear power plant (KMK), a pressurised water reactor with an electrical output of 1,302 MWe (gross); was shut down for the last time after only 13 months of operation in September 1988. Decommissioning of the plant was decided and the application for a dismantling was filed in June 2001. Three independent licensing steps are provided. The last fuel assemblies were removed in 2002. The first licence for decommissioning and the first phase of dismantling was issued on 16 July 2004 so that dismantling work could be started. With the shipping of the last spent fuel in 2002 the plant is free of nuclear fuel.

The licence for dismantling phase 2a was issued on 31 May 2013 which includes, among other things, the dismantling of the reactor coolant pumps and pipes of the reactor coolant loop. Another licence application (2b) for dismantling of the RPV, the steam generator and the biological shield was filed in summer 2013.

In 2012, parts of the generator and a feed water tank were shipped to Egypt as non-radioactive parts of the secondary circuit where they are intended to be used in a combined cycle power plant. Conversion and dismantling work at the personnel airlock and measures to dismantle the infrastructure in the entire controlled area are being carried out. Furthermore, part of the plant premises was released from regulatory control and a further licence for a procedure for further downsizing the plant premises was granted on 31 January 2014.

On the basis of a letter by RWE of 8 May 2008, the licensing procedure for the on-site storage facility and the treatment centre continues to be suspended. Instead, off-site storage capacities are made use of.

Karlsruhe reprocessing plant (WAK) and Karlsruhe vitrification plant (VEK)

The WAK on the premises of today's Karlsruhe Institute of Technology (KIT) was a test facility for the reprocessing of spent fuel from research, experimental and demonstration reactors as well as from power reactors. Apart from the objective of gaining operational experience, development projects for a German reprocessing plant were carried out on an industrial scale. The WAK resumed operation in 1971 under the leadership of the *WAK Betriebsgesellschaft mbH*. Operation ceased at the end of 1990 following a decision against a large-scale reprocessing plant. During this period, approximately 200 Mg of nuclear fuel originating from numerous reactors were reprocessed. The uranium and plutonium obtained in this process was taken to nuclear fuel supply companies for reprocessing.

Operation finally ended on 30 June 1991. At the end of 1991, the Federation, the *Land* of Baden-Wuerttemberg and the utilities decided to decommission and dismantle the reprocessing plant. On 22 March 1993, the first partial decommissioning licence for the WAK was granted. On behalf of the research centre, the *WAK Betriebsgesellschaft mbH* carried out the residual operation and dismantling of the plant on its own responsibility until 2005. Since 1 January 2006, the WAK GmbH, a subsidiary of the federally owned company *Energiewerke Nord GmbH* (EWN), has been responsible for it.

At the end of the reprocessing operation, the plant consisted of

- the process building with the installations for the reprocessing of spent fuel,
- the storage buildings with containers and processing units for the storage of high-active waste concentrate (HAWC) and liquid medium-active waste (MAW), and
- facilities and buildings for media supply and technical infrastructure.

The objective of decommissioning is to completely dismantle all buildings and to achieve the state of "greenfield" by 2023. This overall objective is to be achieved in six technically independent steps.

The process building which had contained the reprocessing process installations has been nearly emptied since 2006 (Steps 1 to 3). Once HAWC vitrification was completed in 2010, work started to adapt the HAWC storage facilities and the Karlsruhe vitrification plant (VEK) to the reduced overall operation (Step 4). Step 5 includes the dismantling of the HAWC storage facilities and the VEK. The conventional demolition of all buildings (Step 6) will only be carried out after the entire plant will have been released from regulatory control.

About 60 m³ of HAWC with an activity of $7.7 \cdot 10^{17}$ Bq originated from the operation of the reprocessing plant, which was last stored in the facility for the storage and evaporation of high-level liquid waste (LAVA). Prior to the dismantling of the storage buildings, the HAWC stored in two containers had to be conditioned such to meet the requirements for disposal. For this specific purpose, Karlsruhe vitrification plant (VEK) was constructed. The first partial construction licence for the VEK was granted in 1998. The construction of the VEK started at the beginning of 2000. The second partial operating licence for hot (nuclear) operation was granted in February 2009. From September 2009 to June 2010, the HAWC was processed in the VEK into 123 canisters containing about 49 Mg of waste glass. During the subsequent flushing process, 17 additional canisters were produced, so that a total of about 56 Mg was produced. With the filling of the 140th canister, which was the last one, the operation of the VEK finally terminated in November 2010 and since then, it has been in the post-operational phase. The melting furnace was emptied and shut down. In August 2012, the operator filed an application for manual unloading of the installations in the VEK already taken out of operation in Step 4. The 140 canisters were placed into 5 transport and storage casks of the CASTOR® HAW 20/28 CG type and were transported to the ZLN of the EWN GmbH in Rubenow near Greifswald in February 2011.

Two emptied HAWC casks each are located in the buildings “LAVA” (storage casks) and “HWL” (reserve casks) in thick-walled concrete cells which – due to the high dose rate – are only accessible by remote handling. For carrying out the remote handling and for the residue logistics, a new access building was constructed south of the HWL and taken into operation in May 2008. One of the reserve casks was in operation for about 15 years and filled with HAWC. Despite of the fact that the cask was flushed several times after it had been emptied, there were about 100 kg of solid HAWC residues in this cask. These solid residues are to be recovered during the dismantling of the HAWC storage casks by remote handling, which has been permitted with the 22nd decommissioning licence of 8 December 2010.

The 23rd decommissioning licence was granted on 14 December 2011. It includes the dismounting of the LAVA high-active laboratory and the LAVA (hot) cells.

Jülich experimental reactor (AVR)

The experimental reactor of the *Arbeitsgemeinschaft Versuchsreaktor GmbH* (AVR) at Jülich (in close vicinity to the FZJ), North Rhine-Westphalia, was a pebble-bed high-temperature reactor with an electrical power of 15 MWe (gross), which was in operation between 1966 and 1988. The initial application for a decommissioning licence included a period of “safe enclosure”: in Germany this term refers to a safe state of a nuclear facility with almost no maintenance, into which it is transferred after final shutdown and removal of the fuel and in which it is kept for a certain time before being dismantled. Implementation of this licence, however, was very difficult, mainly due to the very narrow space inside the plant, leading to a considerable delay with respect to the initial time schedule.

The unloading of the fuel pebbles into the central storage facility at the site of the FZJ was completed in June 1998.

In May 2003, the EWN GmbH became sole proprietor of the *Arbeitsgemeinschaft Versuchsreaktor GmbH* (AVR). After this transfer, the strategy was changed from achieving safe enclosure to complete dismantling (“greenfield”). This change also caused a modification of the dismantling procedure. It is now planned to remove the unloaded reactor vessel in one piece and to store it in a newly constructed storage facility on the premises of the FZJ for making use of the radioactive decay. In November 2008, the reactor vessel was filled with lightweight aerated concrete, by which handling is facilitated and the radioactive inventory (internals and graphite dust) was fixed.

For lifting of the reactors vessel, a material lock was built as an extension of the reactor building (see Figure D-17). This extension, which is markedly higher than the old reactor building, allows lifting and lowering of the reactor vessel and tilting it into a horizontal position suitable for transport. Contamination of structures of the transfer building shall be prevented by appropriate measures against contamination spread, so that later clearance of the transfer building will be possible and production of additional radioactive waste will be avoided. Finally, the reactor vessel is to be transferred into the newly constructed storage facility at the premises of the FZJ in close vicinity. The reactor vessel is to be stored there until the later conditioning for disposal. The lifting of the reactor vessel is expected to take place in 2015, the termination of the entire project is scheduled for 2018.

Figure D-17: AVR reactor building with material lock (Copyright: EWN)

Lingen nuclear power plant (KWL)

The decommissioned Lingen nuclear power plant (KWL) was a boiling water reactor with an electrical power of 252 MWe (gross). Operation started in 1968. In 1977, the plant was permanently shut down due to technical considerations. After removal of the spent fuel, the *Kernkraftwerk Lingen GmbH* applied for dismantling of the turbine building and other conventional auxiliary systems no longer needed, and for safe enclosure of the residual part of KWL remaining under regulatory supervision for about 25 years. The licence was granted on 21 November 1985.

With a notice of 14 November 1997, KWL was granted the licence for modification of the plant, and the operation under safe enclosure conditions for the purposes of disposing of the operational waste. Although the disposal of the radioactive waste could not be continued after termination of the emplacements into the ERAM, the work for conditioning of the operational waste continued and has meanwhile been completed. The plant had been continuously optimised regarding improvement of occupational safety as well as fire prevention and radiation protection. An application for extending safe enclosure in 2004 was withdrawn after the legal validation of the planned commissioning of the Konrad repository; instead KWL applied for a licence for dismantling according to § 7, para. 3 AtG in December 2008.

The documents to be submitted according to the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10] were examined by the experts of the nuclear licensing authority. The dismantling is to be carried out in three projects. In the first licensing step initially applied for (Project 1), all non-contaminated and contaminated plant components are to be dismantled. A second licensing step to be applied for later on (Project 2) is to include the dismantling of RPV and its internals, the biological shield, the residual dismantling, decontamination, and the plant's release from regulatory control. The third project comprises the conventional dismantling of buildings.

The procedure according to Article 37 EURATOM for the dismantling of the Lingen nuclear power plant was completed with statement of the European Commission of 18 December 2012.

The licensing procedure for the dismantling is well advanced. After granting of the licence, the infrastructure of the plant is to be prepared for the dismantling. Subsequent to it, the segmentation of contaminated components can be started. The aim of the dismantling strategy is mainly directed to segmentation suitable for transport, and the handling and decontamination of material in external waste management facilities for minimising the waste volume. The low volume returned from waste conditioning may be prepared for transport to the Konrad repository in the controlled area of the KWL, or stored in the external Ahaus transport cask storage facility.

Hamm-Uentrop thorium high-temperature reactor (THTR-300)

Der THTR-300 mit einem heliumgekühlten 308 MWe (brutto) Kugelhaufen-Hochtemperaturreaktor The THTR-300 was equipped with a helium-cooled 308 MWe (gross) pebble-bed high-temperature reactor and started operation in 1983. Decommissioning of the plant was decided in September 1989, after the plant had been shut down for the scheduled annual revision on 29 September 1988. On 13 November 1989, the Federal Government, the *Land* of North Rhine-Westphalia, the operating company HKG and their proprietors signed a framework agreement concerning the completion of the THTR-300 project.

The first partial licence for the decommissioning, unloading of the reactor core and the dismantling of plant components was granted on 22 October 1993. The fuel pebbles have been removed from the reactor core and delivered to the Ahaus transport cask storage facility in CASTOR® THTR/AVR casks. The reactor core has been unloaded since 1995.

On 21 May 1997, the licence for the operation of safe enclosure (maintenance operation) was granted. Since October 1997, the plant has been in safe enclosure. Currently, it still consists of the reactor hall, the reactor operating building and the reactor auxiliary building with the respective internals. All other structural parts and plant components, such as the turbine building, the electrical systems building, the emergency diesel generators, the transformer stations and the cell cooling towers were released from regulatory control. During maintenance operation, installations are operated for maintenance and monitoring of safe enclosure. It includes permanent and non-permanent activities and measures that may be subject to approvals by the supervisory authority or require separate licences.

The duration of the safe enclosure is specified to be about 30 years, but is not limited by a licensing condition. In 2017, details are to be submitted to the nuclear supervisory authority on whether (and if so, how long) maintenance operation is to be continued or whether the plant will be finally dismantled. Concepts for the dismantling of the THTR-300 plant are regularly reviewed and updated if necessary.

E Legislative and regulatory system

This section deals with the obligations under Article 18 to 20 of the Convention.

Developments since the Fourth Review Meeting:

Since the report for the Fourth Review Meeting, there were several changes in nuclear law.

On 25 April 2013, the Act to speed up the retrieval of radioactive waste and the closure of the Asse mine (*Gesetz zur Beschleunigung der Rückholung radioaktiver Abfälle und der Stilllegung der Schachtanlage Asse* ("Lex Asse") of 20 April 2013 [1A-26] entered into force. § 57b AtG was amended accordingly. Closure, already provided in the old version, shall take place after retrieval of the radioactive waste. However, retrieval shall be discontinued if its performance is not acceptable for the population and the employees for radiological or other safety-relevant reasons. This is particularly the case when mining safety can no longer be ensured. For further operation, including retrieval and related measures, plan approval according to § 9b AtG is not required.

On 27 July 2013, the Act on the search for and selection of a site for a repository for heat-generating radioactive waste and for the amendment of other laws, the Site Selection Act (*Gesetz zur Suche und Auswahl eines Standortes für ein Endlager für Wärme entwickelnde radioaktive Abfälle und zur Änderung anderer Gesetze, Standortauswahlgesetz* – StandAG) of 23 July 2013 [1A-7]) entered into force. Some of its provisions entered into force on 1 January 2014.

The objective of the site selection procedure is to find a site in Germany for a disposal facility in accordance with § 9, para. 3, sentence 3 AtG for radioactive waste, in particular for high-level radioactive waste, produced in Germany, in a transparent procedure on the basis of scientific criteria that ensures best possible safety for a period of one million years.

A Commission has been set up to prepare the site selection procedure whose task is, in particular, to examine and assess the relevant fundamental issues for the selection procedure with regard to nuclear waste management. Among other things, the Commission will review the StandAG and prepare a report addressing all relevant issues for a decision. Furthermore, the Commission will submit a policy recommendation for the German Federal Parliament (*Bundestag*) and the German Federal Council (*Bundesrat*).

It is intended to establish a Federal Office for Nuclear Waste Management (BfE) as an independent higher federal authority within the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). The tasks of the BfE, assigned to it by the Atomic Energy Act (AtG), the Site Selection Act (StandAG) or other federal laws, will include administrative tasks of the Federation in the field of licensing of federal facilities for the safekeeping and disposal of radioactive waste.

In addition, the StandAG contains further amendments to other laws, in particular consequential amendments to the AtG Act resulting from the site selection procedure.

As a consequence of the events in Japan in March 2011, the Nuclear Waste Management Commission (ESK) conducted a stress test for nuclear fuel cycle facilities in Germany carried out (see Chapter G.5.3 for details). The results of the stress tests are documented in two ESK statements [4-11].

E.1 Article 18: Implementing measures

> *Article 18: Implementing measures*
>
> *Each Contracting Party shall take, within the framework of its national law, the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention.*

E.1.1 Implementation of the obligations under the Convention

Within the framework of its national law, the Federal Republic of Germany has already taken all the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention. The specific individual measures are described in the reporting related to Article 19 of the Convention.

E.2 Article 19: Legislative and regulatory framework

> *Article 19: Legislative and regulatory framework*
>
> *(1) Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of spent fuel and radioactive waste management.*
>
> *(2) This legislative and regulatory framework shall provide for:*
>
> *i) the establishment of applicable national safety requirements and regulations for radiation safety;*
>
> *ii) a system of licensing of spent fuel and radioactive waste management activities;*
>
> *iii) a system of prohibition of the operation of a spent fuel or radioactive waste management facility without a licence;*
>
> *iv) a system of appropriate institutional control, regulatory inspection and documentation and reporting;*
>
> *v) the enforcement of applicable regulations and of the terms of the licences;*
>
> *vi) a clear allocation of responsibilities of the bodies involved in the different steps of spent fuel and of radioactive waste management.*
>
> *(3) When considering whether to regulate radioactive materials as radioactive waste, Contracting Parties shall take due account of the objectives of this Convention.*

E.2.1 Legislative and regulatory framework

In Germany, the Basic Law (*Grundgesetz* – GG) [GG 49] sets forth the principles of a democratic social order, namely the government's responsibility to protect life and health and natural resources needed to sustain life, the separation of powers, the independence of licensing and supervisory authorities, and the supervision of administrative actions by independent courts. The legislation, administrative authorities and jurisdiction generated specifically for the peaceful use of nuclear energy provide the framework of a system which safeguards the protection of life, health and property of those directly employed by the industry, and the general public, from the hazards of nuclear energy and the damaging effects of ionising radiation, as well as ensuring the regulation and supervision of safety during the construction, operation and decommissioning of nuclear facilities. In accordance with the statutory requirements; in the field of nuclear technology, ensuring safety is the highest priority. By applying the best available technology as a key guiding principle, measures are taken to ensure that internationally accepted safety standards as specified in the "Fundamental Safety Principles" of the IAEA [IAEA 06], are taken into account. One principal objective of the German Federal Government's safety policy in the field of nuclear energy was, and still is, that the operators of nuclear facilities should maintain and further develop a high safety culture within their own field of responsibility.

Framework requirements due to the federal structure of the Federal Republic of Germany

The Federal Republic of Germany is a federal state. The responsibilities for law-making and law enforcement are assigned differently to the organs of the Federation and the *Länder* according to the respective regulatory duties. Specifications are regulated by the provisions in the Basic Law [GG 49] of the Federal Republic of Germany.

The legislative competence for the use of nuclear energy for peaceful purposes lies with the Federation, Article 73 (1) No. 14 in conjunction with Article 71 GG. The further development of nuclear law is also a task of the Federation. The *Länder* will be involved in the procedure.

The Atomic Energy Act (AtG) [1A-3] and the statutory ordinances based thereon are implemented, with a few exceptions, according § 24, para. 1 AtG in conjunction with Articles 87c, 85 GG by the *Länder* on behalf of the Federation. With respect to the legality and appropriateness of their action, the competent *Länder* authorities are subject to supervision by the Federation.

Article 85 GG

[Execution by the* Länder *on federal commission]

1. Where the *Länder* execute federal laws on federal commission, establishment of the authorities shall remain the concern of the *Länder*, except insofar as federal laws enacted with the consent of the *Bundesrat* otherwise provide.
2. The Federal Government, with the consent of the *Bundesrat*, may issue general administrative provisions. It may provide for the uniform training of civil servants and other salaried public employees. The heads of intermediate authorities shall be appointed with its approval.
3. The *Länder* authorities shall be subject to instructions from the competent highest federal authorities. Such instructions shall be addressed to the supreme *Länder* authorities unless the Federal Government considers the matter urgent. Implementation of the instructions shall be ensured by the supreme *Länder* authorities.
4. Federal supervision shall extend to the legality and appropriateness of execution. For this purpose the Federal Government may require the submission of reports and documents and send commissioners to all authorities.

The competent supervisory and licensing authorities report to the Federation on law enforcement on demand. The Federation has the right to require the submission of reports and documents and may issue binding directives to the *Land* authority in the individual case. The Federal Government may assume the competence for the subject matter, i.e. the decision on the merits, by exercising his right to issue directives. The responsibility for execution, i.e. the implementation of the decision towards the applicant or approval holder, rests with the competent *Land* authority.

Within the framework of nuclear procedures, other legal regulations also have to be considered, such as immission control legislation, water legislation, building legislation. Legal regulations for assessing the environmental impact are, in general, part of the nuclear approval procedure.

In Germany, those concerned, e.g. applicants or approval holders or also third parties concerned, may take legal action against decisions of the public administration, so-called administrative acts, before the administrative courts (right to apply to the courts according to Article 19 (4) of the Basic Law [GG 49]). Action is brought against the competent *Land* authority or the *Land* whose authority issued the administrative act, i.e. the competent *Land* authority. This also applies if the *Land* has taken a decision pursuant to a directive of the Federal Government. Also in case of failure of the authority to act, those concerned may take legal action. So, e.g., the operators may claim granting of licences applied for or the residents the issuance of an administrative order for cessation of operation of a nuclear facility.

Involvement of international and European law

International treaties

In the hierarchy of legislation, the international treaties concluded by the Federal Republic of Germany in accordance with Article 59 (2) sentence 1 of the Basic Law [GG49] are on the same level as formal federal law. As a matter of principle, rights and obligations under the treaty only apply to the Federal Republic of Germany as contracting party.

An overview of the most important international treaties of the Federal Republic of Germany in the fields of nuclear safety, radiation protection and liability, and on national implementing provisions is given in Annex L-(e) [References to National Laws, Regulations, Requirements, Guides, etc.].

For Germany, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [1E-8] entered into force on 18 June 2001.

In the field of nuclear liability, the Federal Republic of Germany is also a contracting party to

- the Paris Convention on Third Party Liability in the Field of Nuclear Energy of 1960 [1E-11],
- the Brussels Supplementary Convention of [1E-12], and
- the Joint Protocol of 21 September 1988 Relating to the Application of the Vienna Convention and the Paris Convention.

As one of currently 87 contracting parties, the Federal Republic of Germany joined the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter of 1972 [1E-3-1] and ratified it in November 1977. The convention revised and adopted in amended form ("London Protocol") in 1996, which prohibits waste dumping at sea with a few exceptions, has also been ratified by the Federal Republic of Germany in October 1998. It entered into force on 24 March 2008.

A similar objective as of the London Convention is pursued by the OSPAR Convention of 1992, which entered into force in early 1998. It unites the Federal Republic of Germany and 14 other western and northern European countries and the European Union for the protection of the North-East Atlantic. The OSPAR Convention was established by the unification and expansion of the Oslo Convention of 1972 and the Paris Convention of 1974.

Legal provisions of the European Union

In Germany, legislation and administrative actions must take into account any binding requirement from regulations of the European Union. However, the EU law – with some exceptions – is not directly applied in the national nuclear licensing and supervisory procedures, but must first be transposed into national law within certain time limits.

In its Title II, the Treaty establishing the European Atomic Energy Community (EURATOM Treaty) contains provisions for the encouragement of progress in the field of nuclear energy. Chapter 3 of this title regulates the protection of health and thus opens up a specific area of competence for European legislation to the European Atomic Energy Community (EURATOM).

In accordance with Articles 77 et seq. of the EURATOM Treaty, any utilisation of ores, source material and special fissile material is subject to the surveillance of the European Atomic Energy Community.

In the field of radiation protection, EURATOM basic standards were laid down for the protection of the health of the general public and workers against the dangers arising from ionising radiations [1F-18] based on Articles 30 ff. (Health and Safety) of the EURATOM Treaty [1F-1]. Council Directive 96/29/EURATOM laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation [1F-18] of 1996 was transposed into national law by the Radiation Protection Ordinance (StrlSchV) [1A-8].

On 5 December 2013, the Council of the European Union adopted the new Directive 2013/59/EURATOM [1F-24] laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing 89/618/EURATOM [1F-29], 90/641/EURATOM [1F-20], 96/29/EURATOM [1F-18], 97/43/EURATOM [1F-23] and 2003/122/EURATOM [1F-22]. Thus, the existing five radiation protection directives of the European Union were combined and updated. The Directive takes account of new scientific findings and the recommendations of Publication 103 of the International Commission on Radiological Protection [ICRP 07]. It must be transposed into national law by 6 February 2018.

On 22 July 2009, the Council Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear facilities [1F-5] entered into force to supplement the directives of the European Atomic Energy Community on radiation protection. Thus, for the first time, binding European regulations on nuclear safety had been established. The Directive pursues the objective of maintaining and continuously improving nuclear safety. The Member States of the European Union are to take appropriate national measures to effectively protect workers and the general public against the dangers of ionising radiation from nuclear facilities. The Directive applies, among others, to nuclear power plants, research reactors, the storage of nuclear fuel (pursuant to § 6 AtG) and the storage of radioactive waste if directly related to the respective nuclear facility and taking place on the same site, but not to repositories. The Directive includes provisions regarding the establishment of a legislative and regulatory framework for nuclear safety, the organisation and functions of the nuclear regulatory authorities, the obligations of the operators of nuclear facilities, on education and training of the staff of all parties involved, and on the information to the public.

The Directive maintains the national responsibility for nuclear safety by, among others, the fact that the Member States have the express right to take more stringent safety measures in addition to the provisions of the Directive in compliance with Community law (Article 2 (2) of the Directive). On 8 December 2010, Directive 2009/71/EURATOM was transposed into national law with the 12th amendment to the Atomic Energy Act.

In the field of nuclear waste management, the Council of the European Union adopted Directive 2011/70/EURATOM [1F-36] establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste upon proposal from the European Commission. In this Directive, the Member States are requested to establish a national nuclear waste management programme and to report to the Commission. The Member States shall specify, among other things, their nuclear waste management tasks as well as the technical and organisational boundary conditions of their programmes.

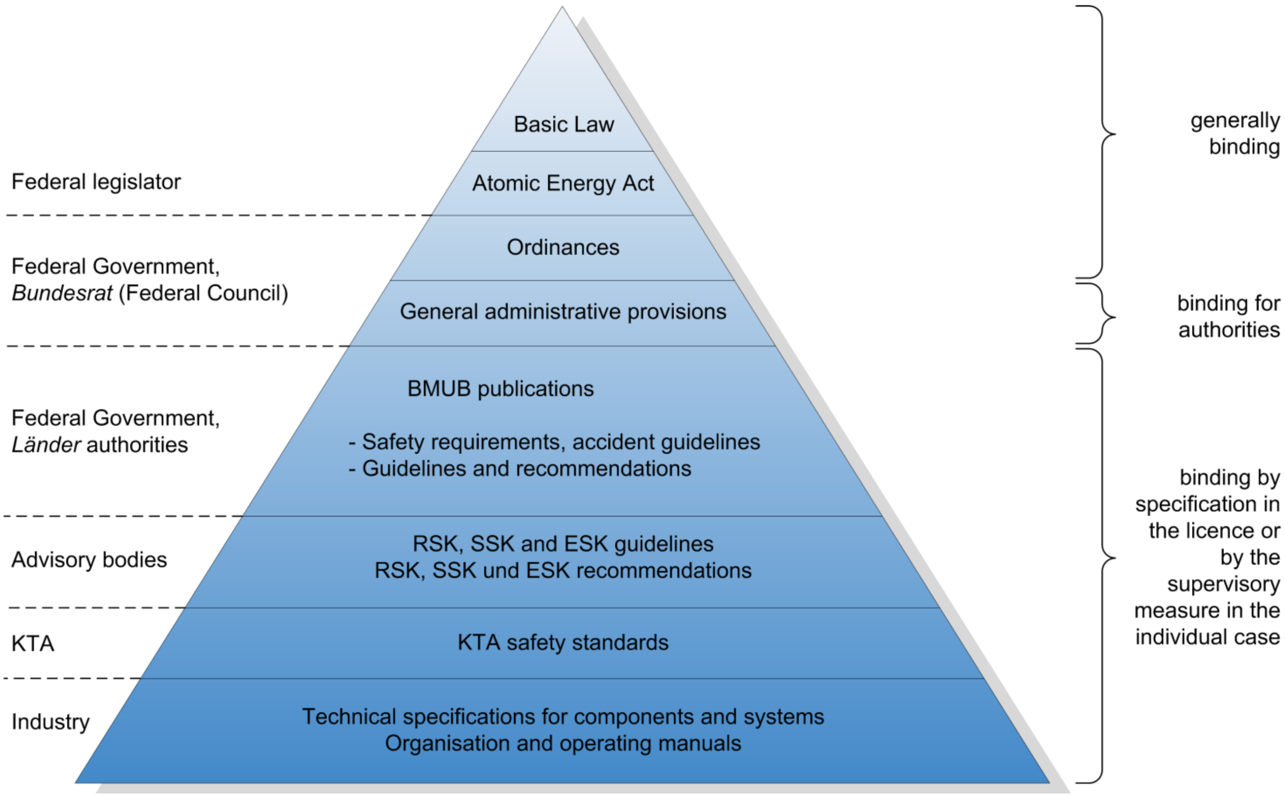
An overview of the legal provisions of the European Union, in particular with regard to radiation protection and radioactive waste, is given in Annex L-(e) Part 1F [Agreements, General Provisions].

E.2.2 National safety provisions and regulations

Hierarchical structure of the regulations

Figure E-1 shows the hierarchy of the national regulations, the authority or institution adopting the regulation and its degree of bindingness.

Figure E-1: Regulatory pyramid



Nuclear regulations not included in laws, ordinances and general administrative provisions only have regulatory relevance by virtue of the legal requirement concerning the state of the art in science and technology referred to in the various nuclear licensing conditions (e.g. in § 7, para. 2, subpara. 3 AtG [1A-3]: "*A licence may only be granted if (…) the necessary precautions have been taken in the light of the state of the art of science and technology to prevent damage resulting from the erection and operation of the installation.*"). According to legal practice, it can be presumed that the nuclear rules and regulations accurately reflect the state of the art. The dynamic improvement in safety requirements required by law is not bound by the formal development of standards. A substantiated scientific advancement will displace the application of an obsolete non-mandatory guidance instrument without explicitly needing to suspend it.

In this report, reference will be made to the contents of the individual regulations when addressing the respective Articles of the Convention. All of the listed regulations are accessible to the public and are published in official publications of the Federation.

In essence, the structure and content of the safety provisions and regulations described herein were developed in the 1970s. Since then, they have been applied in all nuclear licensing and supervisory procedures and have been further developed, where necessary, in line with the state of the art in science and technology.

Acts

Basic Law

The Basic Law [GG 49] contains provisions on the legislative and administrative competencies of the Federation and the *Länder* regarding the use of nuclear energy. In addition, there are fundamental principles that also apply to the nuclear law.

With the basic rights, in particular the right to life and physical integrity, it determines the standard to be applied to the protective and preventive measures at nuclear facilities which is further specified in the above hierarchy levels of the pyramid. The principle of proportionality and guaranty of property, laid down in the Basic Law, must also be considered.

Atomic Energy Act

The Atomic Energy Act (AtG) [1A-3] was promulgated on 23 December 1959 after the Federal Republic of German had officially renounced any use of atomic weapons and, since then, has been amended several times. The purpose of the Atomic Energy Act according to the 2002 amendment is to phase out the use of nuclear energy for commercial electricity generation in a carefully co-ordinated process and to ensure undisturbed operation until this has been achieved as well as to protect life, health and property against the hazards of nuclear energy and the detrimental effects of ionising radiation and, furthermore, to provide for the compensation for any damage and injuries incurred. It also serves the purpose of preventing the internal or external security of the Federal Republic of Germany from being endangered by the application of nuclear energy. Another purpose of the Atomic Energy Act is to ensure that the Federal Republic of Germany meets its international obligations in the field of nuclear energy and radiation protection.

The AtG includes the general national provisions for protective and precautionary measures, radiation protection and the management of radioactive waste and spent fuel in Germany and constitutes the basis for the associated ordinances.

Besides its purpose and general provisions, the AtG also includes supervisory provisions, liability regulations, general regulations on administrative responsibilities, and regulations on administrative fines.

In order to protect against the hazards emanating from radioactive substances and to control their use, the AtG requires that the construction and operation of nuclear facilities is subject to regulatory licensing. Prerequisites and procedure for the granting of licences and for the performance of supervision are regulated, including regulations on the consultation of experts (§ 20 AtG) and on the charging of costs (§ 21 AtG). In the field of nuclear waste management, the AtG provides that the Federation shall construct facilities for the safekeeping and disposal of radioactive waste (§ 9a, para. 3, sentence 1 AtG). The construction and operation of such facilities requires plan approval (§ 9b, para. 1 AtG). In the cases where the site of a facility was determined by federal law, a licence shall substitute the plan approval procedure (§ 9b, para. 1a AtG). Due to the Site Selection Act, § 9b, para. 1a AtG has been inserted into the Atomic Energy Act as a new paragraph. The costs incurred for the planning, construction and operation of facilities for the safekeeping and disposal of radioactive waste shall be borne by the waste producers through fees and contributions together with advance according to §§ 21a and 21b AtG in conjunction with the Repository Prepayment Ordinance (EndlagerVlV) [1A-13]. The site selection procedure is financed through cost allocations to the waste producers according to §§ 21 et seq. StandAG [1A-7].

However, most of the regulations provided in the AtG are not to be regarded as exhaustive but are further concretised, both in the area of procedures and the substantive requirements, by ordinances promulgated on the basis of the AtG as well as by the non-mandatory guidance instruments.

The AtG concretely requires that certain activities are subject to licensing. So, for example, § 7 AtG stipulates that the construction, operation or the ownership of a facility for the production, processing, treatment or fission of nuclear fuel, a material alteration of such facility or its operation and also decommissioning require a licence. There are similar stipulations in § 6 AtG for the storage of nuclear fuel, in § 9 AtG for the treatment, handling and other use of nuclear fuel outside of the facilities specified in § 7 AtG, and in § 9b AtG for facilities of the Federation for the safekeeping and disposal of radioactive waste.

With the 10th amendment to the Atomic Energy Act of 24 March 2009 [1A-24], operation and closure of the Asse II mine were subjected to the provisions of the AtG on federal facilities for the disposal of radioactive waste by insertion of § 57b, and it substantiated the responsibility of the Federal Office for Radiation Protection as its operator.

The 12th amendment to the Atomic Energy Act of 8 December 2010 transposed the obligations under Council Directive 2009/71/EURATOM [1F-5] of the European Union establishing a Community framework for the nuclear safety of nuclear facilities – unless they already represented applicable national law – into national law.

With the 13th amendment to the Atomic Energy Act of 31 July 2011 [1A-25], the nuclear power plant lifetime extensions granted under the 11th amendment to the AtG have been revoked by restoring the validity of the maximum volumes of electricity production listed in Appendix 3, column 2 AtG through the Act on the structured phase-out of the utilisation of nuclear energy for the commercial generation of electricity of 22 April 2002. At the same time, dates were defined for the individual reactors until which the authorisation to be operated for electricity production will expire, namely

- for the nuclear power plants Biblis A, Neckarwestheim 1, Biblis B, Brunsbüttel, Isar 1, Unterweser, Philippsburg 1 and Krümmel the date on which the Act enters into force (the reactors thus remain permanently shut down),
- 31 December 2015 for the Grafenrheinfeld nuclear power plant,
- 31 December 2017 for the Gundremmingen B nuclear power plant,
- 31 December 2019 for the Philippsburg 2 nuclear power plant,
- 31 December 2021 for the nuclear power plants Grohnde, Gundremmingen C and Brokdorf,
- 31 December 2022 for the nuclear power plants Isar 2, Emsland and Neckarwestheim 2.

The Act to speed up the retrieval of radioactive waste and the closure of the Asse II mine (“Lex Asse”) of 20 April 2013 [1A-26] included a revision of § 57b AtG. The revision of § 57b AtG has created the legal framework for an accelerated procedure. Compared to the legal situation until then, the following changes have been made:

- Definition of the objective of retrieval of the waste prior to a closure of the mine,
- specifications on criteria for discontinuation,
- opening the way for procedural flexibility,

- reduction of uncertainties about the enforcement and development of provisions to facilitate law enforcement.

Site Selection Act

After having fixed a date for the end of the peaceful use of nuclear energy for commercial electricity production in Germany with the 13th amendment to the Atomic Energy Act of 31 July 2011, the aim is to find a solution for safe nuclear waste management, in particular of heat-generating radioactive waste, in consensus between the Federation and the *Länder*, the State and society, and the citizens at the national level. The boundary conditions and the main issues of the procedure have been specified in the Act on the search for and selection of a site for a repository for heat-generating radioactive waste and for the amendment of other laws (Site Selection Act – StandAG) [1A-7].

The purpose of the Act is to establish a new comparative site selection procedure to determine that site in Germany which ensures the best possible safety for a period of one million years. Exploration as defined in the StandAG will take place according to criteria that still have to be stipulated by law. In order to ensure a search and selection procedure that is transparent and based on scientific criteria, it is intended to establish a Federal Office for Nuclear Waste Management (BfE) within the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). Its tasks will include the development and establishment of site-specific exploration programmes and examination criteria. In addition, the site decision has to be prepared and active public relations work as well as formal public participation is to be conducted.

The selection procedure is preceded by discussion and clarification of fundamental issues relating to the management of heat-generating radioactive waste. This task is to be performed by the "Commission on Storage of High-Level Radioactive Waste" (Commission) which will prepare the site selection procedure with in timeframe of two years (with an option to extend for further six months). The Commission consists of two alternating chairmen, eight representatives of the *Bundestag* and eight of the *Länder* governments, as well as 16 members from science and social groups. Only the 16 members of science and social groups, which are composed of eight representatives from science and two representatives each from environmental organisations, the industry, religious communities and trade unions, will be entitled to vote. According to § 3, para. 2 StandAG, the Commission is to submit a report until 31 December 2015 (or until 30 June 2016, respectively) which examines and assesses the fundamental issues being relevant for the selection procedure with regard to radioactive waste management. Furthermore, the report should include proposals for decision making according to § 4 StandAG [1A-7] and a policy recommendation for the *Bundestag* and the *Bundesrat*. Based on the conclusions of the Commission, the Site Selection Act as well as the organisational and procedural rules will be evaluated and amended where required (see Chapter H.3.2 for details).

The StandAG also led to amendments to the AtG. In particular, a new § 9b, para. 1 AtG was introduced. Accordingly, federal facilities for the safekeeping and disposal of radioactive waste require a licence instead of plan approval according to § 9b, para. 1 AtG if the site for the facility was determined by federal law. According to § 23d, sentence 1, subpara. 1 AtG, inserted as a new paragraph, the BfE will be responsible for plan approval and licensing. As a transitional provision, the responsibility will rest with the competent authorities of the *Länder* dependent on the individual repository projects.

Other federal laws

The Atomic Energy Act is supplemented by the Precautionary Radiation Protection Act of 1986 [1A-5], which was prompted by the Chernobyl disaster. It regulates governmental tasks regarding the monitoring of radioactivity in the environment as well as precautionary measures to limit radiation exposure of people and the radioactive contamination of the environment in the case of events with potential significant radiological effects (see reporting on Articles 24 and 25 of the Convention).

Another legal basis to be mentioned is the Act on the establishment of a Federal Office for Radiation Protection (*Gesetz über die Errichtung eines Bundesamtes für Strahlenschutz*) [1A-6]. According to § 2 of this Act, this Federal Office fulfils federal administrative tasks in the field of radiation protection including radiation protection precaution as well as nuclear safety, the carriage of radioactive substances and the management of radioactive waste including the construction and operation of federal facilities for the safekeeping and disposal of radioactive waste, which are assigned to it through the Atomic Energy Act, the Precautionary Radiation Protection Act or other federal laws.

The StandAG [1A-7] also led to the adoption of the Act on the establishment of a Federal Office for Nuclear Waste Management (*Gesetz über die Errichtung eines Bundesamtes für kerntechnische Entsorgung*) [1A-27] on 23 July 2013, which entered into force on 1 January 2014. According to § 2 of this Act, the Federal Office for Nuclear Waste Management (BfE) fulfils federal administrative tasks in the field of licensing of federal facilities for the safekeeping and disposal of radioactive waste, which are assigned to it through the Atomic Energy Act, the Site Selection Act or other federal laws or pursuant to these laws. The establishment of the Federal Office will take place in the course of 2014.

Statutory ordinances

For further concretisation of the legal regulations, the Atomic Energy Act includes authorisations for the promulgation of statutory ordinances (see the list in § 54, para. 1 AtG [1A-3]). These statutory ordinances require the consent of the *Bundesrat*. The *Bundesrat* is a constitutional organ of the Federal Government in which the governments of the *Länder* are represented.

In this regard, several statutory ordinances were passed which are also relevant for spent fuel and radioactive waste. The most important ones pertain to:

- radiation protection (Radiation Protection Ordinance – StrlSchV) [1A-8]),
- the licensing procedure (Nuclear Licensing Procedure Ordinance – AtVfV) [1A-10]),
- the transboundary shipment of radioactive waste or spent fuel (Nuclear Waste Shipment Ordinance – AtAV) [1A-18]),
- advance payments for the construction of radioactive waste disposal facilities (Repository Prepayment Ordinance – EndlagerVlV) [1A-13]),
- provisions for sufficient coverage (Ordinance on the Financial Security Pursuant to the Atomic Energy Act – AtDeckV) [1A-11]),
- the reporting of reportable events (Nuclear Safety Officer and Reporting Ordinance – (AtSMV) [1A-17]), and
- the Gorleben Development Freeze Ordinance (GorlebenVSpV) [1A-22].

The safety provisions and regulations of the Atomic Energy Act and associated ordinances are further concretised by general administrative provisions, guidelines, safety standards of the Nuclear Safety Standards Commission (KTA), recommendations by the Reactor Safety Commission (RSK), Commission on Radiological Protection (SSK) and Nuclear Waste Management Commission (ESK), and conventional technical standards.

General administrative provisions

Statutory ordinances may contain additional authorisations for the promulgation of general administrative provisions. Such regulate the actions of the authorities but they only have a direct binding effect for the administration. They have a direct external effect since they are referred to as a basis for administrative decisions.

In the nuclear field, there are six general administrative provisions which deal with the following topics:

- Calculation of radiation exposure during specified normal operation of nuclear facilities [2-1],
- radiation passports [2-2],
- environmental impact assessments [2-3],
- environmental monitoring [2-4],
- monitoring of food [2-5], and
- monitoring of fodder [2-6].

Announcements by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)

After having consulted the *Länder*, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) publishes regulatory guidelines (in the form of requirements, guidelines, criteria and recommendations). In general, these are regulations adopted in consensus with the competent licensing and supervisory authorities of the *Länder* on the uniform application of the Atomic Energy Act (see reporting on Article 20 of the Convention). The announcements of the BMUB describe the view of the federal supervisor on general issues relating to nuclear safety and the administrative practice, and provide orientation for the *Länder* authorities regarding the enforcement of the Atomic Energy Act. Unlike the general administrative provisions, the announcements are not binding for the *Länder* authorities. Their relevance is also given by the right of the BMUB to issue binding individual directives for particular cases to the *Länder* authorities. Currently, about 100 BMUB regulatory guidelines exist in the nuclear field. The part that is also applicable to the management of spent fuel and radioactive waste is included in Annex L-(e) [3-1] et seq.

Related to the management of spent nuclear fuel and radioactive waste are, in particular,

- the Safety Criteria for the Final Disposal of Radioactive Wastes in a Mine [3-13],
- the Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste [BMU 10]
- the Guideline concerning Emission and Immission Monitoring of Nuclear Facilities (REI) [3-23],
- the Guideline on the control of radioactive residues and radioactive wastes [3-60],
- the Guide to the decommission, the safe enclosure and the dismantling of facilities or parts as defined in § 7 AtG [3-73],

- the Guideline of physical radiation protection control for the determination of the body dose, Part 1: Determination of the body dose from external radiation exposure (§§ 40, 41, 42 StrlSchV; § 35 RöV) [3-42-1],

- the Guideline of physical radiation protection control for the determination of the body dose, Part 2: Determination of the body dose from internal radiation exposure (incorporation monitoring) (§§ 40, 41 and 42 StrlSchV) of 12 January 2007 [3-42-2], and

- the Guideline for radiation protection of personnel during the execution of maintenance work in nuclear power plants with light water reactors: Part 2: The radiation protection measures during operation and decommissioning of a facility (IWRS II) [3-43-2].

The “Safety Criteria for the Final Disposal of Radioactive Wastes in a Mine” [3-13], published in the Federal Law Gazette at the beginning of 1983, had the task to concretise the requirement to take the necessary precautions to prevent damage pursuant to the AtG [1-A3], which is also to be met for disposal. In the time following, international recommendations and standards on radiation protection and disposal of radioactive waste were substantially revised and updated according to new findings. Against this background, the BMU has developed the safety requirements for the disposal of heat-generating radioactive waste. The safety requirements put the state of the art in science and technology in concrete terms that is to be complied with regarding the construction, operation and closure of a repository for heat-generating waste and to be reviewed within the plan approval procedure by the respective licensing authority.

From a technical point of view, the *Länder* Committee for Nuclear Energy agreed on the version of 30 September 2010 of the “Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste” [BMU 10].

Guidelines and recommendations of the RSK, SSK and ESK

The recommendations of the Reactor Safety Commission (RSK), the Commission on Radiological Protection (SSK) and the Nuclear Waste Management Commission (ESK) play an important role with respect to licensing and supervisory procedures. These independent expert commissions advise the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) on issues relating to nuclear waste management. By appointing experts in different technical fields, it is intended that the full bandwidth of scientific knowledge should be reflected in these two bodies (see reporting on Article 20 of the Convention).

The RSK, SSK and ESK submit their results of consultations to the Ministry in the form of statements or recommendations which are prepared in committees and working groups. Via publication in the Federal Law Gazette (*Bundesanzeiger*) these recommendations become part of the nuclear rules and, in particular cases, their application is recommended by circulars of the BMUB. The system of the BMUB being advised by independent experts from various disciplines has proved effective.

For spent fuel and radioactive waste management, the following recommendations prepared by the ESK are of particular importance:

- Guidelines for dry cask storage of spent fuel and heat-generating waste [4-2], and

- Guidelines for the storage of radioactive waste with negligible heat generation [4-3].

The following recommendation prepared by the ESK is relevant for the decommissioning of nuclear facilities:

- Guidelines for the decommissioning of nuclear facilities [4-4].

In November 2010, the ESK adopted recommendations for guides to the performance of periodic safety reviews for storage facilities for spent fuel and heat-generating radioactive waste (PSÜ-ZL) [4-5]. The need for appropriate regulations arises from the safety reference levels of the Western European Nuclear Regulators Association (WENRA), to whose practical implementation Germany has committed itself as a WENRA Member State (see Chapter K.5 as well as from the requirements for storage in Council Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear facilities [1F-5]. For implementation of the recommendations, a two-year review phase is planned as a first step, during which the performance of a periodic safety review for two selected storage facilities will be tested (see Chapter G.2.2 for details).

In a statement of May 2011, the ESK formulated requirements for spent fuel from the point of view of waste management [4-7]. The background was that due to the permanent cessation of operation of a number of nuclear power plants, fuel elements existed with only a relatively low burn-up and thus with a content of uranium and plutonium isotopes different from that of fuel assemblies with higher burn-up. The statement deals with the question of which requirements are to be applied to the minimum burn-up of fuel elements and which plutonium vector should be envisaged for irradiated uranium and MOX fuel elements, taking into account safety and security requirements.

As a consequence of the events in Japan in March 2011, the ESK conducted a stress test for nuclear fuel cycle facilities in Germany (see Chapter G.5.3 for details). The results of the stress tests are documented in two ESK statements [4-11].

KTA safety standards

The Nuclear Safety Standards Commission (KTA), founded in 1972, was established at the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). It consists of the following five groups: representatives of the manufacturers and constructors, the plant operators, the federal and *Länder* authorities, the expert organisations as well as of other authorities and representatives of general concerns, e.g. of the unions, the industrial safety and the liability insurers.

The office of the KTA is affiliated to the Federal Office for Radiation Protection (BfS).

According to § 2 of its statutes, the KTA has the task to establish safety standards and to promote their application in fields of nuclear technology where experience indicates that the experts representing the manufacturers, constructors and operators of nuclear facilities, the expert organisations and the authorities would reach a uniform opinion. The standards are developed within six subcommittees of the KTA in special working groups by experts from the groups and adopted by the KTA. With effect from January 2013, the number of KTA members was reduced from 50 to 35. The five groups are equally represented, each with seven (instead of previously ten) votes in the KTA. A safety standard will only be adopted if its draft finds the approval of five sixths of the members. Thus, no group voting unanimously can be outvoted. The number of KTA members has been reduced in response to the changed framework conditions in Germany. Since the last amendment to the official publication on the formation of a Nuclear Safety Standards Commission of July 1990, the number of *Länder* with nuclear power plants has decreased; the number of operators, the manufacturers and the expert organisations has also decreased, e.g. due to mergers. Moreover, the lifetime reductions and the shutdown of nuclear power plants also had an impact on the available resources.

The regulatory powers of the legislator and administrative action by the competent authorities are not restricted by the KTA process. It is possible to formulate necessary requirements, guidelines and recommendations and to implement them regardless of the consensual formulation of KTA safety standards.

Historically, the KTA safety standards have been developed on the basis of applicable German technical standards and regulations and on the American nuclear safety standards. The ASME-Code (Section III) was used as a model for specifying the requirements regarding the design and construction of components. The KTA safety standards contain detailed, concrete specifications of a technical nature. Regular reviews and amendment where necessary of adopted safety standards at intervals of no more than five years ensure that standards are adapted in line with the state of the art in science and technology. In themselves, KTA safety standards are not legally binding. However, by virtue of their process of origination and their high level of detail, their practical effect is wide-ranging as state of the art in science and technology.

The KTA Program of Standards currently comprises 94 standards already issued and three standards in preparation, 35 of the 94 standards are in the process of being revised [KTA 14]. The safety standards generally refer to nuclear power plants so that their application to facilities for spent fuel and radioactive waste management is to be examined in the individual case.

At its 89th meeting in November 2012, the KTA Steering Committee decided on a screening of the KTA Program of Standards regarding the further handling of individual safety standards to take into account the changed framework conditions due to the 13th amendment to the Atom Energy Act. Consequently, in future, the work on a number of standards which are no longer required will be discontinued.

Conventional technical standards

As is the case with the design and operation of all technical installations, conventional technical standards likewise apply, particularly the national standards of the German Institute for Standardisation (DIN) and the international standards of the ISO and IEC.

In this respect, the requirements of the conventional technical standards are to be referred to as a minimum standard for nuclear systems and components. Moreover, federal and *Länder* provisions relating to nuclear law shall not be affected to the extent that stricter or different requirements are made or permitted by them.

Other legal areas

When licensing nuclear facilities, legal requirements outside of nuclear safety and radiation protection legislation must also be taken into account. These include, in particular,

- the Federal Building Code (*Baugesetzbuch*) [1B-18],
- the Regional Planning Act (*Raumordnungsgesetz*) [1B-2],
- the Federal Immission Control Act (*Bundes-Immissionsschutzgesetz*) [1B-3],
- the Federal Water Act (*Wasserhaushaltsgesetz*) [1B-5],
- the Federal Nature Conservation Act (*Bundesnaturschutzgesetz*) [1B-6],
- the Closed Cycle Management Act (*Kreislaufwirtschaftsgesetz*) [1B-13], and
- the Environmental Impact Assessment Act (*Gesetz über die Umweltverträglichkeitsprüfung*) [1B-14].

The following is also important regarding the exploration work for a repository and the approval procedure for a repository in deep geological formations:

- the Federal Mining Act (*Bundesberggesetz*) [1B-15].

E.2.3 Licensing system

With respect to protection against the hazards of radioactive materials and supervision of their utilisation, the Atomic Energy Act (AtG) as well as the Radiation Protection Ordinance (StrlSchV) in certain areas, requires that the construction and operation of nuclear facilities as well as other facts or circumstances, such as the handling of radioactive material, are subject to regulatory approval. The approval requirement is stipulated in various provisions of the nuclear rules and regulations, depending on the type of facility and operation.

- § 7 AtG [1A-3]: The management of spent nuclear fuel and radioactive waste within stationary facilities for the production, treatment, processing or fission of nuclear fuel (e.g. in nuclear power plants) is normally covered by the licence granted to such facilities under § 7 AtG, provided these management phases are directly related to the purpose of the facility. This applies in particular to the storage of spent fuel in the spent fuel pool of the reactor and to the treatment and storage of operational waste. The pilot conditioning plant (PKA) at Gorleben has also been granted a licence pursuant to § 7 AtG. Licensing and supervision of the plant are carried out by the competent authority in the *Land* where the facility is located; in the case of the PKA, this is the *Land* of Lower Saxony.

- § 3 AtG: The import and export of nuclear fuel requires a permit under § 3 AtG. A decision on the application is made by the Federal Office of Economics and Export Control (BAFA). The supervision of imports and exports is the responsibility of the Federal Ministry of Finance or designated customs offices.

- § 6 AtG: The storage of nuclear fuel, including spent fuel and radioactive waste with significant contents of fissile material, requires (if the proportion of certain uranium and plutonium isotopes exceed the limits specified § 2, para. 3 AtG) a licence under § 6 AtG. This refers, for example, to storage facilities at the sites of nuclear power plants and the central storage facilities in Ahaus and Gorleben. The licensing authority is the Federal Office for Radiation Protection (BfS), whilst supervision is performed by the competent authority of the respective *Land*.

- § 9 AtG: The treatment, processing and other use of nuclear fuel outside outside facilities specified in § 7 AtG, e.g. the handling of nuclear fuel on a laboratory scale for research purposes, requires a licence pursuant to § 9 AtG. The respective *Land* authority shall be responsible for licensing and supervision.

- § 9b AtG: According to the Atomic Energy Act, the Federation shall be responsible for the construction of facilities for the safekeeping and disposal of radioactive waste. These facilities require plan approval according to § 9b AtG. In the cases where siting was determined by federal law, a licence substitutes the plan approval procedure, since the interests to be weighed against each other will have already been finally reviewed and assessed in the statutory site selection procedure. As defined in § 23d AtG, the Federal Office for Nuclear Waste Management (BfE) shall be responsible for nuclear waste management. According to § 58 AtG, paras. 6 and 7, the supreme *Länder* authorities designated by the *Länder* governments shall be responsible for the Konrad repository until granting of the approval of commissioning by the nuclear supervisory authority and for the ERAM until the plan approval decision on decommissioning will be enforceable. A plan approval procedure significantly differs from a licensing procedure according to § 6 or 7 AtG in a number of respects. The applicant and future operator of repositories is the Federal Office for Radiation Protection (BfS). § 9a AtG stipulates that, for fulfilment of its obligations, it may avail itself of the services of third parties or may in whole or in part assign the performance of its duties, together with the necessary jurisdictional powers, to third parties if the proper performance of the delegated tasks is guaranteed. The construction and operation of repositories is monitored within the BfS by the organisational unit "Repository Surveillance" (*Endlagerüberwachung* – EÜ).

- § 7 StrlSchV [1A-8]: The handling of radioactive substances not being nuclear fuel requires a licence under § 7 StrlSchV, unless already covered by one of the licences mentioned above. This category includes, in particular, the waste collecting facilities of the *Länder*, and storage facilities for radioactive waste at research centres and conditioning facilities. Licensing and supervision are the responsibility of the competent authorities of the *Länder*. For clarification of the licence obligation it is stated in § 9c AtG that the licensing provisions of the AtG and of the ordinances decreed on its basis referring to the handling of radioactive materials also apply to the storage or treatment of radioactive waste in waste collecting facilities of the *Länder*.

The licensing system with regard to decommissioning is dealt with in the reporting on Article 26.

Responsibilities relating to the licensing of nuclear facilities are summarised in Table E-1. It shows that for licensing and supervision of the different facility types and activities, in some cases different authorities are responsible. A uniform application of the legal requirements and a harmonised licensing practice is ensured by the BMUB’s supervision on legality and appropriateness described more detailed in Chapter E.2.1.

Table E-1: Responsibilities relating to the approval and supervision of nuclear facilities and the handling of radioactive waste in the Federal Republic of Germany

Material	Activity	Legal basis	Licensing	Supervision	Facilities (examples)
Nuclear fuel and waste containing fissile material	Construction and operation	§ 7 AtG	*Land* authority	*Land* authority	PKA, VEK
	Treatment, use	§ 9 AtG	*Land* authority	*Land* authority	Activities outside of facilities governed by § 7 AtG (e.g. laboratory-scale handling of nuclear fuel for research purposes)
	Storage	§ 6 AtG	BfS	*Land* authority	Gorleben, Ahaus, on-site storage facilities
	Import and export	§ 3 AtG	BAFA	Federation	-
Other radioactive material acc. to § 2, para. 3 AtG (e.g. waste with low fissile material content)	Handling, e.g. storage	§ 7 StrlSchV[1)]	*Land* authority	*Land* authority	Collecting facilities of the *Länder*, storage facilities, conditioning facilities
Radioactive waste with negligible heat generation	Disposal	§ 9b AtG	BfE (for Konrad and ERAM, *Land* authority still competent as a transitional provision)	Repository surveillance[2)]	ERAM, Konrad repository
Heat-generating radioactive waste	Disposal	§ 9b para. 1a AtG	BfE	Repository surveillance[2)]	-

1) Unless the activity is already included in a licence according to §§ 6, 7, 9 or 9b AtG.
2) There is no supervision under nuclear law as defined in § 19 AtG for federal facilities for the disposal of radioactive waste; surveillance of such a facility takes place within the BfS by the organisational unit for repository surveillance. The BMUB exercises comprehensive legal and technical supervision of the BfS and the BfE, respectively.

Under the Atomic Energy Act, an approval may only be granted if the licensing conditions laid down in the corresponding section of the Act are met by the applicant. This includes, in particular, the required precautions against damage in accordance with the state of the art in science and technology.

Furthermore, it should be noted that any handling of radioactive material is subject to the binding provisions on supervision and protection outlined in the Radiation Protection Ordinance (StrlSchV). The StrlSchV includes regulations on the designation of responsible individuals by the approval holder and the dose limits of radiation exposure for plant personnel and the general public.

In order to ensure safety, approvals for nuclear facilities may be subject to certain conditions. The operation and ownership of, essential modifications to or decommissioning of a nuclear facility and the handling of radioactive waste without the necessary approval are offences liable to prosecution.

The licensing of nuclear facilities (except for nuclear fuel storage facilities licensed by the BfS under § 6 AtG [1A-3]) is the responsibility of the respective *Länder*. In the *Länder,* ministries are the supreme authorities responsible for licensing according to the Atomic Energy Act (§§ 7 and 9 AtG), subordinate authorities (e.g. trade supervisory offices) are responsible for the granting of licences according to the Radiation Protection Ordinance (handling of radioactive waste, collecting facilities of the *Länder*). The Federation supervises implementation of the Atomic Energy Act and radiological protection regulations by the *Länder* (federal supervision). In particular, it has the right to issue binding directives to the *Land* concerned on factual and legal issues in each individual case.

The actual details and procedure of licensing in accordance with § 7 AtG are specified in the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10]. It deals specifically with the application procedure, the submission of supporting documents, participation of the general public and the option of splitting the procedure into several stages (partial licences). Furthermore, it also addresses the assessment of environmental impacts [1B-14] and the consideration of other licensing requirements (e.g. non-radioactive emissions into the air or discharges into water). The Nuclear Licensing Procedure Ordinance is also applied in the case of other nuclear licensing and plan approval procedures (according to §§ 6 and 9b AtG, respectively [1A-3]). The option of splitting the licensing procedure into several phases (with individual partial licences) is usually taken up for large-scale facilities which take longer to be built and commissioned. The advantage is that the most recent state of the art in science and technology can be applied in each individual procedural step. For example, the first step may include the licensing of the site, the safety concept and the most important structures. Further steps might be the installation of safety-relevant systems, nuclear start-up, and full power operation.

In accordance with § 20 AtG, the competent authorities may consult authorised experts on all technical or scientific matters related to regulatory approval and supervision. However, the authority is not bound by the assessments of their authorised experts.

The current nuclear liability regulations have transposed the Paris Convention on Third Party Liability in the Field of Nuclear Energy [1E-11], amended by the Brussels Supplementary Convention [1E-12], into national law. Details of the required financial security are regulated by a statutory ordinance [1A-11]. In Germany, this means that licensees are generally required to take out liability insurance policies for a maximum financial sum specified in the individual nuclear licensing procedure.

In the following, examples are given for the procedures according to §§ 6, 7 and 9b AtG.

In contrast to licences according to §§ 6 or 7 AtG, the construction, operation and decommissioning of repositories for radioactive waste are subject to a plan approval procedure according to § 9b AtG, unless in the cases where the site was determined by federal law, a licence substitutes the plan approval procedure (§ 9b, para. 1a AtG). This clearly shows that the plan approval procedure is a special type of procedure that is integrated into the environment, taking into account all public and private interests affected. Accordingly, the effects of approval, concentration, replacement, creation of a legal situation and toleration are characteristic for the plan approval decision.

As a central licensing provision of the Atomic Energy Act (for facilities), special attention is to be paid to the licensing for facilities for production, processing, treatment or fission of nuclear fuel or for the reprocessing of spent fuel as well as for decommissioning, safe enclosure and dismantling according to § 7 AtG. Since § 6 AtG does not represent a plant licence but a licence related to the practice of storage of nuclear fuel, this issue will be outlined below for differentiation and a better understanding.

Licence for the storage of nuclear fuel according to § 6 AtG

§ 6 AtG [1A-3] is not a plant licence, as are for example licences according to § 7 AtG, but a so-called activity-related licence. Here, the activity of "storage" of nuclear fuel is permitted, i.e. first of all its storage (in contrast to disposal according to § 9b AtG) at a particular location, but also activities necessary for it (e.g. taking over and preparation of casks, transportation to the cask position, maintenance work and other common operations). This storage does neither require a comprehensive nuclear construction and operation licence nor a formal plan approval procedure. For the construction of such a storage facility, the building laws of the respective *Länder* apply. The construction licence is to be limited regarding the use of the building insofar as it must not contain a final decision binding for third parties on the protection against nuclear-specific risks. This issue is subject to examination by the nuclear regulatory authorities responsible for it.

The licence according to § 6 AtG is a bound decision which means that it is to be granted without discretion if the conditions stated in § 6, para. 2 AtG are fulfilled. The corresponding conditions largely correspond to those of § 7, para. 2 AtG, with the exception of the "knowledge of persons involved" within the meaning of § 7, para. 2, subpara. 2 AtG, and the "conflict with overriding public interests" within the meaning of § 7, para. 2, subpara. 6 AtG.

The nuclear licensing procedure as illustrated by the example of the procedure according to § 7 AtG

According to § 7 AtG [1A-3], construction, operation or ownership of a stationary facility for the production, processing, treatment or fission of nuclear fuel, a material alteration of such facility or its operation and also decommissioning, dismantling and safe enclosure are subject to licensing. A licence may only be granted if the licensing requirements stated in § 7, para. 2 AtG are complied with, i.e. if

- the necessary precautions have been taken in the light of the state of the art in science and technology to prevent damage,
- reliability and the requisite qualification of the responsible persons is given,
- it is assured that the persons who are otherwise engaged in the operation of the facility have the necessary knowledge concerning the safe operation of the facility, the possible hazards and the protective measures to be taken,
- the necessary protection has been provided against disruptive action or other interference by third parties,
- the necessary financial security has been provided to comply with the legal liability to pay compensation for damage, and,
- the choice of the site of the facility does not conflict with overriding public interests, in particular in view of its environmental impacts.

These requirements for licensing also constitute assessment criteria for supervision during operation.

The undefined legal terms used by the legislator, such as the "the necessary precautions in the light of the state of the art in science and technology", were chosen to facilitate a dynamic further development of the precautions according to the latest state of the art. Thus, legislation largely left it to the executive – be it by way of ordinances according to the relevant authorisations, be it in case of individual decisions also under consideration of the non-legally binding regulatory guidance instruments – to decide on the kind and, in particular, the extent of risks to be accepted or not to be accepted (see Chapter E.2.2 for details on the hierarchical structure of the regulations). The Atomic Energy Act does not include specific regulations about the procedure for the assessment of such risks.

The actual details and procedure of licensing in accordance with the Atomic Energy Act are specified in the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10]. It deals specifically with the application procedure, with the submittal of supporting documents, with the participation of the general public and with the possibility to split the procedure into several licensing steps (partial licences). It deals, furthermore, with the assessment of environmental impacts [1F-12] and with the consideration of other licensing requirements (e.g. regarding the possible release or discharge of non-radioactive pollutants into air or water).

Licence application

The licence application is submitted in written form to the competent licensing authority of the *Land* in which the nuclear facility is to be constructed. The licence application is accompanied by documents containing all the relevant data required for evaluation purposes. The documents which should be enclosed with the application are listed in the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10]. The required format is further specified in guidelines.

§ 3 AtVfV defines the character and scope of the documents. It states that documents should be enclosed which allow verification of compliance with the licensing prerequisites, in particular:

1. a safety report outlining the consequences of the project which are relevant to the decision on the application with regard to nuclear safety and radiation protection, and which will enable third parties in particular to evaluate whether their rights could be violated by the facility or the impacts resulting from its operation. For this purpose, as far as this is necessary for a judgement of the project's admissibility, the safety report must include the following information:

    a) a description of the facility and its operation including site plans and drawings;

    b) a description and explanation of the concept (basic design features), the safety relevant design principles, and the function of the facility including its operational and safety systems;

    c) an outline of the precautionary measures taken to meet the requirements of § 7, para. 2, subpara. 3 of the Atomic Energy Act (AtG) [1A-3], i.e. precautions against damage caused by the construction and operation of the facility in accordance with the state of the art in science and technology;

    d) a description of the environment and its constituents;

    e) information on the direct radiation and emission of radioactive substances associated with the facility and its operation, including releases from the facility in the case of accidents as defined in §§ 49 and 50 of the Radiation Protection Ordinance (StrlSchV) [1A-8] (design basis accidents);

    f) a description of the impacts of direct radiation and the emission of radioactive substances referred to under e) on the protected entities outlined in § 1a of the Nuclear Licensing Procedure Ordinance; these are human beings, animals and plants, soil, water, air, climate and landscape, cultural assets and other entities, including interactions with other substances;

2. complementary schemes, drawings and descriptions of the facility and its parts;

3. information on the provisions to protect the facility and its operation against malevolent acts or other illegal interference by third parties in accordance with § 7, para. 2, subpara. 5 AtG;

4. information which will enable verification of the reliability and technical knowledge of the persons responsible for construction of the facility and for management and supervision of its operation;

5. information which will enable verification of the existence of the necessary knowledge of other persons involved in the operation of the facility in accordance with § 7, para. 2, subpara. 2 AtG;

6. a list of all information relevant to the safety of the facility and its operation, the precautions taken for the control of accidents and damages, and a framework plan for the checks foreseen at safety-relevant parts of the facility (safety specifications);

7. proposals on precautions to comply with obligations on statutory liability for damages;

8. a description of the amounts of radioactive residues and information on precautions taken

    a) to avoid accumulation of radioactive residues;

    b) for the non-hazardous utilisation of radioactive residues and removed or dismantled radioactive components;

    c) for the orderly disposal of radioactive residues or removed radioactive components as radioactive waste, including their intended treatment, and for the anticipated storage of radioactive waste until their disposal;

9. information on other environmental impacts of the project required for verification pursuant to § 7, para. 2, subpara. 6 AtG [1A-3] for any approval decisions included in the licensing decision in individual cases, or for any decisions to be made by the licensing authority according to regulations on nature protection and landscape conservation. On this basis, it is necessary to verify that there are no overwhelming public interests, in particular with regard to environmental impacts, opposed to the choice of the site for the facility.

Furthermore, a short description of the planned facility, including information on the estimated consequences for the population and the environment, should be included with the licence application for the purpose of participation by the general public.

Examination of the application

On the basis of the submitted documents, the licensing authority examines whether or not the licence prerequisites have been met. All federal, *Länder*, local and other regional authorities whose jurisdiction is affected are to be involved in the licensing procedure, including in particular the authorities responsible for civil engineering, water, regional planning and off-site disaster control. Given the broad scope of the safety issues to be examined, it is common practice to engage technical expert organisations to support the licensing authority in the evaluation and examination of the application documents. These organisations prepare expert reports outlining whether or not the requirements regarding nuclear safety and radiation protection have been met. They have no autonomous decision-making powers. The licensing authority assesses and decides on the basis of its own judgment. The authority is not bound by the findings of their authorised experts.

Within the framework of federal executive administration, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) may submit a statement from the point of view of federal supervision before the licence is granted. In performing its function of federal supervision, the BMUB consults its advisory bodies, the Reactor Safety Commission (RSK), the

Commission on Radiological Protection (SSK), the Nuclear Waste Management Commission (ESK), and in many cases the *Gesellschaft für Anlagen- und Reaktorsicherheit* (GRS) mbH, for advice and technical support. The *Land* licensing authority must take the BMUB's statement into account when making its decision.

Environmental impact assessment

The Environmental Impact Assessment Act [1B-14], in conjunction with the Atomic Energy Act and the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10] based on it, regulate the need to conduct an environmental impact assessment and its procedure within the nuclear licensing procedure for the construction, operation and decommissioning of a nuclear facility to be licensed according to § 7 of the Atomic Energy Act (AtG) [1A-3] or for an essential modification of the facility or its operation. According to § 3, para. 2 AtVfV, the following documents are to be included with the application additionally in the case that a project is subject to an environmental impact assessment:

1. an overview of the main technical alternatives examined by the applicant, including the main reasons in favour of the preferred solution, insofar as this information may be relevant when assessing the admissibility of the project under § 7 AtG;

2. references to any difficulties which may have arisen when compiling information for the examination according to § 1a, i.e. an examination of the environmental impact assessment requirements, in particular insofar as these difficulties are attributable to a lack of knowledge and methods of examination or technical gaps.

The competent authority performs a final evaluation of the environmental impacts which provides the basis for a decision on the project's admissibility with regard to effective environmental protection.

Participation of the general public

The licensing authority involves the general public in the licensing procedures, including in particular those citizens who might be affected by the planned facility. Details are regulated in the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10].

According to § 4 AtVfV, the project is published in the official Publication Gazette and in local newspapers once the documents to be submitted for public display are complete. According to § 5 AtVfV, this announcement should include details of where and when the application will be available for public inspection, a request to submit any objections in writing to the competent authority within the specified period, and the date of the public hearing or reference to the fact that this date will be announced in future.

According to § 6 AtVfV, the application, the safety report, a short description of the project and – in the case that a project is subject to an environmental impact assessment – information on radioactive residues and other environmental impacts of the project, as described under points 8 and 9 of § 3 AtVfV above, and the documents according to § 3, para. 2 AtVfV are to be laid out for public inspection over a period of two months.

According to § 7 AtVfV, objections may be raised in writing or for recording at the competent authorities.

The public hearing is regulated in §§ 8 to 13 AtVfV. It serves to discuss any objections that have been duly raised with the applicant and those having raised the objections, insofar as this may be important for an examination of the licensing requirements. Any individuals who have raised objections are to be given the opportunity to explain them.

The licensing authority takes these objections into account when making its decision, and addresses them in the licence findings.

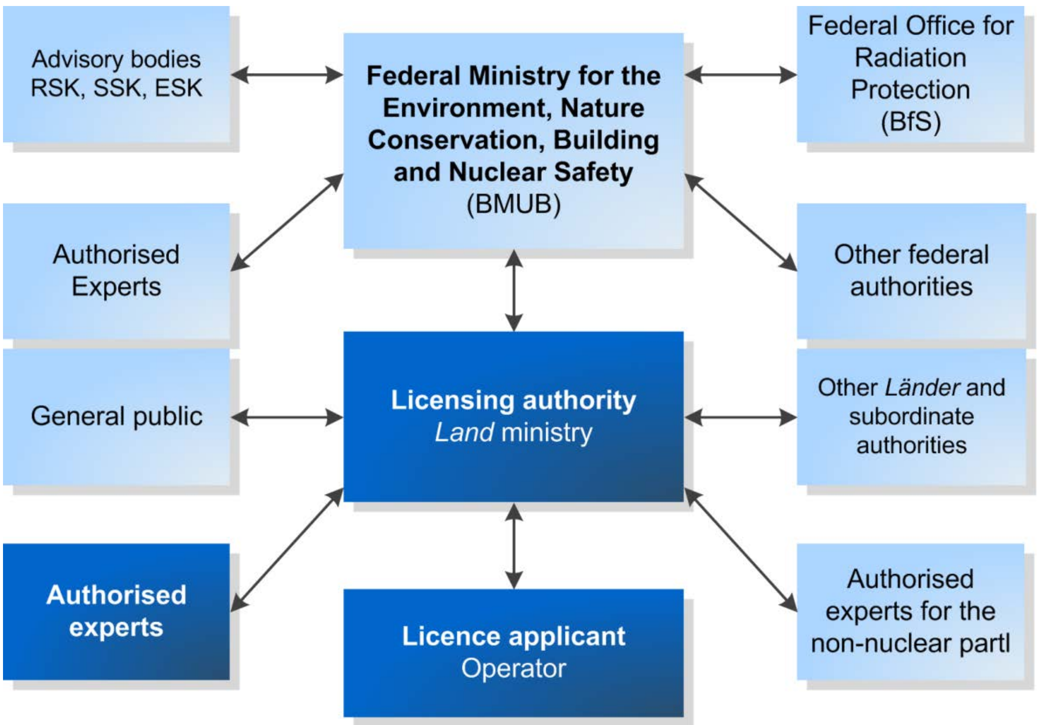
In case of material amendments to a nuclear licence, public participation may not be necessary if the modification applied has no adverse effects for the population.

Licensing decision

The final decision of the licensing authority is based on the entirety of application documents, evaluation reports by the authorised experts, the opinion of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), the opinions of the authorities involved, and the findings from objections raised in the public hearing. One prerequisite for the legality of this decision is that all procedural requirements of the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10] must have been observed. Action may be brought against the decision of the licensing authority before an administrative court by each citizen as far as at least the potential violation of own rights to life, health and property is claimed. Appeals, if applied for and admitted, may be brought up to the Federal Administrative Court. In the case of a licence with immediate enforcement, a court action cannot prevent use being made of the licence. However, action may be brought against immediate enforcement.

The interaction between the various authorities and organisations involved in the nuclear licensing procedure and the participation of the general public is shown in Figure E-2. This creates a broad and differentiated decision-making basis which allows all interests to be taken into account when reaching a final decision.

Figure E-2: Parties involved in the nuclear licensing procedure (taking the procedure according to § 7 AtG as an example)



Plan approval procedure under nuclear law according to 9b AtG for federal facilities for the safekeeping and disposal of radioactive waste

According to § 9a, para. 3 AtG [1A-3], the Federation shall establish facilities for the safekeeping and disposal of radioactive waste. As defined in § 23, para. 1, subpara. 2 AtG, this lies within the responsibility of the Federal Office for Radiation Protection (BfS). According to § 9b, para. 1 AtG, the construction, operation and decommissioning of such facilities require plan approval. Upon application, the project may be carried out in several steps and, accordingly, partial plan approval decisions may be issued. In the cases where the repository site was determined by federal law, a licence shall substitute the plan approval procedure (§ 9b, para. 1a AtG).

The Federal Office Nuclear Waste Management (BfE) shall be responsible for plan approval and licensing according to § 9b AtG and their withdrawal. This, however, does not apply to the Konrad repository until granting of the approval of commissioning by the nuclear supervisory authority and to the ERAM until the plan approval decision on decommissioning will be enforceable. In these two cases, the responsibility will rest with the competent supreme *Land* authority until then. The plan approval for the decommissioning of the Asse II mine is also outside the competence of the BfE.

The approval for a repository may only be granted if the requirements stated § 7, para. 2, subparas. 1, 2, 3 and 5 AtG have been fulfilled. Moreover, approval for a repository shall be refused if

- the construction, operation or decommissioning of the proposed facility suggest that the common welfare will be impaired and that such impairment cannot be prevented by restrictions and obligations, or
- the construction, operation or decommissioning of the facility conflicts with other provisions of public law, in particular with respect to the environmental impact of the facility.

The main peculiarity of the plan approval procedure is the concentration of all areas of law within a single procedure. Thus, the plan approval decision covers, unlike other nuclear procedures, almost all other licences required, e.g. under the terms of building legislation or nature conservation legislation. Exceptions to this result from § 9b, para. 5, subpara. 3 AtG and the Federal Water Act (WHG). Accordingly, plan approval does not extend to the legitimacy of the project under the provisions of mining and subsurface storage law, which requires other procedures. As far as permits are required according to water legislation, they are also decided on separately according to § 19 WHG. Exceptions are decided on by the competent authority. Moreover, the plan approval procedure according to § 9b, para. 5, subpara. 1 AtG also provides for public participation.

The legitimacy of the project regarding all public interests affected by it will also be verified by a licence pursuant to § 9b, para. 1a AtG. Apart from the licence, all other decisions made by the authorities, especially licences issued under public law, concessions, permits, permissions, consents and plan approval decisions shall not be required with the exception of permits and concessions relating to water law and of decisions regarding the legitimacy of the project according to the provisions of the mining and subsurface storage law.

Contrary to licensing pursuant to § 7 AtG, liability provisions are not in place since the State itself shall be responsible for such a facility. § 13, para. 4 AtG explicitly states that the Federation and the *Länder* are not obliged to make liability provisions.

The parties involved in the approval procedure for a repository and in repository supervision and surveillance are summarised in Figure E-3 and Figure E-4.

Figure E-3: Parties involved in the nuclear approval procedure for a repository

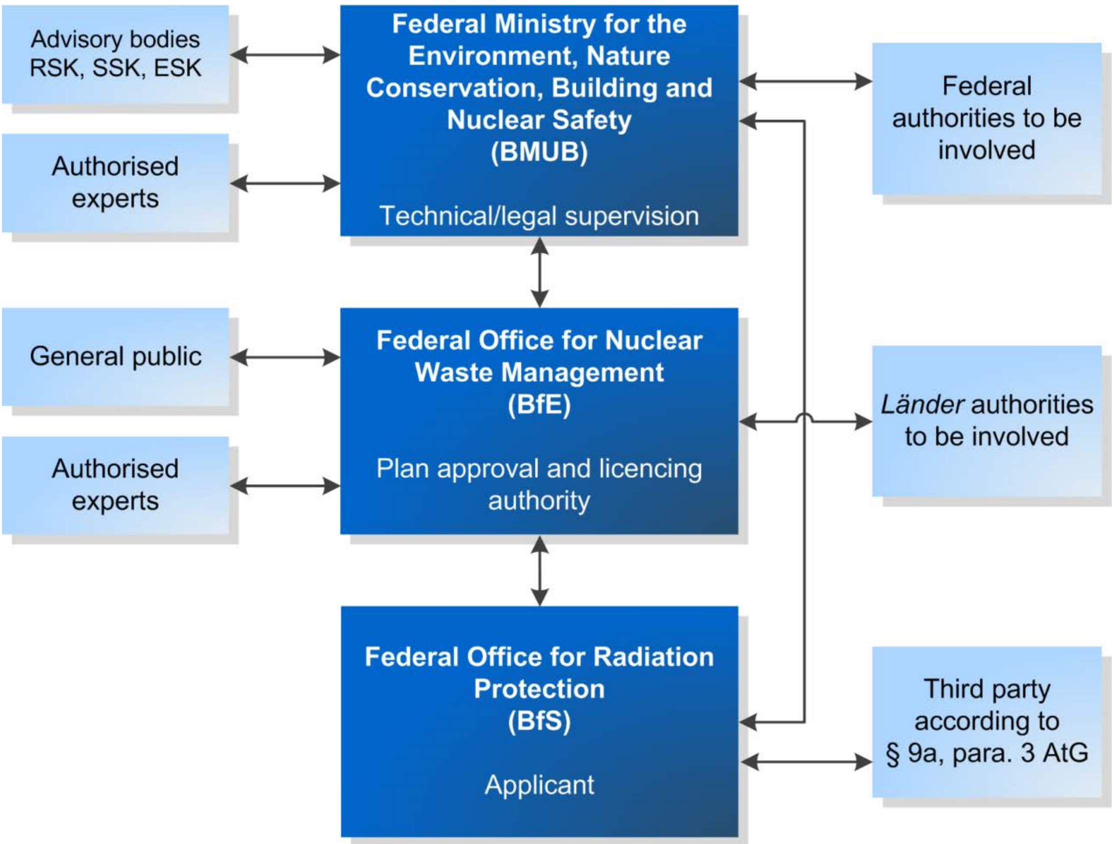
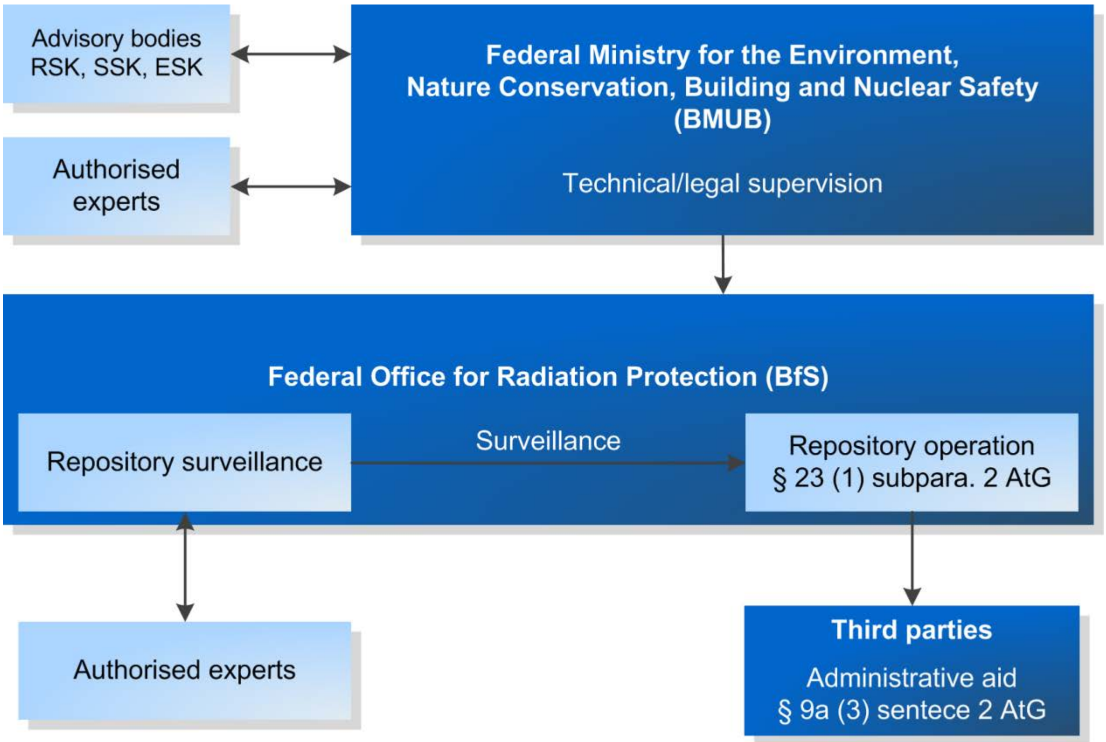


Figure E-4: Parties involved in repository supervision and surveillance



E.2.4 System of prohibiting the operation of a facility without licence

Prohibition of the operation of a spent fuel or radioactive waste management facility without a licence is derived from the requirements contained in the Penal Code, the Atomic Energy Act and the nuclear ordinances. These issues are addressed in greater detail in the reporting on Article 19 (2) v in Chapter E.2.6.

E.2.5 Regulatory inspection and assessment (supervision)

Continuous regulatory supervision

During the entire operating lives, including construction and decommissioning, nuclear facilities are subject to continuous regulatory supervision, after having been granted the necessary approval, according to § 19 AtG [1A-3] – the facilities for disposal are supervised within the BfS by the "Repository Surveillance" – and the associated nuclear ordinances. As with the licensing procedure, a distinction is made between the matters of handling pursuant to §§ 6 and 9 AtG, and the facilities licensed pursuant to § 7 AtG and the repositories, which are subject to plan approval according to § 9b AtG.

Where nuclear facilities or the handling of nuclear fuel have been licensed according §§ 6, 7 or 9 AtG, the *Länder* exercise nuclear supervision. In this respect, they are also acting on behalf of the Federation, i.e. the Federation has the right to issue binding directives on factual and legal issues in each individual case. As in the licensing procedure, the *Länder* are assisted by independent authorised experts. The same applies to the handling of other radioactive substances according to § 7 StrlSchV [1A-8].

As in licensing, the supreme objective of government supervision is to protect the general public and the employees of these facilities against the hazards associated with the operation of the facility.

In particular, it is the duty of the supervisory authority to monitor

- compliance with the provisions, obligations and other ancillary provisions imposed by the licensing notices,
- compliance with the requirements of the Atomic Energy Act, the nuclear ordinances and other nuclear safety standards and guidelines, and
- compliance with any supervisory orders issued, if issued.

To ensure safety, the supervisory authority monitors, also with the aid of its authorised experts or by other authorities,

- compliance with the operating procedure,
- the performance of in-service inspections of components and systems important to safety,
- the evaluation of reportable events,
- the implementation of modifications to the nuclear facility or its operation,
- radiation protection monitoring of the personnel,
- radiation protection monitoring in the vicinity of the nuclear facility,

- compliance with the authorised plant-specific limits for radioactive discharge,
- the measures taken against malevolent acts or other illegal interference by third parties,
- the trustworthiness, technical qualification and maintenance of the qualification of the responsible individuals, as well as of the knowledge of other staff working at the facility,
- the quality assurance measures.

The supervisory authority and the authorised experts consulted by it have access to the facility at any time and entitled to carry out the necessary examinations and to demand information (see § 19, para. 2 AtG [1A-3]).

Contrary to the regulatory supervision by the *Land* for licences according to §§ 6, 7 or 9 AtG, other regulations apply for federal facilities for the safekeeping and disposal of radioactive waste according to § 9b, para. 3 AtG. The responsibility for the construction and operation of these facilities rests with the Federal Office for Radiation Protection (BfS) (§ 23, para. 1, subpara. 2 AtG). According to § 23d, sentence 1, subpara. 1 AtG, the Federal Office for Radioactive Waste Management (BfE) shall be responsible for plan approval and licensing procedures for these facilities. According to § 58 AtG, the supreme *Länder* authorities designated by the *Länder* governments shall be responsible for approvals relating to the Konrad repository until granting of the approval of commissioning by the nuclear supervisory authority and to the Morsleben repository (ERAM) until the plan approval decision on decommissioning will be enforceable (see reporting on Article 20 (2)). For internal surveillance of all tasks to be fulfilled that are related to repositories for radioactive waste, an independent organisational unit has been established within the BfS, "Repository Surveillance". The comprehensive technical and legal supervision of the BfS is exercised by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) to whose portfolio the BfS belongs.

The BfE regulates the implementation of the site selection procedure according to § 19, paras. 1 to 4 AtG.

Reporting obligations

The legal basis for the documentation and reporting of radioactive waste is § 70 StrlSchV [1A-8] (Record Keeping and Notification). It requires the record keeping and notification within one month of any extraction, production, acquisition, delivery or other whereabouts if radioactive substances, also stating their kind and activity. In addition, the current inventory has to be declared annually. The competent authority is entitled to verify the correctness of the record keeping any time. It may in individual cases grant total or partial exemptions from the requirement to keep records and make notifications.

Much more detailed provisions are included in the BMU guideline on the control of radioactive waste with negligible heat generation that is not handed over to a *Land* collecting facility (Waste Control Guideline) [3-59]. This guideline entered into force in 1989. The main contents were adopted into the new Radiation Protection Ordinance of 2001. The new Waste Control Guideline published in 2008 [3-60] only contains those aspects that are not covered by the Radiation Protection Ordinance and has been extended to radioactive residues.

In §§ 72 and 73 StrlSchV, the plant operators and those handling nuclear fuel are committed to preparing a documentation about the arising and whereabouts of waste and to submitting it to the authorities. The documentation is prepared by the plant operators with the help of various computerised systems, such as the Waste Flow Tracking and Product Control System (AVK) of GNS GmbH. Another system is the Waste Flow Tracking and Control System (ReVK) of ISTec GmbH for the documentation, tracking and administration of residues and waste arising e.g. in connection with the operation and dismantling of nuclear facilities. As these systems also fulfil other tasks than merely documentation duties, they are much more detailed than required by the StrlSchV.

The BfS queries the inventories of radioactive waste in Germany as well as the existing storage capacities and their occupancy with the help of standardised form sheets (computer-based) as at reporting date 31 December on an annual basis. The forms completed by the waste proprietors are then sent back via the competent *Land* authority to the BfS and are evaluated there.

A reporting obligation to the corresponding supervisory authority also exists for measures taken by the operators to reuse any radioactive residues arising in a non-hazardous manner or dispose of them in an orderly manner as radioactive waste in accordance with § 9a, para. 1 AtG [1A-3]. In particular, it has to be shown that adequate provisions to fulfil these obligations have been made for already existing and for future arising spent fuel as well as for the waste to be taken back from reprocessing (§ 9a, para. 1a AtG). This proof has to be provided annually. For the orderly disposal of the spent fuel as well as of the radioactive waste from reprocessing, it has to be shown that safe storage in storage facilities is ensured until their disposal in a repository (§ 9a, para. 1b AtG). Realistic plans have to be submitted with regard to the expected need for storage capacity. The availability of the expected storage capacity that is needed has to be demonstrated for the following two years. If the non-hazardous reuse of the plutonium from reprocessing is intended, it also has to be shown that the reuse of the plutonium in the nuclear power plants is ensured (§ 9a, para. 1c AtG). This proof has been furnished if realistic plans for reprocessing, fuel assembly fabrication and fuel assembly use have been provided and their feasibility has been demonstrated. As for uranium from reprocessing, its safekeeping has to be demonstrated by realistic planning of sufficient storage capacities (§ 9a, para. 1d AtG).

In order to give the BMUB an overall survey of the management of the spent fuel and the nuclear fuels to be recycled, the operators' waste management records are submitted to the BMUB by the *Länder*.

All safety-related events in facilities licensed according to § 7 AtG and during handling of nuclear fuel according to § 6 AtG have to be reported to the authorities in accordance with § 6 AtSMV [1A-17]. A corresponding reporting obligation for other plants ensues from § 51, para. 1 StrlSchV. The regulations and procedures relating to reportable events and their evaluation are described in the reporting on Article 9.

E.2.6 Enforcement of provisions and terms of the licences

Enforcement by regulatory order, particularly in urgent cases

According to § 19 AtG, the supervisory authority may order that a situation be discontinued which is contrary to the provisions of the Atomic Energy Act, the nuclear statutory ordinances, or to the terms and conditions of the licence, or to any subsequently imposed obligation, or which may constitute a hazard to life, health or property. Depending on the specific circumstances of the individual case it may order, in particular, that

- certain protective measures shall be taken,
- that operation may only be continued with restrictions or subject to certain conditions, or
- operation is to be discontinued temporarily until the causes of an event are clarified and necessary remedial actions against recurrence are taken.

In case of non-fulfilment of the licensing provisions or the supervisory orders, the supervisory authority of the respective *Land* is authorised to enforce their fulfilment by coercive administrative measures in accordance with the general provisions applicable to the police authorities of the *Land*.

Enforcement by modification or revocation of the licence

Under certain conditions, as stipulated in § 17 AtG, obligations for ensuring safety may be decreed by the nuclear licensing retrospectively. In case a considerable hazard is suspected from the nuclear facility endangering the persons engaged at the facility or the general public, and if this hazard cannot be eliminated within a reasonable period of time by means of appropriate measures, then the licensing authority must revoke the issued licence. Revocation is also possible if certain licence prerequisites cease to be met at a later date, or if the licensee violates legal regulations or decisions by the authorities.

In addition, the Penal Code (*Strafgesetzbuch* – StGB) [1B-1], the Atomic Energy Act [1A-3] and the nuclear statutory ordinances provide sanctions to prosecute violations.

Criminal offences

Any violation that is classed as a criminal offence is dealt with in the Penal Code. For example, anyone who, e.g.:

- operates, otherwise holds, changes or decommissions a nuclear facility without the required licence,
- knowingly constructs a defective nuclear facility,
- handles nuclear fuel or waste containing fissile material without the required licence,
- releases ionising radiation or causes nuclear fission processes that may cause damage to life and limb of other persons,
- procures or manufactures nuclear fuel, radioactive material or other equipment for himself with the intent of performing a criminal offence

shall be liable to imprisonment or fines.

Administrative offences

§§ 46, 49 AtG and the associated ordinances deal with administrative offences and provide for the imposition of fines on the perpetrators. An administrative offence is deemed to have been committed by anyone who, e.g.,

- constructs a nuclear facility without a licence,
- acts in violation of a regulatory order or provision,
- handles radioactive material without a valid licence permit,
- as the ultimately responsible person fails to ensure compliance with the protective and surveillance regulations of the Radiation Protection Ordinance. (The Atomic Energy Act and related ordinances require that the individuals who are ultimately responsible for the handling of radioactive material, for the operation of nuclear facilities or for their supervision should be named.)

For administrative offences, fines may be imposed of up to € 50,000. A legally effective fine against a person may cast doubt on the personal trustworthiness that was a prerequisite for the licence and may therefore require the removal of such individuals from office (see reporting on Article 21 of the Convention).

Experiences

Due to the intensive regulatory supervision (see Chapter E.2.5 for details) of planning, construction, commissioning, operation and decommissioning of nuclear facilities in Germany, inadmissible states and conditions are generally identified in advance and their removal ordered and performed before taking of measures provided by law, as e.g. obligations, orders and proceedings relating to an administrative or criminal offence, becomes necessary.

The instruments presented have proved to be effective since, as a rule, they ensure that the authorities have appropriate sanction possibilities and competencies for the enforcement of provisions and regulations, if required.

E.2.7 Responsibilities

The management of spent fuel and radioactive waste is based on the polluter-pays principle. According to § 9a, para. 1 AtG, the producers of residual radioactive material are required to ensure their non-hazardous recycling or their orderly disposal as radioactive waste. This also means that, as a general principle, the producers are responsible for the conditioning and storage of the spent fuel and the radioactive waste. With the delivery of radioactive waste to a *Land* collecting facility, the ownership is transferred to this facility. Thus, the responsibility for conditioning is assumed by the operator of the *Land* collecting facility.

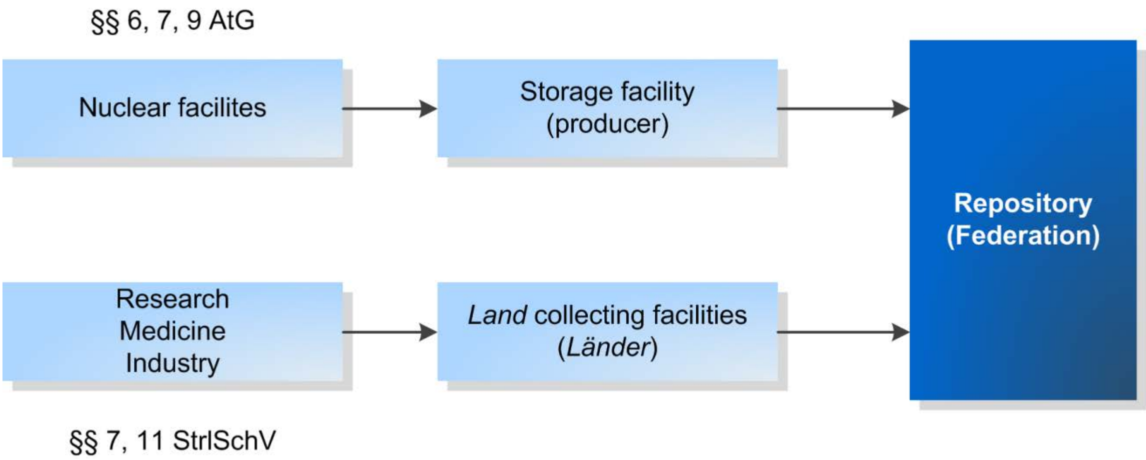
According to § 9a, para. 2 AtG [1A-3], anyone possessing radioactive waste must deliver it to a repository or to a *Land* collecting facility (see Figure E-5).

According to § 9a, para. 3 AtG, the *Länder* shall establish *Land* collecting facilities for the storage of radioactive waste arising within their territory. Radioactive waste with negligible heat generation from research, medicine and industry is delivered to these facilities. The producers of radioactive waste arising from the use of nuclear energy are responsible for its storage and conditioning.

According to § 9a, para. 3 AtG, the Federation shall establish facilities for the disposal of radioactive waste. According to § 23, para. 1, subpara. 2 AtG, the Federal Office for Radiation Protection (BfS) shall be responsible for the construction and operation of repositories as well as for the compliance with the legal requirements and the requirements stipulated in the approval. The other waste management facilities are supervised by the *Länder* within the frame of federal executive administration. The approvals for waste management facilities, except for the storage of nuclear fuel (§ 6 AtG) and disposal, are granted by the *Länder*. Applications for the storage of nuclear fuel (pursuant to § 6 AtG) are reviewed by the Federation and approved if the requirements are met. In future, the Federal Office for Nuclear Waste Management (BfE) shall be responsible for the approval of a repository.

The polluter-pays principle also applies to the financing of spent fuel and radioactive waste management activities. The Federation refinances the necessary expenses for the planning and construction of repositories at the parties' obliged to deliver material by means of advance payments on contributions. The site selection procedure is financed through cost allocations to the waste producers according to §§ 21 et seq. StandAG [1A-7]. The use of repositories and *Land* collecting facilities is (re)financed by costs (fees and expenses) that are payable by the party delivering radioactive waste.

Figure E-5: Obligation to deliver radioactive waste and responsibilities (diagram)



E.3 Article 20: Regulatory body

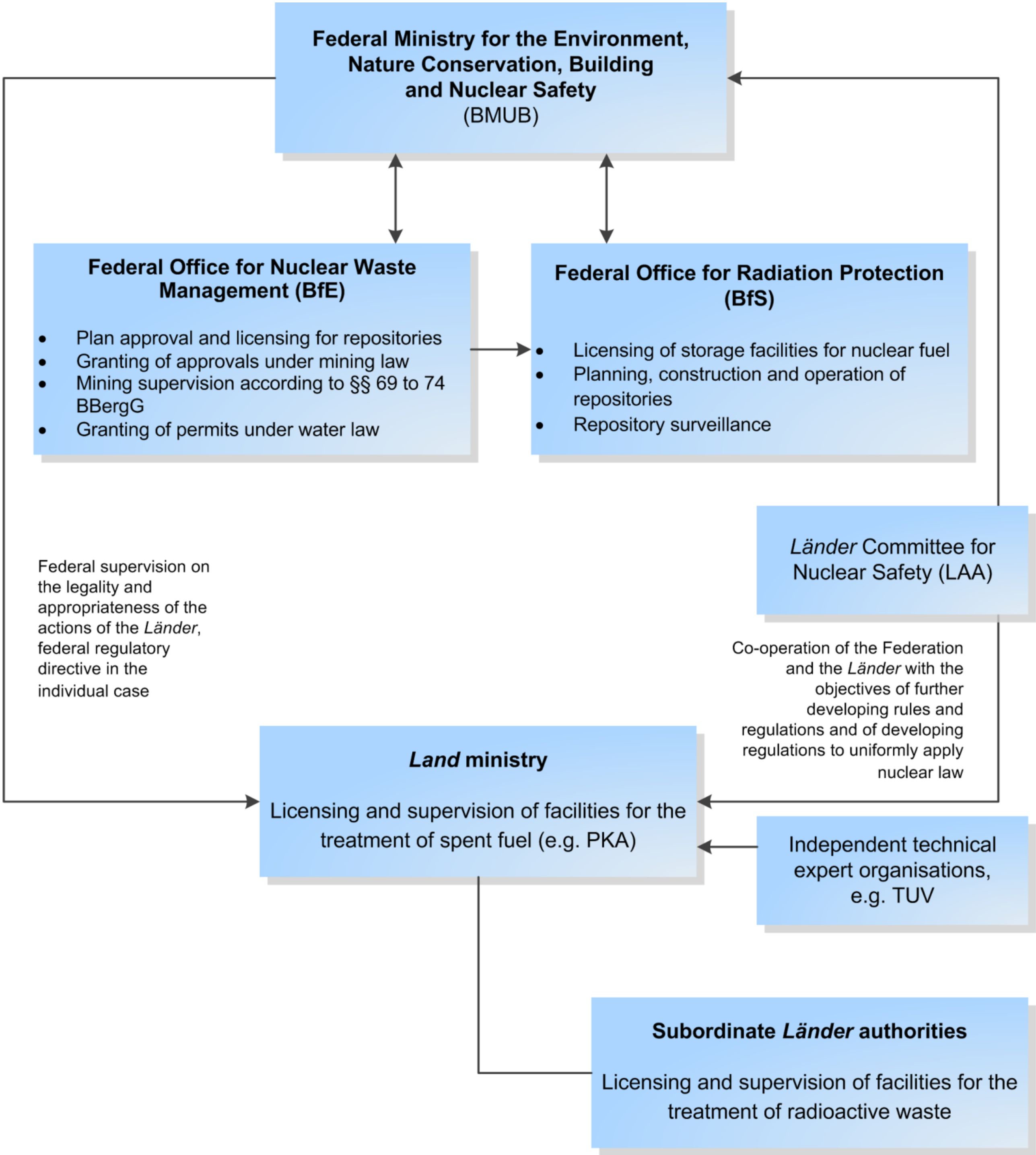
> *Article 20: Regulatory body*
>
> *(1) Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 19, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.*
>
> *(2) Each Contracting Party, in accordance with its legislative and regulatory framework, shall take the appropriate steps to ensure the effective independence of the regulatory functions from other functions where organisations are involved in both spent fuel or radioactive waste management and in their regulation.*

E.3.1 Regulatory body

Responsibilities and powers

In the Federal Republic of Germany as a federal state, the “regulatory body” pursuant to Article 20 consists of authorities of the Federation and the *Länder* (see Figure E-6).

Figure E-6: Organisation of the “regulatory body”



By organisational decree, the Federal Government specifies the Federal Ministry competent for nuclear safety and radiation protection. In 1986, this competence was assigned to the then newly founded Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) [1A-3]. Previously, the Federal Ministry of the Interior (BMI) had been competent for environmental protection as well as for atomic law. The responsibility for the organisation, staffing and financing of the Federal Government's nuclear regulatory authority thus lies with today’s Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). The BMUB has the organisational powers and applies for the requisite human and financial resources from the annual federal budget.

Regarding the obligations under the Convention, the BMUB has the responsibility to ensure, both towards the interior of Germany and towards the international community, that those in charge of the applicants and plant operators, federal and *Länder* authorities, as well as the authorised experts guarantee at any time and in a sustainable manner the effective protection of man and the environment against the hazards of nuclear energy and the harmful effects of ionising radiation.

The fundamental regulations for the further official competences are contained in the Atomic Energy Act (AtG) [1A-3] in §§ 22 – 24 where the regulatory bodies are listed that are responsible for the implementation of and compliance with the provisions of this Act and statutory ordinances issued hereunder:

- According to § 22 AtG, the Federal Office of Economics and Export Control (BAFA) shall be responsible for licences/approvals involving transboundary movement of radioactive material and withdrawal or revocation thereof, while supervision is the responsibility of the Federal Ministry of Finance or the customs authorities designated by it.
- According to § 23 AtG, the Federal Office for Radiation Protection (BfS) shall be responsible for the following with regard to the handling of spent fuel and radioactive waste:
    - the construction and operation of federal facilities for the safekeeping and disposal of radioactive waste and the Asse II mine, the transfer of tasks to third parties by the Federal Government, and the supervision of such third parties,
    - the licensing of nuclear fuel storage outside of federal custody, where this does not constitute preparation or part of an activity subject to licensing under §§ 7 or 9 AtG, and the withdrawal or revocation of such licences,
    - decisions concerning exceptions from the duty to construct a storage facility on the site of a commercial nuclear power plant or in close proximity to it when an application for decommissioning has been filed (§ 9a, para. 2, sentence 4 AtG).
- According to § 23a AtG, the Federal Office of Administration shall be responsible for decisions on exceptions regarding preservation orders to secure plans for repository projects or continue a site exploration for facilities intended for the disposal of radioactive waste pursuant to § 9g AtG. A preservation order shall prevent that at a potential repository site, essentially value-increasing changes or changes which substantially impede the project are performed. It is specified for a maximum of ten years and may be extended two times by a maximum of ten years in each case.
- According to § 23d AtG, the Federal Office for Nuclear Waste Management (BfE) shall be responsible for
    - plan approval and licensing according to § 9b AtG and their withdrawal,
    - the granting of approvals under mining law and other permissions necessary according to mining law as well as licensing procedures pursuant to § 9b AtG for the construction, operation and decommissioning of federal facilities for the safekeeping and disposal pursuant to § 9a, para. 3 AtG after consultation of the responsible mining authority of the respective *Land*,

  - o the mining supervision pursuant to §§ 69 to 74 Federal Mining Act (BBergG) [1B-15] regarding federal facilities for the safekeeping and disposal pursuant to § 9a, para. 3, and
  - o the granting of permits or concessions relating to water law during licensing procedures pursuant to § 9b AtG for federal facilities for the safekeeping and disposal pursuant to § 9a, para. 3 after consultation of the competent water authority.

- § 24 AtG regulates the competence of the *Länder* authorities (excerpt):

(1) The other administrative tasks under the Second Section of the Atomic Energy Act and the resultant statutory ordinances are performed by the *Länder* on behalf of the Federal Government.

(2) The supreme *Länder* authorities designated by the *Länder* governments are responsible for licensing pursuant to §§ 7, 7a and 9 AtG and the withdrawal and revocation thereof. These authorities also exercise supervision of nuclear facilities pursuant to § 7 AtG and the use of nuclear fuels outside these facilities. In individual cases, they may mandate subordinate authorities to carry out such tasks. The supreme *Land* authority decides on any complaints against their orders. Insofar as provisions outside this Act confer supervisory authority upon other authorities, this competence shall remain unaffected.

(3) For matters relating to the official duties of the Ministry of Defence, the competencies outlined in paragraphs 1 and 2 shall be carried out by said Ministry or other authorities designated by it in consultation with the federal ministry responsible for nuclear safety and radiation protection.

According to § 24 AtG, the respective *Land* government determines the competent supreme *Länder* authorities. Thus, the responsibility for the organisation, staffing and financing of these executive authorities lies solely with the *Land* government. In individual cases, subordinate authorities may also be tasked with supervisory functions.

Personnel

All regulatory bodies are obliged to give an account of their human resources by drawing up job plans. The costs depend on the extent of the activities; i.e. different numbers of staff are employed in the various *Länder* depending on the number of nuclear facilities to be supervised there. The required funds are established by the *Länder* parliaments and the *Bundestag* in their respective budgets.

Nuclear authority of the Federation and authorised experts of the Federation

The nuclear authority of the Federation is a technical department of the BMUB – the Directorate-General Reactor Safety (RS). It comprises three directorates (Safety of Nuclear Facilities, Radiological Protection, Nuclear Fuel Cycle). The unit of the Directorate-General RS dealing with the fulfilment of the obligations under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management is Directorate RS III (Nuclear Fuel Cycle). As at 1 January 2014, Directorate RS III and its five divisions have 36 staff members.

As a subordinate authority of the BMUB, the Federal Office for Nuclear Waste Management (BfE) shall perform administrative tasks of the Federation in the field of licensing of federal facilities for the safekeeping and disposal of radioactive waste assigned to it by the Atomic Energy Act (AtG) [1A-3], the Site Selection Act (StandAG) [1A-7] or pursuant to these laws. The BfE will support the BMUB by providing technical and scientific advice in these fields and moreover, if no other jurisdiction is stipulated by law, perform duties of the Federation in these fields with whose fulfilment it will be commissioned by the BMUB or, with its consent, by the competent supreme federal authority.

As another subordinate authority of the BMUB, the Federal Office for Radiation Protection (BfS) performs implementation tasks of the Federation in accordance with the Atomic Energy Act and the Precautionary Radiation Protection Act, fulfils tasks in the fields of radiation protection, nuclear safety, the transport of radioactive material and radioactive waste management. The BfS supports the BMUB in its responsibility by providing technical and scientific advice, among others with regard to radioactive waste management. At the BfS, these tasks are mainly performed by the Department of Safety in Nuclear Waste Management (SE). The Department SE is divided into six divisions, four of them being responsible for the performance and steering of the projects/facilities. For dealing with generic plant- and site-related issues (cross-sectional tasks), another division has been established.

At present, the Department SE and its six divisions (licences, storage facilities and transports, repository projects/disposal facilities, cross-sectional tasks) and the information centres of the repositories/repository projects have 188 staff members.

The BfS also provides technical advice to the BMUB in the field of decommissioning of nuclear facilities. The responsible unit in the field of decommissioning of nuclear facilities belongs to the Department of Safety in Nuclear Engineering (SK).

For supervision of the compliance with the requirements under nuclear law and the stipulations in the plan approval, the Repository Surveillance unit was set up for the Asse II mine, the ERAM and the Konrad repository, which is under construction. The Repository Surveillance unit currently has 12 staff members. In addition, the BfS has a Quality Management Section with a total of 11 staff members being responsible for quality assurance.

Within the framework of product control of radioactive waste, the BfS is supported by independent experts who perform product control on behalf of the BfS. About ten experts of the Product Control *(Produktkontrollstelle* – PKS) and 20 experts of the TÜV NORD EnSys GmbH are working in this field.

The *Gesellschaft für Anlagen- und Reaktorsicherheit* (GRS) *mbH* is a scientific and technical expert organisation of the Federation. GRS performs scientific research in the field of nuclear safety and radiation protection, predominantly under federal contracts, including radioactive waste management and disposal, and supports the BMUB in technical issues. The Radiation and Environmental Protection Division with its departments Nuclear Fuel, Radiation Protection and Disposal has about 40 experts dealing with radioactive waste management issues.

Nuclear authorities of the *Länder* and authorised experts of the *Länder*

In the 16 *Länder*, there are about 120 staff members working on issues related to radioactive waste management. Another 150 staff members support the nuclear authorities of the *Länder* either at subordinate authorities or as authorised experts. The personnel strength of the different *Länder* varies according to the concrete tasks: e.g., *Länder* with larger nuclear facilities have a larger licensing and supervisory authority than those with no or only very small nuclear facilities.

Operation of the Konrad and Morsleben Repositories and the Asse II Mine; keeping the Gorleben salt dome open

For fulfilling its tasks related to the construction and operation of repositories for radioactive waste, the BfS employs the services of the *Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe* (DBE) *mbH*, the German Service Company for the Construction and Operation of Waste Repositories, as administrative aid, in which the public authorities also hold shares. At the end of 2013, 807 staff members were working in the field of waste management/disposal in connection with the Morsleben and Konrad repositories and with keeping the Gorleben mine open.

For the operation and closure of the Asse II mine, the federally owned Asse-GmbH was founded as an administrative aid for the BfS. In this respect, the majority of staff working at the mine was then kept on by the *Helmholtz Zentrum München* being responsible for the Asse II until then. At the end of 2013, the Asse-GmbH had 386 employees. The number of staff has been increased in all fields and particularly for operation in the fields of electric and machinery operation.

Advisory commissions and authorised Experts

The Reactor Safety Commission (RSK) was founded in 1958 and advises the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) on issues relating to nuclear safety and physical protection. In addition, it substantially contributes to the advancement of the safety standards in nuclear facilities. At present, the RSK consists of 17 members, who are appointed for a period of three years. The statements and recommendations of the RSK are published on the Internet (http://www.rskonline.de/EN).

The Commission on Radiological Protection (SSK), founded in 1974, currently has 18 members. It gives recommendations to the BMUB on all issues related to the protection of the population as well as employees in medical facilities, research, industry and nuclear facilities against ionising and non-ionising radiation. The statements and recommendations of the SSK are published on the Internet (http://www.ssk.de/EN). Further, in the event of a nuclear or radiological incident or corresponding exercises, the SSK will set up the SSK Crisis Management Group.

In 2008, the Nuclear Waste Management Commission (ESK) was founded due to the increasing importance of issues related to nuclear waste management. It currently has 13 members and has taken over the tasks until then performed by the RSK Committee on Fuel Supply and Waste Management. With the ESK, an advisory body has been established which, with its way of working, takes into account the increasing importance of nuclear waste management issues and brings together a broad spectrum of technical expertise. International experiences and approaches will be included in the Commission's work, a reason why besides experts from Germany, experts from France and Switzerland are also members of the Commission. The experts advise the BMUB in all matters of nuclear waste management. This comprises the aspects of conditioning, storage and transport of radioactive materials and waste, further the decommissioning and dismantling of nuclear facilities as well as disposal in deep geological formations. As a result of its consultations, the Commission reaches resolutions on scientific and technical recommendations or statements directed to the BMUB which will be published on the website of the Commission (http://www.entsorgungskommission.de/EN).

For in-depth consideration of different focal points, the commissions set up committees and working groups, where additional experts may be involved. The members of the commissions represent a broad spectrum of positions supported and views held according to the state of the art in science and technology. They are independent and not bound to any directives. The BMUB appoints the members of the Commission for a period of up to three calendar years. In general, reappointments in direct succession are possible but should be limited to total tenures of office of no more than six years.

Financial resources of the regulatory body

The financial means available to the authorities for their own personnel and for the consultation of experts are fixed by the *Bundestag* in the respective budgets.

The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) disposes of an approximate annual budget of € 22 million for studies related to reactor safety, including nuclear fuel supply and waste management, and another € 9 million in the field of radiation protection. These funds are used for the financing of the work of the advisory commissions (RSK, SSK and ESK), for the direct support of the BMUB, for scientific and technical support as well as for the participation of external experts in international co-operation. Further, projects are financed from these funds that also serve the maintenance of competence of GRS as expert organisation of the Federation in the field of nuclear safety.

The Federal Ministry for Economic Affairs and Energy (BMWi) provides an account of approximately € 34 million annually for nuclear safety research (in the fields of reactor safety and radioactive waste management and disposal). Two thirds of this account are allocated to reactor safety research in the framework of which about 100 research projects are performed in parallel at an average. In the field of basic site-independent research on radioactive waste management and disposal, about 70 projects are performed in parallel with one third of the account.

The Federal Institute for Geosciences and Natural Resources (BGR), a subordinate authority of the BMWi, is charged with geoscientific issues relating to German repository projects and also participates in work on the repository research. The institutional funding of the BGR comes from the budget of the BMWi, but special tasks in the field of disposal are refinanced by the waste producers according to the Atomic Energy Act (AtG), the Repository Prepayment Ordinance (EndlagerVlV) and, since 27 July 2013, through cost allocations to the waste producers according to the Site Selection Act (StandAG).

To cover the necessary expenses for federal facilities, the BfS collects advance payments for cost-covering contributions to be paid in accordance with § 21b AtG according to the Ordinance Concerning Prepayments for the Erection of Federal Facilities for the Long-Term Engineered Storage and Disposal of Radioactive Waste (*Endlagervorausleistungsverordnung* – EndlagerVlV) [1A-13] from the future users of a repository. The determination of the contributions to be paid is based on the eligible expenses of the federal authorities for the repository projects. The site selection procedure is financed through cost allocations to the waste producers according to §§ 21 et seq. StandAG [1A-7].

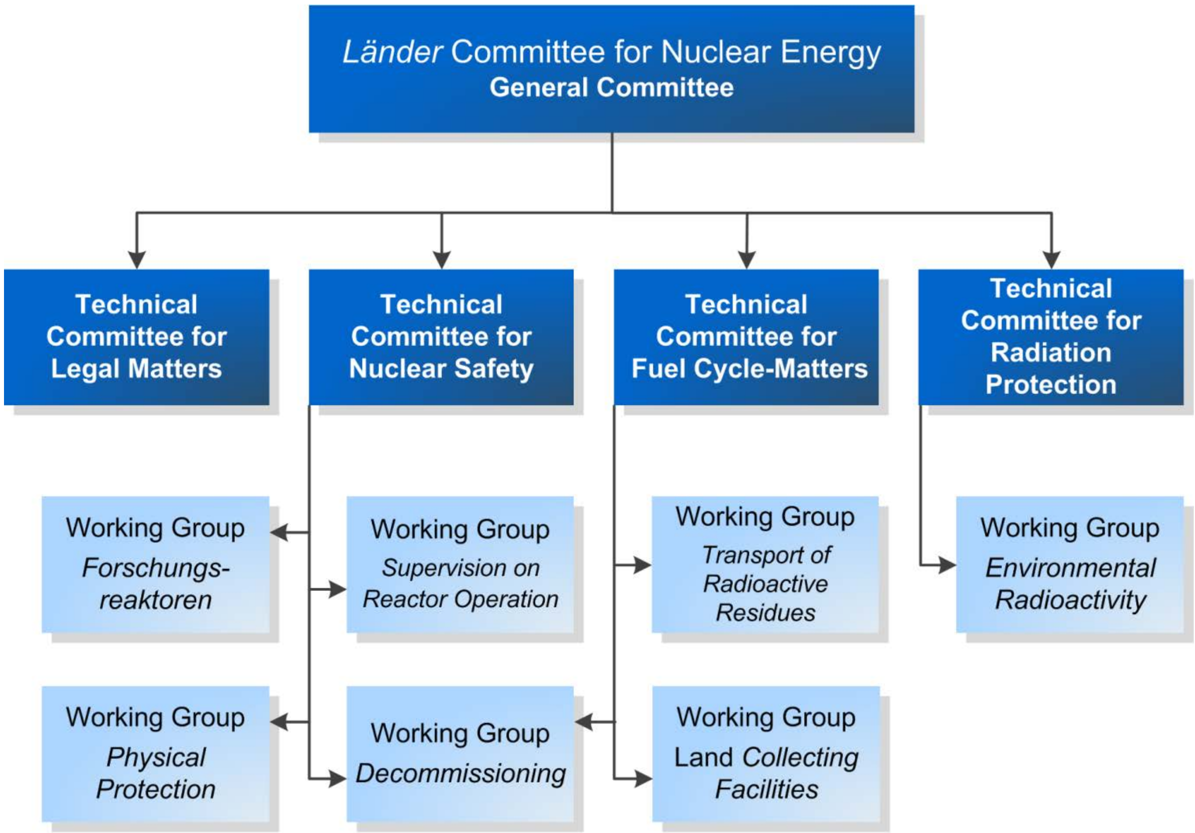
For the decision on approval applications, costs will be charged to the applicant by the competent authorities (federal and *Länder* authorities), which cover the expenses of the authorities and the costs for the consultation of authorised experts (§ 21 AtG [1A-3]). The same applies to measures of the supervisory authorities.

Länder **Committee for Nuclear Energy (LAA)**

The *Länder* Committee for Nuclear Energy (LAA) is a permanent Federation-*Länder* Committee composed of representatives from the nuclear approval and supervisory authorities of the *Länder* and the BMUB. It serves for the preparatory co-ordination of federal and *Länder* authorities in connection with the execution of the nuclear law as well as for the preparation of amendments and the further development of legal and administrative provisions as well as of the non-mandatory guidance instruments.

In the interest of an execution of nuclear law that is as uniform throughout Germany as possible, the competent nuclear approval and supervisory authorities of the *Länder* and the BMUB draft any regulations on the uniform handling of nuclear law in consensus. These regulations are then promulgated by the BMUB. The BMUB chairs the LAA and also manages its affairs. The Committee's decisions are usually made by mutual consent.

Figure E-7: *Länder* Committee for Nuclear Energy



For preparing decisions to be taken by the General Committee, the *Länder* Committee for Nuclear Energy (see Figure E-7) avails itself of several Technical Committees on the issues of “Legal Matters”, “Nuclear Safety”, “Radiation Protection” and “Fuel Cycle Matters”, as well as of the Working Groups assigned to these Technical Committees for special permanent tasks. If need be, the Technical Committees may set up ad hoc Working Groups for special and above all urgent individual issues. The Technical Committees and the permanent Working Groups convene at least twice a year and more frequently if necessary. The General Committee convenes at least once a year.

In the area of legislation, the LAA is an important instrument of early and comprehensive involvement of the *Länder* which supplements the formal right of participation of the *Länder* in the legislative procedure of the *Bundesrat*.

E.3.2 Effective independence of the regulatory functions

The economic use of nuclear energy lies in private hands and not in the public sector. However, nuclear licensing and supervision are functions of the State. Thus, there is a separation of spheres of interest.

The only instance where a conflict of interests might be conceivable at all is in situations where financial promotion or the subsidising of scientific research occurs in the same government sector as nuclear licensing and supervision of the corresponding nuclear facilities. However, at Federal Government level, there is no such risk of a conflict of interests since functions are assigned to different departments. Licensing and supervision of nuclear facilities generally lies within the responsibility of the *Länder*; legality and appropriateness supervision is performed by the BMUB. In the area of economic interests of the nuclear energy industry in Germany, project funding of reactor safety research and site-independent research on radioactive waste management/disposal, the Federation will only take actions through the BMWi.

Thus, the regulatory organisation in Germany fulfils the requirements of Article 20 (2) of the Joint Convention.

This applies, in particular, to the organisation of the planning, construction and operation of repositories for radioactive waste. According to § 9a, para. 3 AtG, this is a federal task allocated to the Federal Office for Radiation Protection (BfS) for execution.

The procedure for approval of such a federal repository is generally performed as a plan approval procedure (see Chapter E.2.3 for details). In the cases where the site of a facility was determined by federal law, a licence shall substitute the plan approval procedure. In future, the BfE will be responsible for plan approval and licensing. In this case, the BfS will be acting as the applicant.

The monitoring of compliance with the requirements under nuclear and radiation protection law and the stipulations in the approvals takes place within the BfS by the organisational unit "Repository Surveillance" (*Endlagerüberwachung* – EÜ). Organisationally, the EÜ is largely separated from the units at the BfS that are responsible for the construction and operation of the repositories.

The BMUB exercises the technical and legal supervision of the BfS.

The BfE regulates the implementation of the site selection procedure according to § 19, paras. 1 to 4 AtG. The BfE is subject to the supervision by the BMUB (§ 3 of the Act on the establishment of a Federal Office for Nuclear Waste Management).

F Other general safety provisions

This section deals with the obligations under Articles 21 to 26 of the Convention.

Developments since the Fourth Review Meeting:

There have been no major developments since the Fourth Review Meeting.

F.1 Article 21: Responsibility of the licence holder

Article 21: Responsibility of the licence holder

(1) Each Contracting Party shall ensure that prime responsibility for the safety of spent fuel or radioactive waste management rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

(2) If there is no such licence holder or other responsible party, the responsibility rests with the Contracting Party which has jurisdiction over the spent fuel or over the radioactive waste.

F.1.1 Responsibility of the licence holder

The licensee has primary responsibility for the safety of a spent fuel management facility or a radioactive waste management facility. He may only be issued with a licence if he meets all the legal prerequisites for licensing. In the case of handling of nuclear fuels licensed under § 6 of the Atomic Energy Act (*Atomgesetz* – AtG) (e.g. storage facilities for spent fuel) [1A-3] or facilities licensed under § 7 AtG (e.g. conditioning plants for spent fuel), one such prerequisite is the trustworthiness and technical qualification of the responsible individuals. Certified proof of this prerequisite and its acknowledgement by the authorities provide the basis for responsible performance under the licence.

In the case of companies with a number of authorised board members to represent it, the licence holder has to nominate to the competent authority the individual from the circle of authorised board members who assume the role of radiation protection supervisor. This same person is also responsible for ensuring a functioning organisational structure and the deployment of qualified personnel at the facility.

The holder of a licence issued according to § 31, para. 1 of the Radiation Protection Ordinance (*Strahlenschutzverordnung* – StrlSchV) [1A-8] is responsible for the entire field of radiation protection. In addition, § 31, para. 2 StrlSchV stipulates that he has to appoint a sufficient number of radiation protection officers for technical activities and monitoring of operation. Together with the radiation protection supervisor, these ensure due compliance with all protection and supervisory provisions of the StrlSchV (see reporting on Article 24 of the Convention). According to § 32, para. 5 StrlSchV, the radiation protection officers must not be hindered in the performance of their duties or suffer any disadvantages by virtue of their activities.

In order to better meet the specific requirements of nuclear safety at facilities licensed under § 7 AtG, para. 1 or facilities licensed under § 6 AtG, the additional position of nuclear safety officer has been created as part of the organisational structure of the plant [1A-17]. It is his responsibility to supervise nuclear safety issues in all areas of operation and in doing so must act independently of the corporate interests of cost-effective plant operation. He should be involved in all activities concerning modifications, should assess any reportable events and the evaluation of operating data, and has the right to report directly and at any time to the plant manager.

When performing their tasks, the radiation protection officers, together with the nuclear safety officer, act independently from the company hierarchy.

The actual structure of the plant organisation is at the sole discretion of the licensee, provided it accommodates the requirements of the aforementioned responsible individuals and their duties, as well as the general requirements pertaining to quality assurance.

Any enforcement measures on the part of the competent authorities will always be directed in the first instance at the holder of the licence, with the objective that the ultimately responsible individuals will personally meet their respective obligations. If this is not the case, the authority can question the trustworthiness of such individuals, which is a prerequisite for granting the licence. Consequently, in such cases, any proceedings relating to an administrative or criminal offence will be directed at individual persons (see reporting on Article 19 (2) v in Chapter E.2.6).

F.1.2 Responsibility if there is no licence holder

If radioactive substances are lost, found or misused, the *Land* concerned is likewise responsible for averting nuclear-specific danger. In severe cases, it is supported in this task by the BfS. This applies, in particular, to the finding of radioactive substances for which no other responsible party can be identified.

If there is no licence holder or other party responsible for management or storage facilities for radioactive waste, or such a person fails to meet his obligations, then responsibility for the safety of the facility or related activities shall rest with the competent *Land*.

In cases where the direct owner of nuclear fuels has no authorisation for possession, he shall establish authorised possession pursuant to § 5, para. 2 AtG. In the case that such authorised possession cannot be established, the BfS shall temporarily take the nuclear fuels into its charge ("government custody") according to § 5, para. 3 AtG [1A-3]. Such a situation may also arise if nuclear fuels are found or in case of loss of authorisation on the part of the private licensee (e.g. in case of insolvency of the former owner or revocation of the licence). If, however, the supervisory authority issued any other order under § 19, para. 3 AtG, then this order shall have priority over government custody. Whoever is responsible for nuclear fuels under government custody shall also ensure authorised possession outside government custody (§ 5, para. 3, sentence 2 AtG). This does not only apply to the direct owner who delivered to the authority responsible for custody but also to the owners of utilisation and consumption rights to nuclear fuel held in government custody, and to anyone who is required to accept or accept the return of nuclear fuel from a third party (§ 5, para. 3, sentence 3 AtG).

According to § 23, para. 1 AtG [1A-3], the BfS is responsible for the execution of government custody. The BfS may cause the private licences to (re-)assume their responsibility with regard to the handling of nuclear fuels by issuing orders stipulating that nuclear fuels under government custody are to be returned to the charge of the private owners. This indicates that government custody of nuclear fuels is an exceptional case in the handling of these materials.

F.2 Article 22: Human and financial resources

> *Article 22: Human and financial resources*
>
> *Each Contracting Party shall take the appropriate steps to ensure that:*
>
> *i) qualified staff is available as needed for safety-related activities during the operating lifetime of a spent fuel and a radioactive waste management facility;*
>
> *ii) adequate financial resources are available to support the safety of facilities for spent fuel and radioactive waste management during their operating lifetime and for decommissioning;*
>
> *iii) financial provision is made which will enable the appropriate institutional controls and monitoring arrangements to be continued for the period deemed necessary following the closure of a disposal facility.*

F.2.1 Human resources

The safe operation of nuclear facilities, including spent fuel and radioactive waste management facilities, requires a high degree of competence of all those involved, i.e. operators, manufacturers, research institutions, authorities and authorised experts. For safe operation of nuclear facilities, the operators are responsible for providing the necessary competence.

According to § 7, para. 2, subparas. 1 and 2 AtG [1A-3], a licence for the construction or operation of a facility may only be granted if

- there are no known facts which could cast doubt on the reliability of the applicant and of the persons responsible for the construction and management of the facility and the supervision of its operation; and the persons responsible for the construction and management of the facility and the supervision of its operation have the required technical qualifications,
- measures have been taken to ensure that the persons otherwise engaged in operation of the facility have the necessary expert knowledge concerning the safe operation of the facility, the potential hazards, and the protective measures to be taken.

Similar requirements as regards the reliability of the applicant can also be found in § 6, para. 2, subpara. 1 AtG on the licensing for the storage of nuclear fuel as well as in § 9, para. 2, subparas. 1 and 2 AtG on the treatment, processing and other utilisation of nuclear fuel outside facilities requiring a licence.

§ 30 StrlSchV [1A-8] includes regulations concerning the requisite qualification and knowledge in the field of radiation protection as well as its acquisition and conservation.

The Ordinance on the Nuclear Safety Officer and the Reporting of Incidents and other Events (*Verordnung über den kerntechnischen Sicherheitsbeauftragten und über die Meldung von Störfällen und sonstigen Ereignissen* – AtSMV) [1A-17] regulates the appointment of nuclear safety officers for nuclear facilities licensed under § 7, para. 1 AtG and § 6 AtG, respectively.

The legal bases are further specified within the framework of guidelines. This is realised in particular by guidelines on the required technical qualification of the responsible personnel and on the assurance of the necessary knowledge of the persons otherwise engaged in nuclear power plants, which are applied accordingly. Furthermore, the exchange of information and knowledge, including experience feedback, is regulated in special requirements.

In addition, there is the Guideline on Technical Qualification in Radiation Protection [3-40] which specifies the extent and required proof of the technical qualification of radiation protection supervisors and radiation protection officers.

Implementing the content of these regulations results in a hierarchy of responsibilities, each of which has varying requirements with respect to technical qualification and expert knowledge.

Prior to the deployment of personnel stated in guideline [3-2] relating to the proof of the technical qualification of nuclear power plant personnel (management personnel), the supervisory authority requires the submission of documents which verify the necessary technical qualification and practical experience. It reviews these documents for compliance with the requirements of the guideline.

The state, in the form of the Federation and the *Länder*, provides educational facilities at which qualified vocational training is given. In addition to public education, in 1957 power plant operating companies founded a power plant training facility to account for the requirements for power plant personnel. As a result of the freedom of movement within the EU, however, there has been an additional increase in the potential of appropriately trained applicants. The operators of nuclear facilities, both state-owned and privately owned, for their part advertise for qualified staff.

In addition to vocational training, there are appropriate training opportunities available in Germany at 14 universities and six technical colleges, for example in the field of nuclear and reactor technology at Aachen, Berlin, Clausthal, Dresden, Essen, Karlsruhe, Munich, Stuttgart and Zittau universities. Officially recognised radiation protection courses are held e.g. at the university and non-university institutes that are joined in the *Qualitätsverbund Strahlenschutzkursstätten* (QSK). During the past ten years, a number of vacant or new professorships were offered by the universities of Aachen, Dresden, Karlsruhe, Munich, Stuttgart, Clausthal, partly with substantial financial support of the industry, in the fields of reactor safety, reactor technology, radiochemistry, repository systems and radiobiology. Since restart of the upgraded AKR-2 training reactor in 2005, the TU Dresden has the most advanced training reactor in Germany.

There are also recognised courses available in the non-governmental sector, e.g. at the various Chambers of Industry and Commerce and at the *Haus der Technik* in Essen.

In order to ensure a sufficient number of qualified/well-educated staff for safety related work, existing knowledge must also be revised and updated.

- In relation to individuals, this is ensured by the regulations on recurring training in the field of radiation protection. Instruction courses are to be held every year according to the Guideline Relating to the Assurance of the Necessary Knowledge of Other Persons Engaged in the Operation of Nuclear Power Plants [3-27]. For the other groups, instructions should be given at least every two or three years, respectively.

- Moreover, research institutions in the field of reactor safety joined to found the *Kompetenzverbund Kerntechnik* (Alliance for Competence in Nuclear Technology) of German research institutes in March 2000 within the framework of the HGF Nuclear Technology Research Pool in order to maintain an adequate level of know-how in the nuclear and radiation protection sector. It consists of the Karlsruhe Institute of Technology (KIT) together with the universities of Karlsruhe, Heidelberg and Stuttgart, the Materials Testing Institute University of Stuttgart, as well as the JRC Institute for Transuranium Elements (JRC-ITU) Karlsruhe, the Jülich Research Centre (FZJ) together with the RWTH Aachen and the FH Aachen/Jülich, the Helmholtz Centre Dresden-Rossendorf together with TU Dresden and Zittau/Görlitz University of Applied Sciences, the *Gesellschaft für Anlagen- und Reaktorsicherheit* (GRS) mbH together with TU München, and the Federal Institute for Geosciences and Natural Resources (BGR) together with the University of Hanover and TU

Berlin. Apart from the national co-ordination of tasks in the field of nuclear safety and repository research, by analysing the education and training situation and providing forecasts for the future, the Alliance for Competence contributes to the determination of the need for junior experts to maintain the necessary competence and thereby reduce the deficit. The success of the work of the Alliance for Competence in the past ten years is mainly due to the improved development of the courses on offer.

- The intensification of the co-operation with the universities at regional level has led to the formation of four affiliated alliances: the *Kompetenzzentrum Ost für Kernenergie* (Competence Centre East for Nuclear Energy) (2004), the *Südwestddeutsche Forschungs- und Lehrverbund Kerntechnik* (South-West German Nuclear Technology Research and Teaching Alliance) (2007), the *Kompetenzverbund Strahlenforschung* (Alliance for Competence in Radiation Research) (2007), and the *Forum Kerntechnik West* (Nuclear Technology Forum West) (2009).

- The power plant operators also have committed themselves to the co-ordinated promotion of German training and research institutions to contribute to the maintenance of competence and junior staff recruitment in the field of nuclear technology. This comprises the creation of a register on nuclear training offers and research activities to identify main fields of competence as well as on decision making within the framework of support of universities. Further, structured support of universities is given by sponsorships in form of support in the development of study courses, specific support of professorships, establishment of endowed professorships, appointment of visiting professors, awarding of postgraduate scholarships, and others. The opportunities to pursue diplomas and gain practical work experience in industrial companies offer students the chance to orientate their academic training increasingly on the conditions of the world of employment.

- The training and further qualification of expert staff from authorities and authorised expert organisations is the objective of the events offered by the *Gesellschaft für Anlagen- und Reaktorsicherheit* (GRS) *mbH* within the framework of its GRS Academy. This includes, in particular, the seminars for authority staff which are conducted by GRS at regular intervals and are intended above all for junior authority staff. There are seminars on e.g. the following topics: fundamentals of reactor physics, nuclear fuel supply and waste management, prominent events/incidents/accidents in nuclear facilities, INES User Manual of the IAEA, fundamentals of radiation protection, radiation emergency preparedness, external hazards, regulatory supervision of the operation of nuclear reactors, legal and technical nuclear standards, selected topical issues of the nuclear licensing and supervisory procedure, fire protection in nuclear power plants, operation management of nuclear power plants, and decommissioning of nuclear facilities.

In addition to the fulfilment of national tasks, the technical skills mentioned are also required for monitoring and assessment of international developments.

To promote and develop scientific and technical collaboration of the technical safety organisations (TSO) in Europe in the field of nuclear safety, the technical safety organisations IRSN, GRS and AVN (now Bel V) founded the “European TSO Network” (ETSON) in May 2006. The objective of the network is to be achieved especially by a systematic exchange of R&D results as well as by exchanging experiences with the operation of nuclear facilities and with safety assessments. It furthermore wants to contribute to the harmonisation of European practices of assessing nuclear safety and support initiatives for the development and realisation of European research programmes. All in all, these activities serve an effective advancement of the state of the art in science and technology by employing common resources and synergies in all fields of work.

In a Memorandum of July 2012 [4-10a], the Reactor Safety Commission (RSK) expressed concern that the phase-out of the use of nuclear energy for electricity production in Germany could lead to a loss of sufficiently qualified and motivated staff which might pose a problem for terminating the use of nuclear energy for electricity production in a structured procedure, including the decommissioning, dismantling and radioactive waste management.

Competent and motivated personnel will also be needed in future for the tasks to be performed during the phase-out of nuclear energy. The motivation for working in an area with only limited career prospects in Germany can only be maintained if this work is regarded as being important, recognised by society and challenging with regard to its contents.

The RSK is concerned that with decreasing motivation of the staff, the maintenance of knowledge required for safe operation and safe storage of waste cannot be ensured in the long term. The RSK therefore calls on all those responsible to contribute to the creation of a work environment in which the staff can continue to commit themselves to a responsible use of nuclear technology.

F.2.2 Financial resources during operation and decommissioning

As far as nuclear facilities are operated by public operators, the competent body provides the necessary financial resources also for safety-related tasks associated with these facilities. Non-public operators have to raise the necessary funds themselves. For nuclear facilities, this obligation has now also been regulated in a legally binding manner with § 7c, para. 2, subpara. 2 AtG [1A-3]. In order to ensure compliance, § 19 AtG requires government supervision as a regulatory instrument.

For the follow-up costs of operation of the facilities, i.e. for spent fuel and radioactive waste management and for decommissioning, the respective private operators are obliged to make provisions as stipulated under tax and commercial law [HGB 02]. The amount of provisions for the decommissioning and dismantling of the German nuclear power plants and for the management of spent fuel and other radioactive waste depends on a variety of influencing factors. These include e.g. the amount of spent fuel generated, which essentially depends on the operating lives of nuclear power plants, or the future time-and cost development as regards the repository projects.

The current provisioning model takes account of the polluter-pays principle by making the companies obliged to carry out decommissioning and waste management responsible for the availability of adequate financial resources. Moreover, the parent companies of the nuclear power plant operators subject to this obligation committed themselves to conclude so-called profit transfer and management control agreements or issue unrestricted letters of comfort for a period until at least 2022 to ensure in the event of insolvency of the operating company that the liabilities of the respective nuclear power plant operator is paid by the parent company.

The provisions carried as liabilities by E.ON SE, RWE AG and EnBW Energie Baden-Wuerttemberg AG according to the International Financial Reporting Standards (IFRS) and by the nuclear power plants Brunsbüttel GmbH & oHG and Krümmel GmbH & oHG (Vattenfall operatorship each) in the trade balances as at balance sheet date 31 December 2013 for the decommissioning and dismantling of nuclear power plants in Germany and radioactive waste management amount to approximately EUR 36 billion.

For the public operators, resources are entered in the respective current budget for the decommissioning and dismantling costs, including the necessary qualified staff (see reporting on Article 26 regarding the decommissioning of nuclear facilities).

F.2.3 Financial resources after sealing of a repository

Once a repository will have been sealed, its surveillance is a governmental task. Control measures performed by the authorities will mainly be confined to passive measures. Active measures will not be necessary, given the selection of the repository site and the design of the repository. Thus, the anticipated costs are low. Since they are carried out under government control, these will be financed from the federal budget.

F.3 Article 23: Quality assurance

> *Article 23: Quality assurance*
>
> *Each Contracting Party shall take the necessary steps to ensure that appropriate quality assurance programmes concerning the safety of spent fuel and radioactive waste management are established and implemented.*

F.3.1 Quality assurance

The concept and design of facilities for the conditioning, storage and disposal of spent fuel and radioactive waste include constructive and administrative measures designed to protect the general public and workers against hazards arising from the release of radioactive substances and ionising radiation. The effectiveness of these measures is ensured within the framework of a quality assurance programme which also considers ageing phenomena and preventive maintenance. Nuclear safety standard 1401 of the Nuclear Safety Standards Commission (KTA) specifies general requirements for quality assurance regarding nuclear power plants. The requirements of this safety standard are applied wherever relevant. These include the principles of operational organisation, planning and design, production and construction including quality control, specified normal operation and incidents, documentation and archiving, as well as auditing of the quality assurance system itself. One essential element of quality assurance is the operating manual. The nature and scope of measures to safeguard quality characteristics are oriented towards their significance for preventing damages caused by radiation exposure. The applicant or licensee is responsible for the planning, performance and control of the effectiveness of quality assurance. In this respect, an essential requirement of KTA nuclear safety standard 1401 is the technical knowledge and qualification of the personnel.

The quality assurance programme is addressed by the nuclear licensing procedure, which specifies the nature and scope of initial inspections and, where necessary, recurrent inspections by the supervisory authority. The supervisory authority monitors compliance with the quality assurance programme and related measures. In this role, it may consult experts. Moreover, it has access to the facility at all times in order to carry out the necessary inspections.

Some quality assurance requirements in international standards, e.g. in DIN EN 45004, are not addressed by nuclear safety standard KTA 1401. However, AtG [1A-3] and StrlSchV [1A-8] generally require compliance with the state of the art in science and technology. It is thus ensured that quality assurance requirements that apply internationally are considered, too.

F.3.2 Product control

Product control exists as a part of general quality assurance. Its task is to ensure compliance with waste acceptance requirements. These are the result of a site-specific safety analysis for the facility being licensed. The proof required in this respect presupposes a number of organisational and administrative regulations defining the spheres of responsibility, tasks and activities of the parties involved. Within the scope of its responsibility for the operation of a repository, the BfS ensures that the waste acceptance requirements are met by examining waste packages and by qualification and accompanying control of conditioning measures.

Product control comprises regulations on quality assurance in the registration and conditioning of radioactive waste and in the production of waste containers, including the registration and documentation of the repository-relevant characteristics of the waste packages. Organisational and administrative regulations governing the spheres of responsibility, tasks and activities of the parties involved are laid down in a decision by the main committee of the LAA of 1/2 December 1994 (see Figure F-1) and through the agreements between the BfS and the waste producers. The supervisory authorities, the BfS, the appointed experts, the waste producers and the service companies acting on their behalf, as well as the operators of the storage facilities and *Land* collecting facilities, are all involved in product control. The nature and extent of product control measures are determined depending on the conditioning technique, waste characteristics and repository requirements. The measures required in order to guarantee the safety of a repository for radioactive waste are laid down in the respective plant licence (plan approval notice).

Figure F-1: Product control procedure for radioactive waste packages from nuclear facilities with respect to their conditioning, storage and disposal

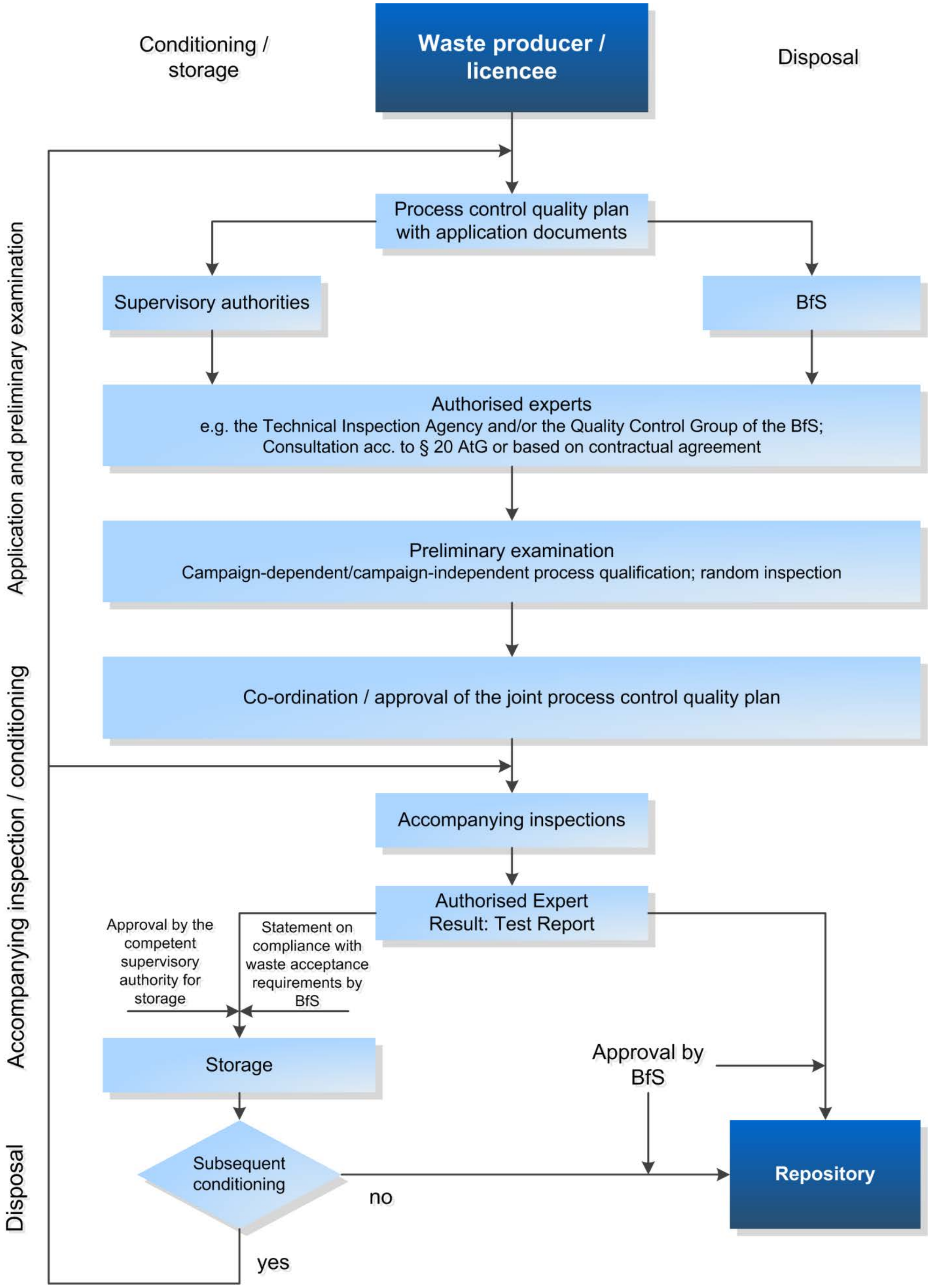


Figure F-2: Wipe test for product control on a MOSAIK container (Copyright: GNS)

Regulations on product control exist for the radioactive waste to be emplaced in the Konrad repository. Only those radioactive wastes may be disposed of in the Konrad repository which demonstrably meet the waste acceptance requirements for disposal.

According to the Konrad waste acceptance requirements (see Chapter D.3.3), these are divided into

- basic requirements for radioactive waste to be disposed of,
- requirements for waste packages,
- requirements for waste products,
- requirements for waste containers,
- activity limitations, and
- mass limitations for non-radioactive harmful substances.

Compliance with these requirements is to be demonstrated as part of the product control by

- design testing of containers including quality assurance measures for the fabrication,
- process qualification and accompanying control of conditioning measures, and
- random checks on waste products/waste packages.

Design testing

As part of the design testing, the containers for disposal are subjected, among other things, to stacking pressure tests, lifting tests, drop tests, thermal tests and, where appropriate, leak tests.

Process qualification

The qualification of conditioning measures is either performed campaign independently determining the relevant operating conditions in a manual or per campaign on the basis of a schedule. Relevant measures with a view to demonstrating compliance with the waste acceptance requirements are, in particular,

- identification of the waste according to type and origin,
- demonstration of compliance with the basic requirements for waste products as well as other requirements to be fulfilled for the specific waste product groups,
- qualified determination of the radionuclide-specific activity inventory,
- determination of the mass of waste products and containers, the waste package mass and the gravity position, and
- determination of dose rate and contamination.

The identification of the waste and determination of the masses do not only meet radiological requirements but also provide significant evidence on the material composition in order to comply with the mass limits for non-radioactive harmful substances.

The procedure described in the schedule is assessed separately for individual raw waste campaigns with regard to its suitability for the production of waste packages meeting the requirements for disposal. The approval of the procedure by the BfS takes place with accompanying controls with regard to the demonstration of compliance with the waste acceptance requirements.

Random checks

Waste packages from not qualified procedures are controlled by the BfS after production for compliance with the waste acceptance requirements. Type and scope of control measures depend on the extent to which the documentation submitted demonstrates compliance with the waste acceptance requirements.

F.4 Article 24: Operational radiation protection

Article 24: Operational radiation protection

(1) Each Contracting Party shall take the appropriate steps to ensure that during the operating lifetime of a spent fuel or radioactive waste management facility:

i) the radiation exposure of the workers and the public caused by the facility shall be kept as low as reasonably achievable, economic and social factors being taken into account;

ii) no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection;

iii) measures are taken to prevent unplanned and uncontrolled releases of radioactive materials into the environment.

(2) Each Contracting Party shall take appropriate steps to ensure that discharges shall be limited:

i) to keep exposure to radiation as low as reasonably achievable, economic and social factors being taken into account; and

ii) so that no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection.

(3) Each Contracting Party shall take appropriate steps to ensure that during the operating lifetime of a regulated nuclear facility, in the event that an unplanned or uncontrolled release of radioactive materials into the environment occurs, appropriate corrective measures are implemented to control the release and mitigate its effects.

F.4.1 Basis

The legal basis for radiation protection in the nuclear facilities mentioned above is the Radiation Protection Ordinance (StrlSchV) [1A-8]. With the amendment of the StrlSchV in 2001, Council Directive 96/29/EURATOM [1F-18] and Council Directive 97/43/EURATOM [1F-23] have been transposed into German law. The transposition of the new Council Directive 2013/59/EURATOM [1F-24] of 5 December 2013, into the national radiation protection legislation of the Member States must be effected by 6 February 2018.

The Radiation Protection Ordinance (StrlSchV) is subordinate to the Atomic Energy Act (AtG) [1A-3], which outlines all the fundamental requirements to be observed in the construction and operation of nuclear facilities and the handling of radioactive materials.

The basic safety standards on radiation protection of the IAEA [IAEA 14a] and the recommendations of the ICRP are taken into account. The ALARA principle is taken into account by § 6 StrlSchV which forbids any unnecessary radiation exposures and contamination of man and the environment and which contains an obligation to keep the contamination of man and the environment as low as possible, even below the limits (imperative of minimisation), by taking into account the state of the art in science and technology and consideration of all circumstances of the individual case.

F.4.2 Radiation exposure of occupationally exposed persons

In § 54 StrlSchV, a distinction is drawn between two categories of occupationally exposed persons, i.e. between Category A and Category B. This categorisation is made for the purpose of defining the corresponding necessary control and preventive occupational medical care. For persons of Category B, the effective dose may exceed 1 mSv during a calendar year, for individuals of Category A it may exceed 6 mSv. For assignment to these categories, different organ dose thresholds are defined. Persons exposed to radiation by virtue of their occupation are monitored for their radiation exposure by means of official and company dosimeters. According to § 55 StrlSchV [1A-8], they must not receive an effective dose of more than 20 mSv in a calendar year. Limits are also specified for individual organ doses. Further details can be found in Table F-1.

Exceptions to these limits apply to persons under the age of 18, for whom the effective dose limit is only 1 mSv during a calendar year (instead of 20 mSv/a). In individual cases, the authority may permit effective doses of up to 6 mSv during a calendar year for apprentices and students between the age of 16 and 18 if this is necessary for them to achieve the objectives of their professional training.

Furthermore, women of child-bearing age must not receive a cumulative dose of more than 2 mSv per month to the womb. For an unborn child whose mother may continue working as occupationally exposed person after her pregnancy has become known, the limit is 1 mSv for the time from the notification of the pregnancy until its end if an incorporation of radioactive materials can be excluded. In these cases, the uterus dose is to be determined per working week. The dose limit refers to the sum of external and internal radiation exposure.

According to § 56 StrlSchV, the maximum effective dose permitted over an individual's entire working life is 400 mSv.

According to § 58 and 59 StrlSchV, the aforementioned dose limits may only be exceeded in specially permitted cases and for measures to avert danger to persons, e.g. in the case of rescue work or measures to avoid or remedy accidents. The rescue work and the ascertained body dose must be notified to the competent supervisory agency, since it is responsible for monitoring body doses.

With the limits cited, the basic safety standards on radiation protection of the IAEA [IAEA 14a] have partially been adopted in Germany and partially, more restrictive provisions have been stipulated.

As a record of their radiation exposure, documentation is kept for all occupationally exposed individuals listing both the results of the official dosimeters and those of any other dosimeters kept for operational reasons, or of dose calculations. The results of the official dosimetry are additionally registered centrally at the radiation protection registry of the Federal Office for Radiation Protection (BfS). Specifications are regulated in § 12c AtG and § 112 StrlSchV. Before commencing work in a controlled area, Category A persons exposed to radiation by virtue of their occupation must undergo a medical examination according to § 60 StrlSchV; this must be repeated every year.

In keeping with the requirements of the StrlSchV, the protection of persons subject to internal and external radiation exposure by virtue of their occupation has already been taken into account in the planning of the nuclear facility, and must be ensured during its operation by appropriate protective measures and protective clothing, especially when handling unsealed radioactive material. According to § 43, para. 1 StrlSchV, the protection of occupationally exposed persons from external and internal radiation exposure shall be effected as a matter of priority by means of structural and technical devices or by means of suitable. According to § 43, para. 2 StrlSchV, the working conditions for pregnant women must be designed in such a way as to preclude internal occupational radiation exposure. For work to be carried out in the restricted-access areas, radiation protection instructions are drawn up as part of the preparation of the work, specifying the actions to be taken.

According to § 6 StrlSchV [1A-8], the operators of nuclear facilities are legally obligated to avoid any unnecessary radiation exposure and contamination of individuals and the environment. Any unavoidable radiation exposure and contamination has to be kept as low as possible in line with the state of the art in science and technology, considering all circumstances of each individual case, even if it lies below the legal limits. Within the nuclear facilities themselves, the radiation protection supervisor and the radiation protection officers (see Chapter F.1.1 for terms and definitions) are responsible for ensuring that radiation exposure is limited in line with the state of the art in science and technology to protect the population at large, the environment, and the personnel. In connection with the granting of licences and the performance of their supervisory duties, the competent authorities check the provision of radiation protection measures and exposure limits and whether these are adhered to.

According to § 32, para. 5 StrlSchV, the radiation protection officer must not be hindered from fulfilling his duties or be disadvantaged as a result. The radiation protection officer ensures as part of the preparation of his work that the time of the employees staying within the restricted-access area is kept as short as possible. If necessary, he checks the measures taken for this purpose himself. He defines the necessary measures of radiation protection and its verification and supervises and documents these. He ensures that all systems and pieces of equipment relevant in connection with radiation protection are regularly maintained and inspected. He instructs the personnel and makes sure that alarm exercises are carried out at regular intervals. Furthermore, he is concerned with the necessary plant-internal emergency measures. To ensure that the radiation protection officer has the technical qualification necessary for his task in accordance with § 30 StrlSchV, he has to acquire the necessary technical qualification (in line with the Guideline relating to Technical Qualification in Radiation Protection, Appendix A, Technical Qualification Groups [3-40] and take part in refresher courses at intervals of no more than five years.

F.4.3 Radiation exposure of the general public

According to § 46 StrlSchV [1A-8], it is a general rule for all nuclear facilities and installations that an effective dose of no more than 1 mSv per calendar year may result for individual members of the general public due to their operation. Adherence to this limit is taken into account at the planning stage of nuclear facilities. A summary of the limits for radiation exposure of the general public and of persons exposed to radiation by virtue of their profession is given in Table F-1.

Table F-1: Dose limits as defined in the Radiation Protection Ordinance (StrlSchV) [1A-8]

§	Scope of application	Period	Limit [mSv]
	Design and operation of nuclear facilities		
46	Limitation of the radiation exposure of the general public		
	Effective dose: direct radiation from facilities, including discharges	Calendar year	1
	Organ dose for the lens of the eye	Calendar year	15
	Organ dose for the skin	Calendar year	50
47	Limitation of discharges during specified normal operation with air or water respectively		
	Effective dose per path (air, water)	Calendar year	0.3
	Organ dose for bone surface and skin per path (air, water)	Calendar year	1.8
	Organ dose for gonads, womb, red bone marrow per path (air, water)	Calendar year	0.3
	Organ dose for large intestine, lung, stomach, bladder, chest, liver, oesophagus, thyroid gland, and other organs or tissue not named above per path (air, water)	Calendar year	0.9
49	Accident planning reference levels for the operation of nuclear power plants, for the on-site storage of spent fuel, and for federal facilities for the safekeeping and disposal of radioactive waste		
	Effective dose		50
	Organ dose for thyroid gland and lens of the eye		150
	Organ dose for skin, hands, forearms, feet, and ankles		500
	Organ dose for gonads, womb, red bone marrow		50
	Organ dose for bone surface		300
	Organ dose for large intestine, lung, stomach, bladder, chest, liver, oesophagus, thyroid gland, and other organs or tissue not named above		150
	Dose limits for occupationally exposed persons		
55	Occupationally exposed persons		
	Effective dose	Calendar year	20
	Organ dose for the lens of the eye	Calendar year	150
	Organ dose for skin, hands, forearms, feet, and ankles	Calendar year	500
	Organ dose for gonads, womb, and red bone marrow	Calendar year	50
	Organ dose for thyroid gland and bone surface	Calendar year	300
	Organ dose for large intestine, lung, stomach, bladder, chest, liver, oesophagus, thyroid gland, and other organs or tissue not named above	Calendar year	150
	Body dose for persons under the age of 18	Calendar year	1
	Apprentices aged 16 – 18, with the permission of the government agency	Calendar year	6
	Partial body dose for womb for women of child-bearing age	Month	2
	Unborn child	From notification of the pregnancy until its end	1
56	Occupational lifetime dose, effective dose	Whole lifetime	400

§	Scope of application	Period	Limit [mSv]
58	Specially permitted radiation exposures (volunteers of Category A only, after authorisation by the authority, no pregnant women)		
	Effective dose (taken into account for the occupation life dose)		100
	Organ dose for the lens of the eye		300
	Organ dose for skin, hands, forearms, feet and ankles		1,000
59	Averting dangers to people (volunteers over 18 years of age only)	Calendar year Once a lifetime	100[1)] 250[1)]

1) No defined limit or reference level. For measures to avert danger to persons, the aim shall be for an effective dose of more than 100 mSv to occur only once during any one calendar year and an effective dose of more than 250 mSv only once in a lifetime.

If the nuclear facilities concerned are subject to licensing under §§ 6, 7 or 9 AtG [1A-3], or to be licensed by means of the plan approval procedure under § 9b AtG, such as the pilot conditioning plant for spent fuel (PKA), the Karlsruhe vitrification plant (VEK) for fission products, the storage facilities for spent fuel and repositories, the radiation exposure is determined at the planning stage for reference persons and the worst-case exposure locations, so as to verify compliance with the limits.

During operation of the nuclear facilities, admissible discharges into air and water are specified by the competent authority by limiting the concentrations and quantities of radioactivity, taking into account the pre-existing burden from other nuclear facilities and from earlier activities.

On-site storage facilities for spent fuel do not generate any discharges of radioactive waste water, since any contaminated waste water e.g. from maintenance work on the containers which exceeds the maximum permitted activity concentrations specified in Appendix VII, Part D StrlSchV [1A-8] is transferred to sewage treatment facilities for disposal. Discharges into the air by releases from the storage casks are not anticipated, although release values have been applied for in order to allow for possible contamination of the cask surfaces, for example. In practice, however, discharges to the air are negligible, due to the leak-tightness criteria for storage casks and the existing rules for surface contamination on the outside of the casks. Radiation exposure due to direct irradiation by gamma and neutron radiation occurs in the immediate vicinity of the storage facilities. In such cases, the aforementioned radiation exposure limits for personnel and the general public must be taken into account.

Nuclear facilities not subject to licensing under §§ 6, 7 or 9 AtG, or to authorisation by means of the plan approval process under § 9b AtG, but which instead require a licence under § 7 StrlSchV [1A-8], such as conditioning facilities or storage facilities for radioactive waste, do not require explicit specification of discharge limits, provided the activity concentration levels listed in Appendix VII, Part D StrlSchV are not exceeded on an annual average. Adherence to the requirements is regularly checked by the supervisory agency or appointed independent experts.

F.4.4 Measures to prevent unplanned and uncontrolled releases

In order to prevent incidents involving uncontrolled releases of radioactive materials, nuclear facilities must be planned and designed in such a way that the effects of such incidents remain limited.

According to § 49 StrlSchV [1A-8], the following requirements apply to the design of on-site storage facilities for spent fuel, and to repositories for radioactive waste:

- a maximum effective dose of 50 mSv due to the release of radioactive substances into the environment (calculated across all exposure paths, 50-year committed doses and up to age 70 for children from intakes) must not be exceeded in a worst-case accident, and
- maximum organ doses for various organs must be taken into account, such as 150 mSv each for the eyes and the thyroid gland, and 300 mSv for bone surfaces.

For the aforementioned types of nuclear facilities, it is necessary to demonstrate during the licensing procedure that they are designed to avert certain accidents, the so-called design basis accidents, in accordance with these specifications.

For all other nuclear facilities according to § 6, para. 1, § 7, para. 1 and § 9, para. 1 AtG [1A-3], respectively, § 50 StrlSchV also applies to activities according to § 7 StrlSchV if certain amounts of radioactive materials handled are exceeded (see § 50, para. 3 StrlSchV). For such facilities, structural or engineering safeguards are specified by the licensing agency according to the hazard potential and the probability of accidents at a given plant. Until general administrative rules on accident prevention enter into force for these facilities, an effective dose of 50 mSv has been set for activities according to § 7 StrlSchV in line with § 117, para. 16 StrlSchV for the worst-case accident.

The requirements for the confinement of radioactive material in connection with the storage of radioactive waste with negligible heat generation and the storage of spent fuel and heat-generating radioactive waste in casks are presented in two ESK statements ([4-2], [4-3]). These statements will be taken as a basis for the assessment of storage facilities already existing and yet to be constructed and emphasise the high level of protection of the respective casks that these can provide according to their design.

F.4.5 Limitation and minimisation of operational discharges of radioactive substances

Basis

According to § 47 StrlSchV [1A-8], radioactive substances shall not be discharged into the surrounding environment of a nuclear facility in an uncontrolled manner. As defined in § 48 StrlSchV, their operational discharges into water or air must be monitored and registered according to specific type and activity. The discharge values specified by the competent authority in the plant’s licence shall be observed with regard to concentration and quantity of radioactivity. As a rule, the actual values fall well below these limits.

The radiation exposure of reference persons at the most unfavourable exposure location is used as the basis for determining the permissible discharge values at the planning stage of nuclear facilities already. According to § 47, para. 1 StrlSchV, an effective dose of 0.3 mSv per calendar year for discharges in air and water shall not be exceeded, with organ dose limits applying separately. The calculation method for the determination of the radiation exposure is set out in a general administrative provision [2-1]. There is also a detailed guideline on the performance of emission and immission monitoring [3-23].

With respect to minimisation of radiation exposure, reference is made to the reporting on Article 24 (1).

Monitoring of emissions and immissions during normal operation and in case of accidents

According to § 48 StrlSchV [1A-8], discharges from nuclear facilities must be monitored, specified by activity and type, and these data reported to the competent authority at least once a year.

The supervisory authority responsible for the nuclear facility may order measures supplementary to monitoring, or in individual cases may exempt the facility operator from this reporting obligation, provided he can prove by demonstrating the safe enclosure of the radioactive materials or by the small radioactive inventory and the kind of work to be carried out within the facility that the limits to be kept will be safely adhered to. This applies in particular to handling of nuclear material to be licensed under § 7 StrlSchV [1A-8], such as some of the conditioning facilities and storage facilities for radioactive waste in which no repairs are carried out. Other than nuclear power plants, these facilities release only little or, in individual cases, no radioactive substances.

For nuclear facilities requiring licensing or planning approval under §§ 6, 7, or 9b AtG, such as the pilot conditioning plant for spent fuel (PKA), the Karlsruhe vitrification plant (VEK) for fission products, the storage facilities for spent fuel, a few conditioning facilities for the treatment of nuclear fuel, and repositories, the determination of meteorological and hydrological dispersion conditions may additionally be required.

It should be noted that the PKA pilot conditioning facility, in which the spent fuel assemblies shall be dismantled and conditioned to meet the requirements for disposal, will only be used for the time being to repair damaged spent fuel casks until selection of a repository site. There is no need to consider radiation exposures here at present.

The Guideline relating to emission and immission monitoring of nuclear facilities (*Richtlinie zur Emissions- und Immissionsüberwachung kerntechnischer Anlagen* = REI) [3-23] contains specifications on the harmonisation of monitoring and the performance thereof. The holder of the licence is responsible for monitoring and internal auditing. Independent institutions perform reference measurements on behalf of the competent supervisory authority.

Appendix C of this Guideline [3-23] contains supplementary specific regulations applicable to storage facilities for spent fuel and repositories for radioactive waste. For spent fuel storage facilities it stipulates that emission monitoring is not required if tightness and integrity of the spent fuel casks have been demonstrated and are monitored continuously. Monitoring of environmental immissions from dry storage facilities shall be regulated such that the monitoring of contributions to the total dosage from direct radiation of the nuclear facility is ensured.

Asse II mine

Monitoring of discharges from the Asse II mine is performed via measurements in the exhaust air current by means of discontinuous or continuous sampling and measurements. In addition, the exhaust air throughput is continuously measured.

The dose-relevant substances in the exhaust air are radon and its decay products. The increased activity concentration in the environment of the Asse II resulting from the discharge is monitored by immission monitoring in accordance with the Guideline relating to emission and immission monitoring of nuclear facilities (REI) [3-23]. Increases in the concentration of activity in the environment due to discharges have not been detected.

The results of emission monitoring are published annually. Table F-2 shows the discharges of radioactive substances with the exhaust air for 2012. All nuclides currently found in higher concentrations than in the ambient air are included.

There are no discharges of radioactive substances from the Asse II mine with waste water.

The removal of saline solutions, solely contaminated with tritium from the mine air, and of industrial waste from the Asse II takes place following clearance according to § 29 StrlSchV. After unrestricted clearance according to § 29 StrlSchV, the saline solutions will be delivered to a salt mine to be closed. Operational waste management will take place after clearance for a specific purpose according to § 29 StrlSchV in ways provided for the respective purpose.

Table F-2: Discharge of radioactive substances in exhaust air from the Asse II mine in 2012

	Exhaust air [Bq]
H-3	$3.5 \cdot 10^{10}$
C-14	$1.8 \cdot 10^{09}$
Rn-222	$1.3 \cdot 10^{11}$
Aerosol-bound radionuclides	$1.5 \cdot 10^{06}$
Pb-210	$7.4 \cdot 10^{05}$

Morsleben repository for radioactive waste (ERAM)

The relevant substances for emission monitoring are substances such as Rn-222 and its decay products, tritium and C-14, radioisotopes of thorium, uranium, and the transuranium isotopes, and fission and activation products (see Table F-3). In particular, the discharges with the exhaust air are monitored by means of continuous measurements, discontinuous or continuous sampling, and measurements in the bypass flow or from the exhaust air. The volumetric flow of the exhaust air must also be registered. Furthermore, the discharges in waste water during specified normal operation are also monitored. Since 2012, the discharges via the Marie exhaust air structure which is the second shaft of the ERAM have also been accounted for in balance sheets and presented in the annual reports. The values are therefore higher compared to the previous report.

Table F-3: Discharge of radioactive substances with exhaust air and waste water from the ERAM in 2012

	Exhaust air [Bq]	Waste water [Bq]
H-3	$1.4 \cdot 10^{10}$	$2.5 \cdot 10^{05}$
C-14	$1.5 \cdot 10^{09}$	-*)
Aerosol-bound radionuclides	$2.7 \cdot 10^{06}$	-*)
Pb-210	$2.6 \cdot 10^{06}$	-*)
Radon decay products	$4.0 \cdot 10^{10}$	-*)
Nuclide mix except H-3	-*)	$5.9 \cdot 10^{03}$

*) Accounting not required

F.4.6 Clearance

Overview

Radioactive residues are produced in nuclear facilities above all during the decommissioning phase, and especially in facilities for radioactive waste and spent fuel management during operation, whose activities per unit mass or area – after decontamination, if necessary – are so low that they can at most lead to insignificant doses in the population. The criterion for insignificance is defined in § 29, para. 2 StrlSchV, in accordance with the provisions in Council Directive

96/29/EURATOM [1F-18], with an effective dose in the range of 10 µSv per year for members of the public. Cleared materials are mainly building rubble, excavated earth, scraps and other operational waste from the dismantling or repair of nuclear facilities. Following the dismantling of facilities, clearance procedures are also applied to site areas (soil areas).

For clearance, various clearance options are available which are listed in § 29, para. 2, subparas. 1 and 2 StrlSchV, in conjunction with the requirements outlined in Appendix IV StrlSchV. Important clearance options include the unrestricted clearance of all types of solid or liquid material as well as rubble, excavated soil and soil surfaces, clearance for disposal (in a conventional landfill or in a thermal waste treatment plant), the clearance of rubble or excavated soil for recycling (e.g. in road building), the clearance of scrap metal for recycling, and the clearance of buildings for demolition or subsequent use.

Insofar as specific provisions of the StrlSchV on clearance are not available or no clearance values have been defined in the StrlSchV, a so-called *Einzelfallnachweis* (case-by-case-decision) on the compliance with an effective dose in the range of 10 µSv per year for members of the public may be carried out. In such cases, the dose is determined on the basis of boundary conditions relating to the site of the intended use, recycling or disposal of the material.

Deliberate mixing or dilution of the materials in order to achieve clearance is not permitted.

Clearable material

Residues produced in the controlled and supervised areas of nuclear facilities are considered to be potentially radioactive and must therefore initially not leave the radiation protection areas. If, however, these residues show a sufficiently low activity (after decontamination, if necessary), they can be prepared for clearance. This concerns, in particular,

- metals (ferrous and non-ferrous metals) from facility components or parts thereof, piping, reinforcements, etc.,
- rubble from the demolition of buildings, and
- insulation material, cables, etc.

The further use or recycling of cleared objects and materials is common practice. Examples are

- direct reuse of tools, lathes, tool cabinets, but also shielding blocks, steel girders or the like in civil engineering projects,
- recycling of metals for the production of waste containers for radioactive waste, but also for unrestricted conventional recycling (e.g. steel, aluminium, copper),
- use of rubble for building of roads and landfill sites,
- use of other materials (electronic scrap, cables, etc.) in its respective resource cycle, and
- direct reuse of equipment and components from nuclear power plants in other nuclear power plants of the same type, generally with prior clearance to facilitate their transport.

With progressing dismantling of a nuclear facility, the clearance of buildings and eventually also of the site will become relevant.

Clearance options and clearance levels

§ 29 StrlSchV states a total of eight clearance options, drawing a distinction between unrestricted and clearance for a specific purpose:

In the case of unrestricted clearance, the materials, buildings or the site need not be controlled for radiological reasons once they have been cleared. Here, there are four clearance options available:

- unrestricted clearance of (solid or liquid) substances that may afterwards be reused, recycled or also disposed of,
- unrestricted clearance of rubble and excavated soil of more than 1,000 Mg per year that after clearance may be used for any chosen purpose, e.g. for the backfilling of excavations, as road bedding, etc.,
- unrestricted clearance of buildings that afterwards may be demolished or also be reused,
- unrestricted clearance of soil areas that may subsequently be used for any purposes, e.g. for the construction of houses and apartment buildings, industrial buildings, etc.

As regards clearance for a specific purpose, this refers to clearance processes in which the first step is exactly specified. Its performance is supervised by the authority, and clearance will only be complete once the step in question has been brought to a close or has been irreversibly initiated. For this type of clearance, there are four clearance options, i.e.

- clearance of solid substances for disposal in a (conventional) landfill with masses of up to 100 Mg/a and up to 1,000 Mg/a, respectively,
- clearance of (solid or liquid) substances for removal in an incinerator with masses of up to 100 Mg/a and up to 1,000 Mg/a, respectively,
- clearance of buildings for demolition, with any conventional use of the buildings prior to their demolition being impermissible,
- clearance of scrap metal for recycling by smelting in a conventional melting shop, e.g. a foundry, a steel works, etc.

For these clearance options, Appendix III, Table 1 StrlSchV [1A-8] contains clearance levels. Table F-4 shows examples of these clearance levels for a selection of radionuclides that are of importance in connection with the decommissioning and dismantling of nuclear facilities. The respective clearance levels are given as values per unit mass or area (Bq/g and Bq/cm², respectively). This depends on the type of measurement to be carried out for demonstrating compliance with these clearance levels.

Table F-4: Examples of clearance levels according to Appendix III Tab. 1 StrlSchV (firstly: options for unrestricted release, secondly: options for clearance for a specific purpose)

	Exemption level			Unrestricted clearance of				
Radio-nuclide	Activity	Specific activity	Surface contamination	Solid substances, liquids with the exception of column 6	Rubble, excavations of more than 1,000 Mg/a	Soil areas	Buildings for reuse or further use	Half life
	[Bq]	[Bq/g]	[Bq/cm^2]	[Bq/g]	[Bq/g]	[Bq/g]	[Bq/cm^2]	[a]
1	2	3	4	5	6	7	8	11
H-3	$1 \cdot 10^{09}$	$1 \cdot 10^{06}$	100	$1 \cdot 10^{03}$	60	3	$1 \cdot 10^{03}$	12.3
C-14	$1 \cdot 10^{07}$	$1 \cdot 10^{04}$	100	80	10	0.04	$1 \cdot 10^{03}$	$5.7 \cdot 10^{03}$
Cl-36	$1 \cdot 10^{06}$	$1 \cdot 10^{04}$	100	0.3	0.3		30	$3.0 \cdot 10^{05}$
Fe-55	$1 \cdot 10^{06}$	$1 \cdot 10^{04}$	100	200	200	6	$1 \cdot 10^{03}$	2.7
Co-60	$1 \cdot 10^{05}$	10	1	0.1	0.09	0.03	0.4	5.3
Ni-63	$1 \cdot 10^{08}$	$1 \cdot 10^{05}$	100	$3 \cdot 10^{02}$	$3 \cdot 10^{02}$	3	$1 \cdot 10^{03}$	100.0
Sr-90+	$1 \cdot 10^{04}$	$1 \cdot 10^{02}$	1	0.6	0.6	$2 \cdot 10^{-03}$	30	28.5
Ag-108m+	$1 \cdot 10^{06}$	10	1	0.2	0.1	$7 \cdot 10^{-03}$	0.5	127.0
Ag-110m+			1	0.1	0.08	0.007	0.5	0.68
I-129	$1 \cdot 10^{05}$	$1 \cdot 10^{02}$	1	0.06	0.06		8	$1.6 \cdot 10^{07}$
Cs-137+	$1 \cdot 10^{04}$	10	1	0.5	0.4	0.06	2	30.2
Eu-152	$1 \cdot 10^{06}$	100	1	0.2	0.2	0.07	0.8	13.3
Eu-154	$1 \cdot 10^{06}$	10	1	0.2	0.2	0.06	0.7	8.8
U-238+	$1 \cdot 10^{04}$	10	1	0.6	0.4		2	$4.4 \cdot 10^{09}$
Pu-238	$1 \cdot 10^{04}$	1	0.1	0.04	0.08	0.06	0.1	87.7
Pu-241	$1 \cdot 10^{05}$	$1 \cdot 10^{02}$	10	2	2	4	10	14.4
Am-241	$1 \cdot 10^{04}$	1	0.1	0.05	0.05	0.06	0.1	432.6

	Exemption level		Clearance of						
Radio-nuclide	Activity	Specific activity	Solid substances up to 100 Mg/a for disposal in landfills	Solid and liquid substances up to 100 Mg/a for removal in incinerators	Solid substances up to 1,000 Mg/a for disposal in landfills	Solid and liquid substances up to 1,000 Mg/a for removal in incinerators	Buildings for demolition	Scrap metal for recycling	Half life
	[Bq]	[Bq/g]	[Bq/g]	[Bq/g]	[Bq/g]	[Bq/g]	[Bq/cm^2]	[Bq/g]	[a]
1	2	3	9a	9b	9c	9d	10	10a	11
H-3	$1{\cdot}10^{09}$	$1{\cdot}10^{06}$	$6{\cdot}10^{04}$	$1{\cdot}10^{06}$	$6{\cdot}10^{03}$	$1{\cdot}10^{06}$	$4{\cdot}10^{03}$	$1{\cdot}10^{03}$	12.3
C-14	$1{\cdot}10^{07}$	$1{\cdot}10^{04}$	$4{\cdot}10^{03}$	$1{\cdot}10^{04}$	$4{\cdot}10^{02}$	$1{\cdot}10^{04}$	$6{\cdot}10^{03}$	80	$5.7{\cdot}10^{03}$
Cl-36	$1{\cdot}10^{06}$	$1{\cdot}10^{04}$	3	3	0.3	0.3	30	10	$3.0{\cdot}10^{05}$
Fe-55	$1{\cdot}10^{06}$	$1{\cdot}10^{04}$	$1{\cdot}10^{04}$	$1{\cdot}10^{04}$	$7{\cdot}10^{03}$	$1{\cdot}10^{04}$	$2{\cdot}10^{04}$	$1{\cdot}10^{04}$	2.7
Co-60	$1{\cdot}10^{05}$	10	6	7	2	2	3	0.6	5.3
Ni-63	$1{\cdot}10^{08}$	$1{\cdot}10^{05}$	$1{\cdot}10^{04}$	$6{\cdot}10^{04}$	$1{\cdot}10^{03}$	$6{\cdot}10^{03}$	$4{\cdot}10^{04}$	$1{\cdot}10^{04}$	100.0
Sr-90+	$1{\cdot}10^{04}$	$1{\cdot}10^{02}$	6	40	0.6	4	30	9	28.5
Ag-108m+	$1{\cdot}10^{06}$	10	9	10	1	1	4	0.8	127.0
Ag-110m+			6	6	2	0.6	4	0.5	0.68
I-129	$1{\cdot}10^{05}$	$1{\cdot}10^{02}$	0.6	0.6	0.06	0.06	8	0.4	$1.6{\cdot}10^{07}$
Cs-137+	$1{\cdot}10^{04}$	10	10	10	8	3	10	0.6	30.2
Eu-152	$1{\cdot}10^{06}$	10	10	10	4	4	6	0.5	13.3
Eu-154	$1{\cdot}10^{06}$	10	10	10	4	4	6	0.5	8.8
U-238+	$1{\cdot}10^{04}$	10	6	10	0.6	5	10	2	$4.4{\cdot}10^{09}$
Pu-238	$1{\cdot}10^{04}$	1	1	1	1	1	3	0.3	87.7
Pu-241	$1{\cdot}10^{05}$	$1{\cdot}10^{02}$	100	100	40	100	90	10	14.4
Am-241	$1{\cdot}10^{04}$	1	1	1	1	1	3	0.3	432.6

Once clearance has been given and the material has left the scope of supervision under atomic law, the provisions of waste management law apply, i.e. the Closed Cycle Management Act (*Kreislaufwirtschaftsgesetz*) [1B-13]. The clearance regulations are devised such that the requirements of conventional waste management law are already adequately taken into account.

Basic prerequisites for clearance

Clearance implies the principle that any radiological consequences conceivable for members of the public will be as low as to be negligible, which means that the doses resulting from the cleared substances will at most be in the range of 10 µSv per calendar year so that clearance will be non-detrimental.

The clearance levels are based on comprehensive studies that have been initiated by the BMU as part of the implementation of Council Directive 96/29/EURATOM, on recommendations of the Commission on Radiological Protection (SSK) and publications of the EU Commission. In 2011 [1A-8], the clearance levels for landfill disposal and incineration of waste have been revised due to changes in waste management law.

F.4.7 Measures for the control of releases and mitigation of their effects

Basis

§ 51 StrlSchV stipulates that in the event of radiological emergency situations, all necessary measures shall be initiated without delay in order to limit dangers to man and the environment to a minimum. Furthermore, there is an obligation to report to the nuclear supervisory authority and, if necessary for the protection of the population against risks to life and health, also to the authority responsible for public safety and order as well as to the authorities responsible for disaster control.

In radiological emergency situations, the competent authorities will notify the potentially affected population without delay, and issue instructions on how to behave in such situations. The reporting on Article 25 in Chapter F.5 gives an overview of the emergency measures to be taken depending on the hazard potential of the nuclear facility.

For nuclear facilities where radioactive substances are handled whose activity exceeds 10^7 times the exemption levels according to Appendix III, Table 1 StrlSchV by (in the case of unsealed radioactive material) or 10^{10} times (in the case of sealed sources), § 53 StrlSchV [1A-8] stipulates that the operator must also take on-site measures in preparation for damage limitation in case of safety-relevant events. This regulation serves for the implementation of Council Directive 89/618/EURATOM [1F-29]. It is based on the idea that in facilities whose radioactive inventory lies below the aforementioned levels, it is possible to exclude any serious consequences of incidents and accidents involving radioactive material and that therefore any specific internal measures will only become necessary above these levels.

The internal measures include, in particular, the provision of

- the necessary trained personnel for limiting and eliminating the dangers generated on the facility site by accidents or incidents, and
- the necessary tools and equipment.

The readiness for action of personnel and equipment must be proven to the competent authority.

The in-house procedure in case of an unplanned and uncontrolled release of radioactive substances into the environment must be specified in an operating manual (see reporting on Article 9). The latter must include a fire protection code and an alarm code. KTA 1201 is to be applied analogously here (see Safety Standards of the Nuclear Safety Standards Commission (KTA) in Annnex L-(e), Part 5). The fire protection code must specify preventive and aversive fire-protection measures. The alarm code should outline measures and rules of conduct for events posing a potential threat to staff and the surrounding area of the facility, as well as information on alarm drills and escape routes. Furthermore, the operating manual must outline the measures initiated automatically and those which must be initiated manually by the staff on shift in the case of an accident. It should also stipulate the criteria under which it is to be assumed that important safety functions are not being performed by the systems as designed, and on-site emergency protection measures have to be taken. The incidents defined in the licensing procedure must be addressed here.

Integrated Measurement and Information System

Besides the monitoring of emissions and immissions at the site of a nuclear facility, the Precautionary Radiation Protection Act (*Strahlenschutzvorsorgegesetz* – StrVG) [1A-5] also stipulates the Integrated Measurement and Information System for Monitoring Environmental Radioactivity (IMIS), which ensures comprehensive monitoring of environmental radioactivity throughout the territory of the Federal Republic of Germany. The respective responsibilities of the Federation and the *Länder* are specified under §§ 2 to 5 StrVG, together with the corresponding information system. The IMIS general administrative provision (AVV-IMIS) [2-4] regulates the overall complex of environmental monitoring, with two appendices – the routine measuring schedule and the intensive measuring schedule – defining the measuring scopes and measuring methods for normal conditions and for incidents.

The federal authorities mentioned in § 48, para. 4 StrlSchV [1A-8] in conjunction with Appendix XIV StrlSchV perform comparative measurements and analyses uniformly throughout the country and develop sampling, analysis, and measurement techniques. The German national metrology institute providing scientific and technical services (*Physikalisch-Technische Bundesanstalt* – PTB) provides radioactivity standards for reference measurements.

The IMIS comprises an automatic measurement network consisting of more than 1800 stationary measurement stations for monitoring the local gamma dose rate and measurement networks for determining the activity concentration in the air, precipitation, and the aqueous environment. In addition, the radioactivity in food, fodder, drinking water, as well as in residual substances and waste waters, is determined. Centralised data logging is performed at the Federal Central Station for Monitoring Environmental Radioactivity (*Zentralstelle des Bundes zur Überwachung der Umweltradioaktivität*) at the Federal Office for Radiation Protection (BfS) in Neuherberg. The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) evaluates the data. If an accident or incident with radiological consequences for the German territory should occur, the BMUB will initiate the activation of intensive operation of the monitoring system according to the AVV-IMIS and alerts the *Länder*. Furthermore, the BMUB recommends actions to be taken to protect the population after consultation with the *Länder*.

F.5 Article 25: Emergency preparedness

> *Article 25: Emergency preparedness*
>
> *(1) Each Contracting Party shall ensure that before and during operation of a spent fuel or radioactive waste management facility there are appropriate on-site and, if necessary, off-site emergency plans. Such emergency plans should be tested at an appropriate frequency.*
>
> *(2) Each Contracting Party shall take the appropriate steps for the preparation and testing of emergency plans for its territory insofar as it is likely to be affected in the event of a radiological emergency at a spent fuel or radioactive waste management facility in the vicinity of its territory.*

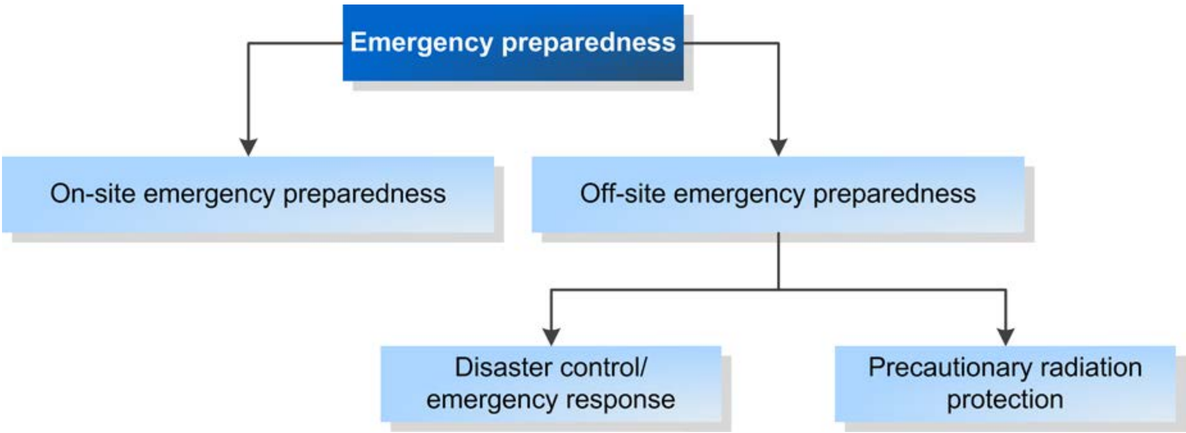
F.5.1 Internal and external emergency plans for nuclear facilities

Basis

In Germany, a concept of nuclear emergency preparedness has been established which is naturally geared primarily around nuclear power plants. However, these rules are generally applicable to any nuclear facility while the effort can be reduced according to the lower hazard potential compared to that of nuclear power plants.

Nuclear emergency preparedness comprises on-site and off-site planning and preparedness for emergencies (see Figure F-3).

Figure F-3: Structure of emergency preparedness



On-site emergency preparedness is realised by technical and organisational measures taken to control an event or to mitigate its consequences.

Off-site emergency preparedness comprises disaster control and precautionary radiation protection. Disaster control serves for averting imminent danger. Precautionary radiation protection aims at coping with consequences of unplanned radiological releases below reference levels for short-term measures by means of precautionary protection of the population and serves for preventive health protection. In light of the accident sequence in the Fukushima Daiichi nuclear power plant, the BfS conducted studies on off-site emergency response in Germany. The results of these studies have been incorporated into the SSK recommendations on reforming the emergency response provisions.

Regulatory basis

Based on the regulations of the AtG [1A-3] and § 51 StrlSchV [1A-8], the operator is responsible, within the framework of on-site emergency preparedness, to keep the risk of potential hazards for man and the environment as low as possible in case of incidents and accidents.

Under § 12 AtG [1A-3] and § 51 StrlSchV, the operator of any nuclear facility must inform the competent supervisory agency without delay of any safety-relevant deviations from specified normal operation, particularly accidents, hazardous incidents, or radiological emergency situations. He should also notify the authority responsible for public safety and the agency responsible for disaster control in the *Land* concerned, if necessary.

The alarm criteria which, when reached, require alerting the disaster control authorities, are based on a joint recommendation of RSK and SSK on criteria for alerting the disaster control authority by the operator of a nuclear facility (*Kriterien für die Alarmierung der Katastrophenschutzbehörde durch die Betreiber kerntechnischer Einrichtungen*) [SSK 13], last amended in February 2013.

According to § 53 StrlSchV, no special emergency preparedness measures are required for a nuclear facility if the activity of the radioactive substances handled there does not exceed certain limits. These thresholds are:

1. 10^7 times the exemption levels for activity according to Appendix III, Table 1, column 2 StrlSchV in the case of unsealed radioactive substances,
2. 10^{10} times these exemption levels in the case of sealed radioactive substances.

Accordingly, some of the radioactive waste management facilities do not require emergency preparedness planning at all, since the possibility of safety-relevant events can be excluded. This usually concerns the handling of radioactive material subject to licensing under § 7 StrlSchV [1A-8].

Within the German Federal Government, the BMUB is responsible for the provision of general criteria for the preparation of emergency plans for the surroundings of nuclear facilities.

To asses the need for measures of disaster control/emergency response and precautionary radiation protection in case of accidents in nuclear facilities in Germany and abroad, a catalogue of measures of the BMUB is available with an overview of measures for the mitigation of radiological exposure following incidents or accidents with non-negligible radiological consequences [BMU 08].

In accordance with the provisions of Council Directive 89/618/EURATOM [1F-29], § 51, para. 2 StrlSchV specifies that the affected population must be informed without delay of a radiological emergency situation and any special conduct which may be required on their part. The individual disaster control agencies will jointly agree and coordinate the process of notifying the general public.

As part of emergency preparedness, disaster control measures may be initiated. On this issue, a BMU recommendation [3-15] specifies

1. basic recommendations for disaster control in the vicinity of nuclear facilities, and
2. radiological bases for decision-making to determine which measures should be taken to protect the population.

With regard to the radiological bases for the recommendation of disaster control measures in [3-15], fixed numerical values for recommended intervention reference levels have been adopted, based on the recommendations in publications No. 63 and No. 40 of the ICRP ([ICRP 93] and [ICRP 84]) and the International Basic Safety Standards of the IAEA [IAEA 14a], which are designed to facilitate decision-making at the start of measures and which can be adjusted later on if necessary (see Table F-5). This is consistent with the approach adopted by the European Commission.

Table F-5: Intervention reference levels for the measures of sheltering, taking iodine tablets, evacuation as well as temporary and long-term resettlement from [3-15]

Measure	Intervention reference levels		
	Organ dose (thyroid)	**Effective dose**	**Integration and exposure paths**
Sheltering		**10 mSv**	External exposure over 7 days and committed effective dose due to radionuclides inhaled within this period
Taking iodine tablets	**50 mSv** Children and adolescents under age 18 and pregnant women **250 mSv** Persons of age 18 to 45		Radioactive iodine inhaled within 7 days
Evacuation		**100 mSv**	External exposure over 7 days and committed effective dose due to radionuclides inhaled within this period
Temporary resettlement		**30 mSv**	External exposure within 1 month
Long-term resettlement		**100 mSv**	External exposure within 1 year due to radionuclides deposited on the ground

For immediate decision-making, dose intervention reference levels are supplemented by measurable parameters, the so-called “derived reference levels”.

Suitable parameters are

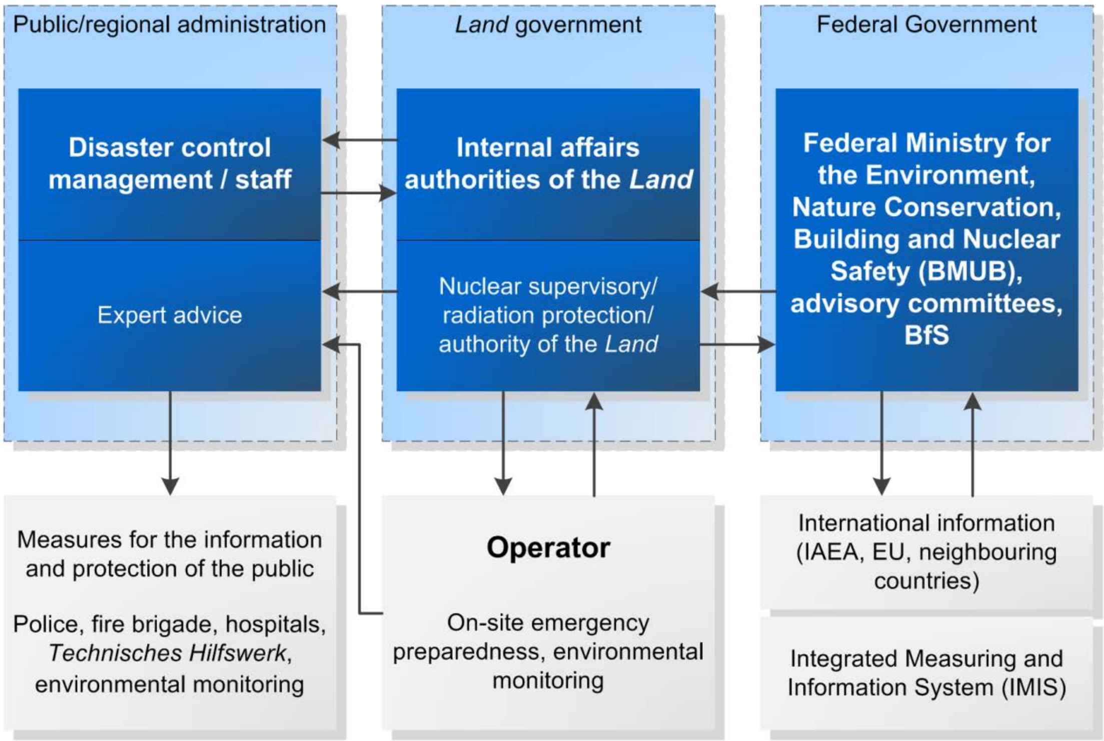
- local dose rate,
- (time-integrated) activity concentrations in the air, and
- surface contamination (ground, objects, skin).

Extensive measures of external emergency preparedness, e.g. preparation of an off-site emergency plan, may not be required if the calculated effective doses for design basis accidents and events with low occurrence probability in the vicinity of a facility are significantly below the limit values of radiation exposure after design basis accidents as defined in §§ 49 and 50 StrlSchV [1A-8]. The decisions are taken by the competent licensing and supervisory authorities for the nuclear facilities in the *Land* concerned.

Organisation

Emergency preparedness is organised in co-operation between the Federal Government and the governments of the *Länder*, regional government agencies, the police, *Technisches Hilfswerk* (the governmental disaster relief organisation), fire fighters, hospitals, and the operator of the nuclear facility. While the operator is responsible for on-site emergency preparedness, off-site emergency preparedness outside the facility is the responsibility of the *Länder* authorities (as part of disaster control). Temporally and geographically limited disaster control measures are co-ordinated and performed by the *Länder* authorities, the regional government agencies, and in particular the management of the disaster control services (see Figure F-4). This requires a precise knowledge of the state of the facility and an evaluation of the radiological situation and the situation in the areas affected.

Figure F-4: Organisation of emergency preparedness



<u>Tasks of the Federation and the *Lände*</u>

Where required, the BMUB makes its resources, including those of the BfS or its advisory committees, available for providing support and advice to the *Länder*.

The basic recommendations for disaster control are prepared under the leadership of the BMUB and involvement of the *Länder*.

Within the framework of precautionary radiation protection, the Federation is authorised to specify limits and measures. However, as far as events with exclusively regional impact are concerned, the *Land* authority competent for precautionary radiation protection may determine measures to be taken for preventive health protection. By means of the Integrated Measurement and Information System for the Monitoring of Environmental Radiation (IMIS), the Federal Government monitors and assesses the radiological situation in Germany both during routine operation and under incident and accident conditions (see reporting on Article 24). Where required, the data are transmitted to the corresponding federal and regional disaster control authorities and the measuring and data transmission frequency of the IMIS will be increased.

In the event of a radioactive release abroad that has effects on German territory, alerting of the *Länder* is ensured on the one hand by the Federation which is informed on the basis of bilateral and international agreements if an event occurs, and on the other hand in parallel by the Integrated Measuring and Information System (IMIS).

It is the task of the competent government agency in a given *Land* to specify the nature and scope of emergency preparedness, taking into account the specific requirements of the respective nuclear facility. The criteria for the nature and scope of emergency planning are determined in particular by the radioactive inventory and the likelihood of an accident or hazardous incident occurring.

The individual *Länder* designate the authority responsible for disaster control. In accordance with the Disaster Control Act (*Katastrophenschutzgesetz*) of the particular *Land*, alarm and action plans must be drafted and updated by this authority, if required, to serve as off-site emergency plans for the nuclear facilities within its jurisdiction. In these plans, all measures are specified that are provided by the disaster control authority in the case of accidents or incidents in the corresponding facility.

The competent authority for disaster control of a nuclear facility has to nominate an expert radiation protection consultant to the disaster response management. This person collects, verifies and assesses all information relevant in connection with an event and consults the disaster response management with regard to the radiological situation. The work of this person is based on the guideline for the expert radiation protection consultant ([SSK 04a], [SSK 04b]), which is applied mutatis mutandis in line with the special requirements of a corresponding nuclear facility.

For the preparation of off-site emergency plans, the disaster control authorities refer to the basic recommendations, the corresponding provisions under disaster control law of the respective *Land,* and the responsibility assignment plans regulating the co-operation among the different *Länder* authorities. The off-site emergency plans show the competences and responsibilities for on-site management, for crisis team management, for the alerting criteria as well as for the definition of the necessary measures.

To limit the extent of preparatory measures, the surrounding area of the facility is divided into three zones:

- According to the basic recommendations for disaster control [3-15], the central zone should not exceed a radius of 2 km around the facility. This, however, depends on the local conditions.
- Adjacent to this central zone there is the intermediate zone with a radius of 10 km around the facility, and
- the outer zone with a radius of 25 km.

Iodine tablets for blocking the thyroid gland are distributed as a precaution or stored in decentralised stocks. Here, the following procedure is recommended: For all persons under age 45, iodine tablets are distributed as a precaution to their households within a radius of 0 to 5 km; in the zone between 5 and 10 km, the tablets are distributed as a precaution to households or they are stored readily accessible at several locations in the communes; in the zone 10 to 25 km, the tablets are to be kept in readily accessible storage. The *Länder* regulate this within their own responsibility. Off-site emergency protection in Germany is currently being reviewed comprehensively in the light of findings from the Fukushima accident.

In a radius of 25 to 100 km, iodine tablets are held in stock in several central stores and made available to the *Länder*, if required, for distribution among children and adolescents under age 18 and for pregnant women for the purpose of iodine blockage.

Taking into consideration the safety report of the plant, the on-site emergency plan and other information from the operator, as well as in consultation with the competent supervisory authority, the disaster control authority may decide that it is not necessary to draw up an off-site emergency plan. In such cases, potential accidents are covered by the measures for general disaster control which must be planned regardless of the hazard potential of specific facilities. This waiving of off-site emergency planning must be justified in detail by the agency.

If an off-site nuclear emergency preparedness plan is drawn up for a nuclear facility, this has to be continuously updated and reviewed at regular intervals. At intervals of several years, the authorities carry out disaster control exercises at the sites of the nuclear facilities in order to verify the efficiency of the emergency preparedness plans and identify weak points (see Figure F-5). The operators also take part in these exercises. § 53, para. 5 StrlSchV stipulates that the population has to be informed periodically every five years about the emergency preparedness plans.

Figure F-5: GNS works fire service during a fire drill at the Gorleben site (Copyright: GNS)

Tasks of the operator

The operator develops the on-site emergency plan in the emergency manual and the alarm code as part of the operating manual and must keep them up to date. In particular, emergency planning has to regulate: duties and responsibilities, criteria for triggering alarms and for taking internal measures, the information flow to the crisis team and to the disaster control authority, and special stipulations for the emergency staff of the facility.

Further, in accordance with § 53 StrlSchV [1A-8], the operator must have trained personnel and any tools which may be required on hand for controlling emergency situations, and must provide the authorities responsible for emergency preparedness with the information necessary to deal with an incident. He must assist the competent authorities in planning emergency measures, and inform them of possible risks when deploying helpers, and of protective measures required.

The operator alerts the disaster control service of the competent *Land* authority after an emergency situation occurred or if there are concerns that such a situation may happen. He recommends to the disaster control service which level of alarm should be raised, either an early warning or an emergency alert.

Specifically for the case of fire-fighting, the operator must agree necessary measures in advance in co-operation with the competent *Länder* authorities, the fire service, or the mine rescue service (in the case of repositories). In this respect, it is particularly important to clarify the special equipment required for fighting fires in the individual areas of the facility.

Implementation for the individual facilities

The central storage facilities for spent fuel at Ahaus and Gorleben, the storage facility Zwischenlager Nord (ZLN), and the storage facility at Jülich are not subject to any special nuclear emergency preparedness planning, despite the fact that their radioactivity inventories exceed the limits given in

§ 53 StrlSchV [1A-8]. On-site emergency plans exist for all central storage facilities. Since the individual spent fuel casks are already designed to withstand external hazards, a safety-related event involving releases that would necessitate emergency protection measures need not be postulated, neither for the case of a design basis accident nor for very rare events such as an aircraft crash or a blast wave caused by an explosion. Studies have shown that the values obtained lie well below the accident planning levels according to § 49 StrlSchV. Disaster control falls under the general disaster control planning of the *Länder* authorities.

In principle, the same applies for on-site storage facilities at nuclear power plants as for the central storage facilities for spent fuel. However, these facilities are already covered by the extensive emergency preparedness plans of the nuclear power plants.

The PKA pilot conditioning plant for spent fuel at Gorleben will not require special measures of off-site emergency preparedness if it becomes operational. The cell wing of the facility is designed against external impacts, in particular against aircraft crashes. In the wing housing the cask storage area, protection is ensured by the design of the type B casks. Other accidents involving significant releases have been analysed They do not lead to any consequences requiring special emergency planning.

No specific emergency plans are available for the ERAM in view of the safety-relevant events conceivable there.

For the Asse II mine, special emergency measures are planned in order to limit potential radiation exposures in the long term for the case of a beyond-design solution inflow. These are measures to establish emergency preparedness, precautionary measures to reduce occurrence probability, and measures to be taken in the event of an impending beyond-design solution inflow (flooding).

Measures to establish emergency preparedness have been and are being implemented in stages. These include increasing the capacity of discharging inflowing solution to the surface to up to 500 m^3 per day as well as the contractual assurance of a disposal option. Above and below ground, emergency storage facilities have been established to ensure replacement of failed devices and equipment and additional equipment provided for an emergency (see Figure F-6).

Figure F-6: Underground material storage at the 490-m level for an emergency in the Asse II mine (Copyright: BfS)

The precautionary measures to reduce the probability of occurrence include the collection of solutions above the emplacement chambers, backfilling of cavities, and the construction of seal structures at the floor level below the emplacement chambers. As part of emergency preparedness, numerous residual cavities at the 775-m level below the waste chambers as well as several blind shafts have been backfilled with Sorel concrete. It is also planned to fill the galleries and other cavities no longer needed at the floor levels with the emplacement chambers (especially the 750-m level and 725-m level) and other blind shafts that are vertical connections between the lower and upper floor levels. The measures will counteract the progressive damage of the rock. In addition, the possible release of radionuclides in an emergency is minimised and delayed, which mitigates the effects of a beyond-design solution inflow. With the sealing of a southbound drift at the 750-m level, the last accessible connection between the mine and the adjoining rock being susceptible to inflow was closed in January 2013.

The backfilling at the 750-m level, necessary as part of emergency preparedness, where most of the emplacement chambers are located, is discussed by the *Begleitgruppe Asse-II* (Asse II advisory group), a panel of local stakeholders and citizens' initiatives. These fear that backfilling measures will counteract the retrieval of the waste. The technical need for the measures which in fact create the conditions for the planned retrieval, among other things, is explained to the *Begleitgruppe Asse-II* by the BfS.

F.5.2 Emergency plans for the case of incidents in nuclear facilities of neighbouring states

The basic recommendations for disaster control in the vicinity of nuclear facilities (*Rahmenempfehlungen für den Katastrophenschutz in der Umgebung kerntechnischer Anlagen*) [3-15] also apply to foreign nuclear facilities requiring planning measures on German territory due to their proximity to national borders. Admissible releases during normal specified operation and under accident conditions are a matter at discretion of the respective country's own legislation. In Germany, international regulations were considered from the start when the limits in the StrlSchV were defined.

The precautions in case of accidents in waste management facilities on neighbouring foreign territory correspond to those applicable to other nuclear facilities, such as nuclear power plants. In order to determine the measures necessary under the Precautionary Radiation Protection Act [1A-5], a list of measures [BMU 08] is applied which includes the necessary instructions on estimating the consequences and on planning measures to be taken.

On the basis of bilateral agreements, the authorities of neighbouring countries are involved in exercises in plants near the border, at least as observers, but usually as active participants. In addition, BMUB officials are involved in EU and OECD/NEA exercises (INEX exercises) in order to gather relevant international experiences with a view to updating emergency preparedness planning in Germany.

Since the early 1980s, the Federal Republic of Germany has entered into bilateral agreements with all adjoining states, and some countries further away, regarding mutual assistance in case of disasters or major accidents ([1D-1], [1D-2], [1D-3], [1D-4], [1D-5], [1D-8], [1D-9]). These agreements specify the responsibilities and points of contact, guarantee cross-border traffic of personnel and resources deployed, and stipulate mutual exclusion of liability in case of personal injury or property damage, and agree a comprehensive exchange of information and experiences. In the years following German reunification, agreements have also been signed with Poland [1D-10], Hungary [1D-6], Lithuania [1D-7] and Russia [1D-11], and a treaty agreed with the Czech Republic [1D-12].

Germany also has an agreement with France on the exchange of information in case of events or accidents with radiological effects dating from 1981, and an administrative agreement without binding effect under international law dating from 1976.

In 2013, the Federal Republic of Germany joined the Response and Assistance Network (RANET) of the IAEA. RANET offers the possibility, in the event of a nuclear or radiological emergency, to be able to quickly access existing national assistance capabilities of other states. The German assistance capabilities offered include, in particular, assistance in patient treatment in the case of a radiation accident, dose determination and dose assessment, dispersion calculations, determination of radiological situations, the provision of measurement capacity and expertise. The offer includes both support provided from Germany as well as support in the country of accident itself.

In addition, there are agreements with neighbouring states on the exchange of information and experience in connection with safety engineering or radiation protection, all of which were concluded prior to 1985 [BMU 13]. There is also a superordinate European regime governing radiological emergencies.

F.6 Article 6: Decommissioning

> *Article 26: Decommissioning*
>
> *Each Contracting Party shall take the appropriate steps to ensure the safety of decommissioning of a nuclear facility.*
>
> *Such steps shall ensure that:*
>
> *i) qualified staff and adequate financial resources are available;*
>
> *ii) the provisions of Article 24 with respect to operational radiation protection, discharges and unplanned and uncontrolled releases are applied;*
>
> *iii) the provisions of Article 25 with respect to emergency preparedness are applied;*
>
> *iv) records of information important to decommissioning are kept.*

F.6.1 Basis

Introduction

The provisions relating to safety during the decommissioning of nuclear facilities are dealt with below in the overall context. The term "decommissioning" is used here for the purpose of the Joint Convention (Article 2) more broadly as a generic term for all decommissioning-related activities (including safe enclosure and dismantling as well as all measures leading to the release of a facility or a site from regulatory control). This corresponds to the technical and international usage. As understood in Germany, a nuclear facility will only be under “decommissioning” if a decommissioning licence has been granted.

Legal basis

With the entry into force of the 13th Act to amend the Atomic Energy Act on 6 August 2011 due to the events in Japan, which led to a reassessment of the risks associated with the use of nuclear energy, the authorisation for power operation expired for the nuclear power plants Biblis A, Neckarwestheim 1, Biblis B, Brunsbüttel, Isar 1, Unterweser, Philippsburg 1 and Krümmel. Until granting of a decommissioning licence, these will be in the post-operational phase. Until the beginning of 2013, applications were made for decommissioning licences for seven of the eight shut-down nuclear power plants. For the remaining nine nuclear power plants still in operation, the authorisation for power operation will expire successively between the end of 2015 and the end of 2022.

In Germany, the legal basis for licensing procedures for the decommissioning of nuclear facilities are the Atomic Energy Act [1A-3], as well as the associated statutory ordinances promulgated on the basis of the AtG and general administrative provisions. § 7, para. 3 AtG contains the basic requirement for the licensing of decommissioning. It stipulates that for any facility which has been licensed according to § 7, para. 1 AtG, the decommissioning, safe enclosure or dismantling of that facility or of parts thereof shall require a licence once operation has been permanently suspended. Here too, a consideration of the state of the art in science and technology is retained as a guiding principle.

The licensing procedure for the decommissioning of nuclear facilities is governed by the Ordinance Relating to the Procedure for the Licensing of Facilities (*Atomrechtliche Verfahrensverordnung* – AtVfV) [1A-10]. It contains regulations pertaining to decommissioning, particularly with regard to third party involvement and environmental impact assessment (EIA).

The prerequisites which have to be fulfilled for issuing a decommissioning licence are listed in § 7, para. 2 AtG. As stipulated in § 7, para. 3 AtG, they “accordingly” pertain to decommissioning as for construction and operation of such a plant. The legislator has put the issuance of a licence according to § 7, paras. 1 and 3 AtG under the reserve of § 7, para. 2 AtG (“A licence may only be granted if” the prerequisites of § 7, para. 2 AtG have been fulfilled). This emphasises the particular weight that was given to construction and operation as well as to decommissioning, safe enclosure and dismantling of a nuclear facility by the legislator. Other licences regulated by the AtG (e.g. §§ 5 and 6 AtG) or by the Radiation Protection Ordinance (StrlSchV) (§§ 7 and 9 StrlSchV) [1A-8] are not furnished with such a reserve (“A licence shall be granted if” the prerequisites are fulfilled).

Dismantling of any buildings or rooms at the site of a nuclear facility where handling or storage of nuclear fuel or other radioactive substances took place and which are covered by the operating licence is carried out within the scope of § 7, para. 3 AtG.

Apart from the AtG, the StrlSchV is also relevant for dismantling, as it specifies technical and operational measures, procedures and precautions to prevent damage caused by ionising radiation. This includes the definition of the principles of radiation protection, the regulations concerning transport and transboundary shipment of radioactive materials, for clearance, for knowledge in radiation protection, for on-site organisation of radiation protection, for protection of individuals in radiation protection areas, including physical supervision of radiation protection, for the protection of the general public and the environment, for the protection against significant safety-related events as well as for radioactive waste.

The implementation of licensed decommissioning activities of nuclear facilities is monitored by the supervisory authority.

Hazard potential of nuclear facilities during the decommissioning phase

The decommissioning phase of a nuclear facility is characterised by a gradual decrease in the radionuclide inventory of the facility, mainly by means of removal of the spent fuel and by decontamination and removal of contaminated and activated material as well as the final removal of any residual radionuclides and the release from nuclear regulatory control. Moreover, there are no energy potentials for the dispersion of the radioactive inventory since, contrary to the operational phase, the facility is cold and depressurised and because the major part of the residual radionuclide is bound in metal and concrete structures by activation. Generally speaking, this coincides with a continuous decrease in the hazard potential as dismantling progresses. This fact is considered, among others, by specific decommissioning regulations and recommendations mainly in the non-mandatory guidance instruments. This is to be taken into account by application of the existing regulatory framework or by revoking supervisory regulations and requirements during the licensing and supervision procedure in line with the decreasing hazard potential.

Measures to ensure safety during decommissioning of nuclear facilities

The information contained in this report with respect to

- Article 18 (Implementing measures),
- Article 19 (Legislative and regulatory framework),
- Article 20 (Regulatory body),
- Article 21 (Responsibility of the licence holder),
- Article 22 (Human and financial resources),

- Article 23 (Quality assurance),
- Article 24 (Operational radiation protection), and
- Article 25 (Emergency preparedness)

also applies analogously to the decommissioning of nuclear facilities. The accounts given in this report with respect to the aforementioned Articles also cover – either partially or in full – the decommissioning of nuclear facilities. Generally speaking, the same general safety standards apply during decommissioning of a nuclear facility as during its operational phase, although there are some significant differences in certain details. For example, the option of criticality no longer applies to nuclear reactors once all spent fuel has been removed from the plant, and the amounts of activity which is discharged with waste water and exhaust air is usually considerably lower. Safety requirements and the implementation thereof are addressed in the reporting on Article 4.

Article 15 (Assessment of safety of facilities) of the Joint Convention is also relevant with regard to the fact that during the decommissioning phase of a nuclear facility, it may become necessary to construct new radioactive waste management facilities. The requirements of Article 15 concerning assessment of the safety of such facilities and their environmental impact prior to construction and commissioning likewise apply to radioactive waste management facilities which are constructed when decommissioning nuclear facilities (see reporting on Article 15). Likewise, the requirements of Article 16 (Operation of facilities) of the Joint Convention concerning the operation of radioactive waste management facilities also apply analogously to the decommissioning phase (see the reporting on Article 16).

As a consensus between the Federal Government and the supervisory authorities of the *Länder* concerning a best possible effective and harmonised approach in licensing procedures for decommissioning, the Main Committee of the *Länder* Committee for Nuclear Energy (LAA) agreed on 26 June 2009 to apply a revised version of the Guide to the Decommissioning, the Safe Enclosure and the Dismantling of Facilities or Parts thereof as Defined in § 7 of the Atomic Energy Act (*Leitfaden zur Stilllegung, zum sicheren Einschluss und zum Abbau von Anlagen oder Anlagenteilen nach § 7 des Atomgesetzes*) AtG [3-73] (shortly: decommissioning guideline) in nuclear licensing and supervisory procedures. This decommissioning guideline was published on 28 October 2009. It pursues the following aims:

- to compile the aspects of licensing and supervision which are relevant in decommissioning procedures,
- to develop a common understanding between the Federation and the *Länder* how to carry out decommissioning procedures, and
- to harmonise the opinions and approaches as far as possible.

In particular, the decommissioning guideline contains proposals for a practical approach concerning decommissioning as well as the safe enclosure and the dismantling of nuclear facilities according to § 7 AtG with respect to the application of the non-mandatory regulatory framework, the planning and preparation of decommissioning measures as well as licensing and supervision.

It identifies the decommissioning-related provisions in the different documents of the legal and non-mandatory regulations and describes their application. It also contains proposals for an expedient procedure of decommissioning nuclear facilities and serves for the harmonisation of the licensing procedures. For example, it is made clear that in connection with the decommissioning and dismantling of nuclear facilities, the work has to be organised in projects in accordance with the continuously decreasing hazard potential, and how in this context the regulations can be applied “analogously”, i.e. in the same way as to construction and operation. In all, the decommissioning guideline thereby promotes the harmonisation of decommissioning procedures, but it does not represent an official guideline or administrative provision.

As a technically oriented supplement to the decommissioning guideline, the Nuclear Waste Management Commission (ESK) adopted the Guidelines for the decommissioning of nuclear facilities [4-4] on 9 September 2010. The Guidelines were published on 9 December 2010. In these Guidelines, the ESK summarises those technical requirements which it considers necessary for the operators of nuclear facilities to fulfil in order to ensure safety in connection with decommissioning. These requirements relate above all to the preparation and execution of decommissioning; some requirements, however, are also directed at the construction and operation of a nuclear facility as they are highly relevant for the later decommissioning. The Guidelines for the decommissioning are not legally binding for any third parties. They rather more form the basis for the ESK's assessments when discussing concrete decommissioning procedures. Hence the Guidelines contribute to the state of the art in science and technology of the German nuclear non-mandatory guidance instruments and thereby to a high level of safety of the decommissioning of nuclear facilities.

The nuclear rules and regulations deal with the two decommissioning options of direct dismantling and later dismantling after safe enclosure equally.

F.6.2 Availability of qualified staff and adequate financial resources

The experience from various decommissioning projects of nuclear facilities in Germany has shown that the operating staff's knowledge of the facility is very valuable for the safe and efficient execution of decommissioning. For this reason, the operator aims at involving the operating staff in the decommissioning phase.

The manner in which the availability of financial resources is secured for the decommissioning phase of a nuclear facility differs between publicly-owned facilities and facilities belonging to the private power utilities:

- The decommissioning of publicly-owned facilities is financed from the current budget. For most projects (see Table F-6), the Federation covers the bulk of the costs. Financing includes all expenses incurred for the remaining operating life, spent fuel management, execution of the licensing procedure, dismantling of facility components, and disposal of the radioactive waste (including all preparatory steps).

- 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, based on an accumulation period of 25 years. The formation of reserves according to commercial law is based on the obligation under public law to ultimately remove the radioactive part of the facility, which is derived from the AtG. The existence of reserves for decommissioning shall guarantee 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. By the expensed formation of reserves during the operational phase of the nuclear power plant, the funds are accumulated, thus preventing the contributions from being distributed as profits to the shareholders. Further reserves are formed for spent fuel management.

- 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 facility itself. This includes the costs of the post-operational phase in which the facility is prepared for dismantling after its final shutdown (including removal of spent fuel and operational waste), the costs of the licensing procedure and supervision, the costs of dismantling (dismantling and storage of all contaminated and activated components and all buildings of the controlled area), and the cost of storage and disposal of all radioactive waste from decommissioning. The total amount of costs is estimated from cost studies which are updated regularly – with due regard for technical advancements and general price trends – by an independent expert. The reserves are regularly checked by independent financial auditors of the fiscal authorities with regard to their adequacy.

- The above statements also apply analogously to commercially operated nuclear fuel cycle facilities and the waste management facilities.

Table F-6: Research institutions in which nuclear facilities are operated or decommissioned and which are financed from public funds

Research institution	Short description	Funding
Karlsruhe Institute of Technology (KIT), formerly Karlsruhe Research Centre	Founded in 1956 as Karlsruhe Research Centre (KfK); initial research topics: development of heavy and light water reactors. Currently various research topics outside nuclear technology. Within the former division of “Decommissioning”, execution of the decommissioning of the research and experimental and demonstration reactors: FR-2, MZFR, KNK II, operation of conditioning plants and storage facilities at the central decommissioning department HDB. In June 2009, all old nuclear facilities at the site were transferred to the *Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH* (a decommissioning and waste management company of the Karlsruhe reprocessing plant), among them not only the decommissioned FR-2, MZFR and KNK II reactors but also the HDB. Whenever other nuclear research facilities are taken out of operation, these will be transferred to WAK GmbH for dismantling.	Federation, *Land* of Baden-Wuerttemberg

Research institution	Short description	Funding
Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs- GmbH (WAK GmbH)	The Karlsruhe reprocessing plant was built between 1967 and 1971, with the Karlsruhe Research Centre being the building contractor. The *Gesellschaft zur Wiederaufarbeitung von Kernbrennstoffen mbH* (GWK), a company founded by the chemical industry in 1964 to handle the reprocessing of nuclear fuel, was tasked with the operation of the plant. In 1979, GWK was taken over by *Deutsche Gesellschaft für Wiederaufarbeitung von Kernbrennstoffen mbH* (DWK), a subsidiary company of the German electric power industry. Under the name of *Wiederaufarbeitungsanlage Karlsruhe Betriebsgesellschaft mbH* (WAK BGmbH), GWK subsequently carried out the reprocessing operations until the plant's decommissioning in 1990; afterwards, it was in charge of the residual operations and the dismantling of the plant. In 2006, WAK BGmbH was taken over by the state-owned EWN GmbH and has since then been operating under the name of *Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH* (WAK GmbH). At the same time, the scope of activities was extended to the operation and dismantling of the Karlsruhe vitrification plant (VEK). In mid-2009, the old nuclear facilities FR-2, KNK II and MZFR as well as the conditioning facilities for radioactive waste of HDB were separated from the Karlsruhe Research Centre and transferred to WAK GmbH. Since then, the latter has been continuing the decommissioning of the research facilities and the operation of HDB. Whenever other nuclear research facilities are taken out of operation by KIT, their dismantling will be handled by the WAK GmbH.	Federation, *Land* of Baden-Wuerttemberg
Research Centre Jülich (FZJ)	Founded in 1956 as *Kernforschungsanlage Jülich* (KFA); initial research topics: development of high temperature reactors. Current research in numerous fields outside nuclear technology. Decommissioning of the research reactors FRJ-1 and FRJ-2. (Close to the FZJ premises, there is the AVR. Owner of the facility in the process of decommissioning is the AVR GmbH whose sole member is the EWN GmbH.)	Federation, *Land* of North Rhine-Westphalia
Helmholtz-Zentrum Geesthacht - Centre for Material and Coastal Research GmbH formerly Research Centre Geesthacht (GKSS)	Founded in 1956 as *Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt* (company for exploitation of nuclear energy in shipbuilding and navigation), operation of the nuclear ship “Otto Hahn”. Current research topics in the fields of traffic and energy technology, process and biomedical technology, water and climate in coastal regions. Decommissioning of the research reactors FRG-1 and FRG-2, storage of the ship reactor, and management of radioactive waste from the nuclear ship Otto Hahn.	Federation, *Länder* of Schleswig-Holstein, Lower Saxony, Hamburg, Bremen
Helmholtz Zentrum München, Neuherberg	Founded in 1964 as *Gesellschaft für Strahlenforschung* (GSF) (company for radiation research) for the construction and operation of radiation research facilities and carrying out research into the underground storage of radioactive waste; safe enclosure of the research reactor FRN; current research topics in environmental and health research. With effect from 1 January 2008, the GSF was renamed *Helmholtz Zentrum München –* German Research Centre for Environmental Health.	Federation, Free State of Bavaria

Research institution	Short description	Funding
Helmholtz-Zentrum Berlin	Founded as the Hahn-Meitner-Institute Berlin in 1959; current research topics in the areas structural research, material sciences etc.; operation of the research reactor BER II	Federation, *Land* of Berlin
Verein für Kern-verfahrenstechnik und Analytik Rossendorf e. V. (VKTA), Dresden	Founded in 1992. VKTA carries out the decommissioning of the nuclear facilities of the former Central Institute of Nuclear Research of the former GDR. These are the RFR research reactor and the AMOR facilities for fission molybdenum production. The zero-power reactors RRR and RAKE have already been dismantled and fully removed.	Free State of Saxony
Technische Universität München	Operation of FRM-II, decommissioning of FRM	Federation, Free State of Bavaria
Various universities	Operation/decommissioning of smaller research reactors	Federation, the respective *Länder*

In all cases, the personnel expenditure is included in full in the calculated funds, whereby personnel costs may account for 50 % of the total costs, and in some decommissioning projects even more. In analogy to operation, the availability of the required numbers of qualified personnel for all tasks is thus guaranteed for the decommissioning phase as well. Education and training courses for achieving and maintaining the required expert knowledge, as well as research and education at universities and technical colleges, help to preserve the high standards of education and qualification in Germany. In this field, considerable progress has been made in the last years which is summarised in Chapter F.2.1.

F.6.3 Radiation protection during decommissioning

The provisions applicable to radiation protection of a nuclear facility which is in the process of decommissioning are similar to those which apply during the operating period. Details can be found in the reporting on Article 24 (Operational radiation protection) of the Joint Convention.

With regard to discharges from a nuclear facility during decommissioning, the same requirements apply as during operation. § 47, para. 1 StrlSchV [1A-8] prescribes limits governing the maximum doses per calendar year caused by discharges of radioactive substances with air or water from these facilities applicable to members of the public. According to § 47, para. 1 StrlSchV, provisions must be taken in order to prevent the uncontrolled discharge of radioactive substances. According to § 47, para. 3 StrlSchV, the permissible discharge of radioactive substances with air and water is determined by the competent authority by limiting the activities or activity concentrations.

The requirements pertaining to the control of emissions and immissions are regulated in § 48 StrlSchV.

F.6.4 Emergency preparedness

The extent of the measures for emergency preparedness during decommissioning of a nuclear facility is adapted in line with the hazard potential posed by the facility. Essentially, however, such measures do not differ from the measures for emergency preparedness during operation (see reporting on Article 25).

F.6.5 Keeping of records

The keeping of records of information important for decommissioning concerns, firstly, records pertaining to the construction and operation of the nuclear facility which will need to be accessed later in the decommissioning phase; and secondly, records generated during decommissioning and which are relevant to the long-term documentation of decommissioning itself. In the following account, those two issues are dealt with separately.

Keeping of records of information pertaining to construction and operation

Records of information and documentation pertaining to the construction and operation of nuclear power plants are regulated in nuclear safety standard KTA 1404 “Documentation during the Construction and Operation of Nuclear Power Plants” (see Safety Standards of the Nuclear Safety Standards Commission (KTA) in Annex L-(e) Part 5). The need for all relevant documentations to be kept available is derived from criterion 2.1 of the “Safety Criteria for Nuclear Power Plants” [3-1] which stipulates that all documentation necessary for quality assessment must be kept available. This requirement is specified in nuclear safety standard KTA 1404, according to which the following applies:

> *The documentation in nuclear power plants comprises all documents which serve as certificates in the licensing and supervisory procedure as well as all organisational regulations that are the basis for the safe operation.*
>
> *The purpose and function of the documentation are, among others,*
>
> a) *proving the existence of or compliance with statutory prerequisites (e.g. licensing prerequisites in accordance with § 7, para. 2 AtG),*
>
> b) *describing the required condition of the facility and the essential processes during its construction,*
>
> c) *enabling an assessment of the actual condition of the facility,*
>
> d) *presenting the circumstances and provisions required for a safe operation of the facility,*
>
> e) *enabling the feedback of experience, and*
>
> f) *providing a knowledge base for ageing management.*

These records also include the documentation of operation. In addition, KTA 1404 stipulates the following with respect to the completeness of documentation and the updating thereof:

> *With respect to the information contained, the documentation shall be complete, explicit and unambiguous.*
>
> *The documentation shall describe both the required state and the actual state of the power plant and its parts and of the organisation.*
>
> *The licence applicant or licensee shall be responsible for creating, maintaining, updating and archiving the documentation.*

This means that not only the state of the facility at the start of operation must be fully documented but that this documentation must also be adapted to all changes and must reflect the actual state of the facility at all times. This ensures that all relevant information from the operating phase is available when required for the decommissioning phase. KTA 1404 further specifies that the documentation must be safely kept at a place and in a form suitable for long-term storage, and that a secondary set of documents must be retained at a place where it is not endangered by any impact that may originate from the facility. According to the decommissioning guideline [3-73], keeping of a duplicate documentation is only required until removal of the spent fuel. The period for which records have to be kept depends on the type of documents and ranges from 1 to 30 years.

These requirements also apply analogously to other types of nuclear facilities in the scope of the Joint Convention. Within the context of nuclear regulatory supervision, the competent authority satisfies itself that the records have been duly updated and correctly filed.

Keeping of records of information from the decommissioning phase

As for the operating phase, information from the decommissioning phase which have to be kept for longer periods of time cover a number of topics, such as operation, surveillance and radiation protection, in particular,

- shift logs including shift handover protocols,
- protocols of surveillance and measurements of activity discharges,
- reports on incidents and abnormal events as well as the chosen countermeasures,
- record keeping on measurements of individual doses and body doses,
- record keeping on production, acquisition, transfer and other dispositions of radioactive substances,
- protocols of contamination measurements according to § 44 StrlSchV in cases where limits were exceeded.

Record keeping on production, acquisition, transfer and other dispositions of radioactive substances and on cleared materials, which is regulated in § 70 StrlSchV [1A-8] is of particular relevance for the decommissioning phase. § 70, para. 6 requires that such records must be kept for 30 years from the date when the material referred to is removed from the facility or when the clearance procedure has been completed. Records and documentation must be deposited with the competent authority at the request of the latter.

§ 70, para. 6 StrlSchV further requires that the records and documentation must be deposited at a place designated by the competent authority without delay if activity ceases prior to the end of the prescribed period. This ensures that the relevant documentation is still kept for the required period even if the operator of a nuclear facility no longer exists.

According to the decommissioning guideline [3-73], the operator should prepare a final decommissioning report after completion of all decommissioning work and keep it together with the documentation.

G Safety of spent fuel management

This section deals with the obligations under Articles 4 to 10 of the Convention.

Developments since the Fourth Review Meeting:

In the spring of 2010, WENRA issued a revised "Waste and Spent Fuel Storage Safety Reference Levels Report" (Version 2.0). The action plan for Germany that resulted from the benchmarking of the national regulations has been largely implemented by the ESK's guidelines for the dry cask storage of spent fuel [4-2] and the ESK guidelines for the performance of periodic safety reviews and on technical ageing management for storage facilities for spent fuel and heat-generating radioactive waste [4-5a].

In 2013, the ESK issued the statements on stress tests for nuclear waste management facilities in Germany [4-11]. These stress tests were performed to assess the robustness of facilities against impacts that go beyond the design requirements in the licensing procedures.

G.1 Article 4: General safety requirements

Article 4: General safety requirements

Each Contracting Party shall take appropriate steps to ensure that all stages of spent fuel management, individuals, society and the environment are adequately protected against radiological hazards.

In so doing, each Contracting Party shall take appropriate steps to:

i) ensure that criticality and removal of residual heat generated during spent fuel management are adequately addressed;

ii) ensure that the generation of radioactive waste associated with spent fuel management is kept to the minimum practicable, consistent with the type of fuel cycle policy adopted;

iii) take into account interdependencies among the different steps in spent fuel management;

iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;

v) take into account the biological, chemical and other hazards that may be associated with spent fuel management;

vi) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation;

vii) aim to avoid imposing undue burdens on future generations.

G.1.1 Basis

The fundamental concepts of precaution regarding spent fuel management are laid down in the Atomic Energy Act (AtG) [1A-3] and the Radiation Protection Ordinance (StrlSchV) [1A-8]. According to these concepts, any unnecessary radiation exposure or contamination of persons and the environment is to be prevented, and, with due regard for the state of the art in science and technology and the particular circumstances of each individual case, is to be kept as low as practicable even where the values are below the authorised limits (§ 6 StrlSchV).

The planning of structural or technical measures to protect against design basis accidents is based on the dose limits for the environment (§§ 49 and 50 StrlSchV) or is applied mutatis mutandis.

The following principles for spent fuel management are derived from the precautionary concept:

- fundamental protection objectives on radioactivity confinement, removal of decay heat power, subcriticality, avoidance of unnecessary radiation exposure,

- requirements regarding shielding, design and quality assurance, safe operation, storage and safe dispatch of radioactive substances.

For the purpose of protection against the hazards emanating from radioactive substances and control their use, the Atomic Energy Act requires that the construction, operation and decommissioning of nuclear facilities is subject to regulatory licensing. The licensing of nuclear facilities is regulated by the Atomic Energy Act (cf. the remarks on Article 19).

Additional requirements regulate liability in case of damages [1A-11], protection against disruptive actions or other interference by third parties ([3-62], [BMU 00]) and the control of fissile material according to international conventions (cf. the remarks on Article 24).

G.1.2 Assurance of subcriticality and residual heat removal

Measures are taken to address the derived fundamental protection objectives of reliable maintenance of subcriticality and safe removal of decay heat power. Particularly regarding the dry interim storage of spent fuel from LWR, HTR, experimental and demonstration as well as research reactors, these measures are specified in greater detail by the ESK Guidelines for dry cask storage of spent fuel and heat-generating waste [4-2]. With regard to criticality safety in connection with the wet interim storage of spent fuel, KTA 3602 is applied, whilst KTA 3303 is applied with regard to the removal of decay heat power (see Safety Standards of the Nuclear Safety Standards Commission (KTA) in Annex L-(e), Part 5). Since 2007, the DIN standard DIN 25712 "Criticality safety taking into account the burn-up of fuel for transport and storage of irradiated light water reactor fuel assemblies in casks" [DIN 25712] has been available.

At present, the nuclear regulations do not yet contain specific requirements concerning subcriticality and discharge of decay heat power in a repository.

According to the safety criteria for the emplacement of radioactive waste in a mine (*Sicherheitskriterien für die Endlagerung radioaktiver Abfälle in einem Bergwerk*) [3-13], the thermal output and surface temperature of the packages for the disposal of heat-generating radioactive waste should be determined in such a way that the specified properties of the packages are maintained and the integrity of the geological formations is not endangered. For this purpose the BMU has submitted “Safety Requirements Governing the Final Disposal of Heat-Generating Waste” [BMU 10] which were adopted on 30 September 2010 by the *Länder* Committee for Nuclear Energy (LAA).

G.1.3 Limitation of radioactive waste generation

§ 6, paras. 1 and 2 of the Radiation Protection Ordinance requires that any unnecessary radiation exposure or contamination of persons and the environment shall be prevented, and, taking due account of the state of the art in science and technology and the particular circumstances of each individual case, radiation exposure or contamination shall be kept as low as practicable, even where the values are below the authorised limits. Based on this, and analogous to § 22 of the Closed Substance Cycle Act [1B-13], the requirement to keep the generation of radioactive waste associated with spent fuel management to the minimum practicable is derived. Due to optimised strategies for nuclear fuel appliance, the accumulation of spent fuel has reduced.

Moreover, private operators of nuclear facilities in the Federal Republic of Germany in any case have a vested interest in minimising waste volumes for economic reasons. These economic reasons result from state requirements in other areas, especially from the provisions of the Waste Disposal Advance Payments Ordinance (EndlagerVlV) [1A-13], according to which the advance payments for financing a repository are calculated on the basis of the volumes of generated waste.

G.1.4 Taking into account interdependencies between the different steps in spent fuel management

According to § 9a AtG it is necessary to prove to the supervising authority that adequate provisions exist for the non-hazardous re-use or controlled disposal of spent fuel (*Entsorgungsvorsorge-nachweis*). For this purpose, realistic plans are submitted annually showing that sufficient interim storage capacity remains available for those spent fuel already existing and those expected to arise in future, and that sufficient and adequate interim storage facilities are legally and technically available to meet concrete requirements for the next two years. Furthermore, similarly structured proof is also furnished to the supervising authorities regarding the interim storage of returned waste from the reprocessing of spent fuel in foreign countries, as well as for the re-use of the separated plutonium from the reprocessing of spent fuel in nuclear power plants, and for the whereabouts of the separated uranium from the reprocessing of spent fuel.

The type of conditioning (processing and packaging) depends on the specifications and requirements of the acceptance criteria laid down in the licence for the planned interim storage facility or repository.

Quantitative information showing the consideration of the reciprocal dependence can be found in the comments on Article 32 (2).

G.1.5 Application of suitable protective methods

The Atomic Energy Act and the Radiation Protection Ordinance require that precautions must be taken against potential damages in keeping with the state of the art in science and technology to guarantee effective protection. For compliance with the state of the art in science and technology on spent fuel management, internationally accepted criteria and standards of the IAEA ([IAEA 12a] and [IAEA 02]), the ICRP and the EURATOM Basic Safety Standards [1F-18] are also referred to. This is ensured by the nuclear licensing applicable to the corresponding nuclear facility (cf. the remarks on Article 19).

Compliance with the provisions of nuclear licensing is ensured by the supervision of the competent authorities of the Federal Government and the *Länder* (cf. the remarks on Article 32 (2)).

G.1.6 Taking into account the biological, chemical and other hazards

The provisions of other legal fields take into account the precautions against damage from biological, chemical and other hazards (see reporting on Article 19). Regarding disposal, which is predominantly affected in Germany, chemical and other hazards are considered within the framework of the plan approval procedure by corresponding safety analyses.

In addition, the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10] stipulates the performance of an environmental impact assessment for the construction of facilities and compliance with other licensing requirements (e.g. for non-radioactive emissions and discharges into waters).

G.1.7 Avoidance of impacts on future generations

There are no plans for a long-term storage of spent fuel in Germany. Interim storage is limited to a maximum of 40 years. The valid guidelines [4-2] require that the permitted impacts of interim storage remain at a consistently low level throughout the entire period.

"Safety criteria for the emplacement of radioactive waste in a mine" entered into force in Germany in 1983 [3-13]. They are being further developed with due regard for national and international developments, and consider the recommendations of the ICRP and OECD/NEA, the standards of the European Communities, and the safety principles of the IAEA on radioactive waste management [IAEA 06].

As things stand, the impacts of a release of radionuclides from repository operation in Germany must not exceed the dose limits applicable to nuclear power plants today. As regards the post-closure phase of a future repository for heat-generating waste, the safety requirements of the BMU [BMU 10] apply. These postulate the integrity of the rock surrounding the repository as well as an optimisation of the repository. Furthermore, limits are given for the admissible individual effective dose. For probable developments, the guidance level is 10 µSv/a, for less probable developments 100 µSv/a.

G.1.8 Avoidance of undue burdens on future generations

The safety criteria for the emplacement of radioactive waste in a mine [3-13] as well as the “Safety Requirements Governing the Final Disposal of Heat-Generating Waste” [BMU 10] already make allowance for Principle 7 of the IAEA Fundamental Safety Principles [IAEA 06]. They ensure that no undue burdens are imposed on future generations.

Financial resources have been set aside by the operators of the nuclear power plants, for decommissioning and dismantling, as well as for the disposal of all radioactive waste and spent fuel, and for the disposal of spent fuel on the basis of commercial law. If required, the reserves will also cover the interim storage of spent fuel and radioactive waste in Germany until their disposal. Once a repository has been sealed, monitoring and maintenance measures, apart from minimal evidence and control measures, are not necessary. For this reason, no relevant costs are incurred after sealing that would have to be borne by future generations.

G.2 Article 5: Existing facilities

> *Article 5: Existing facilities*
>
> *Each Contracting Party shall take the appropriate steps to review the safety of any spent fuel management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility.*

G.2.1 Fulfilment of the obligations under the Convention regarding existing facilities

The fundamental requirements governing the preventive action to be taken are set forth in the Atomic Energy Act (AtG) [1A-3], the Radiation Protection Ordinance (StrlSchV) [1A-8] and other legal provisions, as well as in non-mandatory guidance instruments (cf. the remarks on Articles 18 to 20) which satisfy, and in some cases exceed, all the requirements of this Convention. An explicit review of the faculties to verify compliance with the requirements of this Convention is therefore not felt to be necessary.

Furthermore, existing facilities are also subject to continuous regulatory control throughout their entire operational life. Whenever there are any advancements in the state of the art in science and technology, the regulatory body may insist on a corresponding upgrade in safety in accordance with the provisions of § 17 AtG.

Independently from this, the regulatory framework governing the safe management of spent fuel [4-2] stipulates regular reviews intended to ensure the compliance with the protection objectives stipulated in the Act in line with the latest state of the art in science and technology. The protection objectives encompass the protection of the general public in the vicinity of the facility, the protection of the environment and the protection of operating personnel, as well as the protection of property against the effects of ionising radiation.

G.2.2 Periodic Safety Review of storage facilities for spent fuel

The overall aim of the Periodic Safety Review (PSR) of storage facilities is to review the safety levels of nuclear facilities regularly according to the state of the art in science and technology and to assess and, if necessary, remedy the determined deficiencies.

According to § 19a, para. 3 AtG [1A-3] anyone who operates an installation (according to § 2, para. 3a, subpara. 1 AtG) is required after the start of operations (emplacement of the first cask) to conduct and to evaluate every ten years a safety review of the installation and to improve on this basis the safety of the installation continuously. The results of the safety review and evaluation shall be submitted to the supervisory authority.

Detailed requirements for the performance of the periodic safety review were prepared by the ESK on behalf of the BMU and were adopted as "ESK recommendations for guides to the performance of periodic safety reviews for storage facilities for spent fuel and heat-generating radioactive waste (PSÜ-ZL)" [4-5] in November 2010 (see also Chapter E.2.2). A periodic safety review of a reference facility has been going on since 2011 as part of a pilot project. The guideline was put up for discussion at a workshop to obtain suggestions for modifications and improvements for its further development. On the whole, the workshop showed that the above-mentioned ESK Guidelines of 2010 are in principle applicable and form a good basis for the execution of a periodic safety review for storage facilities. The potential for improvement that was revealed concerned primarily more precise phrasing. Moreover, technical issues were addressed, relating e.g. to the safety review of the casks that have already been in storage for some time. It was also suggested that references to corresponding guidelines for nuclear power plants should be avoided in order to arrive at separate, coherent guidelines for storage facilities. The revised "ESK guidelines for the performance of periodic safety reviews and on technical ageing management for storage facilities for spent fuel and heat-generating radioactive waste" were adopted in March 2014 [4-5a].

The key objectives of the PSR are as follows:

1. a summarised documentation and evaluation of all events and insights with regard to the safety level and operating reliability as well as the minimisation of the radiation exposure gathered in the review period,
2. an updated safety assessment in accordance with the state of the art in science and technology, the compliance with the safety requirements with regard to the handling and the later transfer of the transport and storage casks,
3. if necessary, derivation of findings and measures for further operation.

General requirements on content and scope of the PSR are, among others:

- an up-to-date description of the facility,
- an overview of all safety-relevant amendments that have been carried out or have occurred in the review period,
- an evaluation of operating experience and experience with the operation of similar plants,
- a review and if necessary update of the accident analysis in regard to design basis accidents and beyond design basis accidents as well as the planned measures,
- a review of the ageing measures (ageing management), and
- a review of the safety management for demonstrating the availability of suitable organisational and personnel measures and their combination with the technical safety precautions.

The result of the PSR should demonstrate compliance with the general radiological protection goal (see Chapter G.5.1) as well as the requirements derived regarding the remaining licenced operating lifetime.

The operator of the storage facility is responsible for the conduction of the PSR. The results and the measures derived are to record and to submit to the supervisory authority. If required the supervisory authority defines necessary measures for the operation of the reviewed interim storage facility and supervises the properly realisation at due date. The nuclear licensing authority (Federal Office for Radiation Protection) takes notice of the results of the PSR of the storage facility as well as of the assessment by the supervisory authority and if necessary can derive updated or additional requirements for on-going or future licensing procedures.

G.3 Article 6: Siting of proposed facilities

Article 6: Siting of proposed facilities

(1) Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed spent fuel management facility,

i) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its time of operation;

ii) to evaluate the likely safety impact of such a facility on individuals, society and the environment;

iii) to make information on the safety of such a facility available to members of the public;

iv) to consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory.

(2) In so doing, each Contracting Party shall take the appropriate steps to ensure that such faculties shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 4.

G.3.1 Taking into account site-related factors affecting safety during the operating lifetime

§ 7, para. 1 of the Atomic Energy Act (AtG) [1A-3] regulates the licensing of stationary installations for the management of spent fuel, whilst the licensing of the storage of nuclear fuel outside Government custody is regulated in § 6, para. 1 AtG. The definition in the AtG encompasses storage of spent fuel. In order to obtain such a licence, the applicant must submit documentation containing all the relevant data required for the purposes of assessment. This data is summarised in the safety report (*Sicherheitsbericht*), a key document in the licensing procedure. The nature and scope of documentation and the data it contains are regulated in the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10].

§ 2 AtVfV prescribes that the licence application for the planned construction of a new facility must be submitted in writing to the licensing authority. This application must also contain data pertaining to all relevant site-related factors.

§ 3 AtVfV specifies the nature and scope of documentation referred to in greater detail in the remarks on Article 19 (2) ii in section E.2.3. Usually, the required information pertaining to the site and the installation is compiled in the safety report and supporting documents.

An Environmental Impact Assessment (EIA) is required for installations which are listed in Appendix 1 of the Environmental Impact Assessment Act (UVPG) [1B-14]. According to nos. 11.1 and 11.3 of Appendix 1 of the UVPG, an environmental impact assessment is required for the construction and operation of facilities for the treatment of spent fuel, as follows:

11.1 Construction and operation of a stationary installation for the production, treatment, processing or fission of nuclear fuel or the reprocessing of irradiated nuclear fuel, 11.3 Construction and operation of a facility or installation for the treatment or processing of irradiated nuclear fuel or highly radioactive waste or for the sole purpose of storage of irradiated fuel or radioactive waste which is scheduled to last for more than 10 years at a place different from the one where these materials have arisen.

The licence application must be accompanied by further documents as specified in § 3, para. 2 of the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10] (cf. the section on EIA under the remarks on Article 19 (2) ii) in section E.2.3):

1. an overview of the most relevant alternatives for the technical procedures, including reasons for the choice, as far as these information may be relevant for the assessment of the admissibility of the intended work according to § 7 AtG,

2. indication of difficulties having become apparent during preparation of the data for the assessment of the requirements within the environmental impact assessment, especially insofar as these difficulties may relate to lack of knowledge and evaluation methods or to technological gaps.

Within the meaning of Article 6 (1) i of the Convention, this detailed information will enable the authorities and any authorised experts consulted by them to assess all relevant site-related factors which might affect the safety of spent fuel management facilities during their operational life.

Especially for the dry cask storage of spent fuel and heat-generating radioactive waste, the ESK guideline [4-2] makes further requirements – apart from the legal requirements already mentioned – for the structural installations, for the shielding of ionising radiation to be ensured by the latter, for the heat removal from the casks and from the storage building, for the criticality safety to be ensured, and for other areas. Thus guideline is used as a basis for the licensing of new storage facilities.

G.3.2 Impacts on the safety of individuals, society and the environment

In addition to the information outlined in the remarks on Article 6 (1) i, the safety report and the auxiliary documents must contain data on the following topics (cf. the remarks on Article 19 (2) ii):

- description of construction and operation: overview of the entire project; plant operating procedures, quality management concept, fire protection concept, documentation etc.,

- operational radiation protection: radiation protection areas in the plant, radiation and activity monitoring in rooms and in the plant, physical radiation protection monitoring of individuals, monitoring of releases of radioactive substances and environmental monitoring, surveillance of material which is released from the controlled area, measures to reduce exposure of personnel and in the environment,

- waste and residual material management: release of cleared material from the operation, conditioning, storage and (if relevant) transfer of radioactive operational waste,

- exposure in the environment: applicable limit values for discharges with air and water including substantiation, calculation of the exposure resulting from the discharge of radioactivity and from direct radiation,

- incident (design basis accident) analysis: description of the protection objectives, possible incidents, incident analysis for operation, exposure as a result of incidents, and

- further effects of plant operation on the environment: description, analysis and evaluation of the effects on man, animals, plants, soil, water, air, climate and landscape as well as cultural and other material assets.

In addition to this, other information relating to the site and the planned facility as outlined above are also relevant in this context. The ESK guidelines [4-2] summarise the requirements in particular for the dry cask storage of spent fuel and heat-generating radioactive waste. Within the meaning of Article 6 (1) ii of this Convention, this will enable the competent authorities and any authorised experts consulted by them to assess the presumed effects of a spent fuel management facility on the safety of individuals, society and the environment.

G.3.3 Information of the public on the safety of a facility

Projects to construct a spent fuel management facility are publicly announced and the documents are publicly displayed in accordance with the provisions of § 4 of the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10]. The public hearing which may be necessary is regulated in §§ 8 to 13 AtVfV. The public hearing is the oral discussion of the previously filed objections against the planned work, carried out under participation of the authority, the objectors and the applicant. The public hearing is intended to provide those who have raised objections during the period determined by § 7 AtVfV with the opportunity to explain their objections. According to § 12, para. 1 AtVfV [1A-10], the public hearing is not open to the general public.

Details concerning the related procedures are described in the section on involvement of the public under the remarks on Article 19 (2) ii in section E.2.3.

This approach, particularly the involvement of the public as defined in the AtVfV and the Environmental Impact Assessment Act (UVPG) [1B-14], ensures that the general public has access to all the necessary information regarding the safety of planned spent fuel management facilities as stipulated by Article 6 (1) iii of this Convention.

G.3.4 Consultation of neighbouring Contracting Parties

§ 7a AtVfV [1A-10] regulates the procedure for cases of transboundary environmental impacts; this procedure is also relevant in connection with spent fuel management facilities. According to § 7a, para. 1 AtVfV, in cases where

- a project which is subject to EIA may have substantial impacts (as described in the safety report or in the information on other environmental impacts) on the protected entities cited in § 1a AtVfV (man, animals, plants, soil, water, climate, landscape, cultural or other material assets) in a foreign state, or
- another state that might be considerably affected by the impacts makes a corresponding request,

the competent authorities of the foreign state have to be notified of the project with respect to EIA at the same time and to the same extent as the authorities that are to be involved under the terms of the German Atomic Energy Act (AtG) [1A-3], allowing the authority of the other state a reasonable period of time for notifying whether participation in the procedure is requested.

The licensing authority in Germany should ensure that the project is publicly announced in a suitable way in the foreign state, that details are given of the authority to whom any objections may be submitted, and that mention is made of the fact that any objections not founded on titles under private law are excluded once the set period for objections has expired.

On the basis of §§ 2 and 3 AtVfV, the German licensing authority will give the involved authorities of the foreign state the opportunity to voice their opinions on the application on the basis of the submitted documents within an appropriate period before reaching its decision. Citizens of that state are accorded equal status with German citizens with respect to their further involvement in the licensing procedure.

§ 7a, para. 2 AtVfV specifies that upon request, the applicant must supply translations of the required summary, as well as any other information about the project which may concern trans-boundary involvement, in particular concerning trans-boundary environmental impacts.

According to § 7a, para. 3 AtVfV, consultations are to be held, where necessary, between the supreme German Federal and the authorities of the *Länder* and the competent authorities of the foreign state regarding the trans-boundary environmental impacts of the project and any measures for avoiding or reducing them.

Furthermore, § 8 of the Environmental Impact Assessment Act (UVPG) shall also apply to the participation of the authorities in other countries; insofar a protected commodity in another state may be affected.

In addition, Article 37 of EURATOM [1F-1] requires each Member State of the European Atomic Energy Community to provide the European Commission with general data relating to any plan for the disposal of radioactive waste in whatever form which will enable it to determine whether the implementation of such a plan is liable to result in the radioactive contamination of the water, soil or airspace of another Member State. This also satisfies the requirements of Article 6 (2) of this Convention. Such data usually comprise details of the site, the plant, the release of radioactivity into the atmosphere or in liquid form during normal operation, the management of solid radioactive waste, any unplanned releases of radioactive substances, and environmental monitoring.

G.3.5 Measures to avoid unacceptable effects on other Contracting Parties

The effects of the operation of spent fuel management facilities on protected commodities, such as man, animals, plants, soil, water, air, etc., are described in the documents supplied by the applicant, as outlined in the remarks on Article 6 (1).

Effects on other Contracting Parties of this Convention which are adjacent to the spent fuel management facility may result from the licenced liquid and gaseous releases from the plant during normal operation and from possible additional release of radioactivity into the environment during incidents:

- The release of radioactivity during normal operation is limited by § 47 of the Radiation Protection Ordinance (StrlSchV) [1A-8] in such a way that the doses resulting from discharges with water and air will not exceed the dose limits specified in Table F-2 for any individual member of the general public per calendar year.

- The release of radioactivity during incidents in spent fuel management facilities is regulated by the provisions of §§ 49 and 50 StrlSchV, respectively, depending on the type of facility. § 49 StrlSchV specifies that for local interim storage facilities for spent fuel, the doses caused by releases of radioactive substances into the environment in the case of the most severe design basis accident must not exceed the limits specified in Table F-2. In cases falling under the scope of § 50 StrlSchV, the nature and extent of protective measures are stipulated by the competent authority, with due consideration for the individual case, particularly with regard to the hazard potential of the plant and the likelihood of an incident occurring.

Concerning the effects on other Contracting Parties, it is important to consider that the AtVfV prescribes the involvement of the authorities of affected neighbouring states [1A-10] (see above). As such, those authorities will be informed about the possible radiological effects of normal operation of the plant as well as any potential incidents. Provided the specified dose limits, which correspond to the relevant EU regulations and to international standards, are also used as a basis by other Contracting Parties, then the effects will also be acceptable to them.

G.4 Article 7: Design and construction of facilities

> *Article 7: Design and construction of facilities*
>
> *Each Contracting Party shall take the appropriate steps to ensure that:*
>
> *i) the design and construction of a spent fuel management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases;*
>
> *ii) at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a spent fuel management facility are taken into account;*
>
> *iii) the technologies incorporated in the design and construction of a spent fuel management facility are supported by experience, testing or analysis.*

G.4.1 General protection objectives

For these facilities (cf. Table L-1 to Table L-4) the protection objectives according to § 1 subpara. 2 AtG [1A-3] apply, namely the

- protection of life, health and property against the hazards of nuclear energy and the detrimental effects of ionising radiation

or those of § 1 of the Radiation Protection Ordinance (StrlSchV) [1A-8], i.e. the

- protection of man and the environment against the harmful effects of ionising radiation.

Furthermore, § 6, para. 2 AtG contains the licensing conditions which – if adhered to – ensure that the protection objectives are fulfilled. Both cover the stipulations of the Joint Convention.

During the licensing procedure, the competent licensing authorities make sure that the corresponding requirements are fulfilled. This means that constant checks are performed during the design phase already that the protection objectives are fulfilled, both under normal operating conditions and in the event of an uncontrolled accidental release.

G.4.2 Provisions for decommissioning

The decommissioning and dismantling of a spent fuel management facility is governed by the same legal prerequisites and peripheral requirements as other nuclear facilities. The operation of spent fuel management facilities is licenced for a specified purpose and the facilities must be removed once the licence has expired. There are also regulations governing decommissioning/dismantling. The BMU has decreed that the ESK guidelines on dry cask storage of spent fuel [4-2] must be applied. This guideline contains the following provision concerning decommissioning:

> *"The interim storage facility is to be designed and constructed such that it can be decommissioned in compliance with the radiation protection requirements and can either be made available for alternative use or removed. Prior to any further use or demolition of the storage building, it is to be demonstrated by measurements that the building is not contaminated or has been sufficiently decontaminated and is free of any inadmissible activation. The requirements under building and waste law are to be observed."*

This means that the radiation protection principles and requirements set forth in the StrlSchV must be observed during the decommissioning and dismantling of these types of facilities. However, additional regulations from the Closed Substance Cycle Act [1B-13] and the building regulations of the *Länder* must also be observed. Those statutory requirements combine to form the legal framework within which the technical execution of decommissioning is to be planned, which must furthermore be in line with generally accepted technical rules.

G.4.3 Technical bases

The construction of installations in Germany is governed by the commonly accepted technical rules – e.g. the specifications laid down in the DIN/EAN standards. In the nuclear sector, the requirements specified in KTA safety standards additionally apply (see the remarks on Article 19 (2) i in Section E.2.2) and the state of the art in science and technology must also be observed.

These standards, as well as the state of the art in science and technology, are derived from experience. Hence, in Germany, the experiences gained from nuclear research installations as well as from industrial application have been incorporated into the regulatory framework. Technical safety standards are issued by the KTA, which is comprised of representatives from research, industry and administrative bodies who pool their experience from the various different areas of nuclear safety.

The development of transport and storage casks is based on many years of experience in the design and manufacturing of such casks, as well as on testing e.g. by drop tests and by numerical analysis based on experimental results. Both publicly and privately funded research programmes (e.g. long-term safety analyses) address specific issues, the results of which are incorporated into the revisions of existing KTA safety standards as well as in the specification of new rules.

G.5 Assessment of the safety of facilities

> *Article 8: Assessment of safety of facilities*
>
> *Each Contracting Party shall take the appropriate steps to ensure that:*
>
> *i) before construction of a spent fuel management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its time of operation shall be carried out;*
>
> *ii) before the operation of a spent fuel management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph i).*

G.5.1 Assessment of safety in the licensing procedure

The assessment of the safety of nuclear facilities for the treatment of spent fuel (storage facilities and the Gorleben pilot conditioning plant PKA), and the assessment of environmental impacts conducted prior to the construction of such a facility, take place within the context of a licensing procedure (cf. remarks on Article 19 (2) ii).

An assessment of the safety and environmental impacts conducted prior to commissioning takes place within the context of the accompanying supervision under the relevant nuclear laws.

Regulatory basis

The construction and operation of nuclear facilities for spent fuel management is subject to licensing under the Atomic Energy Act (AtG) [1A-3]. For the building work, a building permit is also required under the Building Code of the respective *Land*.

Applications for licences under the Atomic Energy Act must be submitted to the competent licensing authority. The application must include a statement on the extent to which the nuclear facility ensures the necessary precautions against damage according to the state of the art in science and technology, and meets the requirements of the rules and regulations in force. The nature and content of the documents to be submitted with the application must meet the requirements of the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10], or in the case of facilities for the storage of spent fuel, must fulfil them mutatis mutandis. The necessary documents (see also KTA 1404, cf. Safety Standards of the Nuclear Safety Standards Commission (KTA) in Annex L-(e), Part 5) are listed in detail in the reporting on Article 19 (2) ii and iii in Section E.2.

Transposing the European requirements for an environmental impact assessment under [1F-13], into national law and with the revision of the Environmental Impact Assessment Act (UVPG) [1B-14], environmental impact assessments have been conducted as a subsidiary part of the licensing procedure for the construction of nuclear facilities for the storage of spent fuel for which applications have been submitted since 1999. In such cases, the documents have to be supplemented by

- a presentation of the possible effects of the project on humans, fauna, flora and their habitats, on water, air, and the climate, as well as on the landscape and cultural and material assets,
- an overview of the technical process alternatives examined by the applicant, and the reasons for selection, if significant, as well as by
- notes on any difficulties experienced in compiling the information for the assessment of environmental impacts.

Regulatory reviews

In the licensing and supervision procedure, the competent authorities are responsible for the review of the documents submitted and the licensing prerequisites. According to § 20 AtG [1A-3], experts may be consulted for it. The basic requirements governing expert opinions are formulated in a directive [3-34]. The independent experts review in detail the documents and licensing prerequisites submitted by the applicant. On the basis of the evaluation standards, details of which must be included in the expert opinion, they perform their own tests and calculations - preferably using methods and programmes other than those of the applicant - and give an expert assessment of these results. Unless there are specific provisions governing the safety assessment of nuclear facilities for the treatment of spent fuel, any relevant rules from the existing set of rules and regulations for the safety assessment of nuclear power plants are applied mutatis mutandis (e.g.

[3-23], [3-33-2], [3-0-1], [3-0-2] and KTA 2101). Specific requirements for nuclear facilities for the treatment of spent fuel may be derived from international recommendations, such as those of the IAEA [IAEA 12a].

A licensing prerequisite is the result of the verification of the reliability of persons responsible for the handling of radioactive material. According to § 12b AtG, the reliability check is carried out by the competent authorities as a protection against unauthorised acts which may lead to a diversion or major release of radioactive material [1A-19].

Requirements on design and operation

The requirements for design and operation of facilities for spent fuel management are presented exemplarily by means of the requirements for the dry storage facilities for spent fuel:

Regarding the technical design and the operation of facilities for the dry cask storage of spent fuel, guidelines were recommended in 2001 by the Reactor Safety Commission (RSK). These were last updated in 2013 by the Nuclear Waste Management Commission (ESK) [4-2]. These guidelines were prepared in the wake of the large number of licence applications in 1999 and 2000 to build and operate on-site fuel storage facilities, which were granted in 2004.

The design and operation of an interim storage facility must meet the following radiological protection objectives in order to ensure that the precautions against damage reflect the state of the art in science and technology:

- Safe enclosure of the radioactive inventory
  The barriers or spent fuel casks that ensure the containment must retain sufficient integrity (monitoring of sealing function, formulation of a repair concept) under all credible circumstances (hazardous incidents, accidents, ageing, impacts, etc.).

- Avoidance of unnecessary radiation exposure, limitation and monitoring of the radiation exposure of operating personnel and the general population
  Adherence to the limit values of the effective dose and the organ dose for individuals of the public and for occupationally exposed persons according to §§ 46 and 55 StrlSchV [1A-8] as well as adherence to the accident planning reference levels according to § 49 StrlSchV, even in the most unfavourable case case of an accident; avoidance of unnecessary radiation exposures and dose reduction according to § 6 StrlSchV (receiving and dispatching checks on the fuel assembly casks, formulation of a radiation-protection concept, division of the interim storage facility into radiation protection zones, radiation monitoring in the interim storage facility and the vicinity).

- Reliable maintenance of subcriticality
  Proof of the criticality safety of the fuel assemblies during storage shall be demonstrated for the least favourable conditions to be expected during specified normal operation (limitation of the enrichment of the fuel assemblies, exclusion or limitation of neutron moderation, use of neutron absorbers, maintenance of the appropriate spacing) [DIN 25403], [DIN 25478], [DIN 25712].

- Sufficient removal of decay heat power
  Even in the case of combined impacts on the effectiveness of heat removal, the operators must guarantee that only admissible temperatures will occur. The mechanisms of heat removal must be independently operative (passively by natural convection).

From these protection goals, further requirements can be derived which are essential for compliance with the above targets:

- shielding of the ionising radiation,
- design, execution, and quality assurance suitable for operation and maintenance (KTA 1401, see Safety Standards of the Nuclear Safety Standards Commission (KTA) in Annex L-(e)),
- safety-oriented organisation and performance of operation,
- safe handling and shipment of the radioactive materials (see also [IAEA 12b]),
- design against accidents and provision of measures to reduce the harmful effects of events that exceed the design parameters (incident analysis). Calculation of the effects of hazardous incidents and of pre-existing pollution prevailing at the site before the facility is constructed is regulated by [2-1] and [3-33-2].

In the context of the accident analysis, a distinction is made between external and internal events, the latter being caused by the spent fuel treatment facilities themselves. An assessment of these events is made by the competent licensing authority as part of the licensing procedure. Recommendations for disaster control are made in [3-15] (see reporting on Article 25).

In connection with dry storage, the following internal events generally have to be considered:

- mechanical impacts, such as the crash of a fuel assembly cask, collision of a cask upon handling, and the crash of a load onto the cask (cf. drop test examples of BAM in Figure G-1) and
- fire.

Figure G-1: Drop test of a transport and storage cask (cooled down to -40°C) for vitrified waste at the test facility of the Federal Institute for Materials Research and Testing (BAM) within the framework of an approval procedure under traffic law (Copyright: BAM)

According to the guidelines, external natural impacts and man-made impacts from outside are taken into consideration (see also [BMU 00], [3-62]):

- external natural impacts such as storm, rain, snow, frost, lightning, flooding, landslides and earthquakes,

- man-made impacts from outside such as the effects of harmful substances (e.g. poisonous or explosive gases), blast waves caused by chemical explosions, fires (e.g. forest fires) spreading to the facility, mines caving in, and aircraft crashes.

Further developments have to be taken into account depending on the conditions at the respective sites. For example, effects from events affecting a neighbouring power plant are also considered, e.g. the collapse of structures, a turbine failure, or the failure of vessels with high energy content, as far as debris from such events may affect the storage facility.

The safety-related requirements relate to storage of the waste that is of a limited duration. For concrete verification, the periods applied for in the respective licensing procedures have to be applied. In the storage licences granted so far, this period has been 40 years, which is usually applied as the yardstick for other licensing procedures. By imposing further conditions at a later stage during the operating lifetime, the competent authority may demand adaptations of the facility to comply with the state of the art in science and technology as far as this is necessary to fulfil the safety requirements (cf. § 17, para. 1, subpara. 3 AtG [1A-3]).

G.5.2 Safety assessment in the supervisory procedure prior to operation

The review of the safety of nuclear facilities that accompanies their construction prior to commissioning is carried out by the competent supervisory authority under the Atomic Energy Act, i.e. the competent supreme *Land* authority. The authority determines whether the statements contained in the documents submitted, and any supplementary requirements in the licence, are being observed and implemented. Independent experts are also consulted for these supervisory duties.

If there are any relevant deviations from the state of the art in science and technology as specified in the licensing documents, modifications become necessary according to § 7, para. 1 or § 6 AtG [1A-3] for which a modification licence is required; in this connection, all documents also have to be adapted to the corresponding state of the art in science and technology. Here, it has to be checked whether the modified facility satisfies overall the imperative of damage precaution. This check extends to all effects of the modification on the safety of the facility and its operation. A deviation from the licenced status or operation of the facility is considered as being substantial if it does not show merely irrelevant consequences for the safety level at the facility. Modification licences are applied for at the competent licensing authority by the operator of the respective nuclear facility, sometimes within the framework of an order issued by the nuclear supervisory authority.

Figure G-2: Transport cask storage building at Ahaus (picture rights: GNS)

According to the guidelines of the ESK [4-2], the commissioning of a storage facility (see Figure G-2 showing the transport cask storage building at Ahaus as an example of a fuel store) has to include a commissioning programme consisting of the commissioning tests of all installations. This programme serves for proving that the installations have been properly installed for the planned operations and can be operated as specified, which ensures that the protection goals are met. The commissioning programme is approved by the competent authority.

G.5.3 Stress test

The earthquake off the eastern coast of Japan on 11 March 2011 and the resulting flooding by a tsunami triggered a nuclear disaster at the Fukushima site. Even though the initiating events of the nuclear disaster in Japan, in particular the magnitude of the earthquake and the height of the tidal wave, cannot be applied directly to European and German conditions, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) deemed it nevertheless necessary to perform not only a robustness test for German nuclear power plants and research reactors, but also a stress test for the facilities for the management of spent fuel and radioactive waste in Germany as well as for the uranium enrichment plant at Gronau and the fuel factory at Lingen. The Nuclear Waste Management Commission (ESK) was commissioned to develop appropriate assessment concepts for these facilities. The results of the stress test are documented in two ESK statements [4-11].

The review was based on a questionnaire that was answered by the operators of the facilities. Apart from questions about the load cases earthquake, flooding, heavy rain, other weather-related events, failure of the electrical energy supply, plant-internal fire, fires outside the plant, aircraft crash, and blast pressure wave, the questionnaire also contained the stress level or levels of protection that the ESK applied as a basis in the assessment. The following questions were used as assessment criteria:

a) Will the vital functions be maintained at the stress levels?

b) Which maximum effects are realistically conceivable at the stress levels?

c) Are any cliff edge effects foreseeable and if so, have they been taken into account?

d) On which basis has the assessment been made and is it plausible and comprehensible?

Issues related to the security (physical protection) of facilities were not considered in this review. In terms of the nuclear waste management facilities, the results of the stress test can be summarised as follows:

The storage of the spent fuel and heat-generating waste is based on a robust protection strategy, in which compliance with the essential protection goals during storage in normal operation and in case of accidents is ensured primarily by the metallic thick-walled containers. The design of the containers furthermore ensures that, even in the event of a beyond design basis accident, no major disaster control measures are required.

The investigations and reviews have shown that the storage of spent fuel and heat-generating waste fulfils the highest stress level and achieve the highest degree of protection in almost all load cases.

The facilities for the treatment of spent fuel, the Gorleben pilot conditioning plant and the not-yet dismantled operating sections of the Karlsruhe reprocessing plant have significant reserves against beyond design basis events. They reach the highest stress level or the highest level of protection for many postulated load cases.

Regarding the storage facilities for low- and medium-active radioactive waste as well as the stationary facilities for conditioning low- and medium-active radioactive waste, the examinations showed that even in the case of beyond design basis accident events, any serious consequences will be limited to a region not exceeding 100 meters in diameter around the respective facility. Authorities must therefore decide for a maximum range of 100 meters around the facility whether measures such as access bans need to be taken. In that regard, these facilities also proved to be robust. Any prolonged flooding of the facilities or a tidal wave propagating through the buildings has practically no radiological consequences.

Regarding repositories, the studies focused on their surface installations. The stress test for the repositories included in the examinations (ERAM, Konrad) and the Asse II mine showed that a transgression of the intervention limits for an evacuation of the surrounding area can be excluded under the assumed loads.

Hence, due to postulated beyond design basis load cases, no failure of components or measures that would lead to a sudden increase in the radiological impact outside the plant ("cliff edge effect") has to be feared for any of the facilities that have been assessed. Furthermore, no deficits in the design requirements of the facilities that were assessed have become visible in the stress test.

G.6 Article 9: Operation of facilities

Article 9: Operation of facilities

Each Contracting Party shall take the appropriate steps to ensure that:

i) the licence to operate a spent fuel management facility is based upon appropriate assessments as specified in Article 8 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements;

ii) operational limits and conditions derived from tests, operational experience and the assessments, as specified in Article 8, are defined and revised as necessary;

iii) operation, maintenance, monitoring, inspection and testing of a spent fuel management facility are conducted in accordance with established procedures;

iv) engineering and technical support in all safety-related fields are available throughout the time of operation of a spent fuel management facility;

v) incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body;

vi) programmes to collect and analyse relevant operating experience are established and that the results are acted upon, where appropriate;

vii) decommissioning plans for a spent fuel management facility are prepared and updated, as necessary, using information obtained during the time of operation of that facility, and are reviewed by the regulatory body.

G.6.1 Licence to operate the facility

In Germany, spent fuel management only involves the operation of storage facilities as the licence of the pilot conditioning plant at Gorleben (PKA) is currently only limited to the repair of defective casks and no repository is available yet. Therefore the following will only deal with said facilities.

The storage facilities have a licence for an operating life of 40 years from the beginning of emplacement.

The entire operation should be structured in a suitable manner so as to ensure the safe performance of the operational processes. In particular, the administrative prerequisites regarding personnel, organisation and safety must be fulfilled. Clear instructions must be formulated in an operating manual for operational processes, abnormal operating conditions, accident management and elimination of the consequences of incidents and accidents. Competencies and responsibilities must be clearly defined. The competent authority supervises compliance with the conditions and requirements.

At each facility, cold testing with one cask for each cask type licensed for storage is performed for the entire handling procedure, including radiation protection measures, before casks are stored there for the first time.

G.6.2 Definition and revision of operating limits

All operational processes and the measures to be taken in case of incidents are described in form of clear service instructions, which are laid down in an operating manual in fulfilment of the ESK Guidelines for dry cask storage of spent fuel and heat-generating waste [4-2]. In particular, all aspects relating to safety must be addressed, and the procedure in the event of modifications or additions of components and procedures must be specified. This is intended to ensure that the personnel is able to promptly and confidently initiate and perform the necessary measures in case of abnormal operation or incidents and that the limits defined in the Radiation Protection Ordinance (StrlSchV) [1A-8] as well as the limits specified, in particular, for heat output and inter-lid pressure in the licence are kept for casks for dry interim storage. This procedure is subject to regulatory supervision. Should it turn out during the facility's operating lifetime that there is a need to adjust these limits, this is initiated by the licensing authority upon application of the licensee.

G.6.3 Compliance with specified procedures

For storage facilities, the assumptions and boundary conditions for cask properties and fuel assemblies used in the safety inspections are compiled in the form of technical acceptance criteria. Performance criteria are drawn up for compliance with the technical acceptance criteria. This also includes operating instructions and test procedures which must be taken into account during the loading of the casks. Compliance is supervised by experts from the competent supervisory authority.

The effectiveness of the lid seals has to be verified upon installation. According to the ESK guidelines [4-2], the standard helium leak rate must not exceed a value of 10^{-8} Pa · m³/s for the entire lid barrier. A monitoring system is used for operational monitoring of the sealing function of the casks. This sends a signal to a central monitoring point as soon as a malfunction occurs in one of the two cask sealing systems. The monitoring system allows the affected cask to be identified.

The condition as specified of the safety-relevant installations of the storage facility is ensured by regularly recurring inspections. Their frequency depends on the safety significance of the component to be inspected. The recurring inspections are laid down in a testing manual. The results of the recurring inspections have to be documented and are available for the purpose of long-term monitoring.

The operation of the facility is monitored so that any safety-significant disturbances of operation and accidents will be reliably detected and the counter-measures specified in the operating manual can be taken.

In the event of failures or malfunctions of safety-significant components and systems, repair measures will be initiated immediately in consultation with the competent authority.

Furthermore, regarding components or component parts that may need to be replaced, care will be taken that this work can be executed without any major disturbance of operations in the storage facility and preferably shielded off from the radiation field of the storage casks and that adequate accessibility is provided.

Each emplacement, removal or relocation of casks is documented. In this connection, the constant adherence to the maximum radiological, thermal and mechanical loads on which the design of the storage building is based is documented.

Regular written operation reports are prepared about the operation of the storage facility, containing the information about all relevant operational processes. On the whole, the report is to provide evidence that the radiological, thermal and static boundary conditions are adhered to with the casks that are emplaced.

A monitoring concept is drawn up in order to control long-term and ageing effects during the storage facility's operational period as detailed in the licence application. Here, a general distinction is made between parts and components that are designed for the entire period of use of the facility, and those that may need to be replaced. The essential safety-related properties of the systems, parts and components are ensured for the entire operating period. In particular, the condition of the lifting trunnions must allow the casks to be moved within the facility at any time.

Also the reporting obligation of the condition of the storage building and of the components necessary for the interim storage every 10 years is subject of the monitoring concept.

Regulatory supervision ensures compliance with the procedures on operation, maintenance, monitoring, inspection and testing established in the nuclear licensing procedure for spent fuel management facilities.

G.6.4 Availability of technical support

Report on the measures to ensure engineering and technical support during the operating lifetime of the facilities by providing adequate competent staff was already made in the remarks on Article 22 i.

The technical systems and equipment used for outward shipment of the fuel assembly casks are kept available until all casks loaded with fuel assemblies have been removed.

All auxiliary systems, such as cranes and monitoring systems are provided and maintained throughout the operating lifetime of the facility.

Periodic testing is performed on all essential systems and equipment of the facility. The respective tests are specified in a testing manual. The technical equipment required for this purpose is kept available throughout the facility's operating lifetime.

G.6.5 Reporting of significant incidents

The obligation incumbent upon operators of facilities licenced according to § 6 or § 7 AtG [1A-3] to report accidents, incidents and other safety-significant events to the supervisory authority is regulated in the Nuclear Safety Officer and Reporting Ordinance (AtSMV) [1A-17]. The reporting criteria are formulated as far as possible plant-specifically in the Nuclear Safety Officer and Reporting Ordinance (AtSMV).

The operator of the nuclear facility reports an event to the competent supervisory authority of the *Land* is the event is reportable according to the reporting criteria. The operator is responsible for the accurate and complete reporting of a reportable event in due time. The supervisory authority on its part, following its first assessment of the circumstances, reports the event to the BMUB and at the same time to the central registration agency, the Federal Office for Radiation Protection, and the BMUB's authorised expert organisation, *Gesellschaft für Anlagen- und Reaktorsicherheit* (GRS) *mbH*. The Federal Office for Radiation Protection checks the classification of the event once more by comparing it with other national events. If it is not possible to provide all necessary details by means of the reporting form until the deadline for making a written report, the report has to be marked as provisional. A full report (final report) has to be submitted to the supervisory authority as soon as the missing information has become available, at the latest, however, after two years.

Reportable events are classified into one or several reporting categories by applying the reporting criteria on the basis of a first engineering assessment of the cause of the event. This procedure considers in particular that the authority must be able to take precautionary measures even if an in-depth safety assessment of the event is not yet available.

Category S (Immediate report – deadline: immediately)
Events have to be allocated to Category S that have to be reported immediately to the supervisory authority to enable the latter to initiate or order measures at very short notice if necessary. This also includes events that indicate acute safety deficiencies. Reports of Category S have to be made immediately by telephone or in written form by communications facilities; after no longer than 5 days following first knowledge about the event, any supplement to or, if necessary, correction of the report has to be submitted on a special reporting form.

Category E (Urgent report – deadline: within 24 hours)
Events have to be allocated to Category E that do not require any immediate action by the supervisory authority but whose cause has to be clarified quickly and, if necessary, rectified within an appropriate period of time for reasons of safety. These are usually events of potential – but not acute – safety significance. Reports of category E have to be made after no longer than 24 hours following the event at the latest by telephone or in written form by communications facilities; after no longer than 5 days following first knowledge about the event, any supplement to or, if necessary, correction of the report has to be submitted on a special reporting form.

Category N (Normal report – deadline: within 5 working days by means of reporting form)
Events have to be allocated to Category N that are of little safety significance. They diverge only to a minor extent from the routine operational events of the normal specified plant state and operation. They are evaluated in order to find possible weaknesses before any major disturbances can occur.

Category V (Prior to commissioning – deadline: within 10 working days by means of reporting form)
Events have to be allocated to Category V that occur prior to the commissioning of the facility and about which the supervisory authority has to be informed with a view to the later safe operation of the facility.

Irrespective of the official reporting procedure according to the AtSMV reporting ordinance, the classification of the reportable events is carried out by the operator of the nuclear facility according to the INES assessment scale of the IAEA. The INES classification is notified together with the AtSMV report. The German INES officer, who has been appointed by the BMUB, checks the correctness of the INES classification for each event. The final decision on the classification is made by the BMUB and the INES officer. At present, the functions of the INES officer are fulfilled by a GRS member of staff on behalf of the federal authority.

G.6.6 Collection and use of operating experience

The AtSMV is an essential basis for the evaluation of operating experience. Once the supervisory authority has obtained and evaluated all the information relating to a reportable event, it specifies –

following close consultation with the operator – any rectifying measures that may be necessary as well as the provisions to be made.

The reportable events are registered and evaluated at the incident registration centre of the Federal Office for Radiation Protection on behalf of the BMUB. The BfS publishes the results in annual reports. If any results are of a special and generic significance, GRS will prepare a so-called information notice on behalf of the BMU. Information notices shall serve to enable the operators of comparable to check the applicability of the event to their facilities and, if required, initiate appropriate improvement measures. They include a description of the circumstances, the results of the root cause analysis, the assessment of the safety significance, the measures taken or planned by the operator, and as the most essential element, recommendations for examinations and possibly for the taking of remedial action in other facilities.

Other safety-relevant findings from initial start-up, specified normal operation (especially in the case of maintenance, inspections and repairs) and in-service inspections are also documented and submitted to the supervisory authority. Any consequences derived from the evaluation of the incidents are taken into account in the operating procedures.

The monitoring concept ensures the monitoring of the overall status of the facility and as a minimum requirement ensures the following:

- The condition of the storage building and the components required for interim storage are controlled by means of walk-downs and suitable measurements.
- Recurrent subsidence measurements are performed for the storage building.
- The external condition of the storage casks is monitored by inspections.
- The findings from in-service inspections are evaluated.

Experiences from the operation of similar plants are incorporated into plant management. For this purpose, procedures are put in place to ensure an exchange of experiences (e.g. on the basis of operating reports) between plant operators.

In addition, on behalf of the BMUB, GRS evaluates generally accessible international sources with regard to any disturbances and accidents in foreign nuclear fuel cycle facilities. The information is stored in the VIBS database. At regular intervals, the supervisory are informed about newly registered events by means of database excerpts and short assessments; they will then check whether any new insights can be gained from them to improve the safety of the German facilities.

For the purpose of an international exchange of experiences, Germany also participates in the Fuel Incident Notification and Analysis System (FINAS) that was set up by the OECD/NEA for nuclear fuel cycle facilities following the Incident Reporting System (IRS) for nuclear power plants. Within the context of FINAS, the participating countries exchange information on disturbances and incidents with general safety significance with a view to learning lessons for improving plant safety wherever possible.

G.6.7 Preparation of decommissioning plans

Spent fuel treatment facilities are designed and constructed in such a way that they can be decommissioned in compliance with the regulations on radiological protection and then either be reused or disposed of. Proof to this effect is checked during the course of the nuclear licensing procedure. Applications for changes to the licenced condition of the facility must either be submitted to the supervising authority for approval or in case of significant modifications to the licensing authority. Before further use or demolition of the storage building, proof that the building is either not contaminated or has been decontaminated sufficiently and is free of inadmissible activation must be furnished in the form of measurements. The requirements under construction and waste law must also be observed. The supervisory authorities of the *Länder* ensure that a corresponding exchange of expertise takes place at the level of supervision and with the experts also consulted.

G.7 Article 10: Disposal of spent fuel

> *Article 10: Disposal of spent fuel*
>
> *If, pursuant to its own legislative and regulatory framework, a Contracting Party has designated spent fuel for disposal, the disposal of such spent fuel shall be in accordance with the obligations of Chapter 3 relating to the disposal of radioactive waste.*

Spent fuel is to be disposed of together with radioactive waste from reprocessing.

For spent fuel and radioactive waste from reprocessing, the Act on the search for and selection of a site for a repository for heat-generating radioactive waste and for the amendment of other laws (*Standortauswahlgesetz* – StandAG) [1A-7] that came into force on 27 July 2013 stipulates that a repository site be selected by the year 2031. Even though the underlying planning in Germany for the disposal path of spent fuel is aimed at a geological repository, § 4 StandAG stipulates that a "Commission on Storage of High-Level Radioactive Waste" prepare proposals regarding i. a. whether instead of direct disposal in deep geological formations, other options for a controlled disposal of this waste should be scientifically explored and whether the waste should be kept in surface storage facilities until these studies have been concluded.

Once a site for a repository in deep geological formations has been determined by the year 2031, the licensing procedure and the actual construction of the repository will follow.

The StandAG specifies the time-dependent boundary conditions for the determination of a site for a repository for spent fuel and waste from reprocessing as follows:

- The "Commission on Storage of High-Level Radioactive Waste" adopts the report on the site selection procedure according to Art. 1 § 3 para. 5 by 31 December 2015 (possibly by 30 June 2016).
    - o The report is to contain the exclusion criteria, minimum requirements, weighing criteria and further decision bases that are essential for the selection of a site; these are to be prepared in the form of recommendations. The Commission is also to comment on the requirements for the organisation and the procedure of the selection process.

- o These recommendations will serve as a basis for the evaluation of the Act by the *Bundestag* and will subsequently be adopted by the German *Bundestag* as an act of law (Art. 1 § 4 paras. 4 and 5).

- According to Art. 1 § 17 para. 5, the decision about the sites to be explored underground is to be taken by the end of 2023 and to be adopted as part of a federal law.

- According to Art. 1 § 1 para. 3, the site selection procedure is to be concluded by 2031.

Under the concept of direct disposal without reprocessing, spent fuel is to be packaged in casks suitable for disposal after having been kept in storage for several decades, and these casks are then to be sealed and emplaced in galleries or bore holes in deep geological formations.

In August 2012, the DIN Standards Committee for Materials Testing published the DIN standard 25472 “Criticality safety for final disposal of nuclear fuels to be discarded” [DIN 25472]. Irrespective of the site and the host rock, DIN standard 25472 describes the verification of the criticality safety of a repository during the operational and post-operational phases.

On 30 September 2010, the LAA adopted the “Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste” [BMU 10] and the BMU published these for concretisation of the state of the art in science and technology. These requirements are based on a discussion process in which the BMU, GRS and the advisory committees RSK, SSK and ESK, the Federal Office for Radiation Protection (BfS) and interested citizens (workshop in 2009) were involved. The Safety Requirements apply to the planning, further exploration, construction, emplacement operations and decommissioning of such a repository, and are also to address the required monitoring and evidence preservation measures following its closure. The aim of these Safety Requirements is to outline the purpose, basic principles and requirements to protect man and the environment.

G.7.1 Research activities and international co-operation

The general programmatic fundamentals as well as the research objectives and promotion areas in the field of disposal are formulated in the 6th Energy Research of the Federal Government, "Research for an environmentally sound, reliable and affordable energy supply". The ministry in charge of the fundamental, site-independent waste management research is the Federal Ministry for Economic Affairs and Energy (BMWi).

Apart from the scientific and technical gain, the research that is carried out contributes to the continual development of the state if the art in science and technology and hence to the fulfilment of the stringent requirements of i. a. the Atomic Energy Act for the safety of the handling of radioactive waste.

A significant contribution in the area of support given to national and international repository research is made by the German Association for Repository Research (*Deutsche Arbeitsgemeinschaft Endlagerforschung* – DAEF), which was founded on 16 January 2013. The DAEF serves for the furthering and intensification of the co-operation of its members in the field of repository research and offers scientific and technical advice to the federal government and its authorised federal and *Länder* authorities as well as to the *Bundestag* and other interested institutions. The following are members of the DAEF:

- DBE TECHNOLOGY GmbH,

- Research Centre Jülich GmbH,

- Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH,

- Helmholtz Centre Dresden-Rossendorf (HZDR),
- IfG Institute for Rock Mechanics GmbH,
- Institute for Safety Technology (ISTec) GmbH,
- Karlsruhe Institute of Technology (KIT), represented by the Institute for Nuclear Waste Disposal and the Institute for Technology Assessment and Systems Analysis,
- Institute for Applied Ecology e.V.,
- Technische Universität Bergakademie Freiberg, represented by the Institute for Mining and Special Underground Engineering,
- Clausthal University of Technology, represented by the Institute for Disposal Research, and
- University of Stuttgart, represented by the Institute for Social Sciences.

A further, quite considerable part of the research is done as part of international co-operation. This is based on bilateral and multilateral agreements with foreign institutions within the framework of the participation in international research projects. Moreover, activities like these are carried out in the research framework programmes of the European Union.

Activities in connection with the „Implementing Geological Disposal of Radioactive Waste – Technology Platform“ (IGD-TP) (www.IGDTP.eu) take place in a special context of international co-operation. On the basis of the strategic and programmatic documents, the research agenda and a deployment plan, key issues for all repository concepts are defined and national as well as international research is carried out.

Although defined as a national task, serious efforts are undertaken worldwide across national borders to consider the disposal of radioactive waste as a multinational task guided by safety aspects that has to be tackled jointly at international level. Hence, international co-operation is seen as an important element of the activities relating to waste management research as it opens up the possibility of making use of the expertise of all co-operation partners involved and of exploiting all associated synergies, allowing the financial burdens to be shared, and contributing to solving the task effectively in each national context.

For more than three decades, German scientists have been involved in international research projects on waste management and repository research with the aim to build up and expand experience and knowledge as well as to obtain the necessary expertise in connection with the application and use of methods and technologies. As Germany does not have its own underground laboratory but the need exists nevertheless to carry out specific studies and experiments under realistic conditions, co-operation – especially in underground laboratories (Mt. Terri (CH), Grimsel (CH), Äspö (S), Bure (F)) – and the participation in demonstration projects is of great importance and to be considered indispensable. This co-operation has not only substantially developed further the state of knowledge on clay stone and crystalline rock in Germany, it has also helped create the basis for assessing non-saline host rock types, too. On top of that, thanks to these research activities it has been possible to build up and expand considerable knowledge in German organisations, allowing well-founded evaluations and assessments of repository concepts in all host rock types. This has contributed to the fact that the political call for an analysis and assessment of all relevant host rock types in Germany could be followed.

The research activities that lie within the responsibility of the BMWi and are carried out by German research institutions as part of international co-operation are for the most part performed within the framework of bilateral agreements with repository organisations, by way of project-funded participation in consortia, in EU projects as co-financed work, and as part of direct contractual agreements and work within the framework of scientific and technical co-operation.

Co-operation takes place predominantly with organisations from other European countries and – at varying intensity – with the United States of America, the Russian Federation, and China.

Within the framework of the international co-operation activities, projects with German participation are carried out nationally as well as in connection with the 7th EU research framework programme. A continuation of the international research activities is also intended for the new Horizon 2020 research framework programme of the EU. Within the framework of the co-operation with the OECD-NEA, activities include work in the Integration Group for the Safety Case (IGSC) as well as in the Salt Club and the Clay Club.

H Safety of radioactive waste management

This section deals with the obligations under Articles 11 to 16 of the Convention.

Developments since the Fourth Review Meeting:

In the spring of 2010, WENRA issued a revised „Waste and Spent Fuel Storage Safety Reference Levels Report“ (Version 2.0). The action plan for Germany that resulted from the benchmarking of the national regulations has been largely implemented by the ESK's "Guidelines for the storage of radioactive waste with negligible heat generation" [4-3].

The return of high-active vitrified waste from reprocessing in France (CSD-V) was concluded with the final transport in November 2011. The waste is stored in the Gorleben transport cask storage facility.

H.1 Article 11: General safety requirements

Article 11: General safety requirements

Each Contracting Party shall take the appropriate steps to ensure that at all stages of spent fuel management, individuals, society and the environment are adequately protected against radiological hazards.

In so doing, each Contracting Party shall take the appropriate steps to:

i) ensure that criticality and removal of residual heat generated during spent fuel management are adequately addressed;

ii) ensure that the generation of radioactive waste associated with spent fuel management is kept to the minimum practicable, consistent with the type of fuel cycle policy adopted;

iii) take into account interdependencies among the different steps in spent fuel management;

iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;

v) take into account the biological, chemical and other hazards that may be associated with spent fuel management;

vi) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation;

vii) aim to avoid imposing undue burdens on future generations.

H.1.1 Ensuring subcriticality and residual heat removal

The nuclear regulations presently do not contain any specific requirements on how criticality is to be prevented in a repository and how residual heat is to be removed in a suitable form. Within the framework of the comprehensive site-specific safety analysis for the Konrad repository, studies have been carried out into criticality safety/maintenance of subcriticality and into the thermal influence on the host rock. The results were implemented in the waste acceptance requirements for disposal for the Konrad repository Konrad [BfS 95] and stipulated with the plan approval decision for the Konrad repository of 22 May 2002. It is therefore ensured for the operational and post-operational phases of this facility that each criticality is avoided and that the residual heat arising is taken into account.

Furthermore, the remarks on Article 4 apply analogously to Articles 11 i to vii.

H.1.2 Limitation of the production of radioactive waste

According to the "Guideline relating to the control of radioactive residues and radioactive waste" of 19 November 2008 [3-60], the waste producer has to present to the competent Länder regulatory authority a waste concept for all kinds of radioactive waste arising, containing details about the technical and organisational provisions for collection and registration and also describing the intended paths of non-hazardous recycling and of treatment and packaging. Any modifications of this concept have to be updated in the documentation and presented to the competent supervisory authority.

Furthermore, the remarks on Article 4 apply analogously to Articles 11 i to vii.

H.2 Article 12: Existing facilities and past practices

> *Article 12: Existing facilities and past practices*
>
> *Each Contracting Party shall in due course take the appropriate steps to review:*
>
> *i) the safety of any radioactive waste management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility;*
>
> *ii) the results of past practices in order to determine whether any intervention is needed for reasons of radiation protection bearing in mind that the reduction in detriment resulting from the reduction in dose should be sufficient to justify the harm and the costs, including the social costs, of the intervention.*

H.2.1 Safety of existing facilities

In Germany, all facilities existing at the time when the Joint Convention entered into force have already demonstrated in principle their adequate safety within the licensing procedures and their operation. Construction and operation have to be such that the necessary precaution against damage has been taken in line with the state of the art in science and technology. The competent licensing authority has confirmed this through granting the licence. Following the commissioning of a facility, its safety is reviewed, which is yet again done by the authorities as part of their nuclear supervisory role.

The general requirements regarding the precautionary measures to be taken are stipulated in the Atomic Energy Act (AtG) [1A-3], in the Radiation Protection Ordinance (StrlSchV) [1A-8] and in other legal and subordinate regulations. The safety requirements of the IAEA (above all [IAEA 09b]) are also observed.

The protection goals extend to the protection of the local population in the vicinity of the facility, protection of the environment, protection of the operating personnel, and the protection of property against the effects of ionising radiation (cf. the remarks on Article 11 and 4, respectively). Compliance with these protection goals also satisfies the requirements of the Convention. This is ensured by nuclear licensing and the corresponding supervision.

In the following, a distinction is made between facilities for the treatment and storage of heat-generating waste and waste with negligible heat generation.

Safety of facilities for the treatment and storage of heat-generating waste

In the Gorleben transport cask storage facility (TBL-G), not only spent fuel but also vitrified high-active waste from reprocessing in France (*Colis Standard de Déchets - Vitrifiés*; CSD-V) is stored in transport and storage casks. The return of this waste ended in November 2011. The same safety requirements apply to the storage of high-active waste in the TBL-G as those referred to in Article 5.

The vitrified medium-active decontamination and flush waters from reprocessing in France (*Colis Standard de Déchets - Boues;* CSD-B) were originally also dedicated to be stored at TBL-G. With the entry in to force of the Site Selection Act, which also includes the amendment of other Acts, however, shipment to one or several on-site storage facilities became the prescribed storage option. According to § 9a para. 2a AtG, the operator of installations for the fission of nuclear fuels for the commercial generation of electricity has to ensure that the solidified fission product solutions from the reprocessing of spent fuel abroad will be taken back and stored in near-site storage facilities according to para. 2, subpara. 3 until their delivery to a facility for the disposal of radioactive waste. To this end, it is intended to prepare initially a comprehensive concept for the implementation and execution of on-site storage and to agree on this concept in consensus. The provision of § 9a para. 2a AtG excludes shipments to the TBL-G by definition.

For the Ahaus transport cask storage facility, the storage of compacted hulls and structural parts of German fuel assemblies (*Colis Standard de Déchets - Compactés*; CSD-C) from the French reprocessing plant La Hague has been applied for. A new cask concept is under preparation; the licensing procedure has not yet been concluded.

The HAWC solutions generated during the operation of the Karlsruhe Reprocessing Plant (WAK) were fully vitrified at the Karlsruhe Vitrification Plant (VEK) between September 2009 and November 2010. Together with the solutions generated as part of the flushing of the plant, this resulted in a total of 140 canisters. The canisters were loaded into five transport and storage casks of the CASTOR® HAW 20/28 CG type and transferred to the storage facility "*Zwischenlager Nord*" (ZLN). The former storage facilities and the VEK are being dismantled; this forms part of the decommissioning of the reprocessing plant.

Apart from the vitrified waste from the VEK, spent fuel from operation of the Greifswald and Rheinsberg nuclear power plants, shut down in 1990, and fuel assemblies from KNK II and the nuclear ship Otto Hahn are also stored in the "*Zwischenlager Nord*" (ZLN).

The HDB is a special case. Here, small amounts of medium-active waste are stored that are classified as waste with negligible heat generation and can hence not be directly allocated to the Konrad repository. Current plans provide for the conditioning of this waste by suitable measures so that it will be suitable for the Konrad repository after all. The waste is stored in a storage bunker at HDB where it is handled with remote handling systems. The safety of this storage facility has been checked as part of the licensing procedure and is subject to regulatory supervision over its entire operating period.

The confinement of the radioactive substances is ensured by a system of technical and process-based barriers. The technical barriers include e.g. the casks with their sealing systems or the building parts, such as hot cells, but also the inner packaging, such as the stainless-steel canister and the glass matrix as such. The process-based barriers include special ventilation measures, like e.g. directed airflows in the room and cell exhaust air due to pressure differences and retention systems.

The number and technical design of the barriers are tailored to the state of matter (solid, liquid, gaseous) and activity inventory of the substances to be retained.

The effectiveness of the barriers is monitored in the cells, work rooms and operating rooms by devices for the detection of leakages, pressure deviations and airborne radioactivity in the cells.

Safety of facilities for the treatment and storage of waste with negligible heat generation

Radioactive waste with negligible heat generation is put in interim storage, either at the place where it is generated or in a central facility, until it can be disposed of in a repository. As a repository in Germany will not available before the year 2022, conditioning has to be such that safe storage is guaranteed even for periods of up to 20 years. Recommendations for the storage of radioactive waste with negligible heat generation irrespective of the kind of storage are made in [4-3] (see reporting on Article 15 i).

Different facilities and methods are used for the conditioning of radioactive waste (see Table L-5). In the case of liquid waste, the radioactive components are separated through evaporation, ion exchange, filtration or chemical precipitation. Solid waste is burnt or compacted if necessary in order to reduce its volume. Afterwards, it is safely confined in containers. The conditioning plants are almost all assigned to specific nuclear facilities and, together with the other facilities and industrial premises, are subject to licensing, monitoring and supervision by the competent local authority. The safety of the conditioning plants was assessed in the licensing procedure. During operation, regulatory control ensures that safety-related requirements are fulfilled.

The confinement of radioactive substances during the storage of radioactive waste is ensured by a system of technical barriers and supplementary measures. This can be achieved with a variety of different approaches and may include, for example, integration into the matrix of the waste product, confinement in waste containers or, where applicable, the barrier function of buildings and ventilation systems with retention devices. Overall, safe enclosure can be achieved by one barrier or the combined effects of several barriers.

Compliance with to the required specifications is ensured by means of monitoring and supervision.

Within the context of analysing hazardous incidents, external impacts are also taken into consideration. On this basis, the authority decides which precautionary measures are to be taken for the facility.

The different facilities take measures to ensure safety during long-term storage. These comprise e.g. updates of the documentation pertaining to the waste, technical inspections of the waste packages and - if necessary - their re-packaging or emplacement in additional enveloping containers. The requirements for long-term storage are described in detail in the reporting on Article 15 i.

As expressed in the reporting on Article 32 (2) iii, two different types of interim storage facilities in Germany accept radioactive waste, depending on its origin. These facilities differ from each other not so much in their technical design but in the associated responsibilities.

One group is formed by the interim storage facilities of the nuclear power plant operators who - according to the polluter-pays-principle - are responsible for the lawful and safe treatment of their radioactive waste. These interim storage facilities require a licence according to § 7 StrlSchV [1A-8] to be issued by the respective competent *Land* authority.

In contrast, radioactive waste from research, industrial or medical application may be surrendered to *Land* collecting facilities (see Berlin *Land* collecting facility as an example in Figure H-1) unless it is stored at the originator's site. According to § 9a AtG [1A-3], these *Land* collecting facilities have to be provided by the *Länder* for the radioactive waste generated on their territory. It is also possible for several *Länder* to agree by contract to jointly use one common *Land* collecting facility.

The handling of the radioactive waste within the *Land* collecting facilities as well as any deviations of the handling procedures laid down in the licensing documents (Annex II Part A StrlSchV) also require licensing according to § 7 StrlSchV by the competent *Land* authority. Checks during the licensing procedure ensure that relevant safety requirements are fulfilled (see the reporting on Article 15). If the radioactive waste is not only stored but also treated at the *Land* collecting facility, the regulations have to be applied accordingly (see the reporting on Article 15). Usually, the licence for storage is limited in time.

An application to the *Land* collecting facilities for the delivery of radioactive waste must be submitted in writing by the delivering party and accompanied by a waybill. On the basis of these documents, checks are made to ascertain whether the preconditions for acceptance of the radioactive waste have been met. The acceptance criteria of the *Land* collecting facilities differ from one *Land* to another, and are laid down in the respective regulations for use. They depend on the respective licensing situation, and on the availability of conditioning equipment.

If the radioactive waste fails to meet the preconditions stipulated in the respective regulations for use of the Land collecting facility, the latter may refuse to accept it, and will report this to the supervisory authority responsible for the delivering party. In such cases, the waste will remain in the hands of the delivering party until transformed into a condition conforming to the regulations for use, and the *Land* collecting facility is willing to accept it. Alternatively, the radioactive waste may be delivered by special agreement, subject to the consent of the competent supervisory authority. After acceptance, a further incoming inspection is performed to verify once again that the acceptance criteria have been met.

Figure H-1: Berlin *Land* collecting facility (copyrights: HZB)

When the radioactive waste is delivered to the *Land* collecting facility, it passes into the ownership of the latter on the basis of contractual provisions. This also applies to raw waste. The waste generator's duties in connection with conditioning are thus adopted for this waste by the operator of the *Land* collecting facility. This procedure ensures that waste packages that are stored over a longer period at a *Land* collecting facility have the same quality standard as those in an interim storage facility for waste from nuclear facilities (§ 74 StrlSchV [1A-8]).

The acceptance criteria are laid down in the licence in line with the state of the art in science and technology. Each year, the individual operators of *Land* collecting facilities hold a meeting for the purpose of exchanging information.

Recommendations for the storage of radioactive waste with negligible heat generation [4-3] also contain requirements for the monitoring of the stored waste, i. a. the visual inspection of the outer surfaces of certain waste packages as well as the separate storage and recurring checking with visual inspection of reference packages. Any safety-relevant findings have to be reported to the *Land* authority responsible for storage.

H.2.2 Past practices

Past practices as defined by this Convention, such as the use of radium in the production of luminous paint or of thorium in the manufacture of gas mantles etc. in the first half of the twentieth century resulted in a number of individual sites in Germany which were contaminated to a limited extent. These contaminated sites have been or are currently being cleaned up and redeveloped for radiological and other reasons. Cataloguing and categorisation of such legacy sites has largely been completed in Germany.

Past practices with respect to uranium mining and milling have been carried out at a large number of sites especially in Saxony which have been discontinued prior to 21 December 1962 and therefore do not fall into the responsibility of the Wismut GmbH for carrying out remediation measures. According to the national requirements of the Federal Republic of Germany, which are in line with international requirements, the amount of residues from former uranium ore mining are counted among conventional waste, which is why these practices – as has already been the case in the National reports since the Second Review Meeting – are outlined in a separate report, which describes the state of ecological restoration in March 2014.

To justify this procedure, reference is made to the fact that according to § 118 of the Radiation protection Ordinance (StrlSchV) [1A-8] pursuant to Art. 9, para. 2 in conjunction with Ann. 11, Chapter XII, Section III nos. 2 and 3 of the Unification Treaty of 31 August 1990 [1A-4] individual regulations of the former GDR shall continue to apply in new *Länder* to the ecological restoration of the legacies of former workings as well as to the decommissioning and ecological restoration of the operational installations and sites of uranium ore mining if any radioactive materials, especially the decay products of radon, are present. These regulations are:

- the Ordinance on the Guarantee of Atomic Safety and Radiation Protection (VOAS) of 11 October 1984 together with the implementing regulation, and
- the Regulation for Guaranteeing Radiation Protection in Connection with Heaps and Industrial Tailings Ponds and the Use of Materials Deposited there (HaldenAO).

Compared with other regulations on radioactive waste, both ordinances ensure a different treatment, taking into account the minor radioactivity and the special characteristics of the former Wismut workings and the current Wismut ecological restoration actions. In doing so, radiation protection is fully taken into consideration.

Such an approach is necessary as the StrlSchV can only be applied with restrictions or not at all to ecological restoration in the area of former mining activities. The VOAS is based in its radiation protection principles on the recommendations of the International Commission on Radiological protection (ICRP 26 of 1977 and ICRP 32 of 1981). Regarding the classification of the materials generated at the uranium ore mining locations and other legacies (contaminated sites), it is necessary that the terminology and exemption limits of the above-mentioned regulations of the former GDR be used due to their continued application. In the case of heap materials and tailings as well as other waste materials at the Wismut sites and the contaminated sites of uranium ore mining, the generated waste is generally not radioactive waste according to the VOAS or the implementing regulation regarding the VOAS. More detailed technical explanations regarding these regulations were already provided in the report and the answers for the Second Review Meeting in 2006.

A national legal consideration of the residues from uranium ore mining and processing according to the regulations of the VOAS and the HaldenAO does not contradict the requirements or the purpose of the Joint Convention. What is essential for reaching the objectives of the Convention (Chapter 1, Art. 1 i to iii) and their review is a transparent structure of the measures. This transparency is to be ensured by the respective National Reports. In connection with its previous reports, Germany provided comprehensive information at the Review Meetings on the ecological restoration activities and the progress made; the intention is to keep doing so. The only difference to other views which hold that information in this respect is mandatory is that the accounts are given not as part of the National Report but rather in a separately annexed report. This approach does not, however, mean that those Contracting Parties which interpret the purpose of the Joint Convention differently from Germany are denied any information that they need for the mutual verification of whether the safety objectives formulated in the Joint Convention have been reached.

According to the Federal Office for Radiation Protection, the residues present at those sites amount to about $46.5 \cdot 10^{06}$ m^3 of heaps and about $4.7 \cdot 10^{06}$ m^3 of mill tailings. A register of radiologically relevant sites contaminated from mining activities has been established.

According to § 11, para. 8 of the Precautionary Radiation Protection Act (*Strahlenschutzvorsorge-gesetz* [1A-5]), the BfS was responsible for the determination of the environmental radioactivity originating from mining operation in the presence of natural radioactivity in the new Federal States.

Therefore, the BfS carried out the project “Radiological Survey, Investigation and Assessment of Mining Residues (*Altlastenkataster*)”. Radioactive legacy sites of uranium mining no longer belonging to the Wismut GmbH and radioactive legacy sites from historical mining activities were systematically catalogued, explored and radiologically assessed. This comprised the following objects:

- Milling facilities (facilities for separation and processing of the usable material by mechanical, chemical or metallurgical processes, including the plant areas and associated premises),
- industrial settling ponds (basins for deposition of tailings and cleaning of liquid process media from mining facilities),
- heaps (stockpiles of excavation material from mining or mechanical ore processing or of residues of metallurgic processes (slags)),
- prospected sites (shallow outcrops on small areas for exploration of ores or raw materials),
- galleries (horizontal drifts),
- shafts (vertical drifts),
- unused open pits and cavities,
- plants (unvegetated areas of facilities and possibly undecontaminated mining sites like ore bunkers, uranium ore box storage, hydro-engineering plants etc.) and ore loading facilities (areas away from factory premises on which ore was reloaded).

Apart from these objects, the identification of sites influenced by mining operations in the vicinity of the objects listed above and for which measures for reduction or avoidance of exposure of the general public was of special interest. This project identified those sites for which exposure above 1 mSv/a could not be excluded and for which therefore further investigations and - if necessary - remedial actions or restrictions for use could be considered. The aim, execution and results of this project are summarised in [BfS 02].

In order to make efficient use of financial resources, the investigation was concentrated on potentially contaminated areas. The results of the investigations were stored in the A.LAS.KA database and in the technical information system on environmental radioactivity caused by mining (“*Fachinformationssystem bergbaubedingte Umweltradioaktivität*”, FbU) and were also discussed extensively in area-specific reports. The data and information are available to the competent authorities of the *Länder* Saxony, Saxony-Anhalt and Thuringia.

In parallel to the “*Altlastenkataster*” project, the BfS carried out a measurement programme to investigate the outdoor exposure by radon. The results showed that the radon concentration is markedly increased in the direct vicinity of mining sites compared to the natural background, but that there is no large-scale influence.

Remediation of contaminated Wismut sites in Saxony commenced in 2003 on the basis of an administrative agreement between the Federal Government and the *Land* Saxony. In 2013, the basis for the continuation of remediation work at the Wismut sites in Saxony until 2022 was provided by a “supplementary administrative agreement”. The BMU has prepared a concept for the evaluation of the requirements for remediation of radioactive legacy sites that may form the basis for a legal provision, if required.

H.3 Article 13: Siting of proposed facilities

Article 13: Siting of proposed facilities

(1) Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed radioactive waste management facility:

i) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating lifetime as well as that of a disposal facility after closure;

ii) to evaluate the likely safety impact of such a facility on individuals, society and the environment, taking into account possible evolution of the site conditions of disposal facilities after closure;

iii) to make information on the safety of such a facility available to members of the public;

iv) to consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory.

(2) In so doing, each Contracting Party shall take the appropriate steps to ensure that such facilities shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 11.

The siting process outlined in Article 13 refers to proposed radioactive waste management facilities and repositories. These types of facilities are addressed separately in the following two subsections. As the information required under Article 13 (1) numbers i to iv has already been given in other sections of this report (cf. the remarks on Article 6), the relevant information is merely summarised here and reference is made to the appropriate sections.

H.3.1 Site planning for new facilities for radioactive waste management

For facilities for radioactive waste management which require a licence according to the Atomic Energy Act (AtG) [1A-3], the remarks provided for Article 6 apply accordingly.

For the other facilities for radioactive waste management, only the handling of radioactive substances requires a licence according to § 7 StrlSchV [1A-8], depending on the nature of the facility. In contrast to the facilities mentioned above, this licensing procedure is in principle not regulated by the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10]. An exception is a case where the respective use requires an environmental impact assessment (EIA) according to the requirements in the Environmental Impact Assessment Act (UVPG). Regulations of the Nuclear Licensing Procedure Ordinance are applied at least with respect to the EIA. Licensing is carried out by the competent licensing authority of each *Land* and follows the process described in the following.

The licensing requirements which must be met by such a facility are described in § 9, para. 1 StrlSchV. With respect to the siting of such facilities, the following licensing requirements are particularly relevant:

- the necessary protection must be ensured against disruptive action or other interference by third parties,

- the choice of the site must not conflict with overriding public interests, particularly in view of its environmental impacts.

The required documentation and information depends on the type of facility and in particular on whether or not an environmental impact assessment (EIA) is necessary. According to Appendix 1 of the Environmental Impact Assessment Act (UVPG) [1B-14], an EIA is required for:

- 11.3: Construction and operation of a facility or installation for the handling or management of irradiated fuel assemblies or highly radioactive waste.

By contrast, the following facilities or installations (see Appendix 1 of the UVPG) require a general preliminary assessment of each individual case according to § 3c, para. 1 of the UVPG:

- Construction and operation of a facility or installation for the storage, handling or treatment of radioactive waste where the activities reach or exceed those limits laid down in an ordinance promulgated on the basis of the Atomic Energy Act (AtG) [1A-3] and compliance with such limits does not require any measures for mitigating the consequences of deviations from specified normal operation (according to § 50 StrlSchV [1A-8], such activities are defined as 10^{07} times the exemption levels as specified in Appendix III, Table 1, column 2 of the StrlSchV in the case of unsealed sources and 10^{10} times the exemption levels as specified in Appendix III, Table 1, column 2 of the StrlSchV in the case of sealed sources).

This general preliminary assessment includes a rough review of the individual case with respect to potential substantial negative environmental impacts, with due regard for the criteria listed in Appendix 2 of the UVPG (including characteristics of the project, site, possible effects). Based on the outcome of this preliminary assessment, the competent authority will determine whether or not an environmental impact assessment is required.

Where the cases listed above pertain to the planned radioactive waste management facility or installation and if an EIA is required for the facilities or installations listed in point 11.4, then the type of information outlined in the remarks on Article 6 (1) i und Article 6 (1) ii must be provided. This also implies the involvement of the general public (cf. the remarks on Article 6 (1) iii) as well as the participation of other authorities and, where applicable, the participation of authorities of other countries (cf. the remarks on Article 6 (1) iv).

The ESK Guidelines for the storage of radioactive waste with negligible heat generation [4-3] summarise the requirements especially for storage facilities. For example, they describe i. a. the preference of passive to active safety systems, the great importance of the casks for ensuring the protective functions compared with the storage building which under normal specified operating conditions mostly only has the function of shielding against the environment and of weather protection of the stored radioactive waste and the storage facility's own technical installations, requirements for radiation monitoring inside the building and in the environment, structural requirements, protection systems, etc.

Asse II mine

After the retrieval of the radioactive waste from the Asse II mine it will be necessary to condition the radioactive waste for its storage and later disposal in a yet to be found repository.

Preliminary planning of the storage facility has been concluded. When planning of the concept of its structure – which has in part been begun – will be concluded depends on the site of the storage facility. The BfS has set up criteria for the selection of a storage facility site and is discussing these with the BMUB and the Asse II advisory group. From the point of view of the BfS, the first step should be to look for and assess possible sites in the vicinity of the grounds of the mine. It should be possible to link the storage site with the grounds of the mine. Should it be that there are no suitable areas close to the Asse II mine, a site selection procedure covering a wider area would be required.

In March 2011, the order was given to start fundamental planning of the conditioning technology. In April 2013, a report was presented on possible ways of qualifying the waste retrieved from the Asse II mine. Further research and development needs were identified in particular with regard to the non-destructive testing of waste packages.

Current planning provides for the storage facility building to be completed and ready for accepting waste consignments by 2031.

§ 57b of the AtG (“Lex Asse”) [1A-26], which was newly phrased in 2013, offers the possibility of combining several procedural steps of the environmental impact assessment if expedient.

H.3.2 Site planning for disposal

As part of the governmental task to provide and to operate facilities for the disposal of radioactive waste, the Federal Office for Radiation Protection (BfS) is responsible for the construction and operation of repositories.

According to the Atomic Energy Act, construction of a repository for radioactive waste in Germany requires a plan approval procedure, which includes an environmental impact assessment and the involvement of the general public. This does not apply in cases in which the repository site is specified by law. Instead of a plan approval a licence is granted. The Konrad mine was plan-approved as a repository for radioactive waste with negligible heat generation and affirmed in 2007 by the administrative court.

Regarding the search for a repository for heat-generating radioactive waste, consensus across the political parties was achieved when in July 2013 the Act on the search for and selection of a site for a repository for heat-generating radioactive waste (Site Selection Act – StandAG) was adopted. According to the StandAG, the search for a suitable repository site in Germany is to take place as a nationwide site selection procedure with comprehensive exploration and investigation of the different potential host rock types of salt, clay, or crystalline rock.

The Site Selection Act lays down the individual procedural steps for the search of a site and sets the target of specifying the site in future by a federal act of law. Relevant decisions are to be taken by *Bundestag* and *Bundesrat*. From the start and in all phases of the site selection procedure, the Act demands active public relations work and formal public involvement.

The site selection procedure is prepared by the "Commission on Storage of High-Level Radioactive Waste". The latter is made up of two alternating chairpersons and 32 members from the scientific community, social groups and from the *Bundestag* and the *Bundesrat*. Of these, 16 members from the scientific community and the social groups have a vote. By the end of 2015, but by mid-2016 at the latest, the Commission is to have examined and assessed relevant fundamental issues of radioactive waste disposal that are relevant in connection with the selection procedure as well as proposals for decision bases, like e.g. regarding the safety requirements and geological exclusion and selection criteria and recommendations for actions for the organisation of the procedure and for public involvement. These serve as a basis for an evaluation of the Act by the *Bundestag*. Decisions about relevant steps of the site selection procedure are taken by the German *Bundestag* by act of law. This includes in particular decisions about sites for above-ground and underground exploration as well as about the site for which eventually, as a result of the site selection procedure, a licensing procedure with a view to building a repository is to be performed.

According to the StandAG [1A-7], the Federal Office for Radiation Protection (BfS) assumes the function of the project implementer. In addition, a Federal Office for Nuclear Waste Management (BfE) is to be established which will regulate the site selection procedure.

The BfE is to assume the essential tasks of developing decision bases, specifying the site-specific exploration programmes and assessment criteria for the site selection procedure, preparing the site decision, and informing and involving the general public. The decision bases will be laid down by law. The BfE is to give advice and support to the whole procedure from a scientific point of view and be the competent authority in all procedural steps for the technical assessment of exploration programmes and assessment criteria with consideration of the project implementer's proposals. Furthermore, according to § 23d which was newly added to the Nuclear Energy Act, the BfE is given the responsibility for the nuclear licensing of federal facilities for the storage and disposal of radioactive waste, which used to be the responsibility of the *Länder*. For the Konrad and ERAM repositories, transitional provisions are laid down in § 58 paras. 6 and 7 AtG.

As project implementer, the BfS is responsible for the implementation of the site selection procedure according to the mandatory requirements and has to explore the sites in the respective procedural steps. This involves summarising the exploration results in preliminary safety analyses and assessing them according to the site-specific assessment criteria. Based on existing safety analyses, the project implementer prepares proposals in the respective procedural steps regarding the prospective site regions for above-ground exploration, sites for underground exploration, and the corresponding exploration programmes for a final site decision. Furthermore, the project implementer informs the general public, plays an active part in public involvement, and takes public comments into account. In addition, the BfS acts as public agency for fundamental as well as for facility- and project-specific research and development with relevance to repositories. Following the final legal site decision, the BfS will assume the function of the applicant in the nuclear licensing procedure.

H.4 Article 14: Design and construction of facilities

Article 14: Design and construction of facilities

Each Contracting Party shall take the appropriate steps to ensure that:

i) *the design and construction of a radioactive waste management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases;*

ii) *at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a radioactive waste management facility other than a disposal facility are taken into account;*

iii) *the design stage, technical provisions for the closure of a disposal facility are prepared;*

iv) *the technologies incorporated in the design and construction of a radioactive waste management facility are supported by experience, testing or analysis.*

H.4.1 Impacts on individuals and the environment

Regarding the design and construction of radioactive waste management facilities, both the requirements of relevant acts and ordinances (such as the Atomic Energy Act (AtG) [1A-3] and the Radiation Protection Ordinance (StrlSchV) [1A-8]), and the content and recommendations of non-mandatory guidance instruments are duly taken into account and applied with regard to radiological aspects (e.g. KTA 1301.1; see Safety Standards of the Nuclear Safety Standards Commission (KTA) in Annex L-(e)).

The realisation of these requirements creates the prerequisites for compliance with the radiation exposure limits for persons who are exposed to radiation by virtue of their occupation, as well as for the population in the surrounding area during operation of the facility, as stipulated in the Radiation Protection Ordinance.

Radiological protection of operating personnel

The measures to ensure the radiological protection of operating personnel which must be taken into account during the design and construction of facilities for the treatment of radioactive waste refer, in particular, to structural measures regarding the arrangement and design of the rooms in the controlled area of the facility. In this respect, the emphasis is on the arrangement and accessibility of the rooms, the arrangement and accessibility of the containers, the design of the wall and floor surfaces from the point of view of shielding, the possibility to decontaminate wall and floor surfaces, and the space requirement for tasks related to radiation protection, as well as the design of the entry and exit of the controlled area (including facilities for issuing work and protective clothing, washing facilities for the personnel, and facilities for contamination control before leaving the controlled area). The system design and the ventilation concept, the storage concept, the measurement methods for radiation protection monitoring within the controlled area of the facility (local dose rate, air activity concentration, surface contamination) and monitoring of the internal and external radiation exposure of personnel are additional aspects which must be taken into account during the design and construction of facilities for the treatment of radioactive waste and in the licensing procedure by the competent authority.

Radiological protection of the population during specified normal operation

The radiological protection of the population during specified normal operation is ensured during the planning and construction of radioactive waste management facilities by their structural and technical design. In addition to shielding effect of the walls of the controlled area already mentioned above under the aspect of radiological protection of operating personnel, which also serves to limit direct radiation at the site and in the vicinity of the facility in accordance with § 46 StrlSchV [1A-8], appropriate technical equipment must also be provided to limit the release of radioactive substances with air or water, in order to comply with the limits specified in § 47, para. 1 StrlSchV for individual members of the local population in the vicinity of the facility. Such equipment comprises retention devices for airborne radioactive substances, as well as treatment facilities for contaminated waters and transfer tanks for waters from the controlled area. Moreover, the prerequisites for the measurement of releases and their nuclide-specific balancing are ensured by means of corresponding measurement, sampling and analysis methods.

Radiological protection of the population in case of design basis accidents

In accordance with § 50 StrlSchV [1A-8], the conceptual planning of a radioactive waste management facility (interim storage facility, conditioning facility) includes structural and technical protective measures, with due regard for the potential extent of any damages, to limit radiation exposure caused by the release of radioactive substances into the environment in case of a design basis accident. The licensing authority defines nature and scope of the protective measures with reference to each individual case, particularly with regard to the hazard potential of the facility and the likelihood of a design basis accident occurring.

According to § 49 StrlSchV, the planning of structural or other technical protective measures against design basis accidents in or around a repository for radioactive waste must be based on a maximum effective dose of 50 mSv caused by the release of radioactive substances into the environment in the least favourable case. This requirement remains applicable until decommissioning. Individual dose limits are to be applied for specified organs. Further details can be found in Table F-1. The state of the art in science and technology is decisive for the adequacy of precautionary measures against accidents.

At the same time, the measures to protect the population against radiation also serve to ensure the protection of the environment.

H.4.2 Planning concepts for decommissioning

The decommissioning of radioactive waste management facilities is taken into account already at the design stage and during their construction, thanks to the analogous application of the stipulations and recommendations contained in the statutory rules and regulations and non-mandatory guidance instruments on the decommissioning of nuclear facilities (cf. [3-73]). With regard to facilities for the dry storage of HAW canisters, guidelines [4-2] must also be applied. These guidelines state that an interim storage facility must be designed and executed in such a way that it can either be decommissioned or reused or removed in compliance with the radiological protection regulations.

Regarding the planning and construction of radioactive waste management facilities, the design ensures that the decommissioning of these facilities at a later stage takes place with due regard for the radiological protection of operating personnel and adherence to the radiological protection regulations. In particular, structural prerequisites must be generated in order to ensure the use of specific decontamination and dismantling methods, including remote-controlled methods, during the subsequent decommissioning of the facility.

For this reason, a corresponding decommissioning concept must be available at the design and construction stage of the facility. This concept includes specifications regarding the intended decommissioning option, which depends primarily on whether the radioactive waste management facility is constructed as part of a major nuclear facility, thus being integrated into decommissioning procedure of this facility, or whether it constitutes a separate site, thus entailing an independent decommissioning procedure, directly related to this facility. Further decisive parameters of the decommissioning concept are determined by the composition of the radioactive waste treated at the facility, in particular by whether or not it involves waste containing fissile material.

Within the context of the decommissioning concept, the operator plans the decommissioning procedure, assuming that any residual quantities of the radioactive waste treated at the facility have been removed beforehand. The decommissioning concept also incorporates the requirements with regard to decontamination and dismantling methods and thus the radiological protection of the personnel. Since activation by neutrons can be virtually excluded, these requirements result from the contamination of components. In this respect, however, it is important to consider that during treatment of waste containing fissile material or waste with other alpha-emitters, contamination from alpha-emitting nuclides is also present.

The requirements relating to the proposed decontamination methods take into account the minimisation of individual and collective doses to achieve a condition adequate for the performance of decommissioning and dismantling work, as well as the reduction of volume and the recovery of residues as harmlessly as possible, with due regard for the secondary waste generated.

The requirements relating to the dismantling methods depend on the technological task (material, size of the components, environmental conditions, accessibility), the radiation protection conditions (existing activity, potential for aerosol formation, risk of contamination, confinement of mobile activity, limitation of the individual and collective dose), and the intended subsequent treatment in the form of residual waste for re-use, conventional disposal, or disposal as radioactive waste.

The decommissioning of the Karlsruhe Vitrification Plant (VEK), for example, will primarily be performed using the equipment required for operation, which was already considered in design of the facility. The planned steps and measures for decommissioning of the facility were described by the applicant in his safety case.

H.4.3 Closure of a repository

Upon termination of the operational phase, a repository in deep geological formations must be safely sealed against the biosphere in the long term. Here, it has to be considered that the emplacement of the waste packages will be back to front, which means that depending on the emplacement technique chosen, the emplacement fields consisting of boreholes, chambers or drifts will be filled with waste packages, the remaining cavities backfilled and, if necessary, sealed with dam structures, and the emplacement field subsequently abandoned. This way, a repository in deep geological formations will already be successively closed during the operational phase. Once all waste packages have been emplaced, the closure phase will ensue in which all measures and precautions are taken above and below ground that are necessary for the final closure of the repository. The closure proper will then consist of the backfilling of the drifts and cavities that are still open below ground and the backfilling of the shafts.

As a licensing prerequisite, § 9b, para. 4 of the Atomic Energy Act (AtG) in conjunction with § 7, para. 2, subpara. 3 [1A-3] stipulates that “the necessary precautions have been taken in the light of the state of the art in science and technology to prevent damage resulting from the construction and operation of the installation”.

The SSK recommendation of 15 December 2010 on the Morsleben repository for radioactive waste (ERAM) states that the potential radiological exposure in the post-closure phase should not exceed an individual effective dose of 0.1 mSv/a in the case of probable developments and of 1 mSv/a in the case of less probable developments [4-11b]. In order to take the existing situation and the only limited plannability of the closure of the repository into account, however, these values should not represent limit or reference values but are to be understood as reference values in terms of the ICRP, which here are also used for radiation exposure levels in the remote future.

According to the safety requirements, it is to be demonstrated for a repository for radioactive waste – especially heat-generating radioactive waste – to be constructed that an additional effective dose in the range of 10 µSv/a in the case of probable developments and of 0.1 mSv/a in the case of less probable developments will not be exceeded in the post-closure phase.

Due to requirements in other legal areas, it is necessary to ensure that detrimental environmental impacts are avoided or limited to the bare minimum. Mining law requires that there must be no long-term subsidence on the surface which could have inadmissible consequences for protected commodities. Water legislation stipulates that there must be no reason to fear harmful pollution of groundwater or any other detrimental change to its characteristics.

In order to meet the aforementioned requirements, it is necessary to take into account the respective situation of the repository, such as the natural (geological) and any technical barriers which may be required, the rock-mechanic characteristics of the host rock (such as convergence), the waste inventory, the emplacement technique and the construction materials for backfilling and closing the repository. With the aid of a comprehensive site-specific long-term safety analysis on the basis of a complete scenario analysis and the intended backfilling and closure concept, it is necessary to demonstrate that the closure measures avoid any inadmissible effects caused by the release of radioactive material and non-radioactive hazardous chemical components of the waste packages and construction materials, as well as subsidence on the surface.

For this reason, a plan approval procedure for a repository must include a closure concept as the basis for its long-term safety case. The measures to be taken upon the cessation of emplacement operations are specified. The nature and manner of execution are subject to the supervision of the competent authority.

H.4.4 Technologies used

There is no difference between the requirements governing the technologies applied to the design and construction of radioactive waste management facilities and those for facilities for the treatment of spent fuel. As such, the remarks on Article 7 iii apply in full to Article 14 iv.

H.5 Article 15: Assessment of the safety of facilities

Article 15: Assessment of the safety of facilities

Each Contracting Party shall take the appropriate steps to ensure that:

i) before construction of a radioactive waste management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime shall be carried out;

ii) in addition, before construction of a disposal facility, a systematic safety assessment and an environmental assessment for the period following closure shall be carried out and the results evaluated against the criteria established by the regulatory body;

iii) before the operation of a radioactive waste management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph (i).

H.5.1 Assessment of the safety of facilities before construction of radioactive waste management facilities

Assessment of the safety of radioactive waste management facilities (storage facilities for radioactive waste, conditioning facilities and repositories), and the assessment of environmental impacts prior to construction of such a facility, are carried out as part of a licensing procedure (cf. the remarks on Article 19). An assessment of the safety and of the environmental effects prior to commissioning takes place within the framework of the accompanying nuclear regulatory supervision (see details in Chapter H.5.3).

Regulatory basis

Under § 7 StrlSchV [1A-8], the handling of radioactive materials in nuclear facilities for the management of radioactive waste requires a licence.

Being a special case, the construction of vitrification facilities must be licenced in accordance with § 7 of the Atomic Energy Act (AtG) [1A-3], since apart from the processing of high-active waste, nuclear fuels will also be treated or processed in such facilities. The essential features of the safety assessment in the licensing procedure pursuant to § 7 AtG are outlined in the remarks on Article 8, and apply mutatis mutandis to the licensing procedure for facilities for the vitrification of highly radioactive waste.

Whereas the licence pursuant to § 7 AtG combines the licences required for the construction and operation of the nuclear facility and for the handling of nuclear fuels (cf. the remarks on Article 8), § 7 of the Radiation Protection Ordinance regulates only the handling of radioactive materials. A building permit under the applicable building code must also be applied for.

Applications for licences under the Atomic Energy Act must be submitted to the respective competent authority of the *Land* (Federal State). The application must outline the extent to which the nuclear facility possesses the required safety characteristics, and conforms to the specifications of the applicable rules and regulations. In the licensing procedure under § 7 StrlSchV, the documents listed in Appendix II, Part A, of that Ordinance must be enclosed with the licence application. The preconditions for a licence for handling radioactive materials are governed by § 9 StrlSchV. They are described in detail in the remarks on Article 13.

Regulatory reviews

Among other things, one licensing condition is that on handling radioactive waste, the equipment must be available and the measures taken in accordance with the state of the art in science and technology to ensure that the protective provisions are observed (§ 9 StrlSchV [1A-8]). The standards of the Nuclear Safety Standards Commission (KTA) and the German Standards Institute & German Association of Electrical Engineers (DIN/VDE) are used as the basis for checking the licensing requirements, and are applied mutatis mutandis. During the course of verifying the licensing requirements, the competent licensing authority may call upon the services of independent

According to the Environmental Impact Assessment Act (UVPG) [1B-14], an environmental impact assessment is mandatory for nuclear facilities designed to store radioactive waste for more than ten years at a location other than that where they were generated, and for nuclear facilities requiring a licence under § 7 AtG [1A-3]. For facilities which provide for the storage of radioactive waste for less than 10 years, a basic requirement of performing an EIA is not defined. However, it also applies to facilities that do not require an environmental impact assessment that all radiological effects have to be examined within the framework of the safety assessments of the licensing procedure. More information on the EIA Act can be found in the remarks on Article 13 and Article 6.

In addition, the Environmental Impact Assessment Act provides for general screening of individual cases in the case of nuclear facilities for the storage, handling, or processing of radioactive waste whose activity inventories reach or exceed the values specified in § 53 StrlSchV (see details in Chapter F.5.1). For such facilities, an environmental impact assessment must be performed if the competent authority feels that the project may have substantial adverse environmental impacts.

According to § 12b of the Atomic Energy Act, the competent authorities are required to investigate the reliability of the persons responsible for the handling of radioactive materials, in accordance with the Reliability Assessment Ordinance (*Atomrechtliche Zuverlässigkeitsüberprüfungs-Verordnung*, AtZüV) [1A-19], so as to safeguard against unauthorised actions that might lead to a misappropriation or substantial release of radioactive materials.

Requirements for design and operation

The requirements for the design and operation of facilities for the treatment of radioactive waste are shown by the example of the requirements for interim storage facilities:

In 2002, the Reactor Safety Commission prepared safety requirements in particular for the longer term storage of low- and medium-active waste. These were last updated by the Commission on Radioactive Waste Management in February 2013 [4-3]. The criteria contained in them are used to assess the safety of a facility for the storage of radioactive waste as well as its effects on the environment. As for facilities for the treatment of radioactive waste, these safety requirements have to be applied at least to their storage areas and in analogy to the areas where treatment takes place.

Facilities for the storage of radioactive waste are generally designed for the handling and storage of radioactive sources in waste packages. The waste containers thus assume the function of the safe activity confinement for the entire storage period. It is also admissible to design the storage facility with a view to handling radioactive waste that may cause emissions of radioactive substances, but this requires additional technical efforts with regard to the assumed release of radioactive substances with exhaust air and waste water.

According to [4-3], among others the following requirements for the waste products and packages have to be fulfilled in the storage of radioactive waste with negligible heat generation:

- Over the storage period until disposal, the waste products and waste containers have to be sufficiently chemically/physically stable for storage. By conditioning radioactive waste for storage or disposal, it has to be ensured that the waste package properties relevant in connection with storage and disposal are maintained over the storage period.

- Changes in the waste product properties and the waste container properties (e.g. shrinking in the case of cement products, reactions between residues of organic solvents and coating materials on the inner container wall, gas formation and corrosion) have to be minimised.

- The origin and characteristics of the raw waste have to be recorded and documented. The waste products generated according to qualified procedures and possible interim products have to be assessed with regard to their suitability for long-term storage. Requirements regarding the data to be documented are specified in Appendix X of the Radiation Protection Ordinance. Access to and legibility of the documentation has to be guaranteed until the waste is emplaced in a repository or released according to § 29 StrlSchV [1A-8].

- In view of the principles of radiation protection, especially the ALARA principle, handling and surveillance measures within the storage area are to be kept at a minimum.

To demonstrate that the requirements for storage are fulfilled it is also possible to present the verifications that have been provided as part of a qualified procedure regarding the conditioning of the waste in compliance with the requirements of a repository.

The requirements for the waste containers and the large components that may have to be stored result in particular from the safety analyses and are specified in the technical acceptance criteria of the storage facilities. Moreover, the requirements of the traffic regulations according to the respective applicable dangerous goods regulations also have to be observed. Permission for storage is given by the respective competent authority.

Among others, the following requirements for waste containers ensue from the ESK recommendation [4-3]:

- The design of the waste containers has to be such that their handling can also be ensured during and after interim storage. The long-term integrity has to be ensured by means of an adequate design of the waste containers (e.g. corrosion protection, thick container walls). Possible impairments of the container integrity caused by impacts from the interior of the container (characteristics of the waste product) and from outside (e.g. atmospheric conditions of the interim storage facility) have to be considered. Analogous considerations apply to the storage of large components.

- If the waste containers or large components are not suitable for long-term storage without any doubt due to their design, recurrent controls by non-destructive tests (e.g. visual inspections) shall be performed. To enable these controls, accessibility has to be ensured in the interim storage facility (e.g. by providing alleys between the package stacks or separate storage of packages). The scope of the controls shall be defined individually.

Accident analysis

The ESK recommendation [4-3] contains, among others, requirements for structural and technical installations in order to limit the effects of accidents. The facilities that are identical in construction are to be built according to the respective building codes of the *Länder* and according to the generally recognised engineering rules. Furthermore, the following applies:

- Regarding the protection against safety-relevant events in storage facilities, measures have to be taken upon the planning of structural or other technical protective provisions to limit the release of radioactive materials into the environment in the event of an incident. Here, §§ 49 and 50 StrlSchV in connection with § 117 para. 16 StrlSchV [1A-8] have to be observed.

- Within the framework of an accident analysis it has to be examined which operational disturbances and incidents may occur during the storage of radioactive waste with negligible heat generation. On the basis of this analysis, the design basis accidents for storage are to be derived. Human errors shall be considered in the analysis. The following plant-internal events (internal impacts) are generally to be considered as design basis accidents:

  - mechanical impacts (drop of a waste package or drop of a load onto a waste package),
  - thermal impacts,
  - failures of safety-relevant systems and equipment (power supply, instrumentation and control installations, hoisting gear, transport vehicles).

  Also, the following external hazards have to be taken into account in the analysis of potential impacts, with special site-specific features and possible interactions with neighbouring nuclear power plants having to be taken into account:

  - natural external hazards, e.g. storm, rain, snowfall, freeze, lightning, flooding, earthquakes, landslides,
  - human-induced external hazards, e.g. impacts of harmful substances, blast waves caused by chemical reactions, external fires spreading to the interior, damage by mines caving, aircraft crashes.

Adaptations during operation

The terms of validity of the licences for the storage of waste with negligible heat generation are set differently from one authority to the other; they span several years up to unlimited periods. In order to allow an adaptation to the state of the art in science and technology or the rectification of deficiencies, the competent authority may impose additional licensing requirements.

H.5.2 Assessment of safety before construction of a disposal facility

Assessment of safety before construction of a disposal facility for the period following closure

§ 9b as well as § 7, para. 2, subpara. 3 of the Atomic Energy Act (AtG) [1A-3] stipulate that the necessary precautions must be taken according to the state of the art in science and technology to prevent damage from ionising radiation. These precautions are also pertinent to the period following closure of a repository. As the disposal of radioactive waste in Germany is defined as the maintenance-free, safe emplacement of these materials for an unlimited period of time, the long-term safety assessment is of particular importance within the licensing procedure.

Radiological verification of compliance with the dose limits may be provided in the form of model calculations. These calculations are used to determine and quantify potential releases of radionuclides from the repository through the geosphere into the biosphere and to calculate the possible radiation exposure of humans using a variety of exposure scenarios and model assumptions. The input data for these models is derived from the characteristic data of the radioactive waste, a description of the deposition and technical barrier concept, and the geological data of the model area obtained from a site exploration. The dose is calculated by means of suitable radio-ecological models.

The current state of the art in science and technology is decisive when specifying a forecasting period for the required precautionary measures (isolation period). In other words, all relevant scientific and technological knowledge and experience must be taken into account. With the aid of a geoscientific long-term forecast, an isolation potential of > 10^{05} years has been calculated for the Konrad repository as a repository for radioactive waste with negligible heat generation.

Section 7.2 of the “Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste” [BMU 10] stipulates the following:

> *“... Prior to any major decision pursuant to chapter 5.1, a comprehensive, site-specific safety analysis and safety assessment covering a period of one million years must be carried out ... In particular, this assessment and the documentation thereof should include the following points:*
>
> - *the underlying final repository concept*
> - *the quality-assured collation of data and information from site exploration, research and development*
> - *the quality-assured implementability of requirements pertaining to technical barriers*
> - *the identification, characterisation and modelling of safety-relevant processes, together with confidence-building in this regard and qualification of the models*
> - *the comprehensive identification and analysis of safety-relevant scenarios and their allocation to probability categories pursuant to chapter 6*
> - *the representation and implementation of a systematic strategy for the identification, evaluation and handling of uncertainties.”*

On this basis, a long-term integrity of the containment-providing rock zone has to be demonstrated, a long-term radiological statement be prepared, and the robustness of technical components of the repository system and the exclusion of criticality demonstrated.

The integrity demonstration also contains the verification that the pore water in the containment-providing rock zone does not participate in the hydrogeological cycle in terms of the Federal Water Act and that the protection goals of said Act are adhered to.

Assessment of impacts on the environment

§ 9b AtG [1A-3] stipulates that a plan approval procedure (licensing procedure) is mandatory for repositories for radioactive waste. The plan approval notice may only be granted if the prerequisites listed in the aforementioned section of the AtG have been met by the applicant (cf. the remarks on Article 11 i to iv). This also includes consideration of the common good and other provisions of public law, particularly with respect to the environmental impacts.

The Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10] and the Administrative Procedures Act (VwVfG) regulate the design and implementation of the plan approval procedure. In addition, the Environmental Impact Assessment Act (UVPG) [1B-14] requires the performance of an environmental impact assessment.

Stipulating that the state of the art in science and technology is a prerequisite for the plan approval notice ensures that the safety assessments and the environmental impact assessment are up-to-date at the time of issuing the plan approval notice.

H.5.3 Assessment of safety before the operation of radioactive waste management facilities

Under § 19 AtG [1A-3], the handling and trafficking of radioactive substances is subject to government supervision. An assessment of the safety and the environmental impacts prior to commissioning of the nuclear facility occurs within the context of supervision which accompanies construction under the Atomic Energy Act.

If material deviations in the handling as specified in the licensing documents occur between the time of licensing until the commissioning of a facility for the treatment of radioactive waste, licensing under § 7 StrlSchV [1A-8] or § 7 AtG is required. Modification licences are applied for by the operator of the facility affected, sometimes within the framework of a nuclear regulatory authority order, at the competent licensing authority. The documents to be submitted together with the licence application have to reflect the state of the art in science and technology regarding the scope of effects of the part to be modified. The safety assessment carried out by the safety authority also has to be based on the state of the art in science and technology. Where applicable, in the case of projects requiring an environmental impact assessment under § 3e of the Environmental Impact Assessment Act (UVPG) [1B-14], the assessment of environmental impacts must be repeated, e.g. if the alteration applied for could entail substantially altered impacts on the environment. In such a case, public participation is again necessary as part of the environmental impact assessment.

H.5.4 Stress test

The earthquake off the Japanese coast on 11 March 2011 and the resulting inundation by a tsunami triggered a nuclear disaster at the Fukushima site. Even if the initiating events of the nuclear disaster in Japan, especially the intensity of the earthquake and the height of the flood wave cannot be directly applied to European and German conditions, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) deemed it necessary not only to carry out a robustness assessment of the German nuclear power plants and research reactors but also a stress test for the facilities for the management of irradiated fuel and radioactive waste in Germany as well as for the uranium enrichment plant at Gronau and the fuel fabrication plant at

Lingen. The Nuclear Waste Management Commission (ESK) was tasked with developing corresponding inspection concepts for these facilities. The results of this stress test are documented in ESK statements [4-11], see the reporting in Chapter G.5.3.

H.6 Article 16: Operation of facilities

> *Article 16: Operation of facilities*
>
> *Each Contracting Party shall take the appropriate steps to ensure that:*
>
> *i) the licence to operate a radioactive waste management facility is based upon appropriate assessments as specified in Article 15 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements;*
>
> *ii) operational limits and conditions, derived from tests, operational experience and the assessments as specified in Article 15 are defined and revised as necessary;*
>
> *iii) operation, maintenance, monitoring, inspection and testing of a radioactive waste management facility are conducted in accordance with established procedures. For a disposal facility the results thus obtained shall be used to verify and to review the validity of assumptions made and to update the assessments as specified in Article 15 for the period after closure;*
>
> *iv) engineering and technical support in all safety-related fields are available throughout the operating lifetime of a radioactive waste management facility;*
>
> *v) procedures for characterisation and segregation of radioactive waste are applied;*
>
> *vi) incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body;*
>
> *vii) programmes to collect and analyse relevant operating experience are established and that the results are acted upon, where appropriate;*
>
> *i) decommissioning plans for a radioactive waste management facility other than a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility, and are reviewed by the regulatory body;*
>
> *ii) plans for the closure of a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility and are reviewed by the regulatory body.*

H.6.1 Licensing of operation

Before commencing operation, all systems and equipment are subjected to commissioning tests in accordance with the guidelines for the storage of radioactive waste with negligible heat generation [4-3]. These tests are specified as part of the licensing documents in a commissioning programme which ensures that the safety requirements outlined in Article 15 are met. The commissioning programme is subject to approval by the competent authority. The tests serve to demonstrate that the systems and equipment are qualified for the intended operation and can be operated as specified. The results are documented and assessed.

The overall operation must be suitably structured to ensure the safe performance of the operational processes. In particular, the administrative prerequisites regarding personnel, organisation and safety must be fulfilled. The authority supervises compliance with these prerequisites. Clear instructions must be drawn up in the form of an operating manual for operational processes, accident management and the removal of the consequences of incidents and accidents. Competencies and responsibilities must be clearly defined. The competent authority supervises compliance with these requirements.

Prior to initial emplacement or treatment of waste, the entire handling procedure, including the radiation protection measures, is tested. During the course of testing, any potential deficiencies in the procedure are identified. In this way, optimisations can be tested prior to handling the waste packages, and the envisaged procedures provided can be adapted and finalised.

H.6.2 Specification and revision of operational limits

All operational processes and the measures to be taken in case of an incident or accident are outlined in an operating manual, or in the case of a repository, in amine book/operating manual, in form of clear operating instructions. These pay particular attention to all aspects affecting safety and define operational limits and conditions. The operational limits are defined on the basis of the Atomic Energy Act (AtG) [1A-3] in compliance with the corresponding stipulations of the Radiation protection Ordinance (StrlSchV) [1A-8]. Here, the fundamental protection goals, such as the safe enclosure of activity and the guarantee of decay heat power removal, have to be achieved both during normal operation and under corresponding accident conditions. In the licensing of operational release limits (e.g. for radiolysis gases) the principle of minimisation is applied by providing measures that are as reasonable as achievable. Furthermore, the procedure in case of modification or supplementation of components and processes must also be specified. The operating manual forms part of the licensing documents and is therefore subject to examination. This ensures that operatives are able to initiate and perform the necessary measures swiftly and competently in case of abnormal operation or incidents. This procedure is subject to regulatory supervision.

H.6.3 Compliance with established values

Regulatory supervision ensures observance of the procedures on operation, maintenance, monitoring, inspection and testing established in the nuclear licensing procedure for a radioactive waste management facility (cf. Table L-5 to Table L-13) as well as the consideration of the guidelines for the storage of radioactive waste with negligible heat generation [4-3].

For the treatment of radioactive waste, conditioning plants are used in this context that are subjected to qualification by the BfS, or the conditioned waste is subjected to product control procedures to ensure its suitability for disposal (cf. the remarks made on Article 23 “Quality Assurance”).

For storage facilities it applies in particular that the waste is subjected to incoming inspection prior to any form of treatment or emplacement. The incoming inspection serves the purpose of verification and must facilitate the following evidence:

- Identification control: The incoming inspection verifies whether the waste is the same as those declared for acceptance.
- Fulfilment of acceptance criteria: The incoming inspection ensures that the acceptance criteria defined in the licence are fulfilled. For this purpose, reference may also be made to the quality-assured data of the conditioner.
- Verification of the data stated by the delivering party: The incoming inspection checks specific waste parameters independently from the data supplied by the delivering party. Specific parameters may include, for example, mass, dose rate and surface contamination.

As a general rule, the following aspects are controlled for the purposes of emplacement operation:

- mass, dose rate and surface contamination of the waste packages
- condition and labelling of the waste packages
- compliance with declared data.

Furthermore, the following is also observed:

- the incoming inspections are only performed by trained personnel
- in the case of non-compliance, extended controls are performed
- any disturbances and findings are reported immediately
- the emplacement is logged.

When removing waste from the storage facility, exit inspections are performed. Waste packages leaving the facility are subject to unequivocal identification. In addition, the removal of waste is also logged.

Execution provisions are developed for compliance with the acceptance criteria. These include operating instructions and test procedures which must be observed during handling of the packages.

All the systems and equipment of the facility requiring testing or maintenance must be readily accessible or made accessible by technical means. The spatial conditions are designed in such a way as to allow sufficient space for maintenance work, and any additional shielding required for radiological protection reasons must be kept available. Regulations governing the preparation and performance of maintenance work are included in the operating manual.

At the site of the interim storage facility or management facility, adequate numbers of qualified personnel are employed to ensure fulfilment of all safety requirements; this personnel must be subject to regular training. With regard to said personnel, a distinction is made between the following cases:

- Management and storage facilities that have to be classified as being nuclear facilities which are either in operation or in the process of dismantling: in such cases, the personnel of the nuclear facility perform most functions.
- Management and storage facilities with permanent staffing covered by own personnel: these facilities are regarded as being independent with regard to operation.
- Management and storage facilities which do not require permanent staffing. The functions are restricted to deployment on demand in case of treatment, emplacement or removal operations, and/or regular inspections. The demand is temporary and is generally covered by personnel who primarily perform other tasks.

The technical qualification required for the respective position is demonstrated in accordance with the requirements of the Radiation Protection Ordinance (StrlSchV) or separate regulations. The requirements concerning responsibility for nuclear safety issues are regulated by the Atomic Energy Act (AtG) [1A-3] and the Radiation Protection Ordinance (StrlSchV) [1A-8]. The responsibilities and regulations on representation are defined unambiguously in the operating manual.

Due regard is given to the development and promotion of a pronounced safety culture. This is particularly applicable to facilities where personnel activities are required relatively seldom or where changing personnel are deployed for different tasks. With regard to long-term operation of the storage facilities, it is assumed that changes of personnel are required. In this respect, measures are taken to ensure that the required personnel resources are available in order to maintain a sustainable safety culture. This is achieved by long-term personnel planning and careful planning with regard to the maintenance of experience.

Different emergency procedures may be required, depending on the type of management or storage facility and the waste stored. Based on the possibilities for the release of radioactive substances from the storage facility, an on-site emergency preparedness plan is drawn up, coordinated and agreed, where applicable, with the emergency preparedness plans of neighbouring facilities and the competent local and regional authorities. Hard copies of the on-site emergency preparedness plan are always kept available at a permanently staffed location. Further copies are submitted to the neighbouring facilities, the competent authorities and safety bodies, where applicable.

H.6.4 Availability of technical support

Report has already been given on the measures to ensure engineering support during the facility's operating lifetime via the provision of adequate competent personnel in the comments on Article 22 i. The requirements for interim storage facilities ensue from the guidelines for the storage of radioactive waste with negligible heat generation [4-3], which stipulate that irrespective of the situation at the site, the interim storage facility must provide qualified personnel in sufficient numbers that ensures compliance with safety requirements and is regularly trained.

In-service inspections are performed on the safety-relevant systems and equipment of the facility, such as

- conditioning facilities
- lifting devices
- alarm systems
- equipment and systems for radiation protection
- ventilation systems, where applicable.

The frequency of such testing is determined according to the safety significance of the components to be checked. Typical testing intervals are one or two years. The in-service inspections are specified in a testing manual. The results of the in-service inspections are documented and assessed.

The technical equipment used for the handling of the packages and the transportation thereof must remain available until all packages have been removed. In this respect, it is assumed that removal of the packages, e.g. for the purposes of emplacement in a repository, may take place over a longer period of time. To this end,

- the necessary systems and equipment of the facility (e.g. lifting devices) are kept either in a state of operational readiness or in such a state that operational readiness can be restored in the short term (e.g. by a recurrent test),
- auxiliary equipment (e.g. overpacks, special lading devices) required for transport is kept available,

- necessary type approvals for the cask types are permanently maintained,
- the packages are maintained in a condition that generally facilitates approval under traffic law provisions, and
- any aids required for obtaining approval under transport law provisions are available (e.g. measuring and test devices, documentation).

H.6.5 Characterisation and segregation of radioactive waste

The process-based treatment of waste is divided in great detail into corresponding waste treatment categories: the waste is either raw waste that has not yet been treated, or it comes in the form of an intermediate or final product from one of 22 possible treatment processes.

The sorting and segregation of the waste (if possible, already of the raw waste) and the preparation of the associated documentation are performed initially by the waste producer or by the delivering party. If required, the waste management or storage facilities should be equipped with the necessary means for the sorting of waste with due regard for all requirements relating to the radiological protection of personnel and the environment.

In view of the intended pre-treatment and conditioning, Appendix X StrlSchV [1A-8] demands the sorting and segregation of the waste. Here, a distinction is made between seven main groups:

- solid inorganic waste,
- solid organic waste,
- liquid inorganic waste,
- liquid organic waste,
- gaseous waste,
- mixed waste (solid, liquid, inorganic, organic) and
- radiation sources (sealed sources).

These are subdivided into further subgroups.

A further detailing of the categorisation is the distinction between untreated waste (raw waste), pre-treated waste, waste products in inner containers, waste products in standardised waste containers according to the waste acceptance requirements for disposal in the Konrad repository, product-controlled waste products in inner containers, and product-controlled waste products in standardised waste containers in accordance with the waste acceptance requirements for disposal in the Konrad repository (waste packages suitable for disposal).

The waste characterisation system is sufficiently flexible to ensure that for each relevant waste type a clear allocation according to the processing condition, characterisation and treatment is always guaranteed.

H.6.6 Reporting of significant incidents

At present, the obligation of the licensee to report safety-relevant incidents to the regulatory body is based on the appropriate application of the Nuclear Safety Officer and Reporting Ordinance (AtSMV) [1A-17] or on the stipulations in connection with licensing of the facility. The reporting duties and the reporting procedure are largely identical with the situation described in the remarks on Article 9 v.

H.6.7 Collection and analysis of operating experience

In view of the obligation of the authorities to take precautionary action, reports of incidents significant to safety are registered and evaluated at the incident registration centre of the Federal Office for Radiation Protection (cf. the remarks on Article 9 vi in Chapter G.6.5).

Experiences from the operation of similar plants are taken into account by the plant management. This ensures that experiences, especially regarding

- the behaviour of package material,
- observations on gradual changes of the waste products,
- ageing phenomena of facility equipment as well as
- improvements to or deficiencies in the conditioning procedures

are examined and evaluated with regard to their transferability. Here, international reporting systems (of the IAEA and the OECD) are also considered. In this way, plant operation also makes adequate allowance for processes that occur very slowly as well as occurrences taking place rarely or only in case of certain waste. Procedures are provided which ensure the exchange of experiences (e.g. on the basis of operating reports) between the operators on the one hand, and the competent licensing and supervisory authorities and the experts consulted by them on the other, at adequate intervals.

A monitoring concept is drawn up to allow the detection and control of long-term and ageing effects during the useful life of the storage facility. On the one hand, the monitoring concept includes an evaluation of results from previous inspections, including the experience from other facilities. On the other hand, it can also include special analyses that cannot be performed recurrently at regular intervals due to the effort involved and the slow speed of any anticipated detrimental changes.

The monitoring concept stipulates monitoring of the overall condition of the facility and the packages stored, and as a minimum requirement, must meet the following:

- At ten-year intervals, the licensee prepares regular reports on the condition of the storage building, the components required for storage and handling, and the waste packages. In particular, these reports should also incorporate the findings of in-service inspections. The reports include a prognosis on the continued storability of the packages and waste types, as well as on the further development of the relevant retention properties of the building.
- The condition of the storage building and the components necessary for interim storage are also subjected to a special inspection at intervals of ten years. As a minimum requirement, these should include walk-downs and appropriate measurements. In addition, recurrent subsidence measurements are performed on the storage building and evaluated with regard to long-term detrimental changes.

All operational measures, controls, inspections and modifications are subject to the supervision of the competent authorities.

H.6.8 Preparation of decommissioning plans

For radioactive waste treatment facilities, the remarks made on Article 9 vii apply, too.

H.6.9 Closure of repositories

For the closure of a repository, a plan approval notice or a licence in accordance with the Atomic Energy Act must have been issued. So far, no repository in deep geological formations has been either backfilled or closed in the Federal Republic of Germany.

Repository for heat-generating radioactive waste

The “Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste” stipulate that the decommissioning concept should be reviewed in line with the state of the art as part of the ten-yearly safety reviews, and updated where necessary. At the same time, the mining law is also to be applied. According to § 55, para. 1 of the Federal Mining Act (BBergG) [1B-15], operational plans for the construction and management of a facility may only be approved if the required precautions to facilitate reutilisation of the surface have been taken into account to the extent required under the prevailing circumstances. Furthermore, the relevant § 7, para. 2 of the General Mining Ordinance on Underground Mines, Open-Cast Mines and Salt Mines (ABVO) [ABVO 96] stipulates that open shafts maintained in a state which is neither safe nor descendible are to be backfilled. An application for such backfilling must be submitted in a timely manner in the form of an operational plan.

This aspect of mining legislation therefore ensures that at the time of filing the final operational plan - which may be many years in the future from the date of approval of operation - any new knowledge acquired in the interim period can be duly taken into account.

Konrad repository

Plans relating to the closure of the mine workings and shafts of the Konrad mine as a repository for radioactive waste with negligible heat generation were filed and approved within the scope of the licensing procedure that was concluded in May 2002. Concrete details of the measures required in order to comply with the protection targets following the cessation of emplacement operations have not yet been finalised. Since closure is usually intended no earlier than after several decades, such details must be specified according to the state of the art in science and technology existing at that time within the context of separate procedures encompassing the requirements of nuclear legislation, mining and water legislation as well as other legal requirements.

Morsleben repository

The safe long-term closure of the Morsleben repository (ERAM) is in preparation. During this phase, all relevant information gathered during the operational period (until today) is taken into consideration. For example, the closure concept incorporates findings from the geological, geotechnical, geochemical and mining fields. With respect to radiation protection, the potential release of radionuclides during the post-operational phase shall be limited to an acceptable level by the closure. During the post-operational phase it is required that the entire repository be sufficiently safely sealed against the biosphere (cf. the remarks on Article 14 iii). This has to be demonstrated by a site-specific long-term safety analysis. For such an analysis, partial systems and scenarios within the whole system are modelled using suitable models based on conservative assumptions. Apart from the requirements posed by radiation protection, requirements from other legal areas have to be taken into account.

According to § 9b AtG [1A-3], any major modifications of the Morsleben repository, i.e. also any measures concerning its closure, require a plan approval by the competent environmental ministry of the *Land* Saxony-Anhalt. In the scope of the licensing procedure for the ERAM, the only difference to the plan approval procedure for § 9b AtG (cf. the remarks on Article 19) consists in the fact that for this existing repository the operational phase is finished and that the corresponding procedures can only be directed at the requirements for safe closure. The plan approval according to the Atomic Law states that the plan for closure is permissible with respect to all public interests which are touched. The licensing of the operating plans according to mining law lies within the responsibility of the mining authority of Saxony-Anhalt.

The plan approval procedure for operation of the repository which had been initiated in 1992 was restricted to decommissioning (or closure in the sense of the Convention) upon application of the BfS in 1997. The first step in the environmental impact assessment which is required as part of the plan approval procedure was to define the required documents according to § 5 of the Environmental Impact Assessment Act (UVPG) [1B-14]. Meanwhile, documents for the plan approval procedure relating to the backfilling and closure of the Morsleben repository have been submitted to the competent licensing authority, and the application documents were displayed for public inspection. The competent plan approval authority conducted the public hearing between 13 October and 25 October 2011. As a result of the public hearing, the BMU asked the Commission on Nuclear Waste Management (ESK) do examine whether the methodology used for the long-term safety assessment prepared by the BfS corresponded to the state of the art in science and technology. On 31 January 2013, the ESK presented its statement on the "Long-term safety case for the Morsleben repository for radioactive waste (ERAM)" [4-11a]. On 8 March 2013, the BfS was ordered to implement all the recommendations made by the ESK as the ESK statement established the state of the art in science and technology and hence there was certainty for further planning. Due to the implementation of the ESK recommendations and the complex verification of the functioning of the shaft seals in rock salt and in anhydrite, it has not been possible to keep to the closure schedule that had been originally planned.

In parallel to the environmental impact assessment, other measures for hazard control have been carried out on the basis of licences according to mining law. These have been aimed at the long-term stability of the mine for the closure measures by backfilling cavities in the central part of the Bartensleben mine. In the course of these measures, 27 mine workings had been backfilled with 935,000 m^3 of rock salt concrete by the end of February 2011. This does not anticipate any measures for closure, and the backfilling of the disposal areas is not part of the premature backfilling.

The ERAM was designed and taken into operation at the time of the former GDR. After takeover as a federal repository in the course of the German reunification, new conclusions from the operational phase and from dedicated geological, geotechnical, geochemical and mining technique assessments for the development of a decommissioning concept were included. It provides that any yet open underground workings be largely filled with rock salt concrete. This is to ensure as far as possible the integrity of the protective salt layers around the underground workings and keep the mine dry. In addition, in case of a brine inflow into the mine, which cannot be fully excluded, the emplacement areas East Field, South Field and West Field, i.e. the major mine workings used for the disposal of radioactive waste and their wider surroundings, will be isolated from the rest of the mine workings by sealing of the drifts. The closure concept further includes the sealing of both shafts of the ERAM by systems of sealing elements of various materials with low permeability in order to minimise the inflow of groundwater from the overlying rock into the mine and the discharge of radionuclides in solution from the mine into the overlying rock.

H.7 Article 17: Institutional measures after closure

> *Article 17: Institutional measures after closure*
>
> *Each Contracting Party shall take the appropriate steps to ensure that after closure of a disposal facility*
>
> *i) records of the location, design and inventory of that facility required by the regulatory body are preserved;*
>
> *ii) active or passive institution al controls such as monitoring or access restrictions are carried out, if required;*
>
> *iii) if, during any period of active institution al control, an unplanned release of radioactive materials into the environment is detected, intervention measures are implemented, if necessary.*

H.7.1 Documentation

The official plan approval for the Konrad repository includes the regulations governing the post-operational period. A collateral clause stipulates that:

> *"Documentation must be provided during construction, operation and decommissioning of the repository, comprised of data relating to the mine survey of the repository, the characteristics of the wastes deposited (type, quantity, emplacement area, nuclide spectrum, activities), as well as the relevant technical measures. Full sets of documentation must be kept by the operator of the repository at a suitable place and must be duly protected. In addition, the operator must provide full sets of documentation for the atomic authority and for the competent mining office, respectively, which are to be kept under protection in separate locations. The sets of documentation kept by the supervisory authorities must be updated on an annual basis as long as the repository is operational or in the process of decommissioning. For the period following its closure, the form, extent and the storage locations (at least at two separate locations) of the long-term documentation must be specified in the closure plan and submitted to the supervisory authorities for approval."*

It can be assumed that the regulations laid down in the plan approval decision for the post-operation phase of the Konrad repository will act as a precedent for the ERAM. This repository is being closed, and the required measures for backfilling and closure are currently being planned.

H.7.2 Monitoring and institutional control

The "Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste" stipulate that following decommissioning of the repository, evidence preservation and control measures must be carried out. Prior to the completion of sealing work, it is necessary to determine which measures are to be carried out, which organisation shall perform them, and which resources will be made available for this purpose. For the period after closure, administrative precautions should be implemented to ensure, as effectively as practically possible, that no human activities which could endanger the permanent containment of the waste are carried out in the vicinity of the repository.

Institutional control after closure is regulated in the licence for the Konrad repository as follows:

"No special control and surveillance programme is envisaged for the period following closure. However, routine measurements of the environmental media air, water and soil must be conducted on the area surrounding the repository in accordance with the relevant regulations. These measurements must be examined for any evidence of impacts from the repository and documented in a suitable format. The extent and format must be specified in the closure plan and the results added to the long-term documentation."

Should the results from routine surveillance so require, counteractive measures may be initiated by means of intervention on the part of the authorities. The procedures for the ERAM and the Asse II mine have not yet been specified.

H.7.3 Unplanned release

As outlined in the remarks on Article 17 ii, no special control or surveillance measures are required following the closure of a repository or a mine in deep geological formations.

The usual inspection of surface settlement is carried out within the regime of mining law. The routine measurements of air, water and soil samples are likewise carried out in the area surrounding a repository, in accordance with legal requirements. In this way, any unplanned releases of radioactive substances may be detected and any measures which may be required by the competent authorities in order to avoid or mitigate any hazards can then be initiated.

Collateral clauses in the plan approval decision for the Konrad repository stipulate that routine surveillance data must likewise be evaluated in this respect.

The closures of the Morsleben repository and the Asse II mine are currently in the planning phase, and therefore plan approval is not yet available. It may be that the Asse II mine will only be closed once the waste has been retrieved, if this is possible. According to current planning, retrieval would start in 2033 and is likely to last several decades.

Exhaust air and surroundings of the Morsleben repository and the Asse II mine are continuously monitored by the operator as well as by an independent measuring institution. The necessary programmes are based on the "Guideline concerning Emission and Immission Monitoring of Nuclear Facilities" (REI) [3-23].

Measurements and measured values exist for local gamma dose rates, aerosol activity, soil samples and grass samples. The most important data of the operator's own environmental monitoring and monitoring by an independent measuring institution are published in annual reports. Quarterly reports supplement the documentation.

I Transboundary movement

This section deals with the obligations under Article 27 of the Convention.

Developments since the Fourth Review Meeting:

There have been no major developments since the Fourth Review Meeting.

I.1 Article 27: Transboundary movement

Article 27: Transboundary movement

(1) Each Contracting Party involved in transboundary movement shall take the appropriate steps to ensure that such movement is undertaken in a manner consistent with the provisions of this Convention and relevant binding international instruments.

In so doing:

i) a Contracting Party which is a State of origin shall take the appropriate steps to ensure that transboundary movement is authorised and takes place only with the prior notification and consent of the State of destination;

ii) transboundary movement through States of transit shall be subject to those international obligations which are relevant to the particular modes of transport utilised;

iii) a Contracting Party which is a State of destination shall consent to a transboundary movement only if it has the administrative and technical capacity, as well as the regulatory structure, needed to manage the spent fuel or the radioactive waste in a manner consistent with this Convention;

iv) a Contracting Party which is a State of origin shall authorise a transboundary movement only if it can satisfy itself in accordance with the consent of the State of destination that the requirements of subparagraph (iii) are met prior to transboundary movement;

v) a Contracting Party which is a State of origin shall take the appropriate steps to permit re-entry into its territory, if a transboundary movement is not or cannot be completed in conformity with this Article, unless an alternative safe arrangement can be made.

(2) A Contracting Party shall not licence the shipment of its spent fuel or radioactive waste to a destination south of latitude 60 degrees south for storage or disposal.

(3) Nothing in this Convention prejudices or affects:

i) the exercise, by ships and aircraft of all States, of maritime, river and air navigation rights and freedoms, as provided for in international law;

ii) rights of a Contracting Party to which radioactive waste is exported for processing to return, or provide for the return of the radioactive waste and other products after treatment to the State of origin;

iii) the right of a Contracting Party to export its spent fuel for reprocessing;

iv) rights of a Contracting Party to which spent fuel is exported for reprocessing to return, or provide for the return of, radioactive waste and other products resulting from reprocessing operations to the State of origin.

I.2 Obligation of licensing transboundary movement

Transboundary movements of spent fuel and radioactive waste are, according to Council Directive 2006/117/EURATOM [1F-35], subject to licensing in Germany (and in other Member States of the EU). Current German legislation requires that the carrier must submit an application to the licensing authority Federal Office of Economics and Export Control (BAFA) for each shipment of these materials. The BAFA must determine whether all legal provisions have been met and if so, grants the licence and subsequently, within the framework of waste management control, monitors compliance with the legal requirements during each individual shipment. In principle, a licence for a given quantity of material may be used for several individual shipments of partial amounts. In the case of shipment of spent fuel and radioactive waste from other EU states to Germany, the licensing authority in the delivering country shall be responsible; however, the BAFA is also consulted. The BAFA can attach special provisions to its approval or, if necessary, can refuse the approval on reasoned grounds.

Transboundary movements of spent fuel and radioactive waste will only be authorised if compliance with the safety measures outlined in the comments on Articles 4 to 17 and 21 to 26 is ensured, and compliance with the provisions of international conventions has been checked. This applies equally for the granting of approval in case of consultation.

I.2.1 Authorisation of transboundary movement and co-ordination with state of destination

Spent fuel

Essential for all transboundary movements of spent fuel to, through or from the Federal Republic of Germany is the “Ordinance on the Transboundary Movement of Radioactive Waste and Spent Fuel Assemblies” (AtAV) [1A-18] by which the Council Directive 2006/117/EURATOM [1F-35] has been transposed into national law; according to § 6 and 7 of the AtAV, the BAFA is the competent authority for this. Such a licence will only be granted if there are no concerns regarding the applicant’s reliability and if compliance with national and international safety regulations is ensured.

It primarily comprises the following provisions:

Transboundary movement within the European Community

The holder respectively the sender of spent fuel applies to the competent authority in his country (in Germany, this is the BAFA) for a licence. There is a standard form available for this purpose, which is divided into different sections. Section B-1 is the application form. The competent authority forwards a copy of this section together with section B–2 (“Acknowledgement of receipt of the application form for transboundary movement of spent fuel – request for information”) and Section B–3 (“Approval or refusal of the approval for transboundary movement of spent fuel by the competent authority”) to this competent authority in the state of destination (which in the case of shipments to Germany is the BAFA). This Section B–3 is only approved by the BAFA and mailed back to the competent licensing authority provided both the consignee and his competent supervising authority have likewise given their consent to the proposed shipment. Section B–4a (“Licence for transboundary movement of spent fuel”) can then be issued and handed over to the applicant.

During a shipment, all documents must be carried, including section B–5 (“Description of delivery of spent fuel and the list of the packages) and section B–6 (“Acknowledgement of receipt for spent fuel”).

In advance of each shipment all the aforementioned documents must be transmitted to all authorities concerned. In order to ensure that all authorities concerned are informed about every shipment, and to enable them to log the quantities delivered, they regularly receive copies of the respective sections B–5 and B–6.

Transboundary movement to or from states which are not members of the European Community (third countries)

In case of shipments from Germany to a third country, the BAFA will only grant a licence to the holder or sender of the spent fuel if the competent authority of that third country has confirmed to the BAFA that the consignee holds the necessary licence and the necessary equipment to handle such spent fuel, and it has been proven that the respective specified criteria for the export of spent fuel to third countries have been met.

In case of shipments from a third country to Germany, the consignee is the applicant, and will only receive a licence from the BAFA provided he holds the necessary licence and the necessary equipment to handle such spent fuel or has notified such handling in accordance with an existing obligation.

In case of shipments from Germany, it is additionally necessary to ensure that the state of destination will not put the consignment to any use whatsoever in a manner that will compromise international obligations of the Federal Republic of Germany in the nuclear field or its internal or external security.

Observance of these additional provisions is checked by the BAFA on the basis of contracts and declarations which must be submitted by the state of destination. Within the context of parallel supervision of a material's movements by EURATOM, to whom monthly reports about any inventory changes must be submitted, the correctness of which is verified by inspectors on a regular basis, notification also occurs prior to each individual shipment.

In the case of return deliveries e.g. of spent fuel from research reactors back to the USA, export cannot take place until the BAFA has received an official import certificate from the United States. For other states, an exchange of notes takes place between the affected government prior to the delivery, as part of the licensing procedure under foreign trade law.

Radioactive waste

Each transboundary movement of radioactive waste is subject to the provisions of Council Directive 2006/117/EURATOM [1F-35]. This Directive has been transposed into national law by the Ordinance on the Transboundary Movement of Radioactive Waste (AtAV) [1A-18] as already mentioned above. It primarily comprises the following provisions:

Transboundary movement within the European Community

The holder respectively the sender of radioactive waste applies to the competent authority in his country (in Germany, this is the BAFA) for a licence. There is a standard form available for this purpose, which is divided into different sections. Section A-1 is the application form. The competent authority forwards a copy of this section together with section A-2 ("Acknowledgement of receipt of the application form for transboundary movement of radioactive waste – request for information") and Section A–3 ("Approval or refusal of the approval for transboundary movement of radioactive waste by the competent authority") to this competent authority in the state of destination (which in the case of shipments to Germany is the BAFA). This Section A-3 is only approved by the BAFA and mailed back to the competent licensing authority provided both the consignee and his competent supervising authority have likewise given their consent to the proposed shipment. Section A-4a ("Licence for transboundary movement of radioactive waste") can then be issued and handed over to the applicant.

During a shipment, all documents must be carried, including section A-5 ("Description of delivery of radioactive waste and the list of the packages) and section A-6 ("Acknowledgement of receipt for radioactive waste").

In advance of each shipment all the aforementioned documents must be transmitted to all authorities concerned. In order to ensure that all authorities concerned are informed about every shipment, and to enable them to log the quantities delivered, they regularly receive copies of the respective sections A-5 and A-6.

Transboundary movement to or from states which are not members of the European Community (third countries)

In case of shipments from Germany to a third country, the BAFA will only grant a licence to the holder or sender of the radioactive waste if the competent authority of that third country has confirmed to the BAFA that the consignee holds the necessary licence and the necessary equipment to handle such radioactive waste, and it has been proven that the respective specified criteria for the export of radioactive waste to third countries have been met.

In case of a shipment from a third country to Germany, the consignee is the applicant, and will only receive a licence from the BAFA provided he holds the necessary licence and the necessary equipment to handle such radioactive waste or has notified such handling in accordance with an existing obligation.

I.2.2 Transboundary movement through states of transit

In the case of transit through Germany of spent fuel or radioactive waste the provisions of the AtAV [1A-18] also apply. Supervision of the transit of spent fuel with regard to the compliance with national and international regulations is the additional responsibility of the Federal Office for Radiation Protection (BfS), and in the case of transportation by rail, the Federal Office for Railways (EBA).

In the case of transit of radioactive waste or spent fuel, the BAFA must be consulted under the provisions of Council Directive 2006/117/EURATOM [1F-35] or of the AtAV; these transits therefore are subject to approval. Such approval will only be granted if there are no facts leading to concerns vis-à-vis proper delivery to the country of destination.

I.2.3 Compliance with safety provisions by the consignee in Germany

Transboundary movements of spent fuel and of radioactive waste will only be licensed by the expert staff at Germany's competent authority, the BAFA, provided the consignee in Germany ensures that such materials conform to the safety measures outlined in the comments on Articles 4 to 17 and 21 to 26. Prior to receiving such material, the consignee must apply to the BAFA for a licence under the statutory provisions outlined with respect to Article 27 (1) i. The BAFA will verify compliance with these provisions.

I.2.4 Compliance with safety provisions by the consignee in the state of destination

In the case of deliveries of spent fuel from Germany, a licence will only be granted provided the consignee, according to the documents available, fulfils the provisions outlined under Article 27 (1) iii, i.e. the international and/or European provisions are met and there are no substantiated doubts that this is so. In the case of deliveries of radioactive waste and spent fuel out of Germany, the requirements outlined in Article 27 (1) iii are met by the consultation process pursuant to the AtAV in conjunction with Council Directive 2006/117/EURATOM [1F-35] (see reporting on Article 27 (1) i and ii).

I.2.5 Possibility of re-import

In accordance with the Directory 2006/117/EURATOM [1F-35] respectively the AtAV [1A-18], the re-import of spent fuel or radioactive waste into Germany is possible in principle; the provisions in this respect were explained under Article 27 (1) i.

Generally speaking, a shipment of radioactive waste or spent fuel under the AtAV in conjunction with Council Directive 2006/117/EURATOM allows the option of return shipment in case the envisaged delivery cannot be completed.

According to § 8, para. 1, subpara. 3 AtAV, shipment to another EU Member State will only be licensed provided measures are taken to ensure that the radioactive waste or the spent fuel will be taken back by the original owner/sender if delivery cannot be completed or the provisions for its shipment cannot be met.

According to § 9, para. 1, subpara. 4 AtAV, shipment to a third country will likewise only be licensed provided measures are taken to ensure that the radioactive waste or spent fuel will be taken back by the original owner/sender if delivery cannot be completed or the provisions for its shipment cannot be met.

According to § 10, para. 1, subpara. 3 AtAV, shipment from a third country into Germany will only be licensed provided the domestic consignee of the radioactive waste or spent fuel has reached a binding agreement with the foreign owner/sender of the radioactive waste or spent fuel, with the consent of the competent authority in the third country, that the foreign owner/sender will take back the radioactive waste if the shipment process cannot be completed.

Finally, according to § 14, para. 1, subpara. 2 AtAV, the BAFA may only give its approval to a shipment from another EU Member State to Germany provided measures have been taken to ensure that the radioactive waste or spent fuel will be taken back by the original owner/sender if delivery cannot be completed or the provisions for its shipment cannot be met.

I.3 Antarctic Treaty

Germany ratified the Antarctic Treaty of 1 December 1959 [ANT 78] on 22 December 1978. Article V of this Treaty includes a ban on the shipment of radioactive waste south of latitude 60 degrees South. The Treaty was incorporated into national law and entered into force on 5 February 1979, thereby obligating Germany to comply with this ban. § 5 AtAV [1A-18] likewise prohibits shipments into this region.

I.4 Sovereignty demarcations

I.4.1 Maritime traffic and river navigation

With respect to the freedom of international maritime traffic, Germany has legally committed itself to observe the requirements of this Article insofar as it has acceded to the United Nations Convention on the Law of the Sea of 10 December 1982. It was transformed into national law by the Act on the United Nations Convention on the Law of the Sea of 10 December 1982 [UNCLOS 94].

With regard to the freedom of river navigation, it should be noted that Germany is a Party to the Revised Convention on Navigation on the Rhine (*Revidierte Rheinschifffahrtsakte*) of 17 October 1868 [RHE 68] and to the Convention of 27 October 1956 on the Canalisation of the Moselle [MOS 57].

I.4.2 Air traffic

With respect to air traffic, the requirements of this Article are met by Germany's accession to the International Agreement on the Transit of Air Services (*Vereinbarung über den Durchflug im internationalen Linienverkehr*) [LIN 56]. This Agreement stipulates that the Member States shall reciprocally grant one other the rights of the so-called first and second freedoms of air traffic, i.e. the right to pass over and to land for technical reasons. These commitments have been transformed into national law by the Act of Approval (*Zustimmungsgesetz*) on the basis of Article 59, para. 2 of Germany's Basic Law (*Grundgesetz*) [LIN 56].

I.4.3 Return of radioactive waste after treatment

The right referred to in this Article is not impaired by the incorporation of the Joint Convention into German legislation. German legislation does not include an obligation to accept the return of waste; it is instead agreed contractually with these export procedures. Article 2 of Council Directive 2006/117/EURATOM [1F-35] applies.

I.4.4 Shipment of spent fuel for reprocessing

This right remained unaffected until 30 June 2005. From this date on, it is no longer admissible to ship any German spent nuclear fuel from facilities for fission of nuclear fuels for the commercial generation of electricity to a facility for reprocessing of irradiated nuclear fuels, not because of the incorporation of this Convention into German legislation, but by virtue of the amendment to the German Atomic Energy Act (AtG) of 22 April 2002.

I.4.5 Return of material from reprocessing

The right referred to in this Article is not impaired by including the Convention in German legislation. On the contrary: in an exchange of notes with the French government and with the British government of 1979 and 1990/1991, respectively, the German government reinforced the rights of both these nations to return the waste and other products generated from the reprocessing of German spent fuel to Germany.

J Disused sealed sources

This section deals with the requirements under Article 28 of the Convention.

Developments since the Fourth Review Meeting:

The amount of data relating to sealed sources in the HASS register, maintained by the Federal Office for Radiation Protection (BfS), has increased significantly. The HASS register is continuously further developed with regard to accessibility and usability while maintaining a high level of safety and security.

J.1 Article 28: Disused sealed sources

Article 28: Disused sealed source

(1) Each Contracting Party shall, in the framework of its national law, take the appropriate steps to ensure that the possession, remanufacturing or disposal of disused sealed sources takes place in a safe manner.

(2) A Contracting Party shall allow for re-entry into its territory of disused sealed sources if, in the framework of its national law, it has accepted that they be returned to a manufacturer qualified to receive and possess the disused sealed sources.

J.1.1 Measures for the safe handling of disused sealed sources

Nearly 100,000 sealed sources are used in research, trade, industry, medicine and agriculture in Germany. Approximately 20,000 radioactive sources are registered as high-activity sealed sources (HASS) (see below). The most common fields of application for radioactive sources in the industry are calibration of measuring devices, materials testing, irradiation and sterilisation of products, as well as level and density measurement. In medicine, radioactive sources are mostly used for radiotherapy and for irradiation of blood. The most frequently used radionuclides in radioactive sources are Co-60, Ir-192, Cs-137, Sr-90 and Am-241 whose activity is in the range of some kBq for test and calibration emitters and up to some 10^{12} Bq for radioactive sources for irradiation facilities. In Germany, the safety and security of disused sealed sources has long been ensured by a legal framework in accordance with European and international standards and by an extensive system of licensing and supervision.

In the vast majority of the very rare cases of so-called “orphan sources” in Germany, radioactive sources of low activity are concerned. Loss and discovery of radioactive materials are regularly recorded in the annual reports of the BMUB [BfS 11] and in parliamentary reports [BfS 12a]. In 2012, 91 found and 5 lost sources were registered in Germany. The publication of these reports has also the task to inform the public about this topic and to raise awareness about this subject area.

Improvement of the control of disused sealed sources is therefore a decisive measure in the efforts to avoid any exceptional exposure of humans, the environment and material goods. In this respect, Germany has transposed all relevant EU directives. In the following, the experiences made with the HASS register at the BfS and the international context of control of radioactive sources are described.

High-activity sealed sources (HASS) and the HASS register at the BfS

Based on Council Directive 2003/122/EURATOM of 22 December 2003 on the control of high-activity sealed sources and orphan sources [1F-22], the Act on the Control of High-Activity Radioactive Sources [1A-23] entered into force in August 2005. The scope of application of the Act is limited to high-activity sealed sources. The necessary amendments to the Atomic Energy Act (AtG) [1A-3] and the relevant regulations have been made.

§ 70a of the Radiation Protection Ordinance (StrlSchV) contains requirements for the register of high-active radioactive sources that is kept at the BfS. According to § 12d, para. 2 AtG, the data on HASS have to be transmitted to the register by the licensee. The National Report for the Fourth Review Meeting describes the establishment and operation of the HASS register.

The responsibilities of those authorised to access the HASS register can be summarised as described in the following.

- Licensee: Notification regarding the acquisition, the transfer and the use of a HASS (including its loss or discovery) to the BfS. The licensee submits the data using the standard record sheet of Appendix XV StrlSchV [1A-8] in secured electronic form. For safety and security reasons, the licensee has no direct access to the database.

- The competent authority of the individual *Land*: Verification of the data submitted by the licensee, the loss or discovery of HASS, reports and analyses. The authority has access to the database.

- The BfS: Operation and maintenance of the database, preparation of reports and analyses, check of the data for plausibility, data entry, providing users with advice, development of software and hardware. The BfS is the legally designated operator of the database.

- Other authorities: Reports and analyses if access by security authorities (offices of criminal investigation, police, etc.) is required. These authorities have a read-only access.

Safe and secure operation of the HASS database is ensured by a number of administrative data and technical measures.

The HASS register has been operated since July 2006 and meets the requirements of the above mentioned European Directive. The system is accepted by licensees and authorities and is subject to continuous further development with regard to accessibility, also for the licensees, and user-friendliness while maintaining a high level of safety and security. The development of the data in the HASS register since 2006 is shown in Table J-1. For a total of 97,200 registrations of radioactive sources, 115,300 communications were stored in the database by the end of 2013. However, only about 40 % of these registered sources were HASS as specified in the StrlSchV.

Table J-1: Development of the data in the HASS register since 2006 [BfS 12a]

Status	Licensees	Authorities	Radioactive sources	Communications
End of 2006	321	43	1,740	3,139
End of 2007	453	47	7,625	16,863
End of 2008	540	47	13,800	32,600
End of 2009	580	49	17,300	49,200
End of 2010	590	49	20,100	63,000
End of 2011	630	50	23,500	79,000
End of 2012	646	60	27,200	97,200
End of 2013*)	657	64	31,000	115,300

*) BfS annual report for 2013 not published yet at the time of reporting

General requirements for radioactive sources

According to § 7 StrlSchV [1A-8], the use of sealed sources requires a licence. There is an exception for test emitters whose activity does not exceed the exemption levels of Appendix III, Table 1, Column 2 or 3 StrlSchV (§ 8, para. 1 in conjunction with Appendix I, Part B, No. 1 and 2 StrlSchV), and for type-approved devices that may contain radioactive sources (§ 8, para. 1 in conjunction with Appendix I, Part B, No. 4 StrlSchV).

Furthermore, § 69, para. 1 StrlSchV stipulates that radioactive substances that may only be handled on the basis of a licence, among others according to § 7 StrlSchV, shall only be transferred to persons who are in possession of the requisite licence. According to § 69, para. 2 StrlSchV, anyone delivering radioactive substances to third parties for further use shall certify to the procuring party that the casing is leak-proof and free of contamination. High-active radioactive sources may only be transferred if they are accompanied by a documentation of the manufacturer specified according to StrlSchV. § 69, para. 3 and 4 StrlSchV regulate transport and transfer to the recipient. Non-compliance with these provisions of § 69 will be fined according to § 116 StrlSchV as an administrative offence. In addition, § 328, para. 1, subpara. 2 Criminal Code (StGB) [1B-1] stipulates that the storage, shipment, handling, processing, other use as well as import and export without the requisite licence or contrary to an enforceable prohibition of such other radioactive substances which because of their nature, composition or quantity are capable of causing the death of or serious injury to another by ionising radiation is punishable.

According to § 70, para. 1 StrlSchV, the competent authority must be notified within one month of any extraction, production, acquisition, transfer and whereabouts of radioactive material and therefore also of radioactive sources, specifying type and activity, and records on it must be kept. For any handling of high-active radioactive sources there is an additional duty of informing the BfS thereof. The scope of the information to be provided is clearly regulated (see below). § 70 (4) StrlSchV requires that a certificate of tightness of sealed sources is to be attached to the notification on the acquisition of the radioactive source submitted to the authority. Type-approved devices into which radioactive substances are embedded and that may be used without a licence in accordance with § 8, para. 1 in conjunction with Appendix I, Part B, No. 4 StrlSchV must be returned immediately to the authorisation holder (in Germany, this is usually the manufacturer or distributor) after end of use according to § 27, para. 1 subpara. 5 StrlSchV.

The German regulatory framework transposes those parts of the EURATOM Basic Safety Standards (Council Directive 96/29/EURATOM) [1F-18] that are binding for radioactive sources as well as the Council Directive 2003/122/EURATOM [1F-22] and also takes into account the relevant recommendations and guidance documents of the IAEA (see Chapter J.1.3 on international aspects).

Storage and disposal of disused radioactive sources

The working lives of the sources used are very different, in particular due to the strongly varying half-lives of the radionuclides used. In most cases, the devices operated on the basis of a licence for handling are returned to the equipment manufacturer by the operator after end of use together with the source remaining in the device. The manufacturer may check further use of the sources or returns them to the source manufacturer who may reuse parts of them. The sources that cannot be reused are delivered to the *Land* collecting facilities where they are stored until delivery to the Konrad repository.

The general national regulations for the disposal of radioactive waste are included in the Atomic Energy Act (AtG). § 9a AtG stipulates that the *Länder* shall establish collecting facilities for the storage of the radioactive waste originating within their territories. §§ 72 to 79 StrlSchV regulate the obligation to report to the supervisory authorities of the *Länder*, the type and extent of the notifications as well as the treatment, packaging, storage and delivery of the radioactive waste.

According to the waste acceptance requirements for the disposal of waste packages, there are no special requirements with regard to the processing, packaging and labelling of sealed sources. In the collecting facilities of the *Länder*, disused sources are usually conditioned and documented together with other radioactive waste. For conditioning of disused sources, the same procedures are applied as for radioactive waste. It is carried out according to procedures qualified by the BfS with the objective of producing waste packages that are suitable for storage and disposal. The requirements to be met for the waste packages to be disposed of are laid down in the respective waste acceptance criteria. The compliance of the packages with the requirements set out in the acceptance criteria of the repository is reviewed within the scope of a product control. Subsequent to product control and confirmation that the waste packages produced in this way are suitable for emplacement, the *Länder* will deliver them to the Konrad repository (after its commissioning).

Sealed sources disposed of in the repository for radioactive waste Morsleben (ERAM)

The management of disused radioactive sources is shown by the example of disposal in the ERAM.

By their nature, disused sources with an activity up to $2 \cdot 10^{11}$ Bq, that were disposed of in the ERAM, were assigned to different waste categories. They were assigned to the so-called A 4.10 waste type (special waste types) in case of

- leaking sources,
- contaminated sources,
- mechanically unstable sources,
- sources with gaseous content,
- sources with dimensions larger than the inside dimensions of the source containers, or
- sources incorporated into equipment.

This type of waste was transferred to the A1 waste type (solid wastes) according to specified handling regulations and stacked in the ERAM due to its low activity. Neutron sources were excluded from disposal.

The disposal of sealed disused sources (A3 waste type) was carried out directly by dumping of untreated and non-packaged sources from reusable source containers radiation protection in a working underneath. Since the sealed sources have a very low volume, their volume can be neglected. In the period from 1981 to1998, the major part of a total of 6,617 sealed sources was dumped in the ERAM. In addition, four Co-60 sources were emplaced in the area at the 4a level, three of them in lead containers and one of them in a radiation head.

On 31 December 2012, the total activity of the emplaced sealed sources amounted to approximately $1.1 \cdot 10^{13}$ Bq, taking into account the decay.

In addition, sealed sources were emplaced in boreholes. These are formally not yet disposed of but the licence for it has already been applied for.

The main radionuclides of these sources are: Co-60, Cs-137, Sr-90, Eu-152, Ra-226, Kr-85, Ag-110m, Pm-147, Ir-192 and the alpha emitters Am-241 und Th-228.

Regulations for discovery and loss

§ 71 StrlSchV [1A-8] regulates the loss, discovery and acquisition of actual control over radioactive material and is therefore also relevant for radioactive sources. Accordingly, any loss of actual control over radioactive material whose activity exceeds the exemption levels stipulated in Appendix III, Table 1, Columns 2 and 3 StrlSchV must be reported immediately to the competent nuclear supervisory authority or to the authority responsible for public safety and order by the owner of the material. Loss of a high-active radioactive source also requires immediate reporting to the register for high-active radioactive sources at the BfS in electronic form, using the standard record sheet specified in the StrlSchV (see details on the HASS register). Any discovery of radioactive material or acquisition of actual control over such material must be reported immediately to the competent nuclear supervisory authority or to the authority responsible for public safety and order.

J.1.2 Re-entry of disused sources

In Germany, sealed sources are manufactured and also exported to other countries. Therefore, regulatory requirements for re-entry of disused sealed sources into Germany have existed for a long time. These regulations fully take into consideration the generally high risk potential of radioactive sources and allow implementing the requirements of the Code of Conduct on the Safety and Security of Radioactive Sources [IAEA 04] which deals in §§ 23 to 29 with the import and export of radioactive sources and demands a co-operation of the authorities involved in shipments (i.e. also in the re-entry) of similar extent and intensity as for shipment of radioactive waste. The regulations for transboundary movement contained in §§ 19 to 22 StrlSchV [1A-8] also apply to HASS.

It needs to be mentioned that shipment within the EU is not subject to licensing requirements and that, in addition, a licence for shipment from or into third countries may be replaced by a notification. Transboundary movement inside the EU is regulated by Council Regulation (EURATOM) No. 1493/93 [1F-34]. With respect to sealed sources, the prior notice of the competent authority based on a declaration of the addressee is essential (in Germany: the Federal Office of Economics and Export Control (BAFA). The competent authority of the country of destination must also be notified of the completion of the shipment.

As far as a transboundary movement is subject to legal requirements for licensing or notification, e.g. for re-entry of a radioactive source from a non-EU country, the competent authority according to § 22 AtG [1A-3] is the BAFA.

According to § 69, para. 5 StrlSchV, high-active radioactive sources that are no longer used or for which no further use is intended shall be delivered to the manufacturer, the carrier or another licensee after end of use or delivered as radioactive waste or kept in storage. Recycling of disused radioactive sources after their return is also possible in principle, e.g. at the manufacturer's or by another authorised company possessing the requisite licence. The previous user is not allowed to keep a source without use. The manufacturer and the carrier of high-active radioactive sources are obliged to take back these sources or have to ensure that they are taken back by third parties, as outlined above.

According to § 19 StrlSchV, the transboundary movement of such sources is subject to licensing if the activity exceeds the 100-fold of the value specified in Appendix III, Table 1, Column 3a StrlSchV. If the activity remains below this value, shipment may take place under certain conditions within a notification procedure. For shipments of such sources from a state outside the EU to Germany, this is possible if the importing carrier

1. has taken precautions to ensure that after shipment, the delivered radioactive materials may only initially be bought by persons who hold the necessary licence according to §§ 6, 7 or 9 AtG or according to § 7, para. 1 or § 11, para. 2 StrlSchV, and
2. notifies this shipment to the competent authority as stipulated in § 22, para. 1 AtG or delivers the notification to the regulatory body responsible for supervision as stipulated in § 22, para. 2 AtG or to the body appointed by it in connection with customs clearance at the latest.

In the case of shipment of other radioactive material between EU Member States, the provisions of Council Regulation (EURATOM) No. 1493/93 [1F-34] apply, which stipulates the following for sealed sources:

(Article 4)

(1) A holder of sealed sources who intends to carry out a shipment of such sources, or to arrange for such a shipment to be carried out, shall obtain a prior written declaration by the consignee of the radioactive substances to the effect that the consignee has complied, in the Member State of destination, with all applicable provisions implementing Council Directive 96/29/EURATOM [1F-18] and with national requirements for safe storage, usage or disposal of that class or source of waste.

Note: The declaration shall be made by means of the standard document set out in Annex I to the Council Regulation (EURATOM) No. 1493/93 [1F-34].

(2) The declaration referred to in paragraph 1 shall be sent by the consignee to the competent authority of the Member State to which the shipment is to be made. The competent authority shall confirm with its stamp on the document that it has taken note of the declaration and the declaration shall then be sent by the consignee to the holder.

However, this is merely a statement of intent, which does not permit any control over shipments that have actually taken place, since the Regulation furthermore stipulates:

(Article 5)

(1) The declaration referred to in Article 4 can be valid for more than one shipment, provided that:

- the sealed sources or radioactive waste to which it relates have essentially the same physical and chemical properties,
- the sealed sources or radioactive waste to which it relates do not exceed the levels of activity set out in the declaration, and

- the shipments are to be made from the same holder to the same consignee and involve the same competent authorities.

(2) The declaration shall be valid for a period of not more than three years from the date of stamping by the competent authority.

A reporting system for realised shipments of radioactive materials is outlined below:

(Article 6)

A holder of sealed sources, other relevant sources and radioactive waste who has carried out a shipment of such sources or waste, or arranged for such a shipment to be carried out, shall, within 21 days of the end of each calendar quarter, provide the competent authorities in the Member State of destination with the following information in respect of deliveries during the quarter:

- names and addresses of consignees,
- the total activity per radionuclide delivered to each consignee and the number of such deliveries made,
- the highest single quantity of each radionuclide delivered to each consignee,
- the type of substance: sealed source, other relevant source or radioactive waste.

As a result of this reporting procedure, it is evident that the competent authorities in each EU Member State (in Germany, the Federal Office of Economics and Export Control (BAFA)) only receive data about shipments into their country on a quarterly basis, the completeness of which cannot otherwise be verified. There is no provision under this Regulation for reports regarding shipments from one country to another EU Member State. In order to fill this loophole, Germany has submitted a proposal to the EU Commission outlining the need to report to the authority of the delivering country as well.

J.1.3 International aspects

The German regulations take into account the fact that the safety and security of radioactive sources has a strong international dimension. Of particular importance in this connection are orphan sources, as the global scrap trade contributes to their unintended spread. Radioactive sources hidden in scrap present a much higher potential risk than contaminations with naturally occurring radioactive material (NORM) or other radioactive materials. Therefore, Germany welcomes all efforts aimed to reduce the potential risk and especially to prevent the spread of radioactive sources in the global scrap trade.

Examples:

- The information system operated by the IAEA for transmission of data about loss of radioactive sources worldwide,

- Organisation of international meetings and other forums for information exchange between experts at the international level, as for example the International Conference on Control and Management of Inadvertent Radioactive Material in Scrap Metal in Tarragona (Spain) in February 2009, as this may lead to co-ordinated and harmonised international strategies,

- Development of an international convention regarding the transboundary shipment of scrap and semi-finished products (Code of Conduct on the Transboundary Movement of Radioactive Material Inadvertently Incorporated into Scrap Metal and Semi-finished Products of the Metal Recycling Industries) under the auspices of the IAEA which is being prepared at the moment under leadership of the IAEA [IAEA 14], whose adoption, however, failed due the lack of consensus of the Member States,

- The efforts of individual countries in creating particularly open regulations for accepting the costs for the management of radioactive sources discovered in scrap to ensure that discoveries are reported to the authorities and not suppressed in fear of high disposal costs. In Spain, for example, this has been realised by means of the “Spanish Protocol” whose approach has also been adopted by South American countries.

The final report of the conference in Tarragona expresses that, by the adoption of a binding convention between the states, a standardisation of the approach to prevent unintended transboundary movement of radioactive material contained in scrap could be achieved. This concern is reflected in the drafting of the international convention referred to.

The international data exchange facilitates the worldwide control and tracking of radioactive sources. Within the EU, important prerequisites regarding the international data exchange are fulfilled by the abovementioned rules, in particular Council Regulation (EURATOM) No. 1493/93 [1F-34] and Council Directive 2003/122/EURATOM [1F-22]. Agreements on an electronic data exchange format as well as the consideration of experiences of the Member States of the European Union are relevant objectives in the future.

K General efforts to improve safety

This section summarises the progress made by Germany so far to improve safety since the Fourth Review Meeting in 2012 and explains the implementation of the Site Selection Act as well as the efforts undertaken to ensure safety in connection with the handling, storage and disposal of spent fuel and radioactive waste by applying safety criteria and developing them further.

K.1 State of affairs regarding challenges and planned measures to improve safety according to the Rapporteur's report relating to the German presentation during the Fourth Review Meeting

The Rapporteur's report to the Fourth Review Meeting in 2012 summarises the challenges that still exist, as well as the planned measures to improve safety that have been identified as a result of the German presentation in front of the Country Group. The progress made regarding these items during the review period is described in the following.

(1) Challenges

Preparation of a National Waste Management Programme by mid-2015 according to Council Directive 2011/70/EURATOM

Council Directive 2011/70/EURATOM of 19 July 2011 [1F-36] demands of the Member States of the European Union that they establish a national framework of legislation, execution and organisation for the responsible and safe management of spent fuel and radioactive waste. This includes, amongst other things, the Member Countries' duty to draw up within four years after the Council Directive's entry into force, i.e. by 23 August 2015 at the latest, a national waste management programme that is to be regularly reviewed and – if necessary with consideration of the scientific and technological progress – updated. Germany will quickly transpose the Council Directive 2011/70/EURATOM into national law.

The preparation of the national waste management programme as required by the Council Directive was begun in 2012. The programme will include an inventory of the entire spent fuel and radioactive waste in Germany. In addition, concepts, plans and technical solutions for the construction of repositories as well as for the time after the closure of the repositories will be prepared as part of the programme, as will be a concrete schedule for the implementation, including the specification of responsibilities. The German national waste management programme will be available by the summer of 2015.

Creation of a new regulatory framework for the handling of radioactive waste with a clear separation of operational and regulatory tasks in accordance with Council Directive 2011/70/EURATOM

With the new "Act on the Search for and Selection of a Site for a Repository for Heat-generating Radioactive Waste" (Site Selection Act) that came into force on 27 July 2013, the responsibilities and duties in the area of disposal have partly been reallocated. The new Federal Office for Nuclear Waste Management (BfE) is to become a regulatory authority for the site selection procedure.

The BfE is furthermore to carry out federal administrative tasks in the area of the licensing of federal facilities for the storage and disposal of radioactive waste that have been assigned to it by the Atomic Energy Act, the Site Selection Act or other federal acts of law. The BfE is in future also to be responsible for the plan approval and licensing of disposal facilities. The responsibility for the planning, construction and operation of the facilities will remain with the Federal Office for Radiation Protection (BfS).

Regarding the federal facilities for the disposal of radioactive waste, the technical and legal supervision of the BfS will continue to be carried out by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB).

Gaining public acceptance for the proposed repository strategies (commissioning of Gorleben or development of a new deep geological repository for high-active waste)

The transparent and open procedure intended by the Site Selection Act for the disposal of heat-generating radioactive waste that was passed in 2013 provides for extensive public involvement. In this procedure, the Gorleben salt dome will be assessed and compared like all other sites that will be considered.

The procedure will be prepared by a commission that is to work out proposals i. a. for requirements for the involvement and information of the general public as well as for ensuring transparency. Following the conclusion of the work of the commission and the evaluation provided by the Act – and if necessary a further development of the Act – the BMUB will establish a national advisory committee, to be pluralistically composed of different representatives of society, to monitor the site selection process with public welfare in mind. The members will have access to all files and documents of the Federal Office for Nuclear Waste Management (BfE) and the project implementer (BfS). The consultation results will be published. The BfE and the project implementer will ensure, as part of their functions and powers, that the general public will be comprehensively and systematically informed in good time and for the duration of the site selection procedure about the objectives of the project, the funds and the state of its realisation as well as about its expected effects. This information will be given in town hall meetings, public debates, on the Internet and through other suitable media. The general public will be given the opportunity to comment. For the further involvement of the public, the BfE will initiate public debates with the aim to allow an open dialogue among the general public. Citizens Liaison Bureaus will be set up in the regions taken into consideration for potential sites as well as at the potential sites themselves. These will make sure that the general public in the regions taken into consideration for potential sites as well as at the potential sites themselves will have the opportunity in all matters of each respective procedural step to obtain independent technical advice. The BfE will conduct town hall meetings on the relevant partial steps of the procedure with the aim to prepare the respective procedural steps together with the general public.

This approach provides the chance to achieve public acceptance for the proposed repository strategies and to solve the issue of disposal in consensus with society.

Justification of the retrieval of the radioactive waste from the Asse II mine with consideration of factors other than public acceptance

Having compared three decommissioning options, the Federal Office for Radiation Protection (BfS) tasked with the decommissioning of the Asse II mine has identified the retrieval of all waste as the decommissioning option by which long-term safety can be demonstrated with the highest probability through the controlled disposal of the waste in a plan-approved repository. The retrieval of all waste was hence considered the preferred method in the decommissioning of the Asse II mine. On 28 February 2013, the German *Bundestag* adopted the "Act to Speed up the Retrieval of Radioactive Waste and the Closure of the Asse II Mine" ("Lex-Asse") [1A-26]. This Act governs the decommissioning of the Asse II mine following the retrieval of the radioactive waste. This is to take place without any compromises made regarding safety; the radiation protection of the workforce and the population must be guaranteed. The retrieval will have to be stopped if its execution can no longer be justified for radiological or other safety-relevant reasons that would have negative effects on the population or the workforce.

In connection with the question of retrieval, not only the examination of technical feasibility but also the radiological risks involved in the retrieval compared with the long-term risks of the waste remaining in the Asse II mine have to be considered. Generally, present risks and future risks should be weighted and assessed in the same way. So far, the radiation exposure of the workforce and the population in the case of retrieval has not yet been weighted against the avoidable future exposure through retrieval and long-term safe disposal.

Regarding the retrieval of the waste from the Asse II mine, a well-founded assessment of the associated radiation exposure requires yet more detailed studies and plans for a new shaft, a storage facility with associated conditioning plant as well as retrieval techniques, which are currently under development. In part, new technologies and methods will have to be developed here.

In order to be able to assess the long-term effects of the waste remaining in the old Asse II mine and to weigh them up against their retrieval, the BfS is carrying out a long-term safety analysis. This requires i. a. the detailed knowledge of the geological conditions. For the purpose of a closer examination of the storage conditions on the southern flank of the Asse, seismic test measurements (3D seismics) were performed in March 2013 to validate the method and the necessary parameters.

Implementation of the Site Selection Act

In April 2013, the federal and *Länder* governments as well as the political parties agreed to solve the disposal issue, especially for heat-generating radioactive waste, in broad consensus. The "Act on the Search for and Selection of a Repository for Heat-generating Radioactive Waste" entered into force on 27 July 2013 [1A-7].

The aim of the site selection procedure described in the Act is to find the site for a repository in the Federal Republic of Germany for the radioactive – especially the high-active – waste generated in Germany in a science-based and transparent procedure, with the site guaranteeing the best-possible safety for a period of a million years.

The implementation of the Site Selection Act with the aim to determine a repository site by 2031 will continue to be one of the key challenges in dealing with high-active waste in Germany in the coming decades.

Effects of the premature decommissioning of nuclear power plants in terms of responsibilities, storage of low-burn-up fuel, staff availability, and the parallel execution of several major decommissioning projects

With the 13th amendment of the AtG, the power operation licences of eight German nuclear power plants expired. On 31 December 2022 at the latest, this will also happen to the last German nuclear power plants in operation. This results in the need to execute several large decommissioning protects in parallel and at the same time.

In Germany, there is extensive experience from ongoing and completed decommissioning projects available. The licensing procedures for carrying out decommissioning projects are fully regulated by the Atomic Energy Act and the associated ordinances and are among other things specified by the decommissioning guideline of the BMUB and by the ESK guidelines for the decommissioning of nuclear facilities. The co-ordination paths and the thus predetermined interaction in the licensing and supervisory procedure between applicants, *Länder* authorities and experts are largely mapped out in the regulations and established in practice.

In his application documents, the operator must provide sufficient details about the dismantling project so that it is comprehensible to the authority, reviewers and the general public. A clear separation of licensing-relevant aspects with conceptual and fundamental relevance to safety on the one hand and regulatory-relevant detailed explanations on the other hand allows a rapid execution of the licensing procedure and sufficient flexibility in the implementation of the dismantling measures. To achieve a plant state which is free of nuclear fuel at an early stage, it is essential that the licensing and supervisory procedures for the spent fuel transport casks be executed quickly and the casks be provided in time.

Owing to their premature closure, there are fuel assemblies in the spent fuel pools of the nuclear power plants concerned that have not reached their target burn-up by far. This has effects on different physical properties of the partially spent fuel (lesser decay-heat generation, higher content of fissile U-235, higher percentage of Pu-239 in the isotope composition of the plutonium generated). The ESK has commented on this problem [4-7] and established that the wet storage pools are designed such that subcriticality is ensured even under these conditions. Hence changed cask qualifications and new licences are needed for the safe storage of these fuel assemblies since the required minimum burn-up has not been reached. As regards the storage casks, mixed loading with more or less irradiated fuel is possible while still adhering to the licensing conditions.

The ESK has shown that the nuclear licensing procedures can only be handled quickly and at high safety standards if there is sufficiently qualified personnel available to the applicants, their service providers and the experts and authorities with whom the preparation of the documents and their assessment can be assured with the required quality. Therefore, the long-term availability of sufficient qualified personnel has to be ensured by all parties.

(2) Planned measures to improve safety

Demand-oriented extension of the storage capacities in the course of the decommissioning projects

According to the 13th amendment of the Atomic Energy Act, which came into force on 6 July 2011, the operating licences for eight nuclear power plants expired on 6 August 2011. Seven of the eight nuclear power plants have now applications for decommissioning licences pending (see Table L-14). When the application documents were prepared, the residues and waste resulting from the dismantling were also considered. These have to be processed and – in the case of radioactive waste – temporarily stored prior to transportation to a repository. All applications therefore provide for the storage of the radioactive waste arising from the decommissioning on site. The following plant-specific options are provided for the creation of the necessary storage capacities at the sites of the respective plants to be decommissioned:

- use of existing storage facilities,
- reclassification of rooms and plant areas within the nuclear power plant, or
- construction of new storages especially for this purpose.

The radioactive waste is to be stored at the site until the Konrad repository is ready for operation. For some of the waste, special waste processing methods are applied for volume reduction, e.g. compression, melting or incineration, for which existing facilities operated by third parties are used. After successful processing, the resulting residues are transported back to the site.

Implementation of the Site Selection Act after its entry into force, either with the aim of further exploration of the Gorleben salt dome or the development of a new deep geological repository for high-active waste

The new "Act on the Search for and Selection of a Site for a Repository for Heat-generating Radioactive Waste" came into force on 27 July 2013 [1A-7]. The Gorleben salt dome will be included and assessed in the site selection process described in the Site Selection Act like all other potential sites, in accordance with criteria and requirements that are yet to be determined. The previously conducted exploration of the Gorleben salt dome was discontinued in November 2012 and formally ended with the entry into force of this Act. The Preliminary Safety Analysis of the Gorleben site that was begun in 2010 was completed in March 2013 with a validation of the scientific findings, but without the preliminary suitability prognosis that had been originally planned.

The German repository for the radioactive waste – especially the high-active waste – generated on German territory is now to be found in a comparative, science-based and transparent process. The law provides for this process to be completed by the year 2031. Once selected, the repository site will be run through a licensing procedure.

Updating of the regulatory framework for the decommissioning of nuclear facilities and storage of spent fuel as a consequence of the WENRA process

As part of the WENRA process of harmonisation and further development of European nuclear regulations, the WGWD found in February 2014 that 6 % of the German regulations established in the field of the decommissioning of nuclear facilities deviated from the WENRA safety reference levels. Germany, however, sees no need for an adjustment of the national regulations as the licensing and supervisory practices in Germany ensure compliance with the targets of these safety reference levels.

In the field of storage of spent fuel, the Nuclear Waste Management Commission (ESK) has contributed to the development of the regulations by adopting "Guidelines for dry cask storage of spent fuel and heat-generating waste" in the version of 10 June 2013, based on findings from the WENRA process [4-2] The experience gained from the pilot phase in Gorleben led to the publication of the "ESK guidelines for the performance of periodic safety reviews and on technical ageing management for storage facilities for spent fuel and heat-generating radioactive waste" [4-5a] in March 2014.

K.2 Implementation of the Act on the Search for and Selection of a Site for a Repository for Heat-generating Radioactive Waste

For the establishment of a repository for radioactive waste – especially high-active waste – the "Act on the Search for and Selection of a Site for a Repository for Heat-generating Radioactive Waste and on the amendment of other laws" (Site Selection Act of 23 July 2013 [1A-7]) was passed with broad political consensus. This Act lays down a comparative site selection procedure that is aimed at the determination of the best-possible repository site in Germany in terms of safety. The decision on the site will be is made by the legislator and is a prerequisite for the subsequent licensing process. The Act provides for high standards to be applied to the site selection process in terms of transparency and full public involvement.

To determine and establish criteria for the selection process, the selection procedure will be preceded by a discussion and clarification of basic questions regarding the disposal of heat-generating radioactive waste, especially with respect to the exclusion criteria, minimum requirements and weighing-up criteria for site selection and to the requirements for the method used for the selection process and the consideration of alternatives. This procedure will be conducted by the "Commission on Storage of High-Level Radioactive Waste." The latter will involve research institutions and the general public in its work. Based on the recommendations of this Commission, the Act will be evaluated and amended as necessary.

To ensure a science-based search and selection process and a transparent process development, the Federal Office for Nuclear Waste Management (BfE) is to be established within the portfolio of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). The former is to specify i. a. site-based exploration programmes and test criteria. The Federal Office is to be established as an independent higher federal authority that is to take over the subsequent nuclear licensing of the repository in addition to the above-mentioned new tasks related to the site selection process.

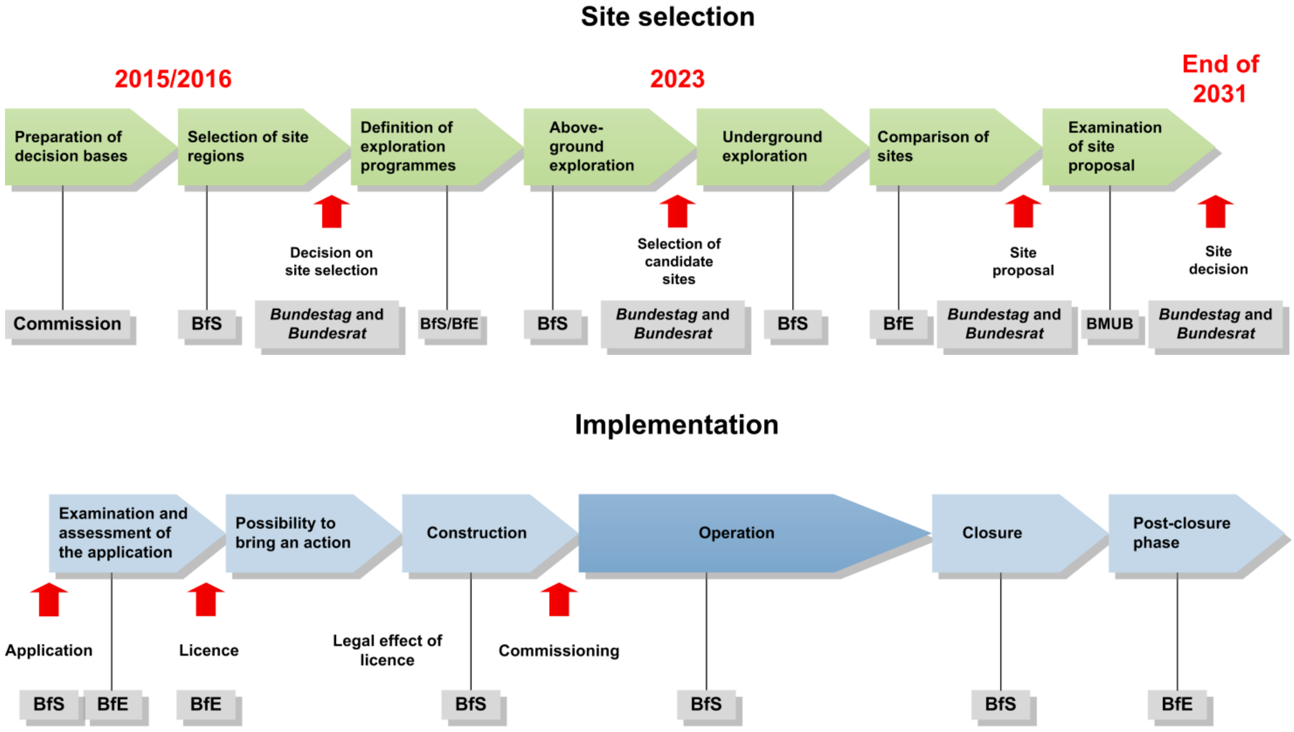
The BfS is the project implementer and has the task of putting the site selection process into practice. This includes making proposals for the selection of the site regions and the sites to be explored, the preparation of site-specific exploration programmes and test criteria, the above-ground and underground exploration of the specified sites, and the preparation of the respective provisional safety studies.

The Site Selection Act defines the individual process steps for the open-ended and unbiased search for and selection of a site for the safe disposal of radioactive waste – especially high-active waste – and normalises the objective of establishing a repository for radioactive waste – especially high-active waste – by federal law.

The site selection process provides for full public involvement and a dialogue with stakeholders in all stages of the procedure. The site selection process ends with the final legal site decision. This requires a prediction of compliance with the site-specific safety requirements. In addition, all public and private as well as socio-economic concerns have to be taken into account in the deliberations. The subsequent authorisation procedure for the construction, operation and decommissioning of the repository will be devised as a licensing procedure since the concerns to be weighed-up against each other will have already been finally examined and assessed in the legal site decision.

The planned sequence of the realisation of a repository for radioactive waste – especially high-active waste – is shown in Figure K-1.

Figure K-1: Steps of the realisation of a repository for radioactive waste – especially high-active waste – including corresponding responsibilities



K.3 Implementation of Council Directive 2011/70/EURATOM of 19 July 2011 on a Community framework for the responsible and safe management of spent fuel and radioactive waste

On 19 July 2011, the Council of the European Union adopted Council Directive 2011/70/EURATOM [1F-36] on a Community framework for the responsible and safe management of spent fuel and radioactive waste. Its purpose is to establish a European Community framework intended to prevent future generations from being burdened with inappropriate loads. Furthermore, the Council Directive is to ensure that the Member States of the European Union make appropriate national arrangements to ensure and, as far as reasonably achievable, continuously improve a high level of safety of nuclear waste disposal. The Council Directive also demands the necessary information and public involvement in connection with the management of spent fuel and radioactive waste.

Essential aspects of the Council Directive, such as public involvement, were also considered in the adoption of "Act on the Search for and Selection of a Site for a Repository for Heat-generating Radioactive Waste and on the Amendment of other Laws" (Site Selection Act) of 23 July 2013 (see the reporting in Section K.1).

It is planned to fully transpose the remaining national contents of the Council Directive that have not yet been regulated into national law by the end of 2014. This is to include e.g. legislation establishing a national waste management programme and the associated principles to be considered. In addition, the obligations contained in the provisions of the Council Directive for operators of facilities with the focus on the disposal of spent fuel and radioactive waste are to be transposed into German law. Furthermore, a requirement for periodic safety reviews will be introduced for the operators of these facilities. The already existing principle that the responsibility for the safe management of spent fuel and radioactive waste rests with the licence holder is also to be specifically addressed in the context of the implementation by law.

K.4 Issues relating to a prolongation of the storage of spent fuel and heat-generating waste

The storage licences for the storage of spent fuel and heat-generating waste are currently limited to 40 years. A possibly necessary prolongation of this period depends on how long it will take until a repository will be available. If after the expiry of the licensed storage periods a repository that is ready to receive radioactive waste is still not available, safety assessments of the prolongation of the storage periods and the subsequent transports will be of particular national and international interest. The law provides that licences may only be renewed for irrefutable reasons and after prior referral to the German *Bundestag*.

In a special project, the BMUB compiles as a precaution basic information and data on national and international experience in order to assess at an early stage the safety issues related to the long-term storage of fuel assemblies and to be able to make competent assessments of corresponding concepts and strategies for their future storage. The project has focused on the topics of ageing management during storage, the long-term behaviour of casks and cask inventories, and the exchange of experience at national and international level.

Lessons learned so far show that the limitation of the storage licences is not down to limiting parameters that are of a physical-technical nature. Operating experience with German storage facilities has so far not revealed any safety-related findings or evidence that would in principle oppose any necessary extension of the storage period beyond 40 years. Descriptions of national and comparisons with international conditions of dry storage in transport and storage casks form the basis for the assessment of the state of the art in science and technology. Here, in particular the regulatory constraints and previous experiences with the operation of storage facilities are compared and available findings evaluated. Regarding the topic of ageing management, technical and non-technical aspects are considered. The measures performed on the casks and structures, such as measuring programmes and inspections, are mirrored on international standards, and the results of studies into the long-term behaviour of casks systems or safety-relevant components, such as seals and moderator material, are taken into account. The transportability of the cask must be ensured at all times during the entire storage period. Requirements for the cask-specific safety demonstration must be valid for longer storage periods. Operational management, safety management as well as knowledge and quality management will also be addressed under the aspect of ageing. Boundary conditions changing over time also have to be considered, such as the transition of the decentralised storage facilities to self-sufficient operations with the progressive dismantling of nuclear power plants. With regard to the identification of safety-relevant aspects, the exchange of experience of the various parties involved – such as operators, manufacturers, regulators and technical safety organisations – at both national and international level plays an essential role since it will result in a broader understanding and thus a gain in the ability to act.

To ensure criticality safety and the ability to handle the fuel with a view to its possible future unloading and conditioning for disposal in a deep geological repository, the fuel assemblies that are inaccessible during inspections and the fuel basket must remain intact during the storage period so that the geometric configuration of the fuel in the casks corresponds to the configuration on which the safety analyses are based. The leak-tightness of all cladding tubes need not necessarily be guaranteed, but there must be no systematic cladding tube failure that would put the geometrical configuration of the fuel pellets at risk. Based on calculations of the fuel rod behaviour of special fuel assemblies (e.g. fuel with high burn-up and MOX fuel), it is to be estimated whether a critical pressure build-up under storage conditions may ensue due to the increased formation of fission gases. In this context, current international cladding tube material studies are evaluated with regard to the long-term behaviour of structure-mechanical parameters under the boundary conditions of dry storage. At international level, the issue of inaccessible cask areas is pursued with vigour in particular by the US (US-NRC, EPRI, US-DOE) jointly with the IAEA by way of strategic and targeted research and development, and a prioritisation of the research needs is sought. The publications on the issue reflect the current state of international research and development and allow the derivation of suitable fields of action adapted to the existing storage concept.

K.5 Western European Nuclear Regulators Association - WENRA - Harmonised approaches in the European nuclear regulatory frameworks in the areas of storage, decommissioning and disposal

The objective of the 17 current WENRA member states is the joint development of safety criteria within national responsibility in the field of nuclear safety in Europe, but also in the areas of the storage of spent fuel and radioactive waste, the decommissioning of nuclear facilities, and the safety of the disposal of radioactive waste, including spent fuel classified as radioactive waste.

The development of safety criteria is to be carried out in terms of a comparison of general national safety requirements with the safety reference levels developed by WENRA in certain areas. Hence the aim is not to completely and exactly adjust the safety approaches of individual institutions in the member states, but to steadily develop the general regulatory safety approaches of the individual member states contained in the national regulations. All member states have committed themselves to implementing the safety requirements of WENRA at national level.

The objective of the WGWD (Working Group on Waste and Decommissioning) set up by WENRA in 2002 is to work out requirements – based on the international standards and the state of the art in science and technology – in the form of safety reference levels in the areas of the storage of spent fuel and radioactive waste, the decommissioning of nuclear facilities, and the disposal of spent fuel and radioactive waste. Currently available are the requirements for storage [WENRA 11a], revised edition of version 1.0 [WENRA 06], and for decommissioning [WENRA 12a], revised edition of version [WENRA 07]. The corresponding requirements for disposal will probably be published in 2014.

The "Waste and Spent Fuel Storage Safety Reference Levels Report" contains in edition 2.2 [WENRA 14] 61 safety reference levels on the topics of safety management, design, operation, and safety verification for storage.

The "Decommissioning Safety Reference Levels Report" deals in edition 2.1 [WENRA 12a] with 62 safety reference levels on the topics of safety management, decommissioning strategy and planning, conduct of decommissioning, and safety verification for decommissioning.

The draft safety reference levels for radioactive waste disposal are available [WENRA 12b]. The draft contains more than 100 requirements on the topics of safety management, development of a repository, waste acceptance requirements for disposal, and safety verification. The stakeholders were able to submit notes and comments to the WENRA WGWD until the end of April 2013. Once all these notes and comments have been discussed, version 1.0 will be prepared in the coming months. This will then be followed – like in the case of the topics of storage and decommissioning – by the benchmarking process regarding the national regulations for the disposal of radioactive waste.

The WGWD is currently also planning the preparation of safety reference levels for the area of waste processing.

Application of the safety reference levels

The safety reference levels provide the basis for the performance of national self-assessments of all WENRA member states. The objective of the self-assessments is to identify any significant differences between the national approaches and the common approach in the safety reference levels. To this end, the provisions of the national regulations are compared with the safety reference levels with the classifications "A" (conforms to the requirements of the safety reference levels), "B" (there are differences, but these can be justified from a safety-related point of view and thus require no adjustment) and "C" (differences exist and should be considered for an improvement in terms of the safety reference levels).

The C-ratings serve as a starting point for the further development of the national regulations. To this end, the WENRA member states develop action plans that serve to rectify any identified deficiencies or deviations within national responsibility. At the meetings of the WGWD WENRA, the member states report on the progress of the implementation of the national action plans. Ultimately, this approach is to achieve that the national regulations of all WENRA member states will arrive at a consistently high level of safety in the coming years.

Benchmarking of the safety reference levels for storage

In the area of storage, Germany successfully implemented all the measures already in 2012 and thus meets all the WENRA safety requirements.

With the publication of the "Guidelines for dry cask storage of spent fuel and heat-generating waste" [4-2], the "Guidelines for the storage of radioactive waste with negligible heat generation" [4-3] and the "ESK guidelines for the performance of periodic safety reviews and on technical ageing management for storage facilities for spent fuel and heat-generating radioactive waste" [4-5], all identified deficiencies in the regulations were eliminated.

Benchmarking of the safety reference levels for decommissioning

As regards the safety reference levels for decommissioning, version 1.0 of March 2007, the national assessments of the regulations relevant in connection with decommissioning were carried out. It was left to the member states themselves to decide whether or not to review their national decommissioning practices since, from the perspective of the WGWD, an analysis of the respective decommissioning practice would not provide any significant contributions to the advancement of the national regulations.

With the support of the *Länder* representatives, the German regulations were reviewed in 2007 and 2008 and the results presented to the WGWD. Following the discussion in early 2009, 23 % of the safety reference levels were classified as "C", among other things in the areas of decommissioning concept for research reactors, site strategy for decommissioning, development of the decommissioning concept during facility operation, and periodic safety reviews during decommissioning.

Besides the evaluation of the regulations relevant in connection with decommissioning, Germany has conducted an analysis of individual decommissioning projects with the support of the licensees of various facilities under decommissioning and the competent licensing and supervisory authorities. The objective was to review the implementation of selected safety reference levels in German decommissioning practice, especially those that had been classified as "B" or "C" in the evaluation of the regulations. Another objective was to identify potential for further development of the safety reference levels. The analysis showed that in the decommissioning projects considered, the safety reference levels that were chosen are reflected in the requirements of the regulations, with these requirements partly being even more stringent. Likewise, the analyses revealed certain aspects that could be seen as further developments of the safety reference levels and that have been proposed by Germany to be considered in the process of revision of the safety reference levels for version 2.1 of the "Decommissioning Safety Reference Levels Report".

The national benchmarking of the regulations relevant in connection with decommissioning regarding the safety reference levels in version 2.1 has revealed deviations for four of the 62 safety reference levels (classification "C"). This concerns two safety reference levels each in the requirement areas "Decommissioning strategy and planning" and "Safety aspects".

L ANNEXES

(a) List of spent fuel management facilities

The following tables list the facilities for spent fuel management:

- Wet storage facilities for spent fuel and their inventories, as at: 31 December 2013 (Table L-1),
- Central storage facilities for spent fuel and heat-generating radioactive waste as well as AVR cask storage facility, as at: 31 December 2013 (Table L-2),
- Pilot conditioning plant (PKA) Gorleben (Table L-3),
- : Main characteristics of the spent fuel storage facilities applied for under § 6 (AtG), as at: 31 December 2013 (Table L-4).

Table L-1: Wet storage facilities for spent fuel and their inventories, as at: 31 December 2013

	Licensed positions	Number of positions available for storage [1]	Of which not yet occupied	Stored quantity [2] [Mg HM]
Brunsbüttel	817	282	282	0
Krümmel	1,690	1,672	578	194
Brokdorf	768	563	56	274
Unterweser	615	608	43	304
Grohnde	768	558	92	254
Emsland	768	569	103	251
Biblis A	582	575	135	235
Biblis B	578	574	68	271
Obrigheim [3]	980	980	638	100
Philippsburg 1 [4]	948 + 11	948 + 11	73	153 + 2 (155)
Philippsburg 2	780	564	64	270
Neckarwestheim 1 [5]	310 + 83	310 + 83	33 + 13 (46)	99 + 25 (124)
Neckarwestheim 2	786	508	18	264
Gundremmingen B	3,219	2,422	246	379
Gundremmingen C	3,219	2,423	337	363
Isar 1	2,232	2,022	288	302
Isar 2	792	584	129	243
Grafenrheinfeld	715	488	84	217

1) taking into account the positions that must be kept free for unloading of the core and other positions that cannot be used
2) spent and partially spent fuel assemblies
3) including extension outside the reactor building
4) in addition to the capacity of the pool in unit 1 there are 11 positions usable in unit 2, all of which occupied
5) in addition to the capacity of the pool in unit 1 there are 83 positions usable in unit 2, 70 of which occupied, 13 vacant

Table L-2: Central storage facilities for spent fuel and heat-generating radioactive waste as well as AVR cask storage facility, as at: 31 December 2013

Site	Types of containers	Licensed quantities	Already stored
Ahaus	CASTOR® V/19, V/19, Series 06 onwards and V/52 at a total of 370 storage positions CASTOR® THTR/AVR at a total of 320 containers positions (50 storage positions) CASTOR® MTR 2	3.960 Mg HM $2x10^{20}$ Bq	3 CASTOR® V/52 (26 Mg HM) 3 CASTOR® V/19 (29 Mg HM) (6 storage positions), 305 CASTOR® THTR/AVR (48 storage positions), 18 CASTOR® MTR 2 (7 storage positions)
Gorleben	CASTOR® Ia, Ib, Ic, IIa, V/19, V/52, TN 900/1-21 and CASTOR® HAW 20/28 CG, up to Series no. 15, CASTOR® HAW 20/28 from Series no. 16 onwards, TS 28V and TN 85, TS 28V and CASTOR® HAW28M at a total of 420 storage positions	3.800 Mg HM $2x10^{20}$ Bq	1 CASTOR® IIa (5 Mg HM), 1 CASTOR® Ic (3 Mg HM), 3 CASTOR® V/19 (29 Mg HM), 74 CASTOR® HAW 20/28 CG with 2,072 glass canisters, 12 TN 85 with 336 glass canisters, 1 TS 28 V with 28 glass canisters, 21 CASTOR® HAW 28M with 588 glass canisters
Rubenow (ZLN)	CASTOR® 440/84, CASTOR® HAW 20/28 CG and CASTOR® KNK at 80 storage positions	585 Mg HM $7,5x10^{18}$ Bq	6 CASTOR® 440/84 from Rheinsberg (48 Mg SM), 56 CASTOR® 440/84 and 3 CASTOR® KRB-MOX from Greifswald (535 Mg SM), 4 CASTOR® KNK with fuel rods from Karlsruhe and the research vessel „Otto Hahn“, 5 CASTOR® HAW 20/28 CG SN 16 with 140 glass canisters from VEK
Jülich	CASTOR® THTR/AVR (max. 158 containers)	225 kg nuclear fuel; no activity limit	approx. 290,000 AVR fuel element spheres in 152 CASTOR® THTR/AVR

Table L-3: Pilot conditioning plant (PKA) Gorleben

Site	Purpose	Capacity	Status
Gorleben	<u>Design</u>: Conditioning of spent fuel assemblies from power and research reactors; reloading of HLW glass canisters into packages suitable for disposal <u>According to stipulation of 11 June 2001</u>: Use restricted to the repair of defect containers	35 Mg SM/a at conditioning	Constructed, but not in operation. Licensed by 3rd Partial Construction License (TEG) of 18/19 December 2000. Immediate execution has not been applied for.

Table L-4: Main characteristics of the spent fuel storage facilities applied for under § 6 (AtG), as at: 31 December 2013

Nuclear power plant *Land* (Federal State)	Applicant Date of application	Mass HM [Mg]	Activity [Bq]	Thermal power [MW]	Storage positions	Type Dimensions L x W x H wall/roof [m]	Container	Mass being stored (Containers)
NPP Biblis (KWB) Hesse	RWE Power AG 23 December 1999	1,400	8.5×10^{19}	5.3	135	WTI concept 92x38x18 0.85/0.55	CASTOR® V/19	518 Mg HM (51 containers)
NPP Brokdorf (KBR) Schleswig-Holstein	E.ON Kernkraft GmbH 20 December 1999	1,000	5.5×10^{19}	3.75	100	STEAG concept 93x27x23 1.20/1.30	CASTOR® V/19	216 Mg HM (21 containers)
NPP Brunsbüttel (KKB) Schleswig-Holstein	NPP Brunsbüttel GmbH 30 November 1999	450	6×10^{19}	2.0	80	STEAG concept 88x27x23 1.20/1.30	CASTOR® V/52 (loading with 32 fuel elements)	78 Mg HM (9 containers)
NPP Grafenrheinfeld (KKG) Bavaria	E.ON Kernkraft GmbH 23 February 2000	800	5×10^{19}	3.5	88	WTI concept 62x38x18 0.85/0.55	CASTOR® V/19	214 Mg HM (21 containers)
NPP Grohnde (KWG) Lower Saxony	E.ON Kernkraft GmbH 20 December 1999	1,000	5.5×10^{19}	3.75	100	STEAG concept 93x27x23 1.20/1.30	CASTOR® V/19	228 Mg HM (22 containers)
NPP Gundremmingen (KRB) Bavaria	RWE Energie AG (now: RWE Power AG) 25 February 2000	1,850	2.4×10^{20}	6.0	192	WTI concept 104x38x18 0.85/0.55	CASTOR® V/52	371 Mg HM (41 containers)
NPP Isar (KKI) Bavaria	E.ON Kernkraft GmbH 23 February 2000	1,500	1.5×10^{20}	6.0	152	WTI concept 92x38x18 0.85/0.55	CASTOR® V/52 CASTOR® V/19	305 Mg HM (31 containers)
NPP Krümmel (KKK) Schleswig-Holstein	NPP Krümmel GmbH 30 November 1999	775	0.96×10^{20}	3.0	80	STEAG concept 83x27x23 1.20/1.30	CASTOR® V/52	175 Mg HM (19 containers)
NPP Emsland (KKE) Lower Saxony	NPPe Lippe-Ems GmbH 22 December 1998	1,250	6.9×10^{19}	4.7	130	STEAG concept 110x30x20 1.20/1.30	CASTOR® V/19	327 Mg HM (32 containers)

Nuclear power plant *Land* (Federal State)	Applicant Date of application	Mass HM [Mg]	Activity [Bq]	Thermal power [MW]	Storage positions	Type Dimensions L x W x H wall/roof [m]	Container	Mass being stored (Containers)
NPP Neckarwestheim (GKN) Baden-Wuerttemberg	Gemeinschafts-kernkraftwerk Neckar GmbH 20 December 1999	1,600	$8.3x10^{19}$	3.5	151	2 tunnel tubes 112 and 82 x 12.8 x 17.3, respectively	CASTOR® V/19	377 Mg SM (41 containers)
NPP Philippsburg (KKP) Baden-Wuerttemberg	EnBW Kraftwerke AG 20 December 1999	1,600	$1.5x10^{20}$	6.0	152	WTI concept 92x37x18 0.70/0.55	CASTOR® V/19 CASTOR® V/52	357 Mg SM (36 containers)
NPP Unterweser (KKU) Lower Saxony	E.ON Kernkraft GmbH 20 December 1999	800	$4.4x10^{19}$	3.0	80	STEAG concept 80x27x23 1.20/1.30	CASTOR® V/19	82 Mg SM (8 containers)
NPP Obrigheim (KWO) Baden-Wuerttemberg	NPP Obrigheim GmbH 22 April 2005	100	$4.4x10^{18}$	0.3	15	Special hybrid solution 35x18x17 0.85/0.55	CASTOR® 440 mvK	-- (License not yet granted)

(b) List of radioactive waste management facilities

The following tables list the radioactive waste management facilities:

- Examples of stationary facilities for the conditioning of radioactive waste for own needs and third parties (Table L-5),
- Examples of mobile facilities for the conditioning of radioactive waste(Table L-6)
- Storage facilities for radioactive waste – Central storage facilities(Table L-7),
- Storage facilities for radioactive waste – Operational buffer storage facilities in nuclear power plants (in operation or permanently shut-down) (Table L-8),
- Storage facilities for radioactive waste – operational buffer storage facilities in nuclear power plants
  (under decommissioning)
  (Table L-9),
- Storage facilities for radioactive waste – storage facilities in research institutions (Table L-10),
- Storage facilities for radioactive waste – storage facilities of the nuclear and other industries(Table L-11),
- Storage facilities for radioactive waste – *Land* collecting facilities (for waste from research institutions see Table L-10) (Table L-12),
- Repositories and other storage facilities for radioactive waste(Table L-13).

Table L-5: Examples of stationary facilities for the conditioning of radioactive waste for own needs and third parties

Operator	Facility site	Facility name	Facility description
GNS Gesellschaft für Nuklear-Service mbH	Duisburg	PETRA drying facility	Drying of high-pressure compressed waste in 200-l drums, 280-l drums or 400-l drums
		FAKIR high-pressure hydraulic press	High-pressure compaction of waste to pellets with the aid of metal cartridges
		MARS metal cutting facility	Compression (pressing) and subsequent cutting up of metal parts that can be melted afterwards
		Disassembly and cleaning cabins	Mechanical disassembly and cleaning processes/decontamination
	Jülich	PETRA drying facility	Drying of waste in 200-l drums, 280-l drums or 400-l drums
		FAKIR high-pressure hydraulic press	High-pressure compaction of waste to pellets with the aid of metal cartridges or 200-l drums; Waste volume reduction up to factor 10
Eckert & Ziegler Nuclitec GmbH	Braunschweig	Drying facility	Drying of drums up to the specified residual humidity
		Compacting facility	Compaction of 200-l drums and scrunch drums, pressing power ≥ 30 MPa; Capacity: 5,000 – 10,000 pressing sequences / a
		Decontamination cell	Decontamination of equipment parts (e. g. sandblasting); Crushing of equipment parts (e. g. cutting, sawing), max. weight 1 Mg/piece
		Cementing facility	Immobilisation of waste water with fixing materials, immobilisation of ion-exchange resins with fixing materials
		Shredding facility	Crushing of waste, segregation of solid and liquid constituents, homogenisation, sampling
Energiewerke Nord GmbH	Rubenow (Greifswald) Zwischenlager Nord	FAKIR high-pressure hydraulic press	Compaction of loose waste to pellets with the aid of metal cartridges; Waste volume reduction up to factor 10
		PETRA drying facility	Drying of high-pressure compressed waste in 200-l drums, 280-l drums or 400-l drums
		Hydraulic shear	Cutting up of solid waste of C and stainless steels (round bars, square bars)
		Dismantling room	Dismantling of metals by use of thermal processes, e.g. autogenous cutting, plasma cutting
		Evaporation facility	Processing of radioactive liquid waste; Throughput up to 3 m³/h

Operator	Facility site	Facility name	Facility description
Energiewerke Nord GmbH	Rubenow (Greifswald) Zwischenlager Nord	In-drum drying facility	Processing of evaporator concentrates; Processing of up to eight 200-l drums simultaneously
		Chamber filtration facility	Separation of solids from radioactive liquids
Wiederauf-arbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH Business unit: *Hauptabteilung Dekontamina-tionsbetriebe*	Karlsruhe	Compacting facility (MAW scrapping)	Compaction of non-heat generating waste with high dose rate; Remote handling techniques with lock and working cells, manipulators, hydraulic shears, hydraulic press
		Compacting facility (LAW scrapping)	Compaction of non-heat generating waste with low dose rate; caisson technique with gas protection suits; compaction with pre- and high-efficiency compactor; Max. throughput 3 000 m³/a; Volume reduction factor: 6
		Combustion facility	Combustion of solid and liquid waste
		Old evaporation and immobilisation facility (evaporation of LAW no. I)	Evaporation of low-level radioactive waste water with subsequent cementation of the residues; Max. throughput 6,000 m³/a; Dismantling since 2012
		New evaporation facility for LAW	Evaporation of low-level radioactive waste water; Max. throughput 600 m³/a; Volume reduction factor: up to approx. 20
		Cementing facility	Cementation of residues from the “New evaporation facility for LAW”
		Equipment decontamination	Disassembling, conditioning and decontamination of solid, non-combustible residues; Throughput up to approx. 1,200 Mg/a
		Fluidised bed drying facility	Drying of scrubber waters from the combustion facility
		Trofa	Drying of containers
Forschungs-zentrum Jülich GmbH (FZJ)	Jülich	Dismantling/decontamination cabin REBEKA	Decontamination in two steel cabins of parts weighing up to 25 Mg by mechanical means with subsequent dismantling
		Fluidised bed granulation drying facility	Drying facility for radioactive waste water concentrates
		HPA drying facility	Drying of liquid and moist waste
		PETRA	Drum drying
		Evaporation facility	Processing of low-active waste water, concentrates and sludges; Total volume 825 m³, delivery in tankers
		Combustion facility JÜV	Processing of low-active waste water and solids; Annual throughput up to 240 Mg of solids and 40 Mg of liquids

Operator	Facility site	Facility name	Facility description
Helmholtz-Zentrum Berlin GmbH	Berlin	Evaporator	Circulation evaporator
		Cementation	Cementation of evaporator concentrates and other aqueous waste from storage tanks
Verein für Kernverfahrens-technik und Analytik Rossendorf e. V. (VKTA)	Rossendorf	Dismantling installations	Plasma cutting facility up to 20 mm; Cold and band-saws up to 350 mm Ø; Hydraulic shear
		In-drum press	30-l to 40-l bags are pressed directly into waste drums.
		Drying facility for drums	2-drum drying facility for the drying of sludges, ion-exchange resins, humid soil; Drying time: 10-14 days; Volume reduction: max. 60 %
		Resin drying facility	Drying of max. 240 l of spent ion-exchange resin; Volume reduction approx. 50 %
		Dismantling box for aerosol filters	In the dismantling box, aerosol filters are dismantled until the parts can be placed in a docked 200-l drum.
		Ion exchange facility	Treatment of radioactive waste water; Plant throughput 2 m^3/h
		High-pressure blast facility	Decontamination of components by means of blasting in a box; Manageable dimensions of the components 600 mm x 600 mm x 200 mm; Mass up to 20 kg
		Ultrasonic cleaning facility	Decontamination of components up to a size of 800 mm x 500 mm x 200 mm with a maximum mass of 20 kg
Siemens AG	Karlstein am Main	Cementation	Filling of Konrad containers with construction rubble and cementation of Konrad containers; Cementation of waste in drums
Siempelkamp Nukleartechnik GmbH	Krefeld	CARLA facility	Melting of contaminated metallic residues
URENCO Deutschland GmbH	Gronau	Solidification facility for concentrates	Cementation

Table L-6: Examples of mobile facilities for the conditioning of radioactive waste

Operator	Facility name	Facility description	License
GNS *Gesellschaft für Nuklear-Service mbH*	High-pressure hydraulic press FAKIR	Processing of waste to pellets with the aid of metal cartridges	Nationwide valid exclusive licence for all nuclear facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV
	Drying facility of the FAVORIT type	Decanting and drying facility for liquid radioactive waste (evaporator concentrates, decontamination solutions, resins) as well as drying of solid waste after the principle of vacuum drying	Nationwide valid exclusive licence for all nuclear facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV
	Drying facility of the PETRA type	Drying facility for humid radioactive waste being packaged in 200-, 280- and 400-l drums after the principle of vacuum drying	Nationwide valid exclusive licence for all nuclear facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV
	Drying facility of the KETRA type	Drying facility for humid solid radioactive waste (e.g. core scrap) being packaged in MOSAIK® containers	Nationwide valid exclusive licence for all nuclear facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV
	Decanting facility of the FAFNIR type	Decanting facility for radioactive resins (e.g. powder and bead resins) after the principle of vacuum drying	Nationwide valid exclusive licence for all nuclear facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV
	Mobile exhaust facility for powder resins of the PUSA type	Decanting facility for dry fluid powder resins (e.g. ion-exchange resins from BWR) after the principle of vacuum suction	Nationwide valid exclusive licence for all nuclear facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV
	Final dewatering facility of the NEWA type	Final dewatering of decanted radioactive resins (e.g. powder and bead resins)	Nationwide valid exclusive licence for all nuclear facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV
	Disassembling and packaging facility of the ZVA type	Underwater disassembly of core scrap with subsequent high-pressure compaction in insert baskets	Nationwide valid exclusive licence for all nuclear facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV
	Underwater shear of the UWS type	Underwater disassembly of core scrap	Nationwide valid exclusive licence for all nuclear facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV

Table L-7: Storage facilities for radioactive waste – Central storage facilities

Name of facility and site	Purpose of the facility	Capacity acc. to licence	Licence	Remarks
Gorleben waste storage facility (drum storage facility), Lower Saxony	Storage of radioactive waste from nuclear power plants, medicine, research and trade	200-l, 400-l drums, type III concrete containers, type I-II cast-iron containers, type I-IV containers with a total activity of up to $5x10^{18}$ Bq	Handling licences according to § 3 StrlSchV*) of 27 October 1983, 13 October 1987 and 13 September 1995	In operation since October 1984
Ahaus waste storage facility, North Rhine-Westphalia	Storage of radioactive waste from NPP	Konrad containers, 20' containers and parts of facilities; total activity for storage area no. I limited to $1.0x10^{17}$ Bq	Handling licences according to § 7 StrlSchV of 9 November 2009	In operation since July 2010
Unterweser waste storage facility, Lower Saxony	Storage of low-level radioactive waste from the nuclear power plants Unterweser and Stade	200-l and 400-l drums, concrete containers, sheet-steel containers, cast-iron containers with a total activity of up to $1.85x10^{15}$ Bq	Handling licences according to § 3 StrlSchV*) of 24 June 1981, 29 November 1991 and 6 November 1998	In operation since autumn 1981
Storage facility of the utilities, Mitterteich, Bavaria	Storage of waste with negligible heat generation from Bavarian nuclear facilities	40,000 waste packages (200-l, 400-l drums or cast-iron containers)	Handling licences according to § 3 StrlSchV*) of 7 July 1982	In operation since July 1987
Zwischenlager Nord (ZLN), Rubenow/Greifswald, Mecklenburg-Western Pomerania	Storage of operational and decommissioning waste from the nuclear power plants Greifswald and Rheinsberg, including interim storage of dismantled large components; Buffer storage of waste that will be conditioned for third party	165,000 m³	Handling licences according to § 3 StrlSchV*) of 20 February 1998	In operation since March 1998
Hauptabteilung Dekontaminationsbe-triebe (HDB), Karlsruhe, Baden-Wuerttemberg	Storage of waste with negligible heat generation from FZK, WAK, ITU, *Land* collecting facility Baden-Wuerttemberg and, in a limited way or for buffering purposes, from third parties	Handling (conditioning and storage) of radioactive residues und waste with contents of fissile material up to a total activity of $4.5x10^{17}$ Bq	Handling licence according to § 9 AtG of 25 November 1983, superseded by licence according to § 9 AtG of 29 June 2009	In operation since December 1964

*) as amended on 13 October 1976 and 30 June 1989, respectively

Table L-8: Storage facilities for radioactive waste – Operational buffer storage facilities in nuclear power plants (in operation or permanently shut-down)

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Remarks
NPP Biblis Units A and B	Storage of radioactive waste from the operation of the NPP	7,500 packages	§ 7 AtG, § 7 StrlSchV*)	Licence according to § 7 StrlSchV for the storage of radioactive operational waste (3,000 m^3) at the on-site storage facility, hall 2
NPP Brokdorf	Storage of radioactive waste from the operation of the NPP	560 m^3	§ 7 AtG	-
NPP Brunsbüttel	Storage of radioactive waste from the operation of the NPP	3,225 m^3 / 4,150 m^3	§ 7 AtG	-
NPP Emsland	Storage of radioactive waste from the operation of the NPP	185 m^3	§ 7 AtG	-
NPP Grafenrheinfeld	Storage of radioactive waste from the operation of the NPP	Raw waste: 200 m^3 Conditioned waste: 200 m^3	§ 7 AtG	-
NPP Grohnde	Storage of radioactive waste from the operation of the NPP	280 m^3	§ 7 AtG	-
NPP Gundremmingen Units B and C	Storage of radioactive waste from the operation of the NPP	300 m^3 conditioned waste 1,305 m^3 liquid waste	§ 7 AtG	-
NPP Isar 1	Storage of radioactive waste from the operation of the NPP	4,000 m^3	§ 7 AtG	-
NPP Isar 2	Storage of radioactive waste from the operation of the NPP	160 m^3	§ 7 AtG	-
NPP Krümmel	Storage of radioactive waste from the operation of the NPP	1,340 m^3	§ 7 AtG	-
NPP Neckarwestheim Units 1 and 2	Storage of radioactive waste from the operation of the NPP	3,264 m^3	§ 7 AtG	-
NPP Philippsburg Units 1 and 2	Storage of radioactive waste from the operation of the NPP	3,775 m^3	§ 7 AtG	-
NPP Unterweser	Storage of radioactive waste from the operation of the NPP	350 m^3	§ 7 AtG	-

*) as amended on 20 July 2001

Table L-9: Storage facilities for radioactive waste – operational buffer storage facilities in nuclear power plants (under decommissioning)

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Remarks
NPP Greifswald Units 1 - 5	Storage of radioactive waste from the decommissioning of the NPP	140 20' Container	§ 7 AtG	Storage space for the collection and storage of radioactive waste/residues
NPP Gundremmingen Unit A	Storage of radioactive waste from the decommissioning of the NPP	1,678 m^3 conditioned waste 318 m^3 liquid waste	§ 7 AtG	Conditioned waste
THTR Hamm-Uentrop	Storage of radioactive waste from the operation and decommissioning of the NPP	1,160 m^3	§ 7 AtG	-
AVR Jülich	Storage of radioactive waste from the decommissioning of the NPP	235 m^3	§ 7 AtG	-
NPP Lingen	Storage of radioactive waste from the operation and decommissioning of the NPP	170 m^3	§ 7 AtG	-
NPP Mülheim-Kärlich	Storage of radioactive waste from the operation of the NPP	43 m^3	§ 7 AtG	-
NPP Obrigheim	Storage of radioactive waste from the operation and the post-operational phase of the NPP	3,300 m^3	§ 7 AtG	-
NPP Rheinsberg	Storage of radioactive waste from the decommissioning of the NPP		§ 7 AtG	Only buffer storage
NPP Stade	Storage of radioactive waste from the operation and the post-operational phase of the NPP	100 m^3	§ 7 AtG	-
NPP Stade	Storage of radioactive waste from the decommissioning of the NPP	4,000 m^3	§ 7 StrlSchV	Commissioning: 1 August 2007
NPP Würgassen	Storage of radioactive waste from the decommissioning of the NPP	4,600 m^3	§ 7 AtG	-

Table L-10: Storage facilities for radioactive waste – storage facilities in research institutions

Name of facility and site	Kind of waste stored	Capacity according to licence	Licence	Remarks
Forschungs- und Messreaktor Braunschweig (FMRB)	Operational waste from FMRB	Decommissioning waste from FMRB (174 m^3)	§ 7 AtG	Buffering of waste
Research reactor Garching	Operational waste from the research reactor	FRM: 100 m^3 FRM II: 68 m^3	§ 7 AtG	There is no waste storage facility with an independent handling or operating licence available at the Garching site. There are capabilities to allocate radioactive waste for transport.
Research centre Geesthacht	Operational waste from the research reactor	145 m^2, 112 m^2, 226 m^2	§ 3 StrlSchV*), § 7 StrlSchV	Storage space for conditioned waste
Research centre Jülich	Waste with negligible heat generation AVR fuel spheres, activated bulky waste	11,470 drums, 780 Konrad containers Licence for the storage of AVR fuel	§ 3 StrlSchV*) §§ 6, 9 AtG	-
VKTA Rossendorf	Operational and decommissioning waste from the research institution	2,270 m^3 (total gross storage volume)	§ 3 StrlSchV*)	Storage facility Rossendorf (ZLR)

*) as amended on 13 October 1976 and 30 June 1989, respectively

Table L-11: Storage facilities for radioactive waste – storage facilities of the nuclear and other industries

Name of facility and site	Kind of waste stored	Capacity according to licence	Licence	Remarks
Nuclear industry				
Advanced Nuclear Fuels GmbH (ANF), Lingen	Operational waste from fuel assembly fabrication	1,000 200-l drums	§ 6 AtG	-
Siemens, Karlstein	Waste from dismantling and operation	5,300 m³ (2,100 m³ according to § 9 AtG, 3,200 m³ according to § 3 StrlSchV*))	§ 9 AtG, § 3 StrlSchV*)	-
Interim storage facility of NCS, Hanau	Conditioned waste with negligible heat generation, operational waste and waste from dismantling originating from 1.: Siemens 2.: NUKEM, AREVA NP, GNS et al.	1.: 1,250 Konrad containers 2.: 800 m²	§ 7 StrlSchV § 3 StrlSchV*)	-
Urenco, Gronau	Operational waste from uranium enrichment	220 m² and 150 200-l drums	§ 7 AtG	-
Other industry				
Eckert & Ziegler Nuclitec GmbH, Leese	Waste from the medical field, research and industry	13,620 200-l drums	§ 7 StrlSchV	

*) as amended on 13 October 1976 and 30 June 1989, respectively

Table L-12: Storage facilities for radioactive waste – *Land* collecting facilities (for waste from research institutions see Table L-10)

Name of facility and site	Kind of waste stored	Capacity according to licence	Licence	Remarks
Land collecting facility Baden-Wuerttemberg, Karlsruhe	Waste from the medical field, research and industry	No capacity limit stated (capacity HDB: 78,664 m³)	§ 9 AtG	*Land* collecting facility in HDB, operator HDB
Land collecting facility Bavaria, Mitterteich	Waste from the medical field, research and industry	10,000 packages	§ 3 StrlSchV*)	Approx. 2,900 m³ available
Land collecting facility Berlin, Berlin	Waste from the medical field, research and industry	800 m³	§ 3 StrlSchV*)	At the *Helmholtz-Zentrum Berlin*
Land collecting facility Hesse, Ebsdorfergrund	Waste from the medical field, research and industry	400 m³	§ 6 AtG § 3 StrlSchV*)	-
Land collecting facility Mecklenburg-Western Pomerania, Rubenow/Greifswald	Waste from the medical field, research and industry	one 20'-container	§ 3 StrlSchV*)	*Land* collecting facility at ZLN, approx. 33 m³ available, joint use by Brandenburg
Land collecting facility North Rhine-Westphalia, Jülich	Waste from the medical field, research and industry	9,000 200-l drums	§ 3 StrlSchV*), § 9 AtG	On the site of the *Forschungszentrum Jülich* (Jülich Research Centre)
Land collecting facility Rhineland-Palatinate, Ellweiler	Waste from the medical field, research and industry	α+β/γ activity limited to 1.6×10^{13} Bq	§ 9 AtG, § 3 StrlSchV*)	Approx. 600 m³ available
Land collecting facility Saarland, Elm-Derlen	Waste from the medical field, research and industry	50 m³	§ 3 StrlSchV*)	-
Land collecting facility Saxony, Rossendorf/Dresden	Waste from the medical field, research and industry	300 m³	§ 3 StrlSchV*)	At VKTA, also used by Thuringia and Saxony-Anhalt
Land collecting facility of the four north German coastal Federal States, Geesthacht	Waste from the medical field, research and industry	68 m² storage area	§ 3 StrlSchV*)	Shared use by Schleswig-Holstein, Hamburg and Bremen, the Lower Saxon contingent has been exhausted for several years already

Name of facility and site	Kind of waste stored	Capacity according to licence	Licence	Remarks
Land collecting facility Saxony, Leese	Waste from the medical field, research and industry	Hired storage capacity: 1,485 drums, 3,400 drums, max. 50 Konrad containers	§ 7 StrlSchV*)	Receipt and conditioning of the radioactive waste from the *Land* collecting facility of Lower Saxony take place at the GNS commercial unit at Jülich. The waste being conditioned in compliance with the requirements for disposal is stored at the storage facility of Eckert & Ziegler Nuclitec GmbH in Leese.
Central collecting point of the *Bundeswehr* (Federal Armed Forces), Munster	Waste originating from *Bundeswehr* activities	1,600 m^3	§ 3 StrlSchV*)	-

*) in the versions dated 13 October 1976 and 30 June 1989, respectively

Table L-13: Repositories and other storage facilities for radioactive waste

Name of facility and location	Purpose of the facility	Amounts/activity disposed of	Licence	Remarks
Asse II mine Remlingen, Lower Saxony	Disposal of low and intermediate level radioactive waste in the context of research and development work for the disposal of radioactive and radiotoxic waste	Between 1967 and 1978, approx. 124,500 LAW waste packages, including approx. 15,000 so-called “Lost concrete shieldings” (VBA) with higher active waste, and approx. 1,300 MAW waste packages were emplaced for trial purposes. Total activity of the waste emplaced: $2{,}3 \times 10^{15}$ Bq (as per 1 January 2010).	Licence according to § 3 StrlSchV in the version dated 15 October 1965 Handling licence according to § 7 StrlSchV and acquisition of facts according to § 9 AtG	Geological host formation: rock salt Retrieval of the waste in process of planning
Konrad repository Salzgitter, Lower Saxony	Repository for radioactive waste with negligible heat generation		Licence according to § 9b AtG, approval of the plan was granted on 22 May 2002, decision is definitive since 26 March 2007	Geological host formation: coral oolite (iron ore) beneath a water-impermeable barrier from the cretaceous period Refitting underway since 2007
Morsleben repository for radioactive waste (ERAM), Saxony-Anhalt	Disposal of low-active and medium-active waste with mainly short-lived radionuclides	Disposal of 36,753 m³ low-active and medium-active waste in total. Total activity of all radioactive waste emplaced in the order of magnitude of 10^{14} Bq, activity of alpha-emitters in the order of magnitude of 10^{11} Bq.	22 April 1986: Permanent operating licence granted. 12 April 2001: A statement is made to the effect that no further radioactive waste will be accepted for disposal.	Geological host formation: rock salt On 28 September 1998, emplacement operations were discontinued. Decommissioning has been applied for.

(c) List of nuclear facilities being out of operation

The following tables list those nuclear facilities which are currently out of operation, divided into the following categories:

- Nuclear power plants in the process of decommissioning as at: 31 December 2013 (Table L-14),
- Research reactors with an electric power of more than 1 MW being permanently shut down, in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at: 31 December 2013 (Table L-15),
- Research reactors being permanently shut down, in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at: 31 December 2013 (Table L-16),
- Experimental and demonstration reactors being in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at: 31 December 2013 (Table L-17),
- Commercial fuel cycle facilities being in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at: 31 December 2013 (Table L-18),
- Research, experimental and demonstration facilities of the nuclear fuel cycle, decommissioning completed and facilities released from nuclear regulatory control, as at: 31 December 2013 (Table L-19).

In each table, the facilities are listed in alphabetical order.

Table L-14: Nuclear power plants in the process of decommissioning as at: 31 December 2013

	Name of facility, location	Operator	Type of facility, electrical output (gross)	First criticality	Final shut down	Status	Planned final status
1	KKR Rheinsberg, Rheinsberg, Brandenburg	*Energiewerke Nord GmbH*	PWR (WWER) 70 MWe	03/1966	06/1990	Disman-tling	Removal
2	KRB A Gundremmingen A, Gundremmingen, Bavaria	*Kernkraftwerk Gundremmingen GmbH*	BWR 250 MWe	08/1966	01/1977	Disman-tling, alteration	Technology centre
3	KWL Lingen, Lingen, Lower Saxony	*Kernkraftwerk Lingen GmbH*	BWR 252 MWe	01/1968	01/1977	Safe enclosure, disman-tling applied for	Removal
4	KWO Obrigheim, Obrigheim, Baden-Wuerttemberg	*EnBW Kernkraft GmbH - Kernkraftwerk Obrigheim*	PWR 357 MWe	09/1968	05/2005	Disman-tling	Removal
5	KWW Würgassen, Würgassen, North Rhine-Westphalia	*E.ON Kernkraft GmbH*	BWR 670 MWe	10/1971	08/1994	Disman-tling	Removal
6	KKS Stade, Stade, Lower Saxony	*E.ON Kernkraft GmbH*	PWR 672 MWe	01/1972	11/2003	Disman-tling	Removal
7	KGR 1 Greifswald 1, Lubmin, Mecklenburg-Western Pomerania	*Energiewerke Nord GmbH*	PWR (WWER) 440 MWe	12/1973	12/1990	Disman-tling	Partial dismantling, use as an industrial site
8	KGR 2 Greifswald 2, Lubmin, Mecklenburg-Western Pomerania	*Energiewerke Nord GmbH*	PWR (WWER) 440 MWe	12/1974	02/1990	Disman-tling	Partial dismantling, use as an industrial site
9	KGR 3 Greifswald 3, Lubmin, Mecklenburg-Western Pomerania	*Energiewerke Nord GmbH*	PWR (WWER) 440 MWe	10/1977	02/1990	Disman-tling	Partial dismantling, use as an industrial site
10	KGR 4 Greifswald 4, Lubmin, Mecklenburg-Western Pomerania	*Energiewerke Nord GmbH*	PWR (WWER) 440 MWe	07/1979	06/1990	Disman-tling	Partial dismantling, use as an industrial site
11	KMK Mülheim-Kärlich, Mülheim-Kärlich, Rhineland-Palatinate	*RWE Power AG*	PWR 1302 MWe	03/1986	09/1988	Disman-tling	Re-use

	Name of facility, location	Operator	Type of facility, electrical output (gross)	First critica lity	Final shut down	Status	Planned final status
12	KGR 5 Greifswald 5, Lubmin, Mecklenburg-Western Pomerania	*Energiewerke Nord GmbH*	PWR (WWER) 440 MWe	03/1989	11/1989	Disman-tling	Partial dismantling, use as an industrial site

Table L-15: Research reactors with an electric power of more than 1 MW being permanently shut down, in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at: 31 December 2013

	Name of facility, location	Last operator	Type, thermal. output	First criticality	Final shut down	Status	Planned final status
1	FMRB – Braunschweig, Lower Saxony	*Physikalisch-Technische Bundesanstalt*	Pool 1 MW	10/1967	12/1995	Released from the scope of the AtG except the interim storage facility	-
2	FR-2 – Karlsruhe, Baden-Wuerttemberg	*WAK GmbH*	Tank 44 MW	03/1961	12/1981	Reactor core in safe enclosure	Removal
3	FRG-1 – Geesthacht, Schleswig-Holstein	*Helmholtz-Zentrum Geesthacht GmbH*	Pool 5 MW	10/1958	06/2010	Shut-down, fuel elements removed, decom-missioning applied for	Removal
4	FRG-2 – Geesthacht, Schleswig-Holstein	*Helmholtz-Zentrum Geesthacht GmbH*	Pool 15 MW	03/1963	01/1993	Shut-down, partly dismantled	Removal
5	FRJ-1 MERLIN – Jülich, North Rhine-Westphalia	*Forschungszentrum Jülich GmbH*	Pool 10 MW	02/1962	03/1985	Removed	-
6	FRJ-2 DIDO – Jülich, North Rhine-Westphalia	*Forschungszentrum Jülich GmbH*	DIDO 23 MW	11/1962	05/2006	Disman-tling	Removal
7	FRM – München, Bavaria	*Technische Universität München*	Pool 4 MW	10/1957	07/2000	Disman-tling	Partial disman-tling, conver-sion into an auxiliary plant of FRM II
8	FRN – Neuherberg, Bavaria	*Helmholtz Zentrum München GmbH*	TRIGA 1 MW	08/1972	12/1982	Safe enclosure	Not yet decided
9	RFR – Rossendorf, Saxony	*VKTA Rossendorf*	Tank, WWR 10 MW	12/1957	06/1991	Disman-tling	Removal

Table L-16: Research reactors being permanently shut down, in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at: 31 December 2013

	Name of facility, location	Operator	Type, thermal output	First criticality	Final shut down	Status	Planned final status
1	ADIBKA – Jülich, North Rhine-Westphalia	*Forschungszentrum Jülich GmbH*	Homog. reactor 0,1 kW	03/1967	10/1972	Removed	-
2	AEG Nullenergie-Reaktor – Karlstein, Bavaria	*Kraftwerk Union*	Tank 0,1 kW	06/1967	01/1973	Removed	-
3	AKR-1 – Dresden, Saxony	*Technische Universität Dresden*	Homog. reactor 2 W	07/1978	03/2004	Converted and rededicated to AKR-2, operation since 07/2005	
4	ANEX – Geesthacht, Schleswig-Holstein	*Helmholtz-Zentrum Geesthacht GmbH*	Critical assembly 0,1 kW	05/1964	02/1975	Removed	-
5	BER-I – Berlin	*Helmholtz-Zentrum Berlin GmbH*	Homog. reactor 50 kW	07/1958	08/1972	Removed	-
6	FRF-1 – Frankfurt/M. (FRF-2 in the same building never reached criticality)	*Johann-Wolfgang-Goethe-Universität Frankfurt/M.*	Homog. reactor 50 kW	01/1958	03/1968	Removed	-
7	FRH – Hannover, Lower Saxony	*Medizinische Hochschule Hannover*	TRIGA 250 kW	01/1973	12/1996	Removed	-
8	HD I – Heidelberg, Baden-Wuerttemberg	*Deutsches Krebsforschungszentrum Heidelberg*	TRIGA 250 kW	08/1966	03/1977	Removed	-
9	HD II – Heidelberg, Baden-Wuerttemberg	*Deutsches Krebsforschungszentrum Heidelberg*	TRIGA 250 kW	02/1978	11/1999	Removed	-
10	KAHTER, Jülich, North Rhine-Westphalia	*Forschungszentrum Jülich GmbH*	Critical assembly 0,1 kW	07/1973	02/1984	Removed	-
11	KEITER, Jülich, North Rhine-Westphalia	*Forschungszentrum Jülich GmbH*	Critical assembly 1 W	06/1971	03/1982	Removed	-
12	PR-10, AEG Prüfreaktor, Karlstein, Bavaria	*Kraftwerk Union*	Argonaut 0,18 kW	01/1961	11/1975	Removed	-
13	RAKE, Rossendorf, Saxony	*VKTA Rossendorf*	Tank 0,01 kW	10/1969	11/1991	Removed	-
14	RRR, Rossendorf, Saxony	*VKTA Rossendorf*	Argonaut 1 kW	12/1962	09/1991	Removed	-
15	SAR, München, Bavaria	*Technische Universität München*	Argonaut 1 kW	06/1959	10/1968	Removed	-

	Name of facility, location	Operator	Type, thermal output	First critica lity	Final shut down	Status	Planned final status
16	SNEAK, Karlsruhe, Baden-Wuerttemberg	*Karlsruher Institut für Technologie*	Homog. reactor 1 kW	12/1966	11/1985	Removed	-
17	STARK, Karlsruhe, Baden-Wuerttemberg	*Karlsruher Institut für Technologie*	Argonaut 0,01 kW	01/1963	03/1976	Removed	-
18	SUR Aachen – Aachen, North Rhine-Westphalia	*RWTH Aachen*	Homog. reactor < 1 W	09/1965	-	Decommis sioning applied for	Removal
19	SUR Berlin – Berlin	*Technische Hochschule Berlin*	Homog. reactor < 1 W	07/1963	10/2007	Removed	-
20	SUR Bremen – Bremen	*Hochschule Bremen*	Homog. reactor < 1 W	10/1967	06/1993	Removed	-
21	SUR Darmstadt – Darmstadt, Hesse	*Technische Hochschule Darmstadt*	Homog. reactor < 1 W	09/1963	02/1985	Removed	-
22	SUR Hamburg – Hamburg	*Fachhochschule Hamburg*	Homog. reactor < 1 W	01/1965	08/1992	Removed	-
23	SUR Hannover – Hannover, Lower Saxony	*Universität Hannover*	Homog. reactor < 1 W	12/1971	-	Decommis sioning applied for	Removal
24	SUR Karlsruhe – Karlsruhe, Baden-Wuerttemberg	*Karlsruher Institut für Technologie*	Homog. reactor < 1 W	03/1966	09/1996	Removed	-
25	SUR Kiel – Kiel, Schleswig-Holstein	*Fachhochschule Kiel*	Homog. reactor < 1 W	03/1966	12/1997	Removed	-
26	SUR München – München, Bavaria	*Technische Universität München*	Homog. reactor < 1 W	02/1962	08/1981	Removed	-
27	SUAK – Karlsruhe, Baden-Wuerttemberg	*Karlsruher Institut für Technologie*	Fast subcritical assembly < 1 W	11/1964	12/1978	Removed	-
28	SUA – München, Bavaria	*Technische Universität München*	Subcritical assembly < 1 W	06/1959	10/1968	Removed	-
29	ZLFR – Zittau, Saxony	*Hochschule Zittau/Görlitz*	10 W	05/1979	03/2005	Removed	-

Table L-17: Experimental and demonstration reactors being in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at: 31 December 2013

	Name of facility, location	Operator	Type, thermal output (gross)	First criticality	Final shut down	Status	Planned final status
1	AVR *Atomversuchskraftwerk*, Jülich, North Rhine-Westphalia	*AVR GmbH*	HTGR, 15 MWe	08/1966	12/1988	Dismantling	Removal
2	HDR *Heißdampfreaktor*, Großwelzheim, Bavaria	*Karlsruher Institut für Technologie*	SSR, 25 MWe	10/1969	04/1971	Removed	-
3	KKN Niederaichbach, Niederaichbach, Bavaria	*Karlsruher Institut für Technologie*	HWGCR, 106 MWe	12/1972	07/1974	Removed	-
4	KNK II *Kompakte Natriumgekühlte Reaktoranlage*, Karlsruhe, Baden-Wuerttemberg	*WAK GmbH*	FBR, 21 MWe	10/1977	08/1991	Dismantling	Removal
5	MZFR *Mehrzweckforschungsreaktor*, Karlsruhe, Baden-Wuerttemberg	*WAK GmbH*	PWR with D_2O, 57 MWe	09/1965	05/1984	Dismantling	Removal
6	Nuclear ship Otto Hahn, Geesthacht, Schleswig-Holstein	*Helmholtz-Zentrum Geesthacht GmbH*	PWR vessel propulsion, 38 MW	08/1968	03/1979	Nuclear ship released from AtG, RPV put into storage	-
7	THTR-300 *Thorium-Hochtemperaturreaktor*, Hamm-Uentrop, North Rhine-Westphalia	*Hochtemperatur-Kernkraft GmbH*	HTGR, 308 MWe	09/1983	09/1988	Safe enclosure	Not yet decided
8	VAK *Versuchsatomkraftwerk*, Kahl, Bavaria	*Versuchsatomkraftwerk Kahl GmbH*	BWR, 16 MWe	11/1960	11/1985	Removed	-

Table L-18: Commercial fuel cycle facilities being in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at: 31 December 2013

	Name of facility, location	Operator	Start of operation	End of operation	Status	Planned final status
1	HOBEG fuel fabrication facility, Hanau, Hesse	*Hobeg GmbH*	1973	1988	Removed	-
2	NUKEM-A fuel fabrication facility, Hanau, Hesse	*Nukem GmbH*	1962	1988	Removed, groundwater remediation	Complete release of the site from AtG
3	Siemens fuel fabrication facility, uranium unit, Hanau, Hesse	*Siemens AG*	1969	1995	Removed	-
4	Siemens fuel fabrication facility, MOX unit, Hanau, Hesse	*Siemens AG*	1968	1991	Removed	-
5	Siemens fuel fabrication facility, Karlstein unit (SBWK), Bavaria	*Siemens AG*	1966	1993	Continued conventional use	-
6	Karlsruhe reprocessing plant (WAK) including Karlsruhe vitrification plant (VEK), Baden-Wuerttemberg	*Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH*	1971	1990	Dismantling	Removal

Table L-19: Research, experimental and demonstration facilities of the nuclear fuel cycle, decommissioning completed and facilities released from nuclear regulatory control, as at: 31 December 2013

	Name of facility, location	Operator	Begin of operation	Final shut down	Status	Planned final status
1	JUPITER test facility reprocessing, Jülich, North Rhine-Westphalia	*Forschungszentrum Jülich GmbH*	1978	1987	Removed	-
2	MILLI extraction facility on a laboratory scale, Karlsruhe, Baden-Wuerttemberg	*Karlsruher Institut für Technologie*	1970	1991	Removed	-
3	PUTE Plutonium extraction facility, Karlsruhe, Baden-Wuerttemberg	*Karlsruher Institut für Technologie*	1980	1991	Removed	-

(d) List of nuclear power plants whose operation licence for power generation operation has expired according to the 13th amendment to the AtG

Table L-20: Nuclear power plants that were shut down according to the 13th amendment to the AtG

	Shut down nuclear power plant, location	a) Operator b) Manufacturer c) Owner (shareholder)	Type, electrical output [MWe]	a) First criticality b) Expiration of permission for power generation c) Application for decommissioning
1	Biblis A (KWB A); Biblis Hesse	a) RWE Power b) KWU c) RWE Power 100%	PWR; 1,225	a) 16.07.1974 b) 06.08.2011 c) 06.08.2012
2	Biblis B (KWB B); Biblis Hesse	a) RWE Power b) KWU b) RWE Power 100%	PWR; 1,300	a) 25.03.1976 b) 06.08.2011 c) 06.08.2012
3	Neckarwestheim 1 (GKN 1); Neckarwestheim Baden-Wuerttemberg	a) EnBW Kernkraft (EnKK) b) KWU c) EnKK 100%	PWR; 840	a) 26.05.1976 b) 06.08.2011 c) 24.04.2013
4	Brunsbüttel (KKB); Brunsbüttel Schleswig-Holstein	a) Kernkraftwerk Brunsbüttel b) AEG / KWU c) VENE 66,7%, (E.ON Kernkraft 33,3%)	BWR; 806	a) 23.06.1976 b) 06.08.2011 c) 01.11.2012
5	Isar 1 (KKI 1); Essenbach Bavaria	a) E.ON Kernkraft b) KWU c) E.ON Kernkraft 100%	BWR; 912	a) 20.11.1977 b) 06.08.2011 c) 04.05.2012
6	Unterweser (KKU); Stadland Lower Saxony	a) E.ON Kernkraft b) KWU c) E.ON Kernkraft 100%	PWR; 1,410	a) 16.09.1978 b) 06.08.2011 c) 04.05.2012
7	Philippsburg 1 (KKP 1); Philippsburg Baden-Wuerttemberg	a) EnBW Kernkraft (EnKK) b) KWU c) EnKK 100%	BWR; 926	a) 09.03.1979 b) 06.08.2011 c) 24.04.2013
8	Krümmel (KKK); Krümmel Schleswig-Holstein	a) Kernkraftwerk Krümmel b) KWU c) VENE 50%, (E.ON Kernkraft 50%)	BWR; 1,402	a) 14.09.1983 b) 06.08.2011 c) -

(e) References to National Laws, Regulations, Requirements, Guides, etc.

The structure and sequence of these references are based on the "Handbook on Nuclear Safety and Radiation Protection". As a general rule, they must be taken into account during licencing and supervisory procedures by the regulatory body. The list contains only those regulations that are relevant directly or by appropriate application in connection with the treatment of spent fuel and radioactive waste. This is why there are gaps in the numbering of the references.

1 Regulations

- 1A National nuclear and radiation protection regulations
- 1B Regulations concerning the safety of nuclear installations
- 1C Regulations for the transport of radioactive material and accompanying regulations
- 1D Bilateral agreements in the nuclear field and in the area of radiation protection
- 1E Multilateral agreements on nuclear safety and radiation protection with national implementing regulations
- 1F Law of the European Union

2 General Administrative Regulations

3 Announcements by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety and the formerly competent ministry, the Federal Ministry for the Interior

4 Recommendations of the RSK

5 Safety Standards of the Nuclear Safety Standards Commission (KTA)

1 Regulations

1A National Nuclear and Radiation Protection Regulations

[1A-2] Gesetz zur geordneten Beendigung der Kernenergienutzung zur gewerblichen Erzeugung von Elektrizität vom 22. April 2002 (BGBl. I 2002, Nr. 26, S. 1351)

[1A-3] Gesetz über die friedliche Verwendung der Kernenergie und den Schutz gegen ihre Gefahren (Atomgesetz – AtG) vom 23. Dezember 1959, Neufassung vom 15. Juli 1985 (BGBl. I 1985, Nr. 41, S. 1565), das zuletzt durch Artikel 5 des Gesetzes vom 28. August 2013 (BGBl.I 2013, Nr. 52, S. 3313) geändert worden ist

[1A-4] Fortgeltendes Recht der Deutschen Demokratischen Republik aufgrund von Artikel 9 Abs. 2 in Verbindung mit Anlage II Kapitel XII Abschnitt III Nr. 2 und 3 des Einigungsvertrages vom 31. August 1990 in Verbindung mit Artikel 1 des Gesetzes zum Einigungsvertrag vom 23. September 1990 (BGBl. II 1990, Nr. 35, S. 885 und 1226), soweit dabei radioaktive Stoffe, insbesondere Radonfolgeprodukte, anwesend sind:

- Verordnung über die Gewährleistung von Atomsicherheit und Strahlenschutz – AtStrlSV – vom 11. Oktober 1984 (GBl. (DDR) I 1984, Nr. 30, S. 341) und Durchführungsbestimmung zur Verordnung über die Gewährleistung von Atomsicherheit und Strahlenschutz – AtStrlSVDBest – vom 11. Oktober 1984 (GBl. (DDR) I 1984, Nr. 30, S. 348, berichtigt GBl. (DDR) I 1987, Nr. 18, S. 196)
- Anordnung zur Gewährleistung des Strahlenschutzes bei Halden und industriellen Absetzanlagen und bei Verwendung darin abgelagerter Materialien – StrSAblAnO – vom 17. November 1980 (GBl. (DDR) I 1980, Nr. 34, S. 347)

[1A-5] Gesetz zum vorsorgenden Schutz der Bevölkerung gegen Strahlenbelastung (Strahlenschutzvorsorgegesetz – StrVG) vom 19. Dezember 1986 (BGBl. I, Nr. 69, S. 2610), zuletzt geändert durch Artikel 1 des Gesetzes vom 8. April 2008 (BGBl. I 2008, Nr. 14, S. 686)

[1A-6] Gesetz über die Errichtung eines Bundesamtes für Strahlenschutz – BAStrlSchG – vom 9. Oktober 1989 (BGBl. I 1989, Nr. 47, S. 1830), zuletzt geändert durch Artikel 2 des Gesetzes vom 3. Mai 2000 (BGBl. I 2000, Nr. 20, S. 636)

[1A-7] Gesetz zur Suche und Auswahl eines Standortes für ein Endlager für Wärme entwickelnde radioaktive Abfälle und zur Änderung anderer Gesetze (Standortauswahlgesetz – StandAG) vom 23. Juli 2013 (BGBl. I 2013, Nr. 41, S. 2553)

[1A-8] Verordnung über den Schutz vor Schäden durch ionisierende Strahlen (Strahlenschutzverordnung – StrlSchV) vom 20. Juli 2001 (BGBl. I 2001, Nr. 38, S. 1714), berichtigt am 22. April 2002 (BGBl. I 2002, Nr. 27, S. 1459), zuletzt geändert durch Artikel 5 Absatz 7 des Gesetzes vom 24. Februar 2012 (BGBl. I 2012, Nr. 10, S. 212)
Hinweis: geändert durch Artikel 2 des Gesetzes vom 29. August 2008 (BGBl.I 2008, Nr. 40, S. 1793), diese Änderung tritt erst in Kraft, wenn das Protokoll vom 12. Februar 2004 zur Änderung des Übereinkommens vom 29. Juli 1960 über die Haftung gegenüber Dritten auf dem Gebiet der Kernenergie in der Fassung des Zusatzprotokolls vom 28. Januar 1964 und des Protokolls vom 16. November 1982 nach seinem Artikel 20 in Kraft tritt

[1A-10] Verordnung über das Verfahren bei der Genehmigung von Anlagen nach § 7 des Atomgesetzes (Atomrechtliche Verfahrensverordnung – AtVfV) vom 3. Februar 1995 (BGBl. I 1995, Nr. 8, S. 180), zuletzt geändert durch Artikel 4 des Gesetzes vom 9. Dezember 2006 (BGBl. I 2006, Nr. 58, S. 2819)

[1A-11] Verordnung über die Deckungsvorsorge nach dem Atomgesetz (Atomrechtliche Deckungsvorsorge-Verordnung – AtDeckV) vom 25. Januar 1977 (BGBl. I 1977, Nr. 8, S. 220), zuletzt geändert durch Artikel 9 Absatz 12 des Gesetzes vom 23. November 2007 (BGBl. I 2007, Nr. 59, S. 2631)

[1A-13] Verordnung über Vorausleistungen für die Einrichtung von Anlagen des Bundes zur Sicherstellung und zur Endlagerung radioaktiver Abfälle (Endlagervorausleistungsverordnung – EndlagerVlV) vom 28. April 1982 (BGBl. I, Nr. 16, S. 562), zuletzt geändert durch Artikel 1 der Verordnung vom 6. Juli 2004 (BGBl. I 2004, Nr. 33, S. 1476)

[1A-17] Verordnung über den kerntechnischen Sicherheitsbeauftragten und über die Meldungen von Störfällen und sonstigen Ereignissen (Atomrechtliche Sicherheitsbeauftragten- und Meldeverordnung – AtSMV) vom 14. Oktober 1992 (BGBl. I 1992, Nr. 48, S. 1766), zuletzt geändert durch Artikel 1 der Verordnung vom 8. Juni 2010 (BGBl. I 2010, Nr. 31, S. 755)

[1A-18] Verordnung über die Verbringung radioaktiver Abfälle oder abgebrannter Brennelemente (Atomrechtliche Abfallverbringungsverordnung – AtAV) vom 30. April 2009 (BGBl. I 2009, Nr. 24, S. 1000)

[1A-19] Verordnung für die Überprüfung der Zuverlässigkeit zum Schutz gegen Entwendung oder Freisetzung radioaktiver Stoffe nach dem Atomgesetz (Atomrechtliche Zuverlässigkeitsüberprüfungs-Verordnung – AtZüV) vom 1. Juli 1999 (BGBl. I 1999, Nr. 35, S. 1525), zuletzt geändert durch Artikel 1 der VO vom 22. Juni 2010 (BGBl. I 2010, Nr. 34, S. 825)

[1A-22] Verordnung zur Festlegung einer Veränderungssperre zur Sicherung der Standorterkundung für eine Anlage zur Endlagerung radioaktiver Abfälle im Bereich des Salzstocks Gorleben (Gorleben-Veränderungssperren-Verordnung – Gorleben VSpV) vom 25. Juli 2005 (BAnz. Nr. 153a vom 16. August 2005)

[1A-23] Gesetz zur Kontrolle hochradioaktiver Strahlenquellen vom 12. August 2005 (BGBl. I 2005, Nr. 49, S. 2365), berichtigt am 11. Oktober 2005 (BGBl. I 2005, Nr. 64, S. 2976)
Hinweis: Umsetzung der Richtlinie 2003/122/EURATOM vom 22. Dezember 2003 zur Kontrolle hochradioaktiver umschlossener Strahlenquellen und herrenloser Strahlenquellen

[1A-24] Zehntes Gesetz zur Änderung des Atomgesetzes vom 24. März 2009 (BGBl. I 2009, Nr. 15, S. 556)

[1A-25] Dreizehntes Gesetz zur Änderung des Atomgesetzes vom 31. Juli 2011 (BGBl. I 2011, Nr. 43, S. 1704)

[1A-26] Gesetz zur Beschleunigung der Rückholung radioaktiver Abfälle und der Stilllegung der Schachtanlage Asse II vom 20. April 2013 (AtGÄndG) (BGBl. I 2013, Nr. 19, S. 921)

[1A-27] Gesetz über die Errichtung eines Bundesamtes für kerntechnische Entsorgung – BfkEG – vom 23. Juli 2013 (BGBl. I 2013, Nr. 41, S. 2553)

1B Regulations concerning the safety of nuclear installations

[1B-1] Strafgesetzbuch – StGB – vom 13. November 1998 (BGBl. I 1998, Nr. 75, S. 3322), zuletzt geändert durch Artikel 15 des Gesetzes vom 4. Juli 2013 (BGBl. I 2013, Nr. 35, S. 1981)

[1B-2] Raumordnungsgesetz – ROG – vom 22. Dezember 2008 (BGBl. I 2008, Nr. 65, S. 2986), zuletzt geändert durch Artikel 9 des Gesetzes vom 31. Juli 2009 (BGBl. I 2009, Nr. 51, S. 2585)

[1B-3] Gesetz zum Schutz vor schädlichen Umwelteinwirkungen durch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge (Bundes-Immissionsschutzgesetz – BImSchG) in der Fassung der Bekanntmachung vom 14. Mai 1990 (BGBl. I 1990, S. 880), Neufassung vom 26. September 2002 (BGBl. I 2002, Nr. 71, S. 3830), zuletzt geändert durch Artikel 1 des Gesetzes vom 2. Juli 2013 (BGBl. I 2013, Nr. 34, S. 1943)

[1B-5] Gesetz zur Ordnung des Wasserhaushalts (Wasserhaushaltsgesetz – WHG) vom 31. Juli 2009 (BGBl. I 2009, Nr. 51, S. 2585), zuletzt geändert durch Artikel 2 des Gesetzes vom 8. April 2013 (BGBl. I 2013, Nr. 17, S. 734)
Hinweis: Abweichendes Landesrecht: Niedersächsisches Wassergesetz (BGBl. I 2010, Nr. 38, S. 970); Schleswig-Holsteinisches Wassergesetz (BGBl. I 2010, Nr. 55, S. 1501); Wassergesetz des Landes Sachsen-Anhalt (BGBl. I 2011, Nr. 15, S. 567); Hessisches Wassergesetz (BGBl. I 2011, Nr. 16, S. 607); Sächsisches Wassergesetz (BGBl. I 2011, Nr. 22, S. 842); Bremisches Wassergesetz (BGBl. I 2011, Nr. 26, S. 1010 und Nr. 27, S. 1035) ; Bayerisches Wassergesetz (BGBl.I 2012, Nr. 49, S. 2176)

[1B-6] Gesetz über Naturschutz und Landschaftspflege (Bundesnaturschutzgesetz – BNatSchG) vom 29. Juli 2009 (BGBl.I 2009, Nr. 51, S. 2542), zuletzt geändert durch Artikel 2 Absatz 24 des Gesetzes vom 6. Juni 2013 (BGBl. I 2013, Nr. 28, S. 1482)
Hinweis: Abweichendes Landesrecht: Bayerisches Naturschutzgesetz (BGBl. I 2010, Nr. 11, S. 275); Landesnaturschutzgesetz Schleswig-Holstein (BGBl. I 2010, Nr. 17, S. 450); Niedersächsisches Ausführungsgesetz zum Bundesnaturschutzgesetz (BGBl. I 2010, Nr. 38, S. 970), Naturschutzausführungsgesetz von Mecklenburg-Vorpommern (BGBl. I 2010, Nr. 58, S. 1621); Naturschutzgesetz des Landes Sachsen-Anhalt (BGBl. I 2011, Nr. 1, S. 30); Hamburgisches Gesetz zur Ausführung des Bundesnaturschutzgesetzes (BGBl. I 2011, Nr. 4, S. 93); Hessisches Ausführungsgesetz zum Bundesnaturschutzgesetz (BGBl. I 2011, Nr. 18, S. 663); Sächsisches Naturschutzgesetz (BGBl. I 2011, Nr. 22, S. 842); Hamburgisches Gesetz zur Ausführung des Bundesnaturschutzgesetzes (BGBl.I 2013, Nr. 18, S. 820)

[1B-13] Gesetz zur Förderung der Kreislaufwirtschaft und Sicherung der umweltverträglichen Bewirtschaftung von Abfällen (Kreislaufwirtschaftsgesetz – KrWG) vom 24. Februar 2012 (BGBl. I 2012, Nr. 10, S. 212), zuletzt geändert durch § 44 Absatz 4 des Gesetzes vom 22. Mai 2013 (BGBl. I 2013, Nr. 25, S. 1324)

[1B-14] Gesetz über die Umweltverträglichkeitsprüfung – UVPG – vom 24. Februar 2010 (BGBl. I 2010, Nr. 7, S. 94), zuletzt geändert durch Artikel 6 des Gesetzes vom 8. April 2013 (BGBl. I 2013, Nr. 17, S. 734)
Hinweis: Abweichendes Landesrecht: Niedersächsisches Gesetz über die Umweltverträglichkeitsprüfung (BGBl. I 2010, Nr. 38, S. 970), Landesgesetz über die Umweltverträglichkeitsprüfung (Landes-UVP-Gesetz – LUVPG) von Schleswig-Holstein (BGBl. I 2011, Nr. 6, S. 244)

[1B-15] Bundesberggesetz – BBergG – vom 13. August 1980 (BGBl. I 1980, Nr. 48, S. 1310), zuletzt geändert durch Artikel 15a des Gesetzes vom 31. Juli 2009 (BGBl. I 2009, Nr. 51, S. 2585)

[1B-18] Baugesetzbuch (BauGB) vom 23. Juni 1960 in der Fassung der Bekanntmachung vom 23. September 2004 (BGBl. I 2004, Nr. 52, S. 2414), zuletzt geändert durch Artikel 1 des Gesetzes vom 11. Juni 2013 (BGBl. I 2013, Nr. 29, S. 1548)

1C Regulations for the transport of radioactive Material and accompanying regulations

Not cited.

1D Bilateral agreements in the nuclear field and in the area of radiation protection

[1D-1] Abkommen zwischen der Bundesrepublik Deutschland und der Bundesrepublik Österreich über die gegenseitige Hilfeleistung bei Katastrophen und Unglücksfällen vom 23. Dezember 1988; Gesetz dazu vom 20. März 1992 (BGBl. II 1992, S. 206); in Kraft seit 1. Oktober 1992 (BGBl. II 1992, S. 593)

[1D-2] Abkommen zwischen der Bundesrepublik Deutschland und dem Königreich Belgien über die gegenseitige Hilfeleistung bei Katastrophen oder schweren Unglücksfällen vom 6. November 1980; Gesetz dazu vom 30. November 1982 (BGBl. II 1982, S. 1006); in Kraft seit 1. Mai 1984 (BGBl. II 1984, S. 327)

[1D-3] Abkommen zwischen der Bundesrepublik Deutschland und der Schweizerischen Eidgenossenschaft über die gegenseitige Hilfeleistung bei Katastrophen oder schweren Unglücksfällen vom 28. November 1984; Gesetz dazu vom 22. Januar 1987 (BGBl. II 1987, S. 74); in Kraft seit 1. Dezember 1988 (BGBl. II 1988, S. 967)

[1D-4] Abkommen zwischen der Bundesrepublik Deutschland und dem Königreich Dänemark über die gegenseitige Hilfeleistung bei Katastrophen oder schweren Unglücksfällen vom 16. Mai 1985; Gesetz dazu vom 17. März 1988 (BGBl. II 1988, S. 286); in Kraft seit 1. August 1988 (BGBl. II 1988, S. 619)

[1D-5] Abkommen zwischen der Bundesrepublik Deutschland und der Französischen Republik über die gegenseitige Hilfeleistung bei Katastrophen oder schweren Unglücksfällen vom 3. Februar 1977; Gesetz dazu vom 14. Januar 1980 (BGBl. II 1980, S. 33); in Kraft seit 1. Dezember 1980 (BGBl. II 1980, S. 1438)

[1D-6] Abkommen zwischen der Bundesrepublik Deutschland und der Regierung der Republik Ungarn über die gegenseitige Hilfeleistung bei Katastrophen und Unglücksfällen vom 9. Juni 1997; Gesetz dazu vom 7. Juli 1998 (BGBl. II 1998, S. 1189); in Kraft seit 11. September 1998 (BGBl. II 1999, S: 125)

[1D-7] Abkommen zwischen der Bundesrepublik Deutschland und der Republik Litauen über die gegenseitige Hilfeleistung bei Katastrophen oder schweren Unglücksfällen vom 15. März 1994; Gesetz dazu vom 12. Januar 1996 (BGBl. II 1996, S. 27); in Kraft seit 1. September 1996 (BGBl. II 1996, S. 1476)

[1D-8] Abkommen zwischen der Bundesrepublik Deutschland und dem Großherzogtum Luxemburg über die gegenseitige Hilfeleistung bei Katastrophen oder schweren Unglücksfällen vom 2. März 1978; Gesetz dazu vom 7. Juli 1981 (BGBl. II 1981, S. 445); in Kraft seit 1. Dezember 1981 (BGBl. II 1981, S. 1067)

[1D-9] Abkommen zwischen der Bundesrepublik Deutschland und dem Königreich der Niederlande über die gegenseitige Hilfeleistung bei Katastrophen einschließlich schweren Unglücksfällen vom 7. Juni 1988; Gesetz dazu vom 20. März 1992 (BGBl. II 1992, S. 198); in Kraft seit 1. März 1997 (BGBl. II 1997, S. 753 und S. 1392)

[1D-10] Abkommen zwischen der Bundesrepublik Deutschland und der Republik Polen über die gegenseitige Hilfeleistung bei Katastrophen oder schweren Unglücksfällen vom 10. April 1997; Gesetz dazu vom 7. Juli 1998 (BGBl. II 1998, S. 1178); in Kraft seit 1. März 1999 (BGBl. II 1999, S. 15)

[1D-11] Abkommen zwischen der Bundesrepublik Deutschland und der Russischen Föderation über die gegenseitige Hilfeleistung bei Katastrophen oder schweren Unglücksfällen vom 16. Dezember 1992; Gesetz dazu vom 19. Oktober 1994 (BGBl. II 1994, S. 3542); in Kraft seit 11. Juli 1995 (BGBl. II 1997, S. 728)

[1D-12] Vertrag zwischen der Bundesrepublik Deutschland und der Tschechischen Republik über die gegenseitige Hilfeleistung bei Katastrophen und schweren Unglücksfällen vom 19. September 2000; Gesetz hierzu vom 16. August 2002 (BGBl. II 2002, Nr. 31); in Kraft seit dem 1. Januar 2003 (BGBl. II 2003, Nr. 2)

1E Multilateral agreements on nuclear safety and radiation protection with national implementing regulations

Nuclear Safety and Radiation Protection

[1E-1] Gemeinsames Übereinkommen über die Sicherheit der Behandlung abgebrannter Brennelemente und über die Sicherheit der Behandlung radioaktiver Abfälle – Übereinkommen über nukleare Entsorgung (Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, INFCIRC/546) vom 5. September 1997, in Kraft seit 18. Juni 2001;
69 Vertragsparteien (10/2013), Depositar: IAEA
Gesetz hierzu mit amtlicher Übersetzung vom 13. August 1998 (BGBl. II 1998, Nr. 31, S. 1752)
in Kraft für Deutschland seit 18. Juni 2001 (BGBl. II 2001, Nr. 36, S. 1283)

[1E-3-1] Übereinkommen über die Verhütung von Meeresverschmutzung durch das Einbringen von Abfällen und anderen Stoffen – London Dumping Convention LDC (Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, INFCIRC/205) vom 29. Dezember 1972, in Kraft seit 30. August 1975, mit seither 5 Änderungen
87 Vertragsparteien (07/11)
Gesetz hierzu vom 11. Februar 1977 (BGBl. II 1977, Nr. 8, S. 165), zuletzt geändert durch Gesetz vom 25. August 1998 (BGBl. I, Nr. 57, S. 2455)
in Kraft für Deutschland seit 8. Dezember 1977 (BGBl. II 1979, Nr. 13, S. 273)
Protokoll LCProt1996 (IMO) vom 7. November 1996 zu diesem Übereinkommen (ersetzt die ursprüngliche Konvention), in Kraft seit 24. März 2006, Änderung vom 2. November 2006, diese in Kraft seit 10. Februar 2007
40 Vertragsparteien (07/11) Depositare: Mexiko, Russische Förderation, UK, USA
Gesetz dazu vom 9. Juli 1998 (BGBl. II 1998, Nr. 25, S. 1345), zuletzt geändert durch Verordnung vom 24. August 2010 (BGBl. II 2010, Nr. 24, S. 1006)
Protokoll LCProt1996 in Kraft für Deutschland seit 24. März 2006 (BGBl. II 2010, Nr. 35, S. 1429)
Hinweis: Keine Einbringung von Materialien mit Radioaktivitätswerten oberhalb de-minimis-Konzentrationen

Liability

[1E-11] Übereinkommen über die Haftung gegenüber Dritten auf dem Gebiet der Kernenergie – Pariser Übereinkommen (Convention on Third Party Liability in the Field of Nuclear Energy – Paris Convention) vom 29. Juli 1960, ergänzt durch das Protokoll vom 28. Januar 1964 in Kraft seit 1. April 1968,
ergänzt durch das Protokoll vom 16. November 1982, das Protokoll vom 12. Februar 1982, in Kraft seit 7. April 1988
und ergänzt durch das Protokoll vom 12. Februar 2004, noch nicht in Kraft
16 Vertragsparteien (10/10), Depositar: OECD
Gesetz dazu vom 8. Juli 1975 (BGBl. II 1975, Nr. 42, S. 957), zuletzt geändert durch Artikel 30 des Gesetzes vom 9. September 2001 (BGBl. I 2001, Nr. 47, S. 2331)
in Kraft für Deutschland seit 30. September 1975 (BGBl. II 1976, Nr. 12, S. 308),
Gesetz dazu vom 21. Mai 1985 (BGBl. II 1985, Nr. 19, S. 690)
in Kraft für Deutschland seit 7. Oktober 1988 (BGBl. II 1989, Nr. 6, S. 144)
Gesetz zum Protokoll 2004 mit amtlicher Übersetzung vom 29. August 2008 (BGBl. II 2008, Nr. 24, S. 902)
Hinweis: Die Bestimmungen des Pariser Atomhaftungs-Übereinkommens gelten in Verbindung mit §§ 25 ff. des Atomgesetzes in der Bundesrepublik Deutschland unmittelbar, d. h. die Haftung für nukleare Schäden bestimmt sich nach den Bestimmungen des Übereinkommens in Verbindung mit dem Atomgesetz.

[1E-12] Zusatzübereinkommen zum Pariser Übereinkommen vom 29. Juli 1960 – Brüsseler Zusatzübereinkommen, (Convention Supplementary to the Paris Convention of 29 July 1960 on Third Party Liability in the Field of Nuclear Energy – Brussels Supplementary Convention) vom 31. Januar 1963, ergänzt durch das Protokoll vom 28. Januar 1964, in Kraft seit 4. Dezember 1974,
ergänzt durch das Protokoll vom 16. November 1982, in Kraft seit 1. August 1991 und ergänzt durch das Protokoll von 2004, noch nicht in Kraft
12 Vertragsparteien (10/10), Depositar: OECD
Gesetz dazu vom 8. Juli 1975 (BGBl. II 1975, Nr. 42, S. 957), zuletzt geändert durch Artikel 30 des Gesetzes vom 9. September 2001 (BGBl. I 2001, Nr. 47, S. 2331)
in Kraft für Deutschland seit 1. Januar 1976 (BGBl. II 1976, Nr. 12, S. 308)
Gesetz dazu vom 21. Mai 1985 (BGBl. II 1985, Nr. 19, S. 690)
in Kraft für Deutschland seit 1. August 1991 (BGBl. II 1995, Nr. 24, S. 657)
Gesetz zum Protokoll 2004 mit amtlicher Übersetzung vom 29. August 2008 (BGBl. II 2008, Nr. 24, S. 902)
Hinweis: Im Brüsseler Zusatzübereinkommen verpflichten sich die Vertragsparteien, bei Schäden, die über den Haftungsbetrag des haftpflichtigen Inhabers der Kernanlage hinausgehen, weitere Entschädigungsbeträge aus öffentlichen Mitteln bereitzustellen. Dieses Übereinkommen gilt in der Bundesrepublik Deutschland nicht unmittelbar, sondern schafft nur völkerrechtliche Verpflichtungen zwischen den Vertragsstaaten.

1F Law of the European Union

Agreements, General Provisions

[1F-1] Vertrag vom 25. März 1957 zur Gründung der Europäischen Atomgemeinschaft **EURATOM** in der Fassung des Vertrages über die **Europäische Union** vom 7. Februar 1992, geändert durch den Beitrittsvertrag vom 24. Juni 1994 in der Fassung des Beschlusses vom 1. Januar 1995 (BGBl. II 1957, S. 753, 1014, 1678 – Artikel 2 bis 4 hiervon aufgehoben durch Artikel 67 des Gesetzes vom 8. Dezember 2010 (BGBl. I 2010, Nr. 63, S. 1864); BGBl. II 1992, S. 1251, 1286; BGBl. II 1993, S. 1947; BGBl. II 1994, S. 2022; ABl. 1995, L 1)
Der Vertrag ist in seiner ursprünglichen Fassung am 1. Januar 1958 in Kraft getreten (BGBl. II 1958 S. 1), die Neufassung trat am 1. November 1993 in Kraft (BGBl. 1993 II S. 1947), Berichtigung der Übersetzung des EURATOM-Vertrages vom 13. Oktober 1999 (BGBl. II 1999, Nr. 31)

[1F-5] Richtlinie 2009/71/EURATOM des Rates vom 25. Juni 2009 über einen Gemeinschaftsrahmen für die nukleare Sicherheit kerntechnischer Anlagen (ABl. 2009 L172)

[1F-12] Richtlinie 85/337/EWG des Rates vom 27. Juni 1985 über die Umweltverträglichkeitsprüfung bei bestimmten öffentlichen und privaten Projekten (ABl. EG 1985, Nr. L175), zuletzt geändert durch die Richtlinie 2009/31/EG des EP und des Rates vom 23. April 2009 (ABl. 2009, L 140), letzte konsolidierte Fassung 2009
Hinweis: Umsetzung vgl. UVP-Gesetz

[1F-13] Richtlinie 97/11/EG des Rates vom 3. März 1997 zur Änderung der Richtlinie 85/337/EWG über die Umweltverträglichkeitsprüfung bei bestimmten öffentlichen und privaten Projekten (ABl. EG 1997, Nr. L73)
„UVP-Änderungsrichtlinie", derzeit in der Umsetzung

Radiation Protection

[1F-18] Richtlinien des Rates, mit denen die Grundnormen für den Gesundheitsschutz der Bevölkerung und der Arbeitskräfte gegen die Gefahren ionisierender Strahlungen festgelegt wurden (EURATOM-Grundnormen)

- Richtlinie vom 2. Februar 1959 (ABl. EG 1959, Nr. 11),
- Richtlinie vom 5. März 1962 (ABl. EG 1962, S. 1633/62),
- Richtlinie 66/45/EURATOM (ABl. EG 1966, Nr. 216),
- Richtlinie 76/579/EURATOM vom 1. Juni 1976 (ABl. EG 1976, Nr. L187),
- Richtlinie 79/343/EURATOM vom 27. März 1977 (ABl. EG 1979, Nr. L83),
- Richtlinie 80/836/EURATOM vom 15. Juli 1980 (ABl. EG 1980, Nr. L246),
- Richtlinie 84/467/EURATOM vom 3. September 1984 (ABl. EG 1984, Nr. L265),
- Neufassung mit Berücksichtigung der ICRP 60 in Richtlinie 96/29/EURATOM vom 13. Mai 1996 (ABl. EG 1996, Nr. L159)

[1F-20] Richtlinie 90/641/EURATOM des Rates vom 4. Dezember 1990 über den Schutz externer Arbeitskräfte, die einer Gefährdung durch ionisierende Strahlung bei Einsatz im Kontrollbereich ausgesetzt sind (ABl. EG 1990, Nr. L349)

[1F-22] Richtlinie 2003/122/EURATOM des Rates vom 22. Dezember 2003 zur Kontrolle hoch radioaktiver umschlossener Strahlenquellen und herrenloser Strahlenquellen (ABl. 2003, Nr. L346 vom 31. Dezember 2003 S. 57-66)
Hinweise: Ausgenommen sind Tätigkeiten, die unter den EURATOM-Vertrag oder eines der speziellen Nuklearhaftungsregime fallen. Die Richtlinie 2003/122/EURATOM wird mit Wirkung zum 6. Februar 2018 aufgehoben durch die Richtlinie 2013/59/EURATOM.

[1F-23] Richtlinie 97/43/EURATOM des Rates vom 30. Juni 1997 über den Gesundheitsschutz von Personen gegen die Gefahren ionisierender Strahlung bei medizinischer Exposition und zur Aufhebung der Richtlinie 84/466/EURATOM (ABl. 1997, L180)

[1F-24] Richtlinie 2013/59/EURATOM des Rates vom 5. Dezember 2013 zur Festlegung grundlegender Sicherheitsnormen für den Schutz vor den Gefahren einer Exposition gegenüber ionisierender Strahlung und zur Aufhebung der Richtlinien 89/618/EURATOM, 90/641/EURATOM, 96/29/EURATOM, 97/43/EURATOM und 2003/122/EURATOM (ABl. 2014, L13)

Radiological Emergencies

[1F-29] Richtlinie 89/618/EURATOM des Rates vom 27. November 1989 über die Unterrichtung der Bevölkerung über die bei einer radiologischen Notstandssituation geltenden Verhaltensmaßregeln und zu ergreifenden Gesundheitsschutzmaßnahmen (ABl. EG 1989, Nr. L357)

- Mitteilung der Kommission betreffend die Durchführung der Richtlinie 89/618/EURATOM (ABl. EG 1991, Nr. C103)

Waste, Hazardous Materials

[1F-34] Verordnung (EURATOM) 1493/93 des Rates vom 8. Juni 1993 über die Verbringung radioaktiver Stoffe zwischen den Mitgliedstaaten (ABl. EG 1993, Nr. L148),

- Mitteilung der Kommission vom 10. Dezember 1993 zu der Verordnung EURATOM/1493/93 (ABl. EG 1993, Nr. C335)

[1F-35] Richtlinie 2006/117/EURATOM des Rates vom 20. November 2006 über die Überwachung und Kontrolle der Verbringungen radioaktiver Abfälle und abgebrannter Brennelemente (ABl. Nr. L337 vom 5. Dezember 2006, S. 21)

[1F-36] Richtlinie 2011/70/EURATOM des Rates vom 19. Juli 2011 über einen Gemeinschaftsrahmen für die verantwortungsvolle und sichere Entsorgung abgebrannter Brennelemente und radioaktiver Abfälle (ABl. Nr. L199 vom 2. August 2001, S. 48)

2 General Administrative Provisions

[2-1] Allgemeine Verwaltungsvorschrift zu § 47 Strahlenschutzverordnung (Ermittlung der Strahlenexposition durch die Ableitung radioaktiver Stoffe aus Anlagen oder Einrichtungen) vom 28. August 2012 (BAnz AT 05.09.2012 B1)

[2-2] Allgemeine Verwaltungsvorschrift zu § 40 Abs. 2, § 95 Abs. 3 StrlSchV und § 35 Abs. 2 RöV (AVV Strahlenpass) vom 20. Juli 2004 (BAnz. 2004, Nr. 142a)

[2-3] Allgemeine Verwaltungsvorschrift zur Ausführung des Gesetzes über die Umweltverträglichkeitsprüfung (UVPVwV) vom 18. September 1995 (GMBl. 1995, Nr. 32, S. 671)

[2-4] Allgemeine Verwaltungsvorschrift zum Integrierten Mess- und Informationssystem zur Überwachung der Radioaktivität in der Umwelt nach dem Strahlenschutzvorsorgegesetz (AVV-IMIS) vom 13. Dezember 2006 (BAnz. 2006, Nr. 244a)

[2-5] Allgemeine Verwaltungsvorschrift zur Durchführung der Überwachung von Lebensmitteln nach der Verordnung (EURATOM) Nr. 3954/87 des Rates vom 22. Dezember 1987 zur Festlegung von Höchstwerten an Radioaktivität in Nahrungsmitteln und Futtermitteln im Falle eines nuklearen Unfalls oder einer anderen radiologischen Notstandssituation (AVV-Strahlenschutzvorsorge-Lebensmittelüberwachung – AW-StrahLe) vom 28. Juni 2000 (GMBl. 2000, Nr. 25, S. 490)

[2-6] Allgemeine Verwaltungsvorschrift zur Überwachung der Höchstwerte für Futtermittel nach der Verordnung (EURATOM) Nr. 3954/87 des Rates vom 22. Dezember 1987 zur Festlegung von Höchstwerten an Radioaktivität in Nahrungsmitteln und Futtermitteln im Falle eines nuklearen Unfalls oder einer anderen radiologischen Notstandssituation (Futtermittel-Strahlenschutzvorsorge-Verwaltungsvorschrift – FMStrVVwV) vom 22. Juni 2000 (BAnz. 2000, Nr. 122)

3 Announcements by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety and the Federal Ministry for the Interior (Extract)

[3-0-1] Sicherheitsanforderungen an Kernkraftwerke vom 22. November 2012 (BAnz. AT 24.01.2013 B3)

[3-0-2] Interpretationen zu den Sicherheitsanforderungen an Kernkraftwerke vom 29. November 2013 (BAnz AT 10.12.2013 B4)

[3-2] Richtlinie für den Fachkundenachweis von Kernkraftwerkspersonal vom 24. Mai

2012 (GMBl. 2012, Nr. 34, S. 611)

[3-13] Sicherheitskriterien für die Endlagerung radioaktiver Abfälle in einem Bergwerk vom 20. April 1983 (GMBl. 1983, Nr. 13, S. 220), in Überarbeitung

[3-15] 1. Rahmenempfehlungen für den Katastrophenschutz in der Umgebung kerntechnischer Anlagen vom 27. Oktober 2008 (GMBl. 2008, Nr. 62/63, S. 1278)
2. Radiologische Grundlagen für Entscheidungen über Maßnahmen zum Schutz der Bevölkerung bei unfallbedingten Freisetzungen von Radionukliden vom 27. Oktober 2008 (GMBl. 2008, Nr. 62/63, S. 1278) mit der Anlage „Verwendung von Jodtabletten zur Jodblockade der Schilddrüse bei einem kerntechnischen Unfall“

[3-23] Richtlinie zur Emissions- und Immissionsüberwachung kerntechnischer Anlagen (REI) vom 7. Dezember 2005 (GMBl. 2006, Nr. 14-17, S. 254)

[3-27] Richtlinie über die Gewährleistung der notwendigen Kenntnisse der beim Betrieb von Kernkraftwerken sonst tätigen Personen vom 30. November 2000 (GMBl. 2001, Nr. 8, S. 153)

[3-33-2] Störfallberechnungsgrundlagen für die Leitlinien zur Beurteilung der Auslegung von Kernkraftwerken mit DWR gemäß § 28 Abs. 3 StrlSchV vom 18. Oktober 1983 (BAnz. 1983, Nr. 245a), Fassung des Kapitels 4 „Berechnung der Strahlenexposition“ vom 29. Juni 1994 (BAnz. 1994, Nr. 222a), Neufassung des Kapitels 4 „Berechnung der Strahlenexposition" gemäß § 49 StrlSchV vom 20. Juli 2001 verabschiedet auf der 186. Sitzung der Strahlenschutzkommission am 11. September 2003, veröffentlicht in der Reihe „Berichte der Strahlenschutz-kommission", Heft 44, 2004

[3-34] Rahmenrichtlinie über die Gestaltung von Sachverständigengutachten in atomrechtlichen Verwaltungsverfahren vom 15. Dezember 1983 (GMBl. 1984, Nr. 2, S. 21)

[3-40] Richtlinie über die im Strahlenschutz erforderliche Fachkunde (Fachkunderichtlinie Technik nach StrlSchV) vom 21. Juni 2004 (GMBl. 2004, Nr. 40/41, S. 779), Änderung vom 19. April 2006 (GMBl. 2006, Nr. 38, S. 735)

[3-42-1] Richtlinie für die physikalische Strahlenschutzkontrolle zur Ermittlung der Körperdosen
Teil 1: Ermittlung der Körperdosis bei äußerer Strahlenexposition (§§ 40, 41, 42 StrlSchV; §§ 35 RöV) vom 8.°Dezember 2003 (GMBl. 2004, Nr. 22, S. 410)

[3-42-2] Richtlinie für die physikalische Strahlenschutzkontrolle zur Ermittlung der Körperdosen
Teil 2: Ermittlung der Körperdosis bei innerer Strahlenexposition (Inkorporations-überwachung) (§§ 40, 41 und 42 StrlSchV) vom 12. Januar 2007 (GMBl. 2007, Nr. 31/32, S. 623), Anhänge 1 bis 6, Anhang 7.1, Anhang 7.2, Anhang 7.3, Anhang 7.4
Hinweis: hiermit wird die Richtlinie über Anforderungen an Inkorporationsmeßstellen vom 30. September 1996 (GMBl. 1996, Nr. 46, S. 996) aufgehoben und ersetzt.

[3-43-2] Richtlinie für den Strahlenschutz des Personals bei Tätigkeiten der Instandhaltung, Änderung, Entsorgung und des Abbaus in kerntechnischen Anlagen und Einrichtungen:
Teil 2: Die Strahlenschutzmaßnahmen während des Betriebs und der Stilllegung einer Anlage oder Einrichtung – IWRS II vom 17. Januar 2005 (GMBl. 2005, Nr. 13, S. 258)

[3-59] Richtlinie zur Kontrolle radioaktiver Abfälle mit vernachlässigbarer Wärmeentwicklung, die nicht an eine Landessammelstelle abgeliefert werden (Abfallkontrollrichtlinie) vom 16. Januar 1989 (BAnz. 1989, Nr. 63a), letzte Ergänzung vom 14. Januar 1994 (BAnz. 1994, Nr. 19)
Hinweis: Inhaltlich ersetzt durch Richtlinie zur Kontrolle radioaktiver Reststoffe und radioaktiver Abfälle vom 19. November 2008 [vgl. 3-60], aber offiziell nicht zurückgezogen

[3-60] Richtlinie zur Kontrolle radioaktiver Reststoffe und radioaktiver Abfälle vom 19. November 2008 (BAnz. 2008, Nr. 197)

[3-62] Richtlinie über Maßnahmen für den Schutz von Anlagen des Kernbrennstoffkreislaufs und sonstigen kerntechnischen Einrichtungen gegen Störmaßnahmen oder sonstige Einwirkungen zugangsberechtigter Einzelpersonen vom 28. Januar 1991 (GMBl. 1991, Nr. 9, S. 228)

[3-73] Leitfaden zur Stilllegung, zum sicheren Einschluß und zum Abbau von Anlagen oder Anlagenteilen nach § 7 des Atomgesetzes vom 26. Juni 2009 (BAnz. 2009, Nr. 162a)

4 Recommendations of the RSK, SSK und ESK

[4-2] Leitlinien für die trockene Zwischenlagerung bestrahlter Brennelemente und Wärme entwickelnder radioaktiver Abfälle in Behältern, Empfehlung der ESK, revidierte Fassung vom 10.06.2013 [DEU] [ENG]

[4-3] ESK-Leitlinien für die Zwischenlagerung von radioaktiven Abfällen mit vernachlässigbarer Wärmeentwicklung, revidierte Fassung vom 10.06.2013 [DEU]

[4-4] Leitlinien zur Stilllegung kerntechnischer Anlagen, Empfehlung der ESK, Anlage zum Ergebnisprotokoll der 13. Sitzung der Entsorgungskommission am 9. September 2010 (BAnz. 2010, Nr. 187) [DEU]

[4-5] ESK-Empfehlungen für Leitlinien zur Durchführung von periodischen Sicherheitsüberprüfungen für Zwischenlager für bestrahlte Brennelemente und Wärme entwickelnde radioaktive Abfälle (PSÜ-ZL), Anlage zum Ergebnisprotokoll der 14. Sitzung der Entsorgungskommission am 4. November 2010 [DEU] [ENG]

[4-5a] ESK-Leitlinien zur Durchführung von periodischen Sicherheitsüberprüfungen und zum technischen Alterungsmanagement für Zwischenlager für bestrahlte Brennelemente und Wärme entwickelnde radioaktive Abfälle, Empfehlung der Entsorgungskommission vom 13.03.2014 [DEU]

[4-7] Anforderungen an bestrahlte Brennelemente aus entsorgungstechnischer Sicht, ESK-Stellungnahme vom 27.05.2011 [DEU] [ENG]

[4-10a] Drohende Gefährdung der kerntechnischen Sicherheit durch Know-how- und Motivationsverlust, RSK-Memorandum vom 12.07.2012 [DEU]

[4-11] ESK-Stresstest für Anlagen und Einrichtungen der Ver- und Entsorgung in Deutschland,
Teil 1: Anlagen der Brennstoffversorgung, Zwischenlager für bestrahlte Brennelemente und Wärme entwickelnde radioaktive Abfälle, Anlagen zur Behandlung bestrahlter Brennelemente
Stellungnahme der Entsorgungskommission vom 14.03.2013 [DEU] [ENG]
Teil 2: Lager für schwach- und mittelradioaktive Abfälle, stationäre Einrichtungen zur Konditionierung schwach- und mittelradioaktiver Abfälle, Endlager für radioaktive Abfälle
Stellungnahme der Entsorgungskommission vom 18.10.2013 (revidierte Fassung) [DEU]

[4-11a] Langzeitsicherheitsnachweis für das Endlager für radioaktive Abfälle Morsleben (ERAM)

Stellungnahme der Entsorgungskommission vom 31.01.2013 [DEU]

[4-11b] Radiologische Anforderungen an die Langzeitsicherheit des Endlagers für radioaktive Abfälle Morsleben (ERAM)
Empfehlung der SSK vom 15.12.2010 [DEU]

5 Safety Standards of the Nuclear Safety Standards Commission (KTA)

Safety Stand-ardNo. KTA	Title	Last version	Published in the Federal Gazette No. – Date	Former versions	Confirmation of continuing validity
1000 KTA internal rules of procedure					
1100 Terms and definitions					
	KTA Collection of Definitions (available in German only)	01/13	-	06/91 01/96 01/04 01/06	-
1200 General, administration, organisation					
1201*	Requirements for the Operating Manual	11/09	3 a – 07.01.10	02/78 03/81 12/85 06/98	
1202*	Requirements for the Testing Manual	11/09	3 a – 07.01.10	06/84	-
1203*	Requirements for the Emergency Manual	11/09	3 a – 07.01.10	-	-
1300 Occupational radiological protection					
1301.1	Radiation Protection Considerations for Plant Personnel in the Design and Operation of Nuclear Power Plants; Part 1: Design	11/12	23.01.13	11/84	-
1301.2*	Radiation Protection Considerations for Plant Personnel in the Design and Operation of Nuclear Power Plants; Part 2: Operation	11/08	15 a – 29.01.09	06/82 06/89	-
1400 Quality assurance					
1401*	General Requirements Regarding Quality Assurance	11/13	17.01.14	02/80 12/87 06/96	-
1402*	Integrated Management Systems for the Safe Operation of Nuclear Power Plants	11/12	23.01.13	06/89	-
1403*	Ageing Management in Nuclear Power Plants	11/10	199 a – 30.12.10	06/89	-
1404*	Documentation During the Construction and Operation of Nuclear Power Plants	11/13	17.01.14	06/89 06/01	-
1408.1*	Quality Assurance for Weld Filler Materials and Welding Consumables for Pressure and Activity Retaining Systems in Nuclear Power Plants; Part 1: Qualification Testing	11/08	15 a – 29.01.09	06/85	-

Safety Stand-ardNo. KTA	Title	Last version	Published in the Federal Gazette No. – Date	Former versions	Confirmation of continuing validity
1408.2*	Quality Assurance for Weld Filler Materials and Welding Consumables for Pressure and Activity Retaining Systems in Nuclear Power Plants; Part 2: Manufacture	11/08	15 a – 29.01.09	06/85	-
1408.3*	Quality Assurance for Weld Filler Materials and Welding Consumables for Pressure and Activity Retaining Systems in Nuclear Power Plants; Part 3: Processing	11/08	15 a – 29.01.09	06/85	-
1500 Radiation protection and monitoring					
1501	Stationary System for Monitoring the Local Dose Rate within Nuclear Power Plants	11/10	199 a – 30.12.10	10/77 06/91 11/04	-
1502*	Volumetric Activity of Radioactive Substances in the Inner Atmosphere of Nuclear Power Plants	11/13	17.01.14	06/86 (1502.1) 11/05	-
1503.1*	Monitoring the Discharge of Radioactive Gases and Airborne Radioactive Particulates; Part 1: Monitoring the Discharge of Radioactive Matter with the Stack Exhaust Air During Specified Normal Operation	11/13	17.01.14	02/79 06/93 06/02	-
1503.2*	Monitoring the Discharge of Radioactive Gases and Airborne Radioactive Particulates; Part 2: Monitoring the Discharge of Radioactive Matter with the Stack Exhaust Air During Design-Basis Accidents	11/13	17.01.14	06/99	-
1503.3*	Monitoring the Discharge of Radioactive Gases and Airborne Radioactive Particulates; Part 3: Monitoring the Non-stack Discharge of Radioactive Matter	11/13	17.01.14	06/99	-
1504	Monitoring and Assessing of the Discharge of Radioactive Substances in Liquid Effluents	11/07	9 a – 17.01.08	06/78 06/94	-
1505	Suitability Verification of the Stationary Measurement Equipment for Radiation Monitoring	11/11	11 – 19.01.12	11/03	-
1507	Monitoring the Discharge of Radioactive Substances from Research Reactors	11/12	23.01.13	03/84 06/98	-
1508	Instrumentation for Determining the Dispersion of Radioactive Substances in the Atmosphere	11/06	245b – 30.12.06	09/88	-

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2100 Overall plant					
2101.1	Fire Protection in Nuclear Power Plants; Part 1: Basic Requirements	12/00	106 a – 09.06.01	12/85	22.11.05
2101.2	Fire Protection in Nuclear Power Plants; Part 2: Fire Protection of Structural Components	12/00	106 a – 09.06.01 Berichtigung 239 – 21.12.07	-	22.11.05
2101.3	Fire Protection in Nuclear Power Plants; Part 3: Fire Protection of Mechanical and Electrical Components	12/00	106 a – 09.06.01	-	22.11.05
2103	Explosion Protection in Nuclear Power Plants with Light Water Reactors (General and Case-Specific Requirements)	06/00	231 a – 08.12.00	06/89	22.11.05
2200 External hazards					
2201.1*	Design of Nuclear Power Plants against Seismic Events; Part 1: Principles	11/11	11 – 19.01.12	06/75 06/90	-
2201.2*	Design of Nuclear Power Plants against Seismic Events; Part 2: Subsoil	11/12	23.01.13	11/82 06/90	-
2201.3*	Design of Nuclear Power Plants against Seismic Events; Part 3: Structural Components (available in German only)	11/13	17.01.14	-	-
2201.4*	Design of Nuclear Power Plants against Seismic Events; Part 4: Components	11/12	23.01.13	06/90	-
2201.5*	Design of Nuclear Power Plants against Seismic Events; Part 5: Seismic Instrumentation	06/96	216 a – 19.11.96	06/77 06/90	07.11.06
2201.6*	Design of Nuclear Power Plants against Seismic Events; Part 6: Post-Seismic Measures	06/92	36 a – 23.02.93	-	18.06.02
2206*	Design of Nuclear Power Plants Against Damaging Effects from Lightning	11/09	3 a – 07.01.10	06/92 06/00	-
2207	Flood Protection for Nuclear Power Plants	11/04	35 a – 19.02.05	06/82 06/92	10.11.09
2500 Structural engineering					

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2501	Structural Waterproofing of Nuclear Power Plants	11/10	72 a – 11.05.11	09/88 06/02 11/04	-
2502*	Mechanical Design of Fuel Assembly Storage Pools in Nuclear Power Plants with Light Water Reactors	11/11	11 – 19.01.12	06/90	-
3000 Systems in general **3100 Reactor core and reactor control**					
3101.1*	Design of Reactor Cores of Pressurized Water and Boiling Water Reactors; Part 1: Principles of Thermohydraulic Design	11/12	23.01.13	02/80	-
3101.2*	Design of Reactor Cores of Pressurized Water and Boiling Water Reactors; Part 2: Neutron-Physical Require-ments for Design and Operation of the Reactor Core and Adjacent Systems	11/12	23.01.13	12/87	-
3103*	Shutdown Systems for Light Water Reactors	11/12	03.12.12	03/84	15.06.99
3104	Determination of the Shutdown Reactivity	10/79	19 a – 29.01.80 Beilage 1/80	-	10.11.09
3107	Nuclear Criticality Safety Require-ments during Refuelling (available in German only)	11/12	03.12.12	-	-
3200 Primary and secondary coolant circuit					
3201.1	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 1: Materials and Product Forms	06/98	170 a – 11.09.98	02/79 11/82 06/90	11.11.03
3201.2*	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 2: Design and Analysis (available in German only)	11/13	17.01.14	10/80 03/84 06/96	-
3201.3	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 3: Manufacture	11/07	9 a – 17.01.08 Berichtigung 82 a – 05.06.09	10/79 12/87 06/98	-

Safety Stand-ardNo. KTA	Title	Last version	Published in the Federal Gazette No. – Date	Former versions	Confirmation of continuing validity
3201.4*	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 4: Inservice Inspections and Operational Monitoring	11/10	199 a – 30.12.10	06/82; 06/90 06/99	-
3203	Surveillance of the Irradiation Behaviour of Reactor Pressure Vessel Materials of LWR Facilities	06/01	235 b – 15.12.01	03/84	07.11.06
3204*	Reactor Pressure Vessel Internals	11/08	15 a – 29.01.09	03/84 06/98	-
3205.1	Component Support Structures with Non-integral Connections; Part 1: Component Support Structures with Non-integral Connections for Components of the Reactor Coolant Pressure Boundary of Light Water Reactors	06/02	189 a – 10.10.02	06/82 06/91	13.11.07
3205.2*	Component Support Structures with Non-integral Connections; Part 2: Component Support Structures with Non-Integral Connections for Pressure and Activity-Retaining Components in Systems Outside the Primary Circuit	06/90	41 a – 28.02.91	-	20.06.00
3205.3	Component Support Structures with Non-integral Connections; Part 3: Series-Production Standard Supports	11/06	163 – 31.08.07	06/89	-
3211.1*	Pressure and Activity Retaining Components of Systems Outside the Primary Circuit; Part 1: Materials	06/00	194 a – 14.10.00 Berichtigung 132 - 19.07.01	06/91	-
3211.2*	Pressure and Activity Retaining Components of Systems Outside the Primary Circuit; Part 2: Design and Analysis (available in German only)	11/13	17.01.14	06/92	-
3211.3	Pressure and Activity Retaining Components of Systems Outside the Primary Circuit; Part 3: Manufacture	11/12	02.05.13 (nach Absch. 5.3 Verf.O)	06/90 11/03	-
3211.4*	Pressure and Activity Retaining Components of Systems Outside the Primary Circuit; Part 4: Inservice Inspections and Operational Monitoring (available in German only)	11/13	29.04.14	06/96 11/12	-

Safety Stand-ardNo. KTA	Title	Last version	Published in the Federal Gazette No. – Date	Former versions	Confirmation of continuing validity
3300 Heat removal					
3301*	Residual Heat Removal Systems of Light Water Reactors 2)	11/84	40 a – 27.02.85	-	15.06.99 1)
3303*	Heat Removal Systems for Fuel Assembly Storage Pools in Nuclear Power Plants with Light Water Reactors	06/90	41 a – 28.02.91	-	20.06.00
3400 Reactor containment					
3401.1*	Steel Containment Vessels; Part 1: Materials	09/88	37 a – 22.02.89	06/80 11/82	16.06.98
3401.2	Steel Containment Vessels; Part 2: Analysis and Design	06/85	203 a – 29.10.85	06/80	22.11.05
3401.3*	Steel Reactor Safety Containment; Part 3: Manufacture	11/86	44 a – 05.03.87	10/79	10.06.97
3401.4	Steel Containment Vessels; Part 4: Inservice Inspections	06/91	7 a – 11.01.92	03/81	07.11.06
3402	Airlocks on the Reactor Containment of Nuclear Power Plants - Personnel Airlocks	11/09	72 a – 12.05.10	11/76	-
3403*	Cable Penetrations through the Reactor Containment Vessel	11/10	199 a – 30.12.10	11/76 10/80	-
3404	Isolation of Operating System Pipes Penetrating the Containment Vessel in the Case of a Release of Radioactive Substances into the Containment Vessel of Nuclear Power Plants	11/13	29.04.14	09/88 11/08	-
3405*	Leakage Test of the Containment Vessel	11/10	199 a – 30.12.10	02/79	-
3407	Pipe Penetrations through the Reactor Containment Vessel	06/91	113 a – 23.06.92	-	07.11.06
3409	Airlocks on the Reactor Containment of Nuclear Power Plants - Equipment airlocks	11/09	72 a – 12.05.10	06/79	-
3413	Determination of Loads for the Design of a Full Pressure Containment Vessel against Plant-Internal Incidents	06/89	229 a – 07.12.89	-	10.11.09
3500 Reactor protection system					
3501*	Reactor Protection System and Monitoring Equipment of the Safety System	06/85	203 a – 29.10.85	03/77	20.06.00

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3502	Accident Measuring Systems	11/12	23.01.13	11/82 11/84 06/99	-
3503	Type Testing of Electrical Modules for the Safety Related Instrumentation and Control System	11/05	101 a – 31.05.06	06/82 11/86	-
3504	Electrical Drive Mechanisms of the Safety System in Nuclear Power Plants	11/06	245 b – 30.12.06	09/88	15.11.11
3505	Type Testing of Measuring Sensors and Transducers of the Safety-Related Instrumentation and Control System	11/05	101 a – 31.05.06	11/84	-
3506*	System Testing of the Instrumentation and Control Equipment Important to Safety of Nuclear Power Plants	11/12	23.01.13	11/84	-
3507*	Factory Tests, Post-repair Tests and Certification of Satisfactory Performance in Service of Modules and Devices for the Instrumentation and Controls of the Safety System	06/02	27 a – 08.02.03	11/86	-
3600 Activity control					
3601	Ventilation Systems in Nuclear Power Plants	11/05	101 a – 31.05.06	06/90	16.11.10
3602	Storage and Handling of Fuel Assemblies and Associated Items in Nuclear Power Plants with Light Water Reactors	11/03	26 a – 07.02.04	06/82 06/84 06/90	11.11.08
3603*	Facilities for Treating Radioactively Contaminated Water in Nuclear Power Plants	11/09	3 a – 07.01.10	02/80 06/91	
3604	Storage, Handling and Plant-internal Transport of Radioactive Substances in Nuclear Power Plants (with the Exception of Fuel Assemblies)	11/05	101 a – 31.05.06	06/83	16.11.10
3605	Treatment of Radioactively Contaminated Gases in Nuclear Power Plants with Light Water Reactors	11/12	23.01.13	06/89	-
3700 Power and media supply					
3701	General Requirements for the Electrical Power Supply in Nuclear Power Plants	11/12	03.12.12	3701.1: (06/78) 3701.2 (06/82) 06/97 06/99	16.11.04

Safety Stand-ardNo. KTA	Title	Last version	Published in the Federal Gazette No. – Date	Former versions	Confirmation of continuing validity
3702	Emergency Power Generating Facilities with Diesel-Generator Units in Nuclear Power Plants	06/00	159 a – 24.08.00	3702.1 (06/80) 3702.2 (06/91)	22.11.05
3703	Emergency Power Facilities with Batteries and AC/DC Converters in Nuclear Power Plants (available in German only)	11/12	23.01.13	06/86 06/99	-
3704	Emergency Power Facilities with Static and Rotating AC/DC Converters in Nuclear Power Plants (available in German only)	11/13	17.01.14	06/84 06/99	-
3705	Switchgear Facilities, Transformers and Distribution Networks for the Electrical Power Supply of the Safety System in Nuclear Power Plants (available in German only)	11/13	29.04.14	09/88 06/99 11/06	-
3706	Ensuring the Loss-of-Coolant-Accident Resistance of Electrotech-nical Components and of Components in the Instrumentation and Controls of Operating Nuclear Power Plants	06/00	159 a – 24.08.00	-	16.11.10
3900 Other systems					
3901	Communication Means for Nuclear Power Plants (available in German only)	11/13	17.01.14	03/77 03/81 11/04	-
3902*	Design of Lifting Equipment in Nuclear Power Plants	11/12	23.01.13 Berichtigung 02.05.13	11/75 06/78 11/83 06/92 06/99	-
3903*	Inspection, Testing and Operation of Lifting Equipment in Nuclear Power Plants	11/12	23.01.13 Berichtigung 02.05.13	11/82 06/93 06/99	-
3904	Control Room, Remote Shutdown Station and Local Control Stations in Nuclear Power Plants	11/07	9 a – 17.01.08	09/88	-
3905*	Load Attaching Points on Loads in Nuclear Power Plants	11/12	23.01.13	06/94 06/99	-

* Revision of an existing KTA rule.

( ) High-temperature reactor (HTR) related rule which is no longer included in the reaffirmation process according to Section 5.2 of the procedural statutes and no longer obtainable via the Carl Heymanns Verlag KG.

1) In its 43th session held on 27 June 1989, the KTA approved “Notes for the user of KTA 3301 (11/84)”.

2) In this rule, the high-temperature reactor (HTR) related requirements were deleted.

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Additional report concerning the remediation of the Wismut GmbH

WISMUT Annex

to the

Report of the Federal Republic of Germany for the Fifth Review Meeting of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (IAEA Joint Convention), May 2015

1 The WISMUT remediation project: starting point and scope

Since 1991, the state-owned Wismut GmbH company has been cleaning up the legacies from the former uranium ore mining activities of what used to be the Soviet-German Joint-Stock Company (*Sowjetisch-Deutsche Aktiengesellschaft* – SDAG*)* Wismut. From 1946 until the end of 1990, the latter extracted a total of 231,000 Mg of uranium in eastern Germany making it the then biggest uranium producer of its time worldwide. Among the legacies of the SDAG Wismut were 32 km² of facility areas, five uranium mines with a total of approx. 1,500 km of open-cast mine workings, an abandoned open-cast mine with an open volume of 84 million m³, 48 heaps with a volume of low-active rocks of approx. 311 million m³, four tailings ponds holding a total of 160 million m³ of radioactive sludge, and two processing factories for uranium ore.

The locations embraced by the WISMUT remediation project span from Königstein in eastern Saxony to Dresden-Gittersee, Schlema-Alberoda and Pöhla up to Crossen in western Saxony. In Thuringia, they include the Ronneburg and Seelingstädt sites. Details about the situation after uranium ore exploitation in Saxony and Thuringia was abandoned, the dimension of the WISMUT project, the legal basis of the project regarding radiation protection, and the remediation technologies have already been described comprehensively in the reports to the previous Review Meetings.

2 Status of remediation

Remediation of the legacies of uranium ore mining at the WISMUT sites was continued successfully during the review period. By the end of 2013, approx. € 5.8 billion (82 %) of the funds provided by the Federal Republic of Germany for the entire project, which amount to about € 7.1 billion, had been used up.

<u>Underground remediation</u>

Underground remediation has almost been concluded. After withdrawal from the pits in Ronneburg and Pöhla was ended in in 2000 and 2007, respectively, withdrawal from the Königstein pit was also completed in April 2013 when shafts 388 and 390 were fully backfilled. Underground work is still outstanding in the pits at Dresden-Gittersee and Schlema-Alberoda. The activities focus on the workover for the creation of pathways for the directed drainage of mine waters.

A tunnel for draining the mine waters of the WISMUT Dresden-Gittersee mine was successfully driven for a length of 3,212 m (including the access ramp) (as at end of March 2014). This corresponds to approx. 99 % of the total length of 3,258 m to be driven. The work in the WISMUT gallery is expected to be concluded in 2014.

A bypass drift driven in the Schlema-Alberoda mine for the drainage tunnel that runs through geologically unstable rock has so far advanced for a length of 1,030 m (as at end of march 2014) (approx. 89 % of the total length of 1;155 m to be driven). Here, too, the work is planned to be completed in 2014. The conclusion of all underground work in this mine is scheduled for 2017.

Remediation of heaps

The heaps at the Dresden-Gittersee and Pöhla sites have been completely remediated. At Schlema-Alberoda, all heaps that are no longer managed are now remediated, with the exception of heaps 309 and 310. At the Ronneburg site, the relocation of the heaps to the abandoned open-cast mine at Lichtenberg has been concluded; approx. 96 % of the backfill volume are now covered.

The profiling and covering of heap 371 at the Schlema-Alberoda site and of the Schüsselgrund heap at the Königstein site was continued. During the course of the management of both heaps, residues from the treatment of contaminated mine, heap waters and leachate will continue to be emplaced for several decades to come. The areas needed for emplacement (approx. 5 % of the total area of heap 371; approx. 20 % of the total area of Schüsselgrund heap) will only be finally covered once water treatment at the sites has ceased. Current knowledge suggests that periods of more than 50 years can be expected in this respect.

Dismantling of facilities, area rehabilitation and remediation of the industrial tailing ponds

The two processing facilities at Crossen and Seelingstädt have in the meantime been fully dismantled, and the associated facility areas have been rehabilitated. Overall, area rehabilitation work has progressed during the review period. The same applies to the remediation of the industrial tailing ponds. Details about the progress made during the review period are given in Table 1.

Table 1: Selected figures showing the state of remediation: comparison of reporting to the Fourth Review Meeting (as at: end of 2010) with reporting to the Fifth Review Meeting (as at end of March 2014)

	End of 2010*		**End of 03/2014****	
	absolute	relative [1)]	absolute	relative [1)]
Abandoned mine workings	1,463 km	99 %	1,467 km	99 %
Rehabilitated shafts/entrances	1,386,000 m³	98 %	1,406,000 m³	99 %
Backfilled mine workings	229,881 m³	99 %	236,916 m³	99 %
Relocation of material to industrial tailings ponds [2)]	12.2 million m³	49 %	17.1 million m³	62 %
Final covering of the industrial tailings ponds	3.5 million m³	32 %	4.7 million m³	43 %
Material from decommissioning of facilities	957,000 m³	91 %	1,007,800 m³	86 %
Remediated facility areas	1,036 ha	72 %	1,135 ha	79 %

[1)] Related to overall WISMUT remediation
[2)] Tailings management areas
* Long-term planning 2007
** Long-term planning 2010

Flooding of the mines and water treatment

The state of flooding of the uranium mines of the WISMUT company still varies from mine to mine. At Pöhla, the natural filling level was already reached in 1995, and at Dresden-Gittersee flooding has also almost been completed. At the Königstein, Ronneburg and Schlema-Alberoda sites, intensive uplift and treatment of mine waters is still ongoing in order to be able to carry out a controlled flooding of the mines. At the same time, leachate from heaps is also treated in the on-site water treatment facilities. The water treatment facilities of the Seelingstädt and Crossen sites treat not only the surplus water but also the leachate and pore waters from industrial tailing ponds.

At Schlema-Alberoda, the large total volume of the water to be treated (in wet years from 750 m³/h up to 1,000 m³/h) and the high pollutant concentration in the residues of water treatment require considerable technical and financial efforts.

At Ronneburg, the capacity of the existing water treatment facility had to be increased to 750 m^3/h due to the high dynamics of the flooding water level rise and the associated spill-over at the surface. The extended facility has been operation in stable conditions since September 2011. This has helped lowering the groundwater level, and there is no longer any spill-over at the surface. Once the groundwater level has gone down further, WISMUT is planning an extension of local water catchment systems.

For the Königstein mine, in which uranium ore was leached underground, the flooding variant applied for by WISMUT – filling up to the natural final level at about 190 m sea level – was not approved by the competent authorities. WISMUT has appealed against this rejection but presently expects that the water level in the mine will have to be at a licensed level of 140 m sea level in the long run. This means that contaminated mine water will have to be uplifted and treated over a very long period of time.

3 Presentation of selected remediation results

In the report to the Fourth Review Meeting, the focus was mainly on the progress made in connection with improving the environmental situation (the positive development has been continuing during the current review period, too). In the report in hand, examples of the active subsequent use of remediated objects are to be at the centre of the presentation of selected remediation results.

Fig. 1: Deformation area Schlema (1993) during remediation and spa garden in the remediated deformation area including the Hammerberg heap (2012) (Copyright: WISMUT archives)

The remediated deformation area with the surrounding heap landscape is part of the parkland and recreation area close to the spa building complex. The municipality of Schlema has been an officially recognised spa town again since 2005.

Fig. 2: Reust heaps (Ronneburg site) before and after remediation, solar park at the former site of the heaps (Copyright: WISMUT archives)

Fig. 3: Abandoned open-cast mine Lichtenberg (1993) and backfilled volume at the site of the former open-cast mine (2013) (Copyright: WISMUT archives)

Fig. 4: Mine lamp on the plateau of the backfilled open-cast mine (Copyright: WISMUT archives)

The surface of the backfilled open-cast mine with the mine lamp erected on it in 2012 is part of a unique post-mine landscape that can be used for leisure activities (hiking, cycling) and which at the same time provides information about the past mining activities by various educational trails and exhibits.

4 Long-term tasks and prospect

The long-term tasks of WISMUT and their arrangement over time have already been described in detail in the reports to the Third and Fourth Review Meetings. Tasks that have already partly been initiated are i.a.:

- inspection, repair, maintenance and care of covers,
- treatment of flooding waters and leachate,
- stability of near-surface mine workings,
- mitigation of mining damage,
- long-term environmental monitoring, and
- preservation and maintenance of the documentation of remediation.

For the preservation of the know-how of the WISMUT remediation and the efficient continuation of the data and information management (i. a. within the framework of long-term monitoring and for institutional control in the long term), WISMUT established an internal data and information centre (*Daten- und Informationszentrum* – DIZ) in 2012.

A re-assessment of the remediation programme in 2015 is to specify once more the time and funds needed for the final remediation by WISMUT. From today's point of view, the core remediation process is to be concluded after 2020. Current planning of the long-term tasks extends to the year 2040.