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for the Environment, Nature Conservation
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in May 2021 on the fulfilment of the obligations of the

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

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AEG	Allgemeine Elektrizitäts-Gesellschaft *General electricity company*
AGO	Arbeitsgruppe Option – Rückholung *Working group option – retrieval*
AKR	Ausbildungskernreaktor *Training reactor*
AtAV	Atomrechtliche Abfallverbringungsverordnung *Nuclear Waste Shipment Ordinance*
AtDeckV	Atomrechtliche Deckungsvorsorge-Verordnung *Nuclear Financial Security Ordinance*
AtEV	Atomrechtliche Entsorgungsverordnung *Nuclear Waste Management Ordinance*
AtG	Atomgesetz *Atomic Energy Act*
AtSMV	Atomrechtliche Sicherheitsbeauftragten- und Meldeverordnung *Nuclear Safety Officer and Reporting Ordinance*
AtVfV	Atomrechtliche Verfahrensverordnung *Nuclear Licensing Procedure Ordinance*
AtZüV	Atomrechtliche Zuverlässigkeitsüberprüfungs-Verordnung *Nuclear Trustworthiness Verification Ordinance*
AVR	Arbeitsgemeinschaft Versuchsreaktor GmbH *Joint Working Group Experimental Reactor (now JEN)*
AVV	Allgemeine Verwaltungsvorschrift *General administrative provision*
AZA	Abfall-Zwischenlager Ahaus *Ahaus radioactive waste storage facility*
AZB	Abfall-Zwischenlager Biblis *Biblis radioactive waste storage facility*
AZG	Abfall-Zwischenlager Gorleben *Gorleben radioactive waste storage facility*
AZR	Abfall-Zwischenlager Grafenrheinfeld *Grafenrheinfeld radioactive waste storage facility*
AZK	Abfall-Zwischenlager Krümmel *Krümmel radioactive waste storage facility*
AZO	Abfall-Zwischenlager Obrigheim *Obrigheim radioactive waste storage facility*
AZP	Abfall-Zwischenlager Philippsburg *Phillipsburg radioactive waste storage facility*
AZS	Abfall-Zwischenlager Stade *Stade radioactive waste storage facility*
AZU	Abfall-Zwischenlager Unterweser *Unterweser radioactive waste storage facility*
AZW	Abfall-Zwischenlager Würgassen *Würgassen radioactive waste storage facility*

BAFA	Bundesamt für Wirtschaft und Ausfuhrkontrolle *Federal Office for Economic Affairs and Export Control*
BAM	Bundesanstalt für Materialforschung und –prüfung *Federal Institute for Materials Research and Testing*
BASE	Bundesamt für die Sicherheit der nuklearen Entsorgung *Federal Office for the Safety of Nuclear Waste Management (formerly BfE)*
BBergG	Bundesberggesetz *Federal Mining Act*
BBK	Bundesamt für Bevölkerungsschutz und Katastrophenhilfe *Federal Office for Civil Protection and Disaster Assistance*
BER II	Berliner Experimentier-Reaktor II *Berlin experimental reactor II*
BfE	Bundesamt für kerntechnische Entsorgungssicherheit *Federal Office for the Safety of Nuclear Waste Management (now BASE)*
BfS	Bundesamt für Strahlenschutz *Federal Office for Radiation Protection*
BGBl.	Bundesgesetzblatt *Federal Law Gazette*
BGE	Bundesgesellschaft für Endlagerung mbH *Federal Company for Radioactive Waste Disposal*
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe *Federal Institute for Geosciences and Natural Resources*
BGZ	BGZ Gesellschaft für Zwischenlagerung mbH *BGZ Company for Storage*
BLG	Brennelemente-Lager Gorleben GmbH *Spent fuel storage facility Gorleben*
BMBF	Bundesministerium für Bildung und Forschung *Federal Ministry of Education and Research*
BMU	Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety*
BMWi	Bundesministerium für Wirtschaft und Energie *Federal Ministry for Economic Affairs and Energy*
BNFL	British Nuclear Fuels plc
BWR	Boiling Water Reactor
BZA	Brennelement-Zwischenlager Ahaus GmbH *Ahaus spent fuel storage facility*
CASTOR	Cask for storage and transport of radioactive material
CEA	Commissariat à l'énergie atomique et aux énergies alternatives *French Alternative Energies and Atomic Energy Commission*
CNS	Convention on Nuclear Safety
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*
DAEF	Deutsche Arbeitsgemeinschaft Endlagerforschung *German Association for 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*
DDR	Deutsche Demokratische Republik *German Democratic Republic*
DIN	Deutsches Institut für Normung e. V. *German Institute for Standardization*
EB	Entsorgungsbetriebe der Kerntechnische Entsorgung Karlsruhe GmbH *Waste management facilities of the Kerntechnische Entsorgung Karlsruhe GmbH*
EIA	Environmental Impact Assessment
EndlagerVlV	Endlagervorausleistungsverordnung *Repository Prepayment Ordinance*
EndLaNOG	Gesetz zur Neuordnung der Organisationsstruktur im Bereich der Endlage-rung
EntsorgFondsG	Entsorgungsfondsgesetz *Waste Management Fund Act*
EntsorgÜG	Entsorgungsübergangsgesetz *Waste Management Transfer Act*
ERAM	Endlager für radioaktive Abfälle Morsleben *Morsleben repository for radioactive waste*
ESK	Entsorgungskommission *Nuclear Waste Management Commission*
ESTRAL	Ersatztransportbehälterlager
EU	European Union
EURATOM	European Atomic Energy Community
EUROCHEMIC	European Company for the Chemical Processing of Irradiated Fuels
EVU	Energieversorgungsunternehmen *Electric power utility/utilities Electric power utility/utilities*
EW	Exempt Waste
EWN	EWN Entsorgungswerk für Nuklearanlagen GmbH *(formerly Energiewerke Nord GmbH)*
FA/FAs	Fuel Assembly/Fuel Assemblies
FINAS	Fuel Incident Notification and Analysis System
FMRB	Forschungs- und Messreaktor Braunschweig
FR-2	Forschungsreaktor 2, Karlsruhe *Research Reactor 2, Karlsruhe*
FRG	Forschungsreaktor Geesthacht *Geesthacht research reactor*
FRJ-1	Forschungsreaktor 1 Jülich (MERLIN) *Jülich research reactor 1 (MERLIN)*
FRJ-2	Forschungsreaktor 2 Jülich (DIDO) *Jülich research reactor 2 (DIDO)*
FRM	Forschungsreaktor München, Garching *Munich research reactor, Garching*

FRM II	Forschungsneutronenquelle Heinz Maier-Leibnitz der Technischen Universität München, Garching *Research neutron source Heinz Maier-Leibnitz of the Technical University of Munich*
FR MZ	Mainzer Forschungsreaktor TRIGA Mark II *TRIGA Mark II research reactor Mainz*
FRN	Forschungsreaktor Neuherberg *Neuherberg research reactor*
FZJ	*Forschungszentrum Jülich GmbH* *Jülich research centre (formerly KFA, nuclear sector of the FZJ now JEN)*
FZK	Forschungszentrum Karlsruhe GmbH *Karlsruhe research centre (formerly KfK, now KIT)*
GG	Grundgesetz *Basic Law for the Federal Republic of Germany*
GDR	German Democratic Republic (see DDR)
GKN	Kernkraftwerk Neckarwestheim *Neckarwestheim nuclear power plant*
GMBl.	Gemeinsames Ministerialblatt *Joint Ministerial Gazette*
GMLZ	Gemeinsames Melde- und Lagezentrum von Bund und Ländern *Joint Reporting and Situation Centre of the Federation and the Federal States*
GNS	GNS Gesellschaft für Nuklear-Service mbH
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit gGmbH
GSF	Gesellschaft für Strahlenforschung *Company for radiation research (now HMGU)*
GSI	Helmholtzzentrum für Schwerionenforschung GmbH
HASS	High-Activity Sealed Radioactive Sources
HAW	High Active Waste
HAWC	High Active Waste Concentrate
HDR	Heißdampfreaktor, Großwelzheim *Superheated steam reactor, Großwelzheim*
HKG	Hochtemperatur-Kernkraftwerk GmbH
HLW	High Level Waste
HM	Heavy Metal
HMGU	Helmholtz Zentrum München – Deutsches Forschungszentrum für Gesundheit und Umwelt GmbH *German Research Center for Environmental Health of the Helmholtz Zentrum München (formerly GSF)*
HTGR	High Temperature Gas-Cooled Reactor
HTR	High Temperature Reactor
HWGCR	Heavy Water Gas-Cooled Reactor
HZB	Helmholtz-Zentrum Berlin für Materialien und Energie *Helmholtz-Zentrum Berlin for Materials and Energy (formerly HMI – Hahn-Meitner-Institut)*
HZDR	Helmholtz-Zentrum Dresden-Rossendorf e. V.
HZM	Helmholtz Zentrum München – Deutsches Forschungszentrum für Gesundheit und Umwelt GmbH

IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IEC	International Electrotechnical Commission
ILW	Intermediate Level Waste
IMIS	Integriertes Mess- und Informationssystem zur Überwachung der Umweltradioaktivität *Integrated Measuring and Information System for monitoring environmental radioactivity*
INES	International Nuclear Event Scale
INEX	International Nuclear Emergency Exercise
IRS	Incident Reporting System
ISO	International Organization for Standardization
ITB	Intake of iodine tablets
ITU	Institut für Transurane, Karlsruhe *Institute for Transuranium Elements, Karlsruhe (now Joint Research Center)*
JEN	JEN Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH *(formerly KFA, nuclear sector of the FZJ and AVR)*
KBR	Kernkraftwerk Brokdorf *Brokdorf nuclear power plant*
KENFO	Fonds zur Finanzierung der kerntechnischen Entsorgung *Fund for the financing of nuclear waste management*
KFA	Kernforschungsanlage Jülich (now JEN)
KfK	Kernforschungszentrum Karlsruhe (now Karlsruher Institut für Technologie, KIT)
KFK	Kommission zur Überprüfung der Finanzierung des Kernenergieausstiegs *Commission to Review the Financing for the Phase-out of Nuclear Energy*
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 *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 *Gundremmingen nuclear power plant*
KTA	Kerntechnischer Ausschuss *Nuclear Safety Standards Commission*
KTE	Kerntechnische Entsorgung Karlsruhe GmbH (until 7 Februar 2017 Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH)
KVSF	Kompetenzverbund Strahlenforschung *Competence Network for Radiation Research*
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*
LAW	Low Active Waste
LLW	Low Level Waste
LWR	Light-Water Reactor
LoK	Logistikzentrum für das Endlager Konrad *Logistics Centre for the Konrad repository*
MAW	Medium Active Waste
MLU	Ministerium für Landwirtschaft und Umwelt des Landes Sachsen-Anhalt *Ministry of Agriculture and the Environment of Saxony-Anhalt (now Ministry for the Environment, Agriculture and Energy of Saxony-Anhalt, MULE)*
MOX	Mixed Oxide
MTR	Materialtestreaktor *Material testing reactor*
MULE	Ministerium für Umwelt, Landwirtschaft und Energie des Landes Sachsen-Anhalt *Ministry for the Environment, Agriculture and Energy of Saxony-Anhalt (formerly MLU)*
MWe	Megawatts electrical
MWEIMH	Ministerium für Wirtschaft, Energie, Industrie, Mittelstand und Handwerk des Landes Nordrhein-Westfalen *Ministry of Economic Affairs, Energy, Industry, SMEs and Crafts of North Rhine-Westphalia (now MWIDE)*

MWIDE	Ministerium für Wirtschaft, Innovation, Digitalisierung und Energie des Landes Nordrhein-Westfalen *Ministry of Economic Affairs, Innovation, Digitalization and Energy of North Rhine-Westphalia (formerly MWEIMH)*
MZFR	Mehrzweckforschungsreaktor, Karlsruhe *Multi-purpose research reactor, Karlsruhe*
NaPro	Nationales Entsorgungsprogramm *National Programme (for spent fuel and radioactive waste management)*
NBG	Nationales Begleitgremium National Civil Society Board
NCS	Nuclear Cargo + Service GmbH (now DAHER NUCLEAR TECHNOLOGIES GmbH)
NDA	Nuclear Decommissioning Authority (UK)
NDWV	Notfalldosiswerte-Verordnung *Emergency Dose Value Ordinance*
NEA	Nuclear Energy Agency
NEZ	Nukleares Entsorgungszentrum *Nuclear waste management centre*
NMU	Niedersächsisches Ministerium für Umwelt, Energie, Bauen und Klimaschutz *Lower Saxony Ministry for the Environment, Energy, Building and Climate Protection*
NORM	Naturally Occurring Radioactive Material
NPP	Nuclear power plant
OECD	Organisation for Economic Co-operation and Development
OILs	Operational Intervention Levels
PETRA	Pellet-Trocknungsanlage *Pellet drying facility*
PKA	Pilot conditioning plant, Gorleben
PSR	Periodic Safety Review
PWR	Pressurised Water Reactor
QK	Qualitätsklasse – Konventionell *Quality class – conventional*
QN	Qualitätsklasse – Nuklear *Quality class – nuclear*
REI	Richtlinie zur Emissions- und Immissionsüberwachung kerntechnischer Anlagen *Guideline concerning Emission and Immission Monitoring of Nuclear Installations*
RFR	Rossendorfer Forschungsreaktor *Rossendorf research reactor*
RLB	Radiologisches Lagebild *Radiological situation report*
RLZ	Radiologisches Lagezentrum des Bundes *Federal Radiological Situation Centre*
RöV	Röntgenverordnung *X-Ray Ordinance*
RSK	Reaktor-Sicherheitskommission *Reactor Safety Commission*

RWTH	Rheinisch-Westfälische Technische Hochschule Aachen RWTH Aachen University
SAAS	Staatliches Amt für Atomsicherheit und Strahlenschutz der DDR *State Board for Atomic Safety and Radiation Protection of the GDR*
SKB	Svensk Kärnbränslehantering AB *Swedish Nuclear Fuel and Waste Management Company*
SSK	Strahlenschutzkommission *Commission on Radiological Protection*
StandAG	Standortauswahlgesetz *Site Selection Act*
STEAG	Steinkohlen-Elektrizität AG
StGB	Strafgesetzbuch *Criminal Code*
StrlSAblAnO	Anordnung zur Gewährleistung des Strahlenschutzes bei Halden und industriellen Absetzanlagen und bei Verwendung darin abgelagerter Materialien
StrlSchG	Strahlenschutzgesetz *Radiation Protection Act*
StrlSchV	Strahlenschutzverordnung *Radiation Protection Ordinance*
StrVG	Strahlenschutzvorsorgegesetz *Precautionary Radiation Protection Act*
SUR	Siemens-Unterrichtsreaktor *Siemens research reactor designed for training purposes*
SUR-AA	Siemens-Unterrichtsreaktor Aachen
SUR-FW	Siemens-Unterrichtsreaktor Furtwangen
SUR-H	Siemens-Unterrichtsreaktor Hannover
SUR-S	Siemens-Unterrichtsreaktor Stuttgart
SUR-U	Siemens-Unterrichtsreaktor Ulm
SZS	Staatliche Zentrale für Strahlenschutz der DDR *State Office for Radiation Protection of the GDR*
TBL	Transportbehälterlager *Transport cask storage facility*
TBL-A	Transportbehälterlager Ahaus *Ahaus transport cask storage facility*
TBL-G	Transportbehälterlager Gorleben *Gorleben transport cask storage facility*
THTR	Thorium-Hochtemperaturreaktor, Hamm-Uentrop *Thorium high-temperature reactor, Hamm-Uentrop*
TRIGA	Training Research Isotope General Atomics
TWh	Terawatt-hour
US-DOE	United States Department of Energy
US-NRC	United States Nuclear Regulatory Commission
UVPG	Gesetz über die Umweltverträglichkeitsprüfung *Environmental Impact Assessment Act*
VAK	Versuchsatomkraftwerk Kahl *Kahl experimental nuclear power plant*
VBA	Verlorene Betonabschirmung *Lost concrete shielding*

VDE	Verband der Elektrotechnik, Elektronik Informationstechnik e. V. *Association for Electrical, Electronic & Information Technologies*
VEK	Verglasungseinrichtung Karlsruhe *Karlsruhe vitrification facility*
VIBS	Vorkommnisse im Brennstoffkreislauf *Incidents in fuel cycle facilities*
VkENOG	Gesetz zur Neuordnung der Verantwortung in der kerntechnischen Entsorgung *Act on the Reorganisation of Responsibility in Nuclear Waste Management*
VKTA	Strahlenschutz, Analytik und Entsorgung Rossendorf e. V. *Radiation Protection, Analytics & Disposal Rossendorf Inc. (until December 2014 Nuclear Engineering and Analytics Rossendorf Inc.)*
VLLW	Very Low Level Waste
VOAS	Verordnung über die Gewährleistung von Atomsicherheit und Strahlenschutz *Ordinance on Nuclear Safety and Radiation Protection*
VSLW	Very Short Lived Waste
VVER	Water-cooled and water-moderated energy reactor (Soviet design)
VwVfG	Verwaltungsverfahrensgesetz *Administrative Procedures Act*
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
ZfK	Zentralinstitut für Kernforschung, Rossendorf *Central Institute for Nuclear Research, Rossendorf (now Helmholtz-Zentrum Dresden-Rossendorf (HZDR) and Radiation Protection, Analytics & Disposal Rossendorf Inc. (VKTA))*
ZLN	Zwischenlager Nord, Rubenow *Storage Facility North, Rubenow*

Summary

Status of power and research reactors in Germany

There are currently six nuclear power plants in operation in Germany. These are exclusively light water reactors (five pressurised water reactors and one boiling water reactor) whose fuel assemblies are composed of low-enriched uranium oxide or uranium/plutonium mixed oxide (MOX). With the entry into force of the Thirteenth Act Amending the Atomic Energy Act on 6 August 2011 as a result of the events at the Japanese nuclear power plant Fukushima Daiichi, the authorisation for power operation for the nuclear power plants Biblis Unit A and Unit B, Neckarwestheim I, Brunsbüttel, Isar 1, Unterweser, Philippsburg 1 and Krümmel expired. For the eight nuclear power plants shut down in 2011, applications for decommissioning were filed. The decommissioning licences according to § 7(3) of the Act on the Peaceful Utilisation of Atomic Energy and the Protection against its Hazards (Atomic Energy Act – AtG) [1A-3] were granted for Isar 1 on 17 January 2017, for Neckarwestheim I on 3 February 2017, for Biblis Unit A and Unit B on 30 March 2017, for Philippsburg 1 on 7 April 2017, for Unterweser on 5 February 2018 and for Brunsbüttel on 21 December 2018. The Krümmel nuclear power plant is in the post-operational phase until granting of a decommissioning licence. According to the Atomic Energy Act, the authorisation for power operation of the Grafenrheinfeld nuclear power plant (KKG) would have expired at the latest by 31 December 2015. On 27 June 2015, the KKG had already been finally taken off the grid by the operator. The decommissioning licence for the KKG was granted on 11 April 2018. For Gundremmingen B, the authorisation for power operation expired on 31 December 2017; a decommissioning licence was granted on 19 March 2019. For Philippsburg 2 (KKP 2), the authorisation for power operation expired on 31 December 2019, the decommissioning licence was granted on 17 December 2019.

The electric power utilities E.ON (now: PreussenElektra GmbH), RWE and Vattenfall have filed a constitutional complaint against the amendment to the Atomic Energy Act of 6 August 2011. In its judgment of 6 December 2016, the Federal Constitutional Court confirmed that the Thirteenth Amendment to the Atomic Energy Act of 2011 is, in essence, consistent with the Constitution. Both the introduction of fixed dates by which the nuclear power plants must be shut down and staggering of these dates, as well as the revocation of the lifetime extension of 2010 without compensation and the legislative procedure itself were found to be in conformity with the Constitution. For the six nuclear power plants still in operation, the authorisations for power operation will expire successively between the end of 2021 and the end of 2022. Another 26 reactors (including experimental and demonstration reactors) are in the process of being decommissioned and decommissioning has been completed for three reactors.

In Germany, two research reactors (the Research Neutron Source Heinz Maier-Leibnitz (FRM II) of the Technical University of Munich, the TRIGA Mark II research reactor in Mainz (FR MZ)), three reactors for training purposes and one reactor for educational purposes are currently in operation. Five research reactors are under decommissioning and four research reactors were permanently shut down. For 29 research reactors, decommissioning has been completed.

Spent fuel management facilities

The following facilities shall be considered as spent fuel management facilities within the meaning of the Joint Convention:

- the decentralised spent fuel storage facilities at the sites of the nuclear power plants,
- the central spent fuel storage facilities in Ahaus, Gorleben and Rubenow,

- the AVR cask storage facility in Jülich,
- the pilot conditioning plant in Gorleben.

In the following, the individual types of facilities are presented in summary form. A detailed description is given in Chapter D.1.

(1) Decentralised spent fuel storage facilities

Decentralised storage facilities for spent fuel were licensed under nuclear law, constructed and commissioned at twelve nuclear power plant sites. They are designed as dry storage facilities with passive air convection cooling in which mainly transport and storage casks loaded with spent fuel are emplaced. The protective effect during specified normal operation and in the event of various incidents has been demonstrated in the licensing procedure for a storage period of at least 40 years. Thus, the storage licences are currently limited to 40 years, starting with the emplacement of the first cask. According to § 6(5) of the Atomic Energy Act (AtG) [1A-3], licences for storage facilities may only be renewed on imperative grounds and after prior referral to the German *Bundestag*.

The decentralised spent fuel storage facility in Brunsbüttel had its storage licence withdrawn by a ruling of the Federal Administrative Court. The Court's decision was not made because of insufficient safety of the storage facility. The judgment criticised the scope of the investigations and assessments in the licensing procedure. Storage currently takes place by order of the supervisory authority of Schleswig-Holstein. The new licence was applied for on 16 November 2015.

(2) Central spent fuel storage facilities

The central storage facilities, like the decentralised storage facilities, are designed as dry storage facilities for the storage of transport and storage casks.

Gorleben spent fuel storage facility

The Gorleben spent fuel storage facility (BZG) is licensed for the storage of nuclear fuels in the form of spent fuel from light water reactors and HLW canisters (vitrified high-level radioactive fission product solutions from the reprocessing of German fuel assemblies). According to the Atomic Energy Act, no further storage of HLW canisters is planned.

The application of December 2013 regarding the storage of conditioned radioactive waste with negligible heat generation for a separate area in the spent fuel storage facility was suspended.

Ahaus spent fuel storage facility

According to the licence granted, spent fuel from various German nuclear power plants may be stored in the Ahaus spent fuel storage facility (BZA). In addition, the storage of spent fuel from experimental, demonstration and research reactors in various types of casks is also licensed. It is planned to use the Ahaus spent fuel storage facility for the spent fuel of the research reactors still in operation and those currently being decommissioned.

According to the 8th modification licence of 21 July 2016, the storage of spent fuel of the experimental reactor of the former Arbeitsgemeinschaft Versuchsreaktor GmbH (AVR) in 152 transport and storage casks is also licensed. These casks are currently located at the AVR reactor site.

Furthermore, an application was filed for the storage of high-pressure compacted radioactive waste (CSD-C) from reprocessing at La Hague at the Ahaus spent fuel storage facility. A cask concept is currently being developed for this purpose.

On 9 November 2009, a licence for the storage of waste from operation and decommissioning in the Ahaus radioactive waste storage facility (AZA) was granted for a period of 10 years (former designation: storage area 1 of the cask storage facility for spent fuel). A new application was filed on 29 August 2016.

Storage Facility North in Rubenow

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 glass canisters with high-level radioactive waste from the Karlsruhe reprocessing plant (WAK) are currently stored in the Storage Facility North (ZLN).

On 29 May 2019, the operator submitted an application for a licence to store the 74 CASTOR® casks in a new building due to the safety requirements for the storage of nuclear fuels that have been increased since 2011.

(3) AVR cask storage facility in Jülich

In the AVR cask storage facility in Jülich, now under the responsibility of JEN Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH (JEN), the spent fuel spheres from the operation of the experimental reactor of the former Arbeitsgemeinschaft Versuchsreaktor GmbH (AVR) are stored in 152 transport and storage casks. The original storage licence of 17 June 1993 had been limited to 20 years. An application has been made for the AVR fuel to be stored at the Jülich storage facility for another nine years. The licensing procedure has not yet been completed. At present, storage is based on orders issued by the competent supervisory authority of North Rhine-Westphalia, most recently an order on the removal of the nuclear fuel from the AVR cask storage facility was issued (see Chapter D.1.3 for details).

The operator developed a concept in accordance with specific requirements from the order to remove the fuel from the storage facility, which provides for three options, whose sequence in which they are presented does not imply a priority listing from the technical view:

1. transport of the nuclear fuel to the Ahaus spent fuel storage facility,
2. shipment of the nuclear fuel to its country of origin, the United States of America, and
3. transport of the nuclear fuel to a new storage facility to be built at the Jülich site.

Due to the extent and complexity of the issues to be examined, none of the three options is ready for decision yet.

(4) Gorleben pilot conditioning plant

The original purpose of the Gorleben conditioning plant was to demonstrate the processing and packaging of spent fuel assemblies and thus served to develop and test the techniques and process steps required for direct disposal. According to the agreement between the Federal Government and the electric power utilities of 11 June 2001, the use of the facility is licensed only for the repair of defective casks for spent fuel and for vitrified high-level radioactive waste from reprocessing, if necessary, as well as for the handling of other radioactive material. It is planned to decommission and dismantle the facility. Preparatory work for this is in progress.

Radioactive waste management facilities

The following facilities shall be considered as radioactive waste management facilities within the meaning of the Joint Convention:

- the conditioning facilities,
- the storage facilities for radioactive waste,

- the Konrad repository and the Morsleben repository for radioactive waste (ERAM), and
- the Asse II mine.

In the following, the individual types of facilities are presented in summary form. A detailed presentation is given in Chapter D.3.

(1) Conditioning facilities

The aim of waste conditioning is to meet the requirements for the waste products or packages to be produced resulting from the boundary conditions for storage, transport and disposal. Through treatment and/or packaging of the radioactive waste, it shall be converted into a form qualified for disposal, which results from the waste acceptance criteria of the Konrad repository. Depending on the waste properties, different conditioning methods are applied, where necessary in consecutive steps. The conditioning of radioactive waste is performed with mobile or stationary facilities. With the gradual shutdown of the German nuclear power plants, the need for stationary conditioning for waste from their operation decreases. At the same time, new capacities for conditioning local decommissioning waste are being created at the power plant sites. Examples of stationary and mobile conditioning facilities are given in Table L-5 and Table L-6.

(2) Storage facilities for radioactive waste

For the storage of radioactive waste with negligible heat generation, facilities are available at the sites of the nuclear power plants for the radioactive waste produced on site. Their storage capacities have been and will be increased due to the fact that the Konrad repository is currently not yet available. There are also storage facilities that accept waste from several facilities, such as the Unterweser radioactive waste storage facility (AZU) no. 1, the Mitterteich storage facility, the Gorleben radioactive waste storage facility (AZG) or the Storage Facility North (ZLN) in Rubenow. In addition, storage areas of spent fuel storage facilities are also licensed for the storage of radioactive waste, as is the case with the Biblis storage facility and the Ahaus storage facility. The licences specify details such as handling, delivering facilities and time limits. A comprehensive overview of the storage facilities for radioactive waste is given in Table L-7 to Table L-11.

Radioactive waste from the reprocessing of German fuel assemblies abroad must be taken back pursuant to the Atomic Energy Act. Between 1996 and 2011, 108 casks with high-level radioactive waste (CSD-V), each containing 28 glass canisters, were returned from France and stored in the BZG. Future return deliveries of waste from reprocessing abroad are to be stored in the BZA and the four decentralised spent fuel storage facilities Biblis in Hesse, Brokdorf in Schleswig-Holstein, Isar in Bavaria and Philippsburg in Baden-Wuerttemberg.

Radioactive waste from large research institutions is generally conditioned and stored at its place of origin. Waste from research, industry and medicine are delivered to eleven *Land* collecting facilities.

(3) Morsleben repository for radioactive waste and Konrad repository

In Germany, the disposal of all types of radioactive waste is planned to take place in deep geological formations. Since 2017, the Federal Company for Radioactive Waste Disposal (BGE) has been fulfilling the operator tasks for the disposal facilities.

Morsleben repository for radioactive waste

From 1971 to 1998, with some interruptions, low- and intermediate-level radioactive waste from nuclear power plants as well as from the research, industry and medicine of the GDR and, after the reunification of Germany, of the entire Federal Republic of Germany was stored in the Morsleben repository for radioactive waste (ERAM). After the prohibition of further emplacement in 1998 by a court decision, the operator irrevocably waived further emplacement operation in 2001. The plan approval procedure for the closure of the ERAM was started in 2005.

In January 2013, the Nuclear Waste Management Commission (ESK) presented a statement according to which the submitted documents for the demonstration of long-term safety in the plan approval procedure for the closure of the ERAM in compliance with the state of the art in science and technology are not sufficient, but the demonstration of long-term safety is feasible. The implementation of the recommendations required additional proofs and the revision of the application documents, which are currently in progress.

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 disposal facility for radioactive waste with negligible heat generation was filed.

The plan approval decision was issued on 22 May 2002. After the dismissal of all claims, a final and incontestable plan approval decision for the Konrad repository has been available since 2007. The current status of the work is presented in Chapter D.3.3. Completion of the construction is scheduled for 2027.

A maximum waste package volume of 303,000 m³ may be emplaced in the Konrad repository. The Konrad waste acceptance criteria specify the requirements for the waste packages to be disposed of and are currently available in the version as of December 2014 [BfS 14a].

(4) Asse II mine

From 1967 to 1978, low- and intermediate-level waste had been disposed of in the former potash and rock salt mine Asse II. The mine was used for research work until 1995.

Since 1988, inflow of groundwater from the overburden into the mine has been observed. Currently, about 13 m³ of brines saturated with sodium chloride are collected every day. It is not possible to forecast the evolution of inflow rates. Emergency planning was set up for the case of a beyond-design inflow. After various stabilisation measures, open gaps at the roof of the excavations and mine workings no longer required have been backfilled with Sorel concrete since the end of 2010 to improve stability.

By means of a “comparison of options”, the retrieval of all waste was identified as the closure option by which long-term safety according to the state of the art in science and technology can most probably be ensured at the Asse site. On 24 April 2013, the Act on Speeding up the Retrieval of Radioactive Waste and the Closure of the Asse II Mine (“Lex Asse”) [1A-26] was effected, which governs the closure of the Asse II mine following the retrieval of the radioactive waste. Schedules prepared so far assume that the retrieval of the radioactive waste will begin in 2033.

Already in 2012 it was stated that a new shaft for retrieval of the waste is absolutely necessary. The creation of new underground infrastructure rooms and above-ground facilities for, among other things, waste characterisation, treatment and storage are also required. A suitable retrieval technology is to be identified and partly still to be developed.

The BGE has been the responsible operator of the Asse II mine since 2017 and has published a plan for retrieval [BGE 20] on 27 March 2020 in which all measures to be taken are described in a coherent manner.

Spent fuel management policy and practices

Since 1 July 2005, delivery of spent fuel from commercial electricity generation for the purposes of reprocessing has been prohibited in accordance with an amendment of the Atomic Energy Act (AtG) [1A-3] to this effect by the Act on the structured phase-out of the utilisation of nuclear energy for the commercial electricity generation of 22 April 2002 [1A-2]. Now, only the direct disposal of the spent fuel that exists and will be generated in future in Germany as radioactive waste is permissible.

Spent fuel assemblies are to be disposed of together with heat-generating radioactive waste from reprocessing. The selection of a disposal facility site is reported on under the heading Site Selection Act in Chapter E.2.2. As there is as yet no disposal facility available for the spent fuel, it will generally be stored; corresponding storage capacities exist as needed.

After the amendment to the Atomic Energy Act in the course of the further development of the Act on the Search and Selection of a Site for a Disposal Facility for Heat-Generating Radioactive Waste (StandAG) [1A-7b], the export of spent fuel from research reactors is only permitted for serious reasons of non-proliferation of nuclear fuel or for reasons of sufficient supply of fuel assemblies for medical and other top-level research purposes. An exception to this is the shipment of such fuel assemblies with the aim of producing waste packages that are qualified for disposal and that are to be disposed of in Germany. An export licence shall not be granted if the spent fuel is already stored in Germany pursuant to § 6 AtG.

As at 31 December 2019, a total of 15,777 Mg HM in the form of spent fuel assemblies have been produced in Germany. Of these, a total of 9,104 Mg HM are stored on-site in the fuel pools of the nuclear power plants or in the central and decentralised spent fuel storage facilities. 6,346 Mg HM were reprocessed mostly in other European countries, and 327 Mg HM were otherwise managed.

Radioactive waste management policy and practices

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

For the selection of a disposal site for high-level radioactive waste, the site selection procedure was started with the amendment of the Site Selection Act (StandAG) [1A-7b] in 2017 (see Chapter E.2.2 for details on the Site Selection Act).

Only solid (or solidified) 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.

Proven methods and reliable mobile or stationary facilities already exist for the pretreatment and conditioning of radioactive waste. In addition to German facilities, facilities in other countries are also utilised for waste processing.

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

Due to 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 nuclear power plants in France and the United Kingdom is conditioned there on site (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. As stipulated in the Atomic Energy Act, solidified fission product solutions from reprocessing abroad shall be taken back and stored in future in decentralised spent fuel storage facilities.

For radioactive waste with negligible heat generation, compliance of the packages with the requirements established in the waste acceptance criteria of the disposal facility is reviewed within the scope of a product control. For this, the waste acceptance criteria of the Konrad repository, which is plan-approved and 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 the future. These are designed in such a way that reliable identification of waste packages that do not conform to the specifications is ensured.

As at 31 December 2019, a total of 124,736 m³ (gross volume) of radioactive waste with negligible heat generation in containers were stored in Germany. The waste originates primarily from research institutions, nuclear power plants and the nuclear industry including the Karlsruhe reprocessing plant as well as from medical applications and the non-nuclear industry. In addition to the spent fuel, a total of 577 m³ of heat-generating radioactive waste were stored, which mainly consists of vitrified high-level waste from reprocessing. From 1967 to 1978, a total of 124,494 packages were emplaced in the Asse II mine as low-level waste, including also, in the case of higher activities, those with so-called lost concrete shieldings. In addition, 1,293 drums with intermediate-level waste were emplaced. The waste package volume is about 47,000 m³. By the end of 2019, a total of 37,241 m³ of solid low- and intermediate-level radioactive waste, including radioactive waste from operation for keeping the disposal facility open after 1998, and 6,621 sealed sources were disposed of in the Morsleben repository for radioactive waste (ERAM).

Criteria used to define and categorise radioactive waste

Since disposal in deep geological formations is intended for all types of radioactive waste, there is no need to differentiate between waste containing radionuclides with comparatively short half-lives and waste containing radionuclides with comparatively long half-lives. Thus, there are no measures or precautions required in order to separate the radioactive waste produced in this respect.

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 LLW, ILW and HLW and to choose a new classification instead, 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 radioactive waste, and
- radioactive waste with negligible heat generation

which is then further subdivided according to the categorisation scheme established for this purpose.

Heat-generating radioactive waste is characterised by high activity concentrations and thus by a high decay heat. It comprises, in particular, the vitrified fission product concentrate, hulls, structural components, decontamination and flush waters, feed sludge from the reprocessing of spent fuel, and the spent fuel itself if it has not been reprocessed but is to be directly disposed of as radioactive waste.

Types of waste with significantly lower activity concentrations from the operation and decommissioning of nuclear installations and facilities as well as from the application of radioisotopes are classified among the radioactive waste with negligible heat generation. These are 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 radioactive sources, sludges, suspensions, oils as well as contaminated and activated concrete structures and debris. This categorisation makes it possible, in particular, to register the data for 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. 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 field of spent fuel and radioactive waste management

The management of spent fuel and radioactive waste is based on the polluter pays principle. According to § 9a(1) of the Atomic Energy Act (AtG) [1A-3], the producers of residual radioactive material are required to ensure that these are utilised without detrimental effects or are disposed of as radioactive waste in a controlled manner. This means that, as a general principle, the producers are responsible for the conditioning and storage of spent fuel and radioactive waste. According to the Act Regulating the Transfer of Financing and Action Obligations for the Management of Radioactive Waste from Operators of Nuclear Power Plants (Waste Management Transfer Act – EntsorgÜG) [1A-35], radioactive waste from operation and decommissioning, safe enclosure and dismantling of a facility for the fission of nuclear fuel for the commercial electricity generation may be transferred to a third party (BGZ Company for Storage (BGZ)) commissioned with storage management by the Federation. The conditions for this are that an amount of money determined in accordance with § 7 of the Act on the Establishment of a Fund for the Financing of Nuclear Waste Management (Waste Management Fund Act – EntsorgFondsG) [1A-36] was paid to the foundation fund for the financing of nuclear waste management (KENFO) for the respective facility and certain requirements are fulfilled in accordance with the Waste Management Transfer Act. The electric power utilities have already paid the corresponding amounts of money to the fund in 2017.

The Federal Office for the Safety of Nuclear Waste Management (BASE) is the competent federal authority for plan approval, licensing and supervision of facilities of the Federation for the safekeeping and disposal of radioactive waste, radioactive waste management and the transport and storage of radioactive material. The BASE also performs tasks in the field of nuclear safety that are assigned to it by the Atomic Energy Act, the Site Selection Act (StandAG) [1A-7b] or other federal laws. According to § 4(1)(3) StandAG, this includes in particular monitoring the implementation of the site selection procedure.

According to § 9a(2) AtG, anyone possessing radioactive waste must deliver it to a disposal facility 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, in addition to the obligation of later delivery to a disposal facility, the responsibility for conditioning is assumed by the operator of the *Land* collecting facility. According to § 9a(3) AtG, the *Länder* shall establish collecting facilities for the storage of radioactive waste from research, medicine and industry produced within their territories. The producers of radioactive waste from the use of nuclear energy for the commercial electricity generation are responsible for its conditioning and for its storage if spent fuel and radioactive waste have not been delivered or storage facilities have not been transferred to the Federation according to the Waste Management Transfer Act. The decentralised spent fuel storage facilities for the storage of spent fuel were operated by the electric power utilities until the transfer of responsibilities under the Waste Management Transfer Act, and the two central storage facilities in Ahaus and Gorleben were operated by a subsidiary of the electric power utilities, supervised by the *Länder* and licensed by today's Federal Office for the Safety of Nuclear Waste Management (BASE). In accordance with the Waste Management Transfer Act, the storage facilities for spent fuel and radioactive waste from the reprocessing of spent fuel according to § 6 AtG were transferred with effect from 1 January 2019 and the storage facilities for radioactive waste with negligible heat generation defined in the Act were transferred with effect from 1 January 2020 from the operators at that time to a third party (BGZ) commissioned with storage management by the Federation, which is organised in private legal form and whose sole shareholder is the Federation. The EWN Group is responsible for the dismantling and disposal of nuclear installations of the Federation. Financing is provided from public funds. Three companies belong to the EWN Group. EWN Entsorgungswerk für Nuklearanlagen GmbH (EWN) is responsible for the dismantling and removal of the nuclear power plants of the former GDR in Greifswald and Rheinsberg.

At the Lubmin/Rubenow site, EWN operates several waste management facilities and storage facilities. JEN Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH (JEN) is responsible for the dismantling of the AVR high-temperature reactor, the Chemistry Cells, the FRJ-2 (DIDO) research reactor and the Large Hot Cells at the Jülich site. Kerntechnische Entsorgung Karlsruhe GmbH (KTE) bundles all dismantling activities of decommissioned nuclear experimental and prototype facilities and the necessary waste management activities at the Karlsruhe site. According to § 9a(3) AtG, the Federation is responsible for the provision of disposal facilities, which had to transfer its tasks to a third party. This third party is the Federal Company for Radioactive Waste Disposal (BGE) of the private sector, whose sole shareholder is the Federation.

The BASE is also responsible for plan approval and licensing of disposal facilities. Transitional provisions apply for the Konrad repository and the ERAM, according to which the *Länder* remain responsible for licensing until this responsibility is transferred to the BASE with the granting of the approval of commissioning by the nuclear supervisory authority for the Konrad repository or until the plan approval decision on the closure of the ERAM will be enforceable. As defined in §§ 19(5), 23d, sentence 1, No. 2 AtG, the BASE also supervises the disposal facilities of the Federation and the Asse II mine. Licensing and supervision of other waste management facilities is the responsibility of the *Länder*, as defined in § 24 AtG.

Financing of spent fuel and radioactive waste management

The polluter pays principle also applies to the financing of spent fuel and radioactive waste management activities. Exceptions are the ERAM and the Asse II mine, whose costs are borne by the Federation.

The necessary expenses for the planning, construction and operation of facilities for the safekeeping and disposal of radioactive waste are principally borne by the waste producers through fees and contributions together with advance payments according to §§ 21a and 21b of the Atomic Energy Act (AtG) [1A-3] in conjunction with the Ordinance Concerning Prepayments for the Erection of Federal Facilities for the Long-Term Engineered Storage and Disposal of Radioactive Waste (Repository Prepayment Ordinance – EndlagerVlV) [1A-13]. According to the Waste Management Fund Act [1A-36], the financial obligations of the operators of the nuclear power plants defined in the Act were transferred to the fund for the financing of nuclear waste management when the associated financial means were transferred. Thus, the fund is now obliged to provide advance payments instead of the licence holder. This applies to the site selection procedure, which is financed through cost allocations to the waste producers according to §§ 28 et seq. of the Site Selection Act (StandAG) [1A-7b] accordingly. Waste producers that are not listed in the Waste Management Transfer Act [1A-35] (e.g. research institutions) continue to be directly liable to make advance payments or pay allocated costs.

The use of *Land* collecting facilities is refinanced by costs (fees and expenses) or charges, respectively, that are payable by the party delivering radioactive waste.

As the surveillance of a disposal facility after its sealing is a governmental task, the necessary funds 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 Federation. The further development of nuclear law is also a task of the Federation. The *Länder* will be involved in the procedure dependent on the subject matter.

The Atomic Energy Act [1A-3], the Radiation Protection Act [1A-34] and the statutory ordinances based thereon are implemented by authorities of the Federation and the *Länder*, where many implementation tasks are executed by the *Länder* on behalf of the Federation. With respect to the legality and appropriateness of their action, the competent *Land* authorities are subject to supervision by the Federation.

Assurance of the safe handling of disused sealed sources

Nearly 100,000 sealed radioactive 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 sources and up to some TBq for sealed radioactive sources for irradiation facilities. In Germany, the safety of disused sealed sources is 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 loss or discovery 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 reports of the BfS.

The working lives of the radioactive sources used are very different, in particular due to the strongly varying half-lives of the radionuclides used and the operating conditions. 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 a facility for disposal.

Shipment within the EU is not subject to licensing requirements. Transboundary movement within the EU is regulated by Council Regulation No. 1493/93/EURATOM [1F-34]. For sealed radioactive sources, 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 of the Atomic Energy Act (AtG) [1A-3] is the BAFA.

Main developments in Germany since the Sixth Review Meeting

Five other nuclear power plants permanently shut down (Brunsbüttel, Unterweser, Grafenrheinfeld, Gundremmingen B, Philippsburg 2) have meanwhile been granted decommissioning licences.

On the basis of the Waste Management Transfer Act, the responsibilities with regard to the disposal of radioactive waste from nuclear power plants in Germany were redefined: The decommissioning of the nuclear power plants as well as qualified packaging of the radioactive waste remain the responsibility of the operators, while the responsibility for the implementation and financing of storage and disposal lies with the Federation or is to be transferred to it. With effect from 1 January 2019, eleven storage facilities for spent fuel were transferred to the BGZ. With effect from 1 January 2020, six storage facilities for radioactive waste with negligible heat generation were transferred to the BGZ.

With the Fifteenth Act Amending the Atomic Energy Act of 1 June 2017 [1A-32], Council Directive 2014/87/EURATOM amending Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear installations was transposed into German law. The Act contains the following amendments:

- extension of the obligations of the licence holder regarding the publication of certain minimum information on normal operation, reportable events and accidents,
- provisions on the mandatory peer reviews (introduction of topic-related technical self-assessments and their international review),
- clarification of the responsibilities also for contractors and subcontractors, including the provision of adequate human resources, and
- regulation of on-site emergency preparedness.

The Sixteenth Act Amending the Atomic Energy Act of 10 July 2018 [1A-33] eliminated the constitutional deficit that the Federal Constitutional Court had found in its judgment of 6 December 2016 in peripheral areas of the Thirteenth Act Amending the Atomic Energy Act. On the one hand, owners or licence holders of a nuclear power plant have a claim to appropriate financial compensation for investments which they made in the nuclear power plant between 28 October 2010 and 16 March 2011 in reliance on the legal situation created by the Eleventh Act Amending the Atomic Energy Act for the purpose of generating the additional quantities of electricity allocated to the nuclear power plants to the extent necessary if the investments have become worthless solely due to the withdrawal of the additional quantities of electricity ordered by the Thirteenth Act Amending the Atomic Energy Act. On the other hand, the licence holders of the Brunsbüttel, Krümmel and Mülheim-Kärlich nuclear power plants are entitled to appropriate financial compensation to the extent that the electricity quantities allocated to these nuclear power plants by the Act on the structured phase-out of the utilisation of nuclear energy for the commercial electricity generation of 22 April 2002 will not be generated and not transferred to another nuclear power plant until the commercial use of nuclear energy in Germany ends on 31 December 2022. In accordance with the judgment of the Federal Constitutional Court of 6 December 2016, the compensation is limited to two-thirds of the residual electricity volume for the Brunsbüttel nuclear power plant and half of the residual electricity volume for the Krümmel nuclear power plant after 31 December 2022.

The safety requirements for the storage of nuclear fuel that have been increased since 2011 have prompted EWN Entsorgungswerk für Nuklearanlagen GmbH (formerly Energiewerke Nord GmbH) to plan a new building for all transport and storage casks stored in the ZLN. On 29 May 2019, the operator filed a corresponding licence application.

With the various articles of the Ordinance on the further modernisation of radiation protection law of 29 November 2018, new ordinances are created and existing ordinances updated. The Ordinance on Protection Against the Harmful Effects of Ionising Radiation (Radiation Protection Ordinance – StrlSchV) [1A-8b] and the Ordinance on Requirements and Procedures for the Management of Radioactive Waste (Nuclear Waste Management Ordinance – AtEV) [1B-19], both of which came into force on 31 December 2018, are of particular importance with regard to the Joint Convention. The Radiation Protection Ordinance, which is mainly based on Council Directive 2013/59/EURATOM, continues the amendment of German law on the protection against the harmful effects of ionising radiation, which began with the Radiation Protection Act, and further improves the existing high standard of protection. In particular, it contains more detailed requirements for occupational and medical radiation protection and for the protection of the general public. The Nuclear Waste Management Ordinance describes requirements and procedures for the management of radioactive waste and thus continues further elements of the existing law on the protection against the harmful effects of ionising radiation on the basis of the Atomic Energy Act.

In spring 2019, the second mission of the IAEA's Integrated Regulatory Review Service (IRRS) took place in Germany. It was carried out in fulfilment of the obligation under European law as defined in

Council Directive 2014/87/Euratom amending Directive 2009/71/Euratom, according to which the EU Member States should perform a self-assessment of the national legislative, regulatory and organisational framework for the nuclear safety of nuclear installations at least every ten years and to invite a subsequent international peer review. The IRRS team found that Germany’s nuclear licensing and supervisory authorities are mature and competent and highlighted the effective cooperation with other organisations and interested parties.

Council Directive 2011/70/EURATOM contains an identical obligation in the field of spent fuel and radioactive waste management. For the fulfilment of this obligation, a review mission was carried out in September 2019 by an international expert commission using the IAEA's Radioactive Waste Management Integrated Review Service (ARTEMIS). With the aim of exploiting synergy effects, the scope of the IRRS mission was expanded to include nuclear waste management.

The ARTEMIS review team concluded that Germany meets the internationally applicable IAEA safety standards for the management of radioactive waste and has a well-developed framework for the safe and responsible management of radioactive waste and spent fuel. According to the results of the review team, the National Programme for spent fuel and radioactive waste management and the organisational changes that have taken place in this area have set the right course.

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 installations. 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 IAEA Guidelines regarding the Form and Structure of National Reports INFCIRC/604. As such, it is divided into sections which address the individual Articles of the Joint Convention as prescribed in the guidelines. After an introduction on the historical and political development of the use of nuclear energy in Germany and an overview of the management of spent fuel and radioactive waste, each individual obligation is commented on. 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 Joint 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 installations and facilities currently in operation as defined by the Joint Convention with some 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 for the safety of the facilities as defined by the Joint Convention and which are referred to in this report.

In this report, the term “closure of a disposal facility” used in the text of the Joint Convention is used synonymously with the term “decommissioning of a disposal facility” used in the German Atomic Energy Act. The term "spent fuel" is also used to refer to fuel assemblies which have not yet reached their target burn-up but for which there is no further intention of use.

The seventh German national report does not merely include modifications of the previous reports but provides an integrated overall description. Any major developments since the report for the Sixth Review Meeting in May 2018 are summarised at the beginning of the respective sections in an info box (Developments since the Sixth Review Meeting).

All information and data provided by the report apply as at the deadline of 31 March 2020 unless expressly specified otherwise.

The seventh 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 management 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 operators of the storage facilities and disposal facilities. The report was approved by the Federal Government at its Cabinet meeting on 19 August 2020.

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 2020.

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 at that time was based on intensive international cooperation 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 Organisation for Economic Co-operation and Development (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), Allgemeine Elektrizitäts-Gesellschaft (AEG) and General Electric boiling water reactors (BWRs).

In subsequent years, the following nuclear research centres were founded in West Germany (see Table F-5 for details):

- 1956 in Karlsruhe, Jülich and Geesthacht,
- 1959 in Berlin and Hamburg,
- 1964 in Neuherberg near Munich, and
- 1969 in Darmstadt.

Many universities were equipped with research reactors. The Munich research reactor Garching (FRM) in 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 Research Neutron Source Heinz Maier-Leibnitz of the Technical University of Munich (FRM II) at the same site. 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 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. In 1956, the Central Institute for Nuclear Research (ZfK) in Rossendorf near Dresden was founded; 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 the Rossendorf research centre (FZR, now Helmholtz-Zentrum Dresden-Rossendorf (HZDR)) for the research tasks and by the Nuclear Engineering and Analytics Rossendorf Inc. (VKTA, now Radiation Protection, Analytics & Disposal Rossendorf Inc.) for the decommissioning of the nuclear installations and facilities.

There are currently six research and training reactors in operation in Germany. These are:

- the Research Neutron Source Heinz Maier-Leibnitz (FRM II) of the Technical University of Munich,
- the TRIGA Mark II research reactor in Mainz (FR MZ),
- four reactors for training and educational purposes (three Siemens research reactors designed for training purposes (SURs) and one training reactor for educational purposes (AKR-2)).

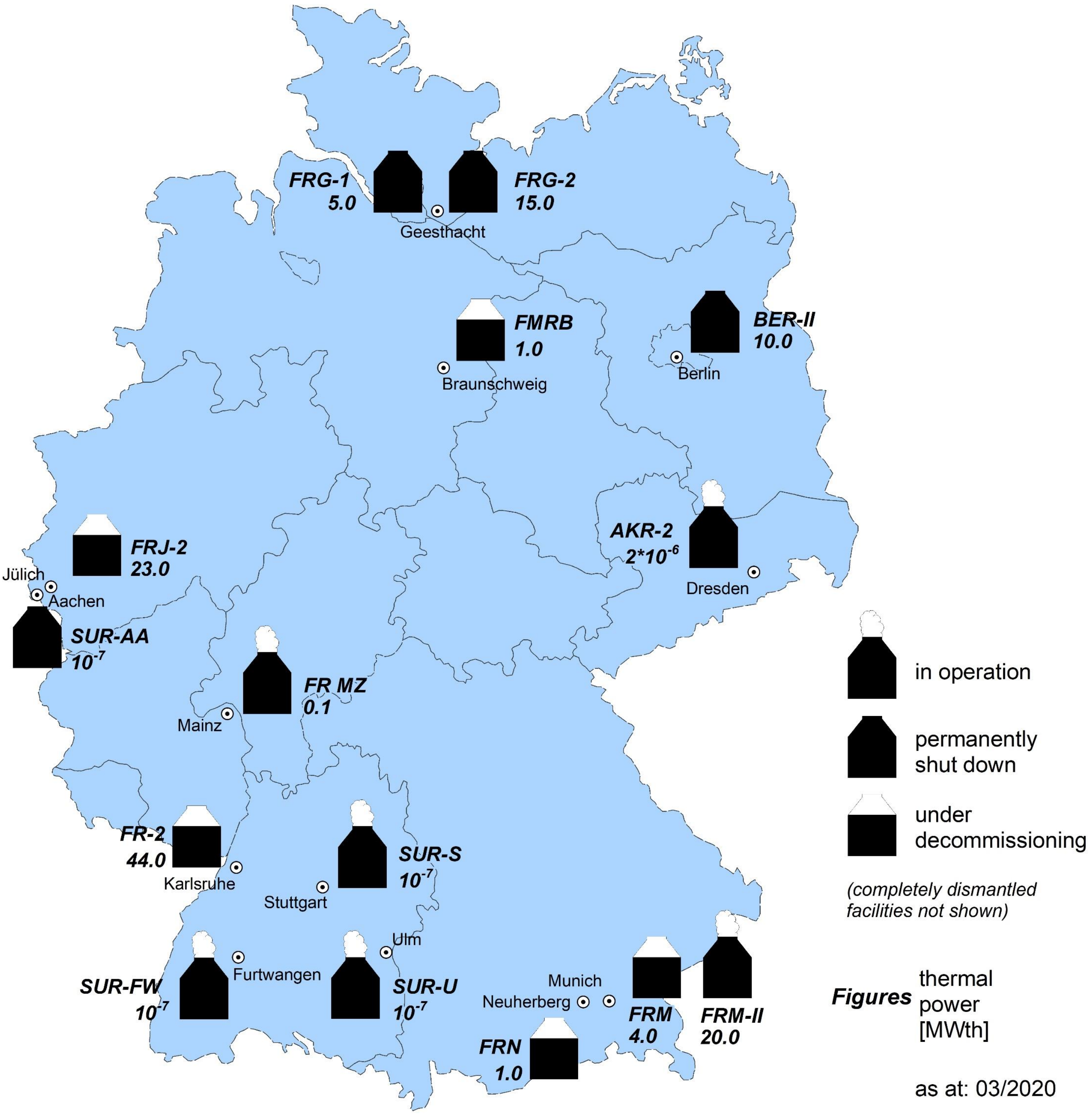
It is planned to convert the FRM II with a view to using fuel with a lower degree of enrichment instead of the highly enriched uranium (93 % U-235) used so far. Intensive research work is being carried out for this purpose. According to current planning, the FR MZ will be operated until at least 2030.

In the 1960s and 1970s, 12 SURs were installed in the Federal Republic of Germany and, taking these as a model, one training nuclear 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 eight to ten fuel plates. The SURs in Stuttgart, Ulm and Furtwangen as well as the AKR in Dresden are to continue operation.

The DIDO research reactor in Jülich (FRJ-2) was permanently shut down on 2 May 2006 and the decommissioning licence was granted on 20 September 2012. For the research reactor Geesthacht-1 (FRG-1) which was permanently shut down on 28 June 2010 and has been free of nuclear fuel 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 research reactor Geesthacht-2 (FRG-2) (common reactor pool). On 3 April 2014, the licence for dismantling of the FRM research reactor in Garching was granted. The BER II was permanently shut down on 11 December 2019. Altogether, eight facilities with a thermal power > 1 MW were shut down or are in various stages of decommissioning. Several reactors with smaller capacities were permanently shut down or are already dismantled. An overview of research reactors permanently shut down or being under decommissioning is given in Annex L-(c) (see Table L-14 and Table L-15).

The geographical locations of research reactors in Germany are shown in Figure A-1.

Figure A-1: Research and training reactors in Germany.



AKR: Training reactor
BER: Berlin experimental reactor
FMRB: Braunschweig research and measuring reactor
FR: Research reactor
FRG: Geesthacht research reactor
FRJ: Jülich research reactor
FRM: München research reactor
FR MZ: Mainz research reactor
FRN: Neuherberg research reactor
RFR: Rossendorf research reactor
SUR-AA: Siemens research reactor for training purposes Aachen
SUR-FW: Siemens research reactor for training purposes Furtwangen
SUR-H: Siemens research reactor for training purposes Hannover
SUR-S: Siemens research reactor for training purposes Stuttgart
SUR-U: Siemens research reactor for training purposes Ulm

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, which became operational in 1960.

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 reactor of this class went into operation in Biblis with the KWB-A (1,225 MWe), the last in 1989 in Neckarwestheim with GKN II (1,400 MWe). All six 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 cooperation between the nuclear research centres and the industry. Worth mentioning in this connection are the 15 MWe high temperature pebble bed reactor AVR (Arbeitsgemeinschaft Versuchsreaktor GmbH) at the former Kernforschungsanlage Jülich 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 and 1989 and is in safe enclosure now; the spent fuel is stored in the Ahaus spent fuel 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, such plants were 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 VVER-440/230 type and one of the VVER-440/W-213 type – started operation in Greifswald.

With the accession of the GDR to the Federal Republic of Germany under Article 23 of the Basic Law (GG) (in the version in force until 1990), the Act on the Peaceful Utilisation of Atomic Energy and the Protection against its Hazards (Atomic Energy Act – AtG) [1A-3] also applies to 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 currently being decommissioned. Work already begun on the construction of three further VVER 440 reactors in Greifswald and two VVER 1000 reactors in the first stage of expansion in Stendal has been discontinued.

Termination of the commercial generation of electricity from nuclear energy

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 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. Under these boundary conditions, the operator decided to permanently shut down the nuclear power plant in Stade (KKS) in 2003. In 2005, the Obrigheim nuclear power plant was permanently shut down (see Table L-13).

In 2010, the legislator decided to extend the operating lives of nuclear power plants still in operation. However, the events in Japan in March 2011 led to a reassessment of the risks associated with the use of nuclear energy. As a result, the Thirteenth Act Amending the Atomic Energy Act of 31 July

2011 [1A-25] terminated the authorisation to operate the eight plants Biblis Unit A and Unit B, Neckarwestheim I, Brunsbüttel, Isar 1, Unterweser, Philippsburg 1 and Krümmel. The Grafenrheinfeld nuclear power plant was also to cease operation by the end of 31 December 2015 at the latest, but the then operator E.ON Kernkraft GmbH (now PreussenElektra GmbH) decided to permanently shut down the plant already on 27 June 2015. For the Gundremmingen B and Philippsburg 2 nuclear power plants, the authorisation for power operation expired on 31 December 2017 and 31 December 2019, respectively. For the six nuclear power plants still in operation, the authorisations for power operation will expire at the end of 2021 or the end of 2022, or when the electricity volumes listed in Table A-1, Column 2 are reached.

For the nuclear power plants shut down in 2011, applications for decommissioning and dismantling were filed (see Table L-13 in Annex L-(c)), applying for immediate dismantling. With the exception of Krümmel, the first decommissioning and dismantling licences were already granted for all other seven plants. Krümmel will be operated on the basis of the existing operating licence until granting of the decommissioning licence (post-operation).

With Isar 1, the first plant shut down in 2011 was granted the first decommissioning and dismantling licence on 17 January 2017. This was followed by the nuclear power plants Neckarwestheim I on 3 February 2017, Biblis Unit A and Biblis Unit B on 30 March 2017, Philippsburg 1 on 7 April 2017, Unterweser on 5 February 2018 and Brunsbüttel on 21 December 2018. The Grafenrheinfeld nuclear power plant was granted its first decommissioning and dismantling licence on 11 April 2018, the Gundremmingen B nuclear power plant on 19 March 2019 and the Philippsburg 2 nuclear power plant on 17 December 2019. Fuel assemblies and fuel rods have been removed from the plants Biblis Unit A (since November 2016), Philippsburg 1 (since December 2016), Brunsbüttel (since February 2018), Neckarwestheim I (since April 2018), Unterweser (since February 2019) and Biblis Unit B (since June 2019).

With the successive phase-out of the use of nuclear energy, the share of nuclear energy in the gross electricity generation in Germany decreased from 29.5 % in 2000 to 13.1 % in 2019.

Table A-1: Electricity volumes and expiry of authorisation for power operation according to the Thirteenth Act Amending the Atomic Energy Act [1A-25]

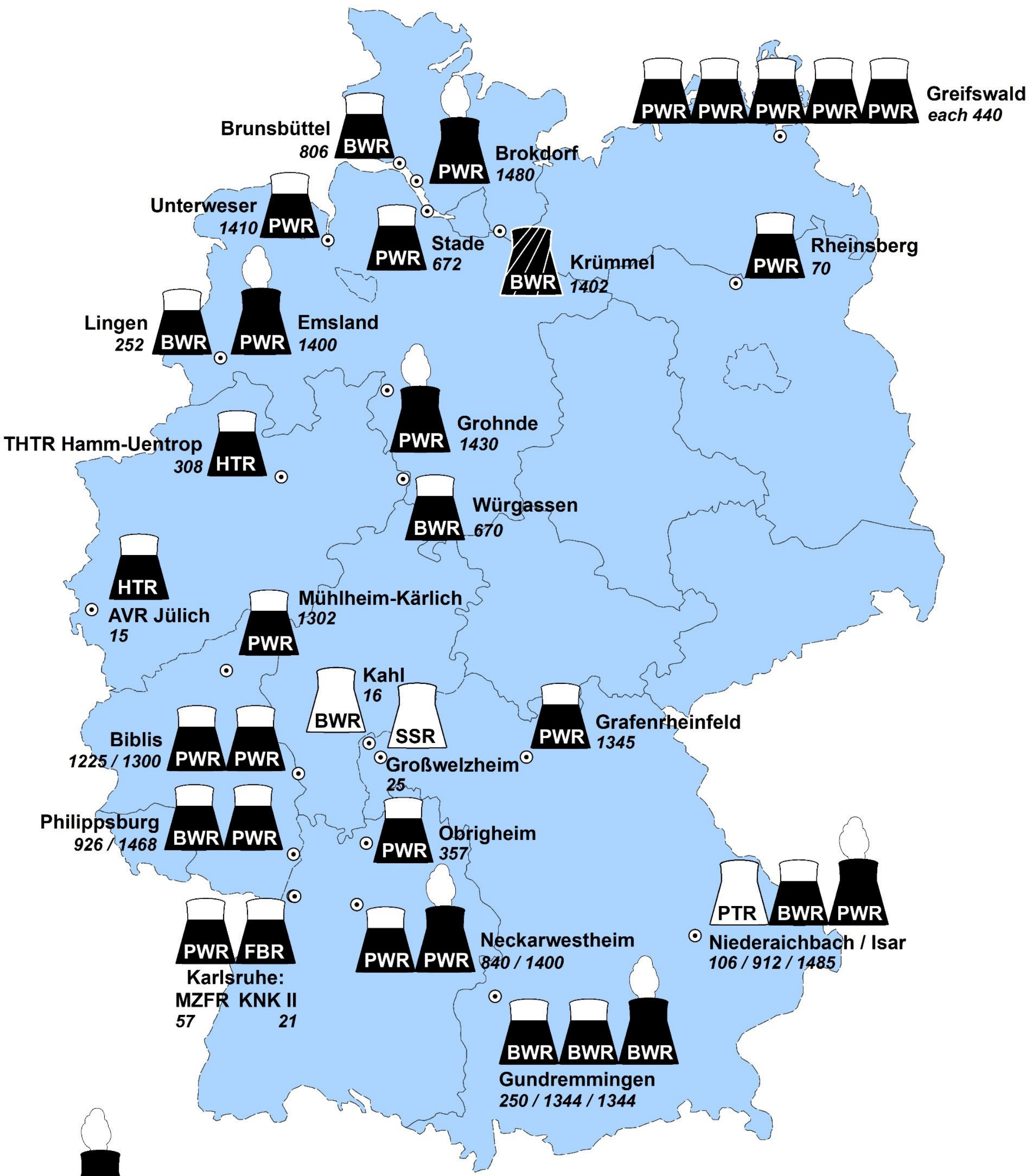
Plant	Electricity volumes as from 1 January 2000 [TWh net]	Start of commercial power operation	Expiry of authorisation for power operation
Biblis Unit A	62.00	26.02.1975	06.08.2011
Neckarwestheim I	57.35	01.12.1976	06.08.2011
Biblis Unit B	81.46	31.01.1977	06.08.2011
Brunsbüttel	47.67	09.02.1977	06.08.2011
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 II	236.04	15.04.1989	31.12.2022
Subtotal	**2,516.06**		
Mülheim-Kärlich	107.25 [2)]	01.08.1987	-
Obrigheim	8.70	01.04.1969	- [1)]
Stade	23.18	19.05.1972	- [1)]
Total	**2,623.31**		

1) The Obrigheim and Stade nuclear power plants were already shut down when the Act came into force.

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

The geographical locations of the German nuclear power plants in operation and under decommissioning are shown in Figure A-2.

Figure A-2: Nuclear power plants, experimental and demonstration reactors in Germany



in operation

licence for power operation terminated in accordance with the Thirteenth Act Amending the Atomic Energy Act

licence granted for decommissioning and dismantling / under decommissioning

fully dismantled

PWR	Pressurised Water Reactor
BWR	Boiling Water Reactor
FBR	Fast Breeder Reactor
HTR	High Temperature Reactor
PTR	Pressure Tube Reactor
SSR	Superheated Steam Cooled Reactor
Figures	Gross capacity [MWe]
as at:	03/2020

Nuclear fuel supply

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.

Facilities for the fabrication of uranium, high temperature reactor (HTR) and mixed-oxide (MOX) fuel were operated at the Hanau site. These have meanwhile been decommissioned and dismantled.

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

Although in the former GDR there were large uranium deposits in the Erzgebirge, no 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 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 and measures

A memorandum of the German Atomic Commission, an advisory body to the former Ministry for Atomic Issues, of 9 December 1957 already pointed out the need for comprehensive development work in the field of radioactive waste management. Since 1976, the Atomic Energy Act (AtG) [1A-3] has been containing the requirement that radioactive waste is to be disposed of in a controlled manner by the introduction of § 9a AtG. Furthermore, the Principles Relating to the Provisions to be Made for the Handling and Disposal of Spent Fuel of Nuclear Power Plants [BUN 79], which were amended by decision of the heads of government of the Federation and the *Länder* on 28 September 1979 stipulated as a prerequisite for licences to commission and operate the nuclear power plants that the guaranteed safe storage of the spent fuel had to be demonstrated six years in advance.

In the GDR, the Office for Residual Radioactive Material and Wastes (*Zentrale für radioaktive Rückstände und Abfälle*) was established in Lohmen, Sebnitz district (Saxony) with effect from 1 April 1959 with the tasks of registration, transportation, treatment and concentration as well as the emplacement of residual radioactive material 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 disposal facility for low- and intermediate-level radioactive waste led to the closure of the Lohmen site. From 1971, the radioactive waste temporarily stored here had been 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.

Spent fuel reprocessing in Germany

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 1990, the WAK was taken out of operation and is currently being dismantled. The approximately 60 m³ of high level fission product solutions from operation were vitrified at the Karlsruhe vitrification facility (VEK) in the period from September 2009 to June 2010. Five casks of the CASTOR® HAW 20/28 CG type filled with the 140 canisters produced were transferred to the Storage Facility North (ZLN) of the Entsorgungswerk für Nuklearanlagen GmbH (EWN) in Rubenow near Greifswald.

In the 1970s, the German electric power utilities planned the so-called Nukleares Entsorgungszentrum (NEZ), a nuclear waste management centre consisting of a reprocessing plant, fuel fabrication plants for uranium and MOX fuel, waste management facilities for all types of waste and a disposal facility for all this waste. The NEZ was to be constructed at the Gorleben site in Lower Saxony (see Chapter D.3.3 for details). With the exception of the disposal facility 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 Wackersdorf in Bavaria. In 1989, this project was also abandoned and the ongoing licensing procedure was cancelled. From then onwards, the utilities exclusively turned their attention instead to reprocessing in other European countries.

In the GDR, planning began in 1968 for a plant for “refabrication of fuel assemblies”, called “Komplex 04” in which spent fuel assemblies were to be reprocessed for the fast experimental reactor BOR-60 in the USSR. The plant went into operation in the USSR in 1977.

Reprocessing of spent fuel in other European countries

Until the end of 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 by 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], 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 objective of direct disposal of spent fuel.

The plutonium separated during reprocessing was used for the fabrication of mixed-oxide (MOX) fuel and fully recycled in German light water reactors. Thus, the recycling of the entire separated plutonium has been completed by reuse. Some of the separated uranium was recycled in German nuclear power plants, but some was also transferred to the reprocessing companies. The radioactive waste produced during reprocessing is subject to mandatory take-back obligations under nuclear and private law as well as corresponding agreements under international law.

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 nuclear power plants Greifswald and Rheinsberg was built in Rubenow and put into operation in 1999. For the fuel spheres of the AVR reactor, a cask storage facility was built in the FZJ. The storage licence was granted on 17 June 1993 and expired on 30 June 2013. The storage of the fuel spheres is currently based on an order issued by the competent supervisory authority of the *Land* of North Rhine-Westphalia (see Chapter D.2 for details).

Since according to § 9a AtG, delivery 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 adequate waste management provisions exist for the spent fuel and for the radioactive waste to be taken back from abroad by the provision of adequate storage capacities with the objective of direct disposal. This requirement was met with the construction and operation of decentralised spent fuel storage facilities for the storage of spent fuel until delivery to a facility of the Federation for disposal.

At twelve nuclear power plant sites, decentralised spent fuel storage facilities were constructed and commissioned (see Table L-4). The storage licence for the Brunsbüttel spent fuel storage facility granted on 28 November 2003 was revoked with the judgment of the Schleswig-Holstein Higher Administrative Court on 19 June 2013 and its confirmation by the Federal Administrative Court on 8 January 2015; a new licence was applied for on 16 November 2015. The legal basis for the storage of the spent fuel is currently a supervisory order issued by the Ministry of Energy, Agriculture, the

Environment, Nature and Digitalisation of the *Land* of Schleswig-Holstein until the licensing procedure has been completed.

With the Act Regulating the Transfer of Financing and Action Obligations for the Management of Radioactive Waste from Operators of Nuclear Power Plants (Waste Management Transfer Act – EntsorgÜG) [1A-34]), storage, so far the responsibility of the nuclear power plant operators, is transferred to the Federation. For the implementation of this operational task, a federally-owned company in private legal form, BGZ Company for Storage (BGZ), was newly founded, whose task is to ensure safe and reliable storage of spent fuel, waste from reprocessing, and low- and intermediate-level radioactive waste from the operation and decommissioning of nuclear power plants. Since 1 August 2017, BGZ has been operating the two central spent fuel storage facilities in Ahaus and Gorleben in technical and organisational terms. On 1 January 2019, the decentralised spent fuel storage facilities at the sites of the German nuclear power plants, with the exception of Brunsbüttel, were also transferred to BGZ. BGZ therefore operates the decentralised spent fuel storage facilities at the sites Biblis, Brokdorf, Grafenrheinfeld, Grohnde, Gundremmingen, Isar, Krümmel, Lingen, Neckarwestheim, Philippsburg and Unterweser in addition to the two central storage facilities. As soon as the licence for Brunsbüttel has been granted, this decentralised spent fuel storage facility will also be transferred to BGZ.

Conditioning of spent fuel

The original purpose of the Gorleben pilot conditioning plant was to demonstrate the processing and packaging of spent fuel assemblies and thus served to develop and test the techniques and process steps required for direct disposal. According to an ancillary provision in the licensing decision, its use is limited to the repair of defective transport and storage casks for spent fuel elements and HLW glass canisters that may become necessary.

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 extended storage. The waste is to be conditioned as quickly as possible in a way that makes it qualified for disposal, or in such a way that it can later be conditioned in a manner qualified for disposal.

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 delivered to external stationary facilities and the conditioned waste returned.

The radioactive waste is stored until it is transferred to a facility of the Federation for disposal. In addition to the storage of radioactive waste, decay storage of residual radioactive material is also pursued to facilitate processing at a later stage and, where intended, the clearance of the materials and thus to reduce the disposal volume (see e.g. Chapter D.3.2 for details).

Disposal

In the Federal Republic of Germany, investigations on the disposal of radioactive waste began with the rededication of the former potash and rock 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 stresses of the overburden and the decreasing load-carrying capacity of the mine workings.

According to § 57b then inserted into the Atomic Energy Act, the Asse II mine is to be closed without delay. The Federal Office for Radiation Protection (BfS), as the then 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, Energy, Building and Climate Protection (NMU) in written form on 11 February 2009.

After having examined three procedural options, 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 (see Chapter D.3.4 for details). In order to gain time for the implementation of retrieval, comprehensive stabilisation measures are being carried out in the mine workings.

The concept of retrieval provides for recovering all the waste, bringing it to the surface in containers and conditioning it there. This requires a facility above ground for the characterisation and conditioning of the waste, for buffer storage of the material and for storage of the conditioned waste. As a planning basis, the operator, the Federal Company for Radioactive Waste Disposal, assumes that all waste and an additional amount of contaminated crushed salt have to be treated and stored. The BfS has proposed criteria for site selection [BfS 14]. According to the BfS proposal, sites that can be connected to the premises of the Asse II mine are to be investigated first.

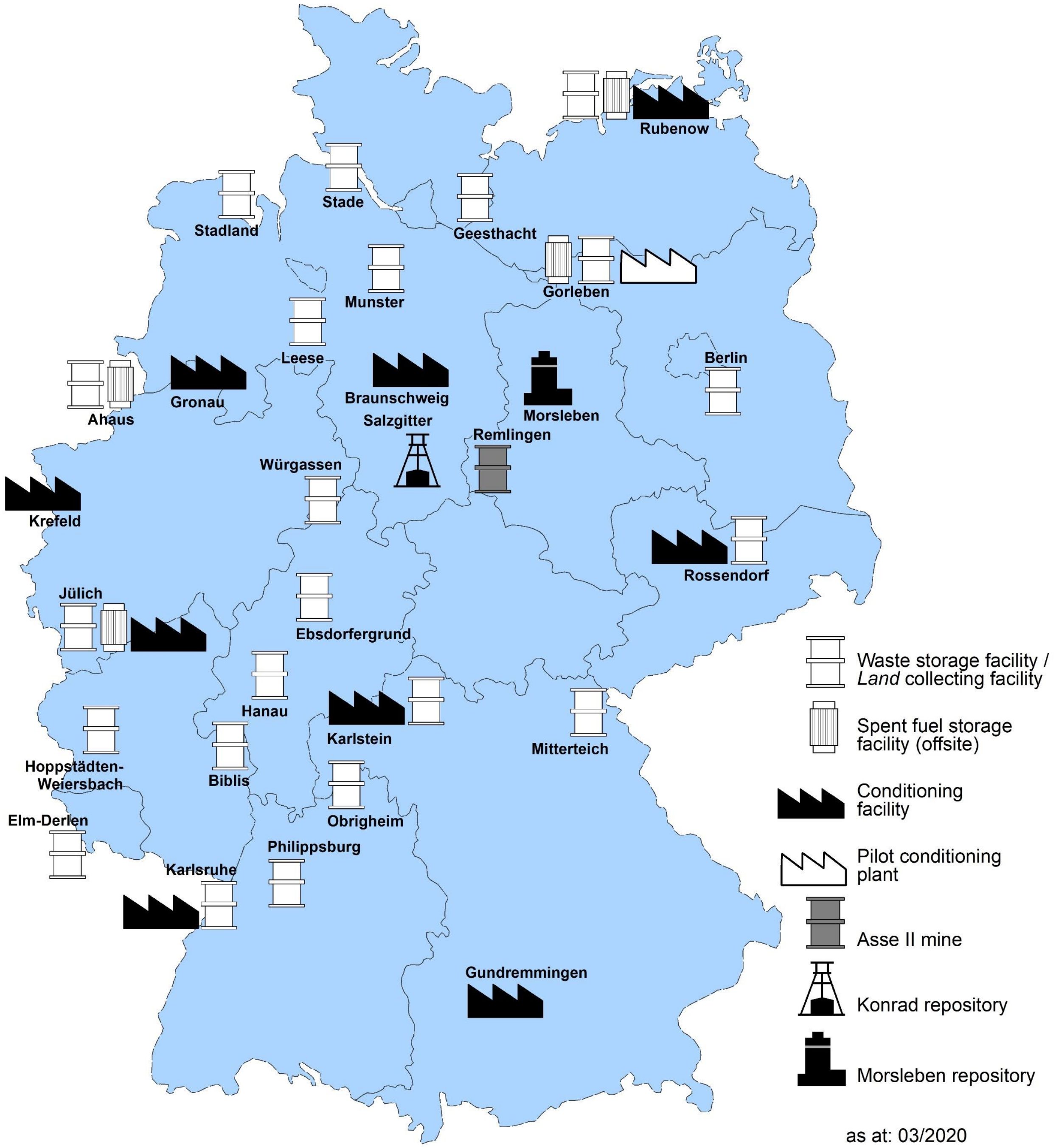
For the **Konrad mine**, a former iron ore mine, the plan approval decision regarding the construction and operation of a disposal facility for radioactive waste with negligible heat generation was issued on 22 May 2002. The complaints raised against the plan approval decision were rejected so that the decision became final in 2007. By letter dated 30 May 2007, the BfS was commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 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 company Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH (DBE) was commissioned with the conversion of the Konrad mine into a disposal facility. The BGE, into which DBE was integrated within the framework of the reorganisation of the organisational structure in the field of disposal [1A-30] in Germany continues this work. The current date given by BGE in the draft framework schedule for commissioning of the Konrad repository is the year 2027 (see Chapter D.3.3 for details).

The **Gorleben site** was initially agreed upon in 1977 for the establishment of a nuclear waste management centre for reprocessing and fuel fabrication as well as for the storage, treatment and disposal of radioactive waste. Later, the planning was limited to the use as a potential disposal facility site. Starting from 1979, the Gorleben salt dome had been explored geoscientifically for its suitability as a host rock for a disposal facility. In 1986, underground exploration of the salt dome began with the sinking of the shafts. The exploratory work was interrupted between October 2000 and September 2010 in the context of the decision to phase out the use of nuclear energy on the basis of a moratorium agreed between the Federal Government and the power plant operators. After clarification of conceptual and safety-related issues by the BfS, the exploration was resumed in October 2010, but then again discontinued in November 2012 in the context of the beginning discussions on the fundamental reorganisation regarding the issue of disposal of high-level radioactive waste. With the entry into force of the Act on the Search for and Selection of a Site for a Disposal Facility for Heat-Generating Radioactive Waste and for the Amendment of Other Laws (Site Selection Act – StandAG 2013) [1A-7a] on 27 July 2013, mining exploration was officially ended. A preliminary safety analysis for a potential disposal facility at the Gorleben site was completed without a suitability prognosis. In accordance with the amended Act on the Search for and Selection of a Site for a Disposal Facility for High-Level Radioactive Waste (Site Selection Act – StandAG) of 5 May 2017 [1A-7b], the mine is kept open in a reduced operating mode, subject to the compliance with all legal requirements and taking of the necessary maintenance measures until decision on a site, unless it will be excluded from the site selection procedure according to criteria laid down by law (§ 36 StandAG).

In the former GDR, the search for a central disposal facility 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 five 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, 37,241 m^3 of radioactive waste and 6,621 disused sealed radioactive 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. Since the end of emplacement operations, the plan approval procedure for backfilling and closure of the ERAM has been pursued which the BfS had already applied for on 9 May 1993.

The sites of today's spent fuel and radioactive waste management facilities – as far as they have not been constructed at the sites of nuclear power plants (see Figure A-2) – are shown in Figure A-3.

Figure A-3: Sites of spent fuel and radioactive waste management facilities (without decentralised spent fuel storage facilities and facilities covered by licences pursuant to § 7 AtG)



<u>Reorganisation regarding the issue of disposal of high-level radioactive waste</u>

With the amended Site Selection Act of 5 May 2017 [1A-7b] (see Chapter E.2.2 for details on the Site Selection Act), the criteria and decision-making basis for site selection were laid down and the site selection procedure started. The further procedure is to take place in three phases: (1) identification of siting regions; (2) surface exploration of selected siting regions and selection of possible sites; (3) underground exploration of selected sites and decision on the site (see Chapter H.3.2 for details on the disposal facility for high-level radioactive waste). In accordance with the Site Selection Act, the aim is to have the site selected by 2031. The site decision will be followed by the licensing procedure according to § 9b(1a) AtG.

On 1 September 2014, today's Federal Office for the Safety of Nuclear Waste Management (BASE) was founded as the new licensing and supervisory authority for radioactive waste management, which also monitors the implementation of the site selection procedure. In July 2016, the Federal Company for Radioactive Waste Disposal (BGE) was founded as the project implementer for planning, construction, operation and decommissioning of disposal facilities, which is organised under private law but remains in federal ownership. On 25 April 2017, the operator tasks were transferred to the BGE (see Chapter E.2.2 for details the Act on the Reorganisation of the Organisational Structure in the Field of Disposal).

<u>Contaminated areas from uranium mining</u>

In 1946, a Soviet-owned stock company began mining uranium ore on the territory that was later to become the GDR. From 1954, mining has been continued by the Soviet-German Wismut joint-stock company but 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 residual material left over from the former uranium ore mining does 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 was added according to a decision of the Second Review Meeting and provides an overview of the situation regarding spent fuel and radioactive waste management in Germany. The polluter pays principle applies to the financing of waste management. The management of spent fuel from nuclear power plants on the territory of the former GDR and the retrieval and management of radioactive waste from the Asse II mine are the responsibility of the Federation. The Morsleben repository for radioactive waste (ERAM) is regarded to be a completed waste management path.

Table A-2: Spent fuel and radioactive waste management in Germany

Waste management task	Long-term strategy	Financing	Current practice/ facilities	Planned facilities
Spent fuel	<u>Power reactors</u>: Dry storage in casks, possible subsequent conditioning and direct disposal in deep geological formations.	Payment by the electric power utilities into a fund under public law; funds are administered by the state. The Federation is responsible for financing the management of spent fuel from the nuclear power plants on the territory of the former GDR.	Three central storage facilities, AVR cask storage facility and 12 decentralised spent fuel storage facilities.	Facility of the Federation for disposal planned; site selection procedure according to the Site Selection Act restarted in 2017.

Waste management task	Long-term strategy	Financing	Current practice/ facilities	Planned facilities
	Research reactors: Dry storage in casks, possible subsequent conditioning and direct disposal in deep geological formations; in exceptional cases return to country of origin.	Financing from public funds.	Temporary on-site storage, storage in the BZA or the Storage Facility North (ZLN).	
Radioactive waste from the nuclear fuel cycle and the operation of the nuclear power plants (incl. research centres and research reactors)	Storage at the site of origin or centrally with the objective of disposal in deep geological formations.	Nuclear fuel supply: Provisions for all steps of waste management; annual reimbursement of costs incurred by the Federation. Power reactors: Provisions for processing and packaging; payment of the funds for storage and disposal by the electric power utilities into a fund under public law; funds are administered by the state. Publicly-owned facilities: Financing from public funds.	Processing and storage at the place of origin or in central facilities.	Waste with negligible heat generation: Konrad repository licensed and under construction; commissioning scheduled for 2027. Heat-generating (high-level radioactive) waste: Federal disposal facility planned; site selection procedure in accordance with the Site Selection Act.
Other radioactive waste	Medical applications, industry and research: Storage by *Land* collecting facilities with the objective of disposal in deep geological formations.	Waste producers pay fees to the *Land* collecting facilities; *Land* collecting facilities pay share for disposal over to the Federation.	Processing and storage; 11 *Land* collecting facilities.	Konrad repository licensed and under construction; commissioning scheduled for 2027.
	Asse II mine: Retrieval of the waste, processing and storage with the aim of disposal in deep geological formations.	Financing by the Federation.	Fact finding and planning of the retrieval as well as stabilisation of the mine workings.	The possibility of emplacement in the planned federal disposal facility has to be considered in the site selection procedure according to the Site Selection Act.
Decommissioning of nuclear installations	Decommissioning of the facilities and release of buildings and site areas from the scope of the Atomic Energy Act.	Formation of provisions in the case of facilities of the electric power utilities and of the nuclear fuel cycle, financing from public funds in the case of publicly-owned facilities.	Mainly immediate dismantling.	If necessary, further storage capacity for waste from decommissioning.

Waste management task	Long-term strategy	Financing	Current practice/ facilities	Planned facilities
Disused sealed radioactive sources	Delivery to the manufacturer/carrier or delivery as radioactive waste to a *Land* collecting facility for processing and storage with the objective of disposal in deep geological formations.	Waste producers pay fees to the *Land* collecting facilities; *Land* collecting facilities pay share for disposal over to the Federation.	Repackaging by the manufacturer or processing and storage as radioactive waste; 11 *Land* collecting facilities.	Konrad repository licensed and under construction; commissioning scheduled for 2027.

B Policies and practices

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

B.1.1 Spent fuel management policy

Germany's objective regarding the management of spent fuel has changed. Until 1994, reusing the fissile material in the spent fuel was required by law. Legislation was changed in 1994, and the nuclear power plant licence holders 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 generation 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 that exists and will be generated in future in Germany as radioactive waste is permissible.

For the spent fuel that had been delivered for reprocessing until 30 June 2005, proof of reuse of the plutonium separated during reprocessing had to be furnished. This was to ensure that throughout the remaining residual operating lives of the nuclear power plants, all separated plutonium was processed into mixed-oxide (MOX) fuel and reused.

Spent fuel assemblies are to be disposed of together with heat-generating radioactive waste (high- and medium-level radioactive waste) from reprocessing. The selection of a disposal facility site is reported on under the heading Site Selection Act in Chapter E.2.2. As there is as yet no disposal facility available for the spent fuel, it will generally be stored at the sites where it was generated until a disposal facility is commissioned; corresponding storage capacities exist as needed.

In connection with the amendment of the Site Selection Act (StandAG) [1A-7b], the recommendation of the Commission on the Storage of High-Level Radioactive Waste (which was active from 2014 until 2016 and consisted of representatives of the scientific community and different social groups as well as of members of *Land* parliaments and the German *Bundestag*) on an export ban for spent fuel from reactors that are not used for commercial electricity generation was implemented by a corresponding amendment of the Atomic Energy Act. According to this amendment, the export of spent fuel from research reactors is only permitted for serious reasons of non-proliferation of nuclear fuel or for reasons of a sufficient supply of German research reactors with fuel asemblies for medical and other top-level research purposes. An exception to this is the shipment of such fuel assemblies with the aim of producing waste packages that are qualified for disposal and that are to be disposed of in Germany. An export licence shall not be granted if the spent fuel is already stored in Germany pursuant to § 6 AtG.

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. The licence holders of the nuclear power plants have provided proof of the safe reuse of all plutonium generated by means of its reuse as MOX fuel in reactors and of 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 disposal facility.

B.1.3 Radioactive waste management policy

With the amendment of the Site Selection Act (StandAG) in 2017 [1A-7b], the procedure to select a site for a disposal facility for high-level radioactive waste was started. The objective of the Site Selection Act is to find a site for a disposal facility that ensures the best-possible safety for a period of one million years. The site selection procedure is to be concluded by 2031.

The legal requirement is that all steps of radioactive waste management are subject to the polluter pays principle.

In accordance with this principle, the state obligates the waste producers by law to ensure the controlled and safe management of radioactive waste generated during the operation and decommissioning of nuclear installations and facilities (e.g. nuclear power plants and research centres). As such, they built or ordered facilities in which the radioactive waste produced can be treated and stored until its disposal. This may take place either in decentralised or central facilities. The Waste Management Transfer Act (EntsorgÜG) [1A-35] regulated the transfer of financing and action obligations for the management of radioactive waste from the licence holders of nuclear power plants to the Federation. The financial means for storage and disposal were made available to the Federation by the licence holders in 2017 in a fund under public law. Accordingly, the Federation has now assumed the financing obligation for the storage and disposal of radioactive waste pursuant to Annex 1 of the Act on the Establishment of a Fund for the Financing of Nuclear Waste Management (Waste Management Fund Act – EntsorgFondsG) [1A-36]. On 1 January 2019, the licence holders transferred the storage facilities (for spent fuel) listed in Annex Table 1 EntsorgÜG free of charge to the third party commissioned with storage management by the Federation, BGZ Company for Storage (BGZ), and on 1 January 2020 free of charge the storage facilities (for radioactive waste) listed in Annex Table 2 EntsorgÜG. In addition, the licence holders' obligation to act with regard to radioactive waste management passes to the Federation, starting with the transfer of the properly packaged waste to the BGZ (see Chapter E.2.2 for details on the Act on the Reorganisation of Responsibility in Nuclear Waste Management).

There are international agreements for the return of radioactive waste from reprocessing of German fuel assemblies in France and the United Kingdom. Until the waste is handed over to a storage facility operated by the BGZ, it will remain the respective waste originator's responsibility.

In so far as it is not stored by the producer, radioactive waste from research, industry and medicine must be delivered to *Land* collecting facilities that have to be 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.

B.1.4 Radioactive waste management practices

For disposal in deep geological formations, the radioactive waste requires conditioning. Radioactive waste is treated according to qualified procedures in such a way that it can be ensured that it is directly conditioned for disposal or at least treated in such a way that it becomes qualified for disposal by further treatment. This comprises several stages, depending on the type and nature of the radioactive waste. After targeted collection or segregation (where necessary), the radioactive waste may first be pretreated and then be either processed into interim products or directly into packages qualified for storage and disposal.

Proven methods and reliable mobile or stationary facilities already exist for the pretreatment and conditioning of radioactive waste. Mobile conditioning facilities are the preferred choice for the treatment and packaging of operational waste from nuclear power plants. Stationary facilities that are capable of conditioning various types of radioactive waste are used, among others, at the major research centres; there are also a number of other stationary conditioning facilities, which are operated on site by the respective waste producers.

In addition to German facilities, facilities abroad are also utilised for waste management. Radioactive waste from the operation of nuclear installations is delivered e.g. to Sweden for conditioning and subsequently returned to Germany.

Both central and decentralised storage facilities are available for the storage of radioactive waste with negligible heat generation from nuclear power plants and the nuclear industry. For waste from the use and handling of radioisotopes in research, industry and medicine (see reporting on Article 32(1)iii in Chapter B.1.3), *Land* collecting facilities operated by the *Länder* are available for storage.

Heat-generating radioactive waste may be kept in storage in decentralised and central storage facilities. Waste from the reprocessing of spent fuel from German nuclear power plants in France and the United Kingdom is conditioned there on site (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. As stipulated in the Atomic Energy Act (AtG) [1A-3], solidified fission product solutions from reprocessing abroad shall now be stored in local storage facilities. According to § 6(5) AtG, the storage of nuclear fuel in nuclear installations shall not exceed 40 years, starting from the emplacement of the first cask. These licenses may only be extended for irrefutable reasons and after prior consultation of the German *Bundestag*.

B.1.5 Criteria used to define and categorise radioactive waste

Residual radioactive materials are produced during the operation of nuclear installations and facilities as well as during the decommissioning or dismantling of such facilities. These materials are composed of reusable or recyclable materials and radioactive waste. Radioactive waste refers to materials which according to the Atomic Energy Act [1A-3] and the Ordinance on Protection Against the Harmful Effects of Ionising Radiation (Radiation Protection Ordinance - StrlSchV) [1A-8b] must be disposed of in an orderly manner (see the definitions in § 2 AtG, regulations on the utilisation of residual radioactive material without detrimental effects and disposal of radioactive waste in § 9a AtG and §§ 31 to 42 StrlSchV). The activities mentioned may also generate material that is marginally contaminated or activated so that its activity may be disregarded. These materials can be cleared and are then no longer radioactive materials in the sense of the law, but are disposed of as conventional waste.

Provided such material is proven to comply with the clearance levels stated in Appendix 4, Table 1 §§ 35 and 36 StrlSchV, it can be cleared and utilised, recycled, disposed of, possessed or transferred to third parties as non-radioactive material (see reporting on Article 24 in Chapter F.4.6). What is essential for clearance is that the effective dose that may occur in case of reuse or disposal will only be in the range of 10 µSv/a for members of the general public. Cleared tools and components can be used e.g. in conventional plants. Metals can be recycled by melting them down. Rubble can be used as raw material in road building, for backfilling of landfills 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. Accordingly, there is no need to differentiate between waste containing radionuclides with comparatively short half-lives and waste containing radionuclides with comparatively long half- lives. Thus, there are no measures or precautions required in order to separate the radioactive waste produced.

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 comply with the requirements for safety assessment of an underground disposal facility. In this respect, the effects of heat generation from radioactive waste on the design and evaluation of a disposal facility system are particularly important since the natural temperature conditions may be significantly altered by the waste emplaced. 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 commonly used at international level and to choose a new classification instead, which was made with 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 radioactive waste and
- radioactive waste with negligible heat generation.

This basic subdivision will also be made if the waste packages to be disposed of are kept in extended surface storage prior to their transportation to a disposal facility. Irrespective of this, the terms LAW or 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 Morsleben repository for radioactive waste (ERAM), 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 future disposal facility according to the Site Selection Act (StandAG) [1A-7b], the term high-level radioactive waste is used for the radioactive waste to be disposed of there. Apart from the spent fuel assemblies, this includes all radioactive waste from reprocessing, both high-level radioactive waste and heat-generating medium-level radioactive radioactive waste.

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 disposal facility in deep geological formations (use of special emplacement techniques, thermal design of the disposal mine). It comprises in particular the vitrified fission product concentrate, the supercompressed hulls and structural components as well as the vitrified waste products from waste water treatment from the reprocessing of spent fuel as well as the spent fuel itself when it is to be disposed of directly as radioactive waste.

Types of waste with significantly lower activity concentrations from the operation and decommissioning of nuclear installations and facilities as well as from the application of radioisotopes are classified among the radioactive waste with negligible heat generation. These are 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 radioactive sources, sludges, suspensions and oils as well as contaminated and activated concrete structures and debris.

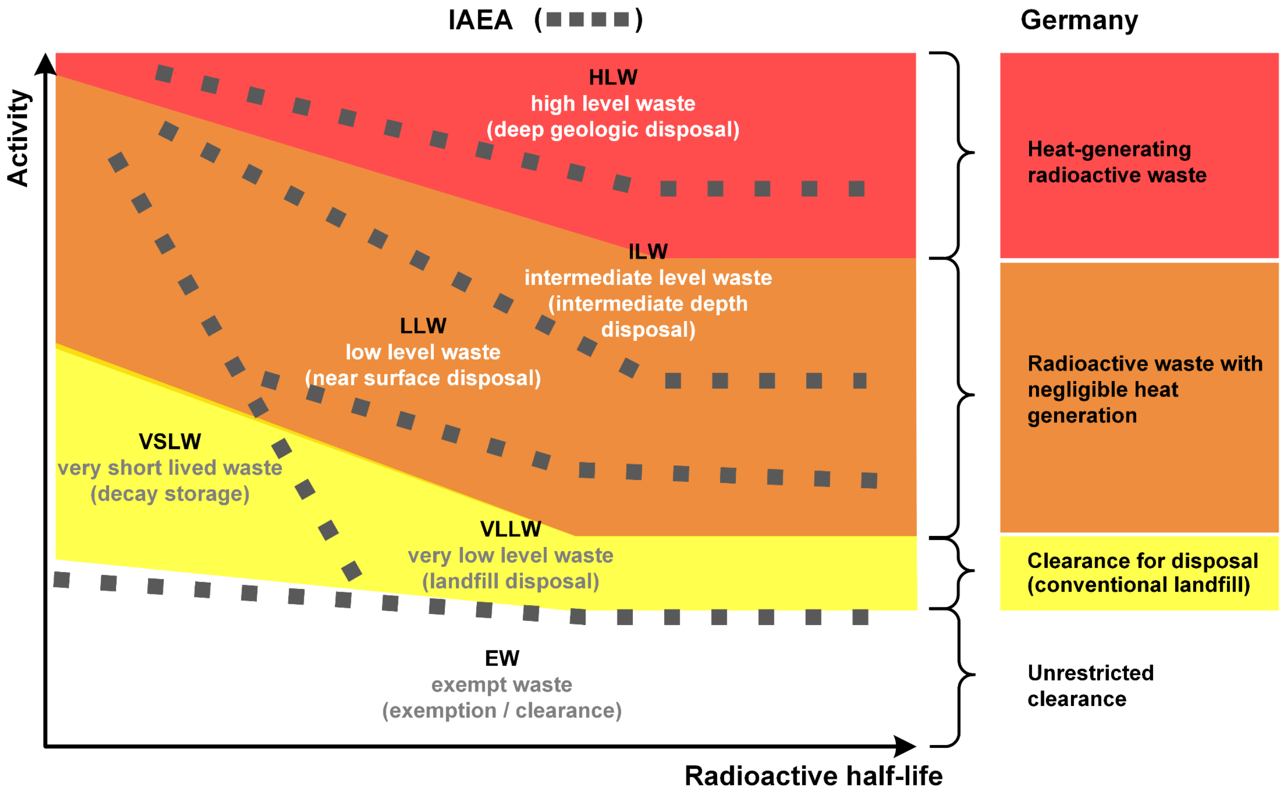
The term “radioactive waste with negligible heat generation” was quantified within the scope of the planning work for the Konrad repository. The objective of the related work was that the temperature conditions prevailing underground would only be influenced by the emplaced waste packages to a negligible 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 Kelvin 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 decision for the Konrad repository of 22 May 2002.

The waste categorisation according to heat-generating radioactive waste and radioactive waste with negligible heat generation has proven expedient. It is compatible with the International Atomic Energy Agency (IAEA) proposal for classification in the Safety Standard *“Classification of Radioactive Waste”* [IAEA 09a] which additionally permits a further subdivision into short lived and long lived waste, thus allowing waste to be assigned to near-surface disposal facilities and geological disposal facilities. In this Safety Standard, the IAEA recommends 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 facility,
- Intermediate Level Waste (ILW), disposal at intermediate depth, and
- High Level Waste (HLW), disposal in deep geological formations.

Figure B-1 includes 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 radioactive waste (red area) yet reaches into the area of ILW and that certain types of waste referred to as VLLW according to the IAEA already exceed the current German clearance levels for management as conventional waste and therefore have 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 [IAEA 09a] and the German classification



Based on Directive 2011/70/EURATOM [1F-36] and the resulting preparation of a report on the National Programme (NaPro) for spent fuel and radioactive waste management [BMU 15], the radioactive waste is further classified according to the processing and examination conditions (see Chapter D.4.1).

C Scope of application

This section deals with the obligations under Article 3 of the Joint 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 Spent fuel and radioactive waste from civil use of nuclear energy

The scope of this Article and therefore the obligation of reporting encompasses the safety of the management of spent fuel from German nuclear power plants and research reactors which is stored with the intention of disposal. Furthermore, the scope of this Article encompasses the safety of the management of radioactive waste from the operation and decommissioning of German nuclear power plants and research reactors as well as from the use for medical, industrial and research purposes, and is therefore subject to reporting.

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

C.2 Distinction between NORM and radioactive waste

In Germany, Council Directive 2013/59/EURATOM [1F-24] of 5 December 2013 has been transposed into the national radiation protection legislation. The new Act on the Protection against the Harmful Effects of Ionizing Radiation of 27 June 2017 (Radiation Protection Act – StrlSchG) [1A-34] came into force in its entirety on 31 December 2018 together with the new Radiation Protection Ordinance of 29 November 2018 (StrlSchV) [1A-8b]. Accordingly, a distinction is drawn between regulations for radioactive material from nuclear installations and other handling licensed according to radiation protection legislation on the one hand, and waste that contains only naturally occurring radioactive material (NORM) on the other hand. For NORM, some of the applicable requirements are principally different from requirements applicable to radioactive materials from nuclear installations and other handling, which is licensed according to nuclear or radiation protection legislation:

According to the Radiation Protection Act, residual substances from activities with NORM are not considered as "radioactive substances" but as "residual materials" or "other materials" whose need for supervision results from the constraint for the effective dose of 1 mSv/a for members of the general public and is specified in the Radiation Protection Ordinance by means of test values of the specific activity. Accordingly, the release from regulatory control of residual materials and other materials is based on the proof that the constraint for the effective dose is not exceeded.

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

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

The processing 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 disposal facility. Until then, it is stored in a central collecting facility. If necessary, the waste will previously be conditioned according to the waste acceptance criteria of the disposal facility. All these waste management stages are subject to the same safety provisions as those applicable in the civil sector.

C.4 Radioactive discharges

The scope of the Joint Convention and therefore the reporting obligation also encompasses the radioactive discharges as provided for in Articles 4 (see Chapter G.1), 7 (see Chapter G.4), 11 (see Chapter H.1), 14 (see Chapter H.4), 24 (see Chapter F.4) and 26 (see Chapter F.6). Reporting on provisions and measures related to limitation of radioactive discharges may be found in Chapter F.4.5.

D Inventories and lists

Developments since the Sixth Review Meeting:

At the Brunsbüttel nuclear power plant, the storage licence for the decentralised spent fuel storage facility was revoked with the Federal Administrative Court's decision of 8 January 2015. The legal basis for the storage of the spent fuel is currently a supervisory order issued by the Ministry of Energy, Agriculture, the Environment, Nature and Digitalisation of the *Land* of Schleswig-Holstein until the licensing procedure has been completed.

In 2017, the fuel assemblies from the wet storage facility of the Obrigheim nuclear power plant were transported in 15 casks by ship to the Neckarwestheim decentralised spent fuel storage facility in five batches.

On 29 May 2019, the operator of the Storage Facility North (ZLN) filed an application for a licence to store the 74 casks of the CASTOR® type in a new building.

At the Konrad repository site, the construction measures were continued. The winding engine house Konrad 1 North and the administration and social building have been erected. Underground, most of the excavation work for the inset on the second level ("transfer station" for transport from the shaft into the drift) has been completed. Before that, the extension of the shaft had been completed there.

At the Asse II mine, the backfilling of mine workings no longer required as a stabilisation measure was continued. By drilling into an emplacement room within the framework of the fact-finding mission, the condition of the casks could be assessed visually for the first time and representative gas samples could be taken from the interior of the emplacement room. As part of the planning of a new shaft site, the salt structure is being explored by surface and underground drilling and seismic measurements.

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

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 A-3.

D.1 Spent fuel management facilities

The spent fuel unloaded from the reactor core is initially stored in spent fuel pools inside the reactors buildings for several years. Wet storage is conducted to achieve the required decay of activity and heat until the fuel assemblies are placed in transport and storage casks for dry storage and gives the operator sufficient flexibility for the operation of the facility.

The following facilities shall be considered as spent fuel management facilities within the meaning of the Joint Convention:

- the decentralised spent fuel storage facilities at the sites of the nuclear power plants,
- the central spent fuel storage facilities in Ahaus, Gorleben and Rubenow,
- the AVR cask storage facility in Jülich,
- the pilot conditioning plant in Gorleben.

The following Table D-1 provides an overview of the storage capacities and stored quantities at the respective sites of the storage facilities and shows in which year the licence for the respective storage facility expires.

Detailed information on existing and planned facilities can be found in Annex L-(a). The tabular overviews there also include the spent fuel pools inside the reactor buildings.

The spent fuel reprocessing plant at Karlsruhe (WAK) is dealt with within the reporting on Article 32(2)(v) in Chapter D.5.

Table D-1: Storage facilities and conditioning plant for spent fuel as at 31 December 2019 a) Spent fuel storage facilities b) Conditioning plant

a) Spent fuel storage facilities

Site	Storage capacity		Status		Stored
	Positions for casks / fuel assemblies	[Mg HM]	Licensed	Applied for	[Mg HM]
Fuel pools inside reactor buildings					
Nuclear power plants in total	16,327 positions [1)]	approx. 5,227 [1)]	x		2,539
Decentralised spent fuel storage facilities (dry storage)					
Biblis (KWB)	135 cask positions	1,400	until 2046		987
Brokdorf (KBR)	100 cask positions	1,000	until 2047		320
Brunsbüttel (KKB)	80 cask positions	450	Licence by court order invalid since 2015	New licence applied for in 2015	161
Grafenrheinfeld (KKG)	88 cask positions	800	until 2046		418
Grohnde (KWG)	100 cask positions	1,000	until 2046		331
Gundremmingen (KRB)	192 cask positions	1,850	until 2046		593
Isar (KKI)	152 cask positions	1,500	until 2047		667
Krümmel (KKK)	80 cask positions	775	until 2046		353
Lingen/Emsland (KKE)	130 cask positions [2)]	1,250	until 2042		455
Neckarwestheim (GKN)	151 cask positions	1,600	until 2046		676 [3)]
Philippsburg (KKP)	152 cask positions	1,600	until 2047		561
Unterweser (KKU)	80 cask positions	800	until 2047		368
Central spent fuel storage facilities (dry storage)					
Gorleben	420 cask positions [4)]	3,800	until 2034		37 [5)]
Ahaus	420 cask positions [6)]	3,960	until 2036		55 [7)]
Rubenow	80 cask positions	585	until 2039		583
AVR cask storage facility					
Jülich	158 casks	0.225 [8)]	until 30.06.2013	Extension/order to remove fuel [9)]	0.086

[1)] Part of the storage capacity has to be kept free for unloaded cores.
[2)] 125 cask positions for loaded casks and 5 cask positions for empty casks.
[3)] 96 Mg HM of it from the Obrigheim NPP.
[4)] Including the positions for HLW canisters.
[5)] An additional 2 Mg HM in the HLW canisters.
[6)] Including cask positions in storage area I, for which a licence for storage of waste from operation and decommissioning was granted pursuant to § 7 StrlSchV on 26 May 2010 for a maximum of 10 years.
[7)] Total amount from power reactors, an additional approx. 6 Mg HM from the THTR and 2 Mg HM from the RFR.
[8)] Thermally fissile isotopes (U-233, U-235, Pu-239, Pu-241).
[9)] The licensing procedure for extending the storage could not be completed by 31 July 2014. On 2 July 2014, an order was issued on the removal of the nuclear fuel from the AVR cask storage facility.

b) Conditioning plant

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

D.1.1 Decentralised spent fuel storage facilities

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 spent fuel storage facilities were licensed, constructed and commissioned under nuclear law 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 stored.

The storage facilities are cooled by passive air convection which removes the heat from the casks independently of 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 qualified for at least 40 years of storage. Thus, the licences currently limit the storage period to 40 years, starting with the emplacement of the first cask. These licences may only be renewed on imperative grounds and after this issue has been discussed in the German *Bundestag*.

In 2017, the fuel assemblies of the Obrigheim nuclear power plant, which had been stored in a pool in the emergency building outside the reactor building until then, were transported to the decentralised spent fuel storage facility Neckarwestheim in 15 CASTOR®-type casks. A corresponding modification licence for the storage of the KWO fuel assemblies in the Neckarwestheim storage facility was granted on 9 August 2016. The licence for the transport of the casks by ship via the river Neckar was granted on 16 May 2017. A roll-on/roll-off ramp had been necessary at the Neckarwestheim site to create the conditions for transport. This was realised within the scope of a plan approval procedure with public participation. The ramp is also to be used for the transport of large components (transformers, steam generators). As a general rule, public participation is provided for projects for which there is an obligation to carry out an environmental impact assessment (EIA). However, according to the Environmental Impact Assessment Act (UVPG) [1B-14], the transport of radioactive material, including nuclear fuel, is not a project requiring an EIA.

The fuel assemblies were transferred to Neckarwestheim by a total of five ship transports, the last of which took place on 19 December 2017. Since then, the Obrigheim nuclear power plant has been free of fuel assemblies and fuel rods.

At the Brunsbüttel nuclear power plant, the storage licence for the decentralised spent fuel storage facility granted in 2003 was revoked with the Federal Administrative Court's decision of 8 January 2015. The decision of the Federal Administrative Court was not made because of insufficient safety of the storage facility. The courts did not comment on the question of actual safety. The judgment criticised the scope of the investigations and assessments in the licensing procedure. The legal basis for the storage of the spent fuel is currently a supervisory order pursuant to § 19 of the Atomic Energy

Act (AtG) [1A-3] issued by the Ministry of Energy, Agriculture, the Environment, Nature and Digitalisation of the *Land* of Schleswig-Holstein until the licensing procedure has been completed.

On 16 November 2015, an application was filed for a new licence for the storage of nuclear fuel pursuant to § 6 AtG in the decentralised spent fuel storage facility. The licensing procedure takes place with the participation of the public. The documents required for this purpose were laid open for public inspection at the Federal Office for the Safety of Nuclear Waste Management (BASE), the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Brunsbüttel Citizens' Office on 11 January 2017.

Figure D-1 shows a view into the interior of the decentralised spent fuel storage facilities at the Gundremmingen and Neckarwestheim sites.

Figure D-1: View into the decentralised spent fuel storage facilities at the Gundremmingen (left) and Neckarwestheim (right) sites (Copyright: BGZ)

D.1.2 Central storage facilities

Gorleben storage facility

The Gorleben storage facility is licensed for the storage of nuclear fuels in the form of spent fuel from light water reactors and HLW canisters (vitrified high-level radioactive fission product solutions from the reprocessing of German fuel assemblies). An application for the provision of storage capacity for radioactive waste with negligible heat generation has been filed (see Chapter D.3.2 for details).

Since 1995, spent fuel from nuclear power plants with a total of about 37 Mg HM has been stored in a total of five casks of the types CASTOR® IIa, CASTOR® Ic and CASTOR® V/19 at the Gorleben spent fuel storage facility (BZG). Within the scope of the 6th modification licence, the BGZ Company for Storage (BGZ) and Brennelemente-Lager Gorleben GmbH (BLG) were granted permission on 21 June 2018 to extend the structural protection against disruptive action or other interference by third parties.

Figure D-2 shows an aerial photograph and Figure D-3 a view into the BZG (including the 108 HLW canisters, see Chapter D.3.2). Further information on the storage facility in Gorleben can be found in Table L-2 of the annex.

Figure D-2: Pilot conditioning plant (PKA), spent fuel storage facility (BZG) and the radioactive waste storage facility (AZG) in Gorleben (Copyright: BGZ)

Figure D-3: View into the Gorleben spent fuel storage facility (Copyright: BGZ)

Ahaus storage facility

According to the licence granted, spent fuel from various German nuclear power plants may also be stored in the central spent fuel storage facility in Ahaus. In addition, the BZA is also 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.

The storage hall consists of two halves separated by a cask reception and maintenance area. One storage area, the Ahaus radioactive waste storage facility (AZA), is currently used for the storage of other radioactive material (see Chapter D.3.2 for details), the other storage area, the BZA, for the storage of spent fuel from light water reactors, from the Rossendorf research reactor and from the Hamm-Uentrop thorium high-temperature reactor (THTR). Currently, nuclear fuel is stored in storage area II (BZA) in a total of 329 casks of the types CASTOR® THTR/AVR (305 casks), CASTOR® MTR 2 (18 casks), CASTOR® V/52 (3 casks) and CASTOR® V/19 (3 casks).

It is planned to use the BZA also for the storage of further spent fuel from research reactors in casks of the CASTOR® MTR 3 type. In a letter dated 30 September 2014, the GNS Gesellschaft für Nuklear-Service mbH (GNS) requested the resumption of the nuclear licensing procedure for the storage of spent fuel of the research neutron source Heinz Maier-Leibnitz (FRM II) of the Technical University of Munich in the BZA. The Helmholtz-Zentrum Berlin for Materials and Energy (HZB) as the operator of the Berlin research reactor BER II which was finally shut down at the end of 2019, informed the BGZ at the beginning of June 2018 of its intention to store spent fuel of the BER II in Ahaus. A total of three casks with fuel are intended to be delivered to Ahaus. Transport and storage will be carried out in casks of the CASTOR® MTR 3 type. Storage in Ahaus requires a licence from the Federal Office for the Safety of Nuclear Waste Management (BASE). According to HZB planning, transport of the fuel to Ahaus is not expected before 2023.

On 21 July 2016, the 8th modification licence was granted for the storage of nuclear fuel in the form of spent fuel elements and other radioactive material in the form of operational elements (absorber and graphite elements with no fissile material content) from the operation of the experimental reactor of the former Arbeitsgemeinschaft Versuchsreaktor GmbH (AVR) in 152 transport and storage casks of the CASTOR® THTR/AVR type in the eastern part of the two storage areas (storage area II), which is still being stored in the AVR cask storage facility at the site of the Forschungszentrum Jülich (FZJ). The execution of the transports depends on the planning of the JEN Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH (JEN) (see Chapter D.1.3 for details).

Figure D-4 shows an aerial photograph of the Ahaus storage facility and Figure D-5 a view into the BZA. Further information on the storage facility in Ahaus can be found in Table L-2 of the annex.

Figure D-4: Ahaus storage facility for spent fuel and radioactive waste (Copyright: BGZ)

Figure D-5: Ahaus spent fuel storage facility (left: CASTOR® V and CASTOR® THTR/AVR, right: CASTOR® MTR 2 between CASTOR® THTR/AVR) (Copyright: BGZ)

Storage Facility North in Rubenow

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 HLW glass canisters from the WAK are currently stored in the Storage Facility North (ZLN), which is designed as a dry storage facility. The KNK fuel rods were emplaced in 2010, the HLW glass canisters in 2011.

The safety requirements for the storage of nuclear fuel that have been increased since 2011 have prompted the EWN Entsorgungswerk für Nuklearanlagen GmbH (formerly Energiewerke Nord GmbH) to plan a new building for all transport and storage casks stored in the ZLN. The plans provide for the erection of a free-standing storage building (ESTRAL) in the immediate vicinity of the ZLN to replace the existing storage facility. On 29 May 2019, the operator submitted an application for a licence to store the 74 CASTOR® casks in a new building.

An extended storage of the casks beyond the previously licensed 40 years has not been applied for. Since the application for storage of the nuclear fuel covers a period of more than 10 years, the project is subject to an environmental impact assessment. For this purpose, the BASE, as the competent licensing authority, will organise public participation.

Further information on the storage facility in Rubenow can be found in Table L-2 of the annex.

D.1.3 AVR cask storage facility in Jülich

In the storage facility in Jülich, i.e. the AVR cask storage facility, the spent fuel spheres from the operation of the experimental reactor of the former Arbeitsgemeinschaft Versuchsreaktor GmbH (AVR) are stored in 152 transport and storage casks of the CASTOR® THTR/AVR type. The original storage licence granted by the Federal Office for Radiation Protection (BfS) on 17 June 1993 had been limited to 20 years. The Forschungszentrum Jülich GmbH (FZJ) applied for the storage of AVR fuel elements in the AVR cask storage facility for a further three years from 1 July 2013, initially on 26 June 2007 and then with a more detailed letter dated 29 April 2009. Due to the reorganisation of responsibilities, today's Federal Office for the Safety of Nuclear Waste Management (BASE) is continuing the procedure. On the part of the applicant, the licensing procedure is now being conducted by the JEN Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH (JEN), which was founded on 1 September 2015 by merging the nuclear sectors of the FZJ with the AVR GmbH.

As the required safety demonstration with regard to seismic safety using standardised procedures had not been provided after expiry of the storage licence of 1993 on 1 July 2013 and thus the licence for continued operation of the AVR cask storage facility applied for could not be granted yet, the then Ministry of Economic Affairs, Energy, Industry, HMEs and Crafts of North Rhine-Westphalia (MWEIMH), as the competent nuclear supervisory authority, issued temporary orders on 27 June 2013 and 17 December 2013 on the basis of the general licensability of the licence application regarding the further storage of the nuclear fuel from the experimental reactor at the AVR cask storage facility in Jülich. It was not possible to conclude the licensing procedure until expiry of the second storage order on 31 July 2014 either, since the safety demonstration with regard to seismic safety could not be provided within the licensing procedure. Consequently, on 2 July 2014, the nuclear supervisory authority gave order to remove the nuclear fuel from the AVR cask storage facility. Monthly written reports must be submitted on the progress of the preparations for removing the nuclear fuel from the AVR cask storage facility and on the status of the licensing procedures required for it. The previous order of 17 December 2013 on the storage of the nuclear fuel has been repealed.

The operator developed a concept for the removal of the fuel from the AVR cask storage facility in accordance with specific requirements from the order and presented it to the MWEIMH. This concept provides for three options, whose sequence in which they are presented does not imply a priority listing from the technical view:

1. transport of the nuclear fuel to the Ahaus spent fuel storage facility,
2. shipment of the nuclear fuel to its country of origin, the United States of America, and
3. transport of the nuclear fuel to a new storage facility to be built at the Jülich site.

The nuclear supervisory authority has commissioned an authorised technical expert according to § 20 of the Atomic Energy Act (AtG) [1A-3] as well as a legal expert with the assessment of the concept in the sense of a plausibility check of the described processes, in particular with regard to issues related to safety and security, and with a legal assessment with regard to issues related to nuclear, environmental, transport and hazardous goods law.

According to the current state of knowledge, it is not yet foreseeable which of the three options of removal will be chosen by the JEN. Due to the extent and complexity of the issues to be examined, none of the three options is ready for decision yet. Government custody according to § 5 AtG can be ruled out, since according to § 5(2) AtG, storage of the nuclear fuel at the direct holder within the framework of a licence according to § 6 AtG has priority. Only in the case of nuclear fuel for which a person authorised to possess it cannot be ascertained or cannot be called upon, it is to be held in government custody.

On 21 July 2016, the then competent BfS granted the operator of the Ahaus storage facility the licence according to § 6 AtG for emplacement of the 152 casks of the CASTOR® THTR/AVR type, which are currently stored in Jülich. In addition, a transport of the casks from Jülich to Ahaus also requires a transport licence according to § 4 AtG. It is not yet foreseeable when the licence can be granted.

Further information on the storage facility in Jülich can be found in Table L-2 of the annex.

D.1.4 Pilot conditioning plant

The reference concept for direct disposal of spent fuel in a salt dome pursued until 2013 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 (PKA) 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, however, the use of the plant is licensed only for the repair of defective casks, if necessary, for spent fuel from light water reactors and for vitrified HLW from reprocessing as well as for the handling of other radioactive material. It is planned to decommission and dismantle the facility. Preparatory work for this is in progress.

Further information on the PKA in Gorleben can be found in Table L-3 of the annex.

D.2 Spent fuel inventory

An overview of the spent fuel from German power reactors by the end of 2019 is given in Table D-2 (classified according to place of origin) and Table D-3 (classified according to whereabouts). Table D-4 shows the whereabouts of the spent fuel from experimental and demonstration reactors.

D.2.1 Spent fuel quantities

Power reactors

In the spent fuel pools of the power plants, there is a total of 2,539 Mg HM of spent fuel (as at 31 December 2019).

In the decentralised storage facilities, which are designed for dry storage, 5,890 Mg HM, and in the central storage facilities in Ahaus and Gorleben 92 Mg HM are stored in transport and storage casks. The inventory is in the form of light water reactor (LWR) spent fuel assemblies which are stored in transport and storage casks. 583 Mg HM of VVER fuel assemblies from Greifswald and Rheinsberg are also stored in transport and storage casks in the Storage Facility North (ZLN) in Rubenow near Greifswald. A total of 6,673 Mg HM of spent fuel assemblies have already been removed from the nuclear power plants either for reprocessing or for permanently remaining abroad. The major part was sent to the La Hague and Sellafield reprocessing facilities. Table D-3 gives an overview of the whereabouts of the spent fuel.

As at 31 December 2019, there was a total of about 15,777 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 (see Table D-2), around 149 Mg HM of which had been produced in 2019. 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 (power > 50 MW) in the Federal Republic of Germany as at 31 December 2019

Type	Abbr.	Installation, site	Total quantities	
			Number FAs	[Mg HM]
Installations in operation				
PWR	KBR	Brokdorf	1,528	808
PWR	KWG	Grohnde	1,680	891
PWR	KKE	Emsland	1,532	798
PWR	GKN II	Neckarwestheim II	1,374	712
BWR	KRB-C	Gundremmingen C	5,035	862
PWR	KKI 2	Isar 2	1,464	765
Subtotal			**12,613**	**4,836**
Installations in the post-operational phase				
BWR	KKK	Krümmel	3,928	680
Installations under decommissioning				
BWR	KWL	Lingen	586	66
BWR	KRB-A	Gundremmingen A	1,028	125
BWR	KRB-B	Gundremmingen B	5,478	937
BWR	KWW	Würgassen	1,989	346
PWR	KMK	Mülheim-Kärlich	209	96
PWR	KWO	Obrigheim	1,235	348
PWR	KKS	Stade	1,517	539
PWR	KKR	Rheinsberg	918	106
PWR	KGR 1-5	Greifswald 1-5	6,813	787
PWR	KWB-A	Biblis Block A	1,676	877
PWR	KWB-B	Biblis Block B	1,824	957
BWR	KKP 1	Philippsburg 1	3,632	631
PWR	KKP 2	Philippsburg 2	1,564	827
PWR	GKN I	Neckarwestheim I	1,830	645
BWR	KKI 1	Isar 1	4,072	708
BWR	KKB	Brunsbüttel	2,664	457
PWR	KKU	Unterweser	1,717	904
PWR	KKG	Grafenrheinfeld	1,725	905
Subtotal			**40,477**	**10,261**
Total			**57,018**	**15,777**

Note: The quantities given in Mg HM are rounded to the nearest whole number. This may result in minor differences in the total compared to other figures published. The Mg HM quantities partly refer to data provided by the operators.

Table D-3: Overview of total quantities of spent fuel assemblies from German light water reactors (power > 50 MW) as at 31 December 31 December 2019

Place of storage/whereabouts	Quantity [Mg HM]
Spent LWR fuel in NPP spent fuel pools	2,539
Dry storage of spent VVER fuel in casks at ZLN	583
On-site dry cask storage	5,890
Dry cask storage in the Ahaus and Gorleben storage facilities	92
Shipped to La Hague (France) for reprocessing	5,393
Shipped to Sellafield (United Kingdom) for reprocessing	854
Reprocessed at the Karlsruhe reprocessing facility (WAK)	85
Reprocessed at the EUROCHEMIC reprocessing plant (Belgium)	14
Returned to the former USSR (VVER fuel)	283
Shipped to Sweden without return (CLAB)	17
Reuse of VVER fuel at Paks (Hungary)	27
Total	**15,777**

Note: The quantities given in Mg HM are rounded to the nearest whole number. This may result in minor differences in the total compared to other figures published. The Mg HM quantities partly refer to data provided by the operators.

Experimental and demonstration reactors

In addition to the power 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 the following (see overview in Annex L-(c), Table L-16):

- experimental reactor of the Arbeitsgemeinschaft Versuchsreaktor GmbH (AVR), Jülich,
- thorium high-temperature reactor (THTR-300), Hamm-Uentrop,
- multi-purpose research reactor (MZFR), Karlsruhe,
- compact sodium-cooled nuclear reactor plant (KNK II), Karlsruhe,
- experimental nuclear power plant (VAK), Kahl,
- Niederaichbach nuclear power plant, Niederaichbach,
- superheated steam reactor (HDR), Großwelzheim,
- nuclear ship Otto Hahn, Geesthacht.

The destinations and corresponding quantities of heavy metals for storage or reprocessing of the accumulated approx. 190 Mg HM spent fuel assemblies are summarised in Table D-4.

Table D-4: Management of spent fuel from experimental and demonstration reactors as at 31 December 2019

Facility	Quantities stored or reprocessed in [Mg HM]									Total
	WAK	BNFL	SKB	CEA	EURO-CHEMIC	FZ Jülich	BZA	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 Karlsruhe reprocessing plant, British Nuclear Fuels plc (BNFL) and the European Company for the Chemical Processing of Irradiated Fuels (EUROCHEMIC) in Belgium. Some of the fuel went to Sweden to the Swedish Nuclear Fuel and Waste Management Company (SKB) and to France to the French Alternative Energies and Atomic Energy Commission (CEA) and will remain there. The THTR fuel spheres are stored at the Ahaus spent fuel storage facility (BZA). They have been reported so far as an intermediate waste product and not as spent fuel. The approx. 290,000 AVR fuel spheres with 1.9 Mg HM (including thorium) are stored in 152 casks at the AVR cask storage facility in Jülich.

Research and training reactors

In Germany, six research and training reactors are in operation, another nine have been shut down permanently or are in the decommissioning phase (see Chapter A.2, section "Research and development" and Table L-14 for details).

The amount of spent fuel from research reactors stored as at 31 December 2019 is several orders of magnitude less than the amount to be managed from power reactors. As at 31 December 2019, 66 spent fuel assemblies with around 102 kg HM were stored at the Berlin experimental reactor (BER II). 46 spent fuel assemblies with around 319 kg HM and two converter plates with a total of around 0.5 kg HM were stored at the Heinz Maier-Leibnitz research neutron source (FRM II) in Garching. Four disused spent fuel assemblies with 764 g uranium were stored at the TRIGA research reactor in Mainz (FR MZ). Approximately 2 Mg of spent fuel (of which approx. 300 kg HM) of the Radiation Protection, Analytics & Disposal Rossendorf Inc. (VKTA) are stored in 18 CASTOR® MTR 2 casks in Ahaus.

The fuel assemblies from the facilities in Geesthacht and Jülich were all shipped to the United States of America and the United Kingdom. Fuel assemblies from the BER II have so far been returned to the United States of America. Due to an amendment of the Atomic Energy Act in the course of the further development of the Site Selection Act (StandAG) [1A-7b], the shipment of fuel assemblies from nuclear fission facilities for research purposes to other countries is now only permitted in exceptional cases. They are stored centrally in Ahaus until their disposal.

D.2.2 Activity inventory

The activity inventory of the spent fuel (as at 31 December 2019) in wet storage 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 assemblies in the storage facilities are classified according to different age categories. For the spent fuel assemblies unloaded until 1998, the assumed mean burn-up is 40 GWd/Mg HM, for the years 1999 to 2006 45 GWd/Mg HM, and as from 2007 50 GWd/Mg HM. Furthermore, a minimum decay period of one year for the last unloading is assumed. The underlying data are determined using an internationally recognised burn-up program.

Accordingly, the radioactive inventories as at 31 December 2019 are estimated as follows:

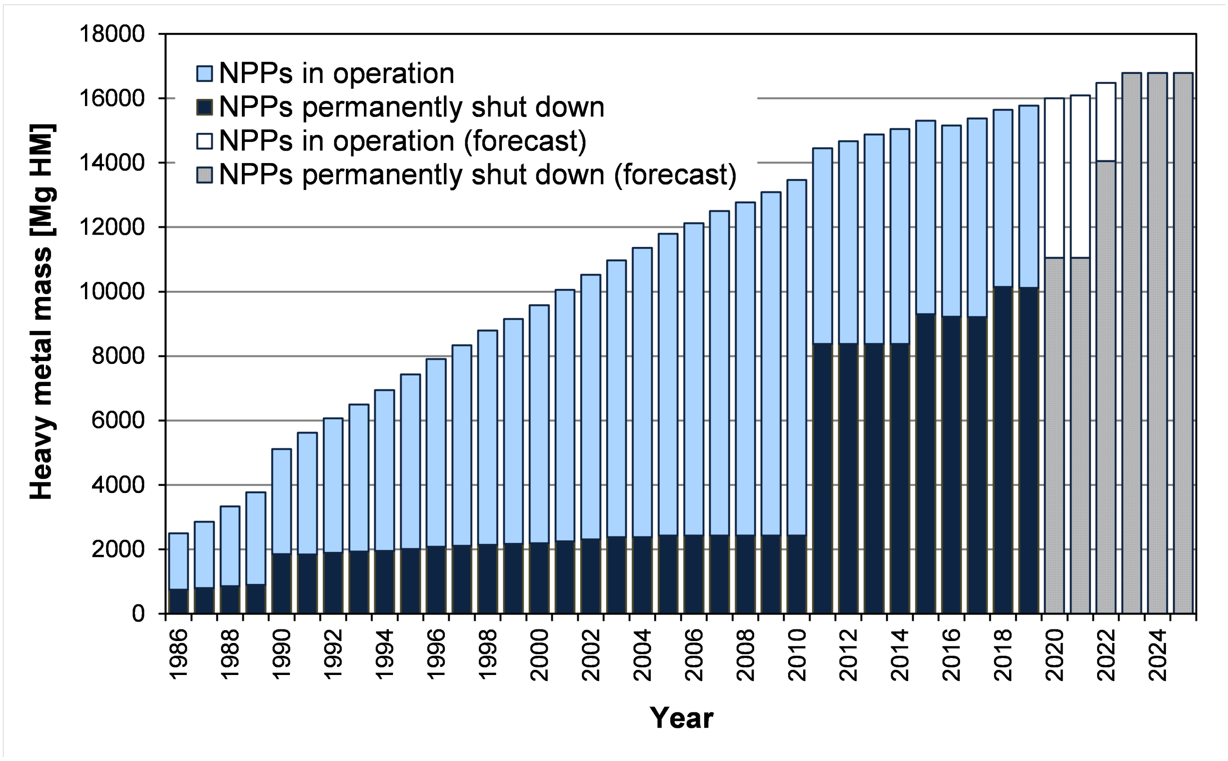
Inventory of spent fuel in wet storage in NPPs: (corresponding to 2,539 Mg HM)	approx. $1.5 \cdot 10^{20}$ Bq
Spent fuel in casks and storage facilities: (corresponding to 6,565 Mg HM)	approx. $1.1 \cdot 10^{20}$ Bq
Total activity inventory of all stored spent fuel:	**approx. $2.6 \cdot 10^{20}$ Bq**

D.2.3 Predicted amounts

The electric power utilities inform the competent supervisory authority about the amounts of spent fuel expected to be produced at each nuclear power plant until their final shutdown at intervals of one year. Under defined boundary conditions of the Thirteenth Act Amending the Atomic Energy Act of 31 July 2011 [1A-25] adopted by the German *Bundestag*, it follows that from 1 January 2020 until the permanent shutdown of all plants, about 1,688 Mg HM (including residual cores) of spent fuel will be produced. Together with the spent fuel already produced until 31 December 2019, this amounts to a total of around 16,786 Mg HM, of which around 10,113 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 heavy metal produced over time including the predictions until 2025 is shown in Figure D-6. The sharp increase in 1990 is mainly due to the accession of the GDR to the Federal Republic of Germany and the associated inclusion of fuel assemblies from the Rheinsberg and Greifswald nuclear power plants. A similar increase in 2011 can be explained by the fact that, due to the shutdown of seven nuclear power plants at the same time, the fuel assemblies from the reactor cores there were classified as spent fuel from that time on. The graph shows a slight decrease in the amount of heavy metal in 2016, compared to 2015. This is solely due to the calculation method applied and does not mean a reduction in the number of fuel assemblies. The effect can be explained as follows: The quantities underlying the graph are based on data collected annually by the competent supervisory authorities of the *Länder*. In this case, only the number of fuel assemblies at the respective storage locations is queried. The amounts of heavy metal were calculated therefrom by multiplication with the average (fresh) fuel assembly mass. After completion of reprocessing, the *Land* authorities for the first time presented final figures for heavy metal quantities delivered to France and the United Kingdom, which partly were slightly lower than the amounts calculated since these also included the burn-up. From 2016 onwards, the *Land* authorities additionally specified the heavy metal quantities for the spent fuel in the decentralised spent fuel storage facilities, which were also lower than the quantities previously calculated. This led to the apparent decline in the accumulated quantities of heavy metal in the graph.

Figure D-6: Accumulated quantities of heavy metal from power reactors by 2025



D.3 Radioactive waste management facilities

D.3.1 Conditioning facilities

Due to the operation and decommissioning of nuclear installations or facilities and the use of radioisotopes in research, trade, industry and medicine, radioactive waste is continuously produced in the Federal Republic of Germany, which must be stored until commissioning of a disposal facility. The aim of waste conditioning is therefore to convert radioactive waste through treatment and/or packaging in a form qualified for disposal according to the waste acceptance criteria 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 as to obtain a qualified waste package qualified for disposal.

Conditioning of radioactive waste may take place in mobile or stationary facilities. Frequently used stationary waste conditioning facilities include decontamination and dismantling facilities, drying facilities, evaporator facilities, high-pressure compaction facilities, melting facilities and cementing facilities, which are located, e.g., in Jülich, Karlsruhe, Krefeld and Lubmin/Rubenow and that are also available for the processing of waste from external waste producers. With the gradual shutdown of the German nuclear power plants, the need for stationary conditioning for waste from their operation decreases. At the same time, new capacities for conditioning and storage of local decommissioning waste are being created at the power plant sites. For this reason, for example, the conditioning of operational waste by the GNS Gesellschaft für Nuklear-Service mbH (GNS) in Duisburg was already discontinued in 2017. After removal of all radioactive material and complete decontamination, the facility there was closed by GNS in 2019 and returned to the lessor for future conventional use.

Since the objective is to provide a sufficient waste package volume for disposal in the Konrad repository, the conditioning capacities were expanded at some sites, e.g. the GNS facility in Jülich was extended by a separate annex to the existing building with an automatic drum measuring system as well as a caisson including equipment for loading of containers.

At the Ahaus storage facility, additional storage capacity was created for waste from operation and decommissioning until its delivery to the Konrad repository. At the Gorleben site, expansion of the conditioning capacity for waste from operation and decommissioning was planned depending on the time of commissioning of the Konrad repository. However, due to the increase in conditioning capacities at other sites, there is currently no need for additional conditioning capacities at the Gorleben site.

D.3.2 Storage facilities

There are different types of radioactive waste which must be treated and disposed of according to their specific characteristics. One of the steps in radioactive waste management is storage.

Radioactive waste from the operation and decommissioning of nuclear installations has to be stored in facilities to be constructed and operated by the operator in accordance with the polluter pays principle until it is delivered to a disposal facility. The Waste Management Transition Act (EntsorgÜG) [1A-35], which came into force on 16 June 2017, redefines the responsibilities for the storage of radioactive waste from the operation and decommissioning of nuclear power plants. The responsibility for storage, which previously lay with the nuclear power plant operators, now falls to the Federation after the radioactive waste has been properly packaged (see Chapter E.2.2 for details on the Act on the Reorganisation of Nuclear Waste Management and Chapter F.3.2 for details on product control).

At present, the waste is stored not only at the nuclear power plant sites but also at the Unterweser radioactive waste storage facility (AZU 1 and AZU 2), the Biblis radioactive waste storage facility (AZB 1 and AZB 2), the Ahaus radioactive waste storage facility (AZA) (in the western wing of the hall), the Gorleben radioactive waste storage facility (AZG), the Obrigheim radioactive waste storage facility (AZO), the Philippsburg radioactive waste storage facility (AZP), the Stade radioactive waste storage facility (AZS), the Würgassen radioactive waste storage facility (AZW), the storage building of the power utilities at Mitterteich, the storage facilities of the DAHER NUCLEAR TECHNOLOGIES GmbH (formerly Nuclear + Cargo Service GmbH (NCS)) in Hanau, the Storage Facility North (ZLN) in Rubenow, the Rossendorf storage facility (ZLR) as well as the storage capacities of the Kerntechnische Entsorgung Karlsruhe GmbH (KTE).

In 1999, the AZG was granted a 20-year licence for the storage of 1,309 drums that could no longer be stored there due to the closure of the Morsleben repository for radioactive waste (ERAM). All drums whose storage licence was limited until mid-June 2019 have been removed from there for post-qualification to meet the waste acceptance criteria for disposal.

The licences for these storage facilities contain restrictions regarding deliveries. For example, only waste from Bavarian nuclear installations 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 KTE for storage.

In addition to spent fuel, radioactive waste is also stored temporarily in the Ahaus storage facility. On 9 November 2009, the district government of Münster granted a licence according to § 7 of the former Radiation Protection Ordinance (StrlSchV 2001) [1A-8a] for the temporary storage of waste from operation and decommissioning in the western part, today AZA, of the Ahaus storage facility. According to § 197 of the Radiation Protection Act (StrlSchG) [1A-34], this licence continues to be valid as a licence according to § 12(1)3. The storage period is limited to ten years. The first waste packages were emplaced on 21 July 2010. On 29 August 2016, the operators filed an application at the district government of Münster for a licence for the handling of other radioactive material in the form of storage in the AZA of the Ahaus storage facility. In the original application, the licence was applied for an unlimited period of time, but in the course of the procedure, the application was adapted to the planned delivery to the Konrad repository. Due to the duration of the storage of more than ten years applied for, the applicant had been obliged to carry out an environmental impact assessment.

Radioactive waste from the reprocessing of German fuel assemblies abroad must be taken back pursuant to the Atomic Energy Act [1A-3]. Between 1996 and 2011, 108 casks with high-level radioactive waste (CSD-V), each containing 28 class canisters, were returned from France and stored in the Gorleben spent fuel storage facility (BZG, former designation: TBL-G). The 4th modification licence of the Gorleben storage facility from 2010 allows the storage of vitrified waste in casks of the newer type CASTOR® HAW 28M.

Future return deliveries of waste from reprocessing abroad are to be accommodated in the Ahaus spent fuel storage facility and in a total of four decentralised spent fuel storage facilities (see Chapter D.4.1 for details). For the high-pressure compacted radioactive waste (CSD-C) from reprocessing at La Hague, a corresponding application for storage at the BZA has been submitted. A cask concept is currently being developed for the storage of 27 canisters each. The four decentralised spent fuel storage facilities Biblis in Hesse, Brokdorf in Schleswig-Holstein, Isar in Bavaria (HLW UK in each case) and Philippsburg in Baden-Wuerttemberg (CSD-B) were defined for the storage of the vitrified radioactive waste from Sellafield and La Hague, which is still to be returned. Corresponding applications for the storage of the waste according to § 6 AtG were submitted. For the decentralised spent fuel storage facility Biblis, the storage licence was granted on 19 December 2019 and the transport licence on 14 February 2020. Within the Federal Government, the decision was taken to postpone the return of vitrified high-level radioactive waste from the Sellafield reprocessing plant in the United Kingdom to the Biblis storage facility. This decision was taken against the background of the emerging rapid spread of the coronavirus (SARS-CoV-2) and the associated considerable risk to life and health.

Due to the currently unavailable disposal facility, the storage capacities for low- and intermediate-level waste at various sites have been and will be increased. At the Philippsburg site, the storage capacity has been increased by 15,000 m³, at Biblis by 8,000 m³ and at Unterweser by 5,000 m³. These additional storage facilities were commissioned in 2018 (Biblis) and 2020 (Philippsburg and Unterweser). Furthermore, the storage capacities in Neckarwestheim are to be increased by 12,000 m³, in Brunsbüttel by 13,000 m³, in Krümmel by 7,000 m³ and in Grafenrheinfeld by 6,000 m³ by erecting new storage facilities. In addition, further storage capacities have been applied for at the sites Grohnde (total activity max. $2 \cdot 10^{17}$ Bq) and Emsland (total activity $3 \cdot 10^{17}$ Bq).

For the BZG, the application submitted in December 2013 regarding the storage of conditioned radioactive waste with negligible heat generation for a separate area in the spent fuel storage facility was suspended.

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 Gorleben radioactive waste storage facility (AZG), the storage building of the power utilities at Mitterteich, or the storage facility of the Daher Nuclear Technologies GmbH in Hanau for storage.

In addition to the storage of radioactive waste, the path of decay storage is also being pursued for residual radioactive material in order to enable simplified processing and, where applicable, clearance of the material at a later date and thus reduce the need for disposal volumes (Figure D-7). Further information on decay storage can be found in Chapter D.5.6 in the section “Greifswald nuclear power plant and Rheinsberg nuclear power plant”.

Figure D-7: Decay storage of large components (steam generator) at the Storage Facility North (Copyright: EWN)

D.3.3 Disposal facilities

The disposal of all radioactive waste is planned to take place in deep geological formations.

Morsleben repository for radioactive waste

After the reunification of Germany, the Morsleben repository for radioactive waste (ERAM) in Saxony-Anhalt was taken over by the Federal Office for Radiation Protection (BfS) as the operator (see Figure D-8). From 1971 to 1998, with some interruptions, low- and intermediate-level radioactive waste from nuclear power plants as well as from research, industry and medicine of the GDR and, after the reunification of Germany, of the entire Federal Republic of Germany was stored in the ERAM.

The continued validity of the unlimited operating licence for the acceptance and disposal of radioactive waste of 1986 was confirmed on 3 October 1990 by § 57a(1)1 of the Atomic Energy Act (AtG) [1A-3] and limited until 30 June 2000. In 1992, the BfS filed an application at the then competent licensing authority of the *Land* of Saxony-Anhalt, i.e. the Ministry of Agriculture and the Environment of Saxony-Anhalt (MLU, now Ministry for the Environment, Agriculture and Energy of Saxony-Anhalt, MULE) for a plan approval decision according to § 9b AtG for emplacement operation beyond 30 June 2000. In 1997 this application was limited to decommissioning by a request for amendment.

After the Higher Administrative Court of the *Land* of Saxony-Anhalt had prohibited further emplacement in the eastern emplacement panel on 25 September 1998, the BfS irrevocably waived further emplacement operation in Morsleben in 2001. In 2005 BfS submitted documents to the MLU for public participation in the plan approval procedure for the closure of the ERAM. After the documents had been revised, the documents were laid open in 2009 for public inspection.

Objections were discussed in a public hearing from 13 to 25 October 2011. The decision on the consideration of objections is made by the MULE within the framework of the on-going plan approval procedure.

A statement [4-11a] prepared by the Nuclear Waste Management Commission (ESK) on behalf of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) on the question whether the long-term safety case prepared for the ERAM complies with the state of the art in science and technology regarding the methods applied was submitted in January 2013. According to this statement, the submitted documents for the demonstration of long-term safety in the plan approval procedure for the orderly closure of the ERAM in compliance with the state of the art in science and technology are not sufficient, but the demonstration of long-term safety is feasible. Six recommendations were made to complete the demonstration of the long-term safety. The implementation of these recommendations requires additional proofs and the revision of the application documents. The necessary work has been specified and commissioned. In accordance with the Act on the Reorganisation of the Organisational Structure in the Field of Disposal [1A-30], the operator tasks were transferred from the BfS to the Federal Company for Radioactive Waste Disposal (BGE) on 25 April 2017.

Figure D-8: Morsleben repository for radioactive waste (ERAM) (left: aerial view, right: emplacement chamber with stacked low-level waste drums) (Copyright: BGE)

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 disposal facility for radioactive waste with negligible heat generation was filed. The plan approval decision was issued on 22 May 2002. After the dismissal of all claims, a final and incontestable plan approval decision for the Konrad repository has been available since 2007.

The Konrad repository may only accept radioactive waste with negligible heat generation and a maximum waste package volume of 303,000 m³.

By letter of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety dated 30 May 2007, the BfS was tasked with retrofitting the Konrad mine to convert it into a disposal facility. Due to the Act on the Reorganisation of the Organisational Structure in the Field of Disposal, the operator tasks were also transferred to the BGE on 25 April 2017. The work started in 2007 has been continued. Completion of the construction is scheduled for 2027.

About 500 ancillary provisions of the plan approval decision have to be observed and already submitted design documents have to be revised for the retrofitting. Due to the advanced time since the plan approval decision was issued, further modification approvals under building law must now also be obtained. On 15 January 2008, the main mining operating plan for the construction of the Konrad repository was approved by the Lower Saxony State Authority for Mining, Energy and Geology. The main mining 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 disposal facility. The main mining operating plan is updated on a regular basis.

Approx. 930 million euros were used for the planning and exploration of the Konrad repository (1977 to 2007). These costs are not included in the subsequent construction costs. Between 2007 and 2019, approx. 1.98 billion euros actual costs were incurred for construction, taking into account other contractors and the costs of the federal authorities.

The Konrad mine is a twin-shaft facility with the two shafts Konrad 1 and Konrad 2, which are separated from each other by 1.5 km. Konrad 1 is used for hoisting, material transport and later on for the transport of debris to the surface. Shaft Konrad 2 is the air exhaust shaft and will in future primarily be used for transporting waste packages underground (see Figure D-9). The construction work at the surface and underground continues to progress. At the shaft site of Konrad 1, the following has already been constructed: southern winding engine house, northern winding engine house, media duct, large parts of media supply and disposal, the weather mast with weather station, the switchgear building, shaft hall extension and materials management building. The assembly work for the fencing at the two shaft sites has been completed, with the exception of a gap closure in the area of the respective guard houses, which is in line with the planning. The construction of the administration and social building has been completed and part of the building is already in use.

The commissioning work for the southern hoisting system in Shaft 1 has been completed. The northern hoisting system has been dismantled; preparations are underway for the construction of the new rope-guided hoisting system. The refurbishment of the shaft walls in the shaft tube has been completed. Transportation of staff and material in Shaft 1 is carried out with the new southern hoisting system.

Important infrastructure components have been completed at the Konrad 2 shaft site. Furthermore, the construction of the ventilation building and the depot (workshop, engine shed, garages, spare conveyor) was started. Underground, in Shaft 2 itself, most of the excavation work for the inset on the second level ("transfer station" from the shaft into the drift) have been completed. Before that, the extension of the shaft had been completed there. Work on the underground strengthening of galleries and the driving of the infrastructure galleries is well advanced. The six emplacement chambers of storage field 5/1 were driven up to the planned final length. Driving of the return air collection roadway has been completed. The workings of the workshop area are already being set up and the workings for processing of backfill material are being completed.

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

With the plan approval decision for the Konrad repository, the Konrad waste acceptance criteria were laid down as at December 1995 and waste-specific ancillary provisions stipulated. New findings from the conditioning processes and container approvals will be included in these waste acceptance criteria by revision, where appropriate. The Konrad waste acceptance criteria are currently available in the version as of December 2014 [BfS 14a].

Figure D-9: Konrad repository construction site in Salzgitter(top left: Konrad 1 shaft site; top right: Konrad 2 shaft site; bottom left: Konrad Shaft 2, view into the inset on the second level; bottom right: graphic representation of the entire site (Copyright: BGE))

D.3.4 Asse II mine

After mining activities from 1909 to 1964, the former potash and rock salt mine Asse II was acquired by the Gesellschaft für Strahlenforschung (GSF), the later German Research Center for Environmental Health of the 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, radioactive waste had been disposed of in the mine. After disposal of the radioactive waste, the mine was used until 1995 for research for the development and demonstration of techniques for the emplacement of radioactive waste.

On 4 September 2008, the competent Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), the BMBF and the Lower Saxony Ministry for the Environment, Energy, Building and Climate Protection (NMU) agreed that the Asse II mine in the future is to be treated like a disposal facility according to the Atomic Energy Act (AtG) [1A-3] This decision was implemented in the Tenth Act Amending the Atomic Energy Act of 24 March 2009 [1A-24]. The Federal Office for Radiation Protection (BfS) took over the operation of the facility from the HMGU on 1 January 2009. For the operation of the facility, the BfS employed the services of the Asse-GmbH, a 100 % federally-owned company. In accordance with the Act on the Reorganisation of the Organisational Structure in the Field of Disposal [1A-30], the operator tasks were transferred to the Federal Company for Radioactive Waste Disposal (BGE) on 25 April 2017.

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

Since 1988, inflow of groundwater from the overburden into the mine has been observed (see Figure D-10, bottom left). Storage locations were established to collect the brines. A total of about 13 m³ of brines saturated with sodium chloride is collected in the mine every day. It is not possible to forecast the evolution of inflow rates. The most important point for accumulation is located on the 658-m level, where most of the brines is collected (about 12.1 m³ per day). The uncontaminated saline solution collected here is pumped to the surface. After release from nuclear regulatory control (clearance), the solution is transferred for external utilisation. In parallel, the BGE is striving to find other ways of disposing of the cleared solution, such as obtaining a water permit for the discharge into surface waters.

For stabilisation of the mine, excavations in the southern flank had been backfilled with fine-grained crushed salt from August 1995 to December 2003. Subsequently, backfilling of shafts and drifts below the emplacement areas with rock salt and magnesium chloride solution started. Despite these backfilling measures, the rates of deformations of the rocks (strongholds) remained high. Since the end of 2010, open roof gaps which have appeared as a result of the crushed salt's subsidence in the backfilled rooms, and mine workings that are no longer required have therefore been backfilled with Sorel concrete to improve the overall stability of the mine. Sorel concrete is made of magnesium oxide, a magnesium chloride solution and rock salt, and is authorised for the backfilling of mine workings within rock salt. Residual voids still existing in some emplacement chambers are not backfilled.

Moreover, for the case of a beyond-design solution inflow, emergency planning was set up describing further emergency preparedness and response measures (e.g. expansion of the capacity for solution management, construction of hydraulical barriers, introduction of supporting backfill or preparatory planning for evacuation, remaining backfill, shaft seals and controlled counter-flooding) (see "Implementation for the individual facilities" in Chapter F.5.1 for details). As a result of a "comparison of options", the then competent BfS identified the retrieval of all waste as the closure option by which long-term safety according to the state of the art in science and technology can most probably be ensured at the Asse site. On 27 April 2013, the the Act on Speeding up the Retrieval of Radioactive Waste and the Closure of the Asse II Mine ("Lex Asse") [1A-26], which governs the closure of the Asse II mine following the retrieval of the radioactive waste was effected.

Due to limited understanding about the condition of the waste and the emplacement rooms, the realisation of retrieval is fraught with uncertainties. The uncertainties were to be removed by a fact-finding mission. The first drilling started on 1 June 2012. A total of nine boreholes were drilled into emplacement room 7/750 and its immediate vicinity, which led to the following key findings:

- no explosive or flammable atmosphere exists in the emplacement room,
- radon and tritium concentrations in the chamber atmosphere fall in the expected range, but are significantly higher than in the mine workings outside the emplacement chamber,
- stope ceiling above the emplacement room shows considerable damage,
- the side pillars of the emplacement rooms bear the loads and show an intact core,
- no significant spread of contamination in pillars and stope ceiling has been observed.

The fact-finding mission at emplacement room 7/750 has meanwhile been completed. Currently, drilling into emplacement room 12/750 is being prepared.

The longer the mine will be kept open, the higher is the risk that either the solution inflow will relocate to inaccessible areas, where the brines can no longer be collected, or the amount of solution in general will increase. With the “Lex Asse” a procedural framework has been created for speeding up the work of retrieval. Accordingly, the retrieval of the radioactive waste no longer requires any justification. Against this background, the fact finding missions and the procedure for retrieval so far were evaluated. As a result of the evaluation, retrieval is to begin from those emplacement rooms for which atmosphere and mechanical conditions are known. The experience gained can then be used for the retrieval from sealed and completely backfilled emplacement chambers.

Work on the conceptual planning of retrieving the low-level radioactive waste from the open, accessible emplacement room 7/725 and the intermediate-level radioactive waste from the 511-m level was completed in summer 2019. Since the beginning of 2015, the working group “*Konzeptplanung Rückholung*“ (Arge KR) has been commissioned with the conceptual planning of the retrieval of radioactive waste from the 750 m level. This planning is expected to be completed in 2020. Schedules prepared so far assume that the retrieval of the radioactive waste will begin in 2033.

Already in 2012 it was stated that a new shaft for retrieval of the waste is mandatory. The creation of new underground infrastructure rooms outside the current mine workings (galleries for retrieval with auxiliary ventilation, locks, buffer storage, etc.) is also mandatory. Prior to the start of the retrieval, emergency preparedness measures (particularly stabilisation and backfilling) need to be fully implemented. In addition, equipment and facilities for waste characterisation, treatment and storage as well as the necessary infrastructure must be available. A suitable retrieval technology is to be identified and partly still to be developed.

The overburden and the salt structure are currently being explored with regard to the new retrieval shaft and the localisation of the shaft site. An exploration drilling at the surface to a depth of 900 m to the east of the site, three underground drillings on the 574 m level (371 m, 293 m and 275 m borehole length) and one underground drilling on the 700 m level (254 m) have been completed so far. Two underground boreholes were drilled on the 700 m level and a 3D seismics campaign was carried out for further exploration of the overburden. Reliable results from the 3D seismics campaign (see Figure D-10, bottom right) are expected in 2021. Furthermore, two straight drillings and two extended reach drillings from surface are planned for exploration.

On 27 March 2020, BGE published a plan for retrieval [BGE 20], in which all measures to be taken are described in a coherent manner.

Figure D-10: Asse II mine(top left: waste packages dumped into an emplacement chamber (no longer accessible today) (Copyright: BfS), top right: view into emplacement chamber 7/750, bottom left: main collecting point for the uncontaminated solution on the 658 m level, bottom right: vibroseis vehicle during a 3D seismic measurement (Copyright: BGE)).

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,
- during the decommissioning of nuclear power plants, of experimental and demonstration reactors, as well as from research and training reactors for educational purposes, and other nuclear installations and 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 applications,
- other waste producers, such as the military sector,
- the future conditioning of spent fuel intended for direct disposal.

According to contractual agreements with the reprocessing companies in France and the 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 to be returned from the United Kingdom and France, plans have been prepared.

In the following, an overview is given of the inventory of untreated residual radioactive material, together with the inventory of intermediate waste products and conditioned waste as at 31 December 2019 as well as a forecast of the volume of waste expected to arise until the year 2080. An overview of the radioactive waste disposed of in the Morsleben repository for radioactive waste (ERAM) and the waste disposed of 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.

Radioactive waste with negligible heat generation

According to its state of processing, the waste is subdivided as follows:

RA Raw waste:

Unprocessed, partially pre-sorted radioactive waste in its original form.

VA Pretreated waste:

Pretreated raw radioactive waste, for which further treatment steps are planned.

P1 Waste products in inner containers:

Waste products packaged in inner containers which are to be placed in standardised basic cask types (disposal containers) intended for disposal. The waste products are generally produced according to qualified procedures, but have not yet been finally product controlled for the Konrad repository. Their processing is completed and, apart from possibly required post-drying, is no longer subject to any physical or chemical change due to treatment steps.

P2 Product-controlled waste products:

Waste products packaged in inner containers which are intended to be placed in standardised disposal containers and which have undergone a qualified conditioning process for the Konrad repository, accompanied and certified by the product control department. The documentation has been prepared, submitted, reviewed and positively assessed by an authorised expert and the BGE.

Note: Classification in Category P2 must also be carried out if the radiological product control has already been completed but the material product control has not yet been carried out or completed.

G1 Waste products packaged in waste packages or in disposal containers:

Waste products packaged in standardised disposal containers with or without an inner container. The waste products are generally produced according to qualified procedures, but are not yet finally product-controlled for the Konrad repository.

G2 Product-controlled waste packages:

Waste packages that are product-controlled and documented in accordance with the requirements of the Konrad waste acceptance criteria and whose suitability for disposal has been confirmed by the BGE and material product control must also be completed.

According to Table D-5 the raw and pretreated waste stored at the waste producers' sites amounted to 20,156 Mg. 16,802 m³ of the 124,736 m³ of waste stored in containers (gross volume) related to waste in inner containers that still has to be packed in disposal containers and 107,934 m³ to waste in disposal containers. Only for a small part of radioactive waste with negligible heat generation which is not qualified for disposal in the Konrad repository due to its nuclide inventory and/or its chemical composition or the time of its generation, it is examined whether it can be disposed of in the disposal facility according to the Site Selection Act (StandAG) [1A-7b].

Table D-5: Overview of masses and volumes of radioactive waste in storage facilities with negligible heat generation as at 31. December 2019 and their intended destinations

Waste category	Unit	Konrad repository	Other disposal facility
RA – raw waste	[Mg]	7,558	209
VA – pretreated waste	[Mg]	12,368	21
P1 – waste in inner containers	[m³]	12,948	145
P2 – product-controlled waste products	[m³]	3,709	0
G1 – waste in disposal containers	[m³]	104,997	1
G2 – product-controlled waste packages	[m³]	2,936	0
Total	**[Mg]**	**19,926**	**230**
	[m³]	**124,590**	**146**

Table D-6 shows the inventory of radioactive waste with negligible heat generation for the different groups of waste producers.

Table D-6: Overview of the inventory of radioactive waste with negligible heat generation according to its state of processing as at 31 December 2019

Waste producer groups	RA	VA	P1	P2	G1	G2
	Mass [Mg]	Mass [Mg]	Volume [m³]	Volume [m³]	Volume [m³]	Volume [m³]
Research institutions	1,383	6,015	1,966 [*)]	136	42,700	0
Nuclear industry	168	12	228	161	7,646	2,921
Nuclear power plants	568	138	2,090	1,058	6,065	0
Decommissioned nuclear power plants	4,865	5,507	5,834	2,046	32,742	15
Land collecting facilities	600	447	2,387	67	946	0
Reprocessing (in Germany)	184	272	589	240	14,899	0
Total	**7,767**	**12,389**	**13,093**	**3,709**	**104,998**	**2,936**

[*)] Here, transposed digits were corrected in comparison to the *Bundestag* printed paper 19/22252.

Table D-7 gives an overview of the distribution of the inventory of conditioned radioactive waste with negligible heat generation to the different storage facilities.

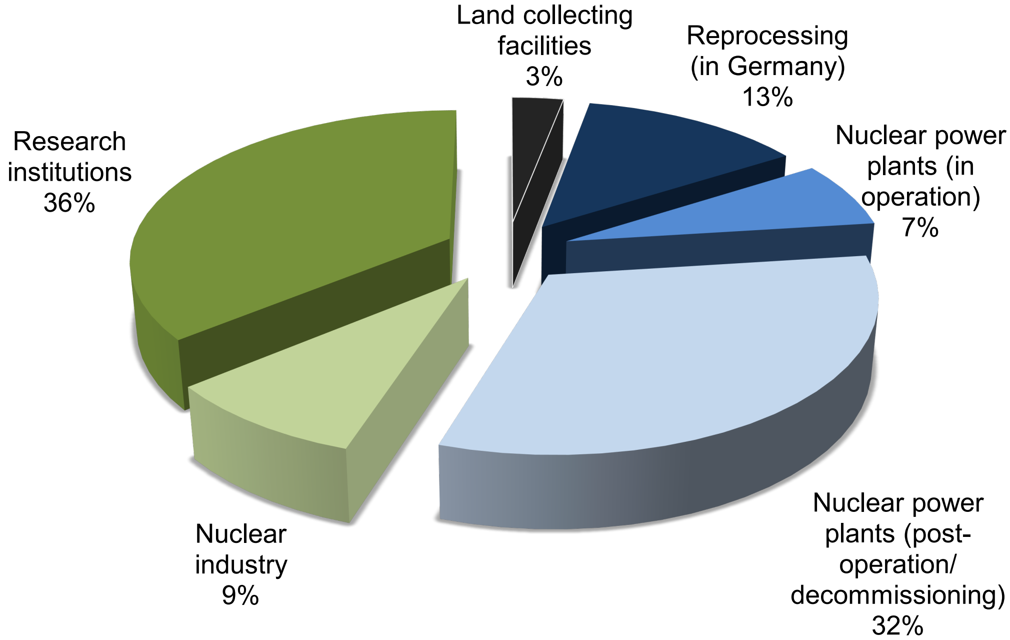
Table D-7: Storage of radioactive waste with negligible heat generation of categories P1 to G2 as at 31 December 2019

Storage facility	Waste volume [m³] *)
Research centres, including customers	63,295
Nuclear industry	2,711
Storage Facility North (ZLN)	6,696
Nuclear power plants	16,465
Land collecting facilities	1,111
Waste storage facility Unterweser 1 and 2	1,437
Storage facility of the utilities at Mitterteich (GRB)	9,187
Waste storage facility Gorleben	6,388
Daher Nuclear Technologies (former NCS)	7,784
GNS and other storage facilities	2,882
Waste storage facility Ahaus	1,992
Waste storage facility Stade	4,787
Total	**124,736**

*) Deviations are possible due to rounding.

Figure D-11 shows the distribution of the radioactive waste inventory with negligible heat generation accumulated by the end of 2019 to the different waste producer groups.

Figure D-11: Distribution of the radioactive waste inventory with negligible heat generation of categories P1 to G2 according to waste producer groups as at 31 December 2019



Heat-generating radioactive waste

As at 31 December 2019, 575 m³ of heat-generating radioactive waste was stored in the Federal Republic of Germany in addition to spent fuel. The major part of the conditioned heat-generating radioactive waste originates 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 casks of the CASTOR® HAW 28M type, 12 casks of the TN85 type) holding a total of 3,024 canisters with vitrified fission product concentrate from the reprocessing of spent fuel in France. In the years 2009 and 2010, the liquid fission product concentrate was vitrified in the Karlsruhe vitrification facility (VEK). Since February 2011, the vitrified waste produced thereby has been stored in five transport and storage casks of the CASTOR® HAW 20/28 CG type at the Storage Facility North (ZLN). The other heat-generating radioactive waste generally consists of activated components and spent fuel assembly parts from the Karlsruhe reprocessing plant (WAK), concentrate and unsorted waste, e.g. from the dismantling of the WAK and the compact sodium-cooled nuclear reactor plant II (KNK II). The distribution of the inventory of heat-generating radioactive waste is shown in Table D-8.

Table D-8: Overview of the inventory of heat-generating radioactive waste as at 31 December 2019

Waste producer groups	Waste [m³]
Research institutions	4
Nuclear industry	0
Nuclear power plants	0
Decommissioned nuclear power plants	0
Land collecting facilities	2
Others	0
Reprocessing (in Germany)	1
Reprocessing (WAK and abroad)	568
Total	**575**

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

Deviations of the inventory of heat-generating radioactive waste from the previous report are due to the changed classification in the inventory query on radioactive waste with negligible heat generation for a disposal facility according to the Site Selection Act.

Return of reprocessing waste from other European countries

In accordance with the contractual obligations of the nuclear power plant operators and their obligations under nuclear law, the radioactive waste must be returned after reprocessing. This approach has been confirmed by binding international treaties between France and the United Kingdom and Germany. With the 108 CASTOR® casks returned to the Gorleben spent fuel storage facility until 2011, the majority of the high-level radioactive waste from reprocessing has already been returned to Germany from other European countries. 25 casks with vitrified waste to be returned are still stored at the corresponding facilities abroad. Due to the amendment of the Atomic Energy Act (AtG) [1A-3] following the entry into force of the Site Selection Act, the 20 casks from the United Kingdom and the five casks from France are no longer to be shipped to the Gorleben spent fuel storage facility, but to several decentralised spent fuel storage facilities in compliance with § 9a(2a) AtG. The basis for a nationwide balanced distribution of the casks is the overall concept for the return of vitrified radioactive waste from reprocessing presented in 2015 by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), which is also regionally based on the polluter pays principle. After completion of the return, the vitrified radioactive waste from reprocessing will be stored in the five *Länder* (Lower Saxony, Hesse, Schleswig-Holstein, Bavaria and Baden-Wuerttemberg) from whose nuclear power plants the largest proportion of nuclear fuel for reprocessing has been shipped abroad. With a broad political consensus, the four sites of Biblis in Hesse, Brokdorf in Schleswig-Holstein, Isar in Bavaria and Philippsburg in Baden-Wuerttemberg were chosen for the return of the remaining casks. For these four decentralised storage facilities, the operators at that time submitted applications for the storage of the casks. On 3 April 2018, applications for the return transports to Philippsburg and Biblis were filed. For the decentralised spent fuel storage facility in Biblis, the licence for the storage of high-level radioactive waste from reprocessing was granted on 19 December 2019 and the transport licence on 14 February 2020.

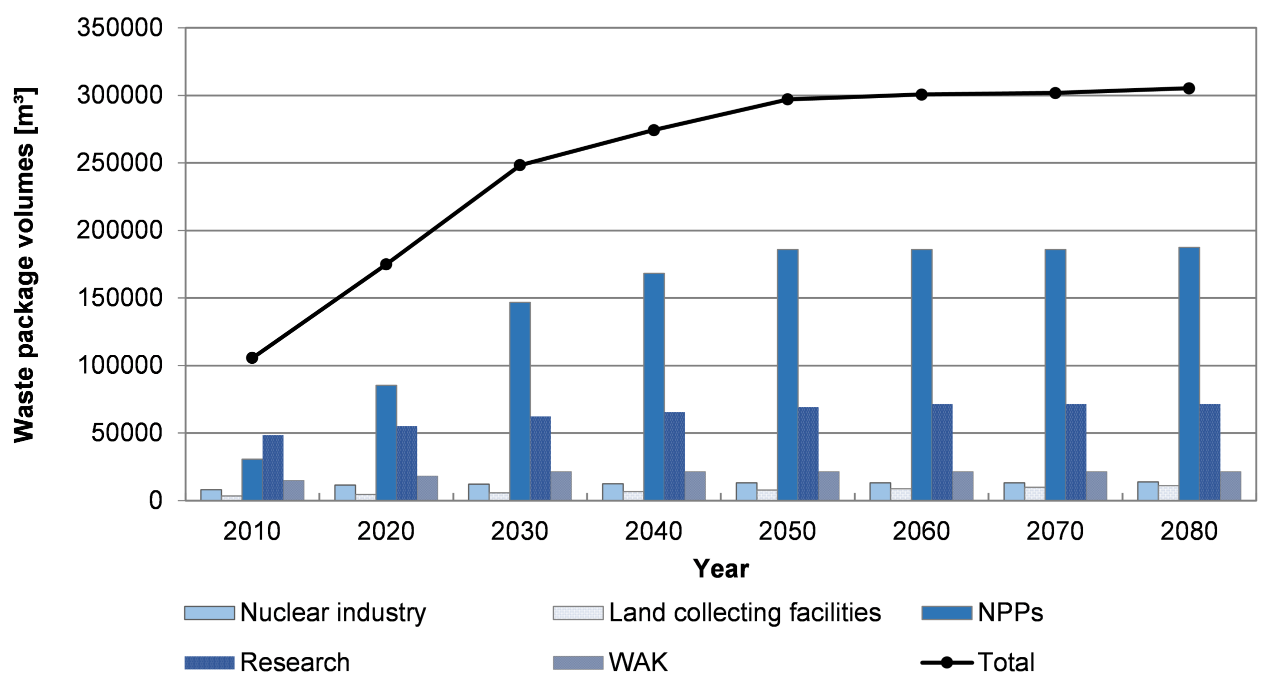
Forecasts

Regarding the work involved in planning a facility for disposal, it is necessary to make forecasts on the waste produced in future and to update these when boundary conditions change. The waste producers provided information about the expected waste volumes. This information also comprises the respective waste volumes expected in connection with the decommissioning of nuclear installations and 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 of the volumes of radioactive waste with negligible heat generation, 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 is performed. During this period, further operational waste is produced. 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 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 applied. 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 (e.g. activated components 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-12 which shows that large amounts of waste are not to be expected after 2050.

Figure D-12: Time-dependent accumulation of radioactive waste with negligible heat generation as waste package volumes until 2080



The accumulated inventory of heat-generating radioactive waste in the year 2080 is estimated under the boundary conditions of the Thirteenth Act Amending the Atomic Energy Act adopted by the German *Bundestag* on 30 June 2011, taking the residual operating times into account. A volume of around 27,000 m³ is obtained for the following cask concept developed for disposal in a salt dome:

- approx. 20,400 m³ 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; 10,113 Mg HM),
- approx. 700 m³ of vitrified waste in canisters (HLW from France, the United Kingdom and Karlsruhe as well as vitrified waste from liquid waste processing at the French La Hague reprocessing plant),
- approx. 740 m³ of compacted structural parts and sleeves in canisters from the La Hague reprocessing facility (France),
- approx. 1,340 m³ of packaged fuel from the Hamm-Uentrop thorium high-temperature reactor (THTR),
- approx. 195 m³ of packaged fuel from the Radiation Protection, Analytics & Disposal Rossendorf Inc. (VKTA), and the research reactors still in operation, and
- approx. 3,400 m³ of waste packages with structural parts of the spent fuel for direct disposal.

D.4.2 Inventory of the Morsleben repository for radioactive waste

In the Morsleben repository for radioactive waste (ERAM), approx. 37,000 m³ of low- and intermediate-level radioactive waste with comparatively low concentrations of alpha emitters were emplaced between 1971 and 1991 and between 1994 and 1998.

This waste originated from

- the operation of nuclear power plants,
- the decommissioning of nuclear installations,

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

The radioactive waste is emplaced packaged in standardised containers (e.g. 200 l to 570 l drums and cylindrical concrete containers) or loosely dumped into an emplacement chamber, and liquid waste solidified on-site and emplaced. The sealed radioactive sources were not further treated and packed in small containers.

In addition, radioactive waste is disposed of which is generated during the operation of the ERAM to keep the mine open and which activity has already been taken into account by recording the overall activity of the radioactive waste delivered. As at 31 December 2019, a total of 37,252 m³ of solid and solidified waste and 6,621 sealed radioactive sources were disposed of, including the radioactive waste from operation to keep the mine open. In addition to the radioactive waste disposed of, sealed cobalt radioactive sources, some caesium radioactive sources and small quantities of europium waste are stored in seven special containers (steel cylinders) with a volume of 4 l each in two downward boreholes and one 280 l drum containing Ra-226 waste in a sealed downward borehole. As at 31 December 2019, the activity of the stored waste amounted to a total of approx. $1.2 \cdot 10^{14}$ Bq. Within the framework of the plan approval procedure for the closure, an application was submitted for on-site disposal of the stored waste.

The data on the emplaced radioactive waste are documented and archived. The total activity of all radioactive waste disposed of is approx. $8.2 \cdot 10^{13}$ Bq, the activity of alpha emitters is approx. $4.7 \cdot 10^{11}$ Bq (as at 31 December 2019). Table D-9 provides an overview of the activity of the relevant radionuclides contained in the waste disposed of in the ERAM.

Table D-9: Radionuclide-specific activities of the waste disposed of in the ERAM as at 31 December 2019

a) Alpha emitters:

Nuclide	Activity [Bq]	Nuclide	Activity [Bq]	Nuclide	Activity [Bq]
Am-241	$2.3 \cdot 10^{11}$	Cm-250	$3.3 \cdot 10^{2}$	Th-229	$4.6 \cdot 10^{5}$
Am-243	$9.5 \cdot 10^{7}$	Np-237	$8.4 \cdot 10^{7}$	Th-230	$1.9 \cdot 10^{6}$
Cf-249	$5.7 \cdot 10^{5}$	Pa-231	$1.7 \cdot 10^{6}$	Th-232	$5.8 \cdot 10^{6}$
Cf-251	$2.3 \cdot 10^{4}$	Pu-238	$7.4 \cdot 10^{10}$	U-232	$4.2 \cdot 10^{7}$
Cf-252	$1.9 \cdot 10^{3}$	Pu-239	$6.8 \cdot 10^{10}$	U-233	$5.0 \cdot 10^{6}$
Cm-243	$5.1 \cdot 10^{5}$	Pu-240	$6.6 \cdot 10^{10}$	U-234	$1.1 \cdot 10^{9}$
Cm-244	$3.8 \cdot 10^{9}$	Pu-242	$9.9 \cdot 10^{7}$	U-235	$8.2 \cdot 10^{7}$
Cm-245	$2.3 \cdot 10^{6}$	Pu-244	$2.1 \cdot 10^{4}$	U-236	$4.8 \cdot 10^{7}$
Cm-246	$2.6 \cdot 10^{6}$	Ra-224	$2.4 \cdot 10^{8}$	U-238	$4.3 \cdot 10^{8}$
Cm-247	$2.6 \cdot 10^{4}$	Ra-226	$2.3 \cdot 10^{10}$		
Cm-248	$2.2 \cdot 10^{7}$	Th-228	$2.4 \cdot 10^{8}$		

b) Beta/Gamma emitters:

Nuclide	Activity [Bq]	Nuclide	Activity [Bq]	Nuclide	Activity [Bq]
Ac-227	$5.4 \cdot 10^{6}$	Eu-155	$9.0 \cdot 10^{9}$	Pd-107	$6.7 \cdot 10^{7}$
Ac-228	$1.9 \cdot 10^{8}$	Fe-55	$3.0 \cdot 10^{10}$	Pm-147	$2.2 \cdot 10^{9}$
Ag-108m	$6.3 \cdot 10^{10}$	H-3	$1.4 \cdot 10^{12}$	Pu-241	$6.7 \cdot 10^{11}$
Al-26	$8.6 \cdot 10^{5}$	Ho-166m	$3.3 \cdot 10^{4}$	Ra-228	$1.9 \cdot 10^{8}$
Am-242m	$2.3 \cdot 10^{8}$	I-129	$2.1 \cdot 10^{8}$	Rb-87	$2.8 \cdot 10^{7}$
C-14	$3.2 \cdot 10^{12}$	K-40	$2.3 \cdot 10^{10}$	Ru-106	$2.3 \cdot 10^{5}$
Ca-41	$7.3 \cdot 10^{7}$	Kr-85	$1.4 \cdot 10^{11}$	Sb-125	$2.4 \cdot 10^{9}$
Cd-113m	$5.9 \cdot 10^{9}$	Mn-54	$8.3 \cdot 10^{2}$	Se-79	$1.9 \cdot 10^{8}$
Cl-36	$3.9 \cdot 10^{9}$	Mo-93	$2.5 \cdot 10^{8}$	Sm-151	$2.5 \cdot 10^{11}$
Co-60	$2.4 \cdot 10^{12}$	Na-22	$6.4 \cdot 10^{7}$	Sn-126	$2.4 \cdot 10^{8}$
Cs-134	$1.2 \cdot 10^{9}$	Nb-94	$2.7 \cdot 10^{10}$	Sr-90	$4.1 \cdot 10^{12}$
Cs-135	$3.7 \cdot 10^{8}$	Ni-59	$1.8 \cdot 10^{11}$	Tc-99	$1.0 \cdot 10^{11}$
Cs-137	$5.5 \cdot 10^{13}$	Ni-63	$1.4 \cdot 10^{13}$	Zr-93	$9.3 \cdot 10^{9}$
Eu-152	$1.6 \cdot 10^{11}$	Np-236	$4.5 \cdot 10^{3}$		
Eu-154	$1.1 \cdot 10^{11}$	Pb-210	$1.4 \cdot 10^{10}$		

The major part (about 80 %) of the emplaced waste originates from the operation and decommissioning of nuclear power plants. The remaining 20 % comes from research, industry, trade, medicine and other waste producers. As the limit for the activity of alpha emitters was very low at ERAM ($4 \cdot 10^{8}$ Bq/m³), the volume of the waste originating from the nuclear industry, the research centres and the WAK is low. Table D-10 shows the volume of waste emplaced in the ERAM, classified according to origin.

Table D-10: Volume emplaced in the ERAM according to origin as at 31 December 2019

Origin	Volume [m³]
Operation of nuclear power plants	23,816
Decommissioning of nuclear power plants	6,528
Research	2,592
Nuclear industry	159
Land collecting facilities	3,090
Other waste and waste from the operation of the ERAM	1,022
Karlsruhe reprocessing plant (WAK)	45
Total	**37,252**

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 Gesellschaft für Strahlenforschung (GSF later HMGU) in 2000. This waste database was last updated in 2010 to check the inventory (ASSEKAT Version 9.2).

The Federal Office for Radiation Protection (BfS) had requested a review of the waste database by TÜV Süd. Based on this, comprehensive recommendations were made. These refer partly to the raw data and partly 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 the revised version of the waste database and are subject to the reservation that the recommendations have not yet been fully implemented. The revision of the calculation modules is very complex and has not yet been completed. There will therefore be changes to the inventory data in the future.

In the Asse II mine, emplacement of low-level radioactive waste (LLW), which was handled without additional shielding, began in 1967, the emplacement of intermediate-level radioactive waste (ILW) in 1972. For transport of intermediate-level radioactive waste, an additional shielded cask was needed. In 1978, the time-limited emplacement licences expired. Until then, about 47,000 m³ of radioactive waste (waste package volume) from the waste producers had been emplaced in various waste package types:

- 124,494 packages as low-level radioactive waste with a total activity of about $1.69 \cdot 10^{15}$ Bq (as at 31 December 2019). 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 on the 750 m level and one chamber on the 725 m level.
- 1,293 drums holding intermediate-level radioactive waste with a total activity of about $4.64 \cdot 10^{14}$ Bq (as at 31 December 2019). These account for about 20 % of the total activity and are stored on the 511 m level. Additionally, eight drums with low-level radioactive waste are also stored there. These eight packages are already included in the total of 124,494 packages of low-level waste and were used to test a new shielded cask (E2).

Table D-11 gives an overview of waste origin and the percentages of the total activity.

Table D-11: Percentages of the waste packages emplaced in the Asse II mine with regard to waste origin, number and activity

Waste producer (waste origin)	Waste packages [%]	Total activity [%]
Kernforschungszentrum Karlsruhe (KfK), partially transferred to KTE Kerntechnische Entsorgung Karlsruhe GmbH (KTE)	48.6	94.7
Kernforschungsanlage Jülich (KFA), partially transferred to Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH (JEN)	10.6	0.9
Nuclear power plants	25.7	2.7
Other waste producers	15.1	1.7
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 radioactive 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 and 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 types of waste are given in Table D-12 for low-level waste (LLW) and intermediate-level 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 the former Kernforschungsanlage Jülich (KFA) (now JEN Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH, JEN) contain fresh fuel rod segments or fuel rod segments irradiated for a short time, or AVR fuel spheres with, in some cases, enriched uranium.

Table D-12: Percentages of the waste packages with regard to the different types of waste for LLW und ILW

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, foils, overalls, galoshes, cleaning rags, wood, glass, etc.	40	-
Total	**100**	**100**

The 125,787 waste packages emplaced, which have a 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-13 gives an overview of the activities of the relevant radionuclides in the waste emplaced in the Asse II mine as at 31 December 2019. At that time, the total activity was about $2.2 \cdot 10^{15}$ Bq, including an alpha activity of about $4.1 \cdot 10^{14}$ Bq.

Table D-13: Activity inventory of relevant radionuclides in the Asse II mine as at 31 December 2019

Radionuclide	Activity [Bq]	Radionuclide	Activity [Bq]
H-3	$3.0 \cdot 10^{11}$	Ra-226	$2.0 \cdot 10^{11}$
C-14	$2.6 \cdot 10^{12}$	Th-232	$3.3 \cdot 10^{11}$
Cl-36	$7.2 \cdot 10^{9}$	U-234	$1.4 \cdot 10^{12}$
Co-60	$5.0 \cdot 10^{12}$	U-235	$5.3 \cdot 10^{10}$
Ni-59	$1.8 \cdot 10^{12}$	U-236	$2.4 \cdot 10^{10}$
Ni-63	$2.5 \cdot 10^{14}$	U-238	$1.3 \cdot 10^{12}$
Se-79	$3.4 \cdot 10^{9}$	Np-237	$4.2 \cdot 10^{9}$
Sr-90	$1.7 \cdot 10^{14}$	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	$1.0 \cdot 10^{15}$
Tc-99	$1.1 \cdot 10^{11}$	Pu-242	$9.1 \cdot 10^{10}$
Sn-126	$4.6 \cdot 10^{9}$	Am-241	$2.4 \cdot 10^{14}$
I-129	$2.7 \cdot 10^{8}$	Cm-244	$6.4 \cdot 10^{11}$
Cs-135	$3.2 \cdot 10^{9}$	Cm-245	$2.7 \cdot 10^{8}$
Cs-137	$3.1 \cdot 10^{14}$	Cm-246	$3.3 \cdot 10^{8}$
Sm-151	$3.2 \cdot 10^{12}$		

D.4.4 Inventory from past practices

Waste from past practices 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 facilities under decommissioning

D.5.1 Overview

As part of this report for the Joint Convention, an overview is given of nuclear installations in Germany that have been permanently shut down and the greatest part of which is already under decommissioning (nuclear power plants, experimental and demonstration reactors, research reactors, nuclear fuel cycle facilities). In Germany, a nuclear installation 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 installations. Table D-14 gives an overview of the nuclear installations permanently shut down including those being under decommissioning and those for which decommissioning has been completed and which were released from nuclear regulatory control. Lists showing the respective facilities can be found in Table L-13 to Table L-18 in Annex L-(c).

The use of nuclear energy for the commercial electricity generation is phased out in Germany step by step. The last nuclear power plant is to be shut down in 2022. The end of the operating lifetimes of the individual nuclear power plants is defined in the Atomic Energy Act (AtG) [1A-3]. The final shutdown of a nuclear power plant is followed by the post-operational phase (operating phase after expiry of the authorisation for power operation until granting of the decommissioning licence). In the post-operational phase, preparatory work for decommissioning can be carried out. Wide experience has already been gained in Germany with the decommissioning of nuclear installations over the past four decades. Many research reactors and all experimental and demonstration reactors but also nuclear power plants as well as nuclear fuel cycle facilities are in various stages of decommissioning. Some of the facilities have meanwhile been completely dismantled and removed and the sites are being reused.

Table D-14: Overview of nuclear installations permanently shut down, being under decommissioning and those for which decommissioning has been completed

Type of facility	Permanently shut down (decommissioning licence pending)	Under decommissioning	Decommissioning completed
Power reactors	1 reactor	22 reactors	-
Experimental and demonstration reactors	-	4 reactors (see explanation in D.5.3)	3 reactors and the nuclear ship Otto Hahn (RPV)
Research reactors ≥ 1 MW thermal power	3 reactors	5 reactors (see explanation in D.5.4)	2 reactors
Research reactors < 1 MW thermal power	1 reactor	-	27 reactors, 1 reactor rededicated
Nuclear fuel cycle facilities (primarily commercial fuel fabrication and reprocessing)	-	1 facility	5 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 Thirteenth Act Amending the Atomic Energy Act on 6 August 2011 as a result of the events at the Japanese nuclear power plant Fukushima Daiichi, the authorisation for power operation for the eight nuclear power plants Biblis Unit A and Unit B, Neckarwestheim I, Brunsbüttel, Isar 1, Unterweser, Philippsburg 1 and Krümmel expired. The operator of the Grafenrheinfeld nuclear power plant (KKG) had already announced in 2014 to take the KKG out of operation prior to the date specified. According to the Atomic Energy Act (AtG) [1A-3], the authorisation for power operation would have expired at the latest by 31 December 2015. On 27 June 2015, the KKG has finally been taken off the grid. For the Gundremmingen B nuclear power plant, the authorisation for power operation expired on 31 December 2017 and for the Philippsburg 2 nuclear power plant on 31 December 2019. For all these nuclear power plants, first decommissioning and dismantling licences have been applied for in accordance with § 7(3) of the Atomic Energy Act. So far, licences were granted for the nuclear power plants Isar 1 (on 17 January 2017), Neckarwestheim I (on 3 February 2017), Biblis Unit A and Unit B (on 30 March 2017), Philippsburg 1 (on 7 January 2017), Unterweser (on 5 February 2018), Grafenrheinfeld (on 11 April 2018), Brunsbüttel (on 21 December 2018), Gundremmingen B (on 19 March 2019) and Philippsburg 2 (on 17 December 2019).

After entry into force of the Act on the Reorganisation of Responsibility in Nuclear Waste Management (VkENOG) on 16 June 2017 with the amendments to the Atomic Energy Act contained therein, these power plants are immediately to be shut down and dismantled. Thus, the option of safe enclosure is no longer possible. In individual cases, the competent authority may permit temporary exceptions for plant components as far and as long as this is necessary for reasons of radiation protection.

The 22 nuclear power plants under decommissioning are the nuclear power plants Greifswald (five units), Rheinsberg, Würgassen, Mülheim-Kärlich, Stade, Lingen, Gundremmingen (two units), Obrigheim, Isar 1, Neckarwestheim I, Biblis (Unit A and Unit B), Philippsburg 1 and Philippsburg 2, Grafenrheinfeld, Unterweser and Brunsbüttel.

D.5.3 Experimental and demonstration reactors

Four reactors for experimental and demonstration purposes are currently being decommissioned. These are the experimental nuclear reactor of the Arbeitsgemeinschaft Versuchsreaktor GmbH (AVR), the compact sodium-cooled nuclear reactor plant (KNK II), the multi-purpose research reactor (MZFR) and the thorium high-temperature reactor (THTR) Hamm-Uentrop. The THTR is in safe enclosure. 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 nuclear regulatory control. The nuclear ship Otto Hahn has been released from nuclear regulatory control, the ship's reactor pressure vessel has been removed and is now stored at the Helmholtz Centre Geesthacht. The disassembly of the reactor pressure vessel was applied for on 6 September 2016 and is to take place together with the dismantling of the research reactor FRG-1/2.

D.5.4 Research reactors

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

27 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 dismantled. The reactor for educational purposes AKR-1 was rededicated for a limited period of time in accordance with § 57a of the Atomic Energy Act (AtG) [1A-3]. In parallel, it was rebuilt as AKR-2, which commenced its operation in July 2005. Furthermore, the fuel plates were removed from the Siemens training reactor in Aachen and an application for decommissioning was filed.

D.5.5 Nuclear fuel cycle facilities

The six commercial facilities of the nuclear fuel cycle are the Karlsruhe reprocessing plant (WAK) together with the Karlsruhe vitrification facility (VEK) in Karlsruhe (in the process of decommissioning) and five fuel fabrication plants at Hanau and Karlstein. Four of the five fuel fabrication plants released from nuclear regulatory control have already been fully removed. A facility in Karlstein has been converted for conventional use.

In addition, the facility of Siemens Power Generation Karlstein (SPGK) – a research facility with hot cells for post-irradiation examination of fuel assemblies and for waste treatment – is currently being decommissioned, which, however, is not included among the commercial nuclear fuel cycle facilities 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 in the process of decommissioning as well as those for which dismantling has been completed and which are released from nuclear regulatory control is provided in Table L-17 of the annex.

D.5.6 Status of some current decommissioning projects

Greifswald nuclear power plant and Rheinsberg nuclear power plant

The decommissioning of both the Greifswald nuclear power plant (KGR) and the Rheinsberg nuclear power plant (KKR) is managed by the federally-owned company EWN Entsorgungswerk für Nuklearanlagen GmbH (EWN).

The KGR was in operation with four out of eight nuclear power plant units of Soviet design until final shutdown in 1990. The fifth unit had been in trial operation for several months when it was shut down in 1989. Units 6 to 8 were still under construction. The decommissioning licence was granted on 30 June 1995[1]; until then, the operating licence from the GDR era remained valid. The decommissioning of the KGR power plant units is well advanced. Parts of the plant buildings have already been put to industrial use or removed.

The KKR was the first nuclear power plant of the former GDR. It was equipped with a pressurised water reactor of the VVER type with a power of 70 MWe (gross), which had been in operation from 1966 to 1990. The first decommissioning licence was granted, as in the case of the KGR, in 1995. The radioactive waste, the reactor pressure vessel and a part of the clearable residual materials are disposed of via the facilities at the Lubmin/Rubenow site.

At present the focus of the work at the Lubmin/Rubenow site is on the preparation of the buildings of the KGR for clearance as well as on the treatment of the radioactive waste and residual materials from the operating period and from residual operation, which were initially emplaced in the Storage Facility North (ZLN). The following facilities for storage and treatment are available:

- the ZLN with several halls for the storage of radioactive waste as well as spent nuclear fuel and facilities for the treatment of radioactive waste and large components,
- the central active workshop (*Zentrale Aktive Werkstatt* – ZAW) with facilities for disassembly and decontamination (see Figure D-13), and
- the central decontamination and water treatment plant (*Zentrale Dekontaminations- und Wasseraufbereitungsanlage* – ZDW) in particular for decontamination, drying of waste containers and water treatment.

A facility for the disassembly of large components is currently in the planning phase. It is intended for the disassembly of the steam generators, reactor pressure vessels and their internals, currently stored in the ZLN, over the next decades.

With the sixth modification licence of December 2007, the ZLN has a licence for the storage of solid residual radioactive material/waste from other nuclear installations with light water reactors (only from decommissioning in the case of facilities for the commercial electricity generation) before and after treatment or conditioning at the Lubmin/Rubenow site up to five years each.

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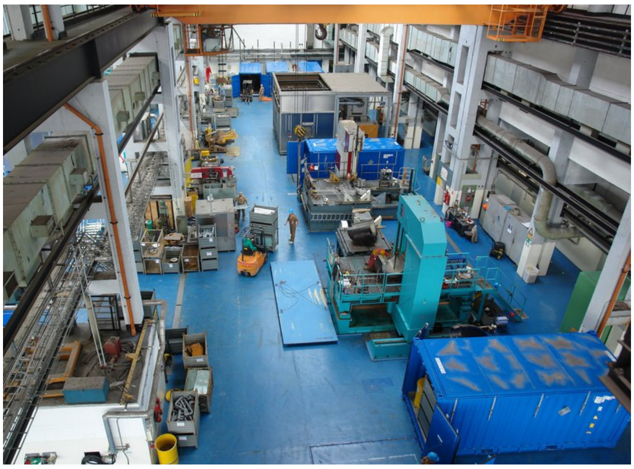
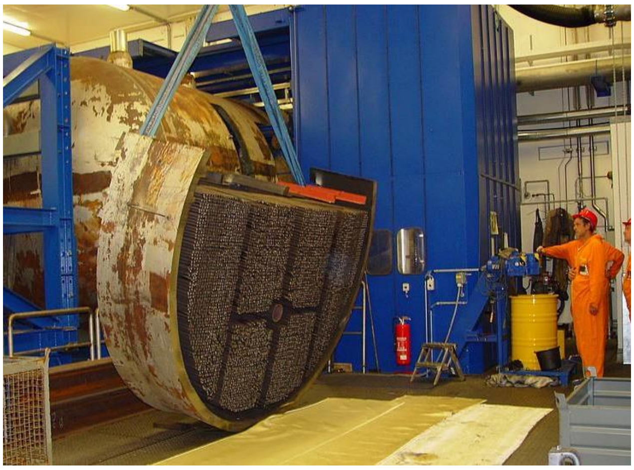
[1] Due to the design as a multi-unit facility and the associated shared use of building parts (e.g. reactor hall), the decommissioning licence of 30 June 1995 covers the decommissioning of Units 1 to 6 of the KGR. Unit 6, however, was still in the construction phase at that time and is therefore not included in the list of reactors under decommissioning in the context of reporting.

Figure D-13: View into the central active workshop (ZAW) with various disassembly and decontamination devices (left) and the ZLN with the Caisson 4 (right) (Copyright: EWN)





Obrigheim nuclear power plant

The Obrigheim nuclear power plant (KWO), a pressurised water reactor with a power of 357 MWe (gross), was in operation from 1968 to 2005. 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 AG.

The fuel assemblies were transported to the Neckarwestheim decentralised spent fuel storage facility. The transport of all fuel assemblies was completed in December 2017.

Under the fourth dismantling licence by now, which was granted in May 2018, the remaining systems and plant components will be dismantled. This includes, e.g., parts of the ventilation systems, freight elevators, the crane system in the reactor building and parts of a large material lock. In addition, this licence also permits the decontamination of the building structures.

Würgassen nuclear power plant

The Würgassen nuclear power plant (KWW), a boiling water reactor with a power 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. A plant state free of nuclear fuel was reached in October 1996.

Currently, plans are being made for removing the waste stored in the former building for the independent residual heat removal system to another location so that the demolition of the reactor building, the engine house and the building for the independent residual heat removal system can be carried out concurrently since the buildings are located in a common “black tank”.

Stade nuclear power plant

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

Currently, final emptying measures are carried out in the KKS as well as decontamination and clearance of buildings. Radioactive waste from operation and decommissioning of the KKS are stored in the on-site storage building constructed for this purpose until delivery to the Konrad repository. During the decommissioning activities, contamination from the power operation phase was detected at the bottom of the containment in January 2014. As a consequence, decontamination and clearance of the reactor building will require more time than originally planned, which will delay the completion of the licensed dismantling for release of the KKS from nuclear regulatory control. Subsequently, conventional demolition of KKS buildings and return to greenfield conditions will take place within the framework of the fifth phase.

Mülheim-Kärlich nuclear power plant

The Mülheim-Kärlich nuclear power plant (KMK), a pressurised water reactor with a power of 1,302 MWe (gross), was permanently shut down after only 13 months of operation in September 1988. Following the decision on decommissioning of the plant the corresponding application was submitted in June 2001. Three independent licensing steps are planned. The last fuel assemblies were removed in 2002.

The dismantling work started with the licence for decommissioning and dismantling phase 1 on 16 July 2004. On 31 May 2013, the licence for dismantling phase 2a followed, which comprises, among other things, the dismantling of the reactor coolant system. Licence 2b of October 2015 now permits the dismantling of the reactor pressure vessel, the steam generators and the biological shield. This work is currently in the planning phase.

Parallel to the work in the supervised and controlled area, major parts of the site have already been released from nuclear regulatory control. Licences 3a, 3b and 3c dealt with the release of site areas from nuclear regulatory control and clearance. A final licensing step 3d is mainly intended to deal with the cessation of residual operation and the clearance of the buildings and site areas or the final release of the overall site from the scope of the Atomic Energy Act.

Karlsruhe reprocessing plant and Karlsruhe vitrification facility

The Karlsruhe reprocessing plant (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.

After final shutdown on 30 June 1991, the Federation, the *Land* of Baden-Wuerttemberg and the electric power utilities decided to decommission the reprocessing plant.

The liquid high-level radioactive waste concentrate (HAWC) produced during the operation of the WAK had been completely vitrified at the Karlsruhe vitrification facility (VEK). The former storage facilities and the VEK will be dismantled; this is part of the decommissioning of the reprocessing plant.

Meanwhile, several decommissioning licences have been granted for the VEK. Since March 2019 the approval for the dismantling of the equipment in the process cells of the VEK has been available. The melting furnace must be disassembled on site. The emptied melting furnace cell is used as a disassembly cell for other components that cannot be transported as a whole to the waste management facilities of the KTE Kerntechnische Entsorgung Karlsruhe GmbH (KTE).

The current schedule for the complete dismantling of the entire plant, consisting of WAK and VEK, until demolition of the buildings extends until about the mid-2030s.

Arbeitsgemeinschaft Versuchsreaktor Jülich

The experimental nuclear reactor of the former Arbeitsgemeinschaft Versuchsreaktor GmbH (AVR) at the Jülich site (a separate area located on the premises of the Forschungszentrum Jülich GmbH

(FZJ)), North Rhine-Westphalia, was a high temperature reactor designed as pebble bed reactor with a power of 15 MWe (gross) and in operation from 1966 to 1988.

The AVR reactor was integrated into the EWN Group through the merger of the nuclear sectors of the FZJ and the AVR in September 2015 to form the JEN Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH (JEN). An initial decommissioning application from the 1990s provided for the strategy of safe enclosure. In May 2003, the objective of the project was changed to complete removal and return to greenfield conditions. Until its final disassembly and conditioning into waste packages qualified for disposal, the reactor vessel will be stored in a storage facility at the site of the FZJ. The current work includes the remote-controlled dismantling of the concrete structures using a demolition robot. The total mass of concrete and heavy concrete structures to be removed is approx. 1,900 Mg, of which about one third is radioactively contaminated and must be conditioned by JEN for disposal.

Lingen nuclear power plant

The Lingen nuclear power plant (KWL) was a boiling water reactor with a power of 252 MWe (gross). This reactor was commissioned in 1968, but due to technical considerations the plant was permanently shut down in 1977.

With a notice of 14 November 1997, KWL was granted the licence for modification of the decommissioned plant and the operation under safe enclosure conditions for the purposes of disposing of the radioactive operational waste. 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(3) AtG in December 2008.

Dismantling is to be carried out in three partial projects. In the first licensing step initially applied for (partial project 1), all uncontaminated and contaminated plant components, including the steam converter, are to be dismantled. A second licensing step (partial project 2) is to include the dismantling of the reactor pressure vessel and its internals, the biological shield, the residual dismantling, decontamination, and the plant’s release from nuclear regulatory control. The third partial project comprises the conventional dismantling of buildings. The licence for partial project 1 was granted in December 2015.

Hamm-Uentrop thorium high temperature reactor

The Hamm-Uentrop thorium high temperature reactor (THTR-300) was equipped with a helium-cooled 308 MWe (gross) pebble bed high temperature reactor and started operation in 1983. Final shutdown 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 Hochtemperatur-Kernkraftwerk GmbH (HKG) and their proprietors signed a framework agreement concerning the completion of the THTR-300 project.

The reactor core has been unloaded since 1995 and the plant has been in safe enclosure since October 1997. HKG intends maintaining the duration of safe enclosure until 2027 according to the current state of planning and to start preparing the facility for complete dismantling in 2028.

E Legislative and regulatory system

Developments since the Sixth Review Meeting:

Council Directive 2014/87/EURATOM amending Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear installations was transposed into German law with the Fifteenth Act Amending the Atomic Energy Act of 1 June 2017.

The Sixteenth Act Amending the Atomic Energy Act of 10 July 2018 regulates the financial compensation of the electric power utilities for phasing out the commercial use of nuclear energy.

On 5 December 2018, the Ordinance for the Further Modernisation of Radiation Protection Law was published in the Federal Law Gazette. It contains a series of individual ordinances that further develop German radiation protection law. These include the revised version of the Radiation Protection Ordinance (StrlSchV), which is based primarily on Council Directive 2013/59/EURATOM. In this new version, regulations of the X-ray Ordinance, which was simultaneously repealed, were also adopted.

Another component of the collective ordinance is the Nuclear Waste Management Ordinance (AtEV), which describes requirements and procedures for the management of radioactive waste. The new Radiation Protection Ordinance came into force on 31 December 2018, as did the new Nuclear Waste Management Ordinance.

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

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 Joint Convention

Within the framework of its national law, the Federal Republic of Germany has already taken all the necessary steps in legislation, regulation and administration for implementing its obligations under the Joint Convention. The specific individual measures are described in the reporting on Article 19 of the Joint Convention. Continuous adaptation of the regulations to new findings and developments ensures that the state of the art in science and technology is taken into account in an appropriate manner.

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

The Basic Law for the Federal Republic of Germany (Basic Law – 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 review of administrative actions by independent courts. In the civil nuclear sector, legislation, administrative authorities and jurisdiction provide a framework for a system for the protection of life, health and property of workers and the general public against the dangers of nuclear energy and the harmful effects of ionising radiation, as well as for the regulation and supervision of safety during the construction, operation and decommissioning of nuclear installations. In accordance with the statutory requirements, in the field of nuclear technology, ensuring safety has priority over economic interests. By requiring that the necessary precautions have to be taken in the light of the state of the art of science and technology to prevent damage as a key guiding principle, internationally accepted safety standards, as specified in the Fundamental Safety Principles of the International Atomic Energy Agency (IAEA) [IAEA 06a], 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 installations and facilities maintain and further develop a high safety culture within their own sphere 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.

The legislative competence for the use of nuclear energy for peaceful purposes lies with the Federation, Article 73(1)(14) in conjunction with Article 71 GG. The further development of nuclear law is also a task of the Federation. The *Länder* are involved in the procedure.

The Atomic Energy Act (AtG) [1A-3] and the statutory ordinances based thereon are executed in large parts by the *Länder* on behalf of the Federation, as stipulated in § 24(1) AtG in conjunction with Articles 87c and 85 GG. The same applies to the Radiation Protection Act. With respect to the legality and appropriateness of their action, the competent *Land* authorities are subject to supervision by the Federation. In other areas, central tasks of nuclear waste management are carried out by direct federal administration in accordance with Articles 86, 87(3) GG. The central tasks to be mentioned here are those of the BASE according to § 23d AtG, in particular the supervision of the federal facilities for disposal in accordance § 9a(3) AtG, sentence 1 and the Asse II mine, as well as, after transitional periods, the task as plan approval and licensing authority for disposal facilities.

Article 85 Basic Law:

[Execution by the *Länder* on federal commission (federal executive administration)]

"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 Land authorities shall be subject to instructions from the competent highest federal authorities. Such instructions shall be addressed to the highest Land authorities unless the Federal Government considers the matter urgent. Implementation of the instructions shall be ensured by the highest Land authorities.

4. Federal oversight 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. Within the frame of federal executive administration, 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 Federation 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 procedures under nuclear and radiation protection law, other legal regulations also have to be considered, such as immission control legislation, water legislation, and building legislation. Legal regulations for assessing the environmental impact are, in general, part of the nuclear approval procedure and the licensing procedure under radiation protection law, respectively.

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) GG). Action is brought against the competent *Land* authority, or the *Land* whose authority issued the administrative act, within the frame of federal executive administration. 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, for example, 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 installation.

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) GG, sentence 1, 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 as well as on national implementing provisions is given in Annex L-(d) [National laws and regulations].

For Germany, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [1E-1] came 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-5-1],
- the Brussels Supplementary Convention of 1963 [1E-5-2], and
- the Joint Protocol of 21 September 1988 Relating to the Application of the Vienna Convention and the Paris Convention [1E-5-4].

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 came into force on 24 March 2008.

The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) of 1992, which came into force at the beginning of 1998, has a similar objective to that of the London Convention. The Convention brings together the Federal Republic of Germany and 14 other western and northern European countries as well as the European Union for the protection of the North-East Atlantic. The OSPAR Convention was established by the unification and extension 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 Atomic Energy Community (EAEC/EURATOM) and the European Union (EU). 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 the EURATOM in the European legislation.

According to Articles 77 et seq. of the EURATOM Treaty, any utilisation of ores, source material and special fissile material is subject to the surveillance of EURATOM.

On 5 December 2013, the Council of the European Union adopted the new Council 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. Council Directive 2013/59/EURATOM takes account of new scientific findings and the recommendations of Publication 103 of the International Commission on Radiological Protection (ICRP) [ICRP 07]. It was implemented into national law by the adoption of the Radiation Protection Act (StrlSchG) of 27 June 2017 [1A-34] (see Chapter E.2.2 for details).

On 22 July 2009, Council Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear installations [1F-5] came into force to supplement the directives of the EURATOM 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 EU member states are to take appropriate national measures to effectively protect workers and the general public against the dangers of ionising radiation from nuclear installations. The Directive applies, among others, to nuclear power plants, research reactors, the storage of nuclear fuel and the storage of radioactive waste if directly related to the respective nuclear installation and taking place on the same site, but not to disposal facilities. 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 installations, the education and training of the staff of all parties involved, and the information of the public. Council Directive 2009/71/EURATOM was amended by Council Directive 2014/87/EURATOM, which came into force on 8 July 2014, in order to include for the first time substantive technical rules in the field of nuclear safety, such as on the safety objective and safety culture. The Directive was transposed into national law by the Fifteenth Act Amending the Atomic Energy Act of 1 June 2017.

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, Council Directive 2009/71/EURATOM was transposed into national law with the Twelfth Act Amending the Atomic Energy Act.

In the field of nuclear waste management, the Council of the EU 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, in particular, 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. Council Directive 2011/70/EURATOM was transposed into national law with the Fourteenth Act Amending the Atomic Energy Act of 20 November 2015.

An overview of the legal provisions of the EU, in particular with regard to radiation protection and radioactive waste, is given in Annex L-(d), Part 1F [Agreements, general provisions].

E.2.2 National safety provisions and regulations

Hierarchical structure of the regulations

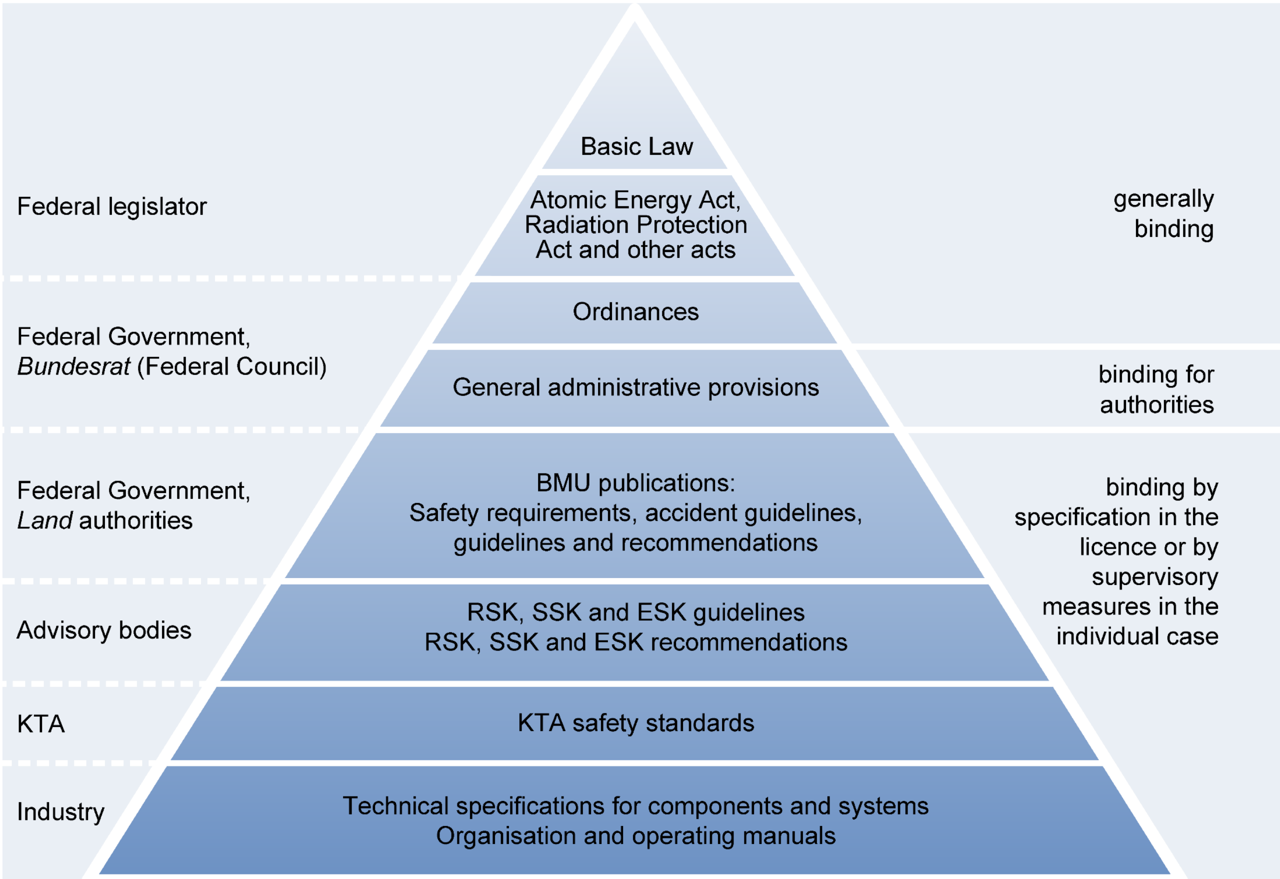
The Manual on Reactor Safety and Radiation Protection [BASE 19] contains all the statutory and non-mandatory guidance instruments that are valid in Germany for the following areas:

- nuclear safety,
- disposal,

- transporting radioactive substances, and
- protection from ionising and non-ionising radiation.

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 have regulatory relevance by virtue of the legal requirement that necessary precautions have to be taken in the light of the state of the art in science and technology to prevent damage referred to in the various nuclear licensing conditions (e.g. in § 7(2)(3) of the Atomic Energy Act (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 assumed that the nuclear 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 being significant in terms of safety aspects will displace the application of an obsolete non-mandatory guidance instrument without explicitly needing to suspend it.

In this report, reference is made to the contents of the individual regulations when addressing the respective articles of the Joint Convention. All regulations are accessible to the public and are published in official publications of the Federation.

The safety provisions were applied in all nuclear licensing and supervisory procedures and have been further developed, where necessary, particularly in the field of spent fuel and radioactive waste management, taking into account the state of the art in science and technology.

Acts

Basic Law

The Basic Law (GG) [GG 49] contains fundamental principles which also apply to nuclear law. It also contains provisions on the legislative and administrative powers of the Federation and the *Länder* regarding the use of nuclear energy. As defined in Article 73 GG, the Federation shall have exclusive legislative power with respect to "the production and utilisation of nuclear energy for peaceful purposes, the construction and operation of facilities serving such purposes, protection against hazards arising from the release of nuclear energy or from ionising radiation, and the disposal of radioactive substances". The *Länder* carry out most of their tasks under nuclear law (with the exception of the regulations of the off-site emergency management system of the Federation and the *Länder*) on behalf of the Federation (federal executive administration). Federal supervision extends to the legality and appropriateness of execution by the *Land* authorities. According to Article 85(3) GG, these shall be subject to the instructions from the competent highest federal authority, i.e. the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

In other areas, central tasks of nuclear waste management are carried out by direct federal administration in accordance with Articles 86, 87(3) GG. The central tasks to be mentioned here are those of the BASE according to § 23d AtG, in particular the supervision of the federal facilities for disposal in accordance § 9a(3) AtG, sentence 1 and the Asse II mine, as well as, after transitional periods, the task as plan approval and licensing authority for disposal facilities.

The basic rights laid down in the Basic Law, in particular the basic right to life and physical integrity, form the basis for the standard to be applied to the protective and preventive measures at nuclear installations and facilities, which is further specified in the above hierarchy levels of the pyramid.

Atomic Energy Act

The Atomic Energy Act 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 since the amendment of 2002 is to phase out the use of nuclear energy for commercial electricity generation in a controlled manner. Until then, undisturbed operation of the nuclear installations is to be ensured, life, health and property are to be protected against the hazards of nuclear energy and the detrimental effects of ionising radiation and, furthermore, compensation for any damage and injuries incurred is to be provided. 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 Atomic Energy Act includes the general national provisions for protective and precautionary measures, radiation protection and radioactive waste and spent fuel management in Germany and constitutes the basis for the associated ordinances.

Besides its purpose and general provisions, the Atomic Energy Act 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 Atomic Energy Act requires that the construction and operation of nuclear installations as well as various types of handling of radioactive substances shall be subject to regulatory licensing. The Atomic Energy Act regulates, in particular, prerequisites and procedure for the granting of licences, the performance of supervision as well as the consultation of authorised experts (§ 20 AtG) and the charging of costs (§ 21 AtG). In the field of waste management, the Atomic Energy Act stipulates that the Federation shall establish facilities for the safekeeping and disposal of radioactive waste (§ 9a(3) AtG, sentence 1). The construction and operation of such facilities requires, in general, plan approval (§ 9b(1) AtG). In the cases where the site of a facility is determined by federal law, a licence shall substitute the plan approval (§ 9b(1a) AtG). § 9b(1a) AtG has been inserted into the Atomic Energy Act as a new paragraph in connection with the Site Selection Act (StandAG 2013) [1A-7a] described below. The costs incurred for the planning, construction and operation of facilities for the safekeeping and disposal of radioactive waste are principally borne by the waste producers through fees and contributions together with advance payments according to §§ 21a and 21b AtG in conjunction with the Ordinance Concerning Prepayments for the Erection of Federal Facilities for the Long-Term Engineered Storage and Disposal of Radioactive Waste (Repository Prepayment Ordinance – EndlagerVlV) [1A-13]. However, insofar as the financing obligation for facilities for the disposal of radioactive waste pursuant to § 1 of the Waste Management Transfer Act (EntsorgÜG) [1A-35] has passed to the fund pursuant to § 1(1) of the Waste Management Fund Act (EntsorgFondsG) [1A-36], the fund will be liable to advance payments instead of the licence holder. This applies to the site selection procedure, which is financed through cost allocations to the waste producers according to §§ 28 et seq. of the Site Selection Act (StandAG) [1A-7b], accordingly. With the transfer of the spent fuel and radioactive waste to the third party commissioned with storage management by the Federation (BGZ Company for Storage (BGZ)), the responsibility for waste management according to § 9a(1) AtG is also transferred to it as stipulated in § 2 EntsorgÜG.

However, most of the regulations laid down in the Atomic Energy Act 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 Atomic Energy Act as well as by the non-mandatory guidance instruments.

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

With the Tenth Act Amending the Atomic Energy Act of 24 March 2009 [1A-24], the operation and decommissioning of the Asse II mine were largely made subject to the provisions of the Atomic Energy Act on federal facilities for the disposal of radioactive waste by the insertion of § 57b AtG and the responsibility of the Federal Office for Radiation Protection (BfS) as operator was substantiated. Due to subsequent amendments to the law, the responsibility for operating the facility now lies with the Federal Company for Radioactive Waste Disposal (BGE).

The Eleventh Act Amending the Atomic Energy Act of 8 December 2010 extended the lifetimes of the German nuclear power plants within the framework of the energy concept adopted by the Federal Government, i.e. by eight years for plants built before 1980 and by 14 years for the other plants.

The Twelfth Act Amending 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 installations – unless they already represented applicable national law – into national law.

The Thirteenth Act Amending the Atomic Energy Act of 31 July 2011 [1A-25] implemented the decision of the Federal Government to phase out the use of nuclear energy for commercial electricity generation in the Federal Republic of Germany at the earliest possible date in response to the events in Fukushima. The amendments to the Atomic Energy Act stipulate the phase out of electricity generation by nuclear installations by 2022 on a step-by-step basis.

Further provisions of Council Directive 2011/70/EURATOM [1F-36] on a Community framework for the responsible and safe management of spent fuel and radioactive waste were transposed into national law with the Fourteenth Act Amending the Atomic Energy Act of 20 November 2015 [1A-28]. The Act mainly contains the duties directed to the operators of waste management facilities – including disposal facilities – such as a corresponding extension of the operators' obligation already enshrined in law to carry out periodic reviews and assessments of the safety of a facility. Furthermore, it contains the standardisation of the State's obligation to draw up a National Programme (NaPro) for spent fuel and radioactive waste management [BMU 15] for Germany.

With the Fifteenth Act Amending the Atomic Energy Act of 1 June 2017 [1A-32], Council Directive 2014/87/EURATOM amending Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear installations was transposed into German law. The Act contains the following amendments:

- extension of the obligations of the licence holder regarding the publication of certain minimum information on normal operation, reportable events and accidents,
- provisions on the mandatory peer reviews (introduction of topic-related technical self-assessments and their international review),
- clarification of the responsibilities also for contractors and subcontractors, including the provision of adequate human resources, and
- regulation of on-site emergency preparedness.

The Sixteenth Act Amending the Atomic Energy Act of 10 July 2018 [1A-33] regulates the financial compensation of the electric power utilities for phasing out the commercial use of nuclear energy. A precondition for compensation is that the owner has made investments in the nuclear power plant in reliance on the legal situation created by the Eleventh Act Amending the Atomic Energy Act of 8 December 2010. Compensation is only possible if the power utilities have made serious efforts to transfer the residual electricity volumes to other plants.

The Act Amending the Environmental Audit Act, the Atomic Energy Act, the Site Selection Act, the Repository Prepayment Ordinance and other acts and ordinances of 12 December 2019 [1A-39] essentially creates the possibility to replace, in individual cases, the imposition of costs based on the cost provisions in the Atomic Energy Act, the Site Selection Act and the Repository Prepayment Ordinance for radioactive waste management by the conclusion of a public-law agreement.

<u>Act on the Reorganisation of the Law on the Protection against the Harmful Effects of Ionising Radiation</u>

With the implementation of Council Directive 2013/59/EURATOM [1F-24], the law on radiation was reorganised and modernised. The Radiation Protection Act (StrlSchG) [1A-34], which was enacted as Article 1 of the Act on the Reorganisation of the Law on the Protection against the Harmful Effects of Ionising Radiation of 27 June 2017 [1A-29], regulates radiation protection for the first time in a formal statute. Most of the provisions of the Radiation Protection Act came into force on 31 December 2018. The provisions of the Radiation Protection Act on radiological emergency preparedness and monitoring of environmental radioactivity, which replace the Act on the Precautionary Protection of the Population against Radiation Exposure (Precautionary Radiation Protection Act – StrVG) [1A-5] formerly in force, as well as the provisions to enable issuing statutory ordinances have been in force since 1 October 2017.

The Radiation Protection Act regulates, among other things,

- radiation protection principles and limits,
- the operational organisation of radiation protection,
- the emergency management system of the Federation and the *Länder*, and

- the protection of emergency workers.

In addition, with the reorganisation of radiation protection law, the Precautionary Radiation Protection Act was repealed and other act and ordinances amended.

Lex Asse

With the Act on Speeding up the Retrieval of Radioactive Waste and the Closure of the Asse II Mine ("Lex Asse"), which was effected on 24 Aprill 2013 [1A-26], the legal framework for an accelerated procedure was created in § 57b AtG. In particular, the following was regulated:

- 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

With the Act Amending the Act on the Search for and Selection of a Site for a Disposal Facility for Heat-Generating Radioactive Waste and for the Amendment of Other Laws, which largely came into force on 16 May 2017, the Site Selection Act [1A-7b] was amended and the site selection procedure was started. The Site Selection Act includes the provision to enable issuing statutory ordinances on the adoption of safety requirements and requirements for carrying out the preliminary safety analyses in terms of disposal. These ordinances will replace the BMU Safety Requirements of 2010 [BMU 10]. In addition, a third provision to enable issuing an ordinance on the documentation of disposal is included. All three ordinances are currently (as of March 2020) in preparation.

The purpose of the amended Site Selection Act is to determine, in a participatory, science-based, transparent, self-questioning and learning procedure, the site for the disposal of high-level radioactive waste that will ensure the best possible safety for a period of one million years. The selection procedure is based on statutory minimum requirements, exclusion criteria and weighing criteria, which are to be applied in several phases of the procedure to narrow down the site options and which are to be supported by safety analyses to be refined successively and further test criteria.

The project implementer for the transparent, science-based search and selection process is Federal Company for Radioactive Waste Disposal (BGE), founded in July 2016. The Federal Office for the Safety of Nuclear Waste Management (BASE), established within the portfolio of the BMU, is responsible for supervising the implementation of the site selection procedure.

The public is to be given the opportunity of intensive participation in the process of site selection at the national and regional level. The BASE is also the organiser and coordinator of public participation.

At the national level, a National Civil Society Board was constituted in December 2016. This board consists of 18 members, twelve of which are respected public figures appointed by the *Bundestag* and the *Bundesrat*. The other six members are citizens who were selected from a random sample according to a qualified selection system and appointed by the Federal Environment Minister, including two representatives of the younger generation.

The central task of the National Civil Society Board is to accompany the process of site selection as a mediating and independent body until reaching a decision on a site, in particular with regard to public participation. To this end, it may seek advice from external experts or request scientific opinions.

The public in the site regions proposed in the site selection procedure will be involved in the procedure by regional conferences and the subareas expert conference. In addition, there will be a Council of the Regions at the cross-regional level. The social bodies will be provided with the necessary resources.

Act on the Establishment of a Federal Office for the Safety of Nuclear Waste Management

The Act on the Establishment of a Federal Office for the Safety of Nuclear Waste Management (BfkEG) [1A-27], which came into force on 1 January 2014, established the Federal Office for the Safety of Nuclear Waste Management (BfE). By a statutory amendment of 12 December 2019 [1A-39], the BfE was renamed the BASE with effect from 1 January 2020. According to § 2 BfkEG, the BASE is the competent authority of the Federation in the field of licensing of federal facilities for the safekeeping and disposal of radioactive waste that are assigned to it by the Atomic Energy Act, the Site Selection Act or other federal laws or by virtue of these laws. Among other things, the BASE is to develop and define site-specific exploration programmes and test criteria in the site selection procedure. Furthermore, the BASE examines the proposals of the project implementer and monitors the implementation of the site selection procedure. It is the organiser and coordinator of public participation in the site selection procedure. The BASE started its work on 1 September 2014. It is headquartered in Berlin. Further offices are located in Salzgitter and Bonn.

Act on the Reorganisation of the Organisational Structure in the Field of Disposal

On 30 July 2016, the Act on the Reorganisation of the Organisational Structure in the Field of Disposal [1A-30] came into force. The purpose of the Act is to reallocate responsibilities in the field of disposal and to ensure a more efficient handling of tasks. In the field of disposal, on 25 April 2017, the operator and operational management tasks, that have so far been performed by the Federal Office for Radiation Protection (BfS) on the one hand and the administrative aides Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH (DBE) and Asse-GmbH on the other hand, were transferred to a newly founded, federally-owned company under private law, the Federal Company for Radioactive Waste Disposal (BGE), and bundled there. DBE, Asse-GmbH and parts of the BfS have been merged into the new company. The BGE is headquartered in Peine.

The licensing and supervisory tasks are concentrated at the BASE. The responsibilities were clearly defined due to the separation of operator tasks and licensing and supervisory tasks.

The BfS continues to work as an independent higher federal authority and concentrates exclusively on the various issues related to radiation protection.

Act on the Reorganisation of Responsibility in Nuclear Waste Management

On 16 June 2017, the Act on the Reorganisation of Responsibility in Nuclear Waste Management [1A-31] came into force. The Act implements the recommendations of the Commission to Review the Financing for the Phase-out of Nuclear Energy (KFK) [KFK 16] and reorganises the responsibility for nuclear waste management. It secures the financing of decommissioning and waste management in the long term without passing on the costs incurred for this purpose unilaterally to society and without jeopardising the economic situation of the operators with a view to the nuclear obligations remaining there.

The operators of the nuclear power plants will continue to be responsible for the entire management and financing of decommissioning and qualified packaging of the radioactive waste. The qualified packaging for the transfer to storage is geared to the fulfilment of the Konrad waste acceptance criteria and is verified within the scope of product control. In future, however, the implementation and financing of storage and disposal will be the responsibility of the Federation. These tasks will be performed by the federally-owned companies BGZ and BGE. The funds for storage and disposal of around 24 billion euros were provided to the Federation by the operators and transferred to a fund, organised as a foundation under public law, by 1 July 2017. The fund collects the funds, invests them and disburses them. The investment of the funds by the fund is intended to increase the total amount so that sufficient funds are available for the respective waste management step to be carried out in the future.

The following acts were enacted or amended under the Act on the Reorganisation of Responsibility in Nuclear Waste Management:

- **Article 1: Act on the Establishment of a Fund for the Financing of Nuclear Waste Management (Waste Management Fund Act – EntsorgFondsG)**

  The Act regulates the establishment of a foundation under public law for the financing of nuclear waste management (KENFO) and the terms of payment into the fund. The operators of the nuclear power plants had to transfer the basic amount of around 17.9 billion euros to the fund by 1 July 2017. Furthermore, they could transfer the liability for interest rate and cost risks to the State against the payment of a risk premium of an extra 6.2 billion euros, which all operators made use of.

- **Article 2: Act Regulating the Transfer of Financing and Action Obligations for the Management of Radioactive Waste from Operators of Nuclear Power Plants (Waste Management Transfer Act – EntsorgÜG)**

  In conjunction with the Waste Management Fund Act, this Act regulates the transfer of the financing and action obligations of the nuclear power plant operators for the management of radioactive waste from operation and decommissioning, safe enclosure as well as the dismantling of nuclear fuel fission installations for the commercial electricity generation. Accordingly, on the one hand, the Federation assumes the financing obligation for storage and disposal of radioactive waste after the above-mentioned amounts have been paid in by the operators. On the other hand, the action obligation of the operators with regard to the management of their radioactive waste is transferred to the Federation from the time of transfer of the properly packaged waste to the federally-owned storage facility operator BGZ. Furthermore, the storage facilities listed in the annex to the Act were transferred to the Federation on 1 January 2019 and 1 January 2020, respectively.

- **Article 3: Amendment of the Atomic Energy Act**

  With the amendment of § 7(3) AtG, the Act aims, among other things, at immediate decommissioning and dismantling of nuclear power plants whose authorisation for power operation expired or whose power operation has ceased permanently. Safe enclosure is thus no longer a decommissioning option. In individual cases, the competent authority may permit temporary exceptions for plant components as far and as long as this is necessary for reasons of radiation protection.

- **Article 7: Act on Transparency Regarding the Costs of Decommissioning and Dismantling Nuclear Power Plants and the Packaging of Radioactive Waste (Transparency Act – TransparenzG)**

  The Transparency Act [1A-37] regulates, inter alia, certain obligations to provide information to the Federal Office for Economic Affairs and Export Control (BAFA), but also requirements concerning the provisions of nuclear power plant operators for the waste management obligations remaining with the operator. In this way, financing shall be secured by means of more transparency and better auditability also for tasks that remain within the responsibility for financing and action of the operators, in particular in terms of the decommissioning of nuclear power plants. In addition, the objective of the Act is to provide clarity to the Federation on the cost estimates on which the formation of provisions for decommissioning are based.

- **Article 8: Act on the Follow-up Liability for Dismantling and Waste Management Costs in the Nuclear Energy Sector (Follow-up Liability Act – NachhG)**

  The Follow-up Liability Act [1A-38] also attributes the payment obligations with respect to the costs for decommissioning of the facilities, the payment obligations to the fund according to the Waste Management Fund Act as well as the payment obligations for cost increases in radioactive waste management that remain with the companies in the event of non-payment of the risk premium to the so-called controlling companies in addition to the controlled operating company. This is to prevent that the electric power utilities can free themselves wholly or partly from the liability for the costs of nuclear phase-out and the management of their radioactive waste by restructuring.

In addition, the Act on the Reorganisation of Responsibility in Nuclear Waste Management amended other acts and ordinances as consequential amendments (the Site Selection Act, the Repository Prepayment Ordinance and the Radiation Protection Ordinance).

Statutory ordinances

For further concretisation of the legal regulations, the Atomic Energy Act and the Radiation Protection Act contain authorisations for the promulgation of ordinances. As a rule, these ordinances require the consent of the *Bundesrat*. The *Bundesrat* is a constitutional organ of the Federation in which the governments of the *Länder* are represented.

In this context, a number of statutory ordinances have been issued on the basis of the Atomic Energy Act and the Radiation Protection Act which are also relevant for the management of spent fuel and radioactive waste. The most important ordinances relate to:

- more detailed regulations on radiation protection (Radiation Protection Ordinance – StrlSchV [1A-8b]),
- radioactive waste management (Ordinance on Requirements and Procedures for the Management of Radioactive Waste (Nuclear Waste Management Ordinance – AtEV) [1B-19]), the licensing procedure (Ordinance on the Procedure for Licensing of Installations under § 7 of the Atomic Energy Act (Nuclear Licensing Procedure Ordinance – AtVfV) [1A-10]),
- the transboundary movement of radioactive waste or spent fuel (Ordinance on the 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]),
- the dose values for early emergency response measures (Ordinance on the Stipulation of Dose Values for Early Emergency Response Measures (Emergency Dose Value Ordinance – NDWV) [1B-20]),
- provisions for sufficient coverage (Ordinance Concerning the Financial Security Pursuant to the Atomic Energy Act (Nuclear Financial Security Ordinance – AtDeckV) [1A-11]),
- the reporting of reportable events (Ordinance on the Nuclear Safety Officer and the Reporting of Incidents and other Events (Nuclear Safety Officer and Reporting Ordinance – AtSMV) [1A-17]), and
- the verification of trustworthiness of persons to protect against diversion or release of radioactive material (Ordinance on the Verification of Trustworthiness as a Protection Against Diversion or Release of Radioactive Material in Accordance with the Atomic Energy Act (Nuclear Trustworthiness Verification Ordinance – AtZüV) [1A-19]).

With the various articles of the Ordinance on the further modernisation of radiation protection law of 29 November 2018, new ordinances are created and existing ordinances updated. The Radiation Protection Ordinance and the Nuclear Waste Management Ordinance, both of which came into force on 31 December 2018, are of particular importance with regard to the Joint Convention. The Radiation Protection Ordinance continues the amendment of German law on the protection against the harmful effects of ionising radiation, which began with the Radiation Protection Act, and further improves the existing high standard of protection. In particular, it contains more detailed requirements for occupational and medical radiation protection and for the protection of the general public. The Nuclear Waste Management Ordinance describes requirements and procedures for the management of radioactive waste and thus continues further elements of the existing law on the protection against the harmful effects of ionising radiation on the basis of the Atomic Energy Act.

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

Ordinances on the permanent storage of data and documents in the field of storage and disposal and on the safety requirements and preliminary safety analyses for the disposal of high-level radioactive waste are in preparation. A Ministry draft of the two latter ordinances (as at 11 July 2019) was made available for public comment. The formulation of the ordinance is based on the requirements set forth by the Commission on the Storage of High-Level Radioactive Waste in its final report, according to which, on the one hand, basic safety requirements must be, among other things, developed in a scientifically based and transparent manner, described precisely and publicly debated before the search for a disposal site actually begins and, on the other hand, all data and documents must be stored for which a necessary or possible future use can be discerned.

General administrative provisions

General administrative provisions (AVV) regulate the actions of the authorities but they only have a direct binding effect for the administration. They have a direct external effect if they are used as a basis for administrative decisions.

In the nuclear field, there are seven AVV which deal with the following topics:

- calculation of radiation exposure during specified normal operation of nuclear installations and facilities [2-1],
- radiation passbook [2-2],
- environmental impact assessment [2-3],
- environmental monitoring [2-4],
- monitoring of food [2-5],
- monitoring of feed [2-6], and
- rapid alert system [2-7].

Announcements by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

After having consulted the *Länder*, the BMU 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 and the Radiation Protection Act (see reporting on Article 20 in Chapter E.3). The BMU announcements describe the view of the federal supervisor under nuclear and radiation protection law and, if the decisions were made in the *Länder* Committee for Nuclear Energy (LAA), also the view of the licensing and supervisory authorities of the *Länder* under nuclear and radiation protection law on general issues relating to nuclear safety and the administrative practice, and they provide orientation for the *Land* authorities regarding the enforcement of the Atomic Energy Act and the Radiation Protection Act. This ensures that enforcement in different *Länder* is carried out according to comparable standards wherever possible. Unlike the general administrative provisions, the announcements are not binding for the authorities of the *Länder*. Their relevance is also given by the right of the BMU to issue binding individual directives for particular cases to the *Land* authorities. Currently, about 100 BMU 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-(d).

Related to spent nuclear fuel and radioactive waste management 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] (replacement by a statutory ordinance planned, in preparation),
- the Guideline concerning Emission and Immission Monitoring of Nuclear Installations (REI) [3-23],
- the Guideline on the Control of Residual Radioactive Material and Radioactive Waste [3-60],
- 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 [3-73] (in short: Decommissioning Guide),
- the Guideline for Physical Radiation Protection Control for the Determination of Body Doses, Part 1: Determination of the Body Dose from External Radiation Exposure (§§ 40, 41, 42 StrlSchV; § 35 RöV) [3-42.1] (revision planned under the new radiation protection legislation),
- the Guideline for Physical Radiation Protection Control for the Determination of Body Doses, 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] (revision planned under the new radiation protection legislation),
- the Guideline Concerning the Radiation Protection of the Personnel During Maintenance, Modification, Waste Management and Dismantling Work in Nuclear Installations and Facilities, Part 2: The Radiation Protection Measures during the Operation and the Decommissioning of an Installation or Facility (IWRS II) [3-43.2],
- the Guideline Relating to the Technical Qualification of Responsible Personnel in Facilities for the Storage of Nuclear Fuel (Storage Facilities) [3-21].

The Safety Criteria for the Final Disposal of Radioactive Wastes in a Mine [3-13], published in the Federal Law Gazette *(Bundesanzeiger)* at the beginning of 1983, had the task of specifying in concrete terms the requirement of precautionary measures under nuclear law, which must also be complied with for disposal. In the period that followed, international recommendations and standards related to radiation protection and disposal of radioactive waste have been substantially revised and updated in line with new knowledge. Against this background, the BMU has drawn up the safety requirements for the disposal of heat-generating radioactive waste. The safety requirements put the necessary precautions to be taken in the light of the state of the art of science and technology to prevent damage in concrete terms that are to be complied with regarding the construction, operation and closure of a disposal facility for heat-generating radioactive waste and to be reviewed within the plan approval procedure by the respective licensing authority.

With the amended Site Selection Act, it was introduced that the BMU will define in the future the safety requirements for disposal in a statutory ordinance. A corresponding ordinance is currently being drafted.

Guidelines and recommendations of the Commission on Radiological Protection and the Nuclear Waste Management Commission

The recommendations of the SSK and the ESK play an important role with respect to licensing and supervisory procedures in the field of spent fuel and radioactive waste management. These independent expert commissions advise the BMU on issues relating to radiation protection and nuclear waste management. By appointing experts in different technical fields and with different fundamental views, it is intended that the full bandwidth of scientific knowledge should be reflected in these two bodies (see reporting on Article 20 in Chapter E.3).

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

Commission on Radiological Protection

On the basis of the findings gained in connection with the accident at the Fukushima Daiichi nuclear power plant, the SSK has subjected the technical bases for emergency protection in Germany and the related regulations to a review. The determination of the accident spectrum which is the basis for emergency planning was based more on the potential impact than on the calculated probability of occurrence of accidents. In a first step, the recommendation on “Planning Areas for Emergency Response Near Nuclear Power Plants” [3-251] was adopted on 13/14 February 2014 and, in addition to this, the recommendation on Planning Areas for Emergency Response Near Decommissioned Nuclear Power Plants [3-252] was adopted on 20/21 October 2014.

At its meeting on 11/12 December 2014, the SSK adopted a recommendation on the “Introduction of Dose Constraints to Protect Against Occupational Radiation Exposure when Transposing Directive 2013/59/EURATOM into German Radiological Protection Law” [3-254]. Previously, the SSK had examined by way of an exemplary view of typical areas of occupational radiation protection the extent to which already existing regulations on dose constraints and optimisation tools are compatible with the requirements of Council Directive 2013/59/EURATOM, and whether an improvement in occupational radiation protection is to be expected by the introduction of dose constraints in terms of this Directive. For none of the areas examined, the SSK considered it necessary to introduce dose constraints at the level of relevant laws and ordinances for the implementation of Council Directive 2013/59/EURATOM.

At its meeting on 19/20 February 2015, the SSK adopted new Basic Recommendations for Disaster Control in the Vicinity of Nuclear Power Plants [3-253]. With this further development of the existing recommendations for the preparation of disaster control plans from the year 2008, the results of the review of the rules and regulations for emergency preparedness carried out after the accident at the Fukushima Daiichi nuclear power plant were taken into account.

At its meeting on 15 September 2016, the SSK adopted a recommendation on radiation protection during the closure of the Asse II mine [4-28]. Accordingly, the SSK recommends, among other things, giving due consideration to the three principles of radiation protection, i.e. justification, optimisation and limitation of radiation exposure, for all future measures and decisions during the closure of the Asse II mine.

At its meeting on 24/25 October 2019, the SSK adopted a recommendation on operational intervention levels for measures to protect the population against incidents involving releases of radionuclides [4-33]. In this recommendation, dose reference levels are related to measurable quantities such as the local dose rate, the surface contamination or the activity concentrations resulting from the event, primarily in air, water, food and on objects, in order to develop operational intervention levels (OILs), which can be used in the early phase of an event to decide on specific protective measures.

Nuclear Waste Management Commission

As regards the storage of spent fuel and radioactive waste, the following recommendations prepared by the ESK are of particular importance:

- "Guidelines for Dry Cask Storage of Spent Fuel and Heat-generating Waste" [3-150] of 2012 (revised in 2013).
  These guidelines apply to the dry storage of spent fuel and heat-generating radioactive waste in tightly closed metallic containers. They provide information on how the radiological protection goals can be achieved by the technical design and operation of the storage facility.
- "Guidelines for the Storage of Radioactive Waste with Negligible Heat Generation" [3-151] of 2012 (revised in 2013) and statements on their implementation of 2015 [4-16] and 2018 [4-16a].
  The objective of these guidelines is to cover all safety-relevant influencing parameters that are of significance for the storage of radioactive waste with negligible heat generation. The resulting requirements for storage facilities and their operation as well as for the radioactive waste and its treatment are presented.

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

- "Guidelines for the decommissioning of nuclear facilities" [4-4] of 2015.
  These guidelines describe the technical requirements and procedures to be applied during the decommissioning of installations and parts thereof licensed pursuant to § 7 AtG. The guidelines take into account recommendations of the international rules and regulations and supplement the requirements and specifications of the Decommissioning Guide [3-73] in technical terms.

In addition, the ESK has developed numerous other guidelines, statements and recommendations.

In November 2010, the "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] were adopted. On this basis, 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" [3-152] were published in March 2014, which concretise review and assessment of the safety status of the storage facilities to be carried out every ten years in accordance with § 19a(3) AtG. The need for corresponding regulations results from the safety reference levels of the Western European Nuclear Regulators Association (WENRA), to whose implementation in the legislation and practical implementation Germany has committed itself as a WENRA member state (see Chapter K.3 for details), as well as from the requirements for storage in Council Directive 2009/71/EURATOM on the nuclear safety of nuclear installations. For implementation of the recommendations, there was a two-year review phase as a first step, during which the performance of a periodic safety review for two selected storage facilities was tested (Gorleben, Lingen).

As a consequence of the accident at the Fukushima Daiichi nuclear power plant 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].

In its statement of 2 July 2014 [4-13], the ESK deals with the state of preparations concerning the provision of radioactive waste packages for the Konrad repository. In this statement, relevant issues for the use of the Konrad repository are worked out, prioritised according to their relevance, and the potential for optimisation is identified, taking into account the current work progress.

On 30 October 2014, the ESK published its statement “Return of vitrified waste from reprocessing in other European countries – storage of the vitrified waste in on-site storage facilities on the basis of the amendment of the Atomic Energy Act on 01.01.2014 (§ 9a, para. 2a AtG)” [4-14]. Here, the ESK focuses on the specific features of the approval of the CASTOR® HAW28M casks under transport regulations and the question of how transportability of the casks can be ensured after expiry of the storage licence in case of failure of a primary lid seal.

In the statements of 7 May 2015 [4-16] and 7 September 2018 [4-16a], the ESK performs a generic, facility-independent assessment of the actual condition of the waste packages on the basis of the reports submitted by the *Länder* and provides a description of the deficiencies that exist from the ESK’s point of view as regards monitoring of the waste packages and their management. The question is addressed as to the extent to which the “Guidelines for the Storage of Radioactive Waste with Negligible Heat Generation” of 10 June 2013 [3-151] prepared by the ESK have been implemented and what measures must be taken to ensure the safe storage of the waste packages also for a longer storage period.

In the “Discussion paper on the extended storage of spent fuel and other heat-generating radioactive waste” of 29 October 2015 [4-20], the storage of spent fuel beyond the licensed period of 40 years is discussed in view of the regulations of the Site Selection Act.

In December 2015, the ESK adopted the “Guideline on the safe operation of a disposal facility for in particular heat-generating radioactive waste” (“Guideline for Safe Operation”) [4-17], which serves to specify the “Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste” [BMU 10] as at 30 September 2010 published by the BMU.

On 17 March 2016, the ESK published the recommendation “Requirements for packages for the disposal of heat generating radioactive waste” [4-18]. These specify the regulatory requirements for containers for the disposal of heat-generating radioactive waste laid down generically in the BMU Safety Requirements of 2010. From the ESK's point of view, this recommendation presents basic aspects for the future development of a more specific “container guideline”.

On 12 May 2016, the ESK adopted its statement “Waste disposal research in Germany: Comments on content of research and research steering” [4-19], which deals with the question of which research projects must be initiated from today's point of view, so that in the future alternative host rocks can be identified efficiently and be explored, assessed and compared with regard to their suitability as a disposal medium.

In its recommendation of 1 March 2018, the ESK submitted a proposal on “Harmonisation of reporting criteria for occurrences involving radioactive waste with negligible heat generation” [4-32].

A statement of 26 July 2018 defines safety-related and logistical requirements for a central reception storage facility for the Konrad repository [4-31]. Here, safety issues play a special role.

An ESK recommendation of 6 December 2018 deals with the protection of disposal facilities against flooding [4-22]. The background is, among other things, the fact that a future disposal facility for high-level radioactive waste is expected to be in operation by the middle of the next century and therefore the influence of climate change and new findings regarding extreme weather conditions must also be taken into account.

An ESK statement of 21 February 2019 [4-30] deals with the safety concept requirements for the barrier system of a disposal facility for high-level radioactive waste and their implementability. This is related to the fact that within the framework of the German site selection procedure, different sites with different host rocks and different safety concepts have to be compared with each other.

KTA safety standards

The KTA, founded in 1972, was established at the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). It consists of the following five groups: representatives of the manufacturers, the plant operators, the federal and *Land* 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. Each of these five groups appoints seven expert members.

The task of the KTA is 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 installations, the expert organisations and the authorities would reach a uniform opinion. The standards are developed within six subcommittees and adopted by the KTA.

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 KTA safety standards contain detailed, concrete specifications of a technical nature. Regular reviews and, where necessary, amendment of adopted safety standards ensure that standards are adapted according to the state of the art in science and technology. KTA safety standards are not legally binding but, by virtue of their process of origination and their high level of detail, their practical effect is wide-ranging as specification of the necessary precautions to be taken in the light of the state of the art in science and technology.

At present (as at 2 March 2020), the KTA Programme of Standards comprises 97 standards, i.e. 88 safety standards and nine safety standards that are no longer part of the revision process. Five safety standards are currently in a revision process. At the last meeting of the KTA in November 2019, draft safety standards of existing safety standards (revisions) were adopted for four of the safety standards currently under revision. It is expected that these draft safety standards will be adopted as safety standards in the course of 2020. The safety standards generally refer to nuclear power plants, so that their analogous application to facilities for the management of spent fuel and radioactive waste will have to be examined in each individual case.

The KTA safety standards are subject to regular reviews. The texts of the adopted safety standards are reviewed at least every five years and, where required, adapted to the state of the art in science and technology in terms of the necessary precautions to prevent damage.

According to the current timetable for the KTA, all safety standards are to be reviewed again by 2022 to determine whether they still reflect the state of the art or whether they need to be revised. In 2022, the KTA will decide for each safety standard whether it will remain valid, undergo a revision process or be given the status “inactive” or “withdrawn”. This process is intended to ensure that all KTA safety standards that are still required remain valid for as long as necessary.

Conventional technical standards

In addition – as is the case with the construction and operation of all technical installations – the conventional technical standards are to be applied, i.e. in particular the national standards of the German Institute for Standardisation (DIN) and the international standards of the International Organization for Standardization (ISO) und the International Electrotechnical Commission (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, provisions of the Federation and the *Länder* 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 installations and 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 (BGB) [1B-18],
- the Regional Planning Act (ROG) [1B-2],
- the Federal Immission Control Act (BImSchG) [1B-3],
- the Federal Water Act (WHG) [1B-5],
- the Federal Nature Conservation Act (BNatSchG) [1B-6],
- the Closed Cycle Management Act (KrWG) [1B-13], and
- the Environmental Impact Assessment Act (UVPG) [1B-14].

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

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

In many of the areas mentioned, the respective laws of the *Länder* also apply.

E.2.3 Licensing system

With respect to the protection against the dangers arising from radioactive substances and the control of their utilisation, the Atomic Energy Act (AtG) [1A-3] and the Radiation Protection Act (StrlSchG) [1A-34] require subjecting the construction, operation and decommissioning of nuclear installations and facilities as well as other facts or circumstances, such as the handling of radioactive substances, to regulatory approval. The approval requirement is laid down in various provisions, depending on the type of facility and activities involved.

- § 3 AtG: As laid down in § 3 AtG imports and exports of nuclear fuel require a licence. The Federal Office for Economic Affairs and Export Control (BAFA) decides on applications for licences. The supervision of imports and exports shall be the responsibility of the Federal Ministry of Finance or customs offices designated by it. The BAFA is subordinate to the Federal Ministry for Economic Affairs and Energy (BMWi); however, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) is the authority having the power to issue directives in technical matters to the BAFA with regard to the granting of licences under § 3 AtG for nuclear fuel.
- § 5 AtG: Any nuclear fuel whose authorised owner cannot be ascertained or cannot be called upon, shall be placed in government custody. In the case of government custody, the necessary precautions in the light of the state of the art in science and technology to prevent damage shall be taken, and necessary protection shall be provided against disruptive action or other interference by third parties.
- § 6 AtG: The storage of nuclear fuel, including spent fuel and radioactive waste with contents of nuclear fuel requires (if the proportion of certain uranium and plutonium isotopes exceeds the limits specified in § 2(3) AtG) a licence according to § 6 AtG. The licensing authority is the Federal Office for the Safety of Nuclear Waste Management (BASE), whereas supervision is performed by the competent authority of the respective *Land*.
- § 7 AtG: This section regulates the licensing requirements for nuclear installations, in particular nuclear power plants. There is a restriction that no further licences shall be granted for

the construction and operation of nuclear fission facilities for the commercial electricity generation and facilities for the reprocessing of spent fuel. 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 generally covered by the licences granted to such facilities according to § 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.

- § 9 AtG: The treatment, processing and other use of nuclear fuel 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. Regulatory supervision of the activities within the framework of the licence under § 9 AtG and other handling licences under radiation protection law at the Asse II mine is exercised by the BASE in accordance with §§ 57b(9) half-sentence 2, 23d, sentence 1, no. 2 in conjunction with § 19(5) AtG.
- § 9b AtG: According to § 9a(3) AtG, sentence 1, the Federation shall establish facilities for the safekeeping and disposal of radioactive waste. These facilities generally require plan approval according to § 9b AtG. In the cases, however, where the site was determined by federal law, a licence shall substitute the plan approval, since interests to be weighed against each other will have already been reviewed and assessed in the preceding statutory site selection procedure. According to § 23d AtG, the BASE shall be responsible for plan approval or licensing and supervision of disposal facilities. According to § 58(2) and (3) AtG, the *Länder* shall be responsible for the Konrad repository until granting of the approval of commissioning by the nuclear supervisory authority (BASE) and for the Morsleben repository for radioactive waste (ERAM) until the decommissioning plan approval decision can be enforced. The responsibilities under mining and water law described in § 23d AtG shall, for the time being, also remain with the *Länder* of Lower Saxony and Saxony-Anhalt for the time being, which have been in charge of the procedures so far.
- § 12 StrlSchG: The Radiation Protection Act contains provisions on other facilities (e.g. electron accelerators, ion accelerators) or activities (e.g. handling of radioactive substances) requiring a licence. Furthermore, §§ 196 to 198 StrlSchG contain transitional provisions for the continuation of licences granted before 31 December 2018. As stipulated in § 10a(2) AtG, a licence for activities according to § 12 StrlSchG shall not be required as long as a licence according to §§ 6, 7, 9 or 9b AtG, or a plan approval decision according to Section 9b AtG, which covers the handling according § 12 StrlSchG, has been issued. Licensing and supervision are the responsibility of the respective competent *Land* authority (see the explanations under § 9 AtG on the Asse II mine).

The licensing system particularly with regard to decommissioning is dealt with in the reporting on Article 26 in Chapter E.3.

The responsibilities for the licensing and supervision of nuclear installations, facilities and activities, such as the handling of radioactive material, are summarised in Table E-1. It shows that in some cases different authorities are responsible for licensing and supervision of different types of facilities and activities. Uniform application of the legal requirements and a harmonised licensing practice is ensured by the supervision of legality and appropriateness on the part of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), as described in more detail in Chapter E.2.1.

Table E-1: Responsibilities for licensing and supervision of nuclear installations, facilities and activities, such as the handling of radioactive waste, in the Federal Republic of Germany

Material	Activity	Legal basis	Licensing	Super-vision	Facilities (examples)
Nuclear fuel and waste containing fissile material	Production, processing, treatment	§ 7 AtG	*Land* authority	*Land* authority	PKA, VEK
	Treatment, use	§ 9 AtG	*Land* authority	*Land* authority (except for Asse II)	Activities outside of facilities governed by § 7 AtG (e.g. laboratory-scale handling of nuclear fuel for research purposes)
	Storage	§ 6 AtG	BASE	*Land* authority	Gorleben, Ahaus, decentralised spent fuel storage facilities
	Import and export	§ 3 AtG	BAFA	Federation	-
Other radioactive substances acc. to § 2(1) AtG, nuclear fuel acc. to § 2(3) AtG (e.g. waste with low fissile material content)	Handling, e.g. storage	§ 12 StrlSchG[1)]	*Land* authority	*Land* authority (except for Asse II)	Collecting facilities of the *Länder*, storage facilities, conditioning facilities
Radioactive waste with negligible heat generation	Disposal	§ 9b AtG	BASE (for Konrad and ERAM *Land* authority still competent as a transitional provision)	BASE	ERAM, Konrad repository
Heat-generating radioactive waste (high-level radioactive waste)	Disposal	§ 9b(1a) AtG	BASE	BASE	-

[1)] Unless there is a licence according to §§ 6, 7, 9 or 9b AtG already extending to the activity.

An approval under the Atomic Energy Act or the Radiation Protection Act may only be granted if the licensing conditions laid down in the corresponding sections of the Act are met by the applicant. This includes, in particular, the precautions against damage as are necessary in the light of 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 Act and in the Radiation Protection Ordinance. The Radiation Protection Act also 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.

Licences for nuclear installations, facilities and activities, such as the handling of radioactive waste, may be subject to specific conditions to ensure safety. The operation, ownership, essential modification or decommissioning of a nuclear installation without the necessary licence are generally liable to prosecution.

Except for storage to be licensed by the BASE under § 6 AtG, the licensing of nuclear installations, facilities and activities is the responsibility of the respective *Länder*. In the *Länder*, ministries are the supreme authorities responsible for licensing according to §§ 7 and 9 AtG. Granting of licences according to the Radiation Protection Ordinance (handling of radioactive waste, collecting facilities of the *Länder*) can be transferred to subordinate authorities (e.g. trade supervisory offices). The Federation supervises the implementation of the nuclear and radiation protection law 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.

As stipulated in § 20 AtG, the competent authorities may consult authorised experts on all technical or scientific matters related to regulatory licensing 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-5-1], amended by the Brussels Supplementary Convention [1E-5-2], into national law. Details of the required financial security are regulated by the Nuclear Financial Security Ordinance (AtDeckV) [1A-11]. In Germany, this means that operators 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 the storage or facility to be licensed according to §§ 6 and 7 AtG, the construction, operation and closure of disposal facilities 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 shall substitute the plan approval (§ 9b(1a) AtG). The plan approval procedure is a special type of procedure by which projects are considered in relation to 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 licence for a facility but an activity-related licence for the storage of nuclear fuel, this issue will be outlined below for differentiation and a better understanding.

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 environmental impact assessment 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. 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.

The nuclear licensing procedure for facilities according to § 7 AtG

According to § 7 AtG, the construction, operation or ownership of a stationary facility for the production, treatment, processing or fission of nuclear fuel or for the reprocessing of nuclear fuel require a licence. The same applies to an essential modification of the facility or its operation. Decommissioning, safe enclosure and dismantling are also subject to licensing. A licence may only be granted if the licensing requirements stated in § 7(2) AtG are complied with, i.e. if

- there are no known facts giving rise to doubts as to the trustworthiness of the applicant and of the persons responsible for the erection and management of the facility and the supervision of its operation, and if the persons responsible for the erection and management of the facility and the supervision of its operation have the requisite qualification,
- 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 precautions have been taken as are necessary in the light of the state of the art in science and technology to prevent damage resulting from the erection and operation of the facility,
- the necessary financial security has been provided to comply with the legal liability to pay compensation for damage,
- the necessary protection has been provided against disruptive action or other interference by third parties, 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.

No licences shall be granted for the construction and operation of nuclear fuel fission installations for the commercial electricity generation and of facilities for the reprocessing of spent fuel.

Modifications of nuclear installations or their operation that are not essential do not require a licence. However, they are to be reported to the nuclear supervisory authority and may be subject to accompanying inspections by the nuclear supervisory authority. Specifications for modification procedures are in place in the written operating procedures of the licence holders.

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-mandatory 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 AtG does not include specific regulations on the procedure for the assessment of such risks.

<u>Licence application</u>

The written licence application is submitted to the competent licensing authority of that *Land* in which the nuclear installation is sited or is to be erected. The applicant has to submit all documents required for the examination of the licensing prerequisites by the nuclear licensing authority and the experts consulted by it. These documents are listed in detail in §§ 2 and 3 AtVfV and their form further specified in guidelines.

In the case of applications for modification licences, the examination of the licensing prerequisites does not only relate to the object of modification. The effects of the modifications on the existing facility are also examined. In order to verify that the licensing prerequisites are fulfilled, appropriate documents are to be submitted on the issues concerned by the modification. Moreover, a safety analysis report is to be submitted (§ 3(1)1 AtVfV), which is reviewed by the competent nuclear licensing authority in the course of the licensing procedure, if necessary with the support of authorised experts.

In addition to the safety analysis report, the applicant also has to submit the following to the nuclear licensing authority:

- supplementary plans, drawings and descriptions of the facility and its components;
- information concerning measures provided for the facility and its operation against disruptive action or other interference by third parties, according to § 7(2)(5) AtG;
- information enabling the examination of the trustworthiness and technical qualification of the persons responsible for the construction of the facility and the management and supervision of its operation;
- information enabling a verification as to whether the persons otherwise engaged in the operation of the facility possess the necessary knowledge in accordance with § 7(2)(2) AtG;
- a schedule containing all the data relevant to the safety of the facility and its operation, the measures to be taken in the event of incidents or damage, and an outline plan of the tests provided for safety-related components of the facility (safety specifications);
- proposals for financial security to cover the legal liability to pay compensation;
- a description of the residual radioactive material accumulating as well as data concerning the measures provided for the prevention of any accumulation of residual radioactive material, for the safe utilisation of accumulated residual radioactive material and dismantled or dismounted radioactive components of the facility in accordance with the purposes referred to in § 1 AtG, nos. 2 to 4, for the disposal of residual radioactive material or dismounted radioactive components in a controlled and structured manner in the form of radioactive wastes, including their intended treatment, as well as for the anticipated storage of radioactive wastes until their disposal, and
- data relating to other environmental impacts of the project which are necessary for the examination pursuant to § 7(2)(6) AtG with respect to approval decisions included in the licensing decision in individual cases, or for decisions to be taken by the licensing authority in accordance with provisions relating to the conservation of nature and the maintenance of landscapes; the requirements for the content of the information are determined by the relevant legal provisions for the above-mentioned decisions.

Furthermore, the application must be accompanied by a brief description of the planned facility, including information on its likely impact on the population and the surrounding environment, for the purpose of participation by the general public.

Examination of the application

On the basis of the submitted documents, the nuclear licensing authority assesses whether or not the licensing prerequisites have been met. All federal, *Land*, local and other regional authorities and, according to circumstances also authorities of other states (§ 7a AtVfV), whose jurisdiction is involved, 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. For the assessment of safety issues, technical expert organisations are commissioned to evaluate the application documents to support the licensing and supervisory authority.

Within the frame of federal executive administration, the licensing authority of the *Land* informs the BMU if it considers the licensing procedure to be significant, or if the BMU issued requirements within the framework of federal supervision (e.g. for power increases applied for). Information is also given if the BMU deems it necessary to involve the Federation in the individual case.

In performing these safety-related tasks within federal supervision, the BMU consults its advisory bodies Reactor Safety Commission (RSK), Nuclear Waste Management Commission (ESK) and Commission on Radiological Protection (SSK) and in many cases the expert organisation Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH for advice and technical support. Where required, the BMU states its position on the draft decision of the nuclear licensing authority.

Environmental impact assessment

The requirement to conduct an environmental impact assessment (EIA) for nuclear installations is regulated in the Act on the Assessment of Environmental Impacts (UVPG) [1B-14] in conjunction with § 2a AtG. The EIA is carried out as a dependent part of the approval procedure for the nuclear facility or its modification. For projects requiring an EIA, the applicant has to enclose an EIA report with his application (§ 3(2) AtVfV). This report must describe, among other things, the measures and features of the project which are intended to exclude, reduce or offset the occurrence of any potential substantial adverse environmental impacts of the project. The environmental impacts to be expected despite these measures must also be presented. Not only the radiological consequences for the environment are considered but also the other impacts caused by the construction, operation or decommissioning of the facility (e.g. impacts on the natural balance, the water balance, noise, light, land consumption, etc.). According to § 7(1) AtVfV and § 7(4)1 AtG, the public and authorities affected in their area of responsibility can comment on the EIA report, but also on other application documents such as the safety analysis report (§ 6(1)2 in conjunction with § 3(1)1 AtVfV).

Subsequently, the competent nuclear licensing and supervisory authority prepares a summary description of the environmental impacts (§ 14a(1) AtVfV) and carries out an assessment of the environmental impacts which are to be taken into account when deciding on the admissibility of the project with regard to effective environmental protection (§ 14a(2) AtVfV).

Germany is a contracting party to the “Convention on Environmental Impact Assessment in a Transboundary Context” (Espoo Convention) [1E-1-1] of 1991. According to this Convention, the authorities and the public in possibly affected neighbouring countries must be involved as part of a transboundary EIA before a project is approved, if the project can have transboundary environmental impacts. Germany applies the participation procedure vis-à-vis all its neighbours.

Public participation

The purpose of public participation is to give the citizens the opportunity to directly pursue their interests within the procedure. Participation of the public was mandatory for construction licences and is mandatory also for the first decommissioning licence. In the case of essential modifications, the authority may refrain from public participation if the modification will have no adverse effects on the public. However, the public has to be involved if this is required pursuant to the Act on the Assessment of Environmental Impacts. The Nuclear Licensing Procedure Ordinance includes detailed regulations on

- the conditions under which the licensing authority may foresee public participation or must involve the public.
- the public announcement of the project and public disclosure of the application documents at a suitable location near the site for a period of two months, including the request for raising any objections within the presentation period (§§ 4 to 7a AtVfV), and
- holding a public hearing where the objections are discussed between licensing authority, licence applicant and those who have raised the objections (§§ 8 to 13 AtVfV).

The licensing authority considers and evaluates the objections from public participation in its decision making and states the reasons for the decision.

If the licensing procedure is conducted with public participation, the applicant shall submit a brief, readily comprehensible description of the facility and the modification applied for to inform the public in addition to the application documents to be submitted in all licensing procedures for examination of the licensing prerequisites by the licensing authority and the authorised experts (§ 6(1)3 in conjunction with § 3(4) AtVfV). In addition to public participation in the licensing procedure, the laws of the *Länder* generally provide for public participation at an early stage (§ 25(3) Administrative Procedure Act (VwVfG) [1B-22]) during which the project implementer informs the public about the project already before application and provides the opportunity for comments and discussions.

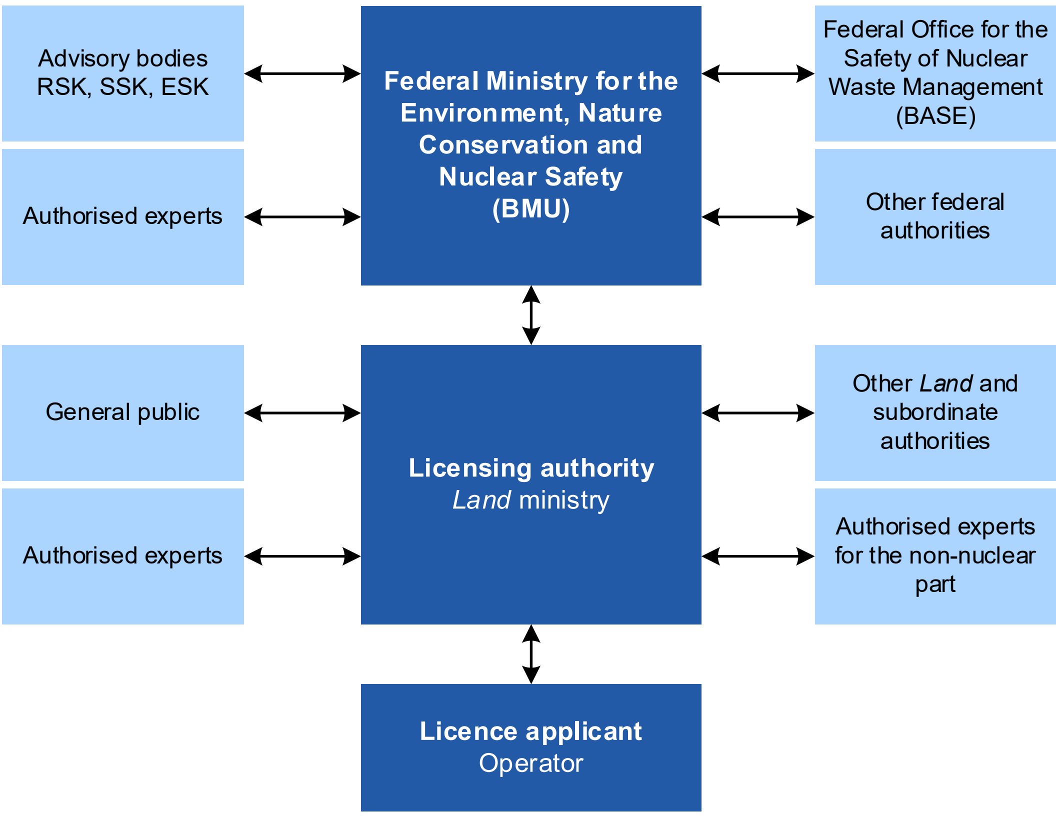
Licensing decision

The final decision of the licensing authority is based on the entirety of application documents, safety evaluation reports by the authorised experts consulted and, if available, the opinions of the BMU and the authorities involved as well as the findings on the objections raised by the public. Prerequisite for the legality of the decision is that all procedural requirements of the Nuclear Licensing Procedure Ordinance are fulfilled. Action may be brought against the decision of the licensing authority before an administrative court of the competent *Land*. 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.

The Atomic Energy Act includes the necessary authorisation providing the basis for the licensing and supervisory authorities of the *Länder* to take action against an unlicensed construction or unlicensed operation of a nuclear installation.

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



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

A licence according to § 6 AtG is not a licence for a facility, 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 licensed, 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 does 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 authority 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(2) AtG are fulfilled. The corresponding conditions largely correspond to those of § 7(2) AtG, with the exception of the “knowledge of persons involved” within the meaning of § 7(2)(2) AtG, and the “conflict with overriding public interests” within the meaning of § 7(2)(6) AtG.

Nuclear approval procedure according to § 9b AtG for federal facilities for the safekeeping and disposal of radioactive waste

According to § 9a(3) AtG, the Federation shall establish facilities for the safekeeping and disposal of radioactive waste. According to § 9b(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 site for a disposal facility was determined by federal law, a licence shall substitute the plan approval decision (§ 9b(1a) AtG).

With the entry into force of the Act on the Reorganisation of the Organisational Structure in the Field of Disposal on 30 July 2016 [1A-30], the BGE was established as a third party within the meaning of § 9a(3) AtG, sentence 2.

The BASE is responsible for plan approval and licensing according to § 9b AtG and their withdrawal. This, however, currently 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 both cases, the responsibility will rest with the competent supreme *Land* authority until then. The plan approval for later closure of the Asse II mine is also outside the competence of the BASE according to § 57b(9) AtG. Here, the responsibility remains with the *Land* of Lower Saxony.

The licence for a disposal facility may only be granted if the requirements stated § 7(2)(1), (2), (3) and (5) AtG have been fulfilled. The licence for a disposal facility shall be refused if

- the construction, operation or closure 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 closure of the facility conflicts with other provisions of public law, in particular with respect to the environmental impact of the facility.

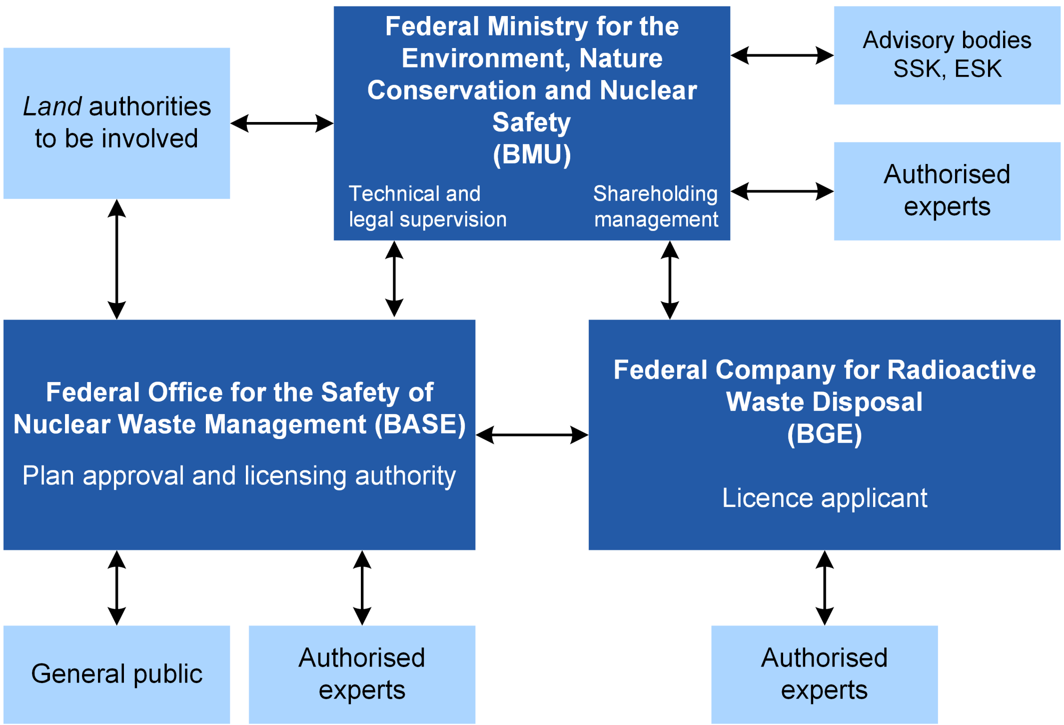
The main peculiarity of the plan approval procedure is the concentration of all areas of law within a single procedure. Thus, the plan approval decision covers, unlike other nuclear procedures, almost all other licences required, e.g. under the terms of building legislation or nature conservation legislation. Exceptions to this result from § 9b(5)(3) AtG and the Act on the Regulation of Matters Pertaining to Water (Federal Water Act – WHG) [1B-5]. 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(5)(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(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(4) AtG explicitly states that the Federation and the *Länder* are not obliged to make liability provisions, which applies accordingly to the third party according to § 9a(3) AtG, sentence 2.

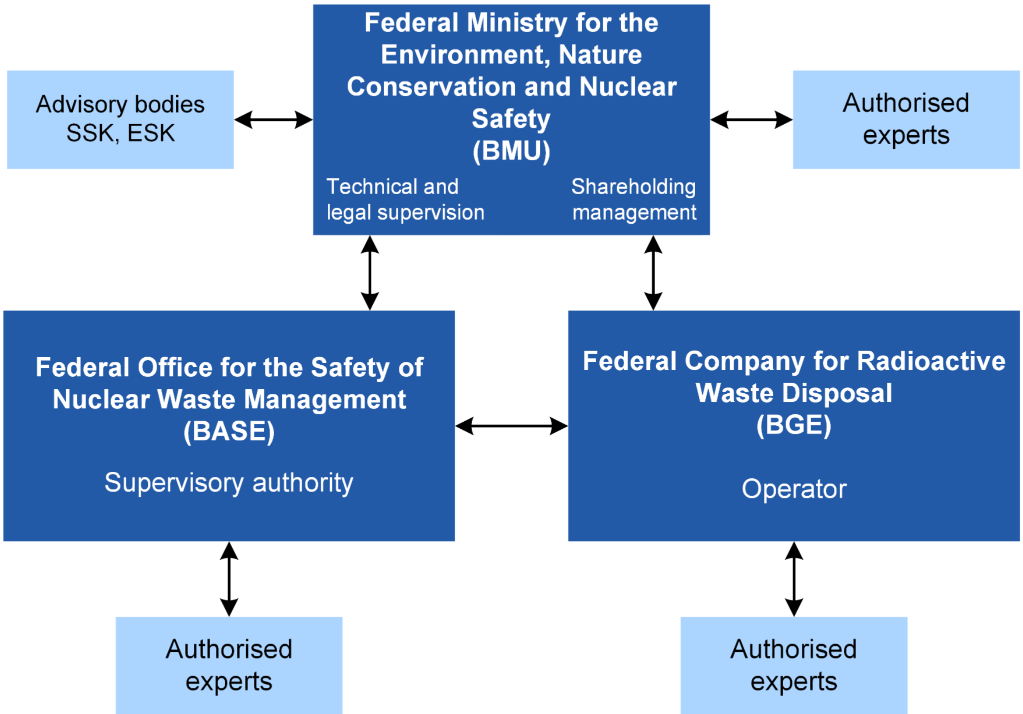
The parties involved in the approval and supervisory procedure of a disposal facility are summarised in Figure E-3 and Figure E-4. For approval procedures for ERAM and Konrad, other provisions apply for a transitional period (see explanations on § 9b AtG).

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



Note: Other provisions apply for ERAM und Konrad for a transitional period, see explanations on § 9b AtG

Figure E-4: Parties involved in nuclear supervision of a disposal facility



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

Prohibition of the operation of a facility for spent fuel or radioactive waste management 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 more 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

Throughout their operating lives, from construction to the release from nuclear regulatory control, nuclear installations and facilities are subject to continuous regulatory supervision, after having been granted the necessary licence, in accordance with § 19 of the Atomic Energy Act (AtG) [1A-3] 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 § 12 of the Radiation Protection Act (StrlSchG) [1A-34], and the facilities licensed pursuant to § 7 AtG and the disposal facilities that require plan approval or licensing according to § 9b AtG.

Where facilities or the handling of nuclear fuel has been licensed according §§ 6, 7 or 9 AtG, the *Länder* carry out nuclear supervision. An exception is the supervision of handling in the Asse II mine. Here, too, the *Länder* act 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. Decisions on pending supervisory measures remain with the nuclear supervisory authority. The same applies to the handling of other radioactive substances according to § 12 StrlSchG (see § 179 StrlSchG).

As in licensing, the primary objective of regulatory supervision is to protect the general public, the environment and the persons employed in 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 of the Atomic Energy Act, the Radiation Protection Act, the ordinances under nuclear and radiation protection law and other safety standards and guidelines,
- compliance with the provisions, conditions and other ancillary provisions imposed by the licensing notices, and
- compliance with supervisory orders issued, if any.

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

- compliance with the safety-relevant operating procedures,
- the performance of recurring inspections of safety-relevant components and systems,
- the evaluation of significant events,
- the implementation of modifications to the facility or its operation,
- radiation protection monitoring of the personnel,
- radiation protection monitoring in the vicinity of the facility,
- compliance with the authorised plant-specific limits for radioactive discharge,
- the measures against disruptive action or other interference by third parties,
- the trustworthiness, technical qualification and maintenance of the qualification of the responsible persons as well as of the knowledge of persons otherwise engaged in the operation of the facility, and
- the quality assurance measures.

The supervisory authority and the authorised experts consulted by it have access to the facility at any time and are entitled to carry out the necessary examinations and to demand information (see § 20 in conjunction with § 19(2) AtG).

Contrary to this regulatory supervision by the respective *Land* or by the Federal Office for the Safety of Nuclear Waste Management (BASE) for the Asse II mine, for licences according to §§ 6, 7 or 9 AtG regulated in § 19 AtG, other regulations apply for regulatory supervision with regard to federal facilities for the safekeeping and disposal of radioactive waste. According to § 23d(2) AtG, sentence 1, the BASE shall also be responsible for the supervision of federal facilities pursuant to § 9a(3) AtG, sentence 1 (facilities for the safekeeping and disposal of radioactive waste). Comprehensive technical and legal supervision of the BASE is exercised by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) to whose portfolio the BASE belongs.

Furthermore, the BASE monitors the implementation of the site selection procedure according to § 19(1) to (4) AtG.

Reporting obligations

Since 2018, the legal basis for the documentation and reporting of radioactive waste has been contained in § 1 and § 2 of the Nuclear Waste Management Ordinance (AtEV) [1B-19] and in § 85 StrlSchV [1A-8b] (Record keeping and notification). These require that records be kept and that notification be given within one month of the extraction, production, acquisition, transfer and other dispositions of radioactive substances, specifying type and activity. In addition, the inventory of radioactive substances with half-lives of more than 100 days is to be is reported annually. The competent authority is entitled to verify the correctness of record keeping at any time. It may in individual cases also grant full or partial exemption from the obligation to keep records and reporting obligation if type and activity of the radioactive substances cannot pose a hazard to man and the environment.

According to §§ 1 and 2 AtEV, the operators and those handling nuclear fuel are required to document the arising and whereabouts of waste and to submit the documentation to the authorities. The documentation is prepared by the operators with the help of various computerised systems.

The BGE 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 BGE and are evaluated there.

An obligation to report to the corresponding supervisory authority also exists for measures taken by the operators to utilise any residual radioactive material without detrimental effects or dispose them of as radioactive waste in a controlled manner in accordance with § 9a(1) AtG. In particular, proof is to be furnished that adequate precautions have been taken in order to comply with the obligations for already existing and for future spent fuel as well as for the waste to be returned from reprocessing (§ 9a(1a) AtG). This proof is to be provided annually. For the purposes of controlled disposal of spent fuel and radioactive waste from reprocessing, proof is to be furnished showing that safe storage in storage facilities is ensured until such time as it is transferred to a disposal facility (§ 9a(1b) AtG). Realistic plans have to be submitted with regard to the expected need for storage capacity. The availability of storage capacity as needed is to be demonstrated for the following two years. If non-detrimental utilisation of the plutonium from reprocessing is intended, it is also necessary to prove that the reuse of the plutonium in the nuclear power plants is ensured (§ 9a(1c) AtG). This proof shall be deemed to be furnished if realistic plans for reprocessing, fuel fabrication and fuel use have been provided and their feasibility has been demonstrated. As for uranium from reprocessing, its safe storage is to be demonstrated by realistic planning of sufficient storage capacities (§ 9a(1d) AtG).

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

Safety-relevant events in facilities approved according to §§ 7 and 9b AtG, in connection with storage according to § 6 AtG, during handling of radioactive material in the Asse II mine and in connection with activities licensed according to § 9 AtG and § 12(1)3 StrlSchG have to be reported to the authorities in accordance with § 6 of the Nuclear Safety Officer and Reporting Ordinance (AtSMV) [1A-17]. The regulations and procedures for reportable events and their evaluation are described in the reporting on Article 9 (see Chapter G.6.5 for details). In addition, the operator has further reporting obligations with regard to operating procedures, maintenance measures, inspections and radiation protection.

E.2.6 Enforcement of provisions and terms of the licences

Enforcement by regulatory order, particularly in urgent cases

According to § 19 of the Atomic Energy Act (AtG) [1A-3], 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, the terms and conditions of the licence, or to any subsequently imposed obligation, or which may constitute a hazard to life, health or property due to the effect of ionising radiation. Depending on the specific circumstances of the individual case it may order, in particular, that

- specific protective measures shall be taken,
- radioactive material shall be stored or kept in custody at a place designated by it, and
- the handling of radioactive material, the construction and operation of facilities shall be suspended or, if a requisite licence has not been granted or definitely revoked, discontinued.

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 authority retrospectively. In case a considerable hazard is suspected from the nuclear installation endangering the persons engaged at the installation or the general public, and if this hazard cannot be eliminated within a reasonable period of time by means of appropriate measures, then the nuclear 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 licence holder violates legal regulations or decisions by the authorities.

In addition, the Criminal Code (StGB) [1B-1], the Atomic Energy Act and the nuclear statutory ordinances provide for sanctions to prosecute violations.

Criminal offences

Any violation that is classed as a criminal offence is dealt with in the Criminal Code. Whosoever, e.g.

- operates, possesses, substantially modifies or decommissions a nuclear installation without the required licence (§ 327 StGB),
- constructs a defective nuclear installation (§ 312 StGB),
- produces, keeps, transports, treats, processes or otherwise uses, imports or exports nuclear fuel without the required licence (§ 328 StGB),
- releases ionising radiation or causes nuclear fission processes capable of harming the life or limb of another person (§ 311 StGB), or
- procures or manufactures nuclear fuel, radioactive material or suitable equipment for himself with the intent of performing a criminal offence (§ 310 StGB)

shall be liable to imprisonment or a fine.

Administrative offences

§ 46 AtG, § 194 of the Radiation Protection Act (StrlSchG) [1A-34] 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 installation or 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 associated ordinances require that the individuals who are ultimately responsible for the handling of radioactive material, for the operation of facilities or for their supervision should be named.)

For administrative offences, fines of up to 50,000 euros may be imposed on these persons. 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 in Chapter F.1).

Experiences

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

The instruments presented have proved to be effective since, as a rule, they ensure that the supervisory authority has appropriate sanction possibilities and powers 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(1) AtG [1A-3], the producers of residual radioactive material and of facility components are required to ensure that these are utilised without detrimental effects or are disposed of as radioactive waste in a controlled manner. If the residual material is classified as radioactive waste, it is to be delivered to a disposal facility or a *Land* collecting facility, as stipulated in § 9a(2) AtG. As a general principle, the producers are also responsible for the conditioning and storage of the spent fuel and 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 of the waste is assumed by the operator of the *Land* collecting facility.

According to § 9a(3) AtG, the *Länder* shall establish *Land* collecting facilities for the storage of radioactive waste produced within their territories. Radioactive waste with negligible heat generation from research, medicine and industry is delivered to these facilities. The producers of radioactive waste from the use of nuclear energy for electricity generation are responsible for its conditioning and storage unless it was delivered as radioactive waste properly packaged pursuant to § 2 of the Waste Management Transfer Act (EntsorgÜG) [1A-35] – upon fulfilment of the requirements – to a third party commissioned by the Federation, i.e. the BGZ Company for Storage (BGZ), who will then be responsible for further storage.

According to § 9a(3) AtG, the Federation shall establish facilities for the disposal of radioactive waste. The Act on the Reorganisation of the Organisational Structure in the Field of Disposal [1A-30], which came into force on 30 July 2016, concentrated operation and supervision of disposal, each in one hand. The operator and operational management tasks will now be bundled in a federally-owned company under private law, the Federal Company for Radioactive Waste Disposal (BGE). Its future privatisation shall be excluded. The BGE thus takes over the operational tasks of the search for a site, the construction, the operation and the closure of disposal facilities as well as of the Asse II mine.

The regulatory functions of licensing and supervision in the field of disposal are concentrated at a single authority, the Federal Office for the Safety of Nuclear Waste Management (BASE), insofar as they are not performed by the *Länder*.

According to the Waste Management Transfer Act, which came into force on 16 June 2017, the implementation and financing of storage and disposal for the cases regulated by law is now the responsibility of the Federation once the relevant requirements have been met or fulfilled. In accordance with the Waste Management Fund Act [1A-36], the funds for nuclear waste management have been made available to the Federation by the operators and transferred to a fund (see Chapter E.2.2 for details on the Act on the Reorganisation of Responsibility in Nuclear Waste Management). Implementation and financing of the decommissioning of the nuclear power plants as well as qualified packaging of the radioactive waste remain the responsibility of the operators. The use of disposal facilities and *Land* collecting facilities is generally (re)financed through costs (fees and expenses) and charges which have to be paid by the party delivering radioactive waste.

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” in terms of Article 20 consists of authorities of the Federation and the *Länder* (see Figure E-5).

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. Previously, the Federal Ministry of the Interior had been competent for environmental protection as well as for nuclear law. The responsibility for the organisation, staffing and financing of the Federation's nuclear regulatory authority thus lies with today's Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The BMU has the organisational powers and applies for the requisite human and financial resources from the annual federal budget.

Regarding the obligations under the Joint Convention, the BMU has the responsibility to ensure, both towards the interior of Germany and towards the international community that those in charge of the applicants and operators, federal and *Land* 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 basic regulations on the determination of official responsibilities are contained in the Atomic Energy Act (AtG) [1A-3] in §§ 22 to 24 AtG, 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 for Economics and Export Control (BAFA) shall be responsible for licences/approvals involving transboundary movement of radioactive material and withdrawal or revocation thereof, while supervision shall be the responsibility of the Federal Ministry of Finance or customs offices designated by it.
- According to § 23a AtG, the Federal Office of Administration (BVA) shall be responsible for decisions pursuant to §§ 9d to 9g AtG. This applies, in particular, to expropriations for the purpose of construction and operation of disposal facilities and the associated compensation, as well as to the determination of preservation orders to ensure planning security for disposal facilities or to secure or continue a site investigation for disposal facilities. A preservation

order is intended to prevent changes leading to a significant increase in the value of the potential site for a disposal facility or changes which substantially impede the project. It shall be valid for a period not exceeding ten years and may be extended twice by a maximum of ten years.

- According to § 23d AtG, and partly according to the transitional provision of § 58 AtG, the Federal Office for the Safety of Nuclear Waste Management (BASE) is responsible for, among other things
  - plan approval and licensing according to § 9b AtG and their withdrawal,
  - the supervision of facilities of the Federation pursuant to § 9a(3) AtG, first sentence and of the Asse II mine pursuant to § 19(5) AtG,
  - the granting of approvals under mining law and other permits and licences under mining law required during approval procedures pursuant to § 9b AtG for the construction, operation and decommissioning of federal facilities for the safekeeping and disposal pursuant to § 9a(3) AtG after consultation of the competent mining authority of the respective *Land*,
  - the mining supervision pursuant to §§ 69 to 74 of the Federal Mining Act (BBergG) [1B-15] regarding federal facilities for the safekeeping and disposal pursuant to § 9a(3),
  - the granting of permits or authorisations under water law during approval procedures pursuant to § 9b AtG for federal facilities for the safekeeping and disposal pursuant to § 9a(3) AtG after consultation of the competent water authority,
  - the granting of licences for the transport of nuclear fuel and large sources as well as their withdrawal or revocation,
  - the granting of licences for the storage of nuclear fuel outside of the government custody as well as their withdrawal or revocation, insofar as these licences are not preparation or part of a licensable activity pursuant to § 7 or § 9 AtG, and
  - the governmental custody of nuclear fuel including the promulgation of decisions pursuant to § 5(7) AtG, sentence 1.
- § 24 AtG regulates the responsibilities of the *Land* authorities (excerpt):

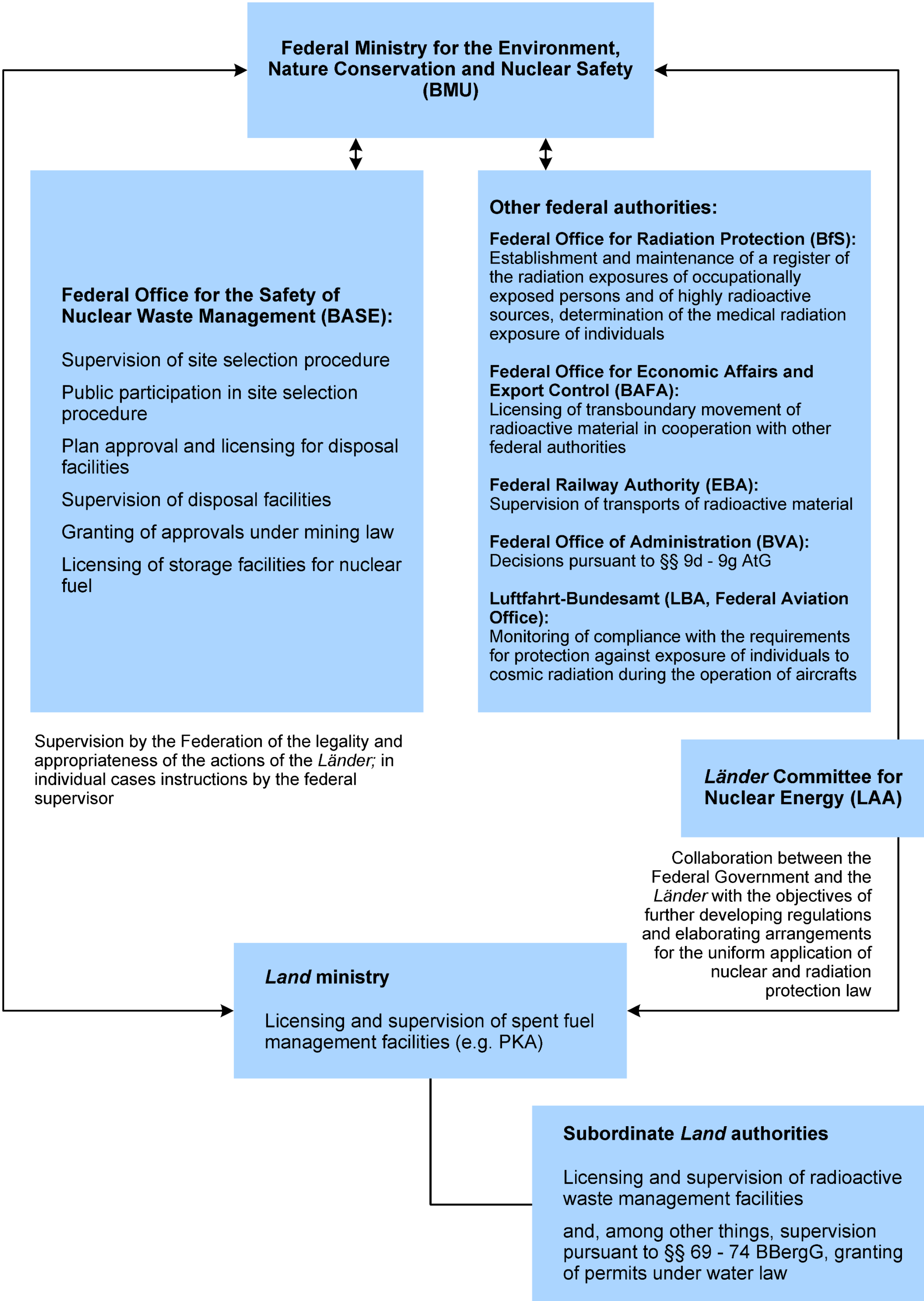
  “(1) All other administrative functions under Chapter 2 (of the Atomic Energy Act) and the statutory ordinances issued thereunder shall be discharged by the Länder on behalf of the Federation. The Federal Railway Authority (EBA) shall be responsible for the supervision of the carriage of radioactive material by rail and ship or on maglev train; this shall not apply to the carriage of radioactive material by private railroad companies if the carriage is exclusively effected on rails owned by those companies. […]

  (2) The supreme Land authorities designated by the Land governments shall be responsible for the granting of licences pursuant to §§ 7, 7a and 9 AtG and the withdrawal and revocation of such licences. These authorities shall supervise the facilities pursuant to § 7 AtG and the use of nuclear fuel outside such facilities. They may delegate their functions to subordinate authorities on a case-by-case basis. Complaints against orders of these subordinate authorities shall be decided upon by the supreme Land authority. To the extent that provisions other than those laid down herein confer supervisory powers to other authorities, such responsibilities shall not be affected.

  (3) In matters relating to the official duties of the Federal Ministry of Defence, the responsibilities outlined in paras. (1) and (2) above will be carried out by said Ministry or the offices appointed by it, in agreement with the federal ministry in charge of nuclear safety and radiation protection. […]”

The respective *Land* government determines the competent supreme *Land* authorities. Thus, the responsibility for the organisation, staffing and financing of these executive au-thorities lies solely with the *Land* government. In individual cases, subordinate authorities may also be tasked with supervisory functions.

Figure E-5: Organisation of the “regulatory body”

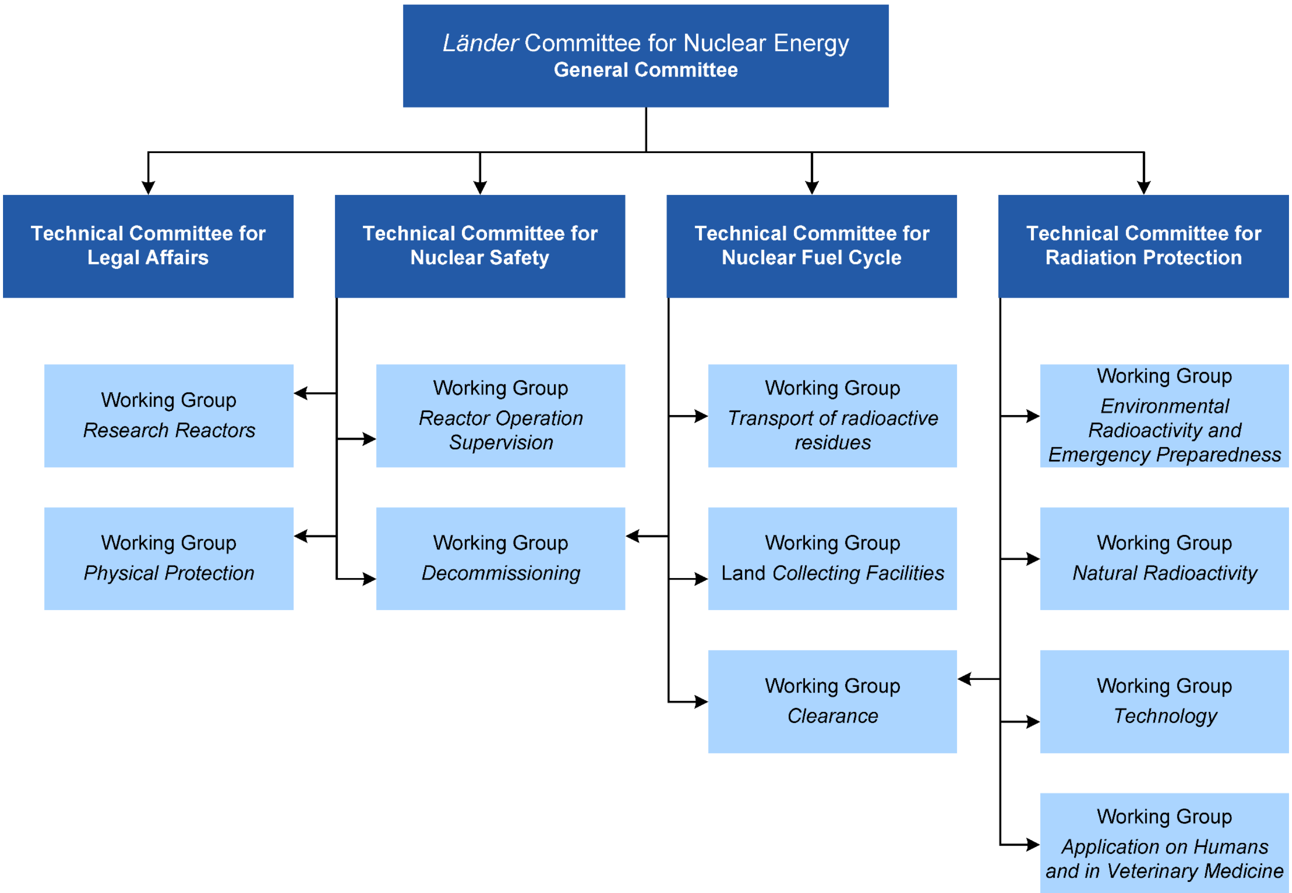


Länder Committee for Nuclear Energy

The *Länder* Committee for Nuclear Energy (LAA) is a permanent Federation-*Länder* Committee composed of representatives from the nuclear licensing and supervisory authorities of the *Länder* and the BMU (see Figure E-6). It serves the purpose of preparatory coordination of the activities of federal and *Land* authorities in connection with the enforcement of the nuclear law as well as 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 enforcement of nuclear and radiation protection law that is as uniform as possible throughout Germany, the competent nuclear licensing and supervisory authorities of the *Länder* and the BMU develop technical rules and procedures for the uniform application of nuclear and radiation protection law by consensus, which are then prepared as regulations and promulgated by the BMU. The BMU chairs the LAA and also manages its affairs. The Committee's decisions are usually made by mutual consent.

Figure E-6: *Länder* Committee for Nuclear Energy



For preparing decisions to be taken by the General Committee, the LAA avails itself of several Technical Committees on the issues of "Legal Affairs", "Nuclear Safety", "Radiation Protection" and "Nuclear Fuel Cycle", 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*.

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 installations and facilities to be supervised there. The required funds are established by the *Land* parliaments and the *Bundestag* in their respective budgets.

<u>Nuclear authority of the Federation and authorised experts of the Federation</u>

The nuclear authority of the Federation is a technical department of the BMU – the Directorate-General Nuclear Safety, Radiological Protection (S). It comprises three directorates. The unit of Directorate-General S 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 S III (Nuclear Waste Management). Directorate S III and its five divisions have 34 staff members, Division S I 3, which is responsible for the federal supervision of operation and decommissioning of nuclear power plants and research reactors, has 11 staff members.

As an authority subordinate to the BMU, the BASE performs administrative tasks of the Federation in the field of licensing of federal facilities for the safekeeping and disposal of radioactive waste that are assigned to it by the Atomic Energy Act or the Site Selection Act (StandAG) [1A-7b]. The BASE provides the BMU with technical and scientific support in these fields and, if no other jurisdiction is stipulated by law, it also performs federal tasks which the BMU or, with its consent, the competent supreme federal authority commissions it to perform. In addition, the BASE performs federal enforcement tasks under the Atomic Energy Act, fulfils regulatory, licensing and supervisory tasks in the fields of nuclear safety, transport of radioactive material, and the management and disposal of radioactive waste. The BASE also supports the BMU in its responsibilities by conducting scientific research. As at 31 March 2020, 139 staff members (without administrative tasks) are active at the BASE in the fields of transport and storage, nuclear safety, disposal, site selection, public participation (both within the framework of storage and site selection) and task-related research. Since the BASE is currently undergoing further development, the number of staff will continue to increase successively also in the future.

The Federation makes use of a scientific and technical expert organisation. It conducts, mainly on behalf of the Federation, scientific research in the field of nuclear safety and radiation protection, including management and disposal of radioactive waste, and supports the BMU in technical matters. Within the Decommissioning and Waste Management Division, the departments Decommissioning and Storage, Radiation and Environmental Protection, and Waste Management Safety, have about 35 experts dealing with radioactive waste management issues. The Geological Disposal Division with its departments Site Selection, Repository Research and Repository Safety has about 40 experts.

<u>Nuclear authorities of the *Länder* and authorised experts of the *Länder*</u>

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 installations or facilities have a larger licensing and supervisory authority than those with no or only very small nuclear installations or facilities.

Advisory bodies and authorised experts

The Reactor Safety Commission (RSK) was founded in 1958 and advises the BMU on issues relating to nuclear safety and physical protection of nuclear installations and facilities. In addition, it substantially contributes to the advancement of the safety level in such facilities. At present, the RSK consists of 15 members, who are appointed for a period of two years. The statements, recommendations and guidelines of the RSK are published on the Internet (www.rskonline.de/en).

The Commission on Radiological Protection (SSK), founded in 1974, currently has 18 members. It gives recommendations to the BMU on all issues related to the protection of the population against ionising and non-ionising radiation as well as occupational radiation protection. The statements and recommendations of the SSK are published on the Internet (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 that brings together a broad spectrum of technical expertise. International experience and approaches are to be incorporated into the Commission’s work, which is why experts from Germany and from abroad are also members of the Commission. The experts advise the BMU in all matters of nuclear waste management. This comprises the aspects of conditioning, storage and transport of radioactive material and waste, further the decommissioning of nuclear installations and facilities as well as disposal of radioactive waste in deep geological formations. As a result of its consultations, the Commission reaches resolutions on scientific and technical statements, recommendations and guidelines directed to the BMU, which are published on the Commission's website (www.entsorgungskommission.de/en).

For dealing with various focal points in greater depth, the commissions set up committees and working groups, where additional experts may also be involved. The members of the commissions represent a broad spectrum of positions taken and views held according to the state of the art in science and technology. They are independent and not bound by any directives. The BMU 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 federal authorities for their own personnel and for the consultation of experts are fixed by the German *Bundestag* in the respective budgets.

The BMU has an annual budget of around 36 million euros for investigations in the fields of nuclear safety, nuclear supply and waste management and on issues related to radiation protection. These funds are used to finance direct support for the BMU, for scientific and technical support and for the participation of external experts in international cooperation. Furthermore, these funds are used to finance projects that also serve to maintain the competence of GRS as expert organisation of the Federation in the above-mentioned areas.

As an authority subordinate to the BMU, the BASE finances contract research for the fulfilment of its own tasks by means of a so-called title for research to the amount of 3 million euros. This concerns research projects in the fields of nuclear safety, storage, transport, waste management and public participation. In addition, the BASE can conduct research via the BMU's departmental research plan.

The Federal Ministry for Economic Affairs and Energy (BMWi) has a title of around 38 million euros annually that is to be allocated to project funding related to nuclear safety research (in the fields of reactor safety, radioactive waste management and disposal). Around two thirds of this title is allocated to reactor safety research in the framework of which about 100 research projects are carried out. In the area of project funding aimed at site-independent application-oriented basic research in the fields of radioactive waste management/disposal, about 70 projects are carried out in parallel with around one third of the title. This includes specific research and development prior to disposal (i.a. on activities relating to storage and waste management), measures of disposal in all host rocks (i.a. on disposal concept development, long-term safety and operational safety), measures during the post-closure phase on sealing systems and monitoring as well as on socio-technical issues.

The Federal Institute for Geosciences and Natural Resources (BGR), an authority subordinate to the BMWi, is charged with geoscientific issues relating to German projects in the field of disposal and also participates in work on research in the field of disposal. 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 in accordance with the Atomic Energy Act, the Repository Prepayment Ordinance (EndlagerVlV) [1A-13] and through cost allocations to the waste producers according to the Site Selection Act.

To cover the necessary expenses for federal facilities, the BMU collects advance payments from the future users of a disposal facility for cost-covering contributions to be paid according to § 21b AtG as stipulated in the Repository Prepayment Ordinance. The determination of the contributions to be paid is based on the eligible expenses for the disposal facility projects. The site selection procedure is financed through cost allocations to the waste producers according to §§ 28 et seq. StandAG.

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

Federal Company for Radioactive Waste Disposal

With the entry into force of the Act on the Reorganisation of the Organisational Structure in the Field of Disposal [1A-30], the separation between operators and the administrative aides ended and the operational management tasks were merged into a federally-owned company in private legal form, the Federal Company for Radioactive Waste Disposal (BGE).

All tasks related to the site selection for a disposal facility for high-level waste, the planning, construction, operation and closure of disposal facilities and the Asse II mine, which were performed by the Federal Office for Radiation Protection (BfS) as operator and the Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH (DBE) and the Asse-GmbH as administrative aides, are now performed by the BGE. The transfer of tasks from the BfS to the BGE took place with effect from 25 April 2017. At the end of 2017, the DBE and the Asse-GmbH were merged with the BGE. The BMU is the sole shareholder of the BGE.

The BGE also assumed the task of the project delivery organisation as defined in the Site Selection Act. In part and to the extent necessary, the BGE was given jurisdictional powers pursuant to § 9a(3) AtG, sentence 3 by way of entrustment of sovereign tasks, which concerns in particular the product control of radioactive waste and call-off logistics. However, the BGE is not a regulatory body within the meaning of the Joint Convention.

The structural change in the area of disposal led to a clearer implementation of the principle of separation according to Article 6(2) of Council Directive 2011/70/EURATOM [1F-36] also with regard to the operators, in particular by assigning the monitoring function for this area to the BASE.

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, whereas nuclear licensing and supervision are regulatory functions. 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 such as nuclear licensing and supervision of the respective nuclear installations. At the federal level, however, there is no danger of such a conflict of interests since the tasks are distributed among various departments. As a higher federal authority committed to nuclear safety, the BASE is responsible for the approval and supervision of federal facilities for disposal under § 9a AtG; the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) is responsible for the supervision of legality and appropriateness of execution by the BASE. In the areas 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 Federal Ministry for Economic Affairs and Energy (BMWi).

The organisation of regulatory functions in Germany thus complies with the requirements of Article 20(2) of the Joint Convention.

This also applies to the organisation of the planning, construction, operation and closure of facilities for the disposal of radioactive waste. According to § 9a(3) of the Atomic Energy Act (AtG) [1A-3], this is a federal task, the performance of which the Federation has assigned to the federally-owned private-law Federal Company for Radioactive Waste Disposal (BGE). The BGE is subject to nuclear supervision by the Federal Office for the Safety of Nuclear Waste Management (BASE).

The BASE also supervises the implementation of the site selection procedure for a disposal facility according to § 19(1) to (4) AtG. The procedure for the approval of a facility for the disposal of radioactive waste is principally carried out as a plan approval procedure (see Chapter E.2.3 for details). In the cases where the site is determined by federal law, a licence shall substitute the plan approval. The BASE is also responsible for the planning and approval of disposal facilities. In this case, the BGE 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 BASE.

The BMU is responsible for supervising the execution of tasks by the BASE in terms of legality and appropriateness as well as the shareholding management for the BGE.

E.3.3 IRRS mission to Germany in 2019

At the invitation of Germany, an Integrated Regulatory Review Service (IRRS) of the International Atomic Energy Agency (IAEA) took place from 31 March to 12 April 2019. The IRRS mission covered all nuclear installations, facilities and activities in the Federal Republic of Germany with the exception of transports, radiation sources, interfaces with nuclear security and aspects of public radiation exposure. This was the first German IRRS mission to explicitly address issues related to spent fuel and radioactive waste management. The results of the IRRS mission will be discussed in detail at the Eighth Review Meeting of the Contracting Parties to the Convention on Nuclear Safety (CNS).

In the field of spent fuel and radioactive waste management, the international experts identified the increased requirements regarding the provision of necessary resources for the management of radioactive waste due to the concurrent decommissioning of numerous nuclear installations as a challenge. Further challenges mentioned in the IRRS report were the retrieval of the radioactive waste from the Asse II mine, the site selection for the disposal facility for high-level radioactive waste and the maintenance of competence in view of the decommissioning of the nuclear installations.

In addition, the international experts made recommendations and suggestions with the aim of further promoting the implementation of the IAEA safety standards in the German rules and regulations and in the performance of regulatory functions.

A detailed presentation of the results of the German IRRS mission was submitted as a report in July 2019 and subsequently published on the website of the BMU [IAEA 19a]. Appropriate measures are currently being developed by the licensing and supervisory authorities of the Federation and the *Länder* for the implementation of the recommendations and suggestions, to be completed until the planned follow-up mission.

F Other general safety provisions

Developments since the Sixth Review Meeting:

With the entry into force of the Radiation Protection Act (StrlSchG) and the amended Radiation Protection Ordinance (StrlSchV), issues of radiation protection in Germany were newly regulated.

The Transparency Act adopted in 2018 introduced increased requirements for the transparency regarding the provisions for the waste management obligations remaining with the operators and, among other things, the right of the Federal Office for Economic Affairs and Export Control (BAFA) to access information.

Based on the amendments to the Atomic Energy Act as a result of the Act on the Reorganisation of Responsibility in Nuclear Waste Management, nuclear power plants will in future have to be decommissioned and dismantled immediately after their final shutdown. Safe enclosure will no longer be a decommissioning option.

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

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 primary responsibility for the safety of a spent fuel management facility or a radioactive waste management facility lies with the licence holder. A licence may only be granted if the applicant proves, among other things, that the persons responsible are trustworthy and have the requisite technical qualification. Certified proof of this prerequisite and its acknowledgement by the authorities provide the basis for responsible performance under the licence. Verification shall be performed with previous written consent obtained from the person to be checked and is regulated in § 12b of the Atomic Energy Act (AtG) [1A-3].

The holder of a licence for a nuclear installation is the person responsible for radiation protection, i.e. the radiation protection executive (§ 69 of the Radiation Protection Act (StrlSchG) [1A-34]). In the case of corporations, the tasks of the radiation protection executive are performed by a person authorised to represent the licence holder. The position and duties of the radiation protection executive are regulated in §§ 70 to 72 StrlSchG. The radiation protection executive is obliged to take protective measures to protect man and the environment from the harmful effects of ionising radiation, taking due account of the state of the art in science and technology. For this purpose, suitable rooms, equipment and devices must be provided. Furthermore, the radiation protection executive shall ensure properly organised operations and sufficient numbers of qualified personnel.

The radiation protection executive shall appoint the required number of radiation protection supervisors for the management or supervision of activities to ensure radiation protection during the operation of the nuclear installation. The radiation protection executive shall also remain responsible even in the case of such appointment. The radiation protection supervisors must not be hindered in the fulfilment of their duties or disadvantaged due to their activities.

Furthermore, the Nuclear Safety Officer and Reporting Ordinance (AtSMV) [1A-17] requires the appointment of a nuclear safety officer in facilities licensed pursuant to § 7(1) AtG. The rights and duties of the nuclear safety officer are regulated in §§ 3 to 5 AtSMV in a legally binding manner. His tasks include the evaluation and implementation of operational experience as well as the verification of the correctness and completeness of the reporting of reportable events.

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

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 responsible for averting nuclear-specific danger. In severe cases, it is supported in this task by the Federal Office for Radiation Protection (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(2) of the Atomic Energy Act (AtG) [1A-3]. If such authorised possession cannot be established, the Federal Office for the Safety of Nuclear Waste Management (BASE) shall temporarily take the nuclear fuels into its charge (“government custody”) according to § 5(3) AtG. Such a situation may also arise if nuclear fuels are found or in case of loss of authorisation on the part of the private licence holder (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(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(3)(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 and to anyone who is required to take over or take back nuclear fuel from a third party (§ 5(3)(3) AtG).

According to § 23d AtG, sentence 8, the BASE is responsible for the execution of government custody. The BASE may cause the private licence holders 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 installations, 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 installations, the operators are responsible for providing the necessary competence.

According to § 7(2)(1) and (2) of the Atomic Energy Act (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 trustworthiness 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 trustworthiness of the applicant can also be found in § 6(2)(1) AtG on the licensing for the storage of nuclear fuel as well as in § 9(2)(1) and (2) AtG on the treatment, processing and other utilisation of nuclear fuel outside facilities requiring a licence.

In §§ 47 to 51, the Radiation Protection Ordinance (StrlSchV) [1A-8b] includes regulations concerning the requisite qualification and knowledge in the field of radiation protection as well as its acquisition and conservation.

The Nuclear Safety Officer and Reporting Ordinance (AtSMV) [1A-17] regulates the appointment of nuclear safety officers for nuclear installations licensed under § 7(1) AtG.

The legal basis is 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 executives.

The implementation of 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) or guideline [3-21] relating to the proof of the technical qualification for facilities for the storage of nuclear fuel, 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 respective guideline.

In addition to vocational training, there are appropriate training opportunities in Germany at universities and technical colleges, for example in the field of nuclear and reactor technology at the universities of Aachen, Clausthal-Zellerfeld, Dresden, Essen, Karlsruhe, Munich, Stuttgart and Zittau.

Recognised courses are also provided in the non-governmental sector, e.g. at the various chambers of industry and commerce and at the Haus der Technik e. V. in Essen.

Ensuring a sufficient number of qualified/trained staff for safety-related work also includes the maintenance and further development of existing knowledge.

- 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 Persons Otherwise 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 Alliance for Competence in Nuclear Technology of German research institutes in March 2000 in order to maintain an adequate level of know-how in the nuclear and radiation protection sector. It consists of the permanent members the Helmholtz-Zentrum Dresden-Rossendorf e. V. (HZDR), the Forschungszentrum Jülich GmbH (FZJ), the Karlsruhe Institute of Technology (KIT) and the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH together with their partner universities and the Materials Testing Institute of University of Stuttgart. In addition, the Alliance for Competence contributes to the close cooperation with the universities and the industry, as well as the cooperative support of international initiatives on maintaining competence in the field of nuclear energy.
- The Competence Network for Radiation Research (KVSF) was established in 2007 and, as a forum of excellence, has the task to highlight the scientific and the social and political importance of radiation research. Active public relation of the KVSF shall contribute to strengthen the position of radiation research and its public perception. One of the KVSF’s primary concerns is to initiate a systematic and continuous promotion of young researchers in the field of radiation research in order to ensure the scientific level in the long-term and to cover the future need for qualified experts. Six experts from large research institutions like e.g. the German Cancer Research Center, FZJ, the Helmholtzzentrum für Schwerionenforschung GmbH (GSI), HZDR, the Helmholtz Zentrum München (HMGU) as well as KIT are appointed to the KVSF. Six further experts from different fields of radiation research are proposed by the German Society of Medical Physics (Deutsche Gesellschaft für Medizinische Physik), Fachverband für Strahlenschutz e. V., Deutsche Gesellschaft für Radioonkologie e. V., Deutsche Gesellschaft für Epidemiologie e. V. and Gesellschaft für biologische Strahlenforschung e. V. The Commission on Radiological Protection (SSK), the Federal Office for

Radiation Protection (BfS) and the Karlsruhe Project Management Agency (PTKA) appoint one representative each.

- The German Association for Repository Research (DAEF) was established in 2013 and considers itself as an independent association with its focus on the safe disposal of radioactive waste and the continuous further development of the scientific and technical expertise in this field also including socioeconomic issues. An essential objective is the further development and intensification of the cooperation of the DAEF members in the field of disposal facility research. In addition, the DAEF offers scientific and technical advice to the Federal Government and its authorised federal and *Land* authorities as well as to the *Bundestag* and other interested institutions. The permanent members of the DAEF are BGE TECHNOLOGY GmbH, the Deutsche Montan Technologie für Rohstoff, Energie, Umwelt e. V. (DMT), FZJ, GRS, HZDR, the Institute of Geomechanics GmbH (IfG), the TÜV Rheinland ISTec GmbH, KIT, the Institute for Applied Ecology Öko-Institut e. V., the Aachen Rhenish-Westphalian University of Technology (RWTH), the Freiberg University of Mining and Technology (TU Bergakademie Freiberg), the Clausthal University of Technology and the University of Stuttgart.
- The power plant operators also have committed themselves to the coordinated promotion of German training and research institutions to contribute to the maintenance of competence and junior staff recruitment in the field of nuclear technology.
- The training and further qualification of expert staff from authorities and authorised expert organisations is the objective of the events offered by the GRS within the framework of its GRS Academy. 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 installations, International Nuclear Event Scale (INES) User Manual of the International Atomic Energy Agency (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 installations.
- The BGZ Company for Storage (BGZ) considers the maintenance of a high level of knowledge in the storage facilities for the coming decades and the continuous training of the staff to be essential. For this reason, the BGZ has initiated the introduction of a holistic knowledge management system by drawing up a “balance sheet of knowledge” (*Wissensbilanz* – Made in Germany). In addition, the area of personnel development will be further expanded to ensure the transfer of knowledge and the development and maintenance of the necessary competencies in the field of nuclear waste management. The aim is to provide a particularly practice-oriented, technically and methodologically up-to-date and scientifically sound education in order to qualify graduates for a wide range of fields of activity. These fields of activity are aimed at ensuring the safe management of radioactive waste, in particular from the use of nuclear energy. Furthermore, the specialisation field Nuclear Waste Management, which is oriented towards the requirements of storage, will be established in the cooperation course EMiNA at the FH Aachen University of Applied Sciences.
- The fields of competence of the Federal Company for Radioactive Waste Disposal (BGE) range from site selection, construction, keeping open, retrieval and closure to the safe operation of disposal facilities.
  In particular, it tries to meet the demand for qualified personnel by developing new, future-oriented concepts, e.g. in the field of talent and applicant management. The BGE also trains its own skilled staff in the form of a dual course of studies in safety engineering with a specialisation in radiation protection. In addition, own training covers the following occupational areas: electronics, industrial mechanics, mining technology, IT systems engineering and industrial management. In order to update and build up expert knowledge, the BGE staff regularly take part in in-house training courses or individual seminars, conferences, symposia and forums. Specifically, the focus is on seminars in the fields of nuclear law, mining law and

environmental law. For the exchange of up-to-date knowledge and as an instrument for recruiting junior staff, there is also cooperation with universities and technical colleges. As a first concrete measure in the field of further education and training, the BGE is seeking cooperation with the BGZ on the topics of maintaining expert knowledge and cooperative study courses. In addition, the BGE as well as the BGZ, the BASE and the BfS were part of a project team set up by the BMU which, among other things, analysed demands in the field of national nuclear waste management safety in order to develop a concept for the perspective maintenance of expert knowledge and qualified personnel.

The importance of the societal task of competence building and the development of future talent for nuclear safety, as well as continuing to actively contribute the German understanding of safety at the international level, is underlined in the coalition agreement of the parties forming the Federal Government of March 2018 and is also set as a strategic goal in the 7th Energy Research Programme of September 2018. The ministries BMWi, BMU and BMBF are jointly dedicated to developing a concept for competence and junior staff development.

For the tasks to be performed during the phase-out of nuclear energy use for the commercial electricity generation and beyond, competent and motivated staff will continue to be required to make their contribution to ensuring nuclear safety. Motivation can only be maintained if this work is regarded as being important and recognized by society.

F.2.2 Dealing with the current spread of the SARS-CoV-2 virus

Due to the global coronavirus pandemic, the Federal Government has set up a crisis management team which decides on measures to control the coronavirus (SARS-CoV-2) and to protect the population and also issues recommendations for action, which are regularly evaluated and updated. Among other things, these measures are also intended to ensure the safe operation of nuclear installations and facilities in the Federal Republic of Germany.

In this context, the Federal Chancellor, together with the heads of government of the *Länder*, had established extended guidelines for the Federation and the *Länder* to control the coronavirus. These included restrictions on freedom of movement and mobility. In this context, the Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) had already continuously switched to home office mode, in which the presence at the place of work was the exception.

Since the Radiation Protection Act came into force in 2017, the BMU has been operating the Federal Radiological Situation Centre (RLZ) for the event of a radiological emergency. Taking into account the national hygiene recommendations for protection against infection with coronavirus, appropriate protective measures were provided for the RLZ staff in the event of an alarm so that constant operational readiness of the RLZ is guaranteed.

The staff of the federal and *Land* authorities, to the extent possible and necessary, work from their home offices and can perform their tasks in this form even over a longer period of time. Face-to-face meetings were cancelled and replaced by correspondence or phone and video conferencing. The necessary monitoring and inspection visits by the federal and *Land* authorities associated with the supervisory activities are carried out in compliance with the hygiene and precautionary measures. The health authorities also monitor the implementation of the infection prevention measures imposed on the operators.

German nuclear power plants and research reactors have pandemic plans that have been adapted to the current coronavirus pandemic. This also applies to facilities under decommissioning. The competent *Land* authorities are informed about the specific precautionary measures taken at the respective facilities. These include a reduction in the workforce and external personnel at the site, additional access control measures to prevent infected persons from entering the facilities, and rules of conduct on hygiene or on reducing personal contact to the necessary extent. Dismantling work is partially or completely suspended temporarily.

All safety-related inspections and tests required in the nuclear installations in Germany must continue to be carried out. In order to avoid personal contacts, the involvement of authorised experts may be temporarily suspended in individual cases if this is covered by the operating procedures. This has to be agreed with the competent supervisory authority.

The operators of the uranium enrichment and fuel fabrication plants have developed a hygiene concept and precautionary measures in response to the spread of coronavirus. They must report weekly to the competent supervisory authority on the current status.

The BGZ Company for Storage (BGZ) already set up a task force in February for prevention and to deal with the COVID-19 pandemic and a crisis management team in the further course of the pandemic and due to its intensification. At the storage facilities it operates, the BGZ has divided the local workforce into groups in order to reduce contact between the groups, but also between the staff members themselves. In this way it was possible to ensure that the safety-related functions as well as the security of the facilities could be ensured at all times. The BGZ provided breathing masks for work where compliance with the specified distancing rules cannot be ensured at all times. In order to compensate for the reduced occupancy, the operation management staff have rescheduled work that can be postponed in consultation with the nuclear supervisory authorities and electric power utilities. Here, the low-maintenance dry cask storage of the fuel assemblies has generally proven to be advantageous.

Similarly, the contact and infection risk has been reduced in various ways in conditioning facilities for radioactive waste, but at the same time the core task – the safe operation of nuclear installations and facilities – has been reliably secured at all times.

The Federal Company for Radioactive Waste Disposal (BGE) already set up a corona crisis management team at the end of February and developed a pandemic plan to be prepared. Since, however, the Morsleben repository, the Asse II mine and the Konrad repository pose special challenges that require continuous work that must also be ensured in case of a worsening crisis situation, site-specific crisis management teams were formed for each mine and adapted emergency plans were prepared in coordination with the technical management. These plans not only contain basic regulations on hygiene measures and distancing rules, but also stipulations on the obligation to wear masks, the adjustment of shift systems, the formation of A/B teams, the establishment of standby and on-call services, the definition of notification chains, etc.

The BGE defined the work that is continuously required to ensure this safety as system-relevant functions and identified function holders and their representatives who must always be capable of working. The activities comprise, for example, radiation protection measurements in the Asse II mine, handling the saline solutions entering the Asse II mine to pump it to the surface, maintenance and repair of machines, for example of the systems that move the elevators in the mines (shaft hoisting systems) so that they remain ready for operation, regular condition controls of the cavities underground so that safe working during normal operation will then be possible again. Particularly qualified colleagues, such as the mine rescue team or the hoisting machine operator who operates the shaft hoisting system, must always be ready for operation.

When applying radiation protection law, the supervisory authorities can make use of their discretionary powers and, where necessary, deviate from the non-mandatory guidance instruments.

F.2.3 Financial resources during operation and decommissioning

In accordance with the principle that the costs of waste management shall be paid by the waste producers, the operators of nuclear power plants are obliged under § 9a(1) of the Atomic Energy Act (AtG), sentence 1 [1A-3], to bear the costs of management for the radioactive waste they produce. For nuclear installations and other waste management facilities (§ 9h AtG) § 7c(2)(2) AtG also generally stipulates that the licence holder shall be obliged to schedule and keep ready permanent appropriate financial instruments to fulfil his obligations concerning the nuclear safety of the particular facility. In order to ensure compliance, § 19 AtG requires government supervision as a regulatory instrument.

The Waste Management Transfer Act (EntsorgÜG) [1A-35] regulates the responsibility for nuclear waste management, and the Waste Management Fund Act (EntsorgFondsG) [1A-36] secures financing of decommissioning and waste management in the long term without passing on the costs unilaterally to society or endangering the economic situation of the operators with regard to their remaining nuclear obligations (see Chapter E.2.2 for details on the Act on the Reorganisation of Responsibility in Nuclear Waste Management).

Financing the decommissioning of the facilities and the qualified packaging of radioactive waste

In accordance with the concept created for the division of responsibility in the field of nuclear waste management, the operators of the nuclear power plants remain responsible for the entire management and financing of decommissioning of the nuclear power plants and qualified packaging of the radioactive waste. To provide for the costs arising from this in the future, they must continue to form provisions.

The adopted Transparency Act (TransparenzG) [1A-37] introduced increased requirements for the transparency regarding the provisions for the obligations remaining with the operators and, among other things, the right of the Federal Office for Economic Affairs and Export Control (BAFA) to access information. In the statement to be submitted annually, the operators must, on the basis of the annual financial statements, present detailed information on the provisions they have made for the decommissioning of the nuclear power plants and for the packaging of radioactive waste, broken down by the various tasks of radioactive waste management. This presentation must include the expenses expected for the individual tasks of the waste management obligations for the coming financial years. It must also show which assets will be available to the operator in the future to cover these expenses. The Federal Ministry for Economic Affairs and Energy (BMWi) has issued an ordinance on the implementation of the obligation to provide information and the content and form of the information pursuant to the Transparency Act (Ordinance on the Transparency of Dismantling Provisions – RückBRTransparenzV) [1B-21], which came into force on 9 July 2018 and contains specific requirements for the provision of information.

The information and data provided by the operators were last verified by the BAFA for the reporting year 2018. The BAFA came to the positive conclusion that there are no objections to the determination of the companies' provision amounts and that there are no indications that the companies might not meet their obligations. As at 31 December 2018, the provisions for obligations, presented in the statement of provisions prepared on the basis of the operators' annual financial statements, amounted to approximately 21.9 billion euros.

The results of the examination by the BAFA formed the basis of the report of the Federal Government to the German *Bundestag* on the financial provisions of the nuclear power plant operators for their obligations, last published in November 2019. The report contains a summary assessment of the information submitted to the BAFA by the operators of nuclear power plants as part of their statutory obligation to provide information.

As an additional provision to secure the operators' financing obligations, legislator has passed the Follow-up Liability Act [1A-38]. The operators of the nuclear power plants are incorporated into groups under company law and, due to profit transfer and management control agreements within the groups, largely in such a financial situation that the groups' assets are liable for the costs of decommissioning, dismantling and waste management. In case of making use of restructuring possibilities by the groups under company law, there was a risk that the operating companies would become insolvent.

The Follow-up Liability Act reacts to these corporate law options for group companies by introducing a statutory follow-up liability of controlling companies for operating companies controlled by them for the costs of decommissioning of their nuclear power plants. For the operating companies and the group companies, the Follow-up Liability Act creates an extension of liability compared to the generally limited liability resulting from company law.

Financing of storage and disposal

According to the Waste Management Transfer Act, the Federation shall be responsible for the storage and disposal of spent fuel and radioactive waste from nuclear power plants.

Implementation and financing of the governmental tasks in the fields of storage and disposal of spent fuel and radioactive waste from nuclear power plants are organised as follows: The responsibility for action in the field of storage lies with the third party within the meaning of § 2(1) EntsorgÜG, sentence 1, i.e. the federally-owned BGZ Company for Storage (BGZ). Financing is provided from the federal budget, refinancing in accordance with the Waste Management Transfer Act by charging the costs in the form of a notice of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) to the foundation fund for the financing of nuclear waste management (KENFO). The Federation's task of establishing facilities for disposal is carried out by the Federal Company for Radioactive Waste Disposal (BGE) on the basis of § 9a(3) AtG, sentence 2, second half-sentence, and the notice of transfer from the BMU. Financing of radioactive waste disposal of the operators of nuclear power plants is provided from the federal budget, refinancing for this area by the KENFO.

The funds for the financing of the governmental tasks in the fields of storage and disposal were provided by the nuclear power plant operators. On 3 July 2017, the operators transferred a total of approximately 24.1 billion euros to the KENFO. The total amount transferred to the KENFO comprised a basic amount of around 17.9 billion euros, with the payment of which the responsibility for storage and disposal was transferred to the Federation, and a risk premium of around 6.2 billion euros, with the payment of which all obligations of the nuclear power plant operators to pay additional contributions to the KENFO ceased to apply.

The KENFO was established as a foundation under public law with the entry into force of the Waste Management Fund Act on 16 June 2017. The legal purpose of the KENFO is to ensure the refinancing of the costs incurred for the safe management of present and future arisings of radioactive waste from the commercial use of nuclear energy for electricity generation in Germany. To this end, the KENFO invests the funds transferred by the nuclear power plant operators at the highest possible interest rate and safely and reimburses the Federation for the costs arising from storage and disposal.

The organs of the KENFO are the Board of Trustees and the Board of Directors. The Board of Trustees as supervisory body consists to the half of representatives of the German *Bundestag* on the one hand and of representatives of the Federal Ministry for Economic Affairs and Energy, the Federal Ministry of Finance and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety on the other. The Board of Directors is KENFO's management body, consisting of three members who have extensive experience in the investment and management of significant assets.

F.2.4 Financial resources after closure of a disposal facility

Once a disposal facility will have been sealed, a monitoring phase can be part of the requirements for closure. After release of the disposal facility from nuclear supervision, the remaining surveillance is a governmental task. It is intended to introduce a system for surveillance which can mainly take credit from the passive safety measures that are to be included in the design of the disposal facility. Since surveillance is carried out under government control, funding is provided through 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 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 KTA 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. Quality assurance measures are implemented by the operational management system and defined in the licence and the related application documents, in particular in the safety report. The type and scope of measures to safeguard quality characteristics are oriented towards their significance for preventing damages caused by radiation exposure. In the licensing procedure, plant components are assigned to quality class “nuclear”, which in turn is subdivided according to safety significance as well as special significance in terms of radiation protection or outstanding significance in terms of radiation protection, and to quality class “conventional”. For nuclear plant components, additional design approval documents have to be prepared according to the requirements, while conventional quality requirements according to the state of the art in technology and the applicable technical rules and regulations are sufficient for conventional plant components.

The applicant or licence holder is responsible for the planning, performance and control of the effectiveness of quality assurance. In this respect, an essential requirement of safety standard KTA 1401 is the technical knowledge and qualification of the personnel.

The type and scope of initial inspection and, where necessary, recurring inspections by the supervisory authority, which also monitors compliance with the measures, are specified within the nuclear licensing procedure. The supervisory authority may consult authorised experts for the inspections. Moreover, it has access to the facility at any time to carry out necessary inspections.

Some quality assurance requirements in international standards, e.g. in DIN EN 45004, are not addressed by safety standard KTA 1401. However, the Atomic Energy Act (AtG) [1A-3], the Radiation

Protection Act (StrlSchG) [1A-34] and the Radiation Protection Ordinance (StrlSchV) [1A-8b] generally require compliance with the state of the art in science and technology. This ensures that international quality assurance requirements are also taken into account.

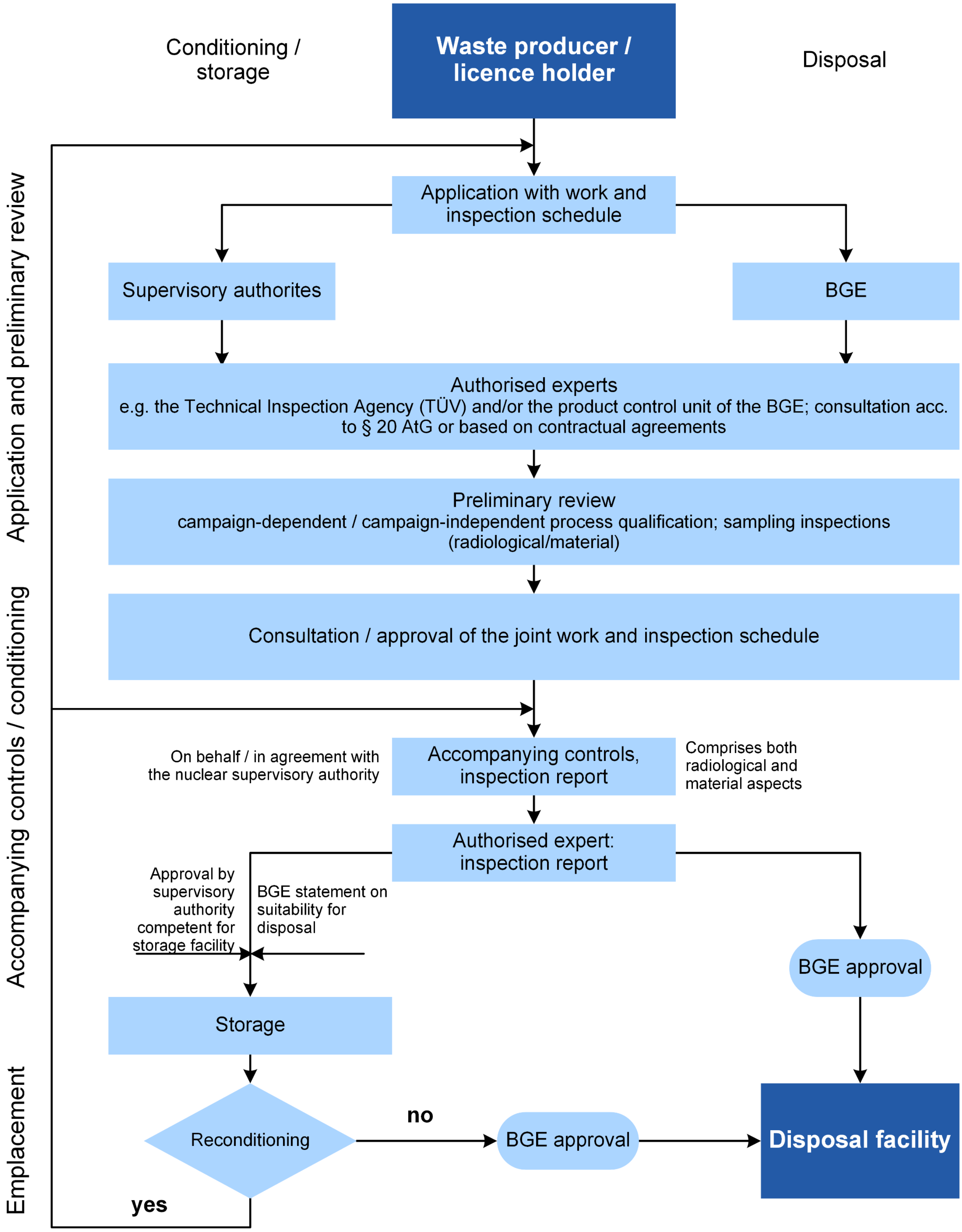
The operators of the storage facilities have a quality management system based on nuclear safety standards KTA 1401, 1402 and on DIN EN ISO 9001. The quality management system refers to the phases of safety-related concept development, planning and design, procurement, fabrication and erection, construction of structural facilities, commissioning and operation of the on-site storage facility and also regulates the requirements for quality assurance measures.

F.3.2 Product control

Product control of radioactive waste exists as a part of general quality assurance. Its task is to ensure compliance with waste acceptance criteria. These are the result of the site-specific safety analysis for the disposal facilities. The corresponding evidence requires the existence of organisational and administrative regulations defining the spheres of responsibility, tasks and activities of the parties involved. Within the scope of the responsibility assigned to it, the Federal Company for Radioactive Waste Disposal (BGE) (third party according to § 9a(3) of the Atomic Energy Act (AtG), sentence 2, second half-sentence [1A-3]) is responsible for the operation of the disposal facility and ensures compliance with the waste acceptance criteria by qualifying conditioning measures and waste packages. The latter is a sovereign task.

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 characteristics of the waste packages relevant for disposal. Organisational and administrative regulations governing the spheres of responsibility, tasks and activities of the parties involved are laid down in the guideline relating to the control of residual radioactive material and radioactive waste of 19 November 2008 (see Figure F-1) and the agreements between the BGE and the waste producers. The nuclear supervisory authorities of the *Länder*, the BGE, the commissioned 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 type and scope of product control measures are determined depending on the conditioning technique, waste characteristics and requirements of the disposal facility. The measures required in order to guarantee the safety of a disposal facility for radioactive waste are laid down in the respective licence of the disposal facility (plan approval decision).

Figure F-1: Product control flow chart for waste packages regarding their conditioning, storage and disposal



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 criteria for disposal.

According to the Konrad waste acceptance criteria (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 accompanying controls during fabrication,
- process qualification and accompanying controls of conditioning measures, and
- sampling inspection 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 criteria 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 centre of gravity position, and
- determination of dose rate and contamination (see Figure F-2).

Figure F-2: Wipe test for product control on a MOSAIK container (Copyright: GNS)

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 BGE takes place with accompanying controls with regard to the demonstration of compliance with the waste acceptance criteria.

Sampling inspection

Waste packages from non-qualified processes are controlled by the BGE after production for compliance with the waste acceptance criteria. Type and scope of control measures depend on the extent to which the documentation submitted demonstrates compliance with the waste acceptance criteria.

Qualified packaging

The Waste Management Transfer Act (EntsorgÜG) [1A-35] stipulates that the Federation is to take over the properly packaged waste packages of the nuclear power plant operators into storage, for which it is responsible.

Qualified packaging for the transfer into storage is aimed at compliance with the Konrad waste acceptance criteria at the time of entry into force of the Waste Management Transfer Act. If a package of the nuclear power plant operators fulfils the applicable waste acceptance criteria, the notification will indicate that the conditions for transfer to the BGZ are also fulfilled. If the BGE finds during its examination of a package of a nuclear power plant operator that it is not possible to fulfil the applicable waste acceptance criteria, it will examine whether the conditions for a transfer to the BGZ are fulfilled and issues a provisional certification confirming the qualified packaging without specific application.

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

With the entry into force of the Radiation Protection Act (StrlSchG) of 27 June 2017 [1A-34] and associated ordinances, Council Directive 2013/59/EURATOM of 5 December 2013 [1F-24] was transposed into national law.

With the Radiation Protection Act, the Radiation Protection Ordinance (StrlSchV) [1A-8b] was also restructured. The X-Ray Ordinance and the Precautionary Radiation Protection Act were repealed and corresponding regulations were included in the Radiation Protection Act and the Radiation Protection Ordinance. The structure is now based on Council Directive 2013/59/EURATOM in such a way that there is a separation according to the following four regulatory areas: Planned exposure situations, emergency exposure situations, existing exposure situations and provisions covering all exposure situations. Other ordinances have been issued or are to be issued. In particular, the new Nuclear Waste Management Ordinance (AtEV) [1B-19] and the Emergency Dose Values Ordinance (NDWV) [1B-20] are already in force.

The regulations on planned exposure situations were extended to workplaces with naturally occurring radioactive material (NORM). With regard to radiation protection, the position of the radiation protection supervisor has been significantly strengthened, the dose limit for the lens of the eye from occupational exposure has been reduced to 20 mSv per calendar year and the national organ dose limits for internal organs, which are additional to those of Council Directive 2013/59/EURATOM, ceased to apply. Furthermore, the international data exchange with regard to exposure data has been simplified, the exemption levels for specific activity have been harmonised with the values for unrestricted clearance and the D-values of the International Atomic Energy Agency (IAEA) have been adopted as activity values for classification as highly radioactive sources, which represent a measure of the hazard potential of the sources [IAEA 06b]. The dose limit for the general public now refers to the sum of all radiation exposures from activities requiring a licence or notification pursuant to the Radiation Protection Act or the Atomic Energy Act (AtG) [1A-3], from government custody of nuclear fuel, from construction, operation and closure of federal facilities for radioactive waste disposal requiring plan approval, and from the prospection, extraction or treatment of radioactive mineral sources, if this is subject to the obligation to prepare a mining operating plan according to § 51 of the Federal Mining Act (BBergG) [1B-15].

The basic safety standards on radiation protection of the IAEA [IAEA 14b] and the recommendations of the International Commission on Radiological Protection (ICRP) are taken into account. The ALARA principle is taken into account by § 8 StrlSchG according to which any unnecessary exposure or contamination of man and the environment shall be avoided and which contains an obligation, in terms of the activities relevant here, to keep the contamination of man and the environment as low as possible, even below the limits, 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

According to § 5(7) of the Radiation Protection Act (StrlSchG) [1A-34], occupationally exposed persons are persons who could receive an effective dose of more than 1 mSv, an equivalent dose for the lens of the eye of more than 15 mSv or an equivalent dose for the skin of more than 50 mSv from activities per calendar year. Occupationally exposed persons shall be monitored for radiation exposure by means of official and operational dosimeters. According to § 78 StrlSchG, they may, in principle, receive a maximum effective dose of 20 mSv per calendar year. Limits are also specified for the individual organ equivalent doses. These are listed in Table F-1.

For occupationally exposed persons under 18 years of age, a significantly lower limit of the effective dose of 1 mSv per calendar year is specified. In individual cases, the authorities may permit effective doses of up to 6 mSv per calendar year for trainees and students aged between 16 and 18 years if this is necessary to achieve their professional objectives.

For women of childbearing age, the limit of 2 mSv per month organ equivalent dose of the uterus must not be exceeded. For an unborn child whose mother may continue to work as an occupationally exposed person after pregnancy has become known, the limit is 1 mSv for the period from notification of the pregnancy to its end. Working conditions of pregnant or breastfeeding women must be such that internal occupational exposure is excluded.

According to § 77 StrlSchG, the effective dose limit for the entire period of occupational activity shall be 400 mSv.

The above dose limits may only be exceeded in special permitted cases, e.g. for averting of a danger. Regulations exist for emergency workers in emergency exposure situations and other hazard situations, for example to protect life or health or to prevent or combat a disaster (see Chapter F.5.1 for details on the protection of emergency workers and Table F-1).

For the documentation of radiation exposure, a physician authorised in accordance with § 175 of the Radiation Protection Ordinance (StrlSchV) [1A-8b] shall keep a health record for an occupationally exposed person, in which, in addition to information on body doses received, information on working conditions, results of medical surveillance and information on decisions of the competent authorities on employment are listed. In accordance with § 170 StrlSchG, the determined body dose is additionally recorded centrally at the Radiation Protection Register of the Federal Office for Radiation Protection (BfS).

In his function as radiation protection executive, the operator of a nuclear installation is obliged according to § 8 StrlSchG to avoid any unnecessary radiation exposure or contamination of man and the environment. Any unavoidable radiation exposure and contamination must be kept as low as possible, taking into account all circumstances of the individual case and the state of the art in science and technology, even below the statutory limits. The radiation protection executive must ensure this by means of suitable technical and organisational measures in accordance with § 72 StrlSchG. The radiation protection executive must ensure that a radiation protection instruction is issued which, in accordance with § 45 StrlSchV, lists the organisational and technical protection measures required during operation.

The radiation protection executive appoints radiation protection supervisors who are responsible for compliance with the operator's obligations under radiation protection law, insofar as these powers have been delegated to them. According to § 70(2) StrlSchG, the duties and scope of decision-making of the individual radiation protection supervisor shall be laid down in writing. The radiation protection supervisor must have the requisite technical qualification for his task, which shall be verified and certified by the competent authority in accordance with § 47 StrlSchV. According to § 48 StrlSchV, the requisite technical qualification shall be updated at regular intervals that must not exceed five years by participation in corresponding courses. According to § 70(6) StrlSchG, the radiation protection supervisor shall not be hindered in the performance of his duties or disadvantaged for this reason.

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.

F.4.3 Exposure of the general public

It is a general rule for all nuclear installations and facilities pursuant to § 80 of the Radiation Protection Act (StrlSchG) [1A-34] that their operation may result in an effective dose of no more than 1 mSv per calendar year for members of the general public. This dose limit refers to the sum of all radiation exposures from activities requiring a licence or notification under the Radiation Protection Act or the Atomic Energy Act (AtG) [1A-3], from government custody of nuclear fuel, from construction, operation and closure of federal facilities for disposal requiring plan approval, and from the prospection, extraction or treatment of radioactive mineral sources, if this is subject to the obligation to prepare a mining operating plan according to § 51 of the Federal Mining Act (BBergG) [1B-15]. In addition, organ equivalent doses are specified. Table F-1 contains a compilation of basic limits and reference levels for exposure from the Radiation Protection Act and the Radiation Protection Ordinance (StrlSchV) [1A-8b].

It is the responsibility of the competent authority and the radiation protection executives to ensure compliance with the limits.

Table F-1: Selected dose limits and reference levels from the Radiation Protection Act (StrlSchG) and Radiation Protection Ordinance (StrlSchV)

§ StrlSchG	§ StrlSchV	Scope of application	Period	Value [mSv]
Limits for the exposure of the general public				
80		Effective dose	Calendar year	1
		Organ equivalent dose: eye lens	Calendar year	15
		Organ equivalent dose: skin	Calendar year	50
Dose limits for discharges of radioactive material				
	99	Effective dose	Calendar year	0.3

§ StrlSchG	§ StrlSchV	Scope of application	Period	Value [mSv]
Dose limits for occupationally exposed persons				
78		<u>Occupationally exposed persons (general):</u> Effective dose	Calendar year	20
		Organ equivalent dose: eye lens	Calendar year	20
		Organ equivalent dose: skin, hands, forearms, feet and ankles each	Calendar year	500
		<u>Occupationally exposed persons under 18 years of age:</u> Effective dose	Calendar year	1
		Organ equivalent dose: eye lens	Calendar year	15
		Organ equivalent dose: skin, hands, forearms, feet and ankles each	Calendar year	50
		<u>Trainees and students, 16 to 18 years of age, with the permission of the competent authority:</u> Effective dose	Calendar year	6
		Organ equivalent dose: eye lens	Calendar year	15
		Organ equivalent dose: skin, hands, forearms, feet and ankles each	Calendar year	150
		<u>Women of childbearing age and unborn children:</u> Organ equivalent dose for women of childbearing age: uterus	Month	2
		Unborn child	From notification of pregnancy to its end	1
77		Occupational lifetime dose, effective dose	Dose determined for occupationally exposed persons, summed over all calendar years	400
Reference levels for emergency workers				
114		<u>Emergency operations (general) – Protection of emergency workers:</u> Levels of § 78 StrlSchG (counted towards the occupational lifetime dose)	Respective exposure situation	(see above)
		<u>Operations to protect life or health:</u> Effective dose (counted towards the occupational lifetime dose)	Respective exposure situation	100
		<u>Operations to save lives, to prevent serious damage to health from radiation or to prevent or combat a disaster (volunteers only):</u> Effective dose (counted towards the occupational lifetime dose)	Respective exposure situation	250
		<u>Exceptional cases (volunteers only):</u> Effective dose (counted towards the occupational lifetime dose)	Respective exposure situation	500

§ StrlSchG	§ StrlSchV	Scope of application	Period	Value [mSv]
Dose limits for accidents (planning levels)				
	104	Limitation of exposure of the general public: Effective dose	Accumulated up to the age of 70 of the exposed person	50
		Organ equivalent dose: skin, hands, forearms, feet and ankles		500
		Organ equivalent dose: eye lens, gonads, uterus and bone marrow (red)		50
		Organ equivalent dose: bone surface		300
		Organ equivalent dose: great gut, lung, stomach, bladder, breast, liver, gullet, other organs or tissues		150

In the case of nuclear installations, facilities or activities that are subject to licensing according to §§ 6, 7 or 9 AtG or to plan approval according to § 9b AtG, such as the pilot conditioning plant (PKA), the Karlsruhe vitrification facility (VEK), the storage facilities for spent fuel and disposal facilities, the radiation exposure for a representative person is determined within the framework of the licensing procedure in the most unfavourable variant in accordance with the specifications of Appendix 11 StrlSchV in order to demonstrate compliance with the limits.

For the operation of the nuclear installations and facilities, permissible discharges into air and water are specified by the competent authority, taking into account the existing pollution from other nuclear installations and facilities and from past activities, by limiting the activity discharged over a certain period of time or the activity concentration. The limit for the effective dose of exposure of members of the general public from discharges of radioactive material into air or water from these facilities is 0.3 Sv per calendar year.

Decentralised storage facilities for spent fuel do not generate any discharges of radioactive wastewater, since any contaminated wastewater, e.g. from maintenance work on the containers, which exceeds the maximum permitted activity concentrations is transferred to sewage treatment facilities. Discharges into the air by releases from the storage casks are not to be expected, although discharge values have been applied for in order to allow for possible contamination of the cask surfaces, for example. In practice, however, discharges into 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.

F.4.4 Measures to prevent unplanned and uncontrolled releases

In order to prevent accidents involving uncontrolled releases of radioactive materials, nuclear installations and facilities must be planned and designed in such a way that the effects caused by them remain limited. Already in the licensing procedure it is to be demonstrated that the facility is designed against certain accidents, the so-called design-basis accidents. The relevant basis is the state of the art in science and technology. The radiation protection executive at the facility is responsible for planning. The type and scope of the protective measures are determined by the licensing authority.

The limitation of exposure of the general public in the event of an accident is specified in § 104 of the Radiation Protection Ordinance (StrlSchV) [1A-8b] on the basis of planning levels. In addition to a maximum effective dose of 50 mSv, organ equivalent doses are also to be considered as upper limits. In any case, the radiation exposure must be kept as low as possible.

§§ 106 to 109 StrlSchV define further obligations of the radiation protection executive with regard to incidents. These include the provision of trained personnel and necessary resources, the provision of information and advice to the authorities responsible for safety, the fulfilment of reporting obligations, and the systematic investigation of the causes and effects of an incident.

For the Asse II mine, the Act on Speeding up the Retrieval of Radioactive Waste and the Closure of the Asse II Mine ("Lex Asse") [1A-26] stipulates that for the planning and closure measures, the accident planning values shall be determined by the licensing authority on a case-by-case basis until general administrative provisions become effective.

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 formulated in two recommendations of the Nuclear Waste Management Commission (ESK) ([3-150], [3-151]) in the form of guidelines. These are 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 of operational discharges of radioactive substances

Basis

Radioactive substances must not be discharged into the surrounding environment of a nuclear installation in an uncontrolled manner. Their operational discharges into water or air must be monitored and registered according to specific type and activity. According to § 99 of the Radiation Protection Ordinance (StrlSchV) [1A-8b], the effective dose for members of the general public from discharges of radioactive substances into water or air must not exceed 0.3 mSv per calendar year.

The radiation exposure for reference persons is already determined during the planning of nuclear installations or facilities in order to determine the permissible discharge values at the most unfavourable receiving points. The calculation method for determining radiation exposure is laid down in a general administrative provision [2-1]. This administrative provision from 2012 shall be applied until a new general administrative provision comes into force.

Monitoring of emissions and immissions during specified normal operation and in case of accidents

Discharges from nuclear installations 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 installation may order supplementary measures for monitoring, or in individual cases may exempt the facility operator from this reporting obligation, provided he can prove by demonstrating the confinement of the radioactive materials or by the small radioactive inventory and the type of work to be carried out within the facility that the limit according to § 99 StrlSchV is safely complied with. This does not apply to nuclear power plants and facilities for reprocessing.

Facilities with a handling licence pursuant to § 12(1)(3) of the Radiation Protection Act (StrlSchG) [1A-34], for example, have low or, in individual cases, no emissions. This includes individual conditioning facilities and storage facilities for radioactive waste where no repairs are carried out.

In the case of nuclear activities and facilities that are subject to licensing or plan approval according to §§ 6, 7 or 9b of the Atomic Energy Act (AtG) [1A-3], such as the pilot conditioning plant (PKA) for spent fuel, the Karlsruhe vitrification facility (VEK) for fission products, the storage facilities for spent fuel, a few conditioning facilities for the treatment of materials containing nuclear fuel as well as disposal facilities, the competent authority may order the determination of meteorological and hydrological dispersion conditions if this is considered necessary for the determination of the exposure received by a representative person.

It should be taken into account that the PKA, in which the conditioning of the spent fuel was to be demonstrated, is for the time being only licensed for the repair of defective spent fuel transport and storage casks and for vitrified high-level radioactive waste from reprocessing as well as the handling and treatment of other radioactive material. At present, no radiation exposures have to be considered here.

The Guideline concerning Emission and Immission Monitoring of Nuclear Installations (REI) [3-23] contains specifications on the harmonisation of monitoring and the performance thereof. The holder of the licence is responsible for monitoring in the form of self-monitoring. Independent institutions conduct reference measurements on behalf of the competent supervisory authority.

Appendix C of the REI contains supplementary specific regulations for storage facilities for spent fuel and facilities for the disposal of 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 is to be regulated such that the monitoring of contributions to the total dosage from direct radiation of the facility is ensured.

F.4.6 Clearance

Overview

Residual radioactive material is produced in nuclear installations and facilities, in particular during the decommissioning phase as well during the operation of facilities for the treatment of radioactive substances and spent fuel, whose activity per unit mass or area – after decontamination, if necessary – is low. This residual radioactive material can be released from nuclear regulatory control. The criterion for this is an effective dose in the range of 10 µSv/a for members of the general public, as laid down in Chapter 3 of Part 2 of the Radiation Protection Ordinance (StrlSchV) [1A-8b] (§§ 31 to 42 StrlSchV) in accordance with the provisions of Council Directive 2013/59/EURATOM [1F-24]. Cleared materials are mainly building rubble, scraps, operational waste as well as other solid substances and liquids from the repair or decommissioning of nuclear installations and facilities. Clearance procedures are also applied for buildings as well as site areas (soil areas) of facilities.

Regulations for clearance at the statutory level were first issued in Germany in 2001. The current regulations in the Radiation Protection Act and in the amended Radiation Protection Ordinance continue these. There are differences in the classification of the various clearance options according to unrestricted and specific clearance, as well as in the clearance levels that are applied for unrestricted clearance. The differences compared to previous regulations are addressed at the end of this section.

For clearance, there is unrestricted clearance according to § 35 StrlSchV for all types of solid and certain liquid substances as well as various options of specific clearance according to § 36 StrlSchV. The corresponding clearance levels are listed in Appendix 4, Table 1 StrlSchV and the boundary conditions to be applied are listed in Appendix 8 StrlSchV. Important options of specific clearance are the clearance of building rubble and soil areas, clearance for disposal (in a landfill or in a thermal waste treatment facility as for conventional waste of other origin), the clearance of metal scrap for recycling and the clearance of buildings for demolition or subsequent use.

Insofar as specific provisions of the Radiation Protection Ordinance on clearance are not available or no clearance levels have been defined in the Radiation Protection Ordinance, compliance with an effective dose in the range of 10 µSv/a for members of the general public is to be demonstrated on a case-by-case basis as defined in § 37 StrlSchV. In such cases, the enveloping dose is determined on the basis of specific boundary conditions relating to the site of the intended use, recycling or disposal of the material.

According to § 34 StrlSchV, deliberate mixing or dilution of the materials in order to achieve clearance is not permitted.

Clearable materials

Residual material produced in the controlled areas of nuclear installations is considered to be contaminated or activated and must initially not leave the radiation protection areas. Once this residual material shows a sufficiently low activity (after decontamination, if necessary), it can be cleared. 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 under continued supervision under nuclear and radiation protection law is common practice. Examples of this are

- the 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
- reuse of equipment and components from nuclear power plants in other nuclear installations.

As the decommissioning of a nuclear installation progresses, the clearance of buildings and, finally, of the site also becomes relevant. Both of these have already been successfully implemented on a larger scale in Germany in various decommissioning projects (see Chapter D.5.6 for details).

Clearance options and clearance levels

§§ 35 and 36 StrlSchV specify various clearance options, drawing a distinction between unrestricted clearance (§ 35 StrlSchV) and all other clearance options (§ 36 StrlSchV), which are summarised under the generic term “specific clearance” in accordance with the nomenclature of Council Directive 2013/59/EURATOM. This expresses that specific provisions are made for these clearance options either with respect to the type of material to be cleared or the waste management or disposal path to be followed.

In the case of unrestricted clearance according to § 35 StrlSchV, the materials can be freely used after clearance from a radiological point of view. Here, there are not restrictions for quantities and types of solid substances. For liquids, the application of this clearance option is limited to oils, oil-bearing liquids, organic solvents and coolants since the specific activity of such liquids cannot be easily increased by concentration processes.

The options of specific clearance according to §36 StrlSchV are

- clearance of rubble of more than 1,000 Mg/a that after clearance may be used for any chosen purpose, e.g. for the backfilling of excavations, as road bedding, etc.,
- 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,
- 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, depending on applicable clearance levels,
- 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, depending on applicable clearance levels,
- clearance of buildings, rooms, sections of rooms and structural elements for reuse or further use (which also includes demolition),
- clearance of buildings, rooms, sections of rooms and structural elements for demolition, with any conventional use of the buildings etc. 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 4, Table 1 StrlSchV contains clearance levels that were adopted from the Radiation Protection Ordinance of 2001. Despite the new designation as specific clearance, the clearance options clearance of building rubble, clearance of soil areas and clearance of buildings, rooms, sections of rooms, and structural elements for reuse or further use do not technically differ from the identical options of the Radiation Protection Ordinance of 2001, which were still referred to as unrestricted clearance there. Table F-2 shows examples of these clearance levels for a selection of radionuclides that are important in the decommissioning of nuclear installations and facilities. The 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-2: Examples of clearance levels according to Appendix 4, Table 1 StrlSchV

Radionuclide	Exemption level [Bq]	Exemption level, unrestricted clearance of solid substances and liquids [Bq/g]	Surface contamination [Bq/cm²]	Specific clearance of: Building rubble of more than 1,000 Mg/a [Bq/g]	Specific clearance of: Soil areas [Bq/g]	Specific clearance of: Buildings for reuse or further use [Bq/cm²]	Specific clearance of: Buildings for demolition [Bq/cm²]	Half-lives [a]
1	2	3	5	6	7	12	13	15
H-3	$1 \cdot 10^9$	100	100	60	3	1,000	4,000	12.3
C-14	$1 \cdot 10^7$	1	100	10	0.04	1,000	6,000	$5.7 \cdot 10^3$
Cl-36	$1 \cdot 10^6$	1	100	0.3	-	30	30	$3.0 \cdot 10^5$
Fe-55	$1 \cdot 10^6$	1,000	100	200	6	1,000	$2 \cdot 10^4$	2.7
Co-60	$1 \cdot 10^5$	0.1	1	0.09	0.03	0.4	3	5.3
Ni-63	$1 \cdot 10^8$	100	100	300	3	1,000	$4 \cdot 10^4$	100.0
Sr-90+	$1 \cdot 10^4$	1	1	0.6	0.002	30	30	28.5
Ag-108m+	$1 \cdot 10^6$	0.1	1	0.1	0.007	0.5	4	418.0
Ag-110m+	$1 \cdot 10^6$	0.1	1	0.08	0.007	0.5	4	249.8
I-129	$1 \cdot 10^5$	0.01	1	0.06	-	8	8	$1.6 \cdot 10^7$
Cs-137+	$1 \cdot 10^4$	0.1	1	0.4	0.06	2	10	30.2
Eu-152	$1 \cdot 10^6$	0.1	1	0.2	0.07	0.8	6	13.5
Eu-154	$1 \cdot 10^6$	0.1	1	0.2	0.06	0.7	6	8.6
U-238+	$1 \cdot 10^4$	1	1	0.4	-	2	10	$4.5 \cdot 10^9$
Pu-238	$1 \cdot 10^4$	0.1	0.1	0.08	0.06	0.1	3	87.7
Pu-241	$1 \cdot 10^5$	10	10	2	4	10	90	14.3
Am-241	$1 \cdot 10^4$	0.1	0.1	0.05	0.06	0.1	3	432.8

Table F-2: (Continued) Examples of clearance levels according to Appendix 4, Table 1 StrlSchV

Radionuclides	Specific clearance of					Half-lives
	Solid substances up to 100 Mg/a to be disposed of in landfills [Bq/g]	Solid substances up to 100 Mg/a for removal in incinerators [Bq/g]	Solid substances up to 1,000 Mg/a to be disposed of in landfills [Bq/g]	Solid substances up to 1,000 Mg/a for removal in incinerators [Bq/g]	Scrap metal for recycling [Bq/g]	[a]
1	8	9	10	11	14	15
H-3	$6 \cdot 10^4$	$1 \cdot 10^6$	$6 \cdot 10^3$	$1 \cdot 10^6$	1,000	12.3
C-14	4,000	$1 \cdot 10^4$	400	$1 \cdot 10^4$	80	$5.7 \cdot 10^3$
Cl-36	3	3	0.3	0.3	10	$3.0 \cdot 10^5$
Fe-55	$1 \cdot 10^4$	$1 \cdot 10^4$	7,000	$1 \cdot 10^4$	$1 \cdot 10^4$	2.7
Co-60	6	7	2	2	0.6	5.3
Ni-63	$1 \cdot 10^4$	$6 \cdot 10^4$	1,000	6,000	$1 \cdot 10^4$	100.0
Sr-90+	6	40	0.6	4	9	28.5
Ag-108m+	9	10	1	1	0.8	418.0
Ag-110m+	6	6	2	0.6	0.5	249.8
I-129	0.6	0.6	0.06	0.06	0.4	$1.6 \cdot 10^7$
Cs-137+	10	10	8	3	0.6	30.2
Eu-152	10	10	4	4	0.5	13.5
Eu-154	10	10	4	4	0.5	8.6
U-238+	6	10	0.6	5	2	$4.5 \cdot 10^9$
Pu-238	1	1	1	1	0.3	87.7
Pu-241	100	100	40	100	10	14.3
Am-241	1	1	1	1	0.3	432.8

Once clearance is completed and the material has been released from nuclear regulatory control, they are subject to the provisions of the Closed Substance Cycle and Waste Management Act (KrWG) [1B-13].

Basis for clearance, current changes and transitional provisions

The clearance levels in Germany are based on comprehensive studies that have been initiated by the BMU as part of the implementation of Council Directive 96/29/EURATOM [1F-18], on recommendations of the Commission on Radiological Protection (SSK) and on publications of the European Commission. In 2011, the clearance levels for landfill disposal and incineration of waste have been modified due to changes in boundary conditions of waste management law [1A-8a].

Furthermore, it should be mentioned that with § 68 of the Radiation Protection Act (StrlSchG) [1A-34] the power to issue an ordinance governing clearance at a statutory level is given and that boundary conditions for the disposal of cleared material have been specified. This was implemented with §§ 31 to 42 StrlSchV. Table F-3 provides an overview of the new sections of the Radiation Protection Ordinance and a comparison with the contents of the previous regulations

Table F-3: List of sections related to clearance in current and previous version of the Radiation Protection Ordinance

§ in current StrlSchV [1A-8b]	Content of the regulation	§ in previous StrlSchV 2001 [1A-8a]
§ 31 Clearance of radioactive substances; dose criterion	Subject matter of clearance, dose criterion, origin of the substances, general requirements for clearance, special regulations for controlled areas which do not belong to a nuclear installation licensed under § 7 of the Atomic Energy Act (AtG).	§ 29(1)
§ 32 Application for clearance	Essential requirements for clearance and application for clearance, applicant, description of unrestricted and specific clearance, clearance in individual cases.	§ 29(1)
§ 33 Granting clearance	Granting of clearance if dose criterion 10 µSv/a is met, indications for the authority of compliance according to §§ 35 and 36, administrative clearance act in written form, conditions precedent, reservation of withdrawal, restrictions and conditions.	§ 29(1) and (2)
§ 34 Mixing ban	Ban on mixing or dilution to bring about fulfilment of the clearance requirements.	§ 29(2), sentence 4
§ 35 Unrestricted clearance	Definition of unrestricted clearance, need for surface contamination measurements.	§ 29(2) § 29(2) sentence 2, No. 1(a)
§ 36 Specific clearance	Definition of specific clearance and each clearance option.	§ 29(2)
§ 37 Clearance in individual cases App. 8, Part A; No. 2	Requirements for proof of compliance in individual cases, possibilities extended compared to previous regulation.	§ 29(2) sentence 3 App. IV, Part A, No. 2
§ 38 Clearance ex officio	Clearance ex officio.	§ 29(7)
§ 39 Agreement regarding the specific clearance for disposal	Regulations on reaching agreement between nuclear and waste management authorities, periods, agreement declared reached of failed.	§ 29(2), sentences 6 and 7
§ 40 Utilisation or disposal route according to waste legislation	Specifications for the utilisation or disposal route under waste law (esp. clearance for disposal in a landfill or incinerator).	§ 29(5)
§ 41 Definition of the procedure	Summary of various regulations on the clearance procedure.	§ 29(4) and (6)
§ 42 Duties of the holder of a clearance	Requirements for the radiation protection executive, who is the holder of the clearance, documentation of the results of the clearance measurements, requirements for the radiation protection supervisor, procedure in case that a requirement on which granting of the clearance depends is no longer fulfilled.	§ 29(3)

§ 187 StrlSchV contains detailed provisions on the transition from the previous regulations to those in force since the beginning of 2019. These stipulate that after the amended Radiation Protection Ordinance has come into force, the previous users of clearance regulations have two years to carry out the extensive adaptation measures in clearance procedures until the new clearance levels automatically take the place of the previous levels. Analogous regulations apply for clearance according to § 33 in conjunction with § 35 StrlSchV granted between 1 January 2019 and 31 December 2020, i.e. for procedures that were started under the previous regulations. There are no changes for proof of compliance in individual cases and for all release options which are now referred to as “specific clearance”.

F.4.7 Measures to control releases and mitigate their effects

Basis

In the case of significant radiological events, 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 as well as to the authorities responsible for disaster control. Corresponding reporting and information obligations are regulated in §§ 105 to 113 of the Radiation Protection Ordinance (StrlSchV) [1A-8b]. This applies, in particular, to the provision of the necessary personnel and the necessary resources to minimise and eliminate hazards, the requisite technical qualification and, in the event of emergencies, the immediate taking of all appropriate measures to avert danger to man and the environment.

In radiological emergency situations, the competent authorities will notify the potentially affected population without delay and issue protective action instructions in such situations. The reporting on Article 25 in Chapter F.5 gives an overview of the emergency measures to be taken in relation to the hazard potential of the nuclear installation or facility.

The procedure at the facility in the event of an unplanned and uncontrolled release of radioactive substances into the environment must be specified in an operating manual (see reporting on Article 9 in Chapter G.6). The latter must include fire safety regulations and an alarm code. In this context, safety standard KTA 1201 is to be applied mutatis mutandis (see Safety standards of the Nuclear Safety Standards Commission (KTA) in Annex L-(d)). The fire safety regulations must specify measures of preventive and defensive fire protection. The alarm code has to outline measures and protective action instructions 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 has to outline the measures initiated automatically and those which must be initiated manually by the staff on shift in case of an accident. It also has to specify the criteria under which it is to be assumed that important safety functions are not performed by the systems as designed and on-site emergency measures have to be taken.

Integrated Measuring and Information System

Besides the monitoring of emissions and immissions at the site of a nuclear installation or facility, there is also the Integrated Measuring and Information System for Monitoring Environmental Radioactivity (IMIS) according to § 163 of the Radiation Protection Act (StrlSchG) [1A-34], 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 §§ 161 and 162 StrlSchG 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 conduct comparative measurements and analyses uniformly throughout the country and develop sampling, analysis, and measurement techniques. The German National Metrology Institute (PTB) provides radioactivity standards for reference measurements.

The IMIS comprises an automatic measurement network consisting of more than 1,800 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, feed, 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 at the BfS in Neuherberg. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) evaluates the data. In the event of an accident or emergency with radiological consequences for the German territory, the BMU will initiate the activation of intensive operation of the monitoring system according to the AVV-IMIS and alerts 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 Emergency plans for nuclear installations and facilities

General and specific emergency plans of the Federation and the *Länder* and off-site emergency plans of the *Länder*

In order to implement Council Directive 2013/59/EURATOM [1F-24], radiation protection law was reorganised and modernised in 2017. The Radiation Protection Act (StrlSchG) [1A-34], which was newly enacted in the course of this process, conceptually adapts the legal and administrative framework for the prevention and management of nuclear accidents and other radiological emergencies to the experiences after the Fukushima reactor accident.

Part 3 of the Radiation Protection Act contains regulations with regard to emergency exposure situations and forms the basis for the emergency management system of the Federation and the *Länder*. As a central innovation, the Radiation Protection Act requires in §§ 97 to 101 coordinated emergency plans of the Federation and the *Länder*:

- the general emergency plan of the Federation (§ 98 StrlSchG),
- the specific emergency plans of the Federation (§ 99 StrlSchG), and
- the general and specific emergency plans of the *Länder* (§ 100 StrlSchG).

In addition, special protection plans continue to exist for nuclear power plants or other plants with special hazard potential, the so-called **off-site** emergency plans of the competent *Land* authorities (§ 101 StrlSchG). These plant-specific **off-site** emergency plans supplement and concretise the planning contained in the **general** and **specific** emergency plans of the Federation and the *Länder*. In particular, they also take into account the local conditions as well as the procedures and arrangements of the radiation protection executive for on-site emergency preparedness (see Figure F-3).

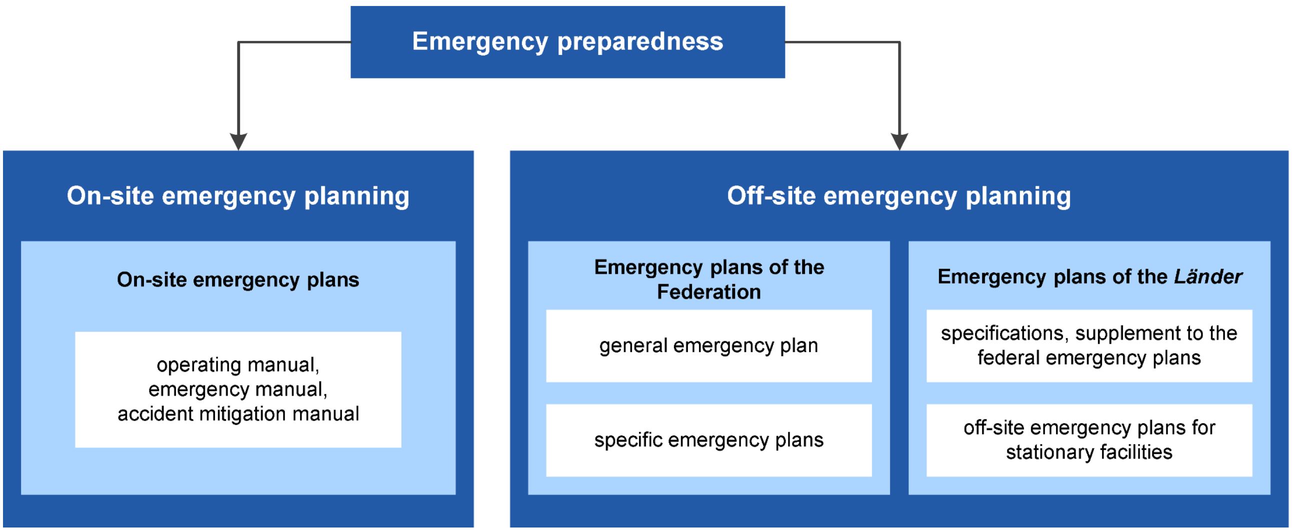
The objective of the emergency plans is to enable the organisations involved in emergency response to take coordinated decisions immediately in the event of an emergency and implement appropriate measures in due time. To this end, the emergency plans should in particular define responsibilities and tasks of the authorities in the emergency management system of the Federation and the *Länder* and contain optimised protection strategies. As a common planning basis, the general emergency plan of the Federation will also provide various reference scenarios. These reference scenarios will not only cover severe nuclear power plant accidents in Germany or abroad, but also emergencies at other nuclear installations or facilities, transport accidents or the crash of a satellite with a radioactive source. The differentiation of the protection strategies for individual reference scenarios or groups of reference scenarios is made to the extent that this proves expedient in the preparation of the plans. This can be dependent on the subject area.

The emergency management system of the Federation and the *Länder* is based on the so-called interlinking approach anchored in the Radiation Protection Act. The interlinking approach provides that authorities and organisations that perform hazard prevention tasks in a specific area of life or economy generally retain their responsibilities also in the event of radiological emergencies. In this way, established and proven structures of other subject areas which cope with other crisis situations and to avert danger to human health and the environment can be used also in the event of radiological emergencies. The interlinking approach also applies to the planning phase. For this reason, the specific emergency plans of the Federation, which specify the emergency response or protection strategies for individual subject areas, are prepared under the leadership of the federal ministries responsible for these subject areas.

The **general** and **specific** emergency plans of the *Länder* specify and supplement the emergency plans of the Federation, particularly with regard to *Land* specific implementation and responsibilities. The authorities responsible for disaster control according to the respective *Land* law draw up the emergency plans for the surroundings of nuclear power plants and stationary nuclear installations or facilities pursuant to § 101 StrlSchG in accordance with their regulations under *Land* law. In doing so, they also take into account, in particular, the local conditions as well as the procedures and arrangements of the radiation protection executive for on-site emergency preparedness.

Within the framework of **on-site** emergency preparedness, the operator takes technical and organisational measures to control a possible event or to mitigate its effects. The measures, procedures and responsibilities for emergencies are laid down by the operator in emergency manuals.

Figure F-3: Structure of emergency preparedness



In the case of a regional emergency or a supra-regional emergency, only one radiological situation report (RLB) is relevant for the assessment of the radiological situation and binding for all authorities of the Federation and the *Länder* (§ 109(2) StrlSchG). For supra-regional emergencies, this will be prepared by the Federal Radiological Situation Centre (RLZ) in accordance with § 106 StrlSchG, for regional emergencies generally by the respective *Land* (§ 108 StrlSchG). The RLZ is established by the BMU as a network of BMU, BfS, BASE, GRS and the Federal Office for Civil Protection and Disaster Assistance (BBK) in accordance with § 106 StrlSchG. In addition, the RLZ is supported by various other authorities and organisations in the performance of its tasks. Other tasks of the RLZ include inter-ministerial, national and international coordination of protective measures (within the scope of its technical competence) as well as information of the public including behavioural recommendations on how to reduce or avoid exposure. Until adoption of the emergency plans of the Federation in accordance with §§ 93 to 95 StrlSchG, the documents specified in § 97(5) in conjunction with Annex 4 StrlSchG function as provisional federal emergency plans. The specifications and representations in plans, concepts and decrees of the *Länder* that serve the purpose of disaster control are also function as provisional general and specific emergency plans of the *Länder*.

Regulatory basis

According to the protective provisions of the Atomic Energy Act (AtG) [1A-3] and § 82(1)(3) StrlSchG in conjunction with § 107 of the Radiation Protection Ordinance (StrlSchV) [1A-8b], the radiation protection executive shall ensure that in the event of an emergency or incident, all measures necessary to mitigate the consequences of the emergency or incident.

According to § 12(5) AtG in conjunction with §§ 6 to 10 AtSMV and according to § 82 StrlSchG in conjunction with § 108(1) StrlSchV, the radiation protection executive of any nuclear installation or facility is required to notify the competent nuclear supervisory authority without delay of the occurrence of an emergency, incident or other major event and, if necessary, also to inform the authority responsible for public safety and the authority responsible for disaster control in the respective *Land*. The radiation protection executive shall make a recommendation to the disaster control authority as to which alarm level to trigger, the pre-alarm or the disaster alarm. In addition, he shall also report the occurrence of a major event that may lead or has led to an emergency in one or more regions to the Federal Radiological Situation Centre without delay in accordance with § 106 StrlSchG. The criteria which when reached require alerting the disaster control authorities are based on a joint recommendation of the Reactor Safety Commission (RSK) and the Commission on Radiological Protection (SSK) on “Criteria for Alerting the Disaster Control Authority by the Operators of Nuclear Facilities” [SSK 13], which was last amended in February 2013. According to § 97(5) in conjunction with Annex 4, No. 2 StrlSchG, this recommendation is one of the provisional emergency plans of the Federation. According to § 106(3) StrlSchV, no special emergency preparedness measures are required for a nuclear installation if the radioactive substances handled there do not exceed certain activities. The threshold values are:

1. 10^7 times the exemption levels for activity according to Annex 4, 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 nuclear installations and facilities for radioactive waste management do generally not require emergency planning. This usually concerns the handling of radioactive material subject to licensing under § 12 StrlSchG.

Extensive measures of off-site emergency planning, e.g. preparation of an off-site emergency plan, can be dispensed with if, for design basis accidents and for events with low probability of occurrence, the calculated effective doses in the vicinity of the facility are clearly below the limits of radiation exposure after incidents according to § 104 StrlSchV. The decision is made by the competent licensing and supervisory authorities of the nuclear installation in the *Land* concerned.

Within the Federal Government, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) is responsible for the provision of general criteria for the preparation of emergency plans for the vicinities of nuclear installations.

For the assessment of the necessity of disaster control measures in the event of accidents in nuclear installations and facilities in Germany and abroad, the BMU's catalogue of measures "measures to reduce radiation exposure following events with radiological effects that are not insignificant" [4-6] is valid as one of the provisional emergency plans of the Federation.

In conformity with Council Directive 2013/59/EURATOM [1F-24], § 112 StrlSchG regulates the obligation of the competent authorities to inform the population potentially affected in an emergency. In an emergency, the information of the potentially affected population, including appropriate protective action recommendations, is immediately provided by the disaster control authorities within their area of competence and, in addition, by the BMU. In the event of local emergencies, this is done by the authorities competent according to *Land* law.

For emergency exposure situations, § 93 StrlSchG stipulates a reference level of the emergency-related residual effective dose of the population of 100 mSv in one year. For the protection of emergency workers, § 114 StrlSchG specifies a staggered reference level system (see Table F-1).

In addition, the Emergency Dose Value Ordinance (NDWV) [1B-20] (see Table F-4) specifies radiological criteria for the adequacy of the protective measures sheltering, ITB and evacuation. Each of these criteria refers to a dose that affected individuals would receive without protective measures within a period of seven days after occurrence of the emergency.

Table F-4: Radiological criteria for the protective measures sheltering, ITB and evacuation from the Emergency Dose Value Ordinance (NDWV)

Measure	Radiological criterion		
	Organ dose (thyroid gland)	Effective Dose	Organ dose (thyroid gland)
Sheltering		**10 mSv**	External exposure within seven days and committed effective dose by radionuclides inhaled during this period, assuming staying outdoors
Intake of iodine tablets (ITB)	**50 mSv** Children and adolescents under 18 years of age as well as pregnant women **250 mSv** Individuals 18 to 45 years of age		Committed equivalent dose from radio-iodine inhaled over a period of seven days, assuming staying outdoors
Evacuation		**100 mSv**	External exposure within seven days and committed effective dose by radionuclides inhaled during this period, assuming staying outdoors

For immediate decision-making, measurable parameters, the operational intervention levels (OILs) are assigned to the measures and dose levels listed in Table F-3. In its recommendation "Operational intervention levels for measures to protect the population against incidents involving releases of radionuclides" [4-33], the SSK has developed detailed OILs for different reference scenarios. The recommendation justifies and explains the OILs assigned to the individual measures and exposure pathways and makes specifications for their metrological determination. It is part of the provisional emergency plans of the Federation.

According to § 94(2) StrlSchG, the BMU shall furthermore be authorised, with the consent of the *Bundesrat*, to specify area-related limits for contamination or dose rates caused by an emergency as criteria for the existence of a hazard due to ionising radiation before, during or after an emergency. This applies to the following areas:

1. members of the general public,
2. drinking water,
3. foodstuffs, animal feed, consumer goods, cosmetics and products within the meaning of § 2, No. 1 of the Tobacco Products Act,
4. pharmaceuticals and their starting materials and for medicinal products,
5. other products, articles and substances,
6. vehicles, goods or luggage, and
7. contaminated areas, in particular contaminated premises and waters.

In addition, § 95(1) StrlSchG authorises the Federal Government to define, by statutory ordinance with the consent of the *Bundesrat*, contamination levels for waste that is or may be contaminated in an emergency below which it can be assumed that safe management of this waste is possible without special protective measures (safety thresholds). Furthermore, § 95(2) StrlSchG authorises BMU to stipulate specific protective measures and exemptions for the management of such waste whose contamination level exceeds these safety thresholds via statutory ordinance.

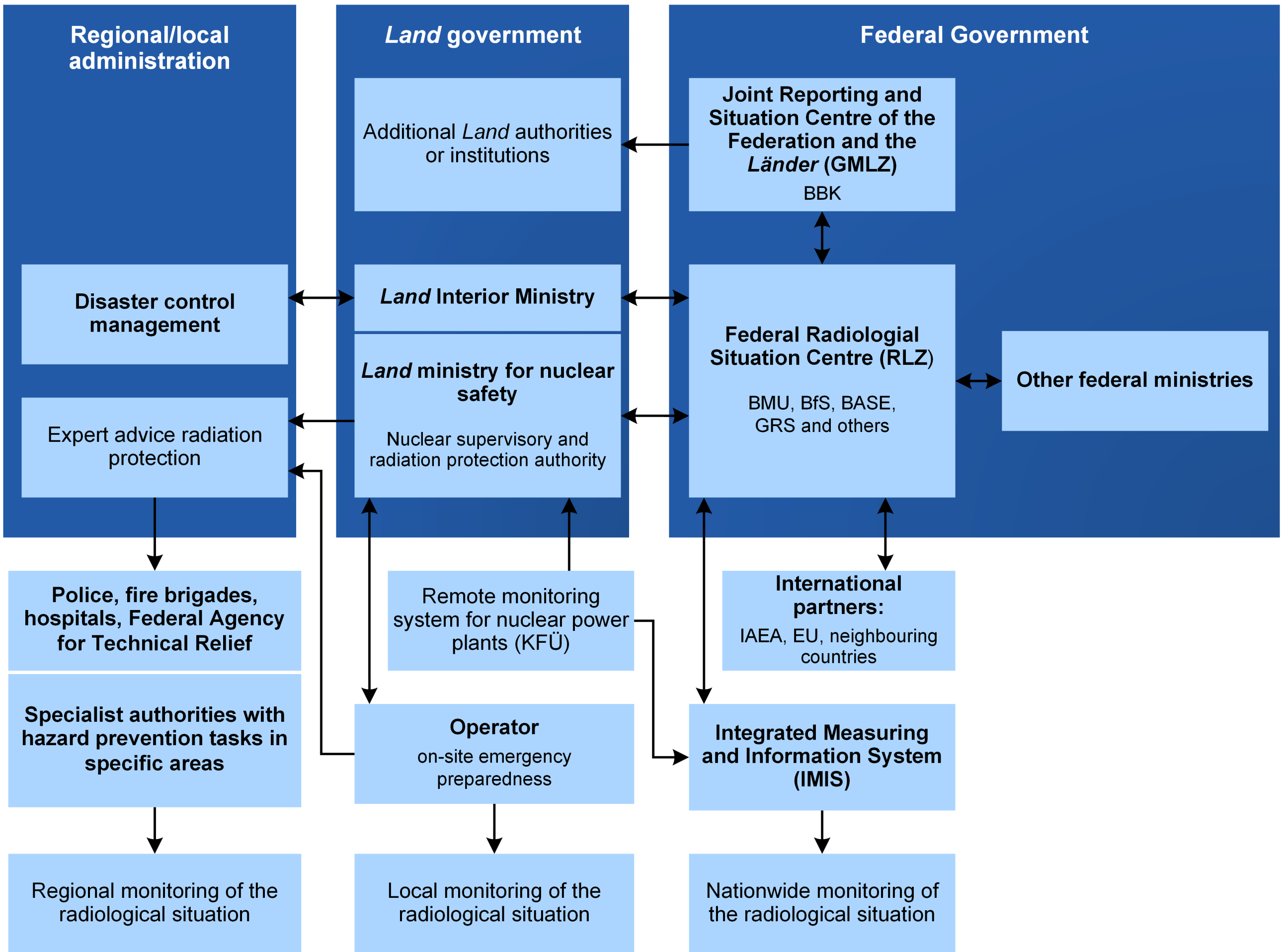
The radiological criteria which, according to §§ 93 to 95 StrlSchG, may be specified in advance or after the occurrence of an emergency by statutory ordinance with the consent of the *Bundesrat*, may be specified or modified in an emergency by emergency regulations in accordance with § 96 StrlSchG.

The disaster control measures to be initiated in case of possible emergencies are e.g. presented in the general guidelines for disaster control in the vicinity of nuclear installations [3-253] of the SSK, which is also part of the provisional emergency plans of the Federation.

Organisation

Emergency preparedness is organised in cooperation between the Federal Government and the governments of the *Länder*, regional authorities, the police, the Federal Agency for Technical Relief, fire brigades, hospitals, and the operator of the nuclear installation or facility. The disaster control measures are coordinated and performed by the *Land* authorities, the regional authorities, 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



Tasks of the Federation and the *Länder*

According to § 106 StrlSchG, the BMU operates the Federal Radiological Situation Centre (RLZ). The RLZ is a network of the BMU, the BfS and the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH and is distributed over several locations. Especially for supra-regional emergencies, the task of the RLZ is to establish the basis for nationwide harmonised emergency response. For this purpose, the RLZ prepares the radiological situation report (RLB) in the event of a supra-regional radiological emergency or, after prior consultation with the respective *Land*, in the event of a regional radiological emergency. The RLB serves to present and assess the radiological situation, in particular with regard to the adequacy of protective measures. It is the relevant presentation of the radiological situation for all competent authorities of the Federation and the *Länder* and shows which of the radiological criteria for protective measures laid down in the Emergency Dose Value Ordinance in force since 31 December 2019 and the emergency plans of the Federation are fulfilled. In the event of a regional emergency, the RLB is usually prepared by the competent *Land* authority. In the event of a local emergency, no RLB is prepared and the local authorities themselves are responsible for determining and assessing the radiological situation. Furthermore, within the emergency management system of the Federation and the *Länder* in the event of supra-regional or regional emergencies the RLZ is responsible, among other things, for the national and international exchange of information and the coordination of protective measures, measures to inform the population, assistance and measurements provided by the Federation and the *Länder* and other organisations involved in managing the emergency.

By means of the Integrated Measurement and Information System (IMIS), the Federation monitors and assesses the radiological situation in Germany both during routine operation and under incident and accident conditions (see reporting on Article 24 in Chapter F.4). IMIS also makes use, among other things, of the decision support and forecasting program RODOS (Realtime Online Decision Support System), which, in the event of a radiological emergency, calculates the future environmental contamination and the doses to be expected for the people affected, based on data from the German Meteorological Service and the nuclear power plant sites. Where necessary, the data are transmitted to the federal and *Land* authorities competent for emergency preparedness and the measuring and data transmission frequency of the IMIS will be increased.

In the event of a radioactive release abroad with possible or significant effects in Germany, the *Länder* are alerted by the RLZ (via the Joint Reporting and Situation Centre of the Federation and the *Länder* GMLZ), which is informed about the occurrence of an event on the basis of bilateral and international agreements. Within the framework of some bilateral agreements with neighbouring states, the bordering countries are also directly alerted. In case of increased measured values of environmental radioactivity, the *Länder* are also alerted by IMIS.

It is the task of the competent *Land* authority to specify the nature and scope of emergency preparedness and response, taking into account the specific requirements of the respective nuclear installation or facility. The criteria for the nature and scope of emergency planning are determined in particular by the radioactive inventory and the occurrence probability of an incident or accident.

The individual *Länder* designate the authority responsible for disaster control. For nuclear facilities with a special hazard potential, these authorities prepare off-site emergency plans in accordance with § 101 StrlSchG and the provisions of disaster control law of the particular *Land*. These plans specify all measures that are to be taken by the disaster control authority in the event of accidents or incidents at the respective facility, in particular also taking into account the procedures and arrangements of on-site emergency preparedness.

The competent authority for disaster control of a nuclear installation 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 advises the disaster response management regarding 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 to be applied mutatis mutandis in accordance with the specific requirements of a particular nuclear installation.

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 cooperation among the different *Land* 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.

Taking into account the safety report of the facility, 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 the preparation of an **off-site** emergency plan according to § 101 StrlSchG is not necessary. In this case, potential accidents are covered by the measures of general disaster control, which have to be planned regardless of the hazard potential of specific facilities. Reasons must be given by the authorities for not having to prepare an **off-site** emergency plan. If an off-site nuclear emergency plan is drawn up for a nuclear installation, it 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 installations and facilities in order to verify the efficiency of the emergency plans and to identify weak points (see Figure F-5). The operators take part in these exercises. According to § 106 StrlSchV, the radiation protection executive has to inform the population about the emergency plans periodically every five years.

For the planning of the protective measures of disaster control, the facility surroundings are divided into three zones [3-253]:

- Central zone (up to 5 km), in which, in particular, the measures sheltering, ITB and evacuation are to be prepared for the protection of the population. The evacuation of the entire population of the central zone and the distribution of iodine tablets to these persons should be completed within 6 hours after the alert of the competent authorities.
- Intermediate zone (up to 20 km), in which, in particular, the measures sheltering, ITB and evacuation are to be prepared. The evacuation of the intermediate zone should be possible within 12 hours. Within this period it should also be possible to complete the distribution of iodine tablets to the persons for whom thyroid blocking is to be conducted.
- Outer zone (up to 100 km), in which measures for the determination and monitoring of the radiological situation are prepared. In addition to the measurement programs, in particular the measures sheltering as well as the distribution of iodine tablets to the persons for whom thyroid blocking is to be conducted are to be prepared.

In the entire territory of Germany, measures are to be taken in particular to carry out measuring programmes to determine the radiological situation and to prepare supply of iodine tablets to children and adolescents under 18 as well as pregnant women.

For decommissioned nuclear power plants, the Commission on Radiological Protection recommends to maintain these planning areas until all nuclear fuel has been removed.

The *Länder* are responsible for the distribution of iodine tablets for thyroid blocking. Depending on the planning of the respective *Land*, these are stored decentralised and distributed to the population in an emergency or are pre-distributed.

Figure F-5: GNS fire brigade during a fire drill at the Gorleben site (Copyright: GNS)

On-site emergency preparedness 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, alerting criteria and criteria for taking on-site measures, the information flow to the crisis team and to the disaster control authority, and special stipulations for the emergency staff of the facility.

Furthermore, according to § 106 StrlSchV, the radiation protection executive must ensure that trained personnel and any resources which may be required are available for controlling emergency situations and must provide the authorities responsible for emergency preparedness with the information necessary to deal with an accident. He shall support the competent authorities in the planning of emergency measures as well as inform them about possible risks when deploying helpers and about necessary protective measures.

As defined in § 54 StrlSchV, the operator coordinates the necessary measures in advance specifically for the case of fire fighting in cooperation with the competent *Land* authorities, the fire brigade or the mine rescue brigade (in the case of disposal facilities). In this context, it is of particular importance to clarify which special equipment is required for fighting fires in the individual areas of the facility.

Requirements for the planning of on-site emergency preparedness include the requirements in a beyond design basis situation due to, among others, possibly changed boundary conditions at the facility, e.g. the necessity to perform emergency measures, improvised system operating modes, high dose rates with closures and inaccessibility of buildings, etc. They are laid down, among others, in the "General Guidelines for Emergency Planning by Nuclear Power Plant Operators" in the revised version of 2014 [3-350]. These take into account the experience gained from the accident in Fukushima and the state of the art in science and technology.

Implementation for the individual facilities

The central spent fuel storage facilities at Ahaus and Gorleben, the Storage Facility North and the storage facility at Jülich are not subject to any special nuclear emergency planning, despite the fact that their radioactivity inventories exceed the limits given in § 106 StrlSchV. However, on-site emergency plans exist for all central spent fuel 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 § 104 StrlSchV. Disaster control falls under the general disaster control planning of the *Land* authorities.

In principle, the same applies to the decentralised spent fuel storage facilities at the nuclear power plant sites as to the central spent fuel storage facilities. However, these facilities are already covered by the comprehensive emergency planning of the nuclear power plants during their operation and up to three years after their decommissioning or until all spent fuel has been removed.

The pilot conditioning plant (PKA) at Gorleben will not require special measures of off-site emergency planning 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 were analysed. They do not lead to any consequences requiring special emergency planning.

No specific emergency plans are needed for the Morsleben repository for radioactive waste (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). The competent supervisory authority is the Federal Office for the Safety of Nuclear Waste Management (BASE). The BASE performs the corresponding tasks for the Asse II mine as specified in § 184 StrlSchG.

Measures to establish emergency preparedness have been and are being implemented successively. These include increasing the capacity of discharging inflowing solution to the surface to up to 500 m³ per day as well as the contractual assurance of a disposal option. Above ground and underground, emergency storage facilities were 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 saline solutions above the level of the emplacement rooms, backfilling of cavities, and the construction of seal structures at the floor level below the emplacement rooms. As part of emergency preparedness, numerous residual cavities at the 775 m level below the emplacement rooms as well as several blind shafts were already backfilled with Sorel concrete. It is also planned to dismantle and backfill cavities in the mine no longer needed (galleries and infrastructure rooms) and to seal cavities and access roads in the vicinity of the emplacement rooms. The measures will lower the progressive damage to the rock. In addition, the possible release of radionuclides in case of 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.

Emergency measures to be taken, when the mine has to be left, are prepared. This includes, among others, the backfilling of residual cavities in the emplacement chambers in case of emergency. Also the so-called counter-flooding, i.e. filling the mine with a saturated magnesium chloride solution, and the sealing of shafts with Sorel concrete are among the measures that need to be taken in case of emergency.

F.5.2 Emergency plans for the case of incidents in nuclear installations and facilities of neighbouring states

In accordance with § 97 of the Radiation Protection Act (StrlSchG) [1A-34], the authorities responsible for drawing up emergency plans shall endeavour to coordinate their emergency plans with other member states of the European Union and the European Atomic Energy Community and with third countries, such as Switzerland, within the scope of their competences.

The general guidelines for disaster control in the vicinity of nuclear installations [3-253] (one of the provisional emergency plans pursuant to § 97 in conjunction with Annex 4 StrlSchG) also apply to foreign nuclear installations and facilities requiring planning measures on German territory due to their proximity to national borders. Permissible discharges during normal specified operation and in case of incidents within design basis conditions are a matter at discretion of the respective country's own legislation. In Germany, international regulations were taken into account from the outset when defining the limits in the Radiation Protection Ordinance (StrlSchV) [1A-8b].

The provisions for the occurrence of accidents in waste management facilities in neighbouring countries correspond to those applicable to other nuclear installations, such as nuclear power plants. The catalogue of measures [4-6] (one of the provisional emergency plans pursuant to § 97 in conjunction with Annex 4 StrlSchG) is used as an aid for determining the necessary measures according to the Radiation Protection Act and corresponding ordinances, which includes the necessary instructions for impact assessment and planning of measures to be taken.

On the basis of bilateral agreements, the authorities of neighbouring countries are involved in exercises in facilities near the border as observers or participants. The RLZ regularly participates, where required together with individual *Länder*, in exercises of the European Union (EU), the International Atomic Energy Agency (IAEA) and the OECD/NEA (the International Nuclear Emergency Exercises (INEX)).

Since the early 1980s, the Federal Republic of Germany has entered into bilateral agreements with all neighbouring states and also with countries further away on mutual assistance in the event of disasters or major accidents ([1D-1], [1D-2], [1D-3], [1D-4], [1D-5], [1D-8], [1D-9]). These agreements define responsibilities and points of contact, guarantee cross-border traffic of personnel and resources deployed, stipulate mutual exclusion of liability for personal injury or damage to property, and cover a comprehensive exchange of information and experience. In the years following German reunification, agreements were also signed with Poland [1D-10], Hungary [1D-6], Lithuania [1D-7], Russia [1D-11] and the Czech Republic [1D-12].

In addition, there are variable forms of non-legally binding bilateral agreements on the exchange of data and information with various neighbouring states.

In 2013, the Federal Republic of Germany joined the Response and Assistance Network (RANET) of the IAEA. In the event of a nuclear or radiological event, RANET offers the possibility to quickly access existing assistance capacities in other countries. German support services include, in particular, assistance in patient treatment in case of a radiation accident, dose determination and dose estimation, dispersion calculations, determination of radiological situations, and the provision of measuring capacities and specialist knowledge. 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 before 1985 [BMU 19]. There is also the superordinate European legal regime governing radiological emergencies.

F.6 Article 26: 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 installations are dealt with below in the overall context. The term "decommissioning" is used here within the meaning 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 supervision under nuclear and radiation protection law). This corresponds to the technical and international usage. As understood in Germany, a nuclear installation will only be “under decommissioning” if a decommissioning licence has been granted.

Legal basis

In Germany, the legal basis for licensing procedures for the decommissioning of nuclear installations are the Atomic Energy Act (AtG) [1A-3] as well as the associated statutory ordinances and general administrative provisions. § 7(3) AtG contains the basic requirement for the licensing of decommissioning. Accordingly, the decommissioning of a facility licensed pursuant to § 7(1) AtG or dismantling of that facility or of parts thereof shall be subject to licensing. Here too, consideration of the state of the art in science and technology is retained as a guiding principle. Safe enclosure is no longer a decommissioning option for nuclear power plants in accordance with the amendments to the Atomic Energy Act resulting from the Act on the Reorganisation of Responsibility in Nuclear Waste Management.

The licensing procedure for the decommissioning of nuclear installations is governed by the Ordinance Relating to the Procedure for the Licensing of Facilities (AtVfV) [1A-10]. It contains regulations pertaining to decommissioning, particularly with regard to third party involvement and the environmental impact assessment (EIA).

The legislator placed the granting of a licence according to § 7(1) and (3) AtG under the reservation of § 7(2) AtG (“A licence may only be granted if” the requirements stated in § 7(2) AtG are 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 installation by the legislator. Other licences regulated by the Atomic Energy Act (e.g. § 6 AtG) and the Radiation Protection Act (StrlSchG) [1A-34] (§ 12) are, however, not subject to such a reservation (“A licence shall be granted provided that” the licensing requirements are fulfilled).

Apart from the Atomic Energy Act, the Radiation Protection Act and the Radiation Protection Ordinance (StrlSchV) [1A-8b] are also relevant for dismantling since the technical and operational measures, procedures and precautions to prevent damage caused by ionising radiation are largely determined by them. These include the definition of the principles of radiation protection, the regulations on transport and transboundary movement of radioactive material, on clearance, on the qualification of the staff, on on-site organisation of radiation protection, on the protection of individuals in radiation protection areas, including the limitations of radiation exposure and preventive occupational medical care, on physical radiation protection, on the protection of the general public and the environment, on the protection against significant safety-related events, as well as on radioactive waste.

The licensed measures for decommissioning of nuclear installations are monitored by supervisory controls.

Hazard potential of nuclear installations during the decommissioning phase

The decommissioning phase of a nuclear installation is characterised by a gradual decrease in the radionuclide inventory of the installation, mainly by means of removal of the spent fuel and by decontamination and removal of contaminated and activated parts of the installation 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 installation is cold and depressurised and since the major part of the residual radionuclides is bound in metal and concrete structures by activation. This is associated with a continuous decrease in the hazard potential as dismantling progresses. This fact is considered, among others, by specific decommissioning regulations 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 which is adapted to the decreasing hazard potential.

Measures to ensure safety during decommissioning of nuclear installations

The reporting on

- Article 18 (Implementing measures) (see Chapter E.1),
- Article 19 (Legislative and regulatory framework) (see Chapter E.2),
- Article 20 (Regulatory body) (see Chapter E.3),
- Article 21 (Responsibility of the licence holder) (see Chapter F.1),
- Article 22 (Human and financial resources) (see Chapter F.2),
- Article 23 (Quality assurance) (see Chapter F.3),
- Article 24 (Operational radiation protection) (see Chapter F.4) and
- Article 25 (Emergency preparedness) (see Chapter F.5)

also applies mutatis mutandis to the decommissioning of nuclear installations. The presentations on the above-mentioned articles in this report relate in whole or in part also to the decommissioning of nuclear installations. In principle, the same general safety requirements apply during decommissioning of a nuclear installation as during its operational phase, while in details there are some significant differences. For example, the possibility of criticality no longer exists for nuclear reactors once all spent fuel has been removed, and the amounts of activity discharged with waste water and exhaust air generally decrease. The requirements as regards safety during decommissioning and their implementation are addressed in the reporting on Article 4.

In view of the fact that during the decommissioning of a nuclear installation it may become necessary to construct new facilities for the management of radioactive waste, Article 15 (Assessment of safety of facilities, see Chapter H.5) of the Joint Convention is also relevant. The requirements of Article 15 on the assessment of the safety of facilities and their environmental impact prior to construction and commissioning likewise also apply to radioactive waste management facilities which are constructed when decommissioning nuclear installations (see reporting on Article 15 in Chapter H.5). Accordingly, the requirements of Article 16 of the Joint Convention on the operation of radioactive waste management facilities also apply to the decommissioning phase by analogy (see the reporting on Article 16 in Chapter H.6).

As a consensus between the Federation and the supervisory authorities of the *Länder* on the most effective and harmonised approach to decommissioning procedures, on 23 June 2016, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) published an amended 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 (Decommissioning Guide) [3-73] for consideration in nuclear licensing and supervisory procedures. The aim of the Decommissioning Guide is

- to summarise the aspects relevant for licensing and supervision,
- to achieve a common understanding between the Federation and the *Länder* to ensure that decommissioning procedures are carried out appropriately, and
- to harmonise the existing views and procedures.

In particular, the Decommissioning Guide includes proposals for an appropriate procedure for decommissioning as well as the safe enclosure and the dismantling of nuclear installations as defined in § 7 AtG in respect of the application of the non-mandatory guidance instruments, for the planning and preparation of decommissioning measures as well as for licensing and supervision.

It identifies the decommissioning-related provisions in the different documents of the legal framework and non-mandatory guidance instruments and describes their application. It also includes proposals for an appropriate procedure for the decommissioning of nuclear installations and serves to harmonise the licensing procedures. For example, it is made clear that in connection with the decommissioning of nuclear installations, 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 Guide thereby promotes the harmonisation of decommissioning procedures.

As a technically oriented supplement to the Decommissioning Guide, on 16 March 2015, the Nuclear Waste Management Commission (ESK) adopted the “Guidelines for the decommissioning of nuclear facilities” [4-4]. In these Guidelines, the ESK summarises those technical requirements and processes which it considers necessary to be observed by the operators of nuclear installations 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 installation as they are highly relevant for the later decommissioning. The Guidelines for decommissioning are not legally binding for any third parties. They rather 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 decommissioning of nuclear installations.

F.6.2 Availability of qualified staff and adequate financial resources

The experience gained from various decommissioning projects of nuclear installations in Germany has shown that the operating staff’s knowledge of the installation is very valuable for the safe and efficient execution of decommissioning. For this reason, the operators involve the operating staff also in the decommissioning phase.

The manner in which the availability of financial resources is secured for the decommissioning phase of a nuclear installation differs between publicly-owned installations and installations belonging to the private electric power utilities:

- The decommissioning of publicly-owned installations is financed from the current budget. For most projects (see Table F-5), 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 installations belonging to the privately-owned electric power utilities are provided in the form of provisions built up during the operational phase, based on an accumulation period of 25 years. The formation of provision according to commercial law is based on the waste management obligation under public law, which is derived from the Atomic Energy Act (AtG) [1A-3]. The existence of provisions for decommissioning shall guarantee that financial resources will be available for decommissioning of the nuclear power plants after final cessation of electricity generation when there are no more revenues from electricity charges. By the expensed formation of provisions 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. The electric power utilities transferred the funds for storage and disposal, which follow the waste management steps of decommissioning of the nuclear power plants and the qualified packaging of the spent fuel and the radioactive waste, to a public-law fund by 1 July 2017, the deadline for payment laid down by law, in accordance with their payment obligations pursuant to the Waste Management Fund Act (EntsorgFondsG) [1A-36] (see Chapter E.2.2 and Chapter F.2.3).
- Decommissioning is carried out by the electric power utilities on their own responsibility under the supervision of the competent authorities. The extent of the provisions covers all costs related to the dismantling of the power plant. These are the costs of the so-called post-operational phase during which the power plant is transferred into a state in which it can be dismantled after final cessation of power operation, the costs for licensing and supervisory procedures, as well as the costs for the dismantling. The total amount of costs is estimated based on basic studies which are regularly updated by an independent expert with due regard for technical advancements and general price trends. Information on the provisions are provided to the Federal Office for Economic Affairs and Export Control (BAFA) by the electric power utilities once a year (see Chapter E.2.2 and Chapter F.2.3).
- The above statements apply to the commercial facilities of the nuclear fuel cycle and for waste management analogously. However, these facilities are not covered by the new provisions of the Act on the Reorganisation of Responsibility in Nuclear Waste Management, so that the provisions to be formed for this purpose must continue to also cover storage and disposal of the waste.

Table F-5: Institutions responsible for the decommissioning of research facilities financed from public funds

Research institution	Short description	Funding
Kerntechnische Entsorgung Karlsruhe GmbH (KTE GmbH)	Founded in 2006 as Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH (WAK GmbH) in the course of the takeover of the Karlsruhe reprocessing plant by the federally-owned EWN GmbH. At the same time, the company's spectrum of tasks was extended to the operation and dismantling of the Karlsruhe vitrification facility (VEK). In mid-2009, the old nuclear installations FR-2, KNK II and MZFR as well as the conditioning facilities for radioactive waste of the waste management facilities of the former Karlsruhe research centre (FZK, now Karlsruhe Institute of Technology, KIT) were separated and transferred to the WAK GmbH. In 2017, the WAK GmbH was renamed KTE GmbH. Since then, the latter has been continuing the decommissioning of the research facilities and operation of the waste management facilities. Whenever other nuclear research facilities are taken out of operation by the KIT, their dismantling will be handled by the KTE GmbH.	Federation (mainly), *Land* of Baden-Wuerttemberg
JEN Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH (JEN)	With effect from 30 September 2015, the nuclear service of Forschungszentrum Jülich GmbH (FZJ) was separated from the FZJ and merged with the AVR GmbH located at the site to form the JEN. Since then, the JEN has been continuing the decommissioning of the research facilities (FRJ-2, AVR, Large Hot Cells, Chemistry Cells) as well as the operation of the waste treatment and conditioning facilities and storage facilities. After shutdown of further nuclear research facilities by the FZJ, they will be dismantled by the JEN.	Federation (mainly), *Land* of North Rhine-Westphalia
Helmholtz-Zentrum Geesthacht – Zentrum für Material- und Küstenforschung GmbH	Founded in 1956 as Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt (company for exploitation of nuclear energy in shipbuilding and navigation). Among other things, it was responsible for the operation of the nuclear ship Otto Hahn. At present, the main focus is on transport and energy technology, process and biomedical engineering and the coastal habitat. Current tasks are the decommissioning of the research reactors FRG-1 and FRG-2, the storage of the ship reactor and the 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. Other tasks included the safe enclosure of the FRN research reactor. At present, the focus is on environmental and health research. With effect from 1 January 2008, the GSF was renamed Helmholtz Zentrum München – Deutsches Forschungszentrum für Gesundheit und Umwelt GmbH.	Federation (mainly), Free State of Bavaria
Helmholtz-Zentrum Berlin	Founded in 2008 by merging the Hahn-Meitner-Institut Berlin and the Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung (BESSY). Research topics are in the areas of structural research, material sciences etc. A current task is the decommissioning of the BER II research reactor.	Federation (mainly), *Land* of Berlin

Research institution	Short description	Funding
Strahlenschutz, Analytik und Entsorgung Rossendorf e.V. (VKTA), Dresden	The VKTA was founded in 1992 and carried out the decommissioning of the nuclear installations and facilities of the former Central Institute for Nuclear Research of the former German Democratic Republic (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
Technical University of Munich (TUM)	The tasks of the TU Munich include the operation of the FRM II as well as work on decommissioning and dismantling of nuclear installations that are no longer required.	Free State of Bavaria (mainly), Federation
Various universities	Several universities have smaller research reactors for whose operation/decommissioning they are responsible.	Federation, respective *Länder*

In all cases, staff costs are fully included in the financing, which account for 50 % of the total costs and more. Analogous to the operating phase, it is thus ensured that qualified staff is also available to the extent required during decommissioning. The high level of education and qualification in Germany is maintained through courses for achieving and maintaining the required technical qualification, education and training courses, as well as research and teaching at universities and technical colleges. Significant progress has been made in this area in recent years, as summarised in Chapter F.2.1.

F.6.3 Radiation protection during decommissioning

The requirements regarding radiation protection of a nuclear installation which is in the process of decommissioning fully correspond to those applicable during operation. Details can be found in the reporting on Article 24 (Operational radiation protection), Chapter F.4, of the Joint Convention.

F.6.4 Emergency preparedness

Compared to emergency preparedness for operation, the scope of emergency preparedness for the decommissioning of a nuclear facility is adapted in line with the risk potential posed by the facility (see reporting on Article 25 in Chapter F.5).

F.6.5 Keeping of records

Keeping of records of information important for decommissioning concerns, on the one hand, records relating to the construction and operation of the nuclear installation which will need to be accessed later in the decommissioning phase and, on the other hand, to records generated during decommissioning and which are relevant for the long-term documentation of decommissioning itself. In the following, these two issues are dealt with separately.

Keeping of records of information pertaining to construction and operation

Records of information and documentation relating to the construction and operation of nuclear power plants are regulated in 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-(d)). The need for keeping all relevant documentations available is derived from Criterion 2.1 of the “Safety Requirements for Nuclear Power Plants” [3-0.1], which stipulates that all documentation necessary for quality assessment must be kept available. This requirement is specified in 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(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 extended 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 Guide [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 mutatis mutandis to other types of nuclear installations within the scope of application 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 residual 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 § 57 of the Radiation Protection Ordinance (StrlSchV) [1A-8b] 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 §§ 85 and 86 StrlSchV is of particular relevance for the decommissioning phase. § 85(3) requires that such records must be kept for 30 years from the date of transfer or other dispositions of the material or, according to § 86(2) StrlSchV, when completion of the clearance procedure has been determined. Records and documentation must be deposited with the competent authority at the request of the latter.

§ 85(3) and § 86(2) StrlSchV further require 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 installation no longer exists.

According to the Decommissioning Guide, 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

Developments since the Sixth Review Meeting:

On 6 December 2018, the Nuclear Waste Management Commission (ESK) published a recommendation on the protection of disposal facilities against flooding [4-22]. The background is, among other things, that for a future disposal facility for heat-generating radioactive waste, the influence of climate change and new findings regarding extreme weather conditions must also be taken into account due to the expected long operating phase.

On 21 February 2019, the ESK adopted a statement on safety concept requirements for the barrier system of a disposal facility for high-level radioactive waste and their implementability in view of the necessity to compare different host rocks and different safety concepts [4-30].

This section deals with the obligations under Articles 4 to 10 of the Joint Convention.

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], the Radiation Protection Act (StrlSchG) [1A-34] and the Radiation Protection Ordinance (StrlSchV) [1A-8b]. In particular, they state that any unnecessary radiation exposure or contamination of man and the environment shall be avoided and that any radiation exposure or contamination shall be kept as low as possible, even below the specified limits, taking into account the state of the art in science and technology and all circumstances of the individual case (§ 8 StrlSchG).

The planning of structural or technical measures to protect against design basis accidents is based on the dose limits for the environment (§ 104 StrlSchV) or is applied mutatis mutandis.

The following principles for spent fuel management are derived from the precautionary concept:

- fundamental protection goals on radioactivity confinement, removal of decay heat power, subcriticality, avoidance of unnecessary radiation exposure, and
- requirements regarding shielding, design and quality assurance, safe operation, storage and safe removal of radioactive substances.

For the purpose of protection against the hazards emanating from radioactive substances and control of their use, the Atomic Energy Act requires that the construction, operation and decommissioning of nuclear installations shall be subject to regulatory licensing (see reporting on Article 19 in Chapter E.2.3).

Additional requirements regulate liability in case of damages [1A-11], protection against disruptive actions or other interference by third parties ([3-62], [BMU 13b]) and the control of fissile material under international conventions [1F-14] (see reporting on Article 24 and Article 27, respectively, in Chapter F.4 and Chapter I.1, respectively).

G.1.2 Assurance of subcriticality and residual heat removal

Measures are taken which take into account the derived fundamental protection goals of reliable maintenance of subcriticality and safe removal of decay heat. Particularly regarding the dry storage of spent fuel from light water reactors (LWRs), high temperature reactors (HTRs), experimental and demonstration as well as research reactors, these measures are specified in greater detail by the "Guidelines for Dry Cask Storage of Spent Fuel and Heat-generating Waste" [3-150] adopted by the Nuclear Waste Management Commission (ESK). With regard to criticality safety in connection with the wet storage of spent fuel, safety standard KTA 3602 is applied, whilst safety standard KTA 3303 is applied with regard to the removal of decay heat (see Safety standards of the Nuclear Safety Standards Commission (KTA) in Annex L-(d)). The DIN standard "Criticality safety taking into account the burn-up of fuel for transport and storage of irradiated light water reactor fuel assemblies in casks", available since 2007 and last updated in 2015 [DIN 25712], is to be applied for demonstrating criticality safety.

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has submitted "Safety Requirements Governing the Final Disposal of Heat-Generating Waste" [BMU 10] which were published on 30 September 2010 and stipulate, among other things, that subcriticality is to be demonstrated and that inadmissible influences on the effect of the geological barrier by the temperature development of the waste are to be excluded. In a statement of March 2016, the ESK formulated "Requirements for waste packages for the disposal of heat generating radioactive waste" [4-18] where the BMU Safety Requirements of 2010 are defined in more detail. Furthermore, in a recommendation of December 2015, the ESK published the "Guideline on the safe operation of a disposal facility for in particular heat-generating radioactive waste" [4-17] on the demonstration of maintenance of subcriticality and safe removal of decay heat power as safety-related boundary conditions.

The Site Selection Act (StandAG) [1A-7b] of 2017 includes the provision to enable issuing statutory ordinances on the adoption of safety requirements and requirements for carrying out the preliminary safety analyses in terms of disposal. These ordinances are currently being drafted and will replace the BMU Safety Requirements of 2010.

In February 2019, the ESK published a statement “Safety concept requirements for the barrier system of a disposal facility for high-level radioactive waste and their implementability” [4-30]. In this statement, different host rocks and different safety concepts are compared. This is regarded as the basis for further regulatory work, in particular on the proof of containment by safety analyses.

G.1.3 Limitation of radioactive waste generation

§ 8(1) and (2) of the Radiation Protection Act (StrlSchG) [1A-34] require that anyone who plans or performs an activity shall avoid any unnecessary exposure or contamination of man and the environment and keep any exposure or contamination as low as possible, even below the specified limits. Based on this, and analogous to § 23 of the Closed Substance Cycle and Waste Management Act (KrWG) [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 decreased.

§ 2d of the Atomic Energy Act (AtG) [1A-3] implies an imperative to limit the accumulation of radioactive waste. Moreover, private operators of nuclear installations in the Federal Republic of Germany themselves have a vested interest in limiting waste volumes for economic reasons. The operators are and will be responsible for the management and funding of the qualified packaging of radioactive waste.

G.1.4 Taking into account interdependencies between the different steps in spent fuel management

According to § 2c of the Atomic Energy Act (AtG) [1A-3], the Federal Government shall present in a national waste management programme how the national strategy for a responsible and safe management of spent fuel and radioactive waste should be implemented. According to § 2d AtG, in this national waste management programme, the mutual dependency of the single steps during accrual and management of spent fuel and radioactive waste shall be taken into account.

According to § 9a AtG, it is necessary to prove to the supervisory authority that adequate provisions exist for the non-hazardous reuse or controlled disposal of spent fuel. For this purpose, realistic plans are submitted annually showing that sufficient storage capacity remains available for spent fuel already existing and expected to arise in future, and that sufficient and adequate storage capacities are legally and technically available to meet concrete requirements for the next two years. Furthermore, similarly structured proof is also furnished to the supervisory authorities regarding the storage of waste from the reprocessing of spent fuel in foreign countries to be returned, as well as for the reuse 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 waste acceptance criteria laid down in the licence for the planned storage facility or disposal facility. Figure F-1 shows how a work and inspection schedule adopted by the Federal Company for Radioactive Waste Disposal (BGE) and involving the supervisory authorities of the *Länder* ensures that the stored waste is either conditioned such as to already meet the waste acceptance requirements for disposal or that conditioning to meet the waste acceptance criteria for disposal is possible at a later date in an uncomplicated way.

For the spent fuel and radioactive waste intended for emplacement in the disposal facility in accordance with the Site Selection Act, waste acceptance criteria have not been defined yet since the disposal concept depends on the site which is to be determined by law not before termination of the selection procedure according to the Site Selection Act. Here, storage must take place in such a way that later conditioning to meet the waste acceptance criteria is possible.

Quantitative information showing the consideration of interdependencies can be found in the reporting on Article 32(2) in Section D.

G.1.5 Application of suitable protective methods

The Atomic Energy Act (AtG) [1A-3], the Radiation Protection Act (StrlSchG) [1A-34] and the Radiation Protection Ordinance (StrlSchV) [1A-8b] require that precautions must be taken against potential damages in accordance with the state of the art in science and technology to ensure effective protection. For compliance with the state of the art in science and technology in spent fuel management, internationally accepted criteria and standards of the International Atomic Energy Agency (IAEA) ([IAEA 12a] and [IAEA 02]), the International Commission on Radiological protection (ICRP) and Council Directive 2013/59/EURATOM [1F-24] are referred to. This is ensured by the nuclear licensing applicable to the corresponding facility (see reporting on Article 19 in Chapter E.2.3).

Compliance with the provisions of the licence is ensured by the nuclear supervision by the competent authorities of the Federation and the *Länder* (see reporting on Article 19(2)iv in Chapter E.2.5).

G.1.6 Taking into account 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 in Chapter E.2). In Germany, these are mainly relevant regarding disposal for which 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

The Site Selection Act (StandAG) [1A-7b] defines the subsequent individual procedural steps for the indeterminate and unbiased search for and selection of a site for the safe disposal of high-level radioactive waste with the aim of establishing a disposal facility that meets the high requirements for the long-term protection of man and the environment against the hazards of radioactive waste. Thus, the Federation and the *Länder* fulfil their responsibility for the long-term protection of man and the environment against the hazards of radioactive waste also with regard to future generations.

As things stand, the impacts of discharges of radionuclides during operation of a disposal facility in Germany must not exceed the dose limits applicable to nuclear power plants today. As regards the post-closure phase of a future disposal facility for heat-generating radioactive (high-level radioactive) waste, the safety requirements of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) [BMU 10] apply. These postulate the integrity of the rock surrounding the disposal facility as well as an optimisation of the disposal facility. Furthermore, it has to be demonstrated that after closure of a disposal facility an additional effective dose in the range of 10 µSv per calendar year for probable developments and 100 µSv per calendar year for less probable developments will not be exceeded.

The Site Selection Act includes the provision to enable issuing statutory ordinances, i.e. two for the adoption of safety requirements and requirements for carrying out the preliminary safety analyses in terms of disposal and one for documentation. The first two ordinances are currently being prepared and will replace the BMU Safety Requirements of 2010. The contents of the BMU Safety Requirements of 2010 will be adapted to the framework conditions changed by the Site Selection Act and further specified while maintaining the established safety level. By means of the ordinance on documentation, the complete and constant availability of data and documents is ensured as an essential prerequisite for maintaining the safety of nuclear waste management. Depending on the information contained, the traceability and integrity of the data and documents must be ensured for decades, centuries or as long as is necessary for safety reasons beyond that, but at least for the period of retrievability.

G.1.8 Avoidance of undue burdens on future generations

The "Safety criteria for the emplacement of radioactive wastes in a mine" [3-13] as well as the "Safety Requirements Governing the Final Disposal of Heat-Generating Waste" [BMU 10] already take into account Principle 7 of the "Fundamental Safety Principles" of the International Atomic Energy Agency (IAEA) [IAEA 06a]. They ensure that no undue burdens are imposed on future generations.

Financial resources for the decommissioning of the nuclear power plants and for the conditioning of the resulting radioactive waste such as to meet the waste acceptance criteria for disposal will continue to be set aside by the operators of the nuclear power plants on the basis of the legal provisions of commercial law, whereas the responsibility for the management and financing of storage and disposal is transferred to the Federation on the basis of the Waste Management Transfer Act (EntsorgÜG) [1A-35] In accordance with the Waste Management Fund Act (EntsorgFondsG) [1A-36], the financial means required for waste management were made available to the Federation by the operators as at 1 July 2017 and transferred to a fund for the financing of nuclear waste management. After the closure of a disposal facility, no monitoring or maintenance measures are required, except for minor measures to preserve evidence and control measures. Therefore, no unreasonable costs are incurred after closure 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 Joint Convention regarding existing facilities

The fundamental requirements governing the precautions to be taken are set forth in the Atomic Energy Act (AtG) [1A-3], the Radiation Protection Act (StrlSchG) [1A-34], the Radiation Protection Ordinance (StrlSchV) [1A-8b] and other legal provisions, as well as in non-mandatory guidance instruments (see reporting on Articles 18 to 20 in in Chapter E.1 to E.3) which satisfy, and in some cases exceed, all the requirements of the Joint Convention. It is therefore not considered necessary to subject the facilities to an explicit review to verify compliance with the requirements of the Joint Convention.

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 § 19 AtG.

Independently from this, the "Guidelines for Dry Cask Storage of Spent Fuel and Heat-generating Waste" [3-150] stipulate regular reviews intended to ensure compliance with the protection goals stipulated in the Act in line with the latest state of the art in science and technology. The protection goals 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 Extended storage of spent fuel

Dry storage of spent fuel and vitrified high-level waste in casks has already been practised in Germany for decades. The licences for storage facilities are limited to 40 years, starting with the storage of the first cask. Table D-1 shows, when the licence for the respective storage facility expires. Spent fuel storage is necessary until transfer to the disposal facility for high-level radioactive waste is possible, whose selection process started with the Act Amending the Site Selection Act (StandAG) [1A-7b] in 2017. According to current knowledge, it cannot be ensured that all fuel will be removed from the storage facilities during the licensed period of 40 years.

The storage period is to be limited to the strictly necessary period, but the period until the commissioning of a disposal facility for high-level radioactive waste may only be partially shortened with required due diligence in order to allow comprehensive participation of the general public during the entire process. An extension of the storage period is subject to licensing. According to § 6(5) AtG [1A-3], licences for storage facilities may only be renewed on imperative grounds and after prior referral to the German *Bundestag*.

The national waste management programme further provides that with the first partial licence for the disposal facility for heat-generating waste, a receiving storage facility is also to be approved at the site for all spent fuel and waste from reprocessing, thus creating the precondition for the start of clearing the existing storage facilities.

In its discussion paper on extended storage of 2015 [4-20], the Nuclear Waste Management Commission (ESK) states that the operational experience gained so far as well as the safety reviews of storage facilities did not indicate any deterioration of safety-relevant functions. For extended storage, however, safety-related proofs will also have to be provided on a reliable database. Dealing with relevant issues on extended storage at an early stage (see Chapter K.2 for details) enables competent assessment of the required measures for the future.

The necessary maintenance of know-how over the required period will become more important in the medium term, also with a view to the increasing independency of the storage facilities due to the decommissioning of nuclear power plants.

Moreover, in the ESK discussion paper of 2015, storage is not considered to be a single, independent step, but only a partial step of the entire waste management process; this is because there is interdependency between storage and other waste management steps (conditioning and disposal) as well as transportation. Thus, an overall view and a better coordination of the different waste management steps are recommended which, under nuclear law, are considered to be legal individual processes and, in addition, are affecting transport law. Thus, the development and implementation of independent standards is proposed for extended storage which should also present alternatives for the permanent maintenance of type approvals under traffic law until the end of extended storage.

According to the ESK, it is necessary to establish clearly defined responsibilities with an appropriate coordinating structure for the implementation of the overall waste management system.

In the German rules and regulations, requirements for storage are laid down in the "Guidelines for Dry Cask Storage of Spent Fuel and Heat-generating Waste" [3-150] of the ESK of 2013. The guidelines refer to a storage limited in time for a period applied for in the respective licensing procedure. The limitation in time of the storage licences for German storage facilities is not based on limiting parameters of physical-technical nature.

Furthermore, the periodic safety review (PSR) of storage facilities is laid down in the AtG. According to § 19a(3) AtG, anyone who operates a facility pursuant to § 2(3a)(1) AtG is required after start of operation (storage of the first cask) to conduct and to evaluate every ten years a safety review of the facility and to improve the safety of the facility on this basis continuously. The results of the safety review and evaluation shall be submitted to the supervisory authority.

Requirements for the performance of the PSR were published by the ESK as "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" in March 2014 [3-152].

The operator of the storage facility is responsible for conducting the PSR. The results and the measures derived are to be documented by the operator and submitted to the nuclear supervisory authority. Where required, the supervisory authority defines the measures necessary for further operation of the storage facility subjected to the review and supervises their timely and proper implementation. The licensing authority, since July 2016 the Federal Office for the Safety of Nuclear Waste Management (BASE), takes note of the results of the PSRs of the storage facilities and their assessment by the nuclear supervisory authorities and – if necessary – can derive updated or additional requirements for ongoing and future licensing procedures.

In addition to the requirements for the PSR, requirements for technical ageing management were also formulated in the ESK guideline [3-152]. The objective of these is to identify and monitor safety-related degradation mechanisms and to control them by appropriate measures. The guideline refers to accessible technical equipment and components that are relevant for compliance with the protection goals. In particular, the exchange of experience across the facilities should also serve the purpose of further development of ageing management. Non-technical aspects such as knowledge management, data protection, personnel planning and securing necessary resources are assigned to safety management. They are not addressed in ageing management.

For an extension of the storage period, on the one hand, findings from the evaluated operational experience and the inspections as available from the PSR are to be taken as a basis and, on the other hand, sufficiently reliable data on the safety-relevant components and materials are required. For this purpose, data that can be transferred to Germany and corresponding findings from international investigation programmes can be used or additional national research studies can be conducted in a targeted manner [4-20]. As the highest supervisory authority, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) promotes national research in this field and supports the participation/cooperation of competent organisations which, on its behalf, participate in international organisations such as the International Atomic Energy Agency (IAEA) and OECD/NEA and take up new aspects of storage or exchange experience. A result thereof is an approach to identify safety-relevant knowledge gaps with regard to the extended storage period. To date, national research programmes have dealt with aspects such as the status of dry storage in Germany and in international comparison, technical and non-technical ageing management, the long-term behaviour of the casks and emplaced inventories, as well as problems specific to storage in Germany and the topic of exchange of experience. Furthermore, some long-term tests have already been initiated, but according to the current state of the art in science and technology, no final statements can yet be made since the data from the experimental studies performed so far are not yet sufficient for this purpose and reliable comparative data from real operation are not freely available yet. The issue of extended storage and the presentation of safety-related aspects were taken up and dealt with in corresponding research programmes.

A major focus of the Federal Ministry for Economic Affairs and Energy (BMWi's) project funding on site-independent waste management research is the investigation of the effects of extended storage periods on waste and casks. The BMWi thus promotes the creation and continuous development of scientific bases for the assessment of the long-term behaviour of casks and waste under storage-specific loading conditions and during the subsequent transports prior to disposal. This will contribute to increasing safety during extended storage and subsequent transports as well as to the enhancement of the state of knowledge about the condition of the spent fuel and containers prior to disposal. The focus is on the investigation of ageing effects and damage mechanisms as well as the provision of appropriately adapted analysis and evaluation methods. Research and development activities on the provision of methods for continuous condition monitoring are also promoted. In addition, work on dealing with damaged fuel assemblies or contributions to the further development of ageing management can also be sponsored.

Since 2017, Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH has been conducting an annual workshop on scientific and technical issues regarding the safety of extended storage. This event deals with both the special national issues and international research in the context of extended storage and includes research topics of the operators, authorised experts as well as major research institutions and universities. The event has established itself nationally and internationally as one of the important platforms for exchange.

In October 2019, BGZ Company for Storage (BGZ) organised a workshop on storage for the interested expert public as a kick-off event for follow-up events. The objectives were the presentation of the technical aspects connected with extended storage and a discourse on the challenges and requirements, the results of which can be considered when initiating specific programmes and project activities.

G.2.3 ARTEMIS mission 2019 in Germany

The reporting obligations resulting from Article 14 of Council Directive 2011/70/EURATOM include the obligation for the Member States to periodically arrange for self-assessments of their national legal and organisational framework, competent regulatory authority, national waste management programme and its implementation every ten years and to have these reviewed by international experts. In order to support the EURATOM Member States in fulfilling this obligation, the International Atomic Energy Agency (IAEA) offers them the possibility of carrying out corresponding review missions using its newly created and expanded Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS).

At the invitation of the Federal Republic of Germany, such an ARTEMIS review mission took place between 22 September and 4 October 2019. The international expert team consisted of eight experienced experts from six European countries and the USA, supported by three IAEA staff members. In a preparatory meeting, the thematic priorities of the mission had been agreed in advance with the BMU as lead ministry, namely the reorganisation of the financing and action responsibilities for the management of radioactive waste, the commissioning of the Konrad repository, the site selection procedure for the disposal facility for high-level radioactive waste, the concepts for the decommissioning of the German nuclear power plants and the management of the radioactive waste arising from this process, and the management plans regarding the radioactive waste to be retrieved from the Asse II mine. In addition, the results of the IRRS review mission carried out in April 2019 (see Chapter E.3.3 for details) were also to be taken into account within the framework of the ARTEMIS mission.

On the German side, in addition to the BMU, the supervisory ministries of the *Länder* of Baden-Wuerttemberg and Lower Saxony, the Federal Office for the Safety of Nuclear Waste Management (BASE), the Federal Company for Radioactive Waste Disposal (BGE) and BGZ Company for Storage (BGZ), the Nuclear Waste Management Commission (ESK) and EWN Entsorgungswerke für Nuklearanlagen GmbH (EWN), the operator RWE Nuclear as well as the expert organisations Brenk Systemplanung GmbH, Öko-Institut and the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH were involved in the preparation of the German self-assessment as well as in the implementation of the review mission. In addition to the technical discussions between the expert team and representatives of the German side, visits to the Konrad repository currently under construction and to the facilities of the Kerntechnische Entsorgung Karlsruhe GmbH (KTE) entrusted with the management of radioactive waste completed the review mission.

The international experts identified the establishment of an independent advisory board for public participation, the National Civil Society Board (NBG), consisting of citizens and public figures and which is to provide explanatory and mediatory support for the site selection procedure, to be an internationally recognised good practice.

Recommendations and suggestions from the team of experts related to the areas of detailed monitoring of progress in the large number of tasks to be performed as well as increasing transparency with regard to some aspects of issuing licences and informing the public.

A final presentation of the review mission and its results was submitted as a report to the BMU in December 2019 and will be published on the BMU website [IAEA 19b].

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(1) of the Atomic Energy Act (AtG) [1A-3] regulates the licensing of stationary facilities for the treatment or processing of spent fuel, whilst the licensing of the storage of nuclear fuel outside Government custody is regulated in § 6(1) AtG. The definition in the AtG encompasses storage of spent fuel. In order to obtain a licence, the applicant must submit documentation containing all the relevant data required for the purposes of assessment. These data are summarised in the safety report, 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 is to 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 reporting on Article 19(2)(ii) in Chapter E.2.3. Usually, the required information pertaining to the site and the facility is compiled in the safety report and supporting documents.

An Environmental Impact Assessment (EIA) is required for facilities which are listed in Appendix 1 of the Environmental Impact Assessment Act (UVPG) [1B-14]. According to numbers 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 management of spent fuel, as follows:

"11.1 Construction and operation of a stationary facility for the production, treatment, processing or fission of nuclear fuel or the reprocessing of spent nuclear fuel,

11.3 Construction and operation of a facility for the treatment or processing of spent nuclear fuel or highly radioactive waste or for the sole purpose of storage of spent fuel or radioactive waste which is scheduled to last for more than ten years at a place different from the one where these materials have arisen."

For projects requiring an EIA, the application must be accompanied by an EIA report pursuant to § 3(2) AtVfV, which contains the information required under § 16(1) UVPG (see section on the EIA in Chapter E.2.3 in the reporting on Article 19(2)(ii)). This also includes a description 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 project according to § 7 AtG.

Within the meaning of Article 6(1)(i) of the Joint 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 a spent fuel management facility during its operational life.

Especially for dry cask storage of spent fuel and heat-generating radioactive waste, the Nuclear Waste Management Commission (ESK) guidelines [3-150] make 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. These guidelines are used as a basis for the licensing of new storage facilities. No regulatory specifications with regard to extended storage have yet been made.

G.3.2 Impacts on the safety of individuals, society and the environment

In addition to the site-related information (see reporting on Article 6(1)(i), the safety report and supporting documents contain information on the following topics (see reporting 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 facility, radiation and activity monitoring in rooms and in the facility, physical radiation protection monitoring of individuals,

monitoring of discharges of radioactive substances and environmental monitoring, surveillance of material which is released from the controlled area, measures to reduce radiation exposure of personnel and the environment,

- waste and residual material management: management of cleared material from the operation, conditioning, storage and (if relevant) transfer of radioactive operational waste,
- radiation exposure in the environment: application values for discharges with air and water including substantiation, calculation of the exposure resulting from the discharge of radioactivity and from direct radiation,
- incident analysis: description of the protection goals, possible incidents, incident analysis for operation, radiation exposure as a result of incidents, and
- further effects of facility operation on the environment: identification, description, and evaluation of the effects on humans, fauna, flora, soil, water, air, climate and landscape as well as cultural and other legally protected goods.

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 [3-150] 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 the Joint 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(1) AtVfV, the public hearing is not open to the general public.

Details concerning the related procedures are described in the section on public participation in the reporting on Article 19(2)(ii) in Chapter E.2.3.

This approach, particularly public participation as defined in the Nuclear Licensing Procedure Ordinance 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 proposed spent fuel management facilities within the meaning of Article 6(1)(iii) of the Joint Convention.

G.3.4 Consultation of neighbouring Contracting Parties

§ 7a of the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10] refers to Sections 1 and 3 of Part 5 of the Environmental Impact Assessment Act (UVPG) [1B-14], which regulates the procedure for cases of transboundary environmental impacts, which is also relevant in connection with spent fuel management facilities. In the case of a project requiring an EIA, the German authority notifies the authority designated by the other state at an early stage in accordance with § 54(1) UVPG by submitting appropriate documentation on the project.

The competent German authority shall request the authority designated by the other state to inform it within a reasonable time whether participation is requested.

According to § 56(2) UVPG, the German licensing authority must ensure that the project is made known in the other state in an appropriate manner, that it is indicated to which German authority comments may be submitted in what form and within what period, and that it is pointed out that, on expiry of the period laid down, all comments which are not based on specific private-law titles are excluded from the procedure on the admissibility of the project.

On the basis of the documents submitted, the licensing authority shall give the authorities of the other state to be involved the opportunity, at least to the same extent as the authorities to be involved pursuant to § 17 UVPG, to submit their comments within a reasonable period before the decision on the application is taken. Persons resident in that state are accorded equal status with German citizens with regard to their further participation in the licensing procedure.

According to § 55(1) UVPG, third sentence, the applicant may be required to provide a translation of the brief description to be submitted and, if necessary, further information on the project that is important for transboundary participation, in particular on transboundary environmental impacts.

According to § 55(5) UVPG, consultations are to be held, where necessary, between the supreme German authorities of the Federation and the *Länder* and the competent authorities of the other state regarding the transboundary environmental impacts of the project and any measures for avoiding or reducing them.

Furthermore, § 8 UVPG shall also apply to the transboundary participation of authorities insofar a protected good 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 discharge 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 the Joint Convention. Such data usually comprise details of the site, the plant, the discharge of radioactivity into the atmosphere or in liquid form during normal operation, the management of solid radioactive waste, any unplanned discharges 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 legally protected goods, such as humans, fauna, flora, soil, water, air, etc., are described in the documents to be submitted by the applicant, as outlined in the reporting on Article 6(1) in Chapter G.3.2.

Effects on other Contracting Parties of the Joint Convention which are adjacent to the spent fuel management facility may result from the licensed liquid and gaseous discharges from the plant during normal operation and from possible additional release of radioactivity into the environment during incidents:

- The discharge of radioactivity during normal operation is limited by § 99 of the Radiation Protection Ordinance (StrlSchV) [1A-8b] in such a way that the doses resulting from discharges with water and air will not exceed the dose limits shown in Table F-1 pursuant to § 99 StrlSchV for members of the general public per calendar year.
- For incidents in spent fuel management facilities, the provisions of § 104 StrlSchV apply, according to which for local 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 shown in Table F-1 pursuant to § 104 StrlSchV. For incidents in other facilities and for decommissioning, the nature and extent of protective measures are determined by the competent authority, taking into account the individual case,

particularly with regard to the hazard potential of the facility and the likelihood of an incident occurring.

Within the framework of the involvement of authorities in the neighbouring states, these are also informed about the possible radiological effects of normal operation and possible incidents. If the specified dose limits, which are in line with the relevant European Union (EU) regulations and generally in line with international standards, are also taken as a basis by other Contracting Parties, the effects are also 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 goals

For facilities for the management of spent fuel (see Table L-1 to Table L-4), the protection goals according to § 1(2) of the Atomic Energy Act (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 Act (StrlSchG) [1A-34]:

- protection of man and, as far as the long-term protection of human health is concerned, the environment against the harmful effects of ionising radiation.

Furthermore, § 6(2) AtG contains the licensing conditions which ensure that the protection goals 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 already performed during the design phase ensuring compliance with the protection goals, both under normal operating conditions and in the event of an uncontrolled accidental release. The design of the facility and the establishment of limits for radioactive discharges in the licence ensure that the radiological impacts on individuals, the society and the environment are limited to a non-hazardous extent in the subsequent operation.

G.4.2 Provisions for decommissioning

The decommissioning of a spent fuel management facility is governed by the same legal prerequisites and peripheral requirements as other nuclear installations. The operation of spent fuel management facilities is licensed for a specified purpose and the facilities must be removed once the licence has expired. There are also regulations governing decommissioning and dismantling.

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has decreed that the “Guidelines for Dry Cask Storage of Spent Fuel and Heat-generating Waste” [3-150] of the Nuclear Waste Management Commission (ESK) must be applied. Section 2.16 of these guidelines contains the following provision concerning decommissioning:

> *“The 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 Radiation Protection Act (StrlSchG) [1A-34] and in the Radiation Protection Ordinance (StrlSchV) [1A-8b] must be observed during the decommissioning and dismantling of these types of facilities. However, additional regulations i.a. from the Closed Substance Cycle and Waste Management Act (KrWG) [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 basis

The construction of facilities in Germany is governed by the commonly accepted technical rules – e.g. the specifications laid down in the German Institute for Standardization (DIN)/European Article Numbering (EAN) standards. In the nuclear sector, the requirements specified in Safety standards of the Nuclear Safety Standards Commission (KTA) (see reporting on Article 19(2)(i) in Chapter 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 result from processes of experience. Hence, in Germany, experience gained from nuclear research institutions as well as experience from industrial application has been incorporated into rules and standards. Such standards are issued by the KTA, which is composed of representatives from research, industry and administrative bodies representing experience from 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 Article 8: 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 installations for the management of spent fuel (storage facilities and the Gorleben pilot conditioning plant) and the assessment of environmental impacts take place prior to the construction of such a facility within the framework of a licensing procedure (see reporting on Article 19(2)(ii) in Chapter E.2).

An assessment of the safety and environmental impacts conducted prior to commissioning takes place within the framework of the accompanying supervision under the relevant nuclear laws.

Regulatory basis

The construction and operation of nuclear installations for spent fuel management is subject to licensing under the Atomic Energy Act (AtG) [1A-3]. In addition, a building permit under the Building Code of the respective *Land* is required for the construction measures.

Applications for licences under the AtG must be submitted to the competent licensing authority. The application must include a statement on the extent to which the nuclear installation 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; Safety standards of the Nuclear Safety Standards Commission (KTA) in Annex L-(d)) are listed in detail in the reporting on Article 19(2)(ii) and (iii) in Chapter E.2.

Based on the European requirements in Directive 2011/92/EU [1F-12] and in accordance with the Environmental Impact Assessment Act (UVPG) [1B-14], an environmental impact assessment was conducted as a subsidiary part of the licensing procedure for licences for the storage of spent fuel applied for since 1999. In these cases, the documents must be supplemented by:

- a presentation of the possible effects of the project on humans, including human health, fauna, flora and the biological diversity, soil, water, air, climate, and the landscape, cultural and other material assets as well as the interactions between the aforementioned legally protected goods,
- a presentation of measures to prevent, reduce and compensate for significant adverse effects on the environment,
- 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, experts may be consulted for it. The basic requirements governing expert opinions are formulated in the “Framework Guideline on the Preparation of Expert Opinions in Nuclear Administrative Procedures” [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 installations for the management 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 installations for the management of spent fuel may be derived from international recommendations, such as those of the International Atomic Energy Agency (IAEA) [IAEA 12a].

A licensing prerequisite is the trustworthiness of persons responsible for the handling of radioactive material. The corresponding verification according to § 12b AtG is carried out by the competent authorities in accordance with the Nuclear Trustworthiness Verification Ordinance (AtZüV) [1A-19] as a protection against unauthorised acts which may lead to a diversion or major release of radioactive material.

Requirements for design and operation

The requirements for design and operation of nuclear installations 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 nuclear installations for dry cask storage of spent fuel, the guidelines of the Nuclear Waste Management Commission (ESK) of 2013 shall be applied [3-150].

The following radiological protection goals must be met in order to ensure that the precautions against damage reflect the state of the art in science and technology:

- Safe containment of the radioactive inventory
  The barriers or spent fuel casks which ensure containment have to maintain sufficient integrity (monitoring of sealing function, preparation of a repair concept) under all circumstances to be assumed (incidents, accidents, ageing, impacts, etc.).
- Avoidance of unnecessary radiation exposure, limitation and monitoring of the radiation exposure of operating personnel and the general population
  Compliance with the limits of the effective dose and organ doses for members of the general public and for occupationally exposed persons in accordance with §§ 80 and 78 of the Radiation Protection Act (StrlSchG) [1A-34] as well as compliance with the accident planning levels in accordance with § 104 of the Radiation Protection Ordinance (StrlSchV) [1A-8b], even under worst case conditions; avoidance of unnecessary radiation exposures and dose reduction according to § 8 StrlSchG (incoming and outgoing inspection of the spent fuel casks, preparation of a radiation protection concept, division of the storage facility into radiation protection areas, radiation monitoring in the storage facility and environmental radiation monitoring).
- Ensuring subcriticality
  Proof of 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 appropriate spacing) ([DIN 25403], [DIN 25478], [DIN 25712]).
- Sufficient removal of decay heat
  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 indispensable for compliance with them:

- shielding of the ionising radiation,

- design, execution and quality assurance appropriate to operation and maintenance g (KTA 1401, see Safety standards of the Nuclear Safety Standards Commission (KTA) in Annex L-(d)),
- safety-oriented organisation and performance of operation,
- safe handling and safe transport of the radioactive material (see also [IAEA 12b]),
- design against design basis accidents and provision of measures to reduce the harmful effects of beyond-design conditions (accident analysis). The calculation of accident impacts and of pollution already existing at the site is dealt with in [2-1] und [3-33.2].

Within the framework of the accident analysis, which is part of the safety report, a distinction is made between external and internal hazards, the latter being caused by the spent fuel management facilities themselves. The assessment of these hazards is carried out by the competent licensing authority as part of the licensing procedure. Recommendations for disaster control are given in the “Basic Recommendations for Disaster Control in the Vicinity of Nuclear Power Plants” [3-253] and in the “Radiological Fundamentals for Decisions on Measures for the Protection of the Population against Accidental Releases of Radionuclides” [3-250] (see reporting on Article 25 in Chapter F.5).

In the context of dry storage, the following events are generally to be considered as internal hazards:

- mechanical impacts, such as the crash of a fuel cask, collision of a cask during handling and dropping of a load onto the cask (see examples of drop tests of the Federal Institute for Materials Research and Testing (BAM) in Figure G-1), and
- fire.

Figure G-1: Drop test of a transport and storage cask for vitrified waste, cooled down to minus 40°C, at the test facility of the BAM within the framework of an approval procedure under traffic law (Copyright: BAM)

According to the guidelines, the following natural and man-made external hazards are considered (see also [BMU 13b], [3-62]):

- natural external events such as storm, rain, snowfall, frost, lightning, floods, landslides and earthquakes,
- man-made external hazards 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.

Other hazards have to be taken into account depending on the conditions at the respective sites. For example, interactions with a neighbouring power plant are also considered, e.g. the collapse of structures, 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 a storage limited in time. For concrete safety demonstrations, the time periods applied for in the respective licensing procedure have to be used. In the storage licences granted so far, this period has been 40 years, which is usually used as a reference period.

Furthermore, after start of operation (storage of the first cask), review and assessment of nuclear safety of the respective facility has to be performed every ten years in the form of a periodic safety review (PSR) in accordance with 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" [3-152] and the safety of the facility has to be continuously improved. The results of the review and assessment are to be submitted to the nuclear supervisory authority. See also the more detailed explanations in Chapter G.2.2.

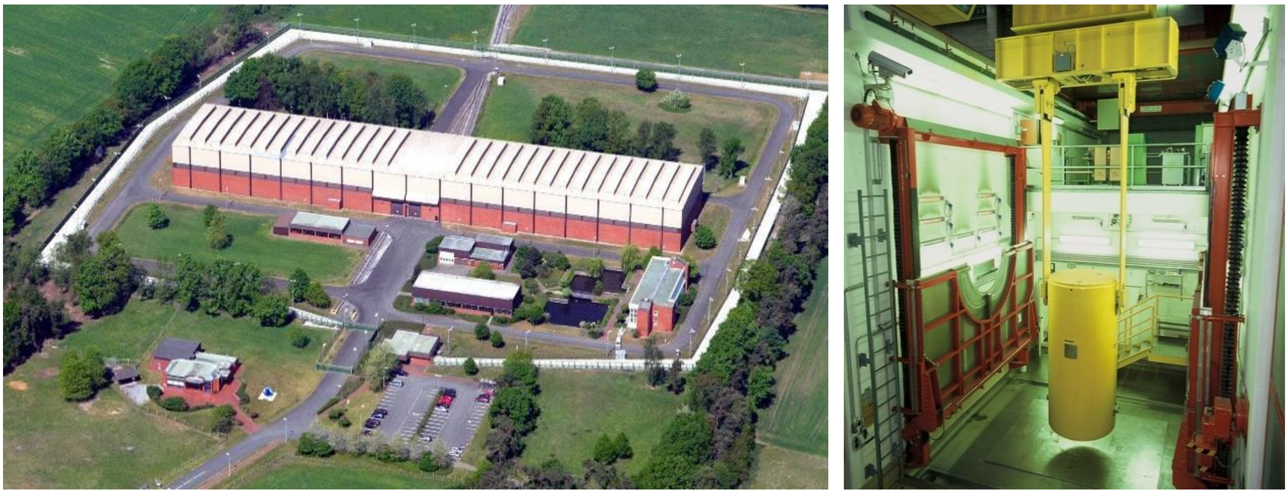
The competent authority may demand adaptations of the facilities to the state of the art in science and technology by subsequent requirements during the operating lifetime, as far as this is necessary to fulfil the safety requirements (§ 17(1) AtG, third sentence). Regarding extended storage, no regulatory specifications have been made yet.

G.5.2 Safety assessment in the supervisory procedure prior to operation

The review of the safety of nuclear installations that accompanies their construction prior to commissioning is carried out by the competent supervisory authority under the Atomic Energy Act (AtG), 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(1) or § 6 AtG [1A-3] for which a modification licence is required. Here, it has to be checked whether the modified facility satisfies 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 licensed 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 installation, sometimes within the framework of an order issued by the nuclear supervisory authority.

Figure G-2: Ahaus storage facility (Copyright: BGZ)



According to the guidelines of the Nuclear Waste Management Commission (ESK) [3-150], the commissioning of storage facilities (see Figure G-2 with the Ahaus storage facility as an example of a spent fuel storage facility) requires the performance of commissioning tests, which are to be specified in a commissioning programme. This serves to demonstrate that the facilities have been appropriately constructed for the planned operation and can be operated as specified and 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 Japanese coast on 11 March 2011 and the resulting flooding by a tsunami at the Fukushima site have prompted the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) to carry out, as a precautionary measure, not only a robustness test for German nuclear power plants and research reactors, but also of a stress test for 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 fabrication plant at Lingen. The results of the stress test are documented in two statements of the Nuclear Waste Management Commission (ESK) [4-11].

The review was based on a catalogue of questions which was answered by the operators of the facilities. With regard to the nuclear waste management facilities, the results of the stress test can be summarised as follows:

Storage of the spent fuel and heat-generating radioactive waste is based on a robust protection concept in which compliance with the fundamental protection goals during storage in specified normal operation and in case of incidents is primarily ensured by the thick-walled metallic casks.

The investigations and reviews have shown that the storage facilities for spent fuel and heat-generating radioactive waste achieve the highest degree of protection in almost all load cases.

The spent fuel management facilities including the pilot conditioning plant (PKA) at Gorleben and the not-yet dismantled operating sections of the Karlsruhe reprocessing plant (WAK) have significant reserves against beyond design basis events. They reach the highest stress level, i.e. the highest level of protection, for many postulated load cases.

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 currently only involves the operation of storage facilities as the licence of the pilot conditioning plant (PKA) at Gorleben is limited to the repair of defective casks and no disposal facility 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 storage. Prior to operation, all installations are subjected to commissioning tests in accordance with the “Guidelines for Dry Cask Storage of Spent Fuel and Heat-generating Waste” [3-150]. These tests are specified in a commissioning programme as part of the licensing documents which is approved by the competent authority. The commissioning programme serves to demonstrate that the facilities have been appropriately constructed for the planned operations in conformity with the licence and can be operated as specified and ensures compliance with the safety requirements contained in Article 8. The results of the tests are documented and evaluated.

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 are to 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 are to be clearly defined. The nuclear supervisory authority supervises compliance with the conditions and requirements.

At each facility, cold testing with one cask for each cask type approved for storage is performed for the entire handling process, including radiation protection measures, before casks are stored there. This is to identify any deficiencies in the process that may still exist, to optimise handling of waste packages and to adapt and finally define the planned proceeding.

G.6.2 Definition and revision of dose reference levels

All operational processes and the measures to be taken in case of incidents are described in the form of clear service instructions, which are laid down in an operating manual in fulfilment of the “Guidelines for Dry Cask Storage of Spent Fuel and Heat-generating Waste” [3-150]. 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 reliably initiate and perform the necessary measures in all operational processes and in case of abnormal operation or incidents and that the limits defined in the Radiation Protection Act (StrlSchG) [1A-34] and in the Radiation Protection Ordinance (StrlSchV) [1A-8b] as well as the limits specified in the licence are kept. 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 licence holder.

G.6.3 Compliance with specified procedures

For storage facilities, the assumptions and boundary conditions for cask properties 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 “Guidelines for Dry Cask Storage of Spent Fuel and Heat-generating Waste” [3-150], 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 in the storage facility. 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 prescribed condition of the safety-relevant installations of the storage facility is ensured by recurring inspections. Their frequency depends on the safety significance of the components to be inspected. The recurring inspections are laid down in a testing manual. The results of the recurring inspections are 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 incidents 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. 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 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

The measures to ensure engineering and technical support during the operating lifetime of the facilities by providing adequate competent staff were already presented in the reporting on Article 22 i in Chapter F.2.1.

The technical systems and equipment used for the removal of the fuel assembly casks is 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.

Recurring inspections are 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 events

The obligation of the holder of a licence pursuant to §§ 6, 7 or 9 of the Atomic Energy Act (AtG) [1A-3] to report accidents, incidents and other safety-significant events to the supervisory authority is regulated by the Nuclear Safety Officer and Reporting Ordinance (AtSMV) [1A-17]. The reporting criteria contained in it are formulated according to the type of facility as far as possible.

The operator of the nuclear installation reports an event to the nuclear supervisory authority of the *Land* if the event is reportable according to the reporting criteria. The operator is responsible for the accurate and complete reporting of the event in due time. The supervisory authority on its part, following its first assessment of the circumstances, reports the event to the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and at the same time to the Incident Registration Centre of the Federal Office for the Safety of Nuclear Waste Management (BASE). The BASE checks the classification of the event once more on a federal level. 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 completed 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 assigned to a category by applying the reporting criteria on the basis of a first assessment of the cause of the event. This procedure takes particular account of the fact that the authority must be able to take precautionary measures even before an in-depth investigation of an event.

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. Events of Category S have to be reported immediately by telephone or in written form by communications facilities. Not later than the fifth working day after detection, 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. Events of category E have to be reported not later than 24 hours after detection by telephone or in written form by communications facilities. Not later than the fifth working day after detection, 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 five 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 ten 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, the classification of the reportable events is carried out by the operator of the nuclear installation in accordance with the International Nuclear Event Scale (INES) of the International Atomic Energy Agency (IAEA). The INES classification is notified together with the AtSMV report. The German INES officer, appointed by the BMU, checks the correctness of the INES classification for each event. The final decision on the classification is made by the BMU and the INES officer. At present, the functions of the INES officer are fulfilled by a member of staff of the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH on behalf of the federal authority.

G.6.6 Collection and use of operating experience

The reporting and assessment procedure laid down in the Nuclear Safety Officer and Reporting Ordinance (AtSMV) [1A-17] is an essential basis for the evaluation of operational experience. Once the supervisory authority has obtained and evaluated all the information relating to a reportable event, it determines – following close consultation with the operator – any remedial 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 the Safety of Nuclear Waste Management (BASE) on behalf of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The BASE publishes the results in annual reports. If any events are of a special and generic significance, Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH prepares a so-called information notice on behalf of the BMU. Information notices are intended to enable the operators of comparable facilities 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 commissioning, specified normal operation (especially during maintenance, inspections and repairs) and recurring inspections are also documented and submitted to the supervisory authority. Any consequences derived from the evaluation of the events are taken into account in the operating procedures.

The monitoring concept ensures that the overall condition of the facility is monitored and at least meets the following requirements:

- The condition of the storage building and the components required for storage are controlled by means of walk-downs and appropriate measurements.
- Recurrent subsidence measurements are performed for the storage building.
- The external condition of the storage casks is monitored by inspections.
- The findings from recurring inspections are evaluated.

Experiences from the operation of similar facilities are incorporated into operation management. For this purpose, procedures are put in place to ensure an exchange of experience (e.g. on the basis of operating reports) between the operators.

In addition, GRS evaluates generally accessible international sources on behalf of the BMU with regard to any disturbances, incidents and accidents in foreign nuclear fuel cycle facilities. The information is stored in the database for incidents in fuel cycle facilities (VIBS). At regular intervals, information on newly recorded events is submitted to the supervisory authorities, operators and authorised experts by means of database excerpts and short assessments, who then examine 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 experience, 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, incidents and accidents 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 management facilities are designed and constructed in such a way that they can be decommissioned in compliance with the radiation protection regulations and either put to further use or removed. Proof to this effect is checked during the course of the nuclear licensing procedure. Information on changes to the licensed condition must either be submitted to the supervisory authority or, in case of significant modifications, to the licensing authority for approval.

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 heat-generating radioactive waste from reprocessing (high-level and intermediate-level waste). The issue of site selection for the disposal of spent fuel and heat-generating radioactive waste from reprocessing is reported on in Chapter H.3.2.

H Safety of radioactive waste management

Developments since the Sixth Review Meeting:

In a statement of 26 July 2018, the Nuclear Waste Management Commission (ESK) defined safety-related and logistical requirements for a central reception storage facility for the Konrad repository with special consideration of safety issues [4-31].

This section deals with the obligations under Articles 11 to 17 of the Joint Convention. As for the safety of the management of heat-generating radioactive waste, the reporting in Section G applies.

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 rules and regulations require that criticality is to be prevented and residual heat is to be removed in a suitable form. Within the framework of comprehensive site-specific safety analyses e.g. for the Konrad repository for radioactive waste with negligible heat generation, 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 requirements for the radioactive waste to be emplaced in a disposal facility (waste acceptance criteria for disposal for the Konrad repository [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-closure phases of this facility that each criticality is avoided and that the removal of the residual heat arising is taken into account.

Furthermore, the reporting on Article 4 applies analogously to Articles 11(i) to (vii).

H.1.2 Limitation of the generation of radioactive waste

The pre-treatment of residual radioactive material that cannot be cleared serves to reduce the volume and to convert the raw waste into manageable intermediate products that can be conditioned for disposal. All radioactive waste is sorted when it is produced and documented according to type, content and activity. The Nuclear Waste Management Ordinance (AtEV) [1B-19] and the "Guideline for the Control of Residual Radioactive Materials and Radioactive Waste" [3-60] specify the sorting criteria and the requirements for recording, determining the activity and documentation. The waste producers can thus provide information on the activity and whereabouts of all radioactive waste at any time.

Furthermore, the reporting on Article 4 applies 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 for the treatment of radioactive waste 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. Through the granting of the licence, the competent licensing authority has confirmed that this prerequisite has been fulfilled. Following the commissioning of a facility, its safety is also reviewed 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 Act (StrlSchG) [1A-34], in the Radiation Protection Ordinance (StrlSchV) [1A-8a] and in other legal and subordinate regulations. The safety standards of the International Atomic Energy Agency (IAEA) (above all *IAEA Safety Standards Series No. GSR Part 5* [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 protection of property against the effects of ionising radiation (see reporting on Article 11 and 4 in Chapters H.1 bzw. G.1, respectively). Compliance with these protection goals also satisfies the requirements of the Joint 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 radioactive waste and facilities for the treatment and storage of radioactive waste with negligible heat generation.

Safety of facilities for the treatment and storage of heat-generating radioactive waste

In the Gorleben spent fuel storage facility (BZG), not only spent fuel but also vitrified high-level 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-level waste in the BZG as those referred to in Chapter G.2 with regard to Article 5.

The vitrified intermediate level decontamination and flush waters from reprocessing in France (*Colis Standard de Déchets – Boues;* CSD-B*)* were originally also dedicated to be stored at BZG. The entry into force of the Site Selection Act (StandAG 2013) [1A-7a] resulted in the amendment of the AtG. According to § 9a(2a) AtG, the operator of facilities for the fission of nuclear fuels for the commercial electricity generation now has to ensure that the solidified fission product solutions from the reprocessing of spent fuel abroad will be taken back and stored in local fuel assembly storage facilities until their delivery to a facility for the disposal of radioactive waste (see the reporting in Chapter D.4.1 "Return of reprocessing waste from other European countries“).

For the Ahaus spent fuel storage facility (BZA), the storage of compacted intermediate-level hulls and structural parts of German fuel assemblies (*Colis Standard de Déchets – Compactés;* CSD-C) from the French reprocessing plant at La Hague has been applied for. A new cask concept is currently under preparation; the licensing procedure has not yet been concluded.

The high-level active waste concentrate (HAWC) solutions from the operation of the Karlsruhe Reprocessing Plant (WAK) were fully vitrified at the Karlsruhe vitrification facility (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 North (ZLN). The former storage facilities and the VEK are being dismantled; this forms part of the decommissioning of the reprocessing plant.

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, working space and control rooms.

Safety of facilities for the treatment and storage of radioactive waste with negligible heat generation

Radioactive waste with negligible heat generation is put in storage, either at the place where it is generated or in central facilities, until it can be disposed of in a disposal facility. As a disposal facility in Germany will not be available before the year 2027, conditioning has to be such that safe storage is guaranteed even for periods of up to 30 years. Recommendations for the storage of radioactive waste with negligible heat generation irrespective of the kind of storage are made in the corresponding guidelines [3-151] (see the remarks in Chapter H.5.1 on Article 15(i)). In addition, the statement of the Nuclear Waste Management Commission (ESK) on the “Implementation of the ESK guidelines for the storage of radioactive waste with negligible heat generation” of 2018 [4-16a] as well as the recommendation “Harmonisation of reporting criteria for occurrences involving radioactive waste with negligible heat generation” of March 2018 [4-32] deal with the safety of these.

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 packed in qualified containers. The conditioning facilities are almost all assigned to specific nuclear installations and are subject to licensing, monitoring and supervision by the competent local authority. The safety of the conditioning facilities was assessed in the licensing procedure. During operation, regulatory control ensures that safety-related requirements are fulfilled. This also applies to mobile conditioning facilities (see Table L-6).

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 the prescribed 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.

Several facilities take measures to ensure safety during extended storage. These comprise, e.g., updates of the documentation pertaining to the waste, technical inspections of the waste packages and – if necessary – their repackaging or emplacement in additional enveloping containers. The requirements for extended storage are described in detail in the remarks in Chapter H.5.1 on Article 15(i).

As expressed in the remarks in Chapter D.3.2 on Article 32(2)(iii), two different types of 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 storage facilities of the operators of nuclear installations who – according to the polluter pays principle – are responsible for the lawful and safe treatment of their radioactive waste. With the transfer of the financing responsibility for storage from the nuclear power plant licensees to the fund, the storage facilities are operated by the federally-owned BGZ Company for Storage (BGZ), see Chapter D.3.2. In these storage facilities, waste that has been technically correctly packaged as well as waste that has not yet been conditioned can be stored. The waste that has been technically correctly packaged is handed over by the licensees to the Federal Government (BGZ), while the waste that has not yet been conditioned and product-controlled remains the licensees’ property and responsibility.These storage facilities require a licence according to § 12

StrlSchG, to be issued by the respective competent *Land* authority. In addition, radioactive waste can be stored in rooms of the power plant covered by the licence pursuant to § 7 AtG. At the Isar, Grohnde and Brokdorf sites, applications have been submitted for licenses to handle radioactive materials in transport allocation halls for radioactive waste and residual materials that are to be built. These storage facilities are not listed in the Act on the Reorganisation of Responsibility for Nuclear Waste Disposal (EntsorgÜG) [1A-35].

In contrast, radioactive waste from research, industrial or medical application are to be delivered 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, these *Land* collecting facilities have to be established 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 also requires licensing according to § 12 StrlSchG by the competent *Land* authority. Within the licensing procedure it is examined whether relevant safety requirements are fulfilled. If the radioactive waste is not only stored but also treated at the *Land* collecting facility, the regulations have to be applied accordingly (see remarks in Chapter H.5 on Article 15).

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 it is checked 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. The actual acceptance of the declared radioactive waste follows the incoming inspection by the *Land* collecting facility.

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 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 it has been 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 in exceptional cases be delivered by special agreement, subject to the consent of the competent supervisory authority.

Figure H-1: Berlin *Land* collecting facility (Copyright: 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 producer's duties in connection with conditioning are thus adopted for this waste by the operator of the *Land* collecting facility.

The acceptance criteria are laid down in the licence in line with the state of the art in science and technology and are oriented on the waste acceptance criteria for disposal in the Konrad repository [BfS 14a]. Each year, the individual operators of *Land* collecting facilities hold a meeting for the purpose of exchanging information.

The recommendations of the ESK for the storage of radioactive waste with negligible heat generation [3-151] 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 and results have to be reported to the supervisory authority responsible for storage.

Following the nuclear disaster at Fukushima, the facilities for the management of radioactive waste in Germany were subjected to a stress test, see Chapter G.5.3.

H.2.2 Past practices

Past practices as defined by the Joint 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 remediated for radiological and other reasons. Cataloguing and categorisation of the legacy sites has largely been completed in Germany.

Past practices with respect to uranium mining and milling were 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 residual materials from former uranium ore mining are not counted as radioactive 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 2020.

When the new radiation protection law came into force on 31 December 2018, the regulations of the former German Democratic Republic (GDR) which continued to apply under Article 9(2) in conjunction with Annex II, Chapter XII, Section III nos. 2 and 3 of the Unification Treaty of 31 August 1990 [1A-4] ceased to apply. Since then, uniform federal regulations for contaminated sites have been in force (§§ 136 et seqq. Radiation Protection Act (StrlSchG) [1A-34] in conjunction with § 160 et seqq. Radiation Protection Ordinance (StrlSchV) [1A-8b]). The requirements and criteria formulated there for the management of contaminated sites also apply to the decommissioning and remediation of uranium ore mining facilities and sites. In view of the complexity of the projects in the field of decommissioning and remediation of uranium ore mining facilities and sites, Section 149 StrlSchG stipulates that planned measures in the area of Wismut GmbH require approval by the competent authority. Essentially, the material requirements reflected in the licensing conditions are compatible with the standards applied before 31 December 2018 for decommissioning and remediation projects in the Wismut area. In this respect, there are no fundamental changes or conceptual discontinuities, neither regarding the course of procedures nor in connection with the material requirements and approaches.

A national legal consideration of the residual materials from uranium ore mining and processing according to the regulations of the Radiation Protection Act and the Radiation Protection Ordinance does not contradict the requirements or the purpose of the Joint Convention. What is essential for reaching the objectives of the Joint Convention (Article 1) and the efficiency of the review process 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 (BfS), the residual materials present at those sites amount to about $46.5 \cdot 10^6$ m³ of heaps and about $4.7 \cdot 10^6$ m³ of mill tailings.

According to § 11(8) of the former Precautionary Radiation Protection Act (StrVG) [1A-5], the BfS was responsible for the determination of the natural environmental radioactivity originating from mining operation 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:

- Processing 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 processing facilities),
- heaps (stockpiles of excavation material from mining or mechanical ore processing or of residual materials of metallurgic processes (slags)),
- prospected sites (shallow outcrops on small areas for exploration of ores or raw materials),
- galleries (horizontal drifts),
- shafts (vertical drifts),
- open pits and cavities (not being backfilled),
- 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 not located on 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 are needed. 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 so-called 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 and were also discussed extensively in area-specific reports. The data and information are available to the competent authorities of the *Länder* of 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 can be 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* of 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.

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 4.

The siting process to be outlined according to Article 13 refers to radioactive waste management facilities including disposal facilities. 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 (see reporting on Article 6 in Chapter G.3), the relevant information is merely summarised here and reference is made to the appropriate sections.

H.3.1 Siting of 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 reporting on Article 6 in Chapter G.3 applies accordingly.

For the other installations for radioactive waste management, only the handling of radioactive substances requires a licence according to § 12 of the Radiation Protection Act (StrlSchG) [1A-34], depending on the nature of the facility. In contrast to the licensing procedures according to §§ 6 or 7 AtG, this licensing procedure according to § 12 StrlSchG is in principle not regulated by the Nuclear Licensing Procedure Ordinance (AtVfV) [1A-10]. An exception is the case where the respective use requires an environmental impact assessment (EIA) according to the requirements in the Environmental Impact Assessment Act (UVPG) [1B-14]. 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 requirements which must be met for being granted a handling licence for such a facility are described in § 13(1) StrlSchG. 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.

In addition, the following facilities (see Appendix 1 of the UVPG) require a general preliminary assessment of each individual case according to § 35 UVPG:

"11.2 Construction and operation of a facility for the safekeeping or disposal of radioactive waste,

11.3 Construction and operation of a facility for the handling or management of irradiated fuel assemblies or highly radioactive waste."

In addition, the following facilities (see Appendix 1 of the UVPG) require a general preliminary assessment of each individual case according to § 35 UVPG:

*"11.4 Construction and operation of a facility 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 Radiation Protection Act and compliance with such limits does not require any measures for mitigating the consequences of deviations from specified normal operation" (*according to § 106 Radiation Protection Ordinance (StrSchV) [1A-8b], such activities are defined as 10^7 times the exemption levels as specified in Appendix 4, Table 1, column 2 StrlSchV in the case of unsealed radioactive material and 10^{10} times the exemption levels as specified in Appendix 4, Table 1, Column 2 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 3 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 EIA is required.

Where the cases listed above pertain to the planned radioactive waste management facility and if an EIA is required for the facilities listed in point 11.4, the type of information outlined in the remarks on Article 6(1)(i) and Article 6(1)(ii) in Chapters G.3.1 and G.3.2 must be provided. This also implies the involvement of the general public (see reporting on Article 6(1)(iii) in Chapter G.3.3) as well as the participation of other authorities and, where applicable, the participation of authorities of other countries (see reporting on Article 6(1)(iv) in Chapter G.3.4).

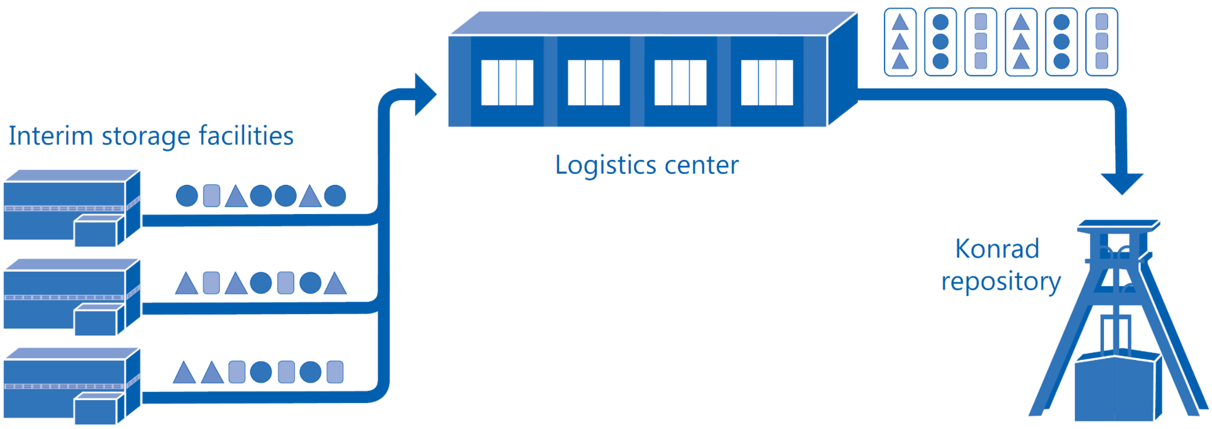
The Nuclear Waste Management Commission (ESK) "Guidelines for the Storage of Radioactive Waste with Negligible Heat Generation" [3-151] summarise the requirements especially for storage facilities. They describe, i.a., the preference of passive to active safety systems, the great importance of the casks 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.

Logistics Centre for the Konrad repository

The establishment of the Logistics Centre for the Konrad repository (LoK) on the site of the former Würgassen nuclear power plant is to create the prerequisites for a simplified and faster emplacement operation of the Konrad repository. BGZ Company for Storage (BGZ) is responsible for the planning, construction and operation of the LoK. At present (as at May 2020), the basic fundamentals for the requisite licences are being prepared.

From 2027 on, the low- and intermediate-level radioactive waste intended for the Konrad repository is to be collected in the LoK at Würgassen and buffered for disposal (see Figure H-2). As the LoK will provide access to a larger number of waste containers, it will be possible to combine the waste into precisely fitting batches for emplacement in terms of quantity and time. Such precision would not be ensured in the various storage facilities due to the storage situation there.

Figure H-2: Schematic diagram of the processes in the LoK (Copyright: BGZ)

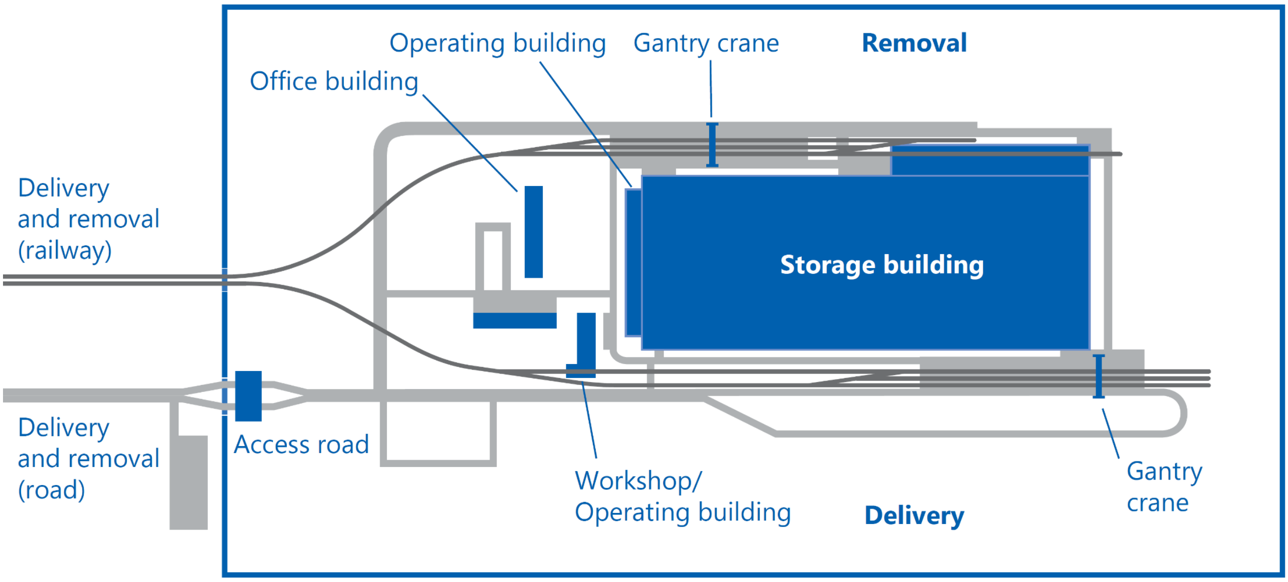


The central element of the LoK is a reinforced-concrete hall with separate areas for the delivery and dispatch of already professionally packed waste. The hall is divided into storage, treatment and loading areas. The storage capacity of the LoK will be around 60,000 m^3, which corresponds to about 15,000 waste containers.

The waste containers are usually transported in transport casks, preferably by rail using freight trains and - if necessary - by road using trucks (see Figure H-3). The predominant part of the containers from the decentralised storage facilities is to be delivered to the LoK by rail. Transport from the LoK to the Konrad repository is to be carried out almost exclusively by rail.

On its LoK website, BGZ provides information about the planning and developments of the project (www.logistikzentrum-konrad.de).

Figure H-3: Schematic, site-independent diagram of the LoK site plan (Copyright: BGZ)



Asse II mine

A precondition for retrieval of the radioactive waste from the Asse II mine is a dedicated storage facility. Furthermore, conditioning of the radioactive waste is necessary for its storage and later disposal in a yet to be determined disposal facility.

The preliminary planning for the storage facility has been completed. The completion of the concept design for the storage facility building, which has in part been started, depends on the site of the storage facility. The formerly competent Federal Office for Radiation Protection (BfS) has set up criteria for the selection of a storage facility site and discussed these with the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Asse II advisory group (*Asse-II-Begleitgruppe*). As a result, a report on the criteria [BfS 14] has been presented in January 2014. The first step was to look for possible sites in the vicinity of the grounds of the mine. The storage site should be linked with the mine site. Only if no suitable areas close to the Asse II mine could be found, the site selection radius would have been extended. The Asse II advisory group requires the inclusion of sites outside the region.

In connection with the storage site selection, the BfS presented two parameter studies on radiological impacts of a storage and on the subsequent transportation procedures. To better justify the approach of the BfS (to consider first the vicinity of Asse II), the direct radiation from the plant resulting from the facility during normal operation at varying distances to residential areas was investigated. In addition, the direct radiation was compared with radiation exposures resulting from waste transport to storage facility sites away from Asse II. Incident analyses as well as the effects of the exhaust air during normal operation were not subject of this parameter study; these are only feasible based on concrete site data. As consideration of the aspects of accident analysis and effect of the exhaust air were explicitly desired during the advisory process, these issues were incorporated into a second parameter study based on data of a real but anonymous site. The results of both parameter studies were presented to the advisory group und published by the BfS [BfS 16a].

Current planning provides for the facilities for waste treatment and storage to be completed and ready for accepting waste by the year 2033.

§ 57b AtG ("Lex Asse") [1A-26], which was amended in 2013, offers the possibility of combining several procedural steps of the EIA if expedient.

H.3.2 Siting of disposal facilities

Disposal facility for high-level radioactive waste

On 5 May 2017, the amended Site Selection Act (StandAG) [1A-7b] entered into force. With the further development of the Act, concrete regulations on a comprehensive participation procedure were introduced by setting up new formats in the various phases of the site selection procedure, such as the "Subareas Conference", the "Regional Conferences" and the "Council of the Regions Conference". Furthermore, the individual phases of the site selection procedure were specified in more detail and the criteria and requirements to be applied in the procedure were defined in order to allow early public participation and to create transparency in the procedure. The amendment introduced extended legal protection for persons affected by a selection decision and an obligation for the supervisory authority to document all relevant data. The task of site protection was introduced in order to protect areas that could be considered the best possible site for a disposal facility from significant underground damage by third-party projects. These measures within the amended Site Selection Act are intended to achieve both transparency and comprehensibility of the site selection procedure and thus ultimately acceptance of the decision on a site.

§ 26(3) and § 27(6) StandAG contain powers to issue statutory ordinances to decree safety requirements for the disposal of high-level radioactive waste and requirements for the conduct of preliminary safety analyses in the site selection procedure for a disposal facility for high-level radioactive waste. Corresponding statutory ordinances are in preparation. They will be based on the "Safety Requirements for the Disposal of Heat-Generating Radioactive Waste" of 2010 [BMU 10], but will also concretise the provisions of the Site Selection Act and take into account the recommendations of the Commission on Storage of High-Level Radioactive Waste. Furthermore, the ordinance will regulate the procedure for the performance of preliminary safety analyses in the site selection procedure for a disposal facility for high-level radioactive waste.

The supervisory authority for the implementation of the site selection procedure for a disposal facility is the Federal Office for the Safety of Nuclear Waste Management (BASE) that was founded in 2014 and is currently being further expanded. Apart from the supervision of the implementation of the procedure, the essential tasks of the BASE regarding the site selection procedure are reviewing reports of the project implementer, specifying the site-specific exploration programmes and assessment criteria for the site selection procedure for a disposal facility as well as public information and participation. Once the German Bundestag has decided on a site, which is aimed to happen in the year 2031, the BASE will act as licensing and supervisory authority for the disposal facility for high-level radioactive waste. The various tasks of supervision of the site selection procedure (before the site decision) and of supervision/licensing of the disposal facility (after the site decision) are separated within BASE in terms of organisation and personnel and are placed within the competence of different departments.

The Federal Company for Radioactive Waste Disposal (BGE) was assigned to perform the duties as the project implementer with effect from 25 April 2017. The BGE is responsible for the implementation of the site selection procedure for a disposal facility according to mandatory requirements.

The site selection procedure for a disposal facility is to be divided into three phases:

- In a first step of the first phase, geo-scientific exclusion criteria and minimum requirements will be applied to the entire territory of the Federal Republic of Germany. Subsequently, subareas with favourable geological conditions will be selected by applying geoscientific weighing criteria. The results will be published in an interim report. The BASE will then convene a Subareas Conference. Within these subareas, site regions for surface exploration will be selected in a second step by further refinement and by applying scientific planning criteria as well as on the basis of results of preliminary representative safety analyses. The BASE will then convene a Regional Conference in each of the site regions suggested for above-ground exploration as well as a conference of the Council of the Regions. The proposal will be decided by federal law.

- In the second phase, the surface exploration of the selected site regions will be carried out. The exploration results will be incorporated in refined preliminary safety analyses, and on this basis the site regions will be compared again according to exclusion criteria, minimum requirements and weighing criteria. The result will be a proposal of sites that are to be explored underground. This proposal, too, will be decided by federal law.
- In the third phase, the underground exploration of the selected sites will be carried out. Comprehensive preliminary safety analyses and comparative analyses of the remaining potential sites aim at selecting the site that ensures the best possible safety for a period of one million years. This phase will be completed with the determination of the site for a disposal facility by federal law. After this final decision on the site, the BGE will assume the task of the applicant in the nuclear licensing procedure, conducted by the BASE as a licensing authority.

All phases of the site selection procedure for a disposal facility are to be accompanied by intensive public involvement and participation. The BASE is responsible for the public participation in the site selection procedure for a disposal facility. The BGE, as the project implementer, will inform about its measures taken within the frame of the site selection procedure for a disposal facility. As the social authority, the “National Civil Society Board” was established at national level in November 2016 (see the remarks in Chapter E.2.2 on the Site Selection Act). At the level of the regions concerned, the so-called regional conferences will be institutionalised. They shall be provided with necessary appropriations to be able to accompany the site selection procedure for a disposal facility critically and constructively by involving independent expertise. The Regional Conferences exist as long as the respective region has not dropped out of the selection process. A Council of the Regions will improve networking of the regions concerned by the site selection procedure for a disposal facility, including the communities of the existing storage facilities for radioactive waste that are already affected by the future disposal issue.

Currently, the criteria and requirements under the Site Selection Act are applied on the basis of geodata, information, and with the aid of three-dimensional geological models provided by the competent authorities in the individual *Länder* and the federal government. The aim here is to designate subareas where favourable geological conditions for the safe disposal of high-level radioactive waste can be expected. The results will be published at the end of the third quarter of 2020 and submitted to the BASE without delay. In the interim report, all facts and considerations relevant to the selection of subareas will be presented. If there are areas that cannot be classified due to insufficient geological data, these also have to be listed and a recommendation on how to deal with them in the future has to be included.

After receipt of the interim report, the BASE will convene a subareas conference.

Disposal facility for radioactive waste with negligible heat generation – Konrad repository

The Konrad mine was plan-approved as a disposal facility for radioactive waste with negligible heat generation and affirmed in 2007 by the administrative court. Construction of the disposal facility is underway (see the reporting in Chapter D.3.3).

Disposal facility for radioactive waste with negligible heat generation that may not be qualified for disposal in the Konrad repository

In the National Programme (NaPro) for spent fuel and radioactive waste management [BMU 15] and in the discussion paper of the Nuclear Waste Management Commission (ESK) [4-23] relating to it, the types and roughly estimated amounts of radioactive waste with negligible heat generation which cannot be disposed of in the Konrad repository are specified in the following:

- in case that there will be no further reutilisation, the expected waste package volume of waste resulting from uranium enrichment is approx. 100,000 m³ of depleted uranium,
- waste to be retrieved from the Asse II mine (approx. 220,000 m³),
- other waste that is not qualified for emplacement in the Konrad repository due to its nuclide inventory and/or its chemical composition or the time of its generation.

According to the NaPro, the additional disposal of the above-mentioned radioactive waste with negligible heat generation at the site of the disposal facility for heat-generating (high-level radioactive) waste is to be examined. Nevertheless, in the site selection procedure for a disposal facility, priority is given to the realisation of a disposal facility for high-level radioactive waste. Additional storage of radioactive waste with negligible heat generation at the same site must not lead to a safety level reduction for high-level radioactive waste or to an exclusion of sites due to the insufficient area size for radioactive waste with negligible heat generation.

H.3.3 Research activities and international cooperation in the field of waste management

The general programmatic fundamentals as well as the research objectives and promotion areas in the field of waste management are formulated in the 7th Energy Research Programme of the Federal Government, "Innovations for the Energy Transition". The ministry in charge of the fundamental, site-independent waste management research is the Federal Ministry for Economic Affairs and Energy (BMWi).

The research that is carried out contributes to the continual development of the state of the art in science and technology as demanded i.a. by the Atomic Energy Act (AtG) [1A-3] so that the stringent requirements for the safe handling and management of the radioactive waste and spent fuel are met. Furthermore, the research activities contribute substantially to the development and maintenance of scientific and technical competence and promotion of young researchers in the field of radioactive waste management.

A significant contribution to the waste management research and, especially, to the research on radioactive waste disposal and to the international cooperation is made by the German Association of Repository Research (DAEF) founded on 16 January 2013. The aim of the DAEF is the further development and expansion of cooperation of its members and the use of their cumulative expertise in the field of research on radioactive waste disposal. The DAEF offers scientific and technical advice to the Federal Government and the Federal and *Land* authorities as well as to the *Bundestag* and other interested institutions. Currently, 14 research institutions and universities focusing on the research on radioactive waste disposal are members of the DAEF.

For more than three decades, German scientists have been involved in international research projects on waste management and disposal 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, on the one hand, there is no underground laboratory in Germany but on the other hand, there is the need to carry out specific studies and experiments under realistic conditions, cooperation – especially in underground laboratories (Mt. Terri (CH), Grimsel (CH), Äspö (S), Bure (F), Bukov (CZ)) – and the participation in demonstration projects is of great importance and has to be considered indispensable. This cooperation does not only substantially develop further the state of knowledge on clay stone and crystalline rock in Germany; it also creates the basis for assessing non-saline host rock types. Furthermore, thanks to these research activities, it is possible to build up and expand considerable knowledge in German organisations, allowing well-founded evaluations and assessments of disposal facility concepts in all host rock types. The research activities that lie within the responsibility of the BMWi and are carried out by German research institutions as part of international cooperations are performed within the framework of the EU's research framework programmes, bilateral agreements with waste management organisations, by way of project-funded participation in multilateral consortia, and as part of direct contractual agreements of scientific and technical cooperation.

International cooperation takes place predominantly with organisations from other European countries and with the United States of America, the Russian Federation, and China.

In the EU context, several German research institutions participate in the European Joint Programme on Radioactive Waste Management (EURAD). In addition, German interests in waste management research are also represented by participation in the European technology platform Implementing Geological Disposal of Radioactive Waste - Technology Platform (IGD-TP). Within the framework of OECD/NEA cooperations, German institutions participate in the Integration Group for the Safety Case (IGSC) and in the Working Party on Information, Data and Knowledge Management (WP-IDKM), the Working Group on the Characterisation, the Understanding and the Performance of Argillaceous Rocks as Repository Host Formations (CLAY CLUB), in the Expert Group on Repositories in Rock Salt Formations (SALT CLUB), in the Expert Group on Repositories in Crystalline Formations (CRYSTALLINE CLUB) and in the Expert Group on Operational Safety (EGOS).

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], the Radiation Protection Act (StrlSchG) [1A-34] and the Radiation Protection Ordinance (StrlSchV) [1A-8b]), and the contents 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-(d)).

The realisation of these requirements creates the prerequisites for compliance with the radiation exposure limits for persons who are occupationally exposed to radiation as well as for the population in the surrounding area during operation of the facility, as stipulated in § 78 and § 80 StrlSchV, respectively.

Radiological protection of the 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 management 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 waste packages,
- the design of the walls from the point of view of shielding,
- the possibility to decontaminate wall and floor surfaces,
- 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 management 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 the shielding effect of the walls of the controlled area already mentioned above under the aspect of radiological protection of operating personnel, which also serve to limit direct radiation at the site and in the vicinity of the facility in accordance with § 80 StrlSchG, appropriate technical equipment must also be provided to limit the discharge of radioactive substances with air or water, in order to comply with the limit of 0.3 mSv per calendar year that is specified in § 99(1) StrlSchV for the effective dose from the exposure due to the discharge of radioactive substances from these facilities with air or water for members of the general public 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 discharges 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 § 104(3) and (4) StrlSchV, the conceptual planning of radioactive waste management facilities (storage facilities, conditioning facilities, disposal facilities) 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 § 104(1) and (2) StrlSchV, the planning of structural or other technical protective measures against design basis accidents in or around a disposal facility 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 design basis 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, with 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 installations (see [3-73]). With regard to facilities for the dry storage of high-level waste casks, the guidelines of the Nuclear Waste Management Commission (ESK) [3-150] must also be applied. These guidelines state that a storage facility must be designed and constructed 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.

For this reason, a corresponding concept for decommissioning must already be available at the design and construction stage of the facility. This concept includes specifications regarding the intended decommissioning strategy, which depends primarily on whether the radioactive waste management facility is constructed as part of a major nuclear installation, thus being integrated into the decommissioning procedure of this installation, 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-sources, contamination from alpha-emitting nuclides may also be present.

The requirements relating to the proposed decontamination methods take into account the need to reduce individual and collective doses to achieve a condition adequate for the performance of decommissioning work, as well as the reduction of volume and the management of residual materials 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 as a residual material for reuse, conventional disposal, or disposal as radioactive waste.

The decommissioning of the Karlsruhe vitrification facility (VEK), for example, will primarily be performed using the equipment required for operation, which was already considered in the 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 disposal facility

Upon termination of the operational phase, a disposal facility 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, i.e. no longer used and backfilled with suitable material. This way, a disposal facility 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 disposal facility. 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(4) of the Atomic Energy Act (AtG) [1A-3] in conjunction with § 7(2)(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 facility"*.

According to the BMU's safety requirements of 2010 [BMU 10], it has to be demonstrated for a disposal facility for high-level radioactive waste to be constructed that an additional effective dose in the range of 10 µSv per calendar year in the case of probable events and processes and of 100 µSv per calendar year in the case of less probable events and processes will not be exceeded in the post-closure phase. Corresponding requirements will also be contained in the Ordinance on Safety Requirements for the Disposal of High-Level Radioactive Waste, which will replace the BMU's safety requirements of 2010.

It has to be ensured on the basis of requirements, codes and guides and legal requirements from various areas of law that detrimental environmental impacts are avoided or limited to the bare minimum. For example, 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 the licensing procedure for a disposal facility, a closure concept has to be presented and included in the long-term safety case. The measures to be taken upon the cessation of emplacement operations are specified. The nature and manner of its 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 management of spent fuel. As such, the reporting on Article 7(iii) in Chapter G.3.4 applies 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 disposal facilities), and the assessment of environmental impacts prior to construction of such a facility, are carried out as part of a licensing procedure (see reporting on Article 19 in Chapter E.2.3). An assessment of the safety and of the environmental impacts prior to commissioning takes place within the framework of the accompanying nuclear regulatory supervision (see Chapter H.5.3 for details).

Regulatory basis

Under § 12 of the Radiation Protection Act (StrlSchG) [1A-34], the handling of radioactive materials in facilities for the management of radioactive waste requires a licence.

A special case is the licence for construction of a vitrification facility in accordance with § 7 of the Atomic Energy Act (AtG) [1A-3], since apart from the processing of high-level 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 reporting on Article 8 and apply mutatis mutandis to the licensing procedure for facilities for the vitrification of high-level waste.

Whereas the licence pursuant to § 7 AtG combines the licences required for the construction and operation of the nuclear installation and for the handling of nuclear fuels (see reporting on Article 8 in Chapter G.5), § 12 StrlSchG regulates only the handling of radioactive materials. A building permit under the applicable building law must also be applied for. Disposal facilities for radioactive waste are subject to authorisation under § 9b AtG.

Applications for licences under the Atomic Energy Act must be submitted to the competent authority of the respective *Land* (for disposal facilities at the Federal Office for the Safety of Nuclear Waste Management (BASE)). The application must outline the extent to which the nuclear installation or facility possesses the required safety characteristics and conforms to the specifications of the applicable regulations. According to § 16 StrlSchG, the documents listed in Appendix 2 StrSchG must be enclosed with the licence application in the licensing procedure. The preconditions for a licence for handling radioactive materials are governed by § 13 StrlSchG. They are described in detail in the reporting on Article 19.

Regulatory review

Among other things, one licensing condition is that on handling radioactive waste, the equipment must be available and the measures must be taken in accordance with the state of the art in science and technology to ensure that the protective provisions are observed (§ 13 StrlSchG). The standards of the Nuclear Safety Standards Commission (KTA) and the German Standards Institute (DIN) and of the German Association of Electrical Engineers (VDE) are used as the basis for checking the licensing requirements and are applied mutatis mutandis. During the course of reviewing the licensing requirements, the competent licensing authority may consult authorized experts under § 20 AtG.

According to the Environmental Impact Assessment Act (UVPG) [1B-14], an environmental impact assessment (EIA) is mandatory for nuclear installations designed to store radioactive waste for more than ten years at a location other than that where they were generated, and for nuclear installations requiring a licence under § 7 AtG. For facilities which provide for the storage of radioactive waste for less than ten years, a basic requirement of performing an EIA is not defined. However, it also applies to facilities that do not require an EIA that all radiological effects have to be examined within the framework of the safety assessments in the licensing procedure. More information on the EIA can be found in the reporting on Article 13 in Chapter H.3.1 and on Article 6 in Chapter G.3.1, respectively.

In addition, the Environmental Impact Assessment Act provides for general screening of individual cases in the case of nuclear installations for the storage, handling, or processing of radioactive waste whose activity inventories reach or exceed the values specified in § 11 of the Radiation Protection Ordinance (StrlSchV) [1A-8b] in combination with Appendix 4 Table 1 StrlSchV (see Chapter F.5.1) for details). For such facilities, an EIA must be performed if the competent authority feels that the project may have substantial adverse environmental impacts.

According to § 12b AtG, 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 (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 management of radioactive waste are shown by the example of the requirements for storage facilities.

In 2002, the Reactor Safety Commission (RSK) prepared safety requirements in particular for the storage of radioactive waste with negligible heat generation. These were last updated by the Nuclear Waste Management Commission (ESK) in February 2013 [3-151]. 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 management of radioactive waste, these safety requirements have to be applied at least to their storage areas and in analogy to the areas where processing takes place.

Facilities for the storage of radioactive waste are generally designed for the handling and storage of radioactive materials 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 airborne and liquid releases of radioactive substances.

According to the “Guidelines for the Storage of Radioactive Waste with Negligible Heat Generation” [3-151], among others the following requirements for the waste products and packages have to be fulfilled:

- Over the storage period until disposal, the waste products and waste containers have to be sufficiently chemically/physically stable. 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 extended storage. Requirements regarding the data to be documented are specified in Appendix Part B of the Nuclear Waste Management Ordinance (AtEV) [1B-19]. Access to and legibility of the documentation has to be guaranteed until the waste is emplaced in a disposal facility or released according to § 31 StrlSchV.
- In view of the principles of radiation protection, especially the ALARA principle, handling and surveillance measures within the storage area requiring the presence of staff 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 disposal facility.

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, for the transport into an external storage facility or for the transport to the disposal facility, 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 [3-151]:

- The design of the waste containers has to be such that their handling can also be ensured during and after storage. The long-term integrity has to be ensured by means of an adequate design of the waste containers (e.g. corrosion protection, thick-walled containers). Possible impairments of the container integrity caused by impacts from the interior of the container (characteristics of the waste product) and from the outside (e.g. atmospheric conditions of the storage facility) have to be considered. Analogous considerations apply to the storage of large components.
- If the waste containers or large components are not qualified for extended 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 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 [3-151] contains, among others, requirements for structural and technical installations in order to limit the effects of accidents. The physical structures 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, the planning levels according to § 104 StrlSchV have to be applied as a basis.

- Within the framework of an accident analysis it has to be examined which operational incidents and accidents 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 facility-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 components (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.

Adaptation during operation period

The terms of validity of the licences for the storage of radioactive waste with negligible heat generation are set differently from one *Land* 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 subsequent obligations.

H.5.2 Assessment of safety before construction of a disposal facility

Assessment of post-closure safety before construction of a disposal facility

§ 9b as well as § 7(2)(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 disposal facility. 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 regarding dose values may be provided in the form of model calculations. These calculations are used to determine and quantify potential releases of radionuclides from the disposal facility through the geosphere into the biosphere and to calculate the possible radiation exposure of humans using a variety of calculation models. 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.

Further verification obligations in connection with the long-term safety assessment of a disposal facility for high-level radioactive waste will be included in the corresponding ordinance. These include, among other things, requirements for the safe containment of the radioactive waste, the robustness of the barrier system, and the assurance of subcriticality. According to § 1(2) of the Site Selection Act (StandAG) [1A-7b], the period to be considered is one million years.

Assessment of impacts on the environment

§ 9b AtG stipulates that a plan approval procedure is mandatory for radioactive waste disposal facilities. The plan approval decision may only be granted if the prerequisites listed in the aforementioned section of the Atomic Energy Act have been met by the applicant (see reporting on Article 11(i) to (iv) in Chapter H.1). 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) [1B-22] regulate the details and implementation of the plan approval procedure according to the Atomic Energy Act. In addition, the Environmental Impact Assessment Act (UVPG) [1B-14] requires the performance of an environmental impact assessment (EIA). Stipulating that the state of the art in science and technology is a prerequisite for the plan approval decision ensures that the safety assessments and the environmental impact assessment are up-to-date at the time of issuing the plan approval decision.

In the cases where siting of a disposal facility is determined by federal law, a licensing procedure substitutes the plan approval procedure. This currently applies exclusively to the site for a disposal facility for high-level radioactive waste to be selected according to the Site Selection Act. Here, too, the licence comprises the authorisation of all public interests affected by it.

H.5.3 Assessment of safety before the operation of radioactive waste management facilities

Under § 19 of the Atomic Energy Act (AtG) [1A-3], the handling of radioactive substances is subject to government supervision. An assessment of the safety and the environmental impacts prior to commissioning of the nuclear installation occurs within the context of supervision under the Atomic Energy Act which accompanies construction.

If major deviations in the handling as specified in the licensing documents are intended between the time of licensing until the commissioning of a facility for the management of radioactive waste, licensing under § 12 of the Radiation Protection Act (StrlSchG) [1A-34] 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 licensing 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 modification 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 (EIA).

H.5.4 Stress test

The earthquake off the Japanese coast on 11 March 2011 and the resulting flooding by a tsunami at the Fukushima site prompted the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) to carry out a stress test of all nuclear installations and facilities.

The results of the stress test of March 2013 are documented in two statements of the Nuclear Waste Management Commission (ESK) [4-11] (see the reporting in Chapter G.5.3).

Regarding the storage facilities for low- and intermediate-level waste and the stationary facilities for conditioning low- and intermediate-level waste, the investigations showed that even in case of beyond-design-basis accidents, serious consequences are generally limited to an area of no more than

100 metres around the respective facility. Authorities must therefore decide for an area of maximum 100 metres around the facility whether any measures, such as bans on entry, must be taken. In this respect, these facilities proved to be robust, too. Prolonged flooding of the facilities or a tidal wave flowing through the buildings has practically no radiological consequences.

As for disposal facilities, the above-ground part was examined. For the disposal facilities included in the investigations (Morsleben repository for radioactive waste (ERAM), Konrad) and the Asse II mine, the stress test showed that with the postulated loads, it can be excluded that the intervention reference levels for an evacuation of the surrounding area will be exceeded.

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;

viii) 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;

ix) 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

For the storage of heat-generating radioactive waste and - in accordance with the safety requirements for storage in the ESK guidelines [3-151] - of radioactive waste with negligible heat generation, the descriptions in Chapter G.6.1 apply analogously.

The procedure described in Chapter G.6.1 is in principle also applicable to conditioning facilities. The guidelines with corresponding requirements are currently being developed.

Operation of the Konrad repository has been permitted by the plan approval decision. According to the collateral clauses to the plan-approval decision, an additional overall acceptance test must be performed prior to commissioning. This will determine whether the constructed facility complies with the provisions of the plan-approval decision. Commissioning may only take place after approval by the nuclear supervisory authority.

H.6.2 Specification and revision of operational dose reference levels

The operating manual covers all aspects affecting safety and defines operational dose reference levels and conditions. The determination and, if necessary, revision of the operational dose reference levels for the planning and optimisation of protective measures for individuals is based on the corresponding provisions of the Radiation Protection Ordinance (StrlSchV) [1A-8b] and is subject to official supervision. The requirement to limit radiation exposure is considered within the framework of rational measures when approving operational discharge values.

H.6.3 Compliance with established procedures

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 (see Table L-5 to Table L-12) as well as the consideration of the safety requirements for the storage of radioactive waste with negligible heat generation [3-151].

For the treatment of radioactive waste, conditioning techniques are used that have been qualified by the Federal Company for Radioactive Waste Disposal (BGE); the already conditioned waste is subjected to product control by the BGE to ensure its suitability for disposal (see reporting on Article 23 "Quality Assurance" in Chapter F.3).

Implementation instructions are prepared for compliance with the acceptance criteria of the storage facilities. These also include work instructions and test specifications that have to be taken into account during the production and handling of the waste packages. For compliance with the requirements for radioactive waste to be disposed of (waste acceptance criteria for disposal), product control measures and technical notes are provided for their explanation and specification. These should also indicate an appropriate method for the procedures.

Prior to any form of treatment or emplacement in a storage or disposal facility, radioactive waste is subject to an incoming inspection. The incoming inspection serves the purpose of verification of the data stated by the delivering party and for identification checking.

As a general rule, the following specific characteristics, among others, 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 waste package number on the waste data sheet data.

Furthermore, the following is also observed:

- The incoming inspections are only performed by trained personnel.
- In case of non-conformance of the data, the waste packages will be treated separately if necessary.
- Any disturbances and findings upon the incoming inspection 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.

All the systems and equipment of the facility requiring testing or maintenance are readily accessible or made accessible by technical means, and any additional shielding required for radiological protection reasons is kept available. Regulations governing the preparation and performance of maintenance work are included in the operating manual.

At the site of the storage facility, the management facility or the disposal facility, adequate numbers of qualified personnel are employed to ensure fulfilment of all safety requirements; these personnel must be subject to regular training. With regard to said personnel, a distinction is made between the following cases:

- Facilities that are associated with nuclear installations which are either in operation or in the process of decommissioning: in such cases, the personnel of the nuclear installation perform most functions.
- Facilities with permanent staffing covered by own personnel: these facilities are regarded as being independent with regard to operation.
- Facilities which do not require permanent staffing for all activities: the functions are restricted to deployment on demand in case of treatment, emplacement or removal operations, or to regular inspections. The demand is temporary and is generally covered by personnel who primarily perform other tasks.

The administrative management of radiation protection is regulated in the Radiation Protection Act (StrlSchG) [1A-34] and the technical qualification required for the respective positions is demonstrated in accordance with the requirements of the StrlSchV [1A-8b] 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 Act. The responsibilities and regulations on representation are defined unambiguously in the operating manual.

Due regard is given to the development and promotion of a high 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 high 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 facility, respectively, 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 facilities' operating lifetime via the provision of adequate competent personnel in the comments on Article 22(i) in Chapter F.2.1. The requirements for storage facilities ensue from the “Guidelines for the Storage of Radioactive Waste with Negligible Heat Generation” [3-151], which stipulate that irrespective of the situation at the site, the storage facility must provide qualified personnel in sufficient numbers that ensures compliance with safety requirements and which is regularly trained.

Recurring inspections are performed on the safety-relevant installations of the conditioning facilities, storage facilities and disposal facilities, such as

- 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 recurring inspections are specified in a testing manual. The results of the recurring inspections are documented and assessed.

The technical equipment used for the handling of the waste packages and the transportation thereof must remain available until all waste packages have been removed. In this respect, it is assumed that removal of the waste packages, e.g. for the purposes of emplacement in a disposal facility, 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 inspection),
- auxiliary equipment (e.g. overpacks, special loading devices) required for transport is kept available,
- necessary type approvals for the cask types are permanently maintained,
- the waste 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 provided (e.g. measuring and test devices, documentation).

H.6.5 Characterisation and segregation of radioactive waste

The process-based treatment of radioactive waste is divided in great detail into corresponding waste treatment categories: the radioactive waste is either raw waste that has not yet been treated, or it comes in the form of an intermediate or final product.

The sorting and segregation of the radioactive 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 facilities for the treatment of radioactive waste and the storage facilities are equipped with the necessary means for the sorting of waste, having regard to all requirements relating to the radiological protection of personnel and the environment.

In view of the intended pretreatment and conditioning, the Appendix of the Nuclear Waste Management Ordinance (AtEV) [1B-19] 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
- radioactive sources (sealed sources).

These are subdivided into further subgroups.

Part A Table 1 AtEV demands further detailing of the categorisation according to the respective state of processing of the radioactive waste. Here, a distinction is made between untreated waste (raw waste), pretreated waste, waste products in inner containers, waste products packed in disposal casks (waste packages), product-controlled waste products in inner containers and product-controlled waste products (waste packages qualified for disposal in accordance with the waste acceptance criteria for disposal in the Konrad repository) (see reporting in Chapter D.4.1).

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 events

At present, the obligation of the operator to report significant events 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) in Chapter G.6.5.

H.6.7 Collection and analysis of operating experience

In view of the obligation of the authorities to take precautionary action, reports of significant events are registered and evaluated at the incident registration centre of the Federal Office for the Safety of Nuclear Waste Management (BASE) (see reporting on Article 9(vi) in Chapter G.6.5).

Experiences from the operation of similar facilities 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 processes

are examined and evaluated with regard to their transferability. Here, international reporting systems (of the International Atomic Energy Agency (IAEA) and the OECD/NEA) 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 operating lifetime of the storage facility. The monitoring concept includes above all an evaluation of results from previous inspections, including the experience from other facilities, but it may 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 waste packages stored, and as a minimum requirement, must meet the following:

- At ten-year intervals, the operator 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 recurring 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 storage are also subjected to a special inspection at intervals of ten years. As a minimum requirement, this

should include walk-downs and appropriate visual inspections and function tests. 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

Regarding the preparation of decommissioning plans, the same requirements as those described in Chapter G.6.7 on Article 9(vii) apply for radioactive waste treatment and storage facilities.

H.6.9 Closure of disposal facilities

For the decommissioning of a disposal facility (closure in the sense of the Joint Convention), a plan approval decision or a licence in accordance with the Atomic Energy Act (AtG) [1A-3] must have been issued. So far, no disposal facility in deep geological formations has been closed in the Federal Republic of Germany.

Disposal facility for high-level radioactive waste

The "Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste" [BMU 10] 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. Corresponding requirements will also be contained in the ordinance on safety requirements for the disposal of high-level radioactive waste. At the same time, the mining law is also to be applied. According to § 55(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.

This ensures that at the time of filing of 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 repository were filed and approved within the scope of the plan approval procedure (see reporting in Chapter D.3.3) 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. Such details must be specified towards the end of emplacement operation in line with 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 for radioactive waste

The decommissioning of the Morsleben repository for radioactive waste (ERAM) is in preparation. During this phase, all relevant information gathered during emplacement and subsequent operation to keep the disposal facility open is taken into consideration. For example, the decommissioning plan incorporates findings from the areas of geology, geotechnics, geochemistry and mining. With respect to radiation protection, the potential release of radionuclides after decommissioning shall be limited to an acceptable level. It is required that the entire disposal facility shall be sufficiently safely sealed against the biosphere (see reporting on Article 14(iii) in Chapter H.4.3). 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 the most realistic assumptions. Apart from the requirements posed by radiation protection, further requirements from codes and guides and statutory provisions from different legal areas have to be taken into account.

According to § 9b AtG, any major modifications of the Morsleben repository, i.e. also any measures concerning its decommissioning, require a plan approval decision. In the scope of the licensing procedure for the ERAM, the only difference to the plan approval procedure according to § 9b AtG (see reporting on Article 19 in Chapter E.2) consists in the fact that for this existing disposal facility the operational phase is finished and that the corresponding procedures can only be directed at the requirements for safe decommissioning. The plan approval according to the Atomic Law states that the ERAM decommissioning plan is permissible with respect to all public interests which are touched. The necessary authorisations according to mining law are within the responsibility of the mining authority of Saxony-Anhalt (see reporting in Chapter D.3.3 on the course of the procedure so far).

The decommissioning concept provides that any yet open underground workings shall be largely filled with rock salt concrete. This is to ensure as far as possible the integrity of the mine workings and of the salt rock layers around the underground workings, respectively, and keep the mine dry to the greatest possible extent. 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 and their wider surroundings will be hydraulically isolated from the rest of the mine workings by sealing of the drifts. The decommissioning concept of the ERAM further includes the sealing of safety-relevant boreholes and of both shafts. Sealing of the shafts is to be realised by systems of sealing elements of various materials with low permeability in order to minimise to a necessary degree the inflow of groundwater from the overlying rock via the shafts into the mine and the escape of radionuclides in solution from the mine workings via the shafts into the overlying rock.

In parallel to the plan approval procedure for decommissioning, comprehensive measures for mining hazard control have been carried out in the central part of the Bartensleben mine on the basis of licences according to mining law. By backfilling cavities, the integrity of the mine workings was improved and the possibility for safe decommissioning of the ERAM ensured. In the course of these measures, a total of 27 mine workings were backfilled with 935,000 m³ of rock salt concrete between 2003 and 2011. The backfilling of disposal areas in which waste has been disposed of was not part of these measures.

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

Disposal facility for high-level radioactive waste

Section 38 of the Site Selection Act (StandAG) [1A-7b] stipulates that data and documents that are or may become important for the storage and disposal of radioactive waste must be permanently stored by the Federal Office for the Safety of Nuclear Waste Management (BASE). A legal ordinance, which requires the approval of the *Bundesrat*, is to contain more detailed provisions, such as details on the content, purpose and scope, on the transfer from current owners of the data and use, and on ensuring the permanent integrity of the data.

The currently applicable “Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste” [BMU 10] include the requirement as regards the documentation after closure of the disposal facility that, prior to decommissioning, binding regulations concerning the scope, the preservation and accessibility of the documentation to be retained shall be adopted after consultation with the licensing authority. The documentation must contain all operating data and documents which could contain relevant information for future generations. In particular, this should include information being relevant for the protection of the disposal mine against human intervention in the deep subsoil. For safeguarding all the information, complete sets of documents must be stored in at least two different suitable locations.

For the storage of the data, the BASE has established a separate organisational unit that will set up the requisite structures to ensure the transfer, processing, safekeeping and provision of the stored data. Through the cross-generational integrity, comprehensibility and transfer, future generations will be put in the position do make their own decisions about the handling of the disposal facility. A statutory ordinance is currently being prepared.

Konrad repository and Morsleben repository for radioactive waste

The plan approval decision for the Konrad repository includes the regulations governing the post-closure period. A collateral clause stipulates the following:

> *“Documentation must be provided during construction, operation and decommissioning of the disposal facility, comprised of data relating to the mine survey of the disposal facility, 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 disposal facility 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 disposal facility is operational or in the process of decommissioning. For the period following its closure, the form, extent and the storage locations (at least two) 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 contents of the documentation stipulated in the plan approval decision for the Konrad repository will also be required in a similar form for the Morsleben repository for radioactive waste (ERAM). The ERAM repository is to be closed with the waste remaining inside. The corresponding necessary licensing procedure is underway.

H.7.2 Monitoring and institutional control

Disposal facility for high-level radioactive waste

The currently valid "Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste" [BMU 10] require that following decommissioning of the disposal facility, evidence preservation and control measures must be carried out. Prior to the completion of sealing work, it is necessary to determine in due course 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 shall be implemented to ensure, as effectively as practically possible, that no human activities which could endanger the permanent containment of the radioactive waste are carried out in the vicinity of the disposal facility.

The future Ordinance on Safety Requirements for the Disposal of High-Level Radioactive Waste will also contain regulations on the monitoring of the disposal facility. These will be supplemented by the Ordinance on the Documentation of Disposal according to Section 38 of the Site Selection Act (StandAG) [1A-7b].

Konrad repository and Morsleben repository for radioactive waste

Institutional control after closure is regulated in the plan approval decision 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 disposal facility in accordance with the relevant regulations. These measurements must be examined for any evidence of impacts from the disposal facility and documented in a suitable format. The extent and type must be specified in the closure plan and the results added to the long-term documentation."

The procedures for the Morsleben repository for radioactive waste (ERAM) have not yet been defined. The Federal Office for Radiation Protection (BfS), which had been tasked with the decommissioning of the ERAM until April 2017, has developed a decommissioning concept on the basis of extensive investigation programmes. This concept provides for the extensive backfilling of the mine, the sealing of the emplacement areas and the closure of the shafts. The licensing procedure for this concept is presently pending at the competent state authority of Saxony-Anhalt. The planning documents for decommissioning also included a long-term safety case. On 31 January 2013, the Nuclear Waste Management Commission (ESK) submitted the statement "Long-term Safety Case for the Morsleben Repository for Radioactive Waste (ERAM)" on behalf of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). In this statement, the Commission concludes that the considerations on long-term safety should be adapted by the operator to the current state of the art in science and technology. The implementation of the ESK recommendations entails supplementary verifications and a revision of the application documents.

H.7.3 Unplanned release

The usual inspection of surface settlement for all present and future underground disposal facilities in Germany 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 disposal facility, 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.

In its final report [KOM 16], the Commission on Storage of High-Level Radioactive Waste has stated that, with regard to a future disposal facility for heat-generating radioactive waste, monitoring is a technical/scientific decision-making basis for failure detection. This includes the direct or indirect detection of unplanned releases. Corresponding regulations on monitoring and documentation of the disposal facility will be contained in the ordinances on the safety requirements for the disposal of high-level radioactive waste and on the documentation of disposal according to Section 38 of the Site Selection Act (StandAG) [1A-7b]. In order to enable future generations to act in the event of an undesirable development, § 26(2) no. 3 StandAG requires the possibility of retrieval of emplaced waste during the operating phase of the disposal facility and precautions to allow a recovery of the waste for a period of 500 years after its planned closure.

For the Konrad repository, no special control and surveillance programme is envisaged for the period following closure. The extent and the type of the routine measurements of the environmental media air, water and soil on the area surrounding the disposal facility must be specified in the closure plan and the results added to the long-term documentation.

According to current planning, the Asse II mine will be closed once the radioactive waste has been retrieved. After successful retrieval, unplanned releases of radioactive substances would no longer need to be expected and thus, no specific measures as referred to in Article 17(iii) would have to be provided.

Exhaust air and surroundings of the Morsleben repository for radioactive waste (ERAM) and the Asse II mine are currently 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 Installations (REI) [3-23].

I Transboundary movement

This section deals with the obligations under Article 27 of the Joint Convention.

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 doing so

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.1.1 Obligation of licensing transboundary movements

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

European Union (EU)). Current German legislation requires that the consignor must submit an application to the competent licensing authority, the Federal Office for Economic Affairs and Export Control (BAFA) for each shipment of these materials from Germany. The BAFA must determine whether all legal provisions for the licence for transboundary movement(s) have been met and if so, grants the licence. In principle, a licence for a given quantity of material may be used for several individual shipments of partial amounts. In the case of shipments of spent fuel and radioactive waste from other EU states to Germany, the licensing authority in the delivering country is responsible; however, the BAFA is also consulted. With its approval, which is subject to certain conditions, the BAFA can lay down provisions 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 (Chapter G.1 to Chapter H.7) and 21 to 26 (Chapter F.1 to Chapter F.6) is ensured and compliance with the provisions of international conventions has been checked. This applies equally for the granting of approval in the case of consultation.

Authorisation of transboundary movements and coordination with the state of destination

Essential for all transboundary movements of spent fuel to, through or from the Federal Republic of Germany is the Nuclear Waste Shipment Ordinance (AtAV) [1A-18] by which Council Directive 2006/117/EURATOM was transposed into national law; according to §§ 6 and 7 AtAV, the BAFA is the competent authority for this. 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 movements within the European Community

The consignor of spent fuel submits an application for shipment to the competent authority of his country (in Germany the BAFA). A standard form exists for this purpose, which is divided into different sections (Annex to the Nuclear Waste Shipment Ordinance). Sections B-1 to B-6 are to be completed for shipments of spent fuel and sections A-1 to A-6 for shipments of radioactive waste. The competent authority submits a copy of the application, together with the acknowledgement of receipt of the application and the consent or refusal of approval, to the competent authority of the Member State of destination (in the case of shipments to Germany, to the BAFA). The BAFA will not return a consent to the competent licensing authority until the consignee has given his consent and the competent supervisory authority for that consignee has been consulted. The competent authority can then grant the approval for the shipment licence and hand it over to the applicant.

During a shipment, all documents must be carried along, including a copy of the consent, the description of the delivery and list of packages as well as the acknowledgement of receipt for the delivery.

In advance of each shipment, the above documents must be transmitted to all authorities involved. In order to ensure that all authorities concerned are informed about every shipment that has taken place and to enable them to log the quantities delivered, they regularly receive copies of the respective description of the delivery and list of packages as well as the acknowledgement of receipt.

Transboundary movements to or from states which are not members of the European Community (third countries)

In the case of shipments from Germany to a third country, the BAFA will only grant a licence to the owner/consignor of the spent fuel or radioactive waste if the competent authority of that third country has confirmed to the BAFA that the consignee holds the necessary licence for handling and appropriate equipment and it has been proven that the respective specified criteria for export to third countries have been met.

In the 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 appropriate equipment to handle such spent fuel or radioactive waste or has notified such handling in accordance with an existing obligation.

When spent fuel is shipped out of 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.

In the case of return deliveries e.g. of spent fuel from research reactors back to the United States of America, export can only take place after the issue of an official import certificate there. For other states, an exchange of notes takes place between the affected governments prior to the delivery, as part of the licensing procedure under foreign trade law.

Transboundary movement through states of transit

The provisions of the Nuclear Waste Shipment Ordinance also apply to the transit of spent fuel or radioactive waste through Germany. The Federal Office for the Safety of Nuclear Waste Management (BASE) or, in the case of transport by rail, the Federal Railway Authority (EBA) is also responsible for supervising the transit of spent fuel regarding the compliance with national and international regulations.

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 or of the Nuclear Waste Shipment Ordinance; these transits are subject to approval. Such approval will only be granted if there are no facts leading to concerns vis-à-vis proper shipment to the country of destination.

Compliance with safety provisions by the consignee in Germany

Transboundary movements of spent fuel and radioactive waste will only be licensed by the expert staff at Germany's competent authority, the BAFA, or, in the case of consultation (shipment into Germany), approval is only given if the consignee of these materials in Germany ensures compliance with the safety provisions outlined in the comments on Articles 4 to 17 and 21 to 26. In the case of imports from third countries, the consignee must submit an application to the BAFA for shipment before receipt in accordance with the statutory provisions outlined with respect to Article 27(1)(i).

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 furthermore met by the consultation process pursuant to the Nuclear Waste Shipment Ordinance in conjunction with Council Directive 2006/117/EURATOM (see reporting on Article 27(1)(i) and (ii)).

Possibility of re-import

According to Council Directive 2006/117/EURATOM respectively the Nuclear Waste Shipment Ordinance, the re-import of spent fuel or radioactive waste into Germany is possible in principle; the provisions in this respect were explained in the comments on Article 27(1)(i).

Principally, a shipment of radioactive waste or spent fuel under the Nuclear Waste Shipment Ordinance in conjunction with Council Directive 2006/117/EURATOM allows the option of return shipment in case the envisaged shipment cannot be completed.

According to § 8(1)(3) AtAV, shipment to another EU Member State and according to § 9(1)4 AtAV, shipment to a third country will only be licensed if it is ensured that the radioactive waste or spent fuel will be taken back by the owner/consignor where a shipment cannot be completed or if the conditions for shipment cannot be complied with.

According to § 10(1)(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/consignor of the radioactive waste or spent fuel, with the consent of the competent authority in the third country, that the foreign owner/consignor will take back the radioactive waste if the shipment process cannot be completed.

Finally, according to § 14(1)(2) AtAV, the BAFA may only give its approval to a shipment from another EU Member State to Germany if it is ensured that the radioactive waste or spent fuel will be taken back by the owner/consignor where a shipment cannot be completed or if the conditions for shipment cannot be complied with.

I.1.2 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 of the Nuclear Waste Shipment Ordinance (AtAV) likewise prohibits shipments into this region.

I.1.3 Sovereignty demarcations

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 contracting party to the Revised Convention for Rhine Navigation of 17 October 1868 [RHE 69] and to the Convention of 27 October 1956 on the Canalisation of the Moselle [MOS 57].

Air traffic

With respect to air traffic, the requirements of this Article are met by Germany's accession to the International Air Services Transit Agreement [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 on the basis of Article 59(2) of Germany's Basic Law (GG) [GG 49].

Return of radioactive waste after treatment

With the incorporation of the Joint Convention into German legislation, the right of a Contracting Party to return radioactive waste after processing, as referred to in Article 27, is not affected. There is no obligation to take back such waste under German legislation; it is contractually agreed for such export operations. Apart from that, Article 2 of Council Directive 2006/117/EURATOM [1F-35] applies.

Shipment of spent fuel for reprocessing

This right remained unaffected until 30 June 2005. Since then, the shipment of German spent fuel from facilities for the fission of nuclear fuel for the commercial electricity generation to a facility for reprocessing of spent nuclear fuel is no longer permitted due to the amendment to the German Atomic Energy Act (AtG) of 22 April 2002 [1A-2].

In the course of the further development of the Site Selection Act (StandAG) [1A-7b] in 2017, the Atomic Energy Act [1A-3] was amended with regard to the export of nuclear fuel. According to the newly introduced § 3(6) AtG, the export of spent fuel from research reactors is only permitted for serious reasons of non-proliferation of nuclear fuel or for reasons of sufficient supply of fuel assemblies for medical and other top-level research purposes. An exception to this is the shipment of such fuel assemblies with the aim of producing waste packages that are qualified for disposal and are to be disposed of in Germany. An export licence shall not be granted if the spent fuel is already stored in Germany pursuant to § 6 AtG.

Return of material from reprocessing

With the incorporation of the Joint Convention into German legislation, the right of a Contracting Party to return radioactive waste in connection with the reprocessing of spent fuel, as referred to in Article 27, is not affected. On the contrary, the German Federal Government, in an exchange of notes with France and the United Kingdom, has confirmed the right of these two States to return the waste and other products from the reprocessing of German spent fuel to Germany.

J Disused sealed sources

Developments since the Sixth Review Meeting:

The amount of data relating to sealed sources in the high-activity sealed sources (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.

This section deals with the requirements under Article 28 of the Joint Convention.

J.1 Article 28: Disused sealed sources

Article 28: Disused sealed sources

(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 radioactive sources are applied in research, trade, industry, medicine and agriculture in Germany, of which approx. 13,250 radioactive sources are high-activity sealed sources (HASS). 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 sources and up to some TBq for sealed radioactive sources for irradiation facilities. In Germany, the safety and security of disused sealed radioactive 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.

Improvement of the control of disused sealed radioactive sources is 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 European Union (EU) directives. In the following, the experiences made with the HASS register at the Federal Office for Radiation Protection (BfS) and the international context of control of radioactive sources are described.

High-activity sources and the HASS register

Regulations governing high-active sources were based on Council Directive 2003/122/EURATOM [1F-22] of 2003 on the control of high-activity sealed radioactive sources and orphan sealed radioactive sources and became applicable law in Germany with the Act on the Control of High-Activity

Sealed Radioactive Sources in 2005. These regulations were incorporated in Council Directive 2013/59/EURATOM [1F-24] issued by the European Union and were implemented in Germany with the Radiation Protection Act (StrlSchG) [1A-34] in 2017 and the Radiation Protection Ordinance (StrlSchV) [1A-8b] that was amended in 2018.

§ 84 StrlSchV contains requirements for the register of high-activity sealed radioactive sources (HASS register) that is kept at the BfS. According to § 85 StrlSchV, the radiation protection executive has to ensure that the data on HASS are transmitted to the register.

The responsibilities of those authorised to access the HASS register can be summarised as follows.

- Licence holder: Notification regarding the acquisition, the transfer and the use of a HASS (including its loss or discovery) to the BfS. The licence holder submits the data in accordance with Appendix 9 StrlSchV in secured electronic form. For safety and security reasons, the licence holder has no direct access to the register. Access authorisations and access possibilities are regulated in § 84(3) StrlSchV.
- Competent authority of the individual *Land*: Verification of the data submitted by the licence holder, notification of the loss or discovery of HASS, reports and analyses. The authority has access to the register.
- Federal Office for Radiation Protection: Operation and maintenance of the register, preparation of reports and analyses, check of the data for plausibility, data entry, providing users of the register with advice, development of software and hardware. The BfS is the legally designated operator of the HASS register.
- Federal Office of Economics and Export Control: Data entry from permits issued for the shipment of high-activity sealed radioactive sources from non-EU countries (entry).
- 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 register is ensured by administrative and data related measures.

The HASS register has been operated since July 2006. The Report of the Federal Republic of Germany for the Fourth Review Meeting described the establishment and operation of the HASS register. The operation of the HASS register meets the requirements of the above mentioned European directive. It is subject to continuous further development with regard to accessibility, also for the licence holders, and user-friendliness while maintaining a high level of safety and security.

The development of the data in the HASS register on registered radioactive sources from 2006 until 2018 is shown in Table J-1.

Table J-1: Development of the data of the radioactive sources registered in the HASS register from 2006 to 2018

Status	Licence holder	Registered radioactive sources (cumulated) *)
End of 2006	321	1,740
End of 2007	453	7,625
End of 2008	540	13,800
End of 2009	580	17,300
End of 2010	590	20,100
End of 2011	630	23,500
End of 2012	646	27,200
End of 2013	657	31,000
End of 2014	667	35,000
End of 2015	684	40,000
End of 2016	694	42,000
End of 2017	702	45,000
End of 2018	716	50,500

*) The column indicates the number of radioactive sources ever recorded in the HASS register from 2006 to 2018 without departures and not the number of radioactive sources actually existing at the respective year-end that were within the scope of the StrlSchV on the respective date.

With the entry into force of the new Radiation Protection Act and the associated adoption of the D values[2] as HASS values, in 2019 about 2,000 of the HASS present in Germany so far are no longer considered as high-level radioactive sources and are therefore no longer subject to reporting. Due to the new HASS values, Table J-1 will no longer be continued from 2019 onwards.

At the end of 2019, 43 % (approx. 22,790 radioactive sources) of the approx. 53,000 radioactive sources ever registered in the HASS register still had an activity above the HASS value and about 25 % (approx. 13,250 radioactive sources) still fall under the scope of the Radiation Protection Act.

General requirements for sealed radioactive sources

According to § 12 StrlSchG, the use of sealed radioactive sources requires a licence. There is an exception for test sources whose activity does not exceed the exemption levels of Appendix 4, Table 1, Column 2 or 3 StrlSchV (§ 5(1) in conjunction with Appendix 3, Part B, No. 1 and 2 StrlSchV), and for type-approved devices that may contain sealed radioactive sources (§ 5(1) in conjunction with Appendix 3, Part B, No. 4 StrlSchV).

Furthermore, § 94(1) StrlSchV stipulates that radioactive substances that may only be handled on the basis of a licence, among others according to § 12 StrlSchG, shall only be transferred to persons who are in possession of the requisite licence. According to § 94(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-activity sealed radioactive sources may only be transferred if they are accompanied by a documentation of the manufacturer specified according to § 94(3) StrlSchV. § 94(5) and (6) StrlSchV regulate transport and transfer to the recipient. Non-compliance with these provisions of § 94 will be fined according to § 184 StrlSchV as an administrative

[2] The D value is the activity level above which severe deterministic damage has to be expected under certain release and exposure scenarios [IAEA 06b].

offence. In addition, § 328(1)(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 § 85(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 sealed radioactive sources, specifying type and activity, and records on it must be kept. For any handling of high-activity sealed 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). A certificate of tightness of sealed radioactive sources is to be attached to the notification on the acquisition of the radioactive source submitted to the authority as defined in § 94(2) StrlSchV. Type-approved devices into which radioactive substances are embedded and that may be used without a licence in accordance with § 5(1) in conjunction with Appendix 3, 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 § 25(5) StrlSchV.

Management of disused sealed radioactive sources

The working lives of the sealed radioactive 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 sealed radioactive source remaining in the device. The manufacturer may check further use of the sealed radioactive sources or returns them to the source manufacturer who may reuse parts of them. The sealed radioactive sources that cannot be reused are delivered to the *Land* collecting facilities where they are stored as radioactive waste until delivery to a disposal facility.

The general national regulations for the disposal of radioactive waste are included in the AtG [1A-3]. § 9a AtG stipulates that the *Länder* shall establish collecting facilities for the storage of the radioactive waste originating within their territories. §§ 1 to 8 of the Nuclear Waste Management Ordinance (AtEV) [1B-19] 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.

Disused sealed radioactive sources arising from handling licensed pursuant to § 12 StrlSchG are delivered to the *Land* collecting facilities. The inventory of the *Land* collecting facilities in Germany varies considerably. In the *Land* collecting facility Saxony, for example, approx. 800 individual sealed radioactive sources packed in different waste packages are stored. Every single sealed radioactive source is documented separately regarding the properties like type, origin, date of delivery, original and current activity, storage position etc. For the most part, these are sources with Co-60, Cs-137, Am-241, Kr-85, Pu-239, Cf-252, Sr-90 sources and some other nuclides. The users are made up of very wide-ranging groups of schools and education institutions, industry, medicine and research and also sources from smoke detectors and other devices.

According to the waste acceptance criteria 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 sealed radioactive sources are usually conditioned and documented together with other radioactive waste. For conditioning, the same procedures that are qualified by the BfS or the Federal Company for Radioactive Waste Disposal (BGE) are applied as for radioactive waste. The objective is to produce waste packages that are qualified for storage and disposal. The requirements to be met for the waste packages to be disposed of are laid down in the

Konrad waste acceptance criteria. The compliance of the packages with the requirements established in the waste acceptance criteria of the disposal facility is reviewed within the scope of a product control. Subsequent to product control and confirmation that the waste packages produced in this way are qualified for emplacement, the *Länder* will deliver them to the Konrad repository (after its commissioning).

Safe disposal of disused sealed radioactive sources

Responsibility of manufacturers and suppliers

The manufacturers and suppliers of radioactive sources in Germany shall ensure that the sealed radioactive sources are only delivered to users who hold the appropriate use licence in the respective country of use. In addition, in case of transboundary movement, the corresponding external regulations must be complied with. Furthermore, the manufacturers and suppliers take back the radioactive sources that are no longer used to the extent permitted by national regulations to ensure the safe management of sealed radioactive sources during the entire life cycle.

Continued use/extended use of radioactive sources

Sealed radioactive sources no longer to be used for their original purpose and meeting the necessary quality requirements can continue to be used for other purposes or by other users having a relevant handling licence. In such a case, in Germany, the sealed radioactive source is transferred in accordance with § 94 StrlSchV, to other EU states in accordance with the Council Regulation No. 1493/93/EURATOM [1F-34] and from Germany to third countries within the licence and notification procedure according to §§ 12 and 13 StrlSchV (see i.a. Chapter I.1 for details).

If continued use is not an option, there is the possibility to either deliver the sealed radioactive sources to its manufacturer or, in case these are declared as radioactive waste, to deliver the sealed radioactive sources as radioactive waste in accordance with the national rules and regulations. In Germany, radioactive waste originating during handling as defined in § 12(1) No. 3 StrlSchG or from the operation of facilities for the generation of ionizing radiation subject to licensing must generally be delivered to the *Land* collecting facility according to AtEV, unless any other disposal or shipment has been approved by the competent authority (see Chapter E.2.7).

In Germany, the manufacturers and suppliers of sealed radioactive sources commonly offer their customers to take back the sealed radioactive sources after use. It is a common practice to return the sealed radioactive sources with relatively short half-life where a regular exchange of the radiation sources is necessary e.g. for medical use or for non-destructive tests to the manufacturer or supplier. This option is becoming increasingly common also among users of longer half-life sealed radioactive sources. Besides the considerations of waste minimization, licensing, logistical and economic reasons also play an important role.

In Germany, the legal means of the manufacturers or suppliers for the acceptance of sealed radioactive sources no longer in use are, however, largely limited to the return of sealed radioactive sources from their own production or return for recycling.

Recycling of sealed radioactive sources by the manufacturer

There are no restrictions regarding the return of sealed radioactive sources to the manufacturer and/or supplier if these are recyclable.

In recent years, the manufacturers of radioactive sources increased their recycling capacity of sealed radioactive sources with the objective of waste reduction.

However, due to the decrease of activity concentration, there are technological limits with regard to recycling of radioactive materials from sealed radioactive sources. At the same time, recycling requires complex technological processes which may result in economical limitations.

The number of the sealed radioactive sources that can be recycled depends on their type and activity. Approx. 30 % of sealed radioactive sources used for process control and for measurement technology is recyclable.

Today, the recycling activities concentrate on sealed radioactive sources where Co-60, Kr-85, Cs-137, Am-241 and Am-241/Be-9 are the dominating radionuclides.

Sealed radioactive sources as radioactive waste

Sealed radioactive sources from industrial, commercial, medical, research and agricultural applications that are to be disposed of as waste are generally to be delivered to the *Land* collecting facilities (see Chapter E.2.7). Such a delivery is subject to special requirements of the individual *Land* collecting facility (e.g. activity limitations, type of waste, physical form, packaging, transportation). These requirements may have the effect that delivery of sealed radioactive sources to *Land* collecting facilities is either not or only possible with considerable effort. For the manufacturers and users of sealed radioactive sources, the disposal of sources no longer in use may present a great challenge.

Sealed radioactive sources at the Morsleben repository for radioactive waste

During the period from 1981 to 1998, a total of 6,621 sealed radioactive sources were disposed of in the Morsleben repository for radioactive waste (ERAM). These sealed radioactive sources are to be classified among the radioactive waste with negligible heat generation. Co-60, Cs-137, Sr-90, Eu-152, Ra-226, Ag-110m, Pm-147, Ir-192, Am-241 and Th-228 are the dominating radionuclides.

Usually, the disposal of sealed radioactive sources was carried out by dumping them from reusable source containers into a working underneath. Furthermore, sealed radioactive sources were solidified in waste drums and disposed of by stacking.

Neutron sources were excluded from disposal.

For research purposes on the development of new disposal technologies of higher-level sealed radioactive sources or solid waste with short-lived radionuclides (Co-60 and Cs-137, as well as waste containing europium), which are to be classified among heat generating radioactive waste, radiation sources were stored in the 1980s and in 1990 in seven special containers in a way that they can be retrieved. This waste, with a total activity of approx. $1.17 \cdot 10^{14}$ Bq (as at: 31 December 2019), is placed in two boreholes in the underground measuring field on the 4th level. Within the frame of closure of the ERAM, these special containers are to be disposed of.

Due to a ministerial council decision in the 1960s, the use of Ra-226 sources was terminated as a result of the assessment of safety events with the Ra-226 radionuclide. From the mid-1960s, all sources were collected from the licence holders by employees of the State Office for Radiation Protection (SZS, from August 1973: State Board for Atomic Safety and Radiation Protection, SAAS). These radiation sources, mostly sealed radioactive sources, were transported to the storage facility of SZS/SAAS in Lohmen and conditioned; the conditioned Ra-226 waste with an activity of approx. $3.7 \cdot 10^{11}$ Bq (as at: 31 December 2019) was placed in eight special containers into a drum and was stored there. When Lohmen was closed, this drum was transported to ERAM and is stored there in the underground measuring field on the 4th level in a way that it can be retrieved. This waste package with the conditioned Ra-226 waste, too, is to be disposed of within the frame of the closure of the ERAM applied for.

Regulations for discovery and loss

§§ 167 and 168 StrlSchV regulate the loss, discovery and acquisition of actual control over radioactive material and are therefore also relevant for radioactive sources. Accordingly, any loss of actual control over radioactive material whose activity exceeds the exemption levels stipulated in Appendix 4, Table 1, Columns 2 and 3 StrlSchV must be reported immediately to the competent nuclear or radiation protection supervisory authority or to the police authority responsible under *Land* law by the owner of the material. Loss of a high-activity sealed radioactive source also requires immediate reporting to the HASS register at the BfS in electronic form in accordance with Appendix 9, No. 11 StrlSchV (see Chapter J.1.1 for 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 or radiation protection supervisory authority or to the police authority responsible under *Land* law.

In the vast majority of the very rare cases of so-called “orphan sources” in Germany, sealed radioactive sources of low activity are concerned. Loss and discovery of radioactive materials are regularly recorded in the annual reports of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) [BfS 17] and in parliamentary reports. In 2017, 56 found and 2 lost radioactive 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.

J.1.2 Re-entry of disused radioactive sources

In Germany, sealed radioactive sources are manufactured and also exported to other countries. Therefore, regulatory requirements for re-entry of disused sealed radioactive sources into Germany have existed for a long time. These regulations fully take into consideration the generally high risk potential of high-activity sealed radioactive sources (HASS) and allow implementing the requirements of the Code of Conduct on the Safety and Security of Radioactive Sources [IAEA 04] which deals in its Sections 23 to 29 with the import and export of sealed 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 §§ 12 to 15 Radiation Protection Ordinance (StrlSchV) [1A-8b] 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 country/countries may be replaced by an application. Transboundary shipment inside the EU is regulated by Council Regulation No. 1493/93/EURATOM [1F-34]. With respect to sealed radioactive 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 sealed radioactive source from a non-EU country, the competent authority according to § 188 Radiation Protection Act (StrlSchG) [1A-3] is the BAFA.

As defined in § 94(4) StrlSchV, high-activity sealed 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 licence holder after end of use or delivered as radioactive waste or kept in storage. Recycling of disused sealed 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. According to § 95 StrlSchV, themanufacturer and the carrier of high-activity sealed 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 § 12 StrlSchV, the transboundary movement of such sealed radioactive sources is subject to licensing if the activity exceeds the 10-fold of the value specified in Appendix 4, Table 1, Column 4 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 presents proof of the application upon customs clearance to the competent authority as stipulated in § 188(2) sentence 1 StrlSchG or to the body appointed by it.

The carrier furthermore has to take precautions to ensure that after shipment, the delivered radioactive materials may only initially be handed over to persons who hold the necessary licence according to § 12(1) No. 1 or 3, each also in conjunction with (2) StrlSchG or § 6(1), § 7(1) sentence 1 or (3) sentence 1 or § 9(1) Atomic Energy Act (AtG) [1A-3].

In the case of shipment of other radioactive material between EU Member States, the provisions of Council Regulation No. 1493/93/EURATOM 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 Article 3 of Directive 80/836/Euratom and with relevant national requirements for safe storage, use or disposal of that class of source […].*

**) replaced by Directive 2013/59/Euratom.*

The declaration shall be made by means of the standard document [set out in Annexe I of Regulation 1493/93/Euratom].

(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 may refer to more than one shipment, provided that

- *the sealed sources […], to which it relates have essentially the same physical and chemical characteristics,*
- *the sealed sources […], 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 as referred to in Article 4(2)."

A reporting system for realised shipments of radioactive materials is outlined below:

"(Article 6)

A holder of sealed sources [and] other relevant sources […] 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 […].”*

As a result of this reporting procedure, it is evident that the competent authorities in each EU Member State (in Germany, the 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 European Commission outlining the need, among others, 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 sealed 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. Sealed 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 sealed radioactive sources in the global scrap trade.

Examples:

- the information system operated by the International Atomic Energy Agency (IAEA) for transmission of data about loss of sealed radioactive sources worldwide,
- organisation of international meetings and other forums for information exchange between experts at the international level, as for example the die International Conference on Control and Management of Inadvertent Radioactive Material in Scrap Metal in Tarragona (Spain) in February 2009, as this may lead to coordinated and harmonised international strategies,
- development of an international convention regarding the transboundary movement of scrap and semi-finished (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 14a], 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 sealed 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 in 2009 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 sealed radioactive sources. Within the European Union (EU), important prerequisites regarding the international data exchange are fulfilled by the abovementioned rules, in particular Council Regulation No. 1493/93/EURATOM [1F-34] and Council Directive 2013/59/EURATOM [1F-24]. 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.

Germany is actively involved in improving the safety of the sealed radioactive sources management, also in different countries. Thus, in the Ukraine with German support, in the frame of bilateral projects, it was possible to achieve that a large number of sealed radioactive sources, approx. 15,000, were recorded and safely stored with regard to radiation and physical protection aspects. Furthermore, modernisation measures at technical installations for the handling of sealed radioactive sources were carried out and the required transportation and storage containers were provided.

Based on the findings and the experiences gained, Germany is planning further bilateral technical assistance programmes. These programmes may refer to the documentation of the disused sealed radioactive sources or to the development of concepts on their safe central storage.

K General efforts to improve safety

This section summarises the progress made by Germany so far to improve safety since the Sixth Review Meeting in 2018 and explains relevant issues that have to be investigated in connection with an extended storage of spent fuel and heat-generating (high-level and intermediate-level) radioactive waste. In addition, this section deals with the efforts undertaken to ensure safety in connection with the handling and management of spent fuel and radioactive waste by applying and further developing safety standards as well as with the planned measures to implement the recommendations and suggestions of the ARTEMIS mission and the recommendations and suggestions of the IRRS mission that are relevant for the area of waste management.

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 Sixth Review Meeting

The Rapporteur's report to the Sixth Review Meeting in 2018 summarises the challenges still ahead as well as the planned measures to improve safety which were identified by the Country Group as a result of the German presentation. The progress made regarding these items during the period under review is set out below.

K.1.1 Challenges

Establishment of a licensed condition with respect to the storage of spent fuel in the AVR cask storage facility in Jülich

The licensed status of the AVR cask storage facility has remained largely unchanged since 2018. The original storage licence of 17 June 1993 was limited to 20 years. An application has been made for the AVR fuel to be stored at the Jülich storage facility for another nine years. The licensing procedure has not yet been completed. The storage is currently being carried out on the basis of orders issued by the competent supervisory authority of the *Land* of North Rhine-Westphalia. The order issued on 2 July 2014 by the then Ministry of Economic Affairs, Energy, Industry, SMEs and Crafts of North Rhine-Westphalia (MWEIMH, today Ministry of Economic Affairs, Innovation, Digitization and Energy of North Rhine-Westphalia, MWIDE) for the removal of the AVR casks from the storage facility continues to apply. Three options are still being considered for the removal of the nuclear fuel (fuel spheres):

Option 1: Transport of the fuel spheres to the Ahaus spent fuel storage facility

The licensing procedure for the transport of the fuel spheres to Ahaus for storage was resumed in January 2015. On 21 July 2016, the 8th modification licence for the Ahaus spent fuel storage facility, which refers to the emplacement of the fuel spheres from Jülich, was granted by the Federal Office for Radiation Protection (BfS). The town of Ahaus and one private individual have filed lawsuits against the licence. The licence for the transport of the fuel spheres to the Ahaus storage facility is still pending. When the granting of this licence can be expected is still unknown.

Option 2: Shipment of the fuel spheres to the United States of America

The option of shipment of the fuel spheres to the United States of America has been examined since mid-2012. In addition to the clarification of numerous technical issues, an environmental impact assessment (EIA) was also carried out in the United States of America (USA). In December 2017, the U.S. Department of Energy published the result of the EIA in the USA and issued the Finding of No Significant Impact (FONSI). Further coordination and clarification on individual issues is currently being undertaken. The spent fuel spheres are no radioactive waste from a commercial nuclear power plant, but recyclable residual materials from a test and demonstration reactor. In accordance with applicable law, this spent nuclear fuel can be returned to the country of origin if, on the one hand, agreement is reached between the responsible actors. On the other hand, the conditions for the export of nuclear fuel (§ 3(6) of the Atomic Energy Act (AtG) [1A-3]), which became effective on 16 May 2017 as part of the further development of the Site Selection Act (StandAG) [1A-7b], must be observed.

Furthermore, a corresponding contract can only be concluded if the necessary conditions for acceptance, like e.g. the clarification of numerous technical questions, have been created at the destination of shipment of the fuel spheres. Only after that will it be clear whether removing the AVR fuel spheres can be achieved by shipment to the United States of America.

Option 3: Construction of a new storage facility in Jülich

The previously suspended licensing procedure was resumed in 2012, also in order to bridge the time until the completion of a new storage facility for the fuel spheres in Jülich if necessary. Corresponding documents are currently being reviewed by the licensing authority.

Until final clarification as to which of the three options is to be implemented, JEN Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH (JEN)'s objective as the owner of the AVR fuel spheres is to keep all options open and to further specify them. The actual decision on the continued storage of the AVR fuel is made by JEN in close coordination with the competent nuclear supervisory authority (MWIDE).

Establishment of a licensed condition with respect to the storage of spent fuel in the Brunsbüttel fuel storage facility

As a result of the decision of the Federal Administrative Court of 8 January 2015, the storage licence for the Brunsbüttel storage facility was revoked. The casks currently stored there will be stored in the decentralised fuel storage facility by order of the Schleswig-Holstein Ministry of Energy Transition, Agriculture, the Environment, Nature and Digitalisation in accordance with § 19(3) AtG until the licensing procedure has been concluded. Emplacement of the fuel assemblies from the reactor pressure vessel into storage casks and transfer to the storage facility took place in 2017.

On 16 November 2015, the Kernkraftwerk Brunsbüttel GmbH & Co. oHG filed an application for a new licence according to § 6 AtG for the storage of the nuclear fuel in the Brunsbüttel fuel storage facility and rendered this application more precise in a letter of 12 February 2016. In January 2019, Kernkraftwerk Brunsbüttel GmbH & Co. oHG was joined by BGZ Company for Storage (BGZ) in the licensing procedure. Like the original licence, the new licence applied for is to be valid until 4 February 2046 and is to cover the storage of all spent fuel assemblies from the operation of the Brunsbüttel nuclear power plant in the existing storage building. Due to the premature shutdown of the nuclear power plant, only up to 24 of the available 80 cask storage positions will now be required. This also reduces the newly applied for total heat output, the total mass of heavy metal, and the overall activity.

In the course of the licensing procedure, the applicant has to prove that the requirements according to § 6(2) AtG are fulfilled. In addition, the Federal Office for the Safety of Nuclear Waste Management

(BASE) has to carry out an environmental impact assessment with public participation for the licensing procedure. Within the framework of public participation, a hearing was already held in June 2017 under the auspices of the BASE. The objections discussed at this meeting will be considered in the further licensing procedure.

Return of the radioactive waste from reprocessing in France and in the United Kingdom

The return of vitrified waste of the CSD-V type from France has been completed. The waste is stored in 108 casks in the Gorleben spent fuel storage facility. Still to be returned are 152 casks with compacted waste of the type CSD-C from France, five casks with vitrified waste (decontamination and rinsing water) of the type CSD-B from France, and 20 casks with vitrified high-level radioactive waste (fission product solutions) from the United Kingdom.

The compacted CSD-C waste from France is to be shipped to the Ahaus spent fuel storage facility. The first transport is expected to be carried out in 2024. For the timely return and balanced distribution of the 5 casks from France and 20 containers from the United Kingdom with vitrified radioactive waste across the country, an overall concept, which is also regionally guided by the polluter pays principle, was presented in 2015 by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). After completion of the return operation, this vitrified radioactive waste from reprocessing will be temporarily stored in the five *Länder* of Lower Saxony, Hesse, Schleswig-Holstein, Bavaria and Baden-Wuerttemberg (see Chapter D.4.1 for details). Corresponding storage and transport licences have been applied for by the power utilities. The nuclear licensing procedures have been carried out by the BGZ since 1 January 2019. The decentralised spent fuel storage facilities, in which high-level radioactive waste in the form of spent fuel from the respective nuclear power plants is already stored today, are technically equipped for the storage of these casks.

According to current planning, the five casks (CSD-B) are scheduled to be returned from France in 2022. From 2020, the 20 casks from the United Kingdom are also to be returned in three shipments. The first return shipment of vitrified radioactive waste from the UK to the decentralised spent fuel storage facility in Biblis was planned for spring 2020. In view of the current spread of the coronavirus (SARS-CoV-2), the police operation associated with the return transport cannot be justified at present, hence the transport has been suspended. The companies and institutions involved in the return will agree on a new date window for the return in due course.

Speeding up product control to achieve higher throughput

The function of product control is to verify compliance with the Konrad waste acceptance criteria for disposal. Due to the reorganisation of the disposal of radioactive waste, the number of applications for product control by the power utilities is constantly increasing. In order to be able to react adequately to this development, the technical assessment of radioactive waste in the area of product control was put out to tender externally within the framework of a tendering procedure. Since January 2019, TÜV NORD EnSys GmbH & Co. KG (TNE), TÜV SÜD AG, the Product Control Group for Radioactive Waste Jülich and the Federal Institute for Materials Research and Testing (BAM) have been commissioned to provide expert services.

In addition to the involvement of experts in the product control procedure, the development of personnel capacities also within the BGE has been and is being pushed forward.

The expert organisations TNE and TÜV SÜD already carried out significantly more procedure qualifications in 2019. In addition, a clear increase in the number of test reports on the suitability for disposal has been observed. The processing of these reports in the BGE's product control division is also keeping pace with this increase. This is a visible sign that the increase in resources has already led to faster and more flexible processing of applications.

Another basis for achieving a higher throughput of product control is the acceleration of administrative processes. For this purpose, internal processes are being extensively revised and optimised and responsibilities are more clearly delineated. The aim is to make process flows more transparent, measurable, and consistently controllable. Another key focus of product control is the establishment of a digital application management system, which is intended to improve the planning, control and cooperation of all parties involved in the process.

K.1.2 Planned measures for enhancing safety

Site selection procedure for a disposal facility for high-level radioactive waste (next steps)

The site selection procedure for a disposal facility for high-level radioactive waste was started in 2017 with the amendment of the Site Selection Act (StandAG) [1A-7b]. The procedure is to take place in three phases, which are to be accompanied by intensive involvement and participation of the public.

Currently, the criteria and requirements according to the Site Selection Act are applied on the basis of geodata and information and with the help of three-dimensional geological models provided by the competent *Land* and federal government authorities. The aim here is to designate subareas where favourable geological conditions for the safe disposal of high-level radioactive waste can be expected. The results will be published at the end of the third quarter of 2020 and will immediately be submitted to the Federal Office for the Safety of Nuclear Waste Management (BASE). The interim report will present all facts and considerations that are relevant in connection with the selection of subareas. If there are areas that cannot be classified due to inadequate geological data, these areas must also be listed and a recommendation on how to proceed with them must be included.

In accordance with § 9 StandAG, after receipt of the interim report, the BASE convenes a Subareas Conference which discusses said interim report and submits the results of its consultations to the project implementer within one month after the last consultation date (see Chapter H.3.2 for details on the disposal facility for high-level radioactive waste).

Closure of the Morsleben repository for radioactive waste

The Federal Office for Radiation Protection (BfS), which was responsible for the closure of the Morsleben repository for radioactive waste (ERAM) until April 2017, has developed a closure concept based on extensive investigation programmes which is to ensure the isolation of the waste emplaced over a period of 1 million years (see Chapter D.3.3 for details).

The inspection by experts focuses on the verifications of the sealing of shafts and drifts, the integrity of the geological barrier, and the reliability of the waste inventory data. The expert review has shown that the application documents still need to be supplemented.

The Commission on Nuclear Waste Management (ESK) evaluated the decommissioning concept presented by the BfS in 2013 and came to the conclusion that the long-term safety case for the ERAM is feasible according to the state of the art in science and technology at a manageable effort and has demanded the submission of further documents for verification. The BGE, which has been tasked with the continuation of the decommissioning procedure since April 2017, has given an estimated update of key dates for further progression: The final application documents are to be submitted to the licensing authority by 2026, and a decision on the application is expected at the beginning of 2029.

Commissioning of the Konrad repository

The plan approval procedure for the Konrad repository has been completed. After the dismissal of all lawsuits, an incontestable plan approval decision has been valid since 2007. Since December 2017, the BGE has been responsible for the work on converting the Konrad mine into a disposal facility. For the conversion, approx. 500 collateral clauses of the plan approval decision have to be observed and already existing implementation documents have to be revised. Further approvals for modifications under building law must also be obtained.

Construction work above and below ground is progressing. Numerous buildings and installations have been erected, and extensive safety and corrosion protection work has also been carried out on the pithead frame. Significant progress has also been made in terms of traffic engineering. Vehicles for the work underground have been procured and transported underground (see Chapter D.3.3 for details).

To improve the logistic process of emplacement in the Konrad repository, the BGZ Company for Storage (BGZ) is to plan and construct a central reception storage facility (see Chapter H.3.1 for details).The planned logistics centre is to accelerate the emplacement in the Konrad repository by a demand-oriented and continuous delivery of the waste packages qualified for disposal and thus significantly shorten the operating times of both the disposal facility and the decentralised storage facilities.

K.2 Issues relating to an extended storage of spent fuel and heat-generating radioactive waste

In Germany, spent fuel and high-level radioactive waste from the reprocessing of spent fuel are kept in dry storage until they are delivered to a disposal facility. The storage licences for the storage facilities are currently limited to 40 years and expire between 2034 and 2047. The search for a disposal facility was restarted in 2017; its commissioning is not expected before 2050. Against this background, it will be necessary to extend the licensed storage period. In § 6(5), the Atomic Energy Act (AtG) [1A-3] subjects the renewal of storage licences to the existence of imperative grounds and requires prior referral to the German *Bundestag*.

The safety proofs for casks and inventories required for extended storage as well as for the maintenance of operational safety of the storage facilities are to be furnished on the basis of sufficiently reliable data and knowledge to be assessed by the competent authorities and their experts. Furthermore, in the case of extended storage, the transportability of the casks must be ensured at all times during the entire storage period.

The long-term behaviour of casks, in particular of their safety-relevant components, the inventories such as fuel assemblies and vitrified fission product solutions as well as the degradation phenomena to be postulated and their impacts on safety are the main focus of the safety assessments for extended storage periods.

As the supreme supervisory authority, the Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU) has initiated projects by way of precaution in which basic information and data on national and international experience are compiled in order to assess the safety issues related to the extended storage of fuel assemblies and heat-generating radioactive waste from reprocessing at an early stage and to be able to make competent assessments of corresponding concepts and strategies for their future storage. At present, there is the expectation that the currently established concept of dry storage (storage buildings and casks) maintains its safety functions even for considerably longer periods of time than 40 years. This assumption has to be confirmed by an explicit proof according to the state of the art in science and technology.

The additional data required for this can be generated both from the systematic evaluation of operating experience of the facilities operated to date during storage within the scope of periodic safety reviews (PSRs) and aging management measures, as well as from additional investigation programmes.

Technical ageing management focuses on the long-term behaviour of casks and inventories. It is to be demonstrated that the safety-relevant components remain intact also in the case of possible ageing-induced changes in properties during the entire storage period in such a way that they can fulfil their functions postulated in the safety analyses. With a view to non-technical ageing management, organisational structure, safety management as well as knowledge and quality management must also be considered. In addition, the changing framework conditions, such as the transition of the decentralised storage facilities to self-sufficient operation with the progressive decommissioning of the nuclear power plants, must also be taken into account. Here, the preservation of know-how will become more important in the medium term.

The future need for research concerning extended storage was already identified at an early stage. In addition to the safety proofs for casks and inventories, this also includes investigations on their long-term behaviour. A further research focus deals with the investigation of social-science and socio-technical aspects. The issues have already been studied within the framework of national research programmes. Further information about national research activities and their partial implementation can be found in Chapter G.2.2.

At the international level, the issue of inaccessible cask components and inventories is being pursued together with the International Atomic Energy Agency (IAEA) through strategic and targeted research and development activities, particularly by the American side (US-NRC, EPRI, US-DOE). When evaluating international findings and data, the transferability to the German storage systems, including cask inventories, is to be examined in particular with regard to the specific boundary conditions in Germany.

K.3 Western European Nuclear Regulators Association – WENRA – Harmonised approaches in the European nuclear regulatory frameworks in the areas of storage, decommissioning, disposal and waste processing

The objective of WENRA and its currently 18 member states is the joint development of safety standards in nuclear technology and their regulatory implementation at a national level.

This development of safety standards is done by comparing general national regulations with the safety reference levels developed by WENRA. The aim is to harmonise the general regulatory safety approach of the individual member states through the establishment of safety standards that are mainly based on International Atomic Energy Agency (IAEA) requirements. All WENRA member states have committed themselves to do so. What is to be achieved is that the national regulations of all WENRA member states will arrive at a consistently high level of safety.

WENRA has entrusted working groups with the implementation of the defined objectives which are composed of representatives of the national nuclear regulatory authorities. The Reactor Harmonisation Working Group (RHWG) is concerned with regulatory issues concerning the safe operation of nuclear power plants. The safety aspects of the nuclear fuel cycle at the back end are dealt with by the Working Group on Waste and Decommissioning (WGWD). The results of the working groups are subject to ratification by WENRA and are considered as adopted only after such ratification. They thus become binding for the member states of WENRA under the terms of self-commitment.

The work of the WGWD is divided into four areas: decommissioning of nuclear installations, as well as processing, storage and disposal of spent fuel and radioactive waste. For these topics, requirements are developed in the form of safety reference levels according to international standards and the state of the art in science and technology. These are the basis for the subsequent review of the national regulations of the member states. If it is recognised that individual requirements are not explicitly covered by the national regulations, the WGWD accompanies and assesses the changes in regulations to be made at national level. The entire process from the development of the safety reference levels to the implementation in the national regulations of the member states is documented and published in the form of a written report by WENRA.

The following WGWD reports are currently available:

- *„Decommissioning Safety Reference Levels Report“* – Version 2.2 of April 2015 [WENRA 15],
- *„Waste and Spent Fuel Storage Safety Reference Levels Report“* – Version 2.2 of April 2014 [WENRA 14a],
- *„Radioactive Waste Disposal Facilities Safety Reference Levels Report“* of December 2014 [WENRA 14b],
- *„Radioactive Waste Treatment and Conditioning Safety Reference Levels Report“* of October 2016 [WENRA 16].

The harmonisation of the national regulations of the member states has been concluded for the topics of decommissioning and storage. However, member states are still given the opportunity to submit revisions of their legislation to the WGWD in order to demonstrate that the WENRA requirements have been implemented. The topic areas of disposal and waste processing are currently under review of national regulations.

Review of the German regulations

The review of the regulations relating to decommissioning in terms of the safety reference levels in Version 2.2 [WENRA 15] showed relevant deviations for four of the 62 safety reference levels. This concerns two safety reference levels each in the requirement areas "decommissioning strategy and planning" and "safety aspects". There is no deviation regarding the implementation of the requirements in practice. Compliance with the requirements of the safety reference levels as to the content is ensured by the system of nuclear supervision.

As regards storage, the Federal Republic of Germany fulfils all safety requirements of WENRA.

The national self-assessment of the German regulations on disposal was prepared on the basis of the corresponding report [WENRA 14b] and submitted for the first time to the WGWD for evaluation in 2017. All in all, it was found that there was a high degree of agreement with the WENRA requirements. However, the formal conclusion of the German disposal self-assessment is only to take place after the adoption of the safety-related requirements for the disposal of high-level radioactive waste that are currently being prepared.

As regards waste processing, the safety reference levels were published in 2018 and serve as the basis for the harmonisation of regulations that is now underway. Germany is in the process of preparing the self-assessment, which is expected to be submitted to the WGWD for examination in 2021.

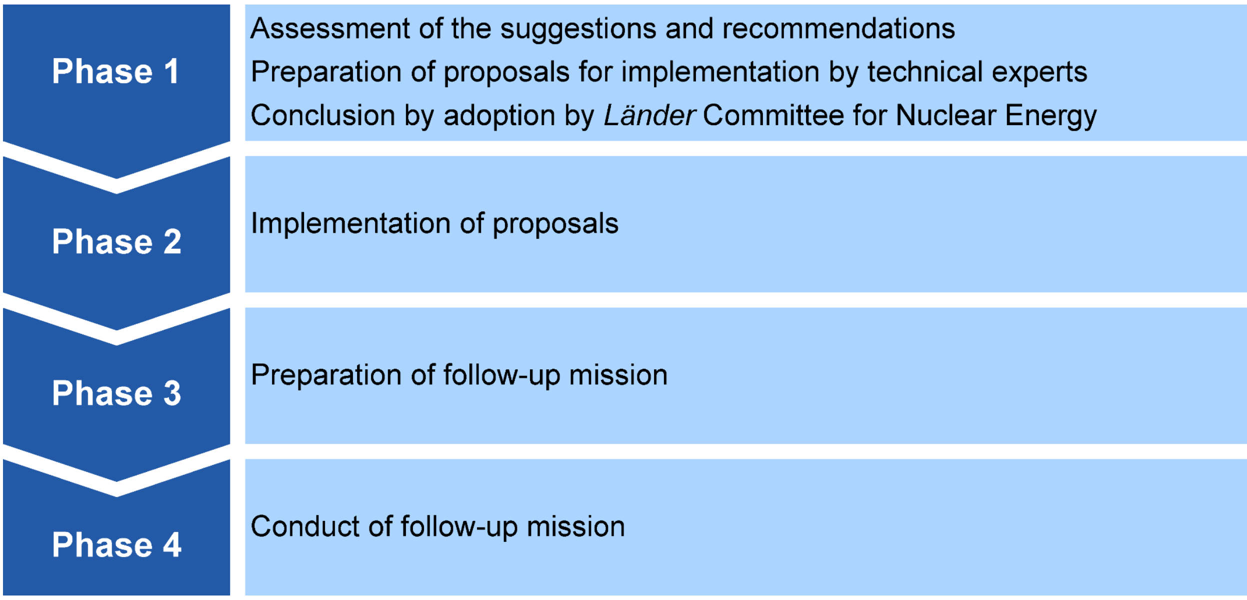
K.4 Implementation of the ARTEMIS recommendations

At the request of the Federal Government, in particular the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), the first review mission for the responsible and safe management of radioactive waste and spent fuel (ARTEMIS mission) took place in Germany from

22 September 2019 to 4 October 2019. Germany has thus fulfilled its obligation under Article 14(3) of Directive 2011/70/EURATOM. At the end of the mission, the IAEA presented Germany with a final report [IAEA 19b]. The team of experts drew attention to future challenges which Germany will face, not least due to the gradual phase-out of nuclear power by the end of 2022 and the tasks associated with this. A total of three recommendations and 12 suggestions were made.

The BMU has started developing proposals for the implementation of the recommendations and suggestions and is currently coordinating activities with the *Länder* participating in the ARTEMIS mission and the subordinate authorities involved. The aim is to discuss the developed proposals within the *Länder* Committee for Nuclear Energy. Once this process has been adopted, concrete implementation will follow with the aim of an ARTEMIS follow-up mission in 2023 (see Figure K-1).

Figure K-1: Sequence diagram of implementation of ARTEMIS recommendations



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 2019 (Table L-1)
- Central storage facilities for spent fuel and high-level radioactive waste from reprocessing and Jülich cask storage facility, as at 31 December 2019 (Table L-2)
- Pilot conditioning plant (PKA) Gorleben (Table L-3)
- Main characteristics of the storage facilities for spent fuel and vitrified radioactive waste from reprocessing licensed or applied for under § 6 of the Atomic Energy Act (AtG) [1A-3], as at 31 December 2019 (Table L-4)

Table L-1: Wet storage facilities for spent fuel and their inventories, as at 31 December 2019

Nuclear Power Plant	Licensed positions	Number of positions available for storage[1)]	Of which not yet occupied	Stored quantity[2)] [Mg HM]
Brunsbüttel	0	0	0	0
Krümmel	1,120	904	904	0
Brokdorf	768	571	36	289
Unterweser	0	0	0	0
Grohnde	768	569	71	271
Emsland	768	569	140	231
Biblis Block A	582	582	582	0
Biblis Block B	578	574	574	0
Obrigheim	0	0	0	0
Philippsburg 1	0	0	0	0
Philippsburg 2	780	575	34	293
Neckarwestheim I[3)]	50	50	1	18
Neckarwestheim II	786	539	64	256
Gundremmingen B	3,219	3,198	876	404
Gundremmingen C	3,219	2,414	154	393
Isar 1	2,232	2,087	1,931	27
Isar 2	792	583	95	261
Grafenrheinfeld	715	695	574	96

[1)] Taking into account 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)] The 50 positions listed can be used in Unit 2 for spent fuel assemblies from Unit 1. 49 of these positions are occupied, one is still available.

Table L-2: Central storage facilities for spent fuel and high-level radioactive waste from reprocessing and Jülich cask storage facility, as at 31 December 2019

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 50 storage positions (equals 320 container positions) CASTOR® MTR 2	3,960 Mg HM $2x10^{20}$ Bq	3 CASTOR® V/52 (26 Mg HM); 3 CASTOR® V/19 (28 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 CG from Series no. 16, TS 28V and TN 85, TS 28V and CASTOR® HAW 28M 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	CASTOR® 440/84, CASTOR® KRB-MOX, 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 HM) 56 CASTOR® 440/84 and 3 CASTOR® KRB-MOX from Greifswald (535 Mg HM) 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; $1.29x10^{17}$ Bq	approx. 290,000 AVR fuel 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 qualified for disposal <u>According to stipulation of 11 June 2001</u>: Use restricted to the repair of defective containers and handling of other radioactive material	35 Mg HM/a (conditioning)	Constructed, but not in operation. Licensed by 3rd partial construction licence of 18/19 December 2000. Immediate execution has not been applied for.

Table L-4: Main characteristics of the storage facilities for spent fuel and vitrified radioactive waste from reprocessing licensed or applied for under § 6 of the Atomic Energy Act (AtG) [1A-3], as at 31 December 2019

Spent fuel storage facility of BGZ *Land*	Applicant Date of application	Mass HM [Mg]	Activity [Bq]	Thermal power [MW]	Storage posi-tions	Type Dimensions (L x W x H) wall/roof [m]	Container	Mass being stored (containers)
Biblis site (BZB), Hesse	RWE Power AG and RWE Rheinbraun AG 23 December 1999	1,400	$8.5 \cdot 10^{19}$	5.3	135	WTI concept 92x38x18 0.85/0.55	CASTOR® V/19	987 Mg HM (102 containers)
	Storage of vitrified HLW containers applied for 29 September 2017						CASTOR® HAW28M (up to 7 con-tainers)	
Brokdorf site (BZF), Schleswig-Holstein	Kernkraftwerk Brokdorf GmbH & Co. oHG and E.ON Kernkraft GmbH[1)] 20 December 1999	1,000	$5.5 \cdot 10^{19}$	3.75	100	STEAG concept 93x27x23 1.20/1.30	CASTOR® V/19	320 Mg HM (33 containers)
	Storage of vitrified HLW containers applied for 29 September 2017						CASTOR® HAW28M (up to 7 con-tainers)	
Brunsbüttel site (KKB)[2)], Schleswig-Holstein	Kernkraftwerk Brunsbüttel GmbH 30 November 1999	450	$6 \cdot 10^{19}$	2.0	80	STEAG concept 83x27x23 1.20/1.30	CASTOR® V/52	161 Mg HM (20 containers)
	New licence applied for 16 November 2015	200	$4.4 \cdot 10^{18}$	0.3	24			
Grafenrheinfeld site (BZR), Bavaria	E.ON Kernkraft GmbH[1)] 23 February 2000	800	$5 \cdot 10^{19}$	3.5	88	WTI concept 62x38x18 0.85/0.55	CASTOR® V/19	418 Mg HM (43 containers)

Spent fuel storage facility of BGZ *Land*	Applicant Date of application	Mass HM [Mg]	Activity [Bq]	Thermal power [MW]	Storage posi-tions	Type Dimensions (L x W x H) wall/roof [m]	Container	Mass being stored (containers)
Grohnde site (BZD) Lower Saxony	Gemeinschaftskern-kraftwerk Grohnde GmbH & Co. oHG, Gemeinschaftskraft-werk Weser GmbH and E.ON Kernkraft GmbH[1)] 20 December 1999	1,000	$5.5\cdot10^{19}$	3.75	100	STEAG concept 93x27x23 1.20/1.30	CASTOR® V/19	331 Mg HM (34 containers)
Gundremmingen site (BZM), Bavaria	RWE Power AG, E.ON Kernkraft GmbH and Kern-kraftwerk Gundremmingen GmbH 25 February 2000	1,850	$2.4\cdot10^{20}$	6.0	192	WTI concept 104x38x18 0.85/0.55	CASTOR® V/52	593 Mg HM (69 containers)
Isar site (BZI), Bavaria	E.ON Kernkraft GmbH[1)] and E.ON Bayern AG 23 February 2000	1,500	$1.5\cdot10^{20}$	6.0	152	WTI concept 92x38x18 0.85/0.55	CASTOR® V/52 CASTOR® V/19 TN 24 E	667 Mg HM (73 containers)
	Storage of vitrified HLW containers applied for 29 September 2017						CASTOR® HAW28M (up to 9 con-tainers)	
Krümmel site (BZK), Schleswig-Holstein	Kernkraftwerk Krümmel GmbH & Co. oHG 30 November 1999	775	$0.96\cdot10^{20}$	3.0	80	STEAG concept 88x27x23 1.20/1.30	CASTOR® V/52	353 Mg HM (42 containers)
Lingen site (BZL), Lower Saxony	Kernkraftwerke Lippe-Ems GmbH 22 December 1998	1,250	$6.9\cdot10^{19}$	4.7	130	STEAG concept 110x30x20 1.20/1.30	CASTOR® V/19	455 Mg HM (47 containers)

Spent fuel storage facility of BGZ *Land*	Applicant Date of application	Mass HM [Mg]	Activity [Bq]	Thermal power [MW]	Storage posi-tions	Type Dimensions (L x W x H) wall/roof [m]	Container	Mass being stored (containers)
Neckarwestheim site (BZN), Baden-Wuerttemberg	Gemeinschaftskern-kraftwerk Neckar GmbH 20 December 1999	1,600	$8.3 \cdot 10^{19}$	3.5	151	2 tunnel tubes 112 bzw. 82 x 12.8 x 17.3	CASTOR® V/19 TN 24 E CASTOR® 440/84	676 Mg HM (86 containers)[3)]
Philippsburg site (BZP), Baden-Wuerttemberg	EnBW Kraftwerke AG 20 December 1999	1,600	$1.5 \cdot 10^{20}$	6.0	152	WTI concept 92x37x18 0.70/0.55	CASTOR® V/19 CASTOR® V/52	561 Mg HM (62 containers)
	Storage of vitrified HLW containers applied for 29 September 2017						CASTOR® HAW28M (5 containers)	
Unterweser site (BZU), Lower Saxony	E.ON Kernkraft GmbH[1)] 20 December 1999	800	$4.4 \cdot 10^{19}$	3.0	80	STEAG concept 80x27x23 1.20/1.30	CASTOR® V/19	368 Mg HM (40 containers)

[1)] Now PreussenElektra GmbH.

[2)] With the decision of the Federal Administrative Court of 16 January 2015 to reject the complaints of the Federal Office for Radiation Protection (BfS) against the non-admission of appeal in the court proceedings concerning the Brunsbüttel storage facility, the judgment of the Schleswig-Holstein Higher Administrative Court revoking the storage licence according to § 6 AtG has become final.

[3)] In total, 96 Mg HM (342 fuel assemblies in 15 casks) from KWO were stored in 2017.

(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 and operational buffer storage facilities at NPP sites (in operation or in post-operation and decommissioning) (Table L-8)
- Storage facilities for radioactive waste – storage facilities in research institutions (Table L-9)
- Storage facilities for radioactive waste – storage facilities of the nuclear and other industries (Table L-10)
- Storage facilities for radioactive waste – *Land* collecting facilities (for waste from research institutions see Table L-9) (Table L-11)
- Disposal facilities and other storage facilities for radioactive waste (Table L-12)

Table L-5: Examples of stationary facilities for the conditioning of radioactive waste for own needs and third parties

Operator, site	Facility	Description
GNS Gesellschaft für Nuklear-Service mbH, 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 by 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
EWN Entsorgungswerk für Nuklearanlagen GmbH, Lubmin/Rubenow	FAKIR high-pressure hydraulic press	High-pressure compaction of radioactive waste in 180-l press drums and 200-l drums as well as loose waste with the aid of metal cartridges
	PETRA drying facility and drying chamber	Drying of solid and liquid radioactive waste in 200-l drums, 280-l drums, 400-l drums or 580-l drums
	Hydraulic shears	Cutting up of metals (scrap shear MARS with pre-compaction)
	Dismantling rooms	Dismantling of metals by use of thermal processes, e.g. autogenous cutting and plasma cutting
	Evaporation facilities	Processing of radioactive liquid waste; throughput up to 3 m^3/h
	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

Operator, site	Facility	Description
Kerntechnische Entsorgung Karlsruhe GmbH – KTE Business unit: Entsorgungsbetriebe (EB), Karlsruhe	Compacting facility (ILW scrap-ping)	Compaction of radioactive waste with negligible heat generation with high dose rate; remote handling techniques with lock and working cells, manipulators, hydraulic shears, hydraulic press
	Compacting facility (LLW scrap-ping)	Compaction of radioactive waste with negligible heat generation 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 contaminated by alpha and beta nuclides; max. through-put: 165 Mg/a; volume reduction factor (with subsequent high-pressure compaction of the ash): approx. 100
	Old evaporation and immobilisa-tion facility (evaporation of LLW no. I)	Evaporation of low-level radioactive waste water with subsequent cementation of the residual materials; max. throughput: 6,000 m³/a; decommissioning since 2012
	New evaporation facility for LLW	Evaporation of low-level radioactive waste water; max. throughput: 600 m³/a; volume reduction factor: up to approx. 20
	Cementing facility	Cementation of residual materials from the “New evaporation facility for LLW”
	Equipment decontamination	Disassembling, conditioning and decontamination of solid, non-combustible residues; through-put: up to approx. 1,200 Mg/a
	Fluidised bed drying facility	Drying of scrubber waters from the combustion facility
	Various drying facilities	Drying of solid radioactive LLW; actual capacity: 38 drums; future capacity: 66 drums; drying of radioactive ILW; capacity: 2 drums/MOSAIK
JEN Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH (JEN), 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
	Drying facility of the PETRA type	Drum drying
	Evaporation facility	Processing of low active waste water, concentrates and sludges; total volume: 825 m³, deliv-ery in tankers

Operator, site	Facility	Description
	Combustion facility JÜV	Processing of low active liquids and solids; annual throughput: up to 240 Mg of solids and 40 Mg of liquids
Helmholtz-Zentrum Berlin GmbH, Berlin	Evaporator	Circulation evaporator
	Cementation	Cementation of evaporator concentrates and other aqueous waste from storage tanks
Strahlenschutz, Analytik und Entsorgung Rossendorf e. V. (VKTA), Rossendorf	Dismantling facilities	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 a. M.	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 residual materials
URENCO Deutschland GmbH, Gronau	Solidification facility for concentrates	Cementation

Table L-6: Examples of mobile facilities for the conditioning of radioactive waste

Operator	Facility	Description	Licence*)
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 facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV (2001)
	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 pursuant to the principle of vacuum drying	Nationwide valid exclusive licence for all facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV (2001)
	Drying facility of the PETRA type	Drying facility for humid radioactive waste being packaged in 200-, 280- and 400-l drums pursuant to the principle of vacuum drying	Nationwide valid exclusive licence for all facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV (2001)
	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 facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV (2001)
	Decanting facility of the FAFNIR type	Decanting facility for radioactive resins (e.g. powder and bead resins) pursuant to the principle of vacuum drying	Nationwide valid exclusive licence for all facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV (2001)
	Mobile exhaust facility for powder resins of the PUSA type	Decanting facility for dry fluid powder resins (e.g. ion-exchange resins from BWR) pursuant to the principle of vacuum suction	Nationwide valid exclusive licence for all facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV (2001)
	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 facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV (2001)
	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 facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV (2001)
	Underwater shear of the UWS type	Underwater disassembly of core scrap	Nationwide valid exclusive licence for all facilities according to §§ 7, 9, 9a AtG and § 7 StrlSchV (2001)

*) Licences according to § 7 StrlSchV refer to StrlSchV 2001 and continue to apply according to § 197 StrlSchG.

Table L-7: Storage facilities for radioactive waste – Central storage facilities

Facility and site	Purpose of the facility	Capacity acc. to licence	First licence	Remarks
Gorleben radioactive waste storage facility (AZG), Lower Saxony	Storage of radioactive waste from NPPs, 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 5×10^{18} Bq	Handling licences according to § 3 StrlSchV[1)] of 27 October 1983, 13 October 1987 and 13 September 1995	In operation since October 1984
Ahaus radioactive waste storage facility (AZA), North Rhine-Westphalia	Storage of radioactive waste from NPPs	Konrad containers, 20' containers and facility components; total activity for storage area no. I limited to 1.0×10^{17} Bq	Handling licences according to § 7 StrlSchV[2)] of 9 November 2009	In operation since July 2010
Unterweser radioactive waste storage facility no. 1 (AZU 1), 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 1.85×10^{15} Bq	Handling licences according to § 3 StrlSchV[1)] of 24 June 1981, 29 November 1991 and 6 November 1998	In operation since autumn 1981
Unterweser radioactive waste storage facility no. 2 (AZU 2), Lower Saxony	Storage of radioactive waste from the NPP Unterweser and other nuclear power plants of the utility PreussenElektra GmbH, of the Unterweser radioactive waste storage facility no. 1 and of the Unterweser spent fuel storage facility	Storage of conditioned waste packages destinated for the Konrad repository; provision of transport or buffer storage of single components or waste in 20 ft-containers or in transport packages with a maximum activity of $2 \cdot 10^{17}$ Bq	Handling licences according to § 7 StrlSchV (2001) of 5 December 2018	In operation since April 2020
Storage facility of the EVU, Mitterteich, Bavaria	Storage of waste with negligible heat generation from Bavarian nuclear installations	40,000 waste packages (200-l, 400-l drums or cast-iron containers)	Handling licences according to § 3 StrlSchV[1)] of 7 July 1982	In operation since July 1987

Facility and site	Purpose of the facility	Capacity acc. to licence	First licence	Remarks
Storage Facility North (ZLN), Rubenow Mecklenburg-West Pomerania	Storage of operational and decommissioning waste from the NPPs Greifswald and Rheinsberg, including storage of dismantled large components; storage of residual materials and waste that will be conditioned for third party	165,000 m³	Handling licences according to § 3 StrlSchV[1)] of 20 February 1998	In operation since March 1998
Entsorgungsbetriebe (EB), Karlsruhe, Baden-Wuerttemberg	Storage of waste with negligible heat generation from FZK, KTE, ITU, *Land* collecting facility Baden-Wuerttemberg and, in a limited way or for buffering purposes, from third parties	Handling (conditioning and storage) of residual radioactive materials and waste with contents of fissile material up to a total activity of 4.5×10^{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

1) As amended on 13 October 1976 or 30 June 1989 respectively.
2) Licences according to § 7 StrlSchV refer to StrlSchV 2001 and continue to apply according to § 197 StrlSchG.

Table L-8: Storage facilities for radioactive waste and operational buffer storage facilities at NPP sites (in operation or in post-operation and decommissioning)

Facility and site	Purpose of the facility	Capacity acc. to licence	Licence*)	Remarks
Biblis site a) Units A and B b) Biblis radioactive waste storage facility (AZB) 1 c) AZB 2	Storage of radioactive waste from the operation and decommissioning of the NPP	a) 7,500 packages b) 2,100 m³ c) 8,000 m³	a) § 7 AtG, § 7 StrlSchV (2001) b) § 7 AtG, § 7 StrlSchV (2001) c) § 7 StrlSchV (2001)	Licence according to § 7 StrlSchV for the storage of radio-active operational waste (3,000 m³) in the on-site storage facility, hall 2; commissioning of AZB 2 in 2018
Brokdorf NPP	Storage of radioactive waste from the operation of the NPP	560 m³	§ 7 AtG	-
Brunsbüttel site a) KKB b) Brunsbüttel radioactive waste storage facility (AZT)	Storage of radioactive waste from the operation and decommissioning of the NPP	a) 3,225 m³ / 4,150 m³ b) 13,000 m³	a) § 7 StrlSchV (2001) b) § 7 StrlSchV (2001)	a) Hall I and II for keeping the waste ready for transport b) Under construction
Emsland NPP	Storage of radioactive waste from the operation of the NPP	185 m³	§ 7 AtG	-
Grafenrheinfeld site a) KKG b) Grafenrheinfeld radio-active waste storage facility (AZR)	Storage of radioactive waste from the operation and decommissioning of the NPP	a) Raw waste: 200 m³ Conditioned waste: 200 m³ b) 6,000 m³	a) § 7 AtG b) § 7 StrlSchV (2001)	a) - b) Under construction

Facility and site	Purpose of the facility	Capacity acc. to licence	Licence*)	Remarks
Grohnde NPP	Storage of radioactive waste from the operation of the NPP	280 m³	§ 7 AtG	-
Gundremmingen NPP Units B and C	Storage of radioactive waste from the operation and decommissioning of the NPP	300 m³ conditioned waste 1,305 m³ liquid waste	§ 7 AtG	-
Isar 1 NPP	Storage of radioactive waste from the operation and decommissioning of the NPP	4,000 m³	§ 7 AtG	-
Isar 2 NPP	Storage of radioactive waste from the operation of the NPP	160 m³	§ 7 AtG	-
Krümmel site a) KKK b) Krümmel radioactive waste storage facility (AZK)	Storage of radioactive waste from the operation of the NPP	a) 1,340 m³ b) 7,000 m³	§ 7 AtG	a) - b) Planned
Neckarwestheim site a) Units I and II b) Neckarwestheim radioactive waste storage facility (AZN)	Storage of radioactive waste from the operation and decommissioning of the NPP	a) 2,322 m³ b) 12,000 m³	a) § 7 AtG b) § 7 StrlSchV (2001)	a) - b) Under construction
Philippsburg site a) Units 1 and 2 b) Philippsburg radioactive waste storage facility (AZP)	Storage of radioactive waste from the operation and decommissioning of the NPP	a) 3,970 m³ b) 15,000 m³	a) § 7 AtG b) § 7 StrlSchV (2001)	a) - b) Commissioning in April 2020
Unterweser site (KKU)	Storage of radioactive waste from the operation and decommissioning of the NPP	350 m³	§ 7 AtG	-

Facility and site	Purpose of the facility	Capacity acc. to licence	Licence*)	Remarks
Greifswald NPP Units 1 – 5	Storage of radioactive waste and residual materials from the decommissioning of the NPP, for the KKR and third parties	140 20’ containers	§ 7 AtG	Storage space for the collection and storage of radioactive waste/residues
Gundremmingen NPP 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 reactor	1,160 m^3	§ 7 AtG	-
AVR Jülich	Storage of radioactive waste from the decommissioning of the reactor	235 m^3	§ 7 AtG	-
Lingen NPP	Storage of radioactive waste from the operation and decommissioning of the NPP	170 m^3	§ 7 AtG	-
Mülheim-Kärlich NPP	Storage of radioactive waste from the operation and decommissioning of the NPP	43 m^3	§ 7 AtG	-
Obrigheim site a) KWO facility b) Obrigheim radioactive waste storage facility (AZO)	Storage of radioactive waste from the operation and decommissioning of the NPP	a) 0 m^3 b) 3,817 m^3	a) § 7 AtG b) § 12 StrlSchG	-
Rheinsberg NPP	Storage of radioactive waste from the decommissioning of the NPP		§ 7 AtG	Only buffer storage
Stade site a) KKS b) Stade radioactive waste storage facility (AZS)	a) Storage of radioactive waste from the operation and the post-operational phase of the NPP b) Storage of radioactive waste from the decommissioning of the NPP	a) 100 m^3 b) 5,000 m^3	a) § 7 AtG b) § 7 StrlSchV (2001)	a) - b) Commissioning: 1 August 2007
Würgassen NPP	Storage of radioactive waste from the decommissioning of the NPP	4,600 m^3	§ 7 AtG	-

*) Licences according to § 7 StrlSchV refer to StrlSchV 2001 and continue to apply according to § 197 StrlSchG.

Table L-9: Storage facilities for radioactive waste – storage facilities in research institutions

Facility and site	Type of waste stored	Capacity acc. 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 FRM2: 68 m^3	§ 7 AtG	There is no radioactive waste storage facility with an independent handling or operating licence available at the Garching site. There are capabilities to allocate radioactive waste for transport.
Helmholtz-Zentrum Geesthacht Geesthacht	Operational waste from the research reactor	145 m^2, 112 m^2, 226 m^2	§ 3 StrlSchV[1)], § 7 StrlSchV[2)]	Storage space for conditioned waste
JEN Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH (JEN)	Radioactive waste with negligible heat generation, and AVR fuel spheres, activated bulky waste	11,470 drums and 780 Konrad containers Licence for storage of AVR fuel elements	§ 3 StrlSchV[1)] §§ 6, 9 AtG	-
VKTA Rossendorf	Operational and decommissioning waste from the research institution	2,270 m^3 (total gross storage volume)	§ 3 StrlSchV[1)]	Storage facility Rossendorf (ZLR)

[1)] As amended on 13 October 1976 or 30 June 1989, respectively.
[2)] Licences according to § 7 StrlSchV refer to StrlSchV 2001 and continue to apply according to § 197 StrlSchG.

Table L-10: Storage facilities for radioactive waste – storage facilities of the nuclear and other industries

Facility and site	Type of waste stored	Capacity acc. to licence	Licence
		Nuclear industry	
Advanced Nuclear Fuels GmbH (ANF), Lingen	Operational waste from fuel fabrication	950 200-l drums	§ 7 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[1)])	§ 9 AtG, § 3 StrlSchV[1)]
Storage facility of DAHER NUCLEAR TECHNOLOGIES (formerly 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	1.: § 7 StrlSchV[2)] 2.: § 3 StrlSchV[1)]
Urenco, Gronau	Operational waste from uranium enrichment	Storage facility: 220 m²; up to 48 Konrad type V containers; buffer storage facility 1: 150 200-l drums; buffer storage facility 2: 230 m², 84 200-l drums (double-stacked); 96 storage positions for “lost concrete shielding” (single-stacked)	§ 7 AtG
		Other industry	
Eckert & Ziegler Nuclitec GmbH, Leese	Waste from medical applications, research and industry	13,620 200-l drums	§ 7 StrlSchV[2)]

[1)] As amended on 13 October 1976 and 30 June 1989, respectively.
[2)] Licences according to § 7 StrlSchV refer to StrlSchV 2001 and continue to apply according to § 197 StrlSchG.

Table L-11: Storage facilities for radioactive waste – *Land* collecting facilities (for waste from research institutions see Table L-9)

Facility and site	Tye of waste stored	Capacity acc. to licence	Licence	Remarks
Land collecting facility Baden-Wuerttemberg, Karlsruhe	Waste from medical applications, research and industry	No capacity limit stated (capacity EB: 78,664 m³)	§ 9 AtG	*Land* collecting facility in EB, operator EB
Land collecting facility Bavaria, Mitterteich	Waste from medical applications, research and industry	10,000 packages	§ 3 StrlSchV*)	Approx. 2,900 m³ available
Land collecting facility Berlin, Berlin	Waste from medical applications, research and industry	800 m³	§ 3 StrlSchV*)	At the Helmholtz-Zentrum Berlin
Land collecting facility Hesse, Ebsdorfergrund	Waste from medical applications, research and industry	400 m³	§ 6 AtG § 3 StrlSchV*)	-
Land collecting facility Mecklenburg-Western Pomerania, Rubenow	Waste from medical applications, research and industry	20‘ containers	§ 3 StrlSchV*)	*Land* collecting facility at ZLN, use shared with Brandenburg
Land collecting facility North Rhine-Westphalia, Jülich	Waste from medical applications, research and industry	9,000 200-l drums	§ 3 StrlSchV*), § 9 AtG	On the site of the Forschungszentrum Jülich
Land collecting facility Rhineland-Palatinate, Hoppenstetten-Weilersbach	Waste from medical applications, research and industry	$\alpha+\beta/\gamma$ activity limited to: 1.6×10^{13} Bq	§ 9 AtG, § 3 StrlSchV*)	Approx. 600 m³ available, use shared with Saarland since 2016
Land collecting facility Saarland, Elm-Derlen	Waste from medical applications, research and industry	50 m³	§ 3 StrlSchV*)	-
Land collecting facility Saxony, Rossendorf/Dresden	Waste from medical applications, research and industry	300 m³	§ 3 StrlSchV*)	At VKTA, use shared with Thuringia and Saxony-Anhalt

Facility and site	Tye of waste stored	Capacity acc. to licence	Licence	Remarks
Land collecting facility of the four north German coastal *Länder*, Geesthacht	Waste from medical applications, 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.
Land collecting facility Lower Saxony, Leese	Waste from medical applications, research and industry	Hired storage capacity: 1,485 drums, 3,400 drums, max. 50 Konrad containers	§ 7 StrlSchV	Storage capacity in the storage facility of the company Eckert & Ziegler Nuclitec GmbH provided for the *Land* collecting facility Lower Saxony (included in the storage capacity listed in Table L-10). (The acceptance of raw waste for the *Land* collecting facility Lower Saxony and their conditioning is performed by GNS Gesellschaft für Nuklear-Service mbH at its facilities on the premises of the Jülich research centre (FZJ)).
Central collecting point of the German Federal Armed Forces, Munster	Waste originating from activities of the German Federal Armed Forces	1,600 m³	§ 3 StrlSchV*)	-

*) As amended on 13 October 1976 or 30 June 1989 respectively.

Table L-12: Disposal facilities and other storage facilities for radioactive waste

Facility and site	Purpose of the facility	Quantity/activity emplaced	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 waste.	Between 1967 and 1978 approx. 124,500 LLW waste packages, including approx. 15,000 so-called “Lost concrete shieldings” (VBA) with higher-level waste and approx. 1,300 ILW waste packages were emplaced for trial purposes. Total activity of the waste emplaced: 2.3×10^{15} Bq (as at 31 December 2019).	Licence according to § 3 StrlSchV as amended on 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	Disposal of radioactive waste with negligible heat generation.	-	Licence according to § 9b AtG, approval of the plan was granted on 22 May 2002, decision is final 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- and intermediate-level waste with mainly short-lived radionuclides.	Disposal of approx. 37,000 m³ low- and intermediate-level waste in total, total activity of all radioactive waste emplaced in the order of magnitude of 10^{14} Bq, activity of alpha sources in the order of magnitude of 10^{11} Bq.	22 April 1986: Permanent operating licence granted. 12 April 2001: A statement is made irrevocably 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. Closure has been applied for.

(c) List of nuclear installations being out of operation

The following tables list nuclear installations in Germany, divided into the following categories:

- Nuclear power plants in the post-operational phase or in the process of decommissioning as at 31 March 2020 (Table L-13)
- Research reactors with an electric power of more than 1 MW permanently shut down (still without decommissioning licence), in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at 31 March 2020 (Table L-14)
- Research reactors with an electric power of less than 1 MW permanently shut down (still without decommissioning licence), in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at 31 March 2020 (Table L-15)
- Experimental and demonstration reactors in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at 31 March 2020 (Table L-16)
- Commercial fuel cycle facilities in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at 31 March 2020 (Table L-17)
- Research, experimental and demonstration facilities of the nuclear fuel cycle, decommissioning completed and facilities released from nuclear regulatory control, as at 31 March 2020 (Table L-18)

Table L-13: Nuclear power plants in the post-operational phase or in the process of decommissioning as at 31 March 2020

	Facility, site	Operator	Type of facility, electrical output (gross)	First criticality	Final shut- down	Status	Planned final status
1	KKR Rheinsberg, Brandenburg	EWN GmbH	PWR (VVER) 70 MWe	03/1966	06/1990	Dismantling	Removal
2	KRB A Gundremmingen, Bavaria	Kernkraftwerk Gundremmingen GmbH	BWR 250 MWe	08/1966	01/1977	Dismantling, alteration	Technology centre
3	KWL Lingen, Lower Saxony	Kernkraftwerk Lingen GmbH	BWR 252 MWe	01/1968	01/1977	Dismantling	Removal
4	KWO Obrigheim, Baden-Wuerttemberg	EnBW Kernkraft GmbH – Kernkraftwerk Obrigheim	PWR 357 MWe	09/1968	05/2005	Dismantling	Removal
5	KWW Würgassen, North Rhine-Westphalia	PreussenElektra GmbH	BWR 670 MWe	10/1971	08/1994	Dismantling	Removal
6	KKS Stade, Lower Saxony	PreussenElektra GmbH	PWR 672 MWe	01/1972	11/2003	Dismantling	Removal
7	KGR 1 Lubmin, Mecklenburg-Western Pomerania	EWN GmbH	PWR (VVER) 440 MWe	12/1973	12/1990	Dismantling	Partial dismantling, use as an industrial site
8	KWB-A Biblis, Hesse	RWE Nuclear GmbH	PWR 1,225 MWe	07/1974	08/2011	Dismantling	Removal
9	KGR 1 Lubmin, Mecklenburg-Western Pomerania	EWN GmbH	PWR (VVER) 440 MWe	12/1973	12/1990	Dismantling	Partial dismantling, use as an industrial site
10	KWB-A Biblis, Hesse	RWE Nuclear GmbH	PWR 1,225 MWe	07/1974	08/2011	Dismantling	Removal
11	GKN I Neckarwestheim, Baden-Wuerttemberg	EnBW Kernkraft GmbH (EnKK)	PWR 840 MWe	05/1976	08/2011	Dismantling	Removal
12	KKB, Brunsbüttel, Schleswig-Holstein	Kernkraftwerk Brunsbüttel GmbH & Co. oHG	BWR, 806 MWe	06/1976	08/2011	Dismantling	Removal

	Facility, site	Operator	Type of facility, electrical output (gross)	First criticality	Final shut-down	Status	Planned final status
13	KGR 3 Lubmin, Mecklenburg-Western Pomerania	EWN GmbH	PWR (VVER) 440 MWe	10/1977	02/1990	Dismantling	Partial dismantling, use as an industrial site
14	KKI 1 Essenbach, Bavaria	PreussenElektra	BWR 912 MWe	11/1977	08/2011	Dismantling	Removal
15	KKP 1 Philippsburg, Baden-Wuerttemberg	EnBW Kernkraft GmbH (EnKK)	BWR 926 MWe	03/1979	08/2011	Dismantling	Removal
16	KGR 4 Lubmin, Mecklenburg-Western Pomerania	EWN GmbH	PWR (VVER) 440 MWe	07/1979	06/1990	Dismantling	Partial dismantling, use as an industrial site
17	KKU Unterweser, Lower Saxony	PreussenElektra GmbH	PWR 1,410 MWe	09/1979	08/2011	Dismantling	Removal, subsequent use as appropriate
18	KKG Grafenrheinfeld, Bavaria	PreussenElektra GmbH	PWR 1,345 MWe	12/1981	06/2015	Dismantling	Removal, subsequent use as appropriate
19	KKK Krümmel, Schleswig-Holstein	Kernkraftwerk Krümmel GmbH & Co. oHG	BWR 1,402 MWe	09/1983	08/2011	Post-operational phase	Removal
20	KRB B Gundremmingen, Bavaria	Kernkraftwerk Gundremmingen GmbH	BWR 1,344 MWe	03/1984	12/2017	Dismantling	Removal
21	KKP 2 Philippsburg, Baden-Wuerttemberg	EnBW Kernkraft GmbH (EnKK)	PWR 1,468 MWe	12/1984	12/2019	Dismantling	Removal
22	KMK Mülheim-Kärlich, Rhineland-Palatinate	RWE Nuclear GmbH	PWR 1,302 MWe	03/1986	09/1988	Dismantling	Subsequent use
23	KGR 5 Lubmin, Mecklenburg-Western Pomerania	EWN GmbH	PWR (VVER) 440 MWe	03/1989	11/1989	Dismantling	Partial dismantling, use as an industrial site

Table L-14: Research reactors with an electric power of more than 1 MW permanently shut down (still without decommissioning licence), in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at 31 March 2020

	Facility, site	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 nuclear regulatory control except the storage facility	-
2	FR-2 Karlsruhe, Baden-Wuerttemberg	KTE 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, decommissioning applied for	Removal
4	FRG-2 Geesthacht, Schleswig-Holstein	Helmholtz-Zentrum Geesthacht GmbH	Pool 15 MW	03/1963	05/1991	Shut down, partially 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	JEN mbH (subsidiary of EWN)	DIDO 23 MW	11/1962	05/2006	Dismantling	Removal
7	FRM München, Bavaria	Technische Universität München	Pool 4 MW	10/1957	07/2000	Dismantling	Partial dismantling, conversion 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	Dismantling	Removal
10	BER II Berlin, Berlin	Helmholtz-Zentrum Berlin GmbH,	Pool 10 MWth	12/1973	12/2019	Shut down	Removal

Table L-15: Research reactors with an electric power of less than 1 MW permanently shut down (still without decommissioning licence), in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at 31 March 2020

	Facility, site	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., Hesse (FRF-2 in the same building never reached criticality)	Johann-Wolfgang-Goe-the-Universität Frank-furt/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-Wuerttem-berg	Deutsches Krebsforschungszentrum Heidelberg	TRIGA, 250 kW	08/1966	03/1977	Removed	-
9	HD II Heidelberg, Baden-Wuerttem-berg	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	-

	Facility, site	Operator	Type, thermal output	First criticality	Final shut-down	Status	Planned final status
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	-
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 North Rhine-Westphalia	RWTH Aachen	Homog. reactor, < 1 W	09/1965	-	Decommission-ing 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 Hesse	Technische Hochschule Darmstadt	Homog. reactor, < 1 W	09/1963	02/1985	Removed	-
22	SUR Hamburg Hamburg	Fachhochschule Ham-burg	Homog. reactor, < 1 W	01/1965	08/1992	Removed	-
23	SUR Hannover Lower Saxony	Universität Hannover	Homog. reactor, < 1 W	12/1971	-	Removed	-
24	SUR Karlsruhe Baden-Wuerttemberg	Karlsruher Institut für Technologie	Homog. reactor, < 1 W	03/1966	09/1996	Removed	-
25	SUR Kiel Schleswig-Holstein	Fachhochschule Kiel	Homog. reactor, < 1 W	03/1966	12/1997	Removed	-

	Facility, site	Operator	Type, thermal output	First criticality	Final shut-down	Status	Planned final status
26	SUR München Bavaria	Technische Universität München	Homog. Reactor, < 1 W	02/1962	08/1981	Removed	-
27	SUAK Karlsruhe, Baden-Wuerttemberg	Karlsruher Institut für Technologie	Fast sub-critical assembly, < 1 W	11/1964	12/1978	Removed	-
28	SUA München, Bavaria	Technische Universität München	Sub-critical as-sembly, < 1 W	06/1959	10/1968	Removed	-
29	ZLFR Zittau, Saxony	Hochschule Zittau/Görlitz	10 W	05/1979	03/2005	Removed	-

Table L-16: Experimental and demonstration reactors in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at 31 March 2020

	Facility, site	Operator	Type, thermal output (gross)	First criticality	Final shut-down	Status	Planned final status
1	AVR Atomversuchskraftwerk Jülich, North Rhine-Westphalia	JEN	HTGR, 15 MWe	08/1966	12/1988	Dismantling	Removal
2	HDR Heißdampfreaktor Großwelzheim, Bavaria	Karlsruher Institut für Technologie	HDR, 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	KTE	Fast breeder reactor, 21 MWe	10/1977	08/1991	Dismantling	Removal
5	MZFR Mehrzweckforschungsreaktor Karlsruhe, Baden-Wuerttemberg	KTE	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	02/1979	Nuclear ship released from nuclear regulatory control, RPV put into storage	Removal (RPV)
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-17: Commercial fuel cycle facilities in the process of decommissioning, or decommissioning completed and released from nuclear regulatory control, as at 31 March 2020

	Facility, site	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	RD Hanau GmbH (formerly Nukem GmbH)	1962	1988	Removed	-
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 including Karlsruhe vitrification facility Baden-Wuerttemberg	KTE	1971	1990	Dismantling	Removal

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 March 2020

	Facility, site	Operator	Start of operation	Final shutdown	Status	Planned final status
1	JUPITER Testanlage Wiederaufarbeitung – Jülich North Rhine-Westphalia	Forschungszentrum Jülich GmbH	1978	1987	Removed	-
2	MILLI Laborextraktionsanlage Karlsruhe, Baden-Wuerttemberg	Karlsruher Institut für Technologie	1970	1991	Removed	-
3	PUTE Plutoniumextraktionsanlage Karlsruhe, Baden-Wuerttemberg	Karlsruher Institut für Technologie	1980	1991	Removed	-

(d) National laws and regulations

The structure and sequence of the following references are based on the “Handbook on Nuclear Safety and Radiation Protection”. As a general rule, the laws and regulations listed in the Handbook must be taken into account during licensing 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, and that are cited in this report. For this reason, there are gaps in the numbering of the references and the numbering does not correspond exactly with the Handbook. The complete handbook is currently available at www.base.bund.de (“Laws and regulations“).

1 Regulations

- 1A National nuclear and radiation protection law
- 1B Regulations to be applied in the nuclear field and in the area of radiation protection
- 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 in the areas of nuclear safety and radiation protection

2 General administrative provisions

3 Announcements by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the formerly competent Federal Ministry for the Interior

4 Recommendations of the SSK and the ESK

5 Safety standards of the Nuclear Safety Standards Commission (KTA)

1 Regulations

1A National nuclear and radiation protection law

[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) in der Fassung der Bekanntmachung vom 15. Juli 1985 (BGBl. I 1985, Nr. 41, S. 1565), das zuletzt durch Artikel 2 des Gesetzes vom 12. Dezember 2019 (BGBl. I 2019, Nr. 48, S. 2510) 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 – AtStrlS-VDBest – 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 – StrlSAblAnO – 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 1986, Nr. 69, S. 2610), zuletzt geändert durch Artikel 91 der Verordnung vom 31. August 2015 (BGBl. I 2015, Nr. 35, S. 1474).

Gemäß Artikel 4 des Gesetzes zur Neuordnung des Rechts zum Schutz vor der schädlichen Wirkung ionisierender Strahlung vom 27. Juni 2017 (BGBl. I 2017, Nr. 42, S. 1966) wird das Strahlenschutzvorsorgegesetz zum 1. Oktober 2017 aufgehoben.

[1A-7a] 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), zuletzt geändert durch Artikel 309 der Verordnung vom 31. August 2015 (BGBl. I 2015, Nr. 35, S. 1474).

[1A-7b] Gesetz zur Fortentwicklung des Gesetzes zur Suche und Auswahl eines Standortes für ein Endlager für Wärme entwickelnde radioaktive Abfälle und anderer Gesetze vom 5. Mai 2017 (BGBl. I 2017, Nr. 26, S. 1074) zuletzt geändert durch Artikel 3 des Gesetzes vom 12. Dezember 2019 (BGBl. I 2019, Nr. 48, S. 2510).

[1A-8a] 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 8 des Gesetzes vom 26. Juli 2016 (BGBl. I 2016, Nr. 37, S. 1843).

[1A-8b] Verordnung zum Schutz vor der schädlichen Wirkung ionisierender Strahlen (Strahlenschutzverordnung – StrlSchV) vom 29. November 2018 (BGBl. I 2018, Nr. 41, S. 2034, 2036), zuletzt geändert durch Artikel 1 der Verordnung vom 27. März 2020 (BGBl. I 2020, Nr. 16, S. 748).

[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), die zuletzt durch Artikel 14 der Verordnung vom 29. November 2018 (BGBl. I 2018, Nr. 41, S. 2034) geändert worden ist.

[1A-11] Verordnung über die Deckungsvorsorge nach dem Atomgesetz (Atomrechtliche Deckungsvorsorge-Verordnung – AtDeckV) vom 25. Januar 1977 (BGBl. I 1977, Nr. 8, S. 220), die zuletzt durch Artikel 13 der Verordnung vom 29. November 2018 (BGBl. I 2018, Nr. 41. S. 2034) geändert worden ist.

[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 4 des Gesetzes vom 12. Dezember 2019 (BGBl. I 2019, Nr. 48, S. 2510).

[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 18 der Verordnung vom 29. November 2018 (BGBl. I 2018, Nr. 41, S. 2034).

[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), zuletzt geändert durch Artikel 16 der Verordnung vom 29. November 2018 (BGBl. I 2018, Nr. 41, S. 2034).

Hinweis: Umsetzung der Richtlinie 2006/117/EURATOM vom 20. November 2006 (ABl. 2006, L 337).

[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 15 der Verordnung vom 29. November 2018 (BGBl. I 2018, Nr. 41, S. 2034).

[1A-24] Zehntes Gesetz zur Änderung des Atomgesetzes vom 17. 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 ((„Lex Asse“) (BGBl. I 2013, Nr. 19, S. 921).

[1A-27] Gesetz über die Errichtung eines Bundesamtes für kerntechnische Entsorgungssicherheit – BfkEG – vom 23. Juli 2013 (BGBl. I 2013, Nr. 41, S. 2553, 2563), zuletzt geändert durch Artikel 5 des Gesetzes vom 12. Dezember 2019 (BGBl. I 2019, Nr. 48, S. 2510).

[1A-28] Vierzehntes Gesetz zur Änderung des Atomgesetzes vom 20. November 2015 (BGBl. I 2015, Nr. 46, S. 2053).

Hinweis: Umsetzung weiterer Vorgaben der Richtlinie 2011/70/EURATOM vom 19. Juli 2011 (ABl. 2011 L 199).

[1A-29] Gesetz zur Neuordnung des Rechts zum Schutz vor der schädlichen Wirkung ionisierender Strahlung vom 27. Juni 2017 (BGBl. I 2017, Nr. 42, S. 1966).

Hinweis: Umsetzung der Richtlinie 2013/59/EURATOM vom 5. Dezember 2013 (ABl. 2014, L. 13) und der Richtlinie 2001/42/EG vom 27. Juni 2001 (ABl. 2001, L 197).

[1A-30] Gesetz zur Neuordnung der Organisationsstruktur im Bereich der Endlagerung (EndLaNOG) vom 26. Juli 2016 (BGBl. I 2016, Nr. 37, S. 1843), zuletzt geändert durch die Berichtigung des Gesetzes zur Neuordnung der Organisationsstruktur im Bereich der Endlagerung vom 15. Dezember 2016 (BGBl. I 2016, Nr. 61, S. 2930).

[1A-31] Gesetz zur Neuordnung der Verantwortung in der kerntechnischen Entsorgung (VkENOG) vom 27. Januar 2017 (BGBl. I 2017, Nr. 5, S. 114).

[1A-32] Fünfzehntes Gesetz zur Änderung des Atomgesetzes vom 1. Juni 2017 (BGBl. I 2017, Nr. 33, S. 1434).

Hinweis: Umsetzung der Richtlinie 2014/87/EURATOM vom 8. Juli 2014 (ABl. 2014, L 219) sowie Umsetzung des Artikels 69 der Richtlinie 2013/59/EURATOM vom 5. Dezember 2013 (ABl. 2014, L 13).

[1A-33] Sechzehntes Gesetz zur Änderung des Atomgesetzes (16. AtGÄndG) vom 10. Juli 2018 (BGBl. I 2018, Nr. 25, S. 1122).

[1A-34] Gesetz zum Schutz vor der schädlichen Wirkung ionisierender Strahlung (Strahlenschutzgesetz – StrlSchG) vom 27. Juni 2017 (BGBl. I 2017, Nr. 42, S. 1966), zuletzt geändert durch Artikel 11 des Gesetzes vom 12. Dezember 2019 (BGBl. I 2019, Nr. 48, S. 2510).

[1A-35] Gesetz zur Regelung des Übergangs der Finanzierungs- und Handlungspflichten für die Entsorgung radioaktiver Abfälle der Betreiber von Kernkraftwerken (Entsorgungsübergangsgesetz – EntsorgÜG) vom 27. Januar 2017 (BGBl. I 2017, Nr. 5, S. 114, 120), zuletzt geändert durch Artikel 9 des Gesetzes vom 12. Dezember 2019 (BGBl. I 2019, Nr. 48, S. 2510).

[1A-36] Gesetz zur Errichtung eines Fonds zur Finanzierung der kerntechnischen Entsorgung (Entsorgungsfondsgesetz – EntsorgFondsG) vom 27. Januar 2017 (BGBl. I 2017, Nr. 5, S. 114), zuletzt geändert durch Artikel 1 der Verordnung vom 16. Juni 2017 (BGBl. I 2017, Nr. 38, S. 1672).

[1A-37] Gesetz zur Transparenz über die Kosten der Stilllegung und des Rückbaus der Kernkraftwerke sowie der Verpackung radioaktiver Abfälle (Transparenzgesetz – TransparenzG) vom 27. Januar 2017 (BGBl. I 2017, Nr. 5, S. 114, 125), zuletzt geändert durch Artikel 10 des Gesetzes vom 12. Dezember 2019 (BGBl. I 2019, Nr. 48, S. 2510).

[1A-38] Gesetz zur Nachhaftung für Abbau- und Entsorgungskosten im Kernenergiebereich (Nachhaftungsgesetz – NachhG) vom 27. Januar 2017 (BGBl. I 2017, Nr. 5, S. 114, 127), zuletzt geändert nach Maßgabe des Artikel 5 Absatz 2 durch Artikel 4 Absatz 3 des Gesetzes vom 5. Mai 2017 (BGBl. I 2017, Nr. 26, S. 1074).

[1A-39] Gesetz zur Änderung des Umweltauditgesetzes, des Atomgesetzes, des Standortauswahlgesetzes, der Endlagervorausleistungsverordnung und anderer Gesetze und Verordnungen vom 12. Dezember 2019 (BGBl. I 2019, Nr. 48, S. 2510).

1B Regulations to be applied in the nuclear field and in the area of radiation protection

[1B-1] Strafgesetzbuch – StGB – vom 13. November 1998 (BGBl. I 1998, Nr. 75, S. 3322), zuletzt geändert durch Artikel 1 des Gesetzes vom 3. März 2020 (BGBl. I 2020, Nr. 11, S. 431).

[1B-2] Raumordnungsgesetz – ROG – vom 22. Dezember 2008 (BGBl. I 2008, Nr. 65, S. 2986), zuletzt geändert durch Artikel 2 Absatz 15 des Gesetzes vom 20. Juli 2017 (BGBl. I 2017, Nr. 52, S. 2808).

Hinweis: Umsetzung von u. a. der Richtlinie 2001/42/EG vom 27. Juni 2001 (ABl. 2001, L 197).

[1B-3] Gesetz zum Schutz vor schädlichen Umwelteinwirkungen durch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge (Bundes-Immissionsschutzgesetz – BImSchG) in der Fassung der Bekanntmachung vom 17. Mai 2013 (BGBl. I 2013, Nr. 25, S. 1274), zuletzt geändert durch Artikel 1 des Gesetzes vom 8. April 2019 (BGBl. I 2019, Nr. 12, S. 432).

[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 4. Dezember 2018 (BGBl. I 2018, Nr. 43, S. 2254); die Änderung durch Artikel 4 Absatz 73 des Gesetzes vom 18. Juli 2016 (BGBl. I 2016, Nr. 35, S. 1666) tritt am 1. Oktober 2021 in Kraft.

[1B-6] Gesetz über Naturschutz und Landschaftspflege (Bundesnaturschutzgesetz – BNatSchG) vom 29. Juli 2009 (BGBl. I 2009, Nr. 51, S. 2542), zuletzt geändert durch Artikel 1 des Gesetzes vom 4. März 2020 (BGBl. I 2020, Nr. 11, S. 440); die Änderung durch Artikel 4 Absatz 96 des Gesetzes vom 18. Juli 2016 (BGBl. I 2016, Nr. 35, S. 1666) tritt am 1. Oktober 2021 in Kraft.

[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 Artikel 2 Absatz 9 des Gesetzes vom 20. Juli 2017 (BGBl. I 2017. Nr. 52, S. 2808).

[1B-14] Gesetz über die Umweltverträglichkeitsprüfung (Umweltverträglichkeitsprüfungsgesetz – UVPG) vom 24. Februar 2010 (BGBl. I 2010, Nr. 7, S. 94), zuletzt geändert durch Artikel 2 des Gesetzes vom 12. Dezember 2019 (BGBl. I 2019, Nr. 48, S. 2513).

Hinweis: Umsetzung der Richtlinie 2011/92/EU vom 13. Dezember 2011 (ABl. 2012, L 26) und der Richtlinie 2001/42/EG vom 27. Juni 2001 (ABl. 2001, L 197).

[1B-15] Bundesberggesetz – BBergG – vom 13. August 1980 (BGBl. I 1980, Nr. 48, S. 1310), zuletzt geändert durch Artikel 2 des Gesetzes vom 29. April 2020 (BGBl. I 2020, Nr. 21, S. 864); die Änderung durch Artikel 4 Absatz 68 des Gesetzes vom 18. Juli 2016 (BGBl. I 2016, Nr. 35, S. 1666) tritt am 1. Oktober 2021 in Kraft.

[1B-18] Baugesetzbuch (BauGB) in der Fassung der Bekanntmachung vom 3. November 2017 (BGBl. I 2017, Nr. 72, S. 3634), zuletzt geändert durch Artikel 6 des Gesetzes vom 27. März 2020 (BGBl. I, 2020, Nr. 14, S. 587).

Hinweis: Umsetzung der Richtlinie 92/43/EWG vom 21. Mai 1992 (ABl. 1992, L 206), der Richtlinie 2001/42/EG vom 27. Juni 2001 (ABl. 2001, L 197), der Richtlinie 2009/147/EG vom 30. November 2009 (Abl. 2010, L 20), zuletzt geändert durch Richtlinie 2013/17/EU (ABl. 2013, L 158) und der Richtlinie 2011/92/EU vom 13. Dezember 2011 (ABl. 2012, L 26), zuletzt geändert durch Richtlinie 2014/52/EU (ABl. 2014, L 124).

[1B-19] Verordnung über Anforderungen und Verfahren zur Entsorgung radioaktiver Abfälle (Atomrechtliche Entsorgungsverordnung – AtEV) vom 29. November 2018 (BGBl. I 2018, Nr. 41, S. 2034, 2172).

Hinweis: Umsetzung der Richtlinie 2013/59/EURATOM vom 5. Dezember 2013 (ABl. 2014, L 13).

[1B-20] Verordnung zur Festlegung von Dosiswerten für frühe Notfallschutzmaßnahmen (Notfall-Dosiswerte-Verordnung - NDWV) vom 29. November 2018 (BGBl. I Nr. 41, S. 2034, 2172).

Hinweis: Umsetzung der Richtlinie 2013/59/EURATOM vom 5. Dezember 2013 (ABl. 2014, L 13).

[1B-21] Verordnung über die Umsetzung der Auskunftspflicht und die Ausgestaltung der Informationen nach dem Transparenzgesetz (Rückbaurückstellungs-Transparenzverordnung – RückBRTransparenzV) vom 9. Juli 2018 (BGBl. I 2018, Nr. 24, S. 1090).

[1B-22] Verwaltungsverfahrensgesetz (VwVfG) vom 23. Januar 2003 (BGBl. I 2003, Nr. 4, S. 102), zuletzt geändert durch Artikel 5 Absatz 25 des Gesetzes vom 21. Juni 2019 (BGBl. I 2019, Nr. 23, S. 846).

1C Regulations for the transport of radioactive material and accompanying regulations

No references.

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

[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;

83 Vertragsparteien (03/20), 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-1-1] Übereinkommen über die Umweltverträglichkeitsprüfung im grenzüberschreitenden Rahmen – Espoo-Konvention (*Convention on the Environmental Impact Assessment in a Transboundary Context* – EIA) vom 25. Februar 1991, in Kraft seit 10. September 1997

45 Vertragsparteien (07/16), Depositar: UN

1. Änderung der Espoo-Konvention vom 27. Februar 2001, in Kraft seit 26. August 2014

35 Vertragsparteien (05/20), Depositar: UN

2. Änderung der Espoo-Konvention vom 4. Juni 2004, in Kraft seit 23. Oktober 2017

35 Vertragsparteien (05/20), Depositar: UN

Gesetz zur Espoo-Konvention und der 1. Änderung mit amtlicher Übersetzung (Espoo-Vertragsgesetz) vom 7. Juni 2002 (BGBl. II 2002, Nr. 22, S. 1406)

Espoo-Konvention in Kraft für Deutschland seit 6. November 2002

1. Änderung der Espoo-Konvention in Kraft für Deutschland seit 26. August 2014 (BGBl. II 2014, Nr. 24, S. 758)

Gesetz zur 2. Änderung mit amtlicher Übersetzung (Zweites Espoo-Vertragsgesetz) vom 17. März 2006 (BGBl. II 2006, Nr. 7, S. 224).

[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 (05/20)

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, mit seither 3 Änderungen, zuletzt vom 18. Oktober 2013

53 Vertragsparteien (05/20) Depositare: Mexiko, Russische Föderation, 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)

Gesetz zu der Entschließung LP.(4)8 vom 18. Oktober 2013 über die Änderung des Londoner Protokolls mit amtlicher Übersetzung vom 4. Dezember 2018 (BGBl. II 2018, Nr. 24, S. 691).

Hinweis: Keine Einbringung von Materialien mit Radioaktivitätswerten oberhalb de-minimis-Konzentrationen.

[1E-5-1] 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 (01/18), 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-5-2] 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 (2/17), 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.

[1E-5-4] Gemeinsames Protokoll über die Anwendung des Wiener Übereinkommens und des Pariser Übereinkommens – Gemeinsames Protokoll (*Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention – Joint Protocol*, INFCIRC/402) vom 21. September 1988, in Kraft seit 27. April 1992

30 Vertragsparteien (09/19), Depositar: IAEA

Gesetz hierzu vom 5. März 2001 (BGBl. II 2001, Nr. 7, S. 202)

in Kraft für Deutschland seit 13. September 2001 (BGBl. II 2001, Nr. 24, S. 786)

1F Law of the European Union in the areas of nuclear safety and radiation protection

Agreements, general provisions

[1F-1] Vertrag vom 25. März 1957 zur Gründung der Europäischen Atomgemeinschaft EURATOM (BGBl. II 1957, S. 1014, berichtigt S. 1678; berichtigt BGBl. II 1999, S. 1024), Konsolidierte Fassung 2016.

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. II 1993, 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 L 172), zuletzt geändert durch die Richtlinie des Rates 2014/87/EURATOM vom 8. Juli 2014 (ABl. 2015, L 219), konsolidierte Fassung 2014.

[1F-12] Richtlinie 2011/92/EU des Europäischen Parlaments und des Rates über die Umweltverträglichkeitsprüfung bei bestimmten öffentlichen und privaten Projekten vom 13. Dezember 2011 (ABl. 2012, L 26), zuletzt geändert durch die Richtlinie 2014/52/EU vom 16. April 2014 (ABl. 2014, L 124), konsolidierte Fassung 2014.

Hinweis: Umsetzung vgl. UVP-Gesetz.

[1F-14] Verordnung (EURATOM) 302/2005 der Kommission vom 8. Februar 2005 über die Anwendung der EURATOM-Sicherungsmaßnahmen (ABl. 2005, L 54), zuletzt geändert durch die Verordnung (EU) 519/2013 der Kommission vom 21. Februar 2013 (ABl. 2013, L 158), letzte konsolidierte Fassung 2013.

Radiation protection

[1F-18] Richtlinien 96/29/EURATOM des Rates vom 13. Mai 1996 zur Festlegung der grundlegenden Sicherheitsnormen für den Schutz der Gesundheit der Arbeitskräfte und der Bevölkerung gegen die Gefahren durch ionisierende Strahlungen (ABl. EG 1996, L 159). Aufgehoben am 6. Februar 2018 durch Richtlinie 2013/59/EURATOM.

[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, L 349). Aufgehoben am 6. Februar 2018 durch Richtlinie 2013/59/EURATOM.

[1F-22] Richtlinie 2003/122/EURATOM des Rates vom 22. Dezember 2003 zur Kontrolle hochradioaktiver Strahlenquellen und herrenloser Strahlenquellen (ABl. 2003, L 346). Aufgehoben am 6. Februar 2018 durch Richtlinie 2013/59/EURATOM.

[1F-23] Richtlinie 97/43/EURATOM der Kommission vom 30. Juni 1997 über den Gesundheitsschutz von Personen gegen die Gefahren ionisierender Strahlung bei medizinischer Exposition (ABl. 1997, L 180). Aufgehoben am 6. Februar 2018 durch Richtlinie 2013/59/EURATOM.

[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, L 13), zuletzt berichtigt am 11. Juni 2019 (ABl. 2019, L 152), letzte konsolidierte Fassung 17. Januar 2014.

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, L 357)

- Mitteilung der Kommission betreffend die Durchführung der Richtlinie 89/618/EURATOM (ABl. EG 1991, C 103)

Aufgehoben am 6. Februar 2018 durch Richtlinie 2013/59/EURATOM.

Waste, hazardous materials

[1F-34] Verordnung (EURATOM) 1493/93 des Rates vom 8. Juni 1993 über die Verbringung radioaktiver Stoffe zwischen den Mitgliedstaaten (ABl. 1993, L 148).

Mitteilung der Kommission vom 10. Dezember 1993 zu der Verordnung EURATOM/1493/93 (ABl. EG 1993, C 335).

[1F-35] Richtlinie 2006/117/EURATOM des Rates vom 20. November 2006 über die Überwachung und Kontrolle der Verbringung radioaktiver Abfälle und abgebrannter Brennelemente (ABl. 2006, L 337).

[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. 2011, L 199).

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).

Hinweis: Das Bundeskabinett hat am 6. Mai 2020 die neue Allgemeine Verwaltungsvorschrift zum Strahlenpass nach § 174 der Strahlenschutzverordnung beschlossen (www.bmu.de/GE761). Die Veröffentlichung im Bundesanzeiger erfolgt zeitnah.

[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).

[2-7] Allgemeine Verwaltungsvorschrift für die Durchführung des Schnellwarnsystems für Lebensmittel, Lebensmittelbedarfsgegenstände und Futtermittel (AVV Schnellwarnsystem – AVV SWS) vom 8. September 2016 (GMBl. 2016, Nr. 39, S. 770).

3 Announcements by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the formerly competent Federal Ministry for the Interior

[3-0.1] Sicherheitsanforderungen an Kernkraftwerke in der Fassung der Bekanntmachung vom 3. März 2015 (BAnz AT 30.03.2015 B2).

[3-0.2] Interpretationen zu den Sicherheitsanforderungen an Kernkraftwerke vom 29. November 2013 (BAnz AT 10.12.2013 B4), geändert am 3. März 2015 (BAnz AT 30.03.2015 B3).

[3-2] Richtlinie für den Fachkundenachweis von Kernkraftwerkspersonal vom 24. Mai 2012 (GMBl. 2012, Nr. 34, S. 611).

Anpassung Fachkundenachweis von Kernkraftwerkspersonal in Kernkraftwerken ohne Berechtigung zum Leistungsbetrieb, RdSchr. d. BMU vom 21. Mai 2013 (Aktenzeichen RS I 6 – 13831-1/1 und 13831-1/2) mit Anlage 1.

[3-13] Sicherheitskriterien für die Endlagerung radioaktiver Abfälle in einem Bergwerk vom 20. April 1983 (GMBl. 1983, Nr. 13, S. 220), in Überarbeitung.

[3-21] Richtlinie für den Fachkundenachweis von verantwortlichen Personen in Anlagen zur Aufbewahrung von Kernbrennstoffen (Zwischenlager) vom 11. September 2019 – S I 6 – 13831-7/4 (GMBl. 2019, Nr. 33, S. 689).

[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 Strahlenschutzkommission“, 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 (Fachkunde-Richtlinie Technik nach Strahlenschutzverordnung) 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 (Inkorporationsüberwachung) (§§ 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).

[3-60] 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 23. Juni 2016 (BAnz. AT 19.07.2016 B7).

[3-150] Leitlinien für die trockene Zwischenlagerung bestrahlter Brennelemente und Wärme entwickelnder radioaktiver Abfälle in Behältern, Empfehlung der Entsorgungskommission, revidierte Fassung vom 10.06.2013 (Banz AT 22.01.2014 B3).

[3-151] ESK-Leitlinien für die Zwischenlagerung von radioaktiven Abfällen mit vernachlässigbarer Wärmeentwicklung, Empfehlung der Entsorgungskommission, revidierte Fassung vom 10.06.2013 (Banz AT 22.01.2014 B3).

[3-152] 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 (Banz AT 23.09.2014 B1).

[3-250] Radiologische Grundlagen für Entscheidungen über Maßnahmen zum Schutz der Bevölkerung bei Ereignissen mit Freisetzungen von Radionukliden, Empfehlung der Strahlenschutzkommission vom 13/14.02.2014 (BAnz AT 18.11.2014 B5), mit der Anlage „Verwendung von Jodtabletten zur Jodblockade der Schilddrüse bei einem kerntechnischen Unfall“, Empfehlung der Strahlenschutzkommission vom 24./25. Februar 2011.

[3-251] Planungsgebiete für den Notfallschutz in der Umgebung von Kernkraftwerken, Empfehlung der Strahlenschutzkommission vom 13./14. Februar 2014 (BAnz AT 21.05.2014 B4).

[3-252] Planungsgebiete für den Notfallschutz in der Umgebung stillgelegter Kernkraftwerke, Empfehlung der Strahlenschutzkommission vom 20./21. Oktober 2014 (BAnz AT 13.05.2015 B4).

[3-253] Rahmenempfehlungen für den Katastrophenschutz in der Umgebung kerntechnischer Anlagen, Empfehlung der Strahlenschutzkommission vom 19./20. Februar 2015 (BAnz AT 04.01.2016 B4).

[3-254] Einführung von Dosisrichtwerten (Dose Constraints) zum Schutz vor beruflicher Strahlenexposition bei der Umsetzung der Richtlinie 2013/59/EURATOM in das deutsche Strahlenschutzrecht, Empfehlung der Strahlenschutzkommission vom 11./12. Dezember 2014 (BAnz AT 10.08.2015 B3).

[3-350] Rahmenempfehlungen für die Planung von Notfallschutzmaßnahmen durch Betreiber von Kernkraftwerken, Empfehlung der Strahlenschutzkommission und der Reaktor-Sicherheitskommission,

verabschiedet in der 242. Sitzung der SSK am 01./02. Juli 2010 und in der 429. Sitzung der Reaktor-Sicherheitskommission am 14. Oktober 2010, ersetzt durch Fassung von 2014 (BAnz AT 13.05.2015 B5).

4 Recommendations of the SSK and the ESK

The recommendations and statements of the SSK and the ESK can be downloaded from the websites www.ssk.de and www.entsorgungskommission.de, respectively under “Consultation Results“.

[4-4] Leitlinien zur Stilllegung kerntechnischer Anlagen, Empfehlung der Entsorgungskommission vom 16.03.2015.

[4-5] ESK-Empfehlungen für Leitlinien zur Durchführung von periodischen Sicherheitsüberprüfungen für Zwischenlager für bestrahlte Brennelemente und Wärme entwickelnde radioaktive Abfälle (PSÜ-ZL), Empfehlung der Entsorgungskommission vom 4. November 2010.

[4-6] Übersicht über Maßnahmen zur Verringerung der Strahlenexposition nach Ereignissen mit nicht unerheblichen radiologischen Auswirkungen (Maßnahmenkatalog):
Band 1: Auswahl von Maßnahmen
Band 2: Hintergrundinformationen, Theorie und Anwendungsbeispiele
Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit, Stand 29. August 2008.

[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;
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).

[4-11a] Langzeitsicherheitsnachweis für das Endlager für radioaktive Abfälle Morsleben (ERAM), Stellungnahme der Entsorgungskommission vom 31.01.2013.

[4-13] Stand der Vorbereitungen hinsichtlich der Bereitstellung radioaktiver Abfallgebinde für das Endlager Konrad, Stellungnahme der Entsorgungskommission vom 02.07.2014.

[4-14] Rückführung verglaster Abfälle aus der Wiederaufarbeitung im europäischen Ausland – Aufbewahrung der verglasten Abfälle in Standortzwischenlagern aufgrund der Änderung des Atomgesetzes am 01.01.2014 (§ 9a Absatz 2a AtG), Stellungnahme der Entsorgungskommission vom 30.10.2014.

[4-16] Umsetzung der ESK-Leitlinien für die Zwischenlagerung radioaktiver Abfälle mit vernachlässigbarer Wärmeentwicklung, Stellungnahme der Entsorgungskommission vom 07.05.2015.

[4-16a] Umsetzung der ESK-Leitlinien für die Zwischenlagerung radioaktiver Abfälle mit vernachlässigbarer Wärmeentwicklung, Stellungnahme der Entsorgungskommission vom 07.09.2018.

[4-17] Leitlinie zum sicheren Betrieb eines Endlagers für insbesondere Wärme entwickelnde radioaktive Abfälle, Empfehlung der Entsorgungskommission vom 10.12.2015.

[4-18] Anforderungen an Endlagergebinde zur Endlagerung Wärme entwickelnder radioaktiver Abfälle, Empfehlung der Entsorgungskommission, redaktionell überarbeitete Fassung vom 20.01.2017.

[4-19] Endlagerforschung in Deutschland: Anmerkungen zu Forschungsinhalten und Forschungssteuerung, Stellungnahme der Entsorgungskommission vom 12.05.2016.

[4-20] Diskussionspapier zur verlängerten Zwischenlagerung bestrahlter Brennelemente und sonstiger Wärme entwickelnder radioaktiver Abfälle, Diskussionspapier der Entsorgungskommission vom 29.10.2015.

[4-22] Leitlinie zum Schutz von Endlagern gegen Hochwasser, Empfehlung der Entsorgungskommission vom 06.12.2018.

[4-23] Diskussionspapier zur Endlagerung von Wärme entwickelnden radioaktiven Abfällen, abgereichertem Uran aus der Urananreicherung, aus der Schachtanlage Asse II rückzuholenden Abfällen und sonstigen Abfällen, die nicht in das Endlager Konrad eingelagert werden können, an einem Endlagerstandort, Diskussionspapier der Entsorgungskommission vom 12.05.2016.

[4-28] Strahlenschutz bei der Stilllegung der Schachtanlage Asse II, Empfehlung der Strahlenschutzkommission vom 15. September 2016.

[4-30] Sicherheitskonzeptionelle Anforderungen an das Barrierensystem eines Endlagers für hoch radioaktive Abfälle und deren Umsetzbarkeit, Stellungnahme der Entsorgungskommission vom 21. Februar 2019.

[4-31] Sicherheitstechnische und logistische Anforderungen an ein Bereitstellungslager für das Endlager Konrad, Stellungnahme der Entsorgungskommission vom 26. Juli 2018.

[4-32] Harmonisierung von Meldekriterien für Vorkommnisse mit radioaktiven Abfällen mit vernachlässigbarer Wärmeentwicklung, Empfehlung der Entsorgungskommission vom 01.03.2018.

[4-33] Abgeleitete Richtwerte für Maßnahmen zum Schutz der Bevölkerung bei Ereignissen mit Freisetzungen von Radionukliden, Empfehlung der Strahlenschutzkommission vom 24./25. Oktober 2019.

5 Safety standards of the Nuclear Safety Standards Commission (KTA)

The following standards of the Nuclear Safety Standards Commission [KTA 19] (as at 15 January 2020) can be downloaded from www.kta-gs.de.

Standard No. KTA	Title	Status	Version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	English translation
1200 General, administration, organisation							
1201	Requirements for the Operating Manual	R	2015-11	29.04.2016 (acc. sec. 5.3 of the procedural statutes)	1978-02; 1981-03; 1985-12; 1998-06; 2009-11	14.11.2017	+
1202	Requirements for the Testing Manual	R	2017-11	17.05.2018 (acc. sec. 5.3 of the procedural statutes)	1984-06; 2009-11	-	+
1203	Requirements for the Emergency Manual	R	2009-11	3a – 07.01.2010	-	10.11.15; 14.11.17	+
1300 Occupational radiological protection							
1301.1	Radiation Protection Considerations for Plant Personnel in the Design and Operation of Nuclear Power Plants; Part 1: Design	R	2017-11	05.02.2018	1984-11; 2012-11	-	+
1301.2	Radiation Protection Considerations for Plant Personnel in the Design and Operation of Nuclear Power Plants; Part 2: Operation	R	2014-11	15.01.2015	1982-06; 1989-06; 2008-11	14.11.2017	+
1400 Quality assurance							
1401	General Requirements Regarding Quality Assurance	R	2017-11	17.05.2018 (acc. sec. 5.3 of the procedural statutes)	1980-02; 1987-12; 1996-06; 2013-11	-	+
1402	Integrated Management Systems for the Safe Operation of Nuclear Power Plants	R	2017-11	17.05.2018 (acc. sec. 5.3 of the procedural statutes)	2012-11	-	+

Standard No. KTA	Title	Status	Version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	English translation
1403	Ageing Management in Nuclear Power Plants	R	2017-11	05.02.2018	2010-11	-	+
1404	Documentation During the Construction and Operation of Nuclear Power Plants	R	2013-11	17.01.2014	1989-06; 2001-06	14.11.2017	+
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	R	2017-11	17.05.2018 (acc. sec. 5.3 of the procedural statutes)	1985-06 2008-11; 2015-11	-	+
1408.2	Quality Assurance for Weld Filler Materials and Welding Consumables for Pressure and Activity Retaining Systems in Nuclear Power Plants; Part 2: Manufacture	R	2017-11	17.05.2018 (acc. sec. 5.3 of the procedural statutes)	1985-06 2008-11; 2015-11	-	+
1408.3	Quality Assurance for Weld Filler Materials and Welding Consumables for Pressure and Activity Retaining Systems in Nuclear Power Plants; Part 3: Processing	R	2017-11	17.05.2018 (acc. sec. 5.3 of the procedural statutes)	1985-06; 2008-11; 2015-11	-	+
1500 Radiation protection and monitoring							
1501	Stationary System for Monitoring the Local Dose Rate within Nuclear Power Plants	R	2017-11	05.02.2018	1977-10; 1991-06; 2004-11; 2010-11	-	+
1502	Monitoring Volumetric Activity of Radioactive Substances in the Inner Atmosphere of Nuclear Power Plants	R	2017-11	05.02.2018	1986-06 (1502.1); 2005-11; 2013-11	-	+
(1502.2)	Monitoring Volumetric Activity of Radioactive Substances in the Inner Atmosphere of Nuclear Power Plants	SR	1989-06	229 a - 07.12.1989	-	15.06.93 inactive	+
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;	R	2016-11	10.03.2017	1979-02; 1993-06; 2002-06; 2013-11	14.11.2017	+

Standard No. KTA	Title	Status	Version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	English translation
1503.2	Monitoring the Discharge of Radioactive Gases and Airborne Radioactive Particulates; Part 2: Monitoring the Discharge of Radioactive Matter with the Vent Stack Exhaust Air During Design-Basis Accidents	R	2017-11	05.02.2018	1999-06; 2013-11	-	+
1503.3	Monitoring the Discharge of Radioactive Gases and Airborne Radioactive Particulates; Part 3: Monitoring the Non-stack Discharge of Radioactive Matter	R	2017-11	05.02.2018	1999-06; 2013-11	-	+
1504	Monitoring and Assessing the Discharge of Radioactive Substances with Water	R	2017-11	17.05.2018 (acc. sec. 5.3 of the procedural statutes)	1978-06; 1994-06; 2007-11; 2015-11	-	+
1505	Suitability Verification of the Stationary Measurement Equipment for Radiation Monitoring	R	2017-11	05.02.2018	2003-11; 2011-11	-	+
(1506)	Measuring Local Dose Rates in Exclusion Areas of Nuclear Power Plants (16.11.2004: standard was withdrawn)	ZR	1986-06	162 a - 03.09.1986 Correction 229 - 10.12.1986	-	11.06.1996	+
1507	Monitoring the Discharge of Radioactive Substances from Research Reactors	R	2017-11	05.02.2018	1984-03; 1998-06; 2012-11	-	+
1508	Instrumentation for Determining the Dispersion of Radioactive Substances in the Atmosphere	R	2017-11	05.02.2018	1988-09; 2006-11	-	+
2100 Overall plant							
2101.1	Fire Protection in Nuclear Power Plants; Part 1: Basic Requirements	R	2015-11	08.01.2016	1985-12; 2000-12	14.11.2017	-
2101.2	Fire Protection in Nuclear Power Plants; Part 2: Fire Protection of Structural Components	R	2015-11	08.01.2016	2000-12	14.11.2017	-

Standard No. KTA	Title	Status	Version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	English translation
2101.3	Fire Protection in Nuclear Power Plants; Part 3: Fire Protection of Mechanical and Electrical Plant Components	R	2015-11	08.01.2016	2000-12	14.11.2017	-
2103	Explosion Protection in Nuclear Power Plants with Light Water Reactors (General and Case-Specific Requirements)	R	2015-11	08.01.2016 Correction 19.12.2017	1989-06; 2000-06	14.11.2017	-
2200 External hazards							
2201.1	Design of Nuclear Power Plants against Seismic Events; Part 1: Principles	R	2011-11	11 – 19.01.2012	1975-06; 1990-06	22.11.16; 14.11.17	+
2201.2	Design of Nuclear Power Plants against Seismic Events; Part 2: Subsoil	R	2012-11	23.01.2013	1982-11; 1990-06	14.11.2017	+
2201.3	Design of Nuclear Power Plants against Seismic Events; Part 3: Structural Components	R	2013-11	17.01.2014	-	14.11.2017	+
2201.4	Design of Nuclear Power Plants against Seismic Events; Part 4: Components	R	2012-11	23.01.2013	1990-06	14.11.2017	+
2201.5	Design of Nuclear Power Plants against Seismic Events; Part 5: Seismic Instrumentation	R	2015-11	08.01.2016	1977-06; 1990-06; 1996-06	14.11.2017	+
2201.6	Design of Nuclear Power Plants against Seismic Events; Part 6: Post-Seismic Measures	R	2015-11	08.01.2016	1992-06	14.11.2017	+
2206	Design of Nuclear Power Plants Against Damaging Effects from Lightning	R	2019-11	14.01.2020	1992-06; 2000-06; 2009-11	-	-
2207	Flood Protection for Nuclear Power Plants	R	2004-11	35 a - 19.02.2005	1982-06; 1992-06	10.11.09; 11.11.14	+
2500 Structural engineering							
2501	Structural Waterproofing of Nuclear Power Plants	R	2015-11	29.04.2016 (acc. sec. 5.3 of the procedural statutes)	1988-09; 2002-06; 2004-11; 2010-11	14.11.2017	+
2502	Mechanical Design of Fuel Assembly Storage Pools in Nuclear Power Plants with Light Water Reactors	R	2011-11	11 – 19.01.2012	1990-06	22.11.16; 14.11.17	+

Standard No. KTA	Title	Status	Version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	English translation
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	R	2016-11	19.06.2017 (acc. sec. 5.3 of the procedural statutes)	1980-02; 2012-11	14.11.2017	+
3101.2	Design of Reactor Cores of Pressurized Water and Boiling Water Reactors; Part 2: Neutron-Physical Requirements for Design and Operation of the Reactor Core and Adjacent Systems	R	2012-11	23.01.2013	1987-12	14.11.2017	+
3101.3	Design of Reactor Cores of Pressurized Water and Boiling Water Reactors; Part 3: Mechanical and Thermal Design	R	2015-11	08.01.2016 Correction 10.03.2017	-	14.11.2017	+
(3102.1)	Reactor Core Design for High Temperature Gas-Cooled Reactors; Part 1: Calculation of the Material Properties of Helium	SR	1978-06	189 a - 06.10.1978 Supplement 23/78	-	29.11.83; 20.09.88; 15.06.93 inactive	+
(3102.2)	Reactor Core Design for High Temperature Gas-Cooled Reactors; Part 2: Heat Transfer in Spherical Fuel Elements	SR	1983-06	194 - 14.10.1983 Supplement 47/83	-	20.09.88; 15.06.93 inactive	+
(3102.3)	Reactor Core Design for High Temperature Gas-Cooled Reactors; Part 3: Loss of Pressure through Friction in Pebble Bed Cores	SR	1981-03	136 a - 28.07.1981 Supplement 24/81	-	25.11.86; 12.06.91; 15.06.93 inactive	+
(3102.4)	Reactor Core Design for High Temperature Gas-Cooled Reactors; Part 4: Thermohydraulic Analytical Model for Stationary and Quasi-Stationary Conditions in Pebble Bed Cores	SR	1984-11	40 a - 27.02.1985 Correction 124 – 07.07.89	-	27.06.93; 15.06.93 inactive	+
(3102.5)	Reactor Core Design for High Temperature Gas-Cooled Reactors; Part 5: Systematic and Statistical Errors in the Thermohydraulic Core Design of the Pebble Bed Reactor	SR	1986-06	162 a - 03.09.1986	-	11.06.91; 15.06.93 inactive	+
3103	Shutdown Systems for Light Water Reactors	R	2015-11	08.01.2016	1984-03	14.11.2017	+

Standard No. KTA	Title	Status	Version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	English translation
(3104)	Determination of the Shutdown Reactivity	SR	1979-10	19 a - 29.01.1980 Supplement 1/80	-	27.03.84; 27.06.89; 14.06.94; 15.06.99; 16.11.04; 10.11.09	+
3107	Nuclear Criticality Safety Requirements during Refuelling	R	2014-11	15.01.2015	-	14.11.2017	+
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	R	2017-11	05.02.2018 Correction 24.04.2019	1979-02; 1982-11; 1990-06; 1998-06	-	+
3201.2	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 2: Design and Analysis	R	2017-11	17.05.2018 (acc. sec. 5.3 of the procedural statutes)	1980-10; 1984-03 1996-06; 2013-11	-	+
3201.3	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 3: Manufacture	R	2017-11	17.05.2018 (acc. sec. 5.3 of the procedural statutes) Correction 24.04.2019	1979-10; 1987-12; 1998-06; 2007-11	-	+
3201.4	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 4: Inservice Inspections and Operational Monitoring	R	2016-11	10.03.2017	1982-06; 1990-06; 1999-06; 2010-11	14.11.2017	+
3203	Surveillance of the Irradiation Behaviour of Reactor Pressure Vessel Materials of LWR Facilities	R	2017-11	17.05.2018 (acc. sec. 5.3 of the procedural statutes)	1984-03; 2001-06	-	+
3204	Reactor Pressure Vessel Internals	R	2017-11	17.05.2018 (acc. sec. 5.3 of the procedural statutes)	1984-03; 1998-06; 2008-11; 2015-11	-	+

Standard No. KTA	Title	Status	Version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	English translation
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	R	2018-10	14.12.2018	1982-06; 1991-06; 2002-06	-	-
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	R	2018-10; Correction 14.01. 2020	14.12.2018	1990-06; 2015-11	-	-
3205.3	Component Support Structures with Non-integral Connections; Part 3: Series-Production Standard Supports	R	2018-10	08.11.2018	1989-06 2006-11	-	-
3206	Verification Analysis for Rupture Preclusion for Pressure Retaining Components in Nuclear Power Plants	R	2014-11	15.01.2015 Corrections 26.11.2015 and 17.12.2019	-	14.11.2017	-
3211.1	Pressure and Activity Retaining Components of Systems Outside the Primary Circuit; Part 1: Materials	R	2017-11	17.05.2018 (acc. sec. 5.3 of the procedural statutes) Correction 24.04.2019	1991-06; 2000-06; 2015-11	-	+
3211.2	Pressure and Activity Retaining Components of Systems Outside the Primary Circuit; Part 2: Design and Analysis	R	2013-11	17.01.2014	1992-06	14.11.2017	+
3211.3	Pressure and Activity Retaining Components of Systems Outside the Primary Circuit; Part 3: Manufacture	R	2017-11	17.05.2018 (acc. sec. 5.3 of the procedural statutes) Correction 24.04.2019	1990-06; 2003-11; 2012-11	-	+
3211.4	Pressure and Activity Retaining Components of Systems Outside the Primary Circuity; Part 4: Inservice Inspections and Operational Monitoring	R	2017-11	17.05.2018 (acc. sec. 5.3 of the procedural statutes)	1996-06; 2012-11; 2013-11	-	+

Standard No. KTA	Title	Status	Version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	English translation
3300 Heat removal							
3301	Residual Heat Removal Systems of Light Water Reactors	R	2015-11	08.01.2016	1984-11	14.11.2017	-
3303	Heat Removal Systems for Fuel Assembly Storage Pools in Nuclear Power Plants with Light Water Reactors	R	2015-11	08.01.2016	1990-06	14.11.2017	-
3400 Reactor containment							
(3401.1)	Steel Containment Vessels; Part 1: Materials	SR	1988-09	37 a - 22.02.1989	1980-06; 1982-11	15.06.93; 16.06.98	+
3401.2	Steel Containment Vessels; Part 2: Analysis and Design	R	2016-11	10.03.2017	1980-06; 1985-06	14.11.2017	+
(3401.3)	Steel Reactor Safety Containment; Part 3: Manufacture	SR	1986-11	44 a - 05.03.1987	1979-10	23.06.92; 10.06.97	+
3401.4	Steel Containment Vessels; Part 4: In-service Inspections	R	2017-11	05.02.2018	1981-03; 1991-06	-	+
3402	Airlocks on the Reactor Containment of Nuclear Power Plants - Personnel Airlocks	R	2014-11	06.05.2015 (acc. sec. 5.3 of the procedural statutes)	1976-11; 2009-11	14.11.2017	+
3403	Cable Penetrations through the Reactor Containment Vessel	R	2015-11	29.04.2016 (acc. sec. 5.3 of the procedural statutes)	1976-11; 1980-10; 2010-11	14.11.2017	+
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	R	2017-11	17.05.2018 (acc. sec. 5.3 of the procedural statutes)	1988-09; 2008-11; 2013-11	-	+
3405	Leakage Test of the Containment Vessel	R	2015-11	29.04.2016 (acc. sec. 5.3 of the procedural statutes)	1979-02; 2010-11	14.11.2017	+
3407	Pipe Penetrations through the Reactor Containment Vessel	R	2017-11	17.05.2018 (acc. sec. 5.3 of the procedural statutes)	1991-06; 2014-11	-	+
3409	Airlocks on the Reactor Containment of Nuclear Power Plants - Equipment airlocks	R	2009-11	72 a - 12.05.2010	1979-06	11.11.14; 14.11.17	+

Standard No. KTA	Title	Status	Version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	English translation
3413	Determination of Loads for the Design of a Full Pressure Containment Vessel against Plant-Internal Incidents	R	2016-11	10.03.2017	1989-06	14.11.2017	+
3500 Reactor protection system							
3501	Reactor Protection System and Monitoring Equipment of the Safety System	R	2015-11	08.01.2016	1977-03; 1985-06	14.11.2017	+
3502	Accident Measuring Systems	R	2012-11	23.01.2013	1982-11; 1984-11; 1999-06	14.11.2017	+
3503	Type Testing of Electrical Modules for the Safety Related Instrumentation and Control System	R	2015-11	08.01.2016	1982-06; 1986-11; 2005-11	14.11.2017	+
3504	Electrical Drive Mechanisms of the Safety System in Nuclear Power Plants	R	2015-11	29.04.2016 (acc. sec. 5.3 of the procedural statutes)	1988-09; 2006-11	14.11.2017	+
3505	Type Testing of Measuring Sensors and Transducers of the Safety-Related Instrumentation and Control System	R	2015-11	08.01.2016 Correction 17.05.2018	1984-11; 2005-11	14.11.2017	+
3506	System Testing of the Instrumentation and Control Equipment Important to Safety of Nuclear Power Plants	R	2017-11	05.02.2018	1984-11; 2012-11	-	+
3507	Factory Tests, Post-Repair Tests and the Certification of Proven Performance of Modules and Devices of the Instrumentation and Control System Important to Safety	R	2014-11	15.01.2015	1986-11; 2002-06	14.11.2017	+
3600 Activity control							
3601	Ventilation Systems in Nuclear Power Plants	R	2017-11	05.02.2018	1990-06; 2005-11	-	+
3602	Storage and Handling of Fuel Assemblies and Associated Items in Nuclear Power Plants with Light Water Reactors	R	2003-11	26 a - 07.02.2004	1982-06; 1984-06; 1990-06	11.11.08; 19.11.13; 14.11.17	+
3603	Facilities for Treating Radioactively Contaminated Water in Nuclear Power Plants	R	2017-11	05.02.2018	1980-02; 1991-06; 2009-11	-	+

Standard No. KTA	Title	Status	Version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	English translation
3604	Storage, Handling and Plant-internal Transport of Radioactive Substances in Nuclear Power Plants (with the Exception of Fuel Assemblies)	R	2005-11	101 a - 31.05.2006	1983-06	16.11.2010	+
3604	Storage, Handling and Plant-internal Transport of Radioactive Substances in Nuclear Power Plants (with the Exception of Fuel Assemblies)	ÄE	2019-11	17.12.2019	1983-06; 2005-11	16.11.2010	+
3605	Treatment of Radioactively Contaminated Gases in Nuclear Power Plants with Light Water Reactors	R	2017-11	05.02.2018	1989-06; 2012-11	-	+
3700 Power and media supply							
3701	General Requirements for the Electrical Power Supply in Nuclear Power Plants	R	2014-11	15.01.2015	KTA 3701.1: (1978-06); KTA 3701.2: (1982-06); 1997-06; 1999-06	14.11.2017	+
3702	Emergency Power Generating Facilities with Diesel-Generator Units in Nuclear Power Plants	R	2014-11	15.01.2015	KTA 3702.1: (1980-06); KTA 3702.2: (1991-06); 2000-06	14.11.2017	+
3703	Emergency Power Facilities with Batteries and AC/DC Converters in Nuclear Power Plants	R	2012-11	23.01.2013	1986-06; 1999-06	14.11.2017	+
3704	Emergency Power Facilities with Static and Rotating AC/DC Converters in Nuclear Power Plants	R	2013-11	17.01.2014	1984-06; 1999-06	14.11.2017	+
3705	Switchgear Facilities, Transformers and Distribution Networks for the Electrical Power Supply of the Safety System in Nuclear Power Plants	R	2013-11	29.04.2014 (acc. sec. 5.3 of the procedural statutes)	1988-09; 1999-06; 2006-11	14.11.2017	+

Standard No. KTA	Title	Status	Version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	English translation
3706	Ensuring the Loss-of-Coolant-Accident Resistance of Electrotechnical Components and of Components in the Instrumentation and Controls of Operating Nuclear Power Plants	R	2000-06	159 a - 24.08.2000	-	22.11.05; 16.11.10; 10.11.15; 14.11.17	+
3900 Other systems							
3901	Communication Means for Nuclear Power Plants	R	2017-11	05.02.2018	1977-03; 1981-03; 2004-11; 2013-11	-	+
3902	Design of Lifting Equipment in Nuclear Power Plants	R	2012-11	23.01.2013; Correction 02.05.2013	1975-11; 1978-06; 1983-11; 1992-06; 1999-06	-	+
3902	Design of Lifting Equipment in Nuclear Power Plants	ÄE	2019-11	17.12.2019	1975-11; 1978-06; 1983-11; 1992-06; 1999-06; 2012-11	-	+
3903	Inspection, Testing and Operation of Lifting Equipment in Nuclear Power Plants	R	2012-11	23.01.2013; Correction 02.05.2013	1982-11; 1993-06; 1999-06	-	+
3903	Inspection, Testing and Operation of Lifting Equipment in Nuclear Power Plants	ÄE	2019-11	17.12.2019	1982-11; 1993-06; 1999-06; 2012-11	-	+
3904	Control Room, Remote Shutdown Station and Local Control Stations in Nuclear Power Plants	R	2017-11	05.02.2018	1988-09; 2007-11	-	+
3905	Load Attaching Points on Loads in Nuclear Power Plants	R	2012-11	23.01.2013	1994-06 1999-06	-	+
3905	Load Attaching Points on Loads in Nuclear Power Plants	ÄE	2019-11	17.12.2019	1994-06 1999-06; 2012-11	-	+

Standard No. KTA	Title	Status	Version	Published in the Federal Gazette No. - of	Former versions	Reaffirmed	English translation

R	Safety Standard
RE	Draft Safety Standard
ÄE	Draft Safety Standard of an existing Safety Standard (Revision)
REV	Draft Safety Standard in Preparation
ÄEV	Draft Revised Safety Standard in Preparation
VB	Primary Report
SR	Inactive Safety Standard (Safety standard no longer included in the reaffirmation process acc. sec. 5.2 of the procedural statutes)
ZR	Withdrawn Safety Standard (Safety Standard withdrawn by decision of the KTA)

(e) Other documents

[ABE 00] J. Abele, Kernkraft in der DDR – Zwischen nationaler Industriepolitik und sozialistischer Zusammenarbeit 1963-1990, Berichte und Studien Nr. 26, Herausgegeben vom Hannah-Arendt-Institut für Totalitarismusforschung e. V. an der Technischen Universität Dresden, 2000.

[ABVO 96] Allgemeine Bergverordnung über Untertagebetriebe, Tagebaue und Salinen vom 2. Februar 1966 (Nds. MBl. S. 337), zuletzt geändert durch die Bekanntmachung des Bundesministeriums für Wirtschaft nach § 25 der Allgemeinen Bundesbergverordnung über gegenstandslose landesrechtliche Vorschriften vom 10. Januar 1996 (BAnz 1996 S. 729).

[ANT 78] Antarktisvertrag BGBl. 1978 II S. 1517; UNTS Vol. 402 S. 71.

[BASE 19] Bundesamt für die Sicherheit der nuklearen Entsorgung (BASE), Handbuch Reaktorsicherheit und Strahlenschutz.

[BfS 95] Bundesamt für Strahlenschutz (BfS), Anforderungen an endzulagernde radioaktive Abfälle (Endlagerungsbedingungen, Stand: September 1994) – Schachtanlage Konrad – Salzgitter, Dezember 1995, ET-IB-79.

[BfS 02] Erfassung und Bewertung bergbaulicher Umweltradioaktivität, Ergebnisse des Projektes Altlastenkataster, Bundesamt für Strahlenschutz, Salzgitter, 2002.

[BfS 14] „Kriterienbericht Zwischenlager – Kriterien zur Bewertung potenzieller Standorte für ein übertägiges Zwischenlager für die rückgeholten radioaktiven Abfälle aus der Schachtanlage Asse II“, Bundesamt für Strahlenschutz, Salzgitter, 10. Januar 2014.

[BfS 14a] Bundesamt für Strahlenschutz (BfS), Anforderungen an endzulagernde radioaktive Abfälle, Endlagerungsbedingungen – Endlager Konrad, Stand: Dezember 2014, Salzgitter, SE-IB-29/08-REV-2, 2014.

[BfS 16a] Parameterstudie zur Simulation von Ableitungen und Freisetzungen eines übertägigen Zwischenlagers für die Rückgeholten Abfälle aus der Schachtanlage Asse II, Bundesamt für Strahlenschutz, Salzgitter, 08.04.2016.

[BfS 17] Bundesamt für Strahlenschutz (BfS), Umweltradioaktivität und Strahlenbelastung, Jahresbericht 2017 (Gesamtbericht).

[BGE 20] Bundesgesellschaft für Endlageung mbH (BGE), Plan zur Rückholung der radioaktiven Abfälle aus der Schachtanlage Asse II – Rückholplan, 19. Februar 2020, URL: www.bge.de/de/asse/wesentliche-unterlagen/rueckholungsplanung

[BMU 10] Sicherheitsanforderungen an die Endlagerung wärmeentwickelnder radioaktiver Abfälle, 30. September 2010.

[BMU 13b] Richtlinie zur Sicherung von Zwischenlagern gegen Störmaßnahmen oder sonstige Einwirkungen Dritter (SEWD) (SEWD-Richtlinie Zwischenlager), Bekanntmachung des BMU vom 04. Februar 2013, RS I 6 – 13151 – 6/22 VS-NfD.

[BMU 15] Programm für eine verantwortungsvolle und sichere Entsorgung bestrahlter Brennelemente und radioaktiver Abfälle (Nationales Entsorgungsprogramm), August 2015.

[BMU 19] Handbuch Reaktorsicherheit und Strahlenschutz, Band 1, Teil D „Bilaterale Vereinbarungen im Rahmen der Kerntechnik und des Strahlenschutzes“, fortlaufende Aktualisierung.

[BUN 79] Bericht der Bundesregierung zur Entsorgung der Kernkraftwerke und anderer kerntechnischer Einrichtungen, Deutscher Bundestag, Drucksache 11/1632 vom 28. September 1979.

[DDR 59] „Anordnung über die Errichtung der Zentrale für radioaktive Rückstände und Abfälle vom 1. April 1959“, Gesetzblatt der Deutschen Demokratischen Republik, Jahrgang 1959, Teil II, Nr. 9, S. 125-126, Ausgabetag: 27. April 1959.

[DIN 25403] Kritikalitätssicherheit bei der Verarbeitung und Handhabung von Kernbrennstoffen – Teil 1: Grundsätze, DIN 25403-1Dezember 2013.

[DIN 25478] Einsatz von Berechnungssystemen beim Nachweis der Kritikalitätssicherheit; Beiblatt 1: Erläuterungen, September 2012.

[DIN 25712] Kritikalitätssicherheit unter Anrechnung des Brennstoffabbrands bei Transport und Lagerung bestrahlter Leichtwasserreaktor-Brennelemente in Behältern, April 2015.

[GG 49] Grundgesetz für die Bundesrepublik Deutschland in der im Bundesgesetzblatt Teil III, Gliederungsnummer 100-1, veröffentlichten bereinigten Fassung, das zuletzt durch Artikel 1 des Gesetzes vom 15. November 2019 (BGBl. I S. 1546) geändert worden ist.

Hinweise:

- geändert bezüglich Kernenergie durch Gesetz vom 23. Dezember 1959, betreffend Artikel 74 Nr. 11a und 87c (BGBl. I 1959, Nr. 56, S. 813), erneut geändert bezüglich Kernenergie durch Gesetz vom 28. August 2006 betreffend Artikel 73, 74 und 87c (BGBl. I 2006, Nr. 41, S. 2034).
- Verlagerung des Gebietes Kernenergie in die ausschließliche Gesetzgebungskompetenz des Bundes.

[IAEA 02] Core Management and Fuel Handling for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.5, Wien, Mai 2002.

[IAEA 04] Code of Conduct on the Safety and Security of Radioactive Sources, IAEA/CODEOC/2004, Wien, 2004.

[IAEA 06a] Fundamental Safety Principles – Safety Fundamentals, IAEA Safety Standards Series No. SF-1, Wien, November 2006.

[IAEA 06b] Dangerous quantities of radioactive material (D-values), EPR-D-VALUES 2006, August 2006.

[IAEA 09a] Classification of Radioactive Waste, IAEA Safety Standards Series No. GSG-1, Wien, November 2009.

[IAEA 09b] Predisposal Management of Radioactive Waste, IAEA Safety Standards Series No. GSR Part 5, Wien, Mai 2009.

[IAEA 12a] Storage of Spent Nuclear Fuel, IAEA Safety Standards Series No. SSG-15, Wien, Februar 2012.

[IAEA 12b] Regulations for the Safe Transport of Radioactive Material, 2012 Edition, IAEA Safety Standards Series No. SSR-6, Wien, Oktober 2012.

[IAEA 14a] Control of Transboundary Movement of Radioactive Material inadvertently incorporated into Scrap Metal and Semi-Finished Products of the Metal Recycling Industries – Results of the Meetings Conducted to Develop a Draft Code of Conduct, IAEA, Wien, February 2014.

[IAEA 14b] Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, Wien July 2014.

[IAEA 19a] Report of the Integrated Regulatory Review Service (IRRS) Mission to Germany, 1 to 12 April 2019, IAEA Department of Nuclear Safety and Security.

[IAEA 19b] Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS), Mission to Germany, Köln, 22. September bis 4. Oktober 2019, URL: www.iaea.org/sites/default/files/documents/review-missions/final_artemis_report-germany.pdf

[ICRP 07] ICRP Publication 103 (Annals of the ICRP Vol. 37 No. 2-4, 2007), The 2007 Recommendations of the International Commission on Radiological Protection.

[KFK 16] Abschlussbericht der Kommission zur Überprüfung der Finanzierung des Kernenergieausstiegs, 27. April 2016.

[KTA 19] KTA Website, Stand September 2019, URL: www.kta-gs.de

[KOM 16] Kommission Lagerung hoch radioaktiver Abfallstoffe – Abschlussbericht: Ein faires und transparentes Verfahren für die Auswahl eines nationalen Endlagerstandortes, 5. Juli 2016.

[LIE 00] P. Liewers, J. Abele, G. Barkleit, Zur Geschichte der Kernenergie in der DDR, Verlag Peter Lang GmbH, 2000.

[LIN 56] Vereinbarung über den Durchflug im internationalen Linienverkehr (BGBl. 1956 II S. 442).

[MOS 57] Vertrag vom 27. Oktober 1956 über die Schiffbarmachung der Mosel (BGBl. 1956 II S. 1837, 1957 II S. 2).

[RHE 69] Revidierte Rheinschifffahrtsakte vom 17. Oktober 1868 in der Fassung der Bekanntmachung vom 11. März 1969 (BGBl. 1969 II S. 597).

[SSK 04a] „Leitfaden für den Fachberater Strahlenschutz der Katastrophenschutzleitung bei kerntechnischen Notfällen“, Berichte der Strahlenschutzkommission (SSK) des Bundesministeriums für Umwelt, Naturschutz, Bau und Reaktorsicherheit, Heft 37 (2004).

[SSK 04b] „Erläuterungsbericht zum Leitfaden für den Fachberater Strahlenschutz der Katastrophenschutzleitung bei kerntechnischen Notfällen“, Berichte der Strahlenschutzkommission (SSK) des Bundesministeriums für Umwelt, Naturschutz, Bau und Reaktorsicherheit, Heft 38 (2004).

[SSK 13] „Kriterien für die Alarmierung der Katastrophenschutzbehörde durch die Betreiber kerntechnischer Einrichtungen“, Gemeinsame Empfehlung der Reaktor-Sicherheitskommission und der Strahlenschutzkommission; Verabschiedet in der 366. Sitzung der RSK am 16. Oktober 2003 und in der 186. Sitzung der SSK am 11./12. September 2003; Ergänzung verabschiedet in der 453. Sitzung der RSK am 13. Dezember 2012 und der 260. Sitzung der SSK am 28. Februar 2013.

[SZS 65] „Richtlinie für die Erfassung radioaktiver Abfälle“, Mitteilungen der Staatlichen Zentrale für Strahlenschutz, 2. Jahrgang (1965) Nr. 3, 7 S.

[UNCLOS 94] Gesetz zu dem Seerechtsübereinkommen der Vereinten Nationen vom 10. Dezember 1982 (BGBl. 1994 II S. 1798).

[WENRA 14a] WENRA Working Group on Waste and Decommissioning (WGWD): Report Waste and Spent Fuel Storage Safety Reference Levels – Version 2.2, April 2014.

[WENRA 14b] WENRA Working Group on Waste and Decommissioning (WGWD): Report Radioactive Waste Disposal Facilities Safety Reference Levels, 22 December 2014.

[WENRA 15] WENRA Working Group on Waste and Decommissioning (WGWD): Report Decommissioning Safety Reference Levels – Version 2.2, April 2015.

[WENRA 16] WENRA Working Group on Waste and Decommissioning (WGWD): Report Radioactive Waste Treatment and Conditioning Safety Reference Levels, October 2016.

Additional report concerning the remediation of the Wismut GmbH

WISMUT-Annex

to the

Report of the Federal Republic of Germany for the Seventh Review Meeting of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention), March 2020

1 The Wismut remediation project: starting point and scope

For more than 28 years now, 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 t of uranium in eastern Germany making it the fourth largest 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-level radioactive rocks of approx. 311 million m³, four tailings ponds holding a total of 160 million m³ of radioactive sludges, and two processing factories for uranium ore.

The locations embraced by the Wismut remediation project span from Königstein in the eastern part of the *Land* of Saxony to Dresden-Gittersee, Schlema-Alberoda and Pöhla up to Crossen in western Saxony. In the *Land* of 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.

In 2015, a review was carried out on the status of remediation. With this 2015 Remediation Programme, the remaining remediation tasks, including long-term tasks in the time horizon 2016 to 2045, were re-evaluated in terms of content and financing. A re-evaluation of the remaining tasks in the time horizon 2021 to 2050 is planned for the year 2020.

2 Status of remediation

Remediation of the legacies of uranium ore mining at the Wismut sites was continued successfully during the review period. For the entire project, funding of around 8 billion euros are to be provided by the Federal Republic of Germany on the basis of the Remediation Programme 2015. At the end of 2019, around 6.7 billion euros (approx. 84 %) had been used up.

Underground remediation

Underground remediation has almost been completed. In the Schlema-Alberoda mine, underground work is still outstanding. The activities focus on the creation and maintenance of pathways for ventilation and on the closure of adits and near-surface mine workings.

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 heap

310. At the Ronneburg site, the relocation of the heaps to the abandoned open-cast mine at Lichtenberg has been completed. The resulting backfill volume is now fully covered. Water engineering and road construction have also been concluded (see. Fig. 3).

The profiling and covering of heap 371 at the Schlema-Alberoda site and of the Schüsselgrund heap at the Königstein site were continued. During the course of the management of both heaps, residual materials from the treatment of contaminated mine waters, 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 the Schüsselgrund heap) will only be finally covered once water treatment at the sites has ceased. Current knowledge suggests that this can be expected in 50 years at the earliest.

Dismantling of facilities, area rehabilitation and remediation of industrial tailings ponds

In the period under review, the work on the dismantling of facilities and area rehabilitation continued continuously, for example by the demolition of the Pipe Conveyor at the Crossen site (see Fig. 2). The main focus of the work was again on the remediation of the industrial tailings ponds. Details about the progress made during the review period are shown in Tab. 1.

Tab. 1: Comparison of selected figures showing the status of remediation

Object of remediation	End of 03/2017		End of 03/2020	
	absolute	relative [1)]	absolute	relative [1)]
Abandoned mine workings	1,467 km	100 %	1,468 km	100 %
Rehabilitated shafts/entrances	1.4 m m^3	100 %	1.4 m m^3	100 %
Backfilled mine workings	243,000 m^3	99 %	245,000 m^3	99 %
Relocation of material to industrial tailings ponds	20.8 m m^3	63 %	25.1 m m^3	73 %
Final covering of the industrial tailings ponds	5.3 m m^3	52 %	6.5 m m^3	61 %
Material from decommissioning of facilities	1.0 m m^3	81 %	1.3 m m^3	94 %
Remediated facility areas	1,168 ha	86 %	1,195 ha	88 %

[1)] Related to overall Wismut remediation.

Flooding of the mines and water treatment

The status of flooding of the uranium mines of the Wismut GmbH company still varies from mine to mine. At Pöhla, the natural filling level was already reached in 1995. At Dresden-Gittersee, flooding was completed with the commissioning of the "Wismut-Stollen" in 2014. 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 plants. The water treatment plants at the Seelingstädt and Crossen sites treat the leachate and pore waters from the industrial tailing ponds. At the Crossen site, construction of a new water treatment facility was started in 2019. This will replace the oversized old facility from 2021 onwards.

At Schlema-Alberoda, the large total volume of the water to be treated (in wet years up to around 1,000 m^3/h) and the high pollutant concentration in the residues of water treatment require considerable technical and financial efforts.

At Ronneburg, the water treatment plant has been operated with increased capacity (850 m³/h) since September 2011 without any failures. The flooding level has reached the area of the main reservoir (see Fig. 1).

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 – has so far not been approved by the competent authorities. In 2017, however, the competent authorities agreed to a hydraulic test, namely the flooding up to a level of 150 m sea level, i.e. 10 m above the currently licensed level of 140 m sea level with subsequent re-lowering. The test was carried out between August 2017 and June 2018.

3 Presentation of selected remediation results

The past reports have already illustrated by way of examples the progress made in improving the environmental situation as well as the reuse of remediated objects. The following figures show some aspects of the remediation activities during the reporting period.

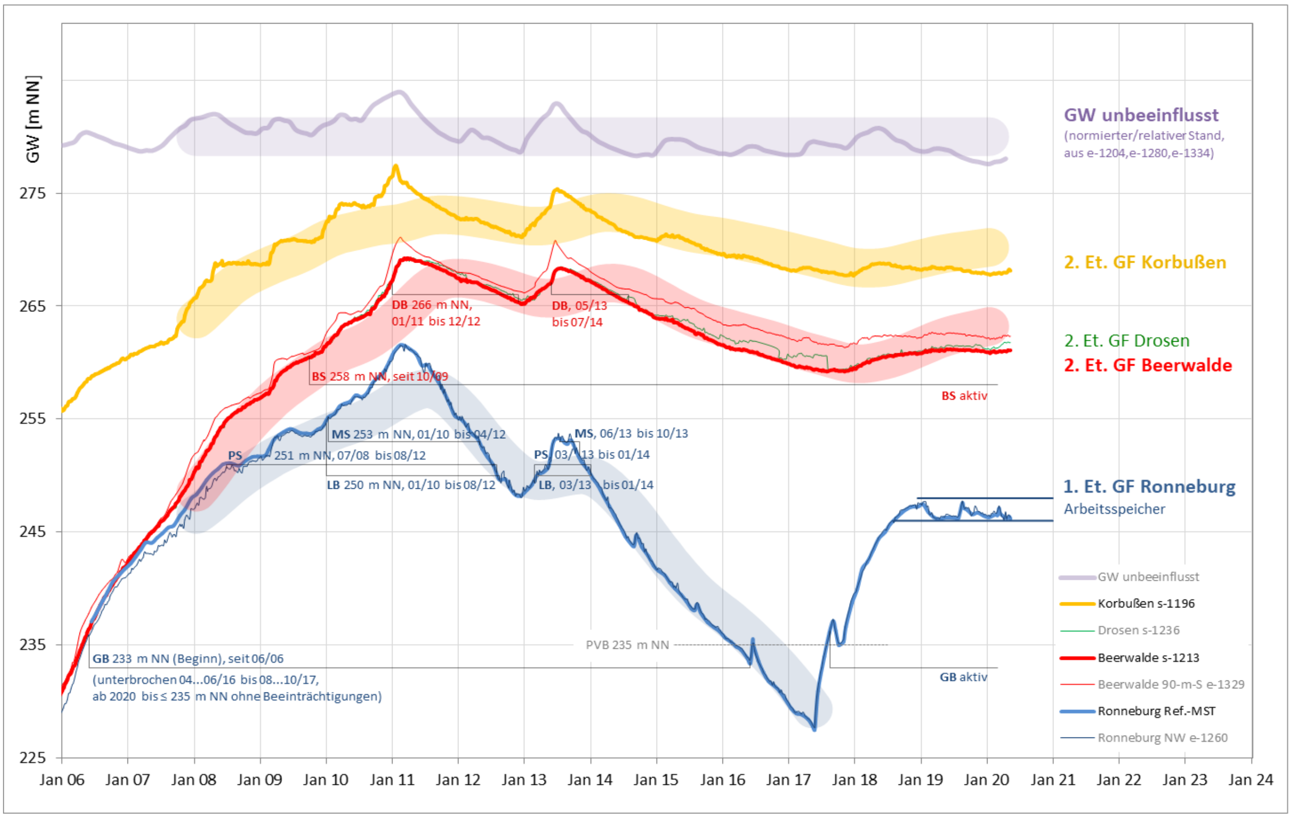


Fig. 1: Course of flooding in the Ronneburg mine fields

Fig. 2: Dismantling and demolition of the Pipe Conveyer at the Crossen site (2017/2018, copyright: Wismut Archives).

Fig. 3: Gessental with New Landscape Ronneburg and the embankment above the former opencast mine Lichtenberg with the "Schmirchauer Höhe" hill (as at: April 2019, copyright: Wismut Archives).

4 Long-term tasks and prospect

The long-term tasks of Wismut and their performance over time have already been described in detail in the reports to the third, fourth and fifth review meetings. Some of the tasks that have already been undertaken include

- 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 remediation documentation.

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), the internal data and information centre (*Daten- und Informationszentrum* – DIZ) continued its work and transferred it to the information management department (AIM).

With a re-assessment of the remediation programme in 2020, the time and funds needed for the final remediation by Wismut have been further specified. According to current knowledge, the core remediation process is to be completed in 2028.