State and Development of Nuclear Energy Utilization in the Federal Republic of Germany 2011

Department of Nuclear Safety

Ines Bredberg

Johann Hutter

Kerstin Kühn

Frank Philippczyk

Julia Dose

Bundesamt für Strahlenschutz

BfS-SK-20/12

Bitte beziehen Sie sich beim Zitieren dieses Dokuments immer auf folgende URN:

urn:nbn:de:0221-2012102610019

Zur Beachtung:
BfS-Berichte und BfS-Schriften können von den Internetseiten des Bundesamtes für Strahlenschutz unter http://www.bfs.de kostenlos als Volltexte heruntergeladen werden.

Salzgitter, November 2012

State and Development of Nuclear Energy Utilization in the Federal Republic of Germany 2011

Department of Nuclear Safety

Ines Bredberg

Johann Hutter

Kerstin Kühn

Frank Philippczyk

Julia Dose

CONTENTS

ZUSAMMENFASSUNG

Der vorliegende Bericht mit dem Stand 31.12.2011 gibt einen Überblick über die Nutzung der Kernenergie in der Bundesrepublik Deutschland. Im Bericht aufgeführt sind die wesentlichen Daten aller Kernkraftwerke, Forschungsreaktoren mit einer thermischen Dauerleistung größer als 50 kWth und der Anlagen der Kernbrennstoffver- und -entsorgung. Von den 17 betriebenen Kernkraftwerken haben am 06.08.2011 acht Kernkraftwerke per Gesetz die Berechtigung zum Leistungsbetrieb verloren. Zum Berichtszeitpunkt 31.12.2011 waren noch neun Kernkraftwerksblöcke in Betrieb. Die Stromerzeugung durch Kernenergie im Jahr 2011 betrug insgesamt ca. 108,0 TWh (2010: 140,5 TWh). Der Anteil an der Gesamt-Brutto-Stromerzeugung betrug 17,6 % (2010: 22,4 %)[1].

Für die Kernkraftwerke enthält der Bericht in zusammengefasster Form die wesentlichen Betriebsergebnisse und Hinweise auf die im Berichtsjahr erteilten atomrechtlichen Genehmigungen. Zu den abgeschalteten bzw. stillgelegten Kernkraftwerken sowie den eingestellten Vorhaben wird eine Kurzbeschreibung des gegenwärtigen Status gegeben. Für die Forschungsreaktoren mit einer thermischen Dauerleistung größer als 50 kW_{th} sind die wesentlichen Angaben zum Typ, den Kenndaten (thermische Leistung, thermischer Neutronenfluss) und dem Nutzungszweck der Anlage dargestellt. Des Weiteren wird ein Überblick über die Genehmigungs- und Betriebshistorie sowie den aktuellen Betriebszustand gegeben. Zu den Anlagen der Kernbrennstoffver- und -entsorgung werden Angaben zu Zweckbestimmung und Leistungsgröße gemacht. Dargestellt werden weiterhin die Genehmigungshistorie und der momentane Betriebs- und Genehmigungszustand. Die Informationen sind am Ende des Berichts zu einer Übersicht in Tabellenform zusammengefasst. Der Bericht wird jährlich in aktualisierter Form herausgegeben.

SUMMARY

This report describes the use of nuclear energy in the Federal Republic of Germany as of December, 2011. It contains the essential data of all nuclear power plants, research reactors with a continuous thermal power above 50 kW_{th} and the facilities of nuclear fuel supply and waste management. According to law eight of the 17 nuclear power plants “in operation” lost the authorisation for power operation on 6 August 2011. At the time of reporting 31 December 2011, nine nuclear power plants were still in operation. The power generation from nuclear energy in 2011 amounted to 108.0 TWh (2010: 140.5 TWh). That is a share of 17.6% of the total gross electricity production (2010: 22.4%).[1]

The report summarises the essential operational results of the nuclear power plants and information on granted licences. A short description of the present state of the nuclear power plants that have been shut down or decommissioned and of the stopped projects is given. Concerning research reactors with a continuous thermal power above 50 kW_{th}, essential data on type, characteristics (thermal power, thermal neutron flux) and purpose of the facility are represented. Furthermore, an overview of the licensing and operation history and the present state of the operating condition is given. For the plants of nuclear fuel supply and waste management data on purpose and capacity, the licensing history and the present state of operation and licensing are given. To give a survey, the data are summarised in tabular form in the report annexes. The report will be updated and published once a year.

[1] Vorläufige Schätzwerte Februar 2012 / preliminary estimated values as of February 2012; Quelle / source: Bundesverband der Energie- und Wasserwirtschaft e.V. (BDEW e.V.)

LIST OF ABBREVIATIONS

AG	Incorporated company
AGO	Comparision of Options working group
ANF	Advanced Nuclear Fuels GmbH
AREVA	French industrial group of companies in the field of nuclear technology
AREVA	French industrial group of companies in the field of nuclear technology
AtG	Atomic Energy Act
AtVfV	Nuclear Licensing Procedure Ordinance
AVR	Jülich Experimental NPP
BBergG	Federal Mining Law
BDEW	Federal Association of Energy and Water Economy e.V.
BE	Fuel element
BER II	Berlin Experimental Reactor Unit II
BfS	Federal Office for Radiation Protection
BGR	Federal Institute for Geosciences and Natural Resources
BLG	Brennelementlager Gorleben GmbHGorleben Fuel Emement Storage Facility
BMBF	Federal Ministry of Education and Research
BMFT	Federal Ministry of Research and Technology
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BNFL	British Nuclear Fuels Ltd.
Bq	Bequerel
BStMUG	Bavarian State Ministry of the Environment and Health
BVerfG	Federal Constitutional Court
BVerwG	Federal Administrative Court
BWE	German Wind Energy Association
BWR	Boiling Water Reactor (BWR)
BZA	Brennelement-Zwischenlager-Ahaus Interim Storage Facility for Spent Fuel Elements-GmbH
CASTOR®	Cask for Storage and Transport of Radioactive material
CEA	Commissariat à l'Energie Atomique et aux Energies Alternatives, a French government-funded technological research organization
CLAB	Centralt mellanlager för använt bränsle, Centrales interim storage facility for spent fuel elements in Sweden
COGEMA	Compagnie Générale des Matières Nucléaires, AREVA-Group
DBE	German Company for the Construction and Operation of Waste Repositories
DBG	Permanent operating licence
DDR	German Democratic Republic
DIDO	Heavy-water Moderated and Cooled Research Reactor in Jülich
DKFZ	German Cancer Research Centre
DWK	German Company for the Reprocessing of Nuclear Fuels
EEG	Renewable Energies Act
E.ON	E.ON Kernkraft GmbH
EnBW	Energiewerke Baden-Württemberg AG
ERAM	Morsleben Repository for Radioactive Waste
ERU	Enriched-Uranium
ESK	Nuclear Waste Management Commission
EVU	Electric Utilities
EWN	Energiewerke Nord GmbH
FBR	Sodium-cooled Fast Breeder Reactor
FDR	Advanced Pressurised Water Reactor
FMRB	Research and Measuring Reactor Braunschweig
FR 2	Karlsruhe Research Reactor Unit 2
FRF 1	Research Reactor Frankfurt Unit 1
FRF 2	Research Reactor Frankfurt Unit 1
FRG-1	Research Reactor Geesthacht Unit 1
FRG-2	Research Reactor Geesthacht Unit 1
FRH	Research Reactor of the Hannover Medical School
FRJ-1	Research Reactor Jülich Unit 1
FRJ-2	Research Reactor Jülich Unit 2
FRM	Research Reactor Munich
FRM-II	Munich High-flux Neutron Source in Garching Unit II
FRMZ	TRIGA Mark II Research Reactor of the Mainz University
FRN	Research Reactor Neuherberg
FZJ	Forschungszentrum Jülich
FZK	Forschungszentrum Karlsruhe
GKN 1	Neckar nuclear power plant Unit 1
GKN 2	Neckar nuclear power plant Unit 2
GKSS	Research Centre Geesthacht, Today: Helmholtz-Zentrum Geesthacht, Centre for Materials and Coastal Research
GNS	Gesellschaft für Nuklear Service mbH
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit mbH
GWh	Giga-Watt hour

HAW	High-level Active Waste
HAWC	High-level Active Waste Concentrate
HDR	Großwelzheim, Superheated Steam Reactor
HEU	High-Enriched Uranium
HKG	Hochtemperatur-Kernkraftwerk GmbH
HM	Heavy Metal
HMGU	Helmholtz Zentrum München, German Research Centre for Environmental Health
HOBEG	Hochtemperatur-Brennelement Gesellschaft
HTR	High-temperature Gas-cooled Reactor
HWL	High-Active Waste Storage Facility
IBS	Commissioning
KBR	Brokdorf NPP
KGR	Greifswald NPP
KIT	Karlsruhe Institute of Technology
KKB	Brunsbüttel NPP
KKE	Emsland NPP
KKG	Grafenrheinfeld NPP
KKI 1	Isar NPP Unit 1
KKI 2	Isar NPP Unit 2
KKK	Krümmel NPP
KKN	Niederaichbach NPP
KKP 1	Philippsburg NPP Unit 1
KKP 2	Philippsburg NPP Unit 1
KKR	Rheinsberg NPP
KKS	Stade NPP
KKU	Unterweser NPP
KMK	Mülheim-Kärlich NPP
KNK II	Karlsruhe, Karlsruhe Sodium-cooled Reactor
KRB A	Gundremmingen NPP Unit A
KRB-II-B	Gundremmingen NPP Unit B
KRB-II-C	Gundremmingen NPP Unit C
KTA	Nuclear Safety Standards Commission
KWB A	Biblis NPP Unit A
KWB B	Biblis NPP Unit B
KWG	Grohnde NPP
KWL	Lingen NPP
KWO	Obrigheim NPP
KWU	Siemens AG, Fachbereich Kraftwerk-Union
KWW	Würgassen NPP
LAVA	Facility for the Storage and Vaporisation of High-Active Waste Liquids in Hannover
LAW	Low-Active Waste
LBEG	State Authority for Mining, Energy and Geology
LEU	Low-Enriched Uranium
LWR	Light Water Reactor
MERLIN	Medium Energy Research Light Water Moderated Industrial Nuclear Reactor in the Jülich Research Center (FZJ)
MEU	Medium-Enriched Uranium
MLU	Saxony-Anhalt Ministry for Agriculture and the Environment
MOX	Mixed-oxide (fuel)
MTR	Materials Testing Reactor
MW_e	Megawatt electrical power
MWh	Megawatt Hour
MW_{th}	Megawatt Thermal Power
MZFR	Multipurpose Research Reactor Karlsruhe
NMU	Lower Saxon Ministry for the Environment, Energy and Climate Protection
NPP	Nuclear Power Plant
NUKEM	NUKEM GmbH Alzenau
OH	Nuclear ship “Otto Hahn”
oHG	General Partnership
OVG	Higher Administrative Court
PFB	Plan-approval Decision
PKA	Pilot Conditioning Plant
PTB	Federal Institute of Physics and Metrology
PuO_2	Plutonium dioxide
PWR	Pressurised Water Reactor (PWR)
RDB	Reactor Pressure Vessel
RFR	Research Reactor Rossendorf
RRRFR	Russian Research Reactor Fuel Return
RSK	Reactor Safety Commission
RWE	Rheinisch-Westfälische Elektrizitätsgesellschaft
SAAS	Federal Office for Nuclear Safety and Radiation Protection (of the former GDR)
SE	Safe Enclosure
SG	Decommissioning Licence
SMUL	Saxon State Ministry for the Environment and Agriculture
SSK	German Commission on Radiological Protection
StrlSchV	Radiation Protection Ordinance
SW/a	Uranium separative work per year
SZL	On-site Interim Storage Facilities
TBG	Partial Operating Licence
TBL-A	Ahaus Transport Cask Storage Facility
TBL-G	Gorleben Transport Cask Storage Facility
TEG	Partial Construction Licence
TG	Partial Licence
THTR-300	Hamm-Uentrop Gas-cooled High-temperature Pebble Bed Reactor
TRIGA	Training Research Isotope General Atomics
TRIGA HD I	TRIGA HD I Research Reactor Heidelberg

TRIGA HD II	TRIGA HD II Research Reactor Heidelberg
TSG	Partial Decommissioning Licence
TUM	Technische Universität München
TWh	Tera Watt hour
U-235	Uranium Isotope 235
U_3O_8	Triuranium octoxide
UAG	Gronau Uranium Enrichment Plant
UF_6	Uranium hexafluoride
UNS	Independent Emergency System
UO_2	Uranium dioxide
UTA	Uranium Separative Work
UVP	Environmental Impact Assessment
VAK	Kahl Experimental NPP
VBA	Lost Concrete Shielding
VDEW	Verband der Elektrizitätswirtschaft e.V.
VEK	Karlsruhe Vitrification Facility
VGB	Technische Vereinigung der Großkraftwerksbetreiber e.V.
VKTA	Verein für Kernverfahrenstechnik und Analytik Rossendorf e.V.
VSG	Preliminary safety assessment for the Gorleben site
w/o	Abbreviation of weight per cent
WAK	Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH
WAW	Wackersdorf Reprocessing Plant
WTI	Wissenschaftlich-Technische Ingenieursberatung GmbH
WWER	Water-cooled Water-moderated Energy Reactor (Russian Type PWR)
WWR-S (M)	Water-cooled water-moderated reactor of the Russian type, S stands for serial production and M for modification (RFR: Modifications of core and fuel)
ZLN	Interim Storage Facility North Rubenow

1. ELECTRICITY PRODUCTION FROM NUCLEAR ENERGY IN GERMANY

1.1 GENERAL

In the Federal Republic of Germany, altogether approximately 614 TWh (2010: ca. 628 TWh) of electric energy were produced in 2011 (gross electricity production including electricity transfers, BDEW February 2012). The total gross electricity production in Germany decreased by approximately 14 TWh compared with the preceding year (cf. Table 1.1). Power generation from nuclear energy decreased to approximately 108 TWh (2010: ca. 140 TWh). The decrease by about 32 TWh was due to the final shut-down of eight nuclear power plants in the year under report as a result of the reactor accident in March 2011 in Fukushima (Japan) and the resulting Amendment to the Atomic Energy Act as of 6 August 2011. More information on the topic is included in Chapter 1.2 “Phase-out of electricity production from nuclear energy”.

Table 1.1: Share of energy sources in the total gross electricity production in % incl. supplies

	2009		2010*		2011*	
	TWh	%	TWh	%	TWh	%
Nuclear energy	134.9	22.8	140.6	22.4	108.0	17.6
Lignite	145.6	24.6	145.9	23.2	153.0	24.9
Hard coal	107.9	18.2	117.0	18.6	114.5	18.6
Mineral oil	9.6	1.6	8.4	1.3	7.0	1.1
Natural gas	78.8	13.3	86.8	13.8	84.0	13.7
Renewables	94.1	15.9	102.9	16.4	122.0	19.9
Others (total)**	21.5	3.6	26.7	4.3	26.0	4.2
TOTAL	592.4	100.0	628.3	100.0	614.5	100.0

* All figures relating to the years 2010 and 2011 are preliminary estimations

** The category “Others” has not been specified in the BDEW data. The category “Renewables” is described in more detail in a sub-chapter and in Table 1.2 (p.9).

[Source: BDEW e.V. February 2012]

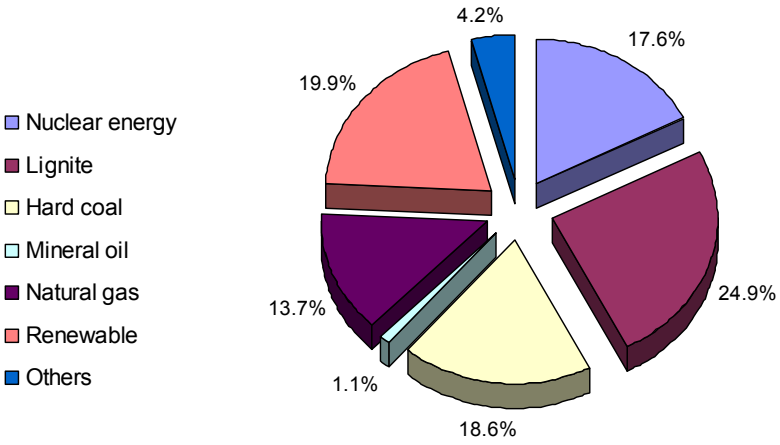


Fig. 1: Share of renewable sources of energy in the total gross electricity production (basis: 614.5 TWh)

The overall gross electricity production of the general electricity supply (i.e. without companies producing electricity or heat for self supply) amounted to 561.5 TWh in 2011 (571.8 TWh in 2010). The share of nuclear

power plants was 19.2 % in 2011 (24.6 in 2010) [source: BDEW]. The share of nuclear energy in the total final energy consumption is estimated to have been approximately 4 % in 2010.

Renewable sources of energy

The increased utilisation of renewables is a component of the German climate protection strategy. This is contained in the Renewable Energies Act (EEG) of 25 October 2008 (BGBl I p. 2074) which was last amended by Art. 2 para. 69 of the law of 22 December 2011 (BGBl I p. 3044). According to §1 EEG the share of renewables in power supply is to be increased to minimum 35% until the year 2020. In 2011, the percentage of renewables in the gross electricity production was approximately 19.9% according to BDEW (2010: 16.4%).

Today, wind energy, water power (regenerative contribution, i.e. without pump storage plants), solar energy and biomass energy are the most essential renewables. Altogether, energy production from renewable sources of energy amounted to approximately 122.0 TWh in 2011 (102.9 TWh in 2010).

The strongest growth in the year under report was experienced by the wind market. 895 wind turbines were newly installed in 2011. The capacity connected to the grid amounted to approximately 2,086 MW in 2011 (2010: ca. 1,493 MW). 108 MW of this capacity came from offshore facilities. Further offshore wind parks are currently under construction. The solar power industry, too, increased considerably. In the year under report the share of solar energy in the total gross electricity production increased to ca. 19.0 TWh (2010: ca. 11.7 TWh). (data: BWE, BDEW)

Table 1.2: Share of renewable energy sources in the total gross electricity production

	2009		2010*		2011*	
	TWh	%	TWh	%	TWh	%
Water**	19.0	3.2	21.0	3.2	19.5	3.2
Wind	38.6	6.5	37.8	5.9	46.5	7.6
Solar	6.6	1.1	11.7	1.9	19.0	3.1
Biomass	25.5	4.3	27.6	4.6	32.0	5.2
Refuse**	4.4	0.7	4.8	0.7	5.0	0.8
Geothermal energy	0.02	***	0.02	***	0.03	***
TOTAL	94.1	15.9	102.9	16.4	122.0	19.9

* All figures relating to the years 2010 and 2011 are preliminary estimations

** Only the regenerative share is taken into account.

*** The share is very small and is not stated here

[Source: BDEW February 2012]

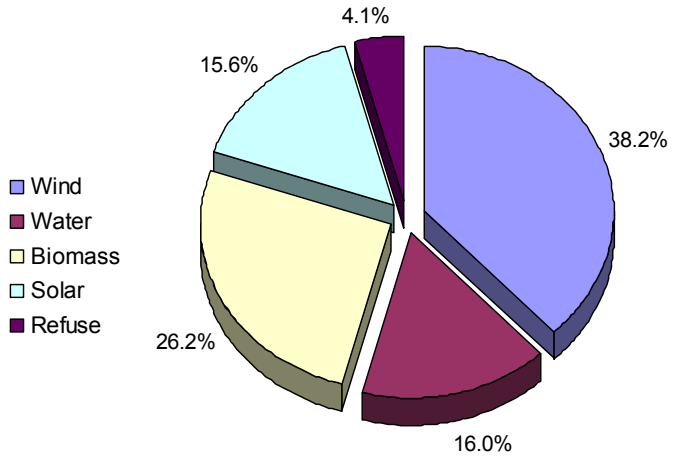


Fig. 2: Share of renewables (basis: 122.0 TWh)

1.2 PHASE-OUT OF ELECTRICITY PRODUCTION FROM NUCLEAR ENERGY

On 11 June, 2001, an agreement between the federal government and the largest power utilities was signed concerning the phase-out of electricity production from nuclear energy. With the Amendment to the Atomic Energy Act (AtG) of April 2002 this agreement was implemented into law.

1.2.1 CONSEQUENCES OF THE REACTOR ACCIDENT IN FUKUSHIMA TO ELECTRICITY PRODUCTION FROM NUCLEAR ENERGY IN GERMANY

As a result of the reactor accident in Fukushima Daiichi, Japan, of 11 March 2011, the federal government decided in a Moratorium on 14 March 2011 for all German nuclear power plants that had been commissioned until and including 1980 to take them from the grid and shut them down for a period of three months. This decision affected the nuclear power plants Biblis A, Neckarwestheim 1, Biblis B, Brunsbüttel, Isar 1, Unterweser and Philippsburg 1. The nuclear power plants Biblis B, Brunsbüttel and Krümmel had already been taken from the grid at that point of time.

For these eight shut-down nuclear power plants and the nine NPPs still in operation the Reactor Safety Commission (RSK) conducted a safety check. In Germany, the results and the cross-social dialogue with the participation of the Ethics Commission “Secure Supply of Energy” have led to a re-evaluation of the risks associated with the use of nuclear energy. The federal government decided to end the use of nuclear energy for commercial energy production in Germany as soon as possible.

1.2.2 AMENDMENT TO ATOMIC ENERGY ACT 2011

The 13th Law amending the Atomic Energy Act dated 31 July 2011 specifies that the last nuclear power plants in Germany shall be shut down at the end of 2022.

Dates for shutting down

When the new Atomic Energy Act became effective on 6 August 2011, the further authorisation for power operation expired for the nuclear power plants Biblis A, Neckarwestheim, Biblis B, Brunsbüttel, Isar 1, Unterweser, Philippsburg and Krümmel. The installations have been shut down entirely.

The following dates for the end of operating times or, respectively for the final shutdown of the remaining nine nuclear power plants still in operation have been stated in the Atomic Energy Act:

- 31 December 2015 Grafenrheinfeld NPP
- 31 December 2017 Gundremmingen NPP Unit B
- 31 December 2019 Philippsburg NPP Unit 2
- 31 December 2021 Grohnde NPP, Gundremmingen NPP Unit C and Brokdorf NPP
- 31 December 2022 Isar NPP Unit 2, Emsland NPP and Neckarwestheim NPP Unit 2.

During their residual times, all nuclear power plants still in operation are authorised to produce electricity volumes allocated to them individually (cf. Chapter 1.2.3).

No nuclear power plant as reserve

According to the Atomic Energy Act the Federal Network Agency (Bundesnetzagentur) would have had the option to commit one of the NPPs of Biblis A, Neckarwestheim 1, Biblis B, Brunsbüttel, Isar 1, Unterweser, Philippsburg 1 or Krümmel to constitute a reserve until 31 March 2013. If technical bottlenecks or unacceptable tensions in electricity supply occur, this nuclear power plant would have had to remedy the jeopardised security of supply in case of emergency.

In its investigations the Federal Network Agency stated that one could do without using a reserve power plant, even in cases of exceptional circumstances, as additional conventional power plant reserves are available. Therefore, the Federal Network Agency decided on 31 August 2011 that none of the nuclear power plants shut down on 6 August 2011 will be required to constitute a reserve to guarantee electricity supply.

1.2.3 GERMAN NUCLEAR POWER PLANTS' ELECTRICITY VOLUMES

As early as in June 2001 the federal government and the power utilities agreed upon a certain electricity volume for each nuclear power plant which the respective plant is authorised to produce with reference date 01 January 2000. This resulted in an operating time of approximately 32 years for each nuclear power plant, which was determined in the Atomic Energy Act in April 2002. In 2010 the federal government decided to extend the operating times by eight years of those nuclear power plants that had taken up power operation until and including 1980 or, respectively, to extend the operating times of the younger nuclear power plants by 14 years. Correspondingly, the Atomic Energy Act as amended in December 2010 allocated additional electricity volumes to individual nuclear power plants. In the wake of the reactor accident in Fukushima Daiichi, Japan, on 11 March 2011, the federal government decided – as already mentioned – to end the use of nuclear energy for commercial electrical power generation as quickly as possible. As a result, the Atomic Energy Act was amended in August 2011. It does again specify exclusively the electricity volumes for each individual nuclear power plant that had already been set out in the previous version of the Atomic Energy Act of April 2002. The extension of operating times laid down in December 2010 was revoked and the additional electricity volumes were cancelled.

With the Amendment to the Atomic Energy Act in August 2011 a concrete date for shut down was set by law for each single nuclear power plant to shut down. Furthermore, the AtG specified in Column 2 of Annex 3 to § 7 para. 1a the electricity volumes (previously referred to as residual electricity volumes) that can still be produced with reference date 01 January 2000. Once they have been produced, the authorisation for operating the plant will expire. According to the Atomic Energy Act the transfer of electricity volumes from one NPP to another is an option. They may be transferred in part or as a whole from one – usually older and smaller – nuclear power plant to another. The transfer of the remaining electricity volumes of the nuclear power plants shut down according to the Atomic Energy Act on 6 August 2011 (Biblis A, Neckarwestheim 1, Biblis B, Brunsbüttel, Isar 1, Unterweser, Philippsburg and Krümmel) is also an option. According to the Atomic Energy Act, any transfer from a newer onto an older NPP requires the approval by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), in agreement with the Federal Chancellery and the Ministry of Economics and Technology. From the BMU point of view, it is necessary to compare the safety level of both NPPs involved in the transfer. Transfers of electricity volumes must be reported to the Federal Office for Radiation Protection and are taken into account when registering the electricity volumes.
In January 2011, the Neckarwestheim NPP Unit 1 (GKN 1) had expired its electricity amount listed in Column 2 of Annex 3 to § 7 para. 1a Atomic Energy Act in the version that was effective at that point in time. Since then the plant was operated with the additional electricity volumes according to the Atomic Energy Act as of December 2010. GKN 1 shut down in the scope of the federal government's Moratorium of 14 March 2011 and its shut-down has been implemented into the Atomic Energy Act since 6 August 2011.

Tasks of the Federal Office for Radiation Protection (BfS)

The Federal Office for Radiation Protection registers and documents the net electricity volumes produced in the German nuclear power plants and the electricity volumes remaining according to the Atomic Energy Act. The utilities measure the produced net electricity and, since May 2002, have reported the data to the BfS monthly. The measuring devices are tested by an independent expert organisation and the reported electricity volumes are certified by a public accountant. The functional inspection reports and the certificates by the public accountant are submitted to the BfS.

In 2001 and 2002, the nuclear power plant operators, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the BfS agreed upon details on the measurement of the electricity volumes and data transfer, on the measuring devices' calibration capability and on the confirmation through independent experts and the public accountant.

Publication of electricity volumes

The BfS has been publishing the produced, transferred and remaining electricity volumes according to Atomic Energy Act in the Bundesanzeiger (Federal Gazette) since 10 July 2002. The figures are published annually. Should an operating time of less than six months be expected due to the residual electricity volumes, the figures are published monthly. Table 1.3 shows the status of electricity volumes as of 31 December 2011. It was published as an annual report 2011 in the Bundesanzeiger on 30 March 2012.

Note on Table 1.3:

The total net electricity production in 2011 amounted to 102,224.76 GWh. This value is calculated as the sum of the annual total net production listed in Column 6 amounting to 101,058.43 GWh and the additionally produced electricity amounting to 1,166.33 GWh (net) of the Neckarwestheim NPP Unit 1 as a result of the extension of operating times decided in 2010 (cf. footnote 5). According to the Atomic Energy Act of 6 August 2011, Neckarwestheim 1 is out of operation. The same applies to seven further plants.

Table 1.3: Produced, transferred and remaining electricity volumes (net) of German nuclear power plants

Announcement acc. to § 7 para. 1c Atomic Energy Act (AtG) – annual statement 2011 -

Electricity volumes produced, transferred and remaining during the period from 01 January 2000 and 31 December 2011 [GWh net] acc. to § 7 para. 1a Annex 3 Column 2 AtG

Nuclear Power Plant	Electricity volume from 01 January 2000	01 January 2000 to 31 December 2008	Total 2009	Total 2010	Total 2011	Electricity volumes transferred until 31 December 2011	Remaining electricity volume
1	2	3	4	5	6	7	8
Biblis A[1) 4)]	62,000.00	56,791.15	1,012.98	4,675.88	2,111.28	4,785.53	2,194.24
Neckarwestheim 1[4) 5)]	57,350.00	50,889.02	4,361.98	1,910.34	188.66		0.00
Biblis B[3) 4)]	81,460.00	68,860.58	1,511.33	9,726.62	1,638.99	8,100.00	7,822.48
Brunsbüttel[4)]	47,670.00	36,670.33	0.00	0.00	0.00		10,999.67
Isar 1[4)]	78,350.00	61,683.60	6,796.00	6,285.18	1,561.10		2,024.12
Unterweser[4)]	117,980.00	83,679.99	10,028.91	10,698.90	2,369.34		11,202.86
Philippsburg 1[2) 4)]	87,140.00	59,132.06	6,149.84	6,488.68	1,415.29	-5,499.89	8,454.24
Grafenrheinfeld	150,030.00	90,205.32	10,447.26	7,492.57	8,532.31		33,352.54
Krümmel[4)]	158,220.00	69,639.92	334.97	0.00	0.00		88,245.11
Gundremmingen B	160,920.00	90,840.65	10,389.87	9,460.79	10,320.08		39,908.61
Philippsburg 2	198,610.00	95,943.41	10,969.60	11,192.14	10,727.21		69,777.64
Grohnde	200,900.00	97,603.85	10,867.47	10,782.44	9,603.19		72,043.05
Gundremmingen C	168,350.00	89,163.28	10,275.18	10,394.76	9,454.97		49,061.81
Brokdorf	217,880.00	100,970.86	11,459.42	11,360.45	9,701.26		84,388.01
Isar 2	231,210.00	103,524.70	11,484.85	11,375.28	11,655.84		93,169.33
Emsland	230,070.00	99,142.42	10,849.24	10,977.91	10,971.12		98,129.31
Neckarwestheim 2	236,040.00	94,528.12	10,779.73	10,180.30	10,807.79		109,744.06
Total	**2,484,180.00**	**1,349,269.26**	**127,718.63**	**133,002.24**	**101,058.43**		**780,517.08**
Stade[1)]	23,180.00	18,394.47				-4,785.53	0.00
Obrigheim[2)]	8,700.00	14,199.89				5,499.89	0.00
Mülheim-Kärlich[3)]	107,250.00					-8,100.00	99,150.00
Sum total	**2,623,310.00**						**879,667.08**

The data in Column 6 "Total 2011" contain the values examined by certified accountants according to § 7 para. 1a AtG.

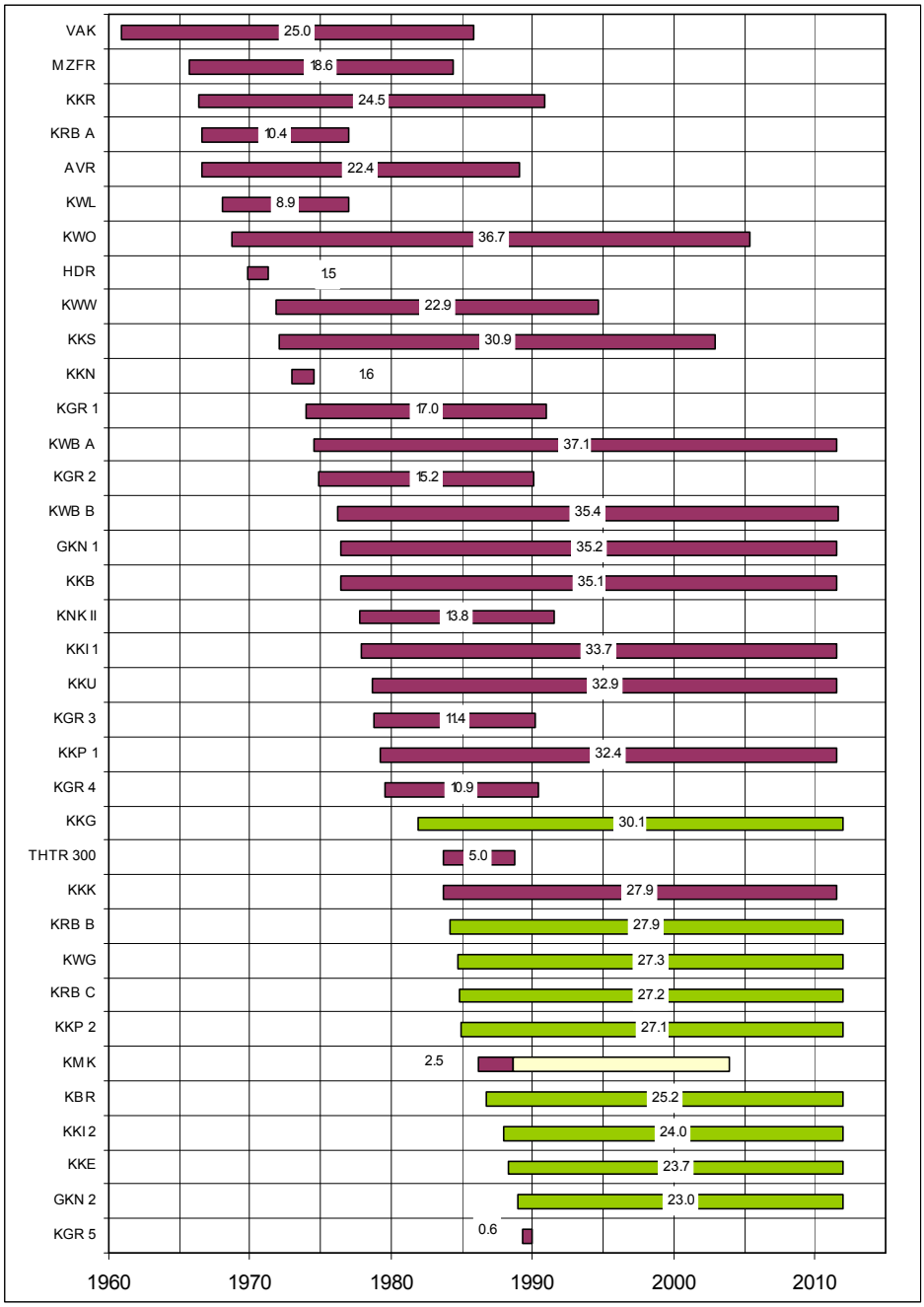
[1)] The Stade NPP was shut down on 14 November 2003 and was decommissioned on 7 September 2005.
The remaining electricity volume of the Stade nuclear power plant amounting to 4,785.53 GWh was transferred to the Biblis A nuclear power plant on 11 May 2010.

[2)] The Obrigheim NPP was shut down on 11 May 2005 and was decommissioned on 28 August 2008. The remaining electricity volume of the Obrigheim nuclear power plant amounting to 0.11 GWh was transferred back to the Philippsburg 1 nuclear power plant.

[3)] With letter PNN/Dr.Pa of 30 June 2010 the RWE Power AG reported the transfer of 8,100 GWh of the electricity volume allocated to the decommissioned plant Mülheim-Kärlich (KMK) to the Biblis B plant (KWB B) acc. to § 2010 para. 8.100 Atomic Energy Act. Prior to the transfer on 30 June 2010 the remaining electricity volume of KWB B amounted to 5,889.11 GWh .

[4)] Since the Atomic Energy Act was amended on 6 August 2011, the nuclear power plants Biblis A, Neckarwestheim 1, Biblis B, Brunsbüttel, Isar 1, Unterweser, Philippsburg 1 and Krümmel do no longer have authorisation for power operation.

[5)] In the year under report 2011, the Neckarwestheim1 nuclear power plant additionally produced 1,166.33 GWh according to § 7 para. 1a Annex 3 Column 4 AtG as amended on 8 December 2010.



	Karl Experimental NPP	KWB A	Biblis NPP Unit A	THTR	Hamm-Uentrop Gas-cooled High-temperature
MZFR	Multipurpose Research Reactor Karlsruhe	KGR 2	Greifswald NPP Unit 2	KKK	Krümmel NPP
KKR	Rheinsberg NPP	KWB B	Biblis NPP Unit B	KRB B	Gundremmingen NPP Unit B
KRB A	Gundremmingen A	GKN 1	Neckar NPP Unit 1	KWG	Grohnde NPP
AVR	Jülich Experimental NPP	KKB	Brunsbüttel NPP	KRB C	Gundremmingen NPP Unit C
KWL	Lingen NPP	KNK II	Karlsruhe Sodium-cooled Reactor	KKP 2	Philippsburg NPP Unit 1
KWO	Obrigheim NPP	KKI 1	Isar NPP Unit 1	KMK	Mülheim-Kärlich NPP
SSR	Großwelzheim Superheated Steam Reactor	KKU	Unterweser NPP	KBR	Brokdorf NPP
KWW	Würgassen NPP	KGR 3	Greifswald NPP Unit 3	KKI 2	Isar NPP Unit 2
KKS	Stade NPP	KKP 1	Philippsburg 1 NPP	KKE	Emsland NPP
KKN	Niederaichbach NPP	KGR 4	Greifswald NPP Unit 4	GKN 2	Neckar NPP Unit 2
KGR 1	Greifswald NPP Unit 1	KKG	Grafenrheinfeld NPP	KGR 5	Greifswald NPP Unit 5

Fig. 3: Operating times of nuclear power plants in Germany in years since first criticality, as of 31 December 2011

2. NUCLEAR POWER PLANTS IN GERMANY

In the Federal Republic of Germany there are currently (as of 31 December 2011)

9 Nuclear power plants in operation

8 Nuclear power plants finally shut down,

16 Nuclear power plants under decommissioning

3 Nuclear power plants entirely dismantled and released from regulatory control

6 Nuclear power plant projects that were stopped.

Table 2.1: Nuclear power plants in Germany in 2011

Status	PWR Number	PWR MWe (gross)	BWR Number	BWR MWe (gross)	Others Number	Others MWe (gross)	Total Number	Total MWe (gross)
In operation	7	10,008	2	2,688	—	—	9	12,696
Final shut down	4	4,775	4	4,046	—	—	8	8,821
Under decom-missioning	10	4,658	3	1,172	3	344	16	6,174
Entirely dismantled	—	—	1	16	2	131	3	147
Project stopped	5	3,320	—	—	1	327	6	3,647

The operational status of the individual nuclear power plants are described in chapters 2.1 to 2.5 and in the corresponding tables contained in Annex I.

A survey of the sites of all NPPs in the Federal Republic of Germany is given in Figure I at the end of the report in Annex I.

2.1 NUCLEAR POWER PLANTS IN OPERATION

A list of the nine nuclear power plants in operation with their essential features is given in Table I.2.a in Annex I.

2.1.1 AVAILABILITIES AND REPORTABLE EVENTS

Table 2.2 shows a list of the respective availabilities and reportable events of German nuclear power plants over the past 10 years. The BfS publishes annual reports and, since January 2010, also monthly reports on reportable events. These reports contain events in nuclear power plants and research reactors of the Federal Republic of Germany that have been reported on the basis of the Nuclear Safety Officer and Reporting Ordinance (AtSMV). The events are registered by the BfS Incident Registration Centre.

You will find details and more information on reportable events on the BfS website by clicking at http://www.bfs.de/en/kerntechnik/ereignisse/berichte_meldepflichtige_ereignisse.

Table 2.2: Average availabilities and total number of reportable events in nuclear power plants

Year	Time availability* [%]	Energy availability* [%]	Capacity availability* [%]	Number of reportable events**
2011	82.1	81.9	68.2	103
2010	76.4	77.5	74.0	81
2009	73.2	74.2	71.2	104
2008	80.0	80.9	78.4	92
2007	76.0	76.4	74.4	118
2006	91.1	90.8	89.1	130
2005	88.8	88.0	86.3	135
2004	89.8	89.2	87.4	153
2003	87.7	87.0	84.3	137
2002	85.6	86.0	83.8	167

* Source: Technische Vereinigung der Großkraftwerksbetreiber e.V. (VGB)

** Sources: BfS annual reports and reports of the Federal Republic of Germany for the Fifth Preview Meeting in April 2011 on the Convention on Nuclear Safety

2.1.2 PLANT AND LICENSING STATUS OF THE NUCLEAR POWER PLANTS

The following section gives a short description of each nuclear power plant in operation and provides information about the essential licences according to § 7 AtG in the year under report granted by the competent federal state authorities under nuclear law as shown in Table I.1 (Annex I). Also licensing procedures in progress are dealt with if they are of special relevance to the plant and licensing status. Furthermore, details on the capacity increases carried out so far are shown in Table I.2.b in Annex I.

The terrorist attacks of 11 September 2001 in the USA have also directed attention to nuclear facilities as possible targets. Although the security authorities opine that there is no particular concrete risk for nuclear facilities, German nuclear power plants have also been included into the packages of measures for the protection from terrorist attacks with airliners. One target is to make interference with air traffic more difficult, another target is to reduce possible consequences. Apart from a number of in-plant measures which could be implemented immediately, also applications for aggravating the targeting precision in case of a targeted terrorist air crash (camouflage protection through artificial smokescreen) were filed in the scope of this overall complex. Corresponding nuclear licences according to § 7 AtG have already been granted and implemented for some plants.

Neckarwestheim NPP Unit 2 (GKN 2)

Neckarwestheim Unit 2 is a pressurized water reactor (PWR) of the 4th generation and was commissioned in 1988 with a capacity of 1,316 MW_e. The current reactor output of 1,400 MW_e results from several thermal and electric power changes.

Commissioned in December 1988, the Neckarwestheim nuclear power plant Unit 2 is the youngest NPP operated in Germany.

An application according to § 7 Atomic Energy Act for thermal capacity increase is currently subject to the licensing procedure.

Philippsburg NPP Unit 2 (KKP 2)

The Philippsburg NPP Unit 2 is a PWR of the 3rd generation, a pre-Convoy plant. The plant was commissioned in 1984 with a capacity of 1,349 MW_e. The electrical output of the plant was gradually increased to 1,468 MW_e by several thermal and electrical capacity increases.

Isar NPP Unit 2 (KKI 2)

The Isar NPP Unit 2 is a Convoy plant with PWR of the 4th generation. As the first of three Convoy plants (Neckarwestheim 2, Emsland) it was commissioned in 1988 with a capacity of 1,370 MW_e. The current reactor output of 1,485 MW_e results from two thermal capacity increases and several electrical capacity increase measures. The latest one being the remediation of the high-pressure turbine in the revision of 2009. Thus the KKI 2 is currently the most powerful nuclear power plant unit in Germany.

Grafenrheinfeld NPP (KKG)

The Grafenrheinfeld NPP is a PWR of the 3rd generation (pre-Convoy plant) and was commissioned in 1981 with a capacity of 1,299 MW_e. The current reactor output of 1,345 MW_e is due to two electrical capacity increases.

An application for an increase in thermal reactor capacity to 3,950 MW_{th} has been filed to the licensing authority.

Gundremmingen NPP Unit B and Unit C (KRB-II-B and KRB-II-C)

Gundremmingen is a dual-unit plant with the two units KRB-II-B and KRB-II-C that are of identical design. Each of them is a boiling water reactor (BWR) of design series 72. Both units were commissioned in 1984 with a capacity of 1,310 MW_e each. The current reactor output of 1,344 MW_e results from two electrical capacity increases in either unit. In terms of electrical capacity, the Gundremmingen NPP is the largest German nuclear power plant.

An application for an increase in thermal reactor capacity for both units to 4,000 MW_{th} was filed to the licensing authority on 19 December 2001 and is currently subject to the licensing procedure.

Grohnde NPP (KWG)

The Grohnde NPP is a PWR of the 3rd generation and was commissioned in 1984 with a capacity of 1,365 MW_e. One thermal and two electrical capacity increases have led to the current reactor output of 1,430 MW_e.

In the past years, applications were filed for the Grohnde plant for the utilisation of uranium fuel elements with an initial enrichment of up to 4.4 weight per cent uranium 235 and for an increase of the thermal reactor capacity to 4,000 MW_{th}. Furthermore, applications for the introduction of digital instrumentation and control systems in the area of neutron ex-core instrumentation and for the modification of the safety-related parameters “hold-down capacity” for the design and the operation of the reactor core are subject to the licensing procedure according to § 7 Atomic Energy Act.

Emsland NPP (KKE)

The Emsland plant is a PWR of the 4th generation, one of three Convoy plants in the Federal Republic of Germany. The plant was commissioned in 1988 with a capacity of 1,316 MW_e. The current reactor output of 1,400 MW_e results from one thermal and several electrical capacity increases.

An application for an increase of the thermal reactor capacity to 3,950 MW_{th} is currently subject to the nuclear licensing procedure.

The KKE operator was granted the licence for the modification of the safety-related parameters “interior fuel element pressure” and “plastic reference expansion” for the design and operation of the reactor core on 02 March 2011. The licence replaces the relevant data described in the licensing document “Status regarding the analyses on safety-related parameters for 3,850 MW_{th}” of 10 May 1985.

Brokdorf NPP (KBR)

The Brokdorf NPP is a PWR of the 3rd generation (pre-Convoy). The plant was commissioned in 1986 with a capacity of 1,380 MW_e. The reactor output is currently 1.480 MW_e resulting from two thermal and several electrical capacity increases. The last licence for increasing the thermal reactor power was granted on 23 May 2006.

An application for the modification of the primary design parameter “hold-down capacity for fuel elements” is in the nuclear licensing procedure.

2.2 NUCLEAR POWER PLANTS FINALLY SHUT DOWN

In the year under report eight nuclear power plants finally shut down on the basis of the Amendment to the Atomic Energy Act of 31 July 2011 (cf. Chapter 1.2 and Table I.3 in Annex I).

Neckarwestheim NPP Unit 1 (GKN 1)

The Neckarwestheim NPP Unit 1 is a pressurised water reactor (PWR) of the 2nd generation and was commissioned in 1976 with a capacity of 855 MW_e. The reactor output was at last 840 MW_e resulting from a power decrease due to an exchange of condenser pipes in 1990. On 16 March 2011 the federal government gave order to shut down the plant, which has been in the post-operational phase since. With the Amendment to the Atomic Energy Act the authorisation for power operation expired on 6 August 2011 (cf. Chapter 1.2). The fuel elements were removed from the reactor and taken into the fuel pool.

An application for decommissioning the plant has not been filed so far.

Philippsburg NPP Unit 1 (KKP 1)

The Philippsburg NPP Unit 1, together with the Isar NPP Unit 1, Brunsbüttel NPP and Krümmel NPP, belongs to the boiling water reactors (BWR) of design series 69 and was commissioned in 1979 with a capacity of 900 MW_e. The reactor output valid when the reactor shut down in 2011 was 926 MW_e, resulting from two electrical capacity increases. The authorisation for power operation expired on 6 August 2011 due to the Amendment to the Atomic Energy Act. The KKP 1 is in the post-operational phase (cf. Chapter 1.2). Since the beginning of 2012 the fuel elements are in the fuel pool.

An application for decommissioning the plant has not been filed so far.

Isar NPP Unit 1 (KKI 1)

Isar 1 also belongs to the BWR of design series 69 and was commissioned in 1977 with an electrical output of 907 MW_e. The last valid reactor output was 912 MW_e. Since 17 March 2011 Isar Unit 1 has permanently shut down. The authorisation for power operation expired with the Amendment to the Atomic Energy Act on 6 August 2011 (cf. Chapter 1.2). The reactor core was entirely unloaded; the fuel elements are in the fuel pool.

An application for decommissioning the plant has not been filed so far.

Biblis NPP – Unit A (KWB A) and B (KWB B)

The plants Biblis A and B are among the eight nuclear power plants that had to finally cease power operation on the basis of the Amendment to the Atomic Energy Act in the year under report (cf. Chapter 1.2).

Biblis A with a PWR of the 2nd generation and was commissioned in 1974 with a capacity of 1,204 MW_e. The last valid reactor output was 1,225 MW_e. The Biblis nuclear power plant was designed as dual-unit plant. Unit B, which is likewise a PWR of the 2nd generation, was commissioned in 1976 with an electrical capacity of 1,300 MW_e. This output was also the last effective one. The fuel elements of both units have already been unloaded and are in the fuel pool.

On 11 May 2010, 4.78 TWh were transferred from the decommissioned Stade NPP to the KWB A in the scope of the electricity volume transfers according to § 7 para. 1b AtG. An electricity volume of 8.1 TWh was transferred to the KWB B on 30 June 2010. This electricity volume came from the decommissioned Mülheim-Kärlich nuclear power plant (KMK). This contingency was made use of in the year under report until the plant was shut down (cf. Table 1.3 in Chapter 1.2.3).

In the year under report 2011, a licence according to § 7 Atomic Energy Act was granted for the establishment of a sampling system from the reactor safety vessel in the aftermath of design-exceeding events.

An application for decommissioning the plants has not been filed so far.

Unterweser NPP (KKU)

The Unterweser NPP was commissioned in 1978 with a capacity of 1,300 MW_e. It is a nuclear power plant with PWR of the 2nd generation. The last reactor output was 1,410 MW_e. With the 13th Amendment to the Atomic Energy Act power operation expired on 6 August 2011. The fuel elements were removed from the reactor and are now in the fuel pool.

An application for decommissioning the plant has not been filed so far.

Brunsbüttel NPP (KKB)

The Brunsbüttel NPP, the oldest BWR of design series 69, was granted its first operation licence on 22 June 1976. The reactor output of 806 MW_e has not been changed since it was commissioned. The plant has shut down since summer 2007.

Brunsbüttel is one of the eight nuclear power plants in Germany that were finally shut down in 2011 as a result of the Amendment to the German Atomic Energy Act (cf. chapter 1.2). The KKB is in the post-operational phase. Part of the reactor has been unloaded.

An application for decommissioning the plant has not been filed so far.

Krümmel NPP (KKK)

The Krümmel NPP is the BWR of the design series 69 with the largest electrical capacity. The plant was commissioned in 1983 with a capacity of 1,316 MW_e. At the time power operation ceased, the reactor output was 1,402 MW_e.

As a result of a fire in a transformer in June 2007 the plant shut down. In June 2009, another short-circuit occurred in a machine transformer after a brief start-up of the reactor. The KKK has been shut down since.

As a result of the Amendment to the Atomic Energy Act 2011 the plant ultimately ceased power operation (cf. Chapter 1.2). The reactor has been unloaded. The fuel elements are in the fuel pool.

An application for decommissioning the plant has not been filed so far.

2.3 NUCLEAR POWER PLANTS UNDER DECOMMISSIONING

In Germany there are currently 16 nuclear power plant units under decommissioning (cf. Table I.4). Two of them are in the phase of safe enclosure, the others are being dismantled with the objective of total dismantling (“greenfield”).

Rheinsberg NPP (KKR)

The Rheinsberg NPP with a capacity of 70 MW_e (WWER reactor type) was commissioned in 1966. It served to help the GDR develop reactors independently. The produced electric energy was fed into the state grid. After 24 years of operation, the plant finally shut down in 1990. Since 9 May 2001, all nuclear fuel has been removed from the site, the fuel elements were delivered to the Interim Storage Facility North (ZLN). It is planned to entirely dismantle the plant by 2012. The first decommissioning licence was granted on 28 April 1995. Decommissioning work is carried out step by step with the relevant licences.

The transport of the reactor pressure vessel to the Interim Storage Facility North was carried out on 30 October 2007. Thus the activity inventory in the plant has considerably decreased. The last major component of the reactor “annular water tank” was taken from its position in 2010. The dissected segments are to be stored intermediately in the ZLN.

Karlsruhe Sodium-Cooled Reactor (KNK II)

The Karlsruhe Sodium-Cooled Reactor served to develop the breeder technology. The plant contained a 21 MW_e sodium-cooled fast-breeder reactor and was commissioned in 1977. After the test programme was completed, the reactor was finally shut down on 23 August 1991.

The decommissioning concept provides for a dismantling of the plant in 10 steps eight of which having already been carried out. The 1st licence for the decommissioning of the plant was granted on 26 August 1993. Since 28 May 1994, the plant has been free of nuclear fuel, which was transported to Cadarache (F). The

dismantling of the reactor tank licensed in the ninth dismantling step has concluded. The dismantling of the thermal insulation concluded in May 2011. The next dismantling measure concerns the primary shielding. Works to dismount and clean the primary and secondary cold traps have continued. The works were approved with a modification licence to the 9th decommissioning licence on 12 January 2007.

It is intended to dismantle the remaining buildings conventionally and to recultivate the premises after the plant has been released from regulatory control. The objective is to conclude the work by 2013.

Since July 2009 the Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH, a company of the Energiewerke Nord GmbH, has been responsible for dismantling the KNK II plant.

Karlsruhe Multi-Purpose Research Reactor (MZFR)

The Karlsruhe Multi-Purpose Reactor with a 57 MW_e heavy-water cooled pressure vessel reactor was operated from 1965 to 1984. Apart from electricity production, it also served the heat supply of the Forschungszentrum Karlsruhe on account of the combined heat and power generation. After it had finally shut down, it was decided to dismantle the plant immediately and entirely. The spent fuel elements were reprocessed in the Karlsruhe Reprocessing Plant (WAK). Since then, dismantling has been carried out separately in several steps, each of them requiring nuclear licensing (partial decommissioning licences).

With the 8th decommissioning licence of 31 January 2007 the dismantling of the activated part of the biological shield, the dismantling of all systems and equipment, the decontamination and the dismantling of all building structures were approved. The remote-controlled dismantling of the activated concrete of the biological shield has concluded. Further focal points of dismantling the MZFR are the works on the dismantling and decontamination of the fuel pool building, the collecting tank building and the assembly and storage building.

The dismantling works will probably conclude in 2015.

Since July 2009 the Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH, a company of the Energiewerke Nord GmbH, has been responsible for dismantling the multi-purpose research reactor.

Obrigheim NPP (KWO)

The Obrigheim NPP, a PWR with a capacity of 357 MW_e went critical for the first time on 22 September 1968, and started up its power operation in 1969. After 36 years of operation, the KWO finally shut down on 11 May 2005 due to the expiry of the licence for power operation according to § 7 para. 1a AtG.

Dismantling is to be carried out in altogether three independent licensing steps and will take approximately 10 to 15 years. The nuclear fuel was removed from the core. The fuel elements that had still been in the internal fuel pool were brought into the external wet storage facility in the emergency building. Since March 2007, all fuel elements have been removed from the internal fuel pool. Dry storage in CASTOR® casks is planned and an application for a licence according to § 6 AtG was filed to the BfS on 22 April 2005. The licensing procedure has not yet been concluded (cf. chapter 4.3.2).

The 1st decommissioning and dismantling licence to finally and permanently shut down operation was granted on 28 August 2008. Two steam generators that had already been dismantled in 1983 and had been stored on the premises of the Obrigheim NPP were transported in September/October 2008 by waterway to Lubmin with the objective of being decontaminated and dissected in the Interim Storage Facility North (ZLN). Furthermore the plant's generator was dissected and sold within the scope of the 1st decommissioning licence. The 2nd licence for decommissioning and dismantling was granted on 24 October 2011. Among others, it regulates the dismantling of plant components and allocated auxiliary systems in the control area (such as reactor coolant system and steam generator) and the operating procedures for continuing decommissioning operations. Furthermore, application was filed for the 3rd dismantling licence for the lower part of the reactor pressure vessel (RPV), the RPV installations and single structural components in the reactor building on 29 March 2010. The application is being evaluated.

On 21 April 2010, a modification licence to the 1st decommissioning and dismantling licence was granted for the replacement of the reactor building's material lock in order to optimise residue logistics. The material lock was replaced in 2010.

Gundremmingen NPP Unit A (KRB A)

The Gundremmingen NPP Unit A (BWR) was commissioned in August 1966 with a capacity of 250 MW_e. Characteristic of this plant was a water-steam separating and steam-drying plant in the reactor which was used for the first time in a BWR. After an incident in 1977, the operator decided in 1980 not to repair the plant but to shut it down finally for economic reasons. The last fuel elements were removed from the plant by 1989

and were subsequently reprocessed. The decommissioning licence according to § 7 para. 3 AtG was granted on 26 May 1983 and was followed by the entire dismantling in individual phases on the basis of the existing nuclear licences.

In the year under report the dismantling works continued to be carried out and the conditioning of the liquid old waste originating from the operating time of Unit A is coming to an end.

New technical equipment for a technology centre is almost completed. Focal points are currently the fitting of the ventilation system and fire protection measures. The purpose of technology centre will be the decontamination and waste treatment for the two still running units KRB-II-B and KRB-II-C. The relevant nuclear licence was granted on 5 January 2006.

Greifswald NPP (KGR) Units 1 to 5

The construction of the Greifswald NPP (PWR) traces back to a decision made in 1955 by the government of the former GDR to use nuclear energy for electrical energy production. Of the eight PWR units of the KGR of the Russian WWER type (Reactor W-230 and W-213) with 440 MW_e each, Unit 1 was commissioned in 1973. Units 2 to 4 were commissioned in 1974, 1977 and 1979. Units 1 to 4 shut down on the basis of a safety assessment made by Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) and the Federal Office for Nuclear Safety and Radiation Protection (SAAS) of the former GDR. It was furthermore decided to decommission Unit 5, too, which went critical for the first time in 1989 and whose commissioning was stopped by the SAAS, the regulatory authority at that time. Due to the dual-unit construction, Unit 5 is connected to Unit 6. All six units are to be dismantled without a longer period of prior safe enclosure. Units 6 to 8 were still under construction at that time (cf. Chapter 2.4).

Since 22 May 2006 all nuclear fuel has been removed from the Greifswald NPP.

The first licence according to § 7 para. 3 Atomic Energy Act for the decommissioning of the entire plant and for the dismantling of plant components was granted on 30 June 1995. On the basis of the 35th modification licence granted on 16 August 2007 and the 1st modification licence to the 4th partial licence to the aforementioned decommissioning licence, the reactor pressure vessels of Units 1 and 2 could be transported to the ZLN for interim storage in 2007, and the reactor pressure vessels with reactor shaft and shaft bottom of Units 3 and 4 could be taken there in 2009.

On the basis of the 36th modification licence granted on 7 May 2008 referring to the licence of 30 June 1995 and the 20th licence, the dismantling of plant components in the control and monitored area continued to be dismantled. Already 75% of the plant components of the control areas including special buildings and 95% of the plant components of the monitored areas have been dismantled.

Stade NPP (KKS)

The Stade NPP, a PWR with a capacity of 672 MW_e, was in operation from 1972 to 2003. The plant was finally shut down on 14 November 2003. With letter of 23 July 2001, the operator E.ON filed an application according to § 7 para. 3 AtG for decommissioning and dismantling of the plant. Direct dismantling of the plant was applied for.

At the end of April 2005, the fuel elements were transported to France for reprocessing.

The 1st licence according to § 7 para. 3 AtG for decommissioning and dismantling the KKS was granted on 7 September 2005. It provides for the necessary provisions concerning the treatment, conditioning and storage of the material arising in the process of dismantling (waste and residual materials concept), for release, dismantling phase 1, and for the construction of the storage facility for radioactive waste (LarA). The second licence granted on 15 February 2006 permits the dismantling of large components (steam generator) and the necessary modification of the lock. In September 2007, the dismounted steam generators were shipped to Studsvik Nuclear Dept. Radwaste AB, Sweden, for further treatment.

In the year under report dismantling works were carried out on the basis of the licences already granted. Dismantling of the biological shield was concluded.

The licence 1/2011 for dismantling phase 4 was granted on 4 February 2011. Phase 4 of dismantling consists, among others, of the further dismantling of the plant and all measures required for releasing buildings and soil surfaces. The release of buildings and terrain from regulatory control is regulated in the notice of assessment according to § 29 Radiation Protection Ordinance (StrlSchV) which was granted on 24 June 2010.

Lingen NPP (KWL)

The Lingen plant, a BWR with a capacity of 252 MW_e, was commissioned in 1968. After 9 years of power operation the plant was shut down in January 1977 due to steam-to-steam heat exchangers being damaged, so new ones could be installed. During the major plant revision, further damage became apparent, so that the licensing authority required additional comprehensive improvement measures before approving a new commissioning of the plant. However, costs were so high that the operator decided in March 1979 to decommission the nuclear part and to use the available steam turbine with a natural gas fired high-temperature gas turbine that had still to be installed. On the basis of the licence of 21 November 1985 the plant has been operated in safe enclosure since 1988. Prior to safe enclosure the fuel elements were transported to Sellafield (GB). The safe enclosure is monitored by the adjacent Emsland NPP (KKE).

In December 2007, Kernkraftwerk Lingen GmbH withdrew the application of 21 December 2004 for continuation of safe enclosure. On 15 December 2008, the operator filed an application according to § 7 para. 3 AtG for dismantling the plant. In the first licensing step initially applied for, all non-contaminated and contaminated plant components are to be dismantled. A second licensing step to be applied for later on is to include the dismantling of the reactor pressure vessel with its installations, the biological shield, the residual dismantling, decontamination, and the plant's release from nuclear regulatory control. The application documents are in the licensing procedure.

A meeting on the type and extent of the documents to be submitted (scoping schedule) took place on 22 June 2011 in the scope of the nuclear licensing procedure for the dismantling of the Lingen NPP.

In the year under report waste campaigns and clearance campaigns were carried out.

Jülich Experimental NPP (AVR)

The Jülich Experimental NPP was an experimental reactor exclusively developed in Germany. It was commissioned in 1966 with a 15 MW_e pebble bed high-temperature reactor (HTR) and served the development of this reactor type with ball-shaped graphite fuel elements (in which there were uranium and thorium containing coated particles), the development having started in Germany. It was finally shut down at the end of 1988 when with the decommissioning of the prototype reactor THTR-300 (308 MW_e) in Hamm-Uentrop the further development of this technology was no longer pursued in Germany either. On 9 March 1994 the licence for decommissioning, unloading of the reactor core, dismantling of plant components and safe enclosure was granted. The unloading of the ball-shaped fuel elements into the central interim storage facility at the site of the Jülich Research Centre was completed in June 1998, leaving only maximum 197 pieces. Until the reactor containment has been dismounted it is impossible to recover the remaining ball-shaped fuel elements at reasonable cost and with sufficient radiation protection measures.

The operator has dealt with a concept modification, i.e. direct dismantling instead of safe enclosure. An application for complete dismantling according to § 7 para. 3 AtG was submitted to the responsible federal state authority on 25 February 2005 and revised with letter of 27 April 2006. The respective licence was granted on 31 March 2009. Subject matter of the notification are preparatory works to lift the reactor vessel, the lifting and putting down of the reactor vessel in the material lock and measures following the removal of the reactor vessel. It is intended to take the reactor vessel filled with pore lightweight concrete in November 2008 to an interim storage facility erected at the site. The licence for the operation of the interim storage facility was granted on 1 March 2010.

In the year under report further measures to lift the reactor core were carried out. This includes, among others, the commissioning of sealing system 2 which serves to separate the reactor protection vessel (contaminated area) from the material lock (non-contaminated area) in terms of space and air. The building of the transport route to take the reactor core to the interim storage facility has almost concluded.

Würgassen NPP (KWW)

The Würgassen NPP, a boiling water reactor with a capacity of 670 MW_e, was in operation from 1971 to 1994. Since cracks were found at the core shroud of the reactor during a scheduled major plant revision in 1994, the former operator PreussenElektra decided to finally shut down the plant. Since October 1996, there is no more nuclear fuel in the plant. The fuel elements were delivered to La Hague (F) for reprocessing.

The 1st decommissioning licence was granted on 14 April 1997. Three additional decommissioning licences have been granted for the plant since.

In the year under report dismantling works for the NPP continued on the basis of the decommissioning licences granted. The biological shield has been dismounted. As the last part of the reactor pressure vessel

(RPV) the RPV-calotte is decontaminated and dismounted. Last works on dismounting the pressure suppression system are being carried out. The water treatment equipment no longer required is being dismantled.

Two interim storage facility buildings (UNS building and transport preparation hall) for low-level and intermediate-level radioactive waste remain on the site until the waste will be taken to a repository.

Hamm-Uentrop Gas-cooled High-temperature Pebble Bed Reactor (THTR-300)

The THTR-300 with a helium-cooled pebble-bed high-temperature reactor (308 MW_e) was commissioned in 1983. In September 1989, the final decommissioning of the plant was decided after it had been shut down on 29 September 1988 for the scheduled annual revision. On 13 November 1989, the federal government, the Federal State of Northrhine-Westphalia, the HKG operating company and its partners signed a framework agreement concerning the completion of the THTR-300 project. The first partial licence for the decommissioning, unloading of the reactor core and the dismantling of plant components was granted on 22 October 1993. Since then the ball-shaped fuel elements have been removed from the reactor core and delivered in CASTOR® casks to the Ahaus fuel element interim storage facility (BZA). The reactor core has been unloaded since 1995. On 21 May 1997, the licence for the operation of safe enclosure (maintenance operation) was granted. Since October 1997, the plant has been in safe enclosure which is to cover a period of approximately 30 years.

Mülheim-Kärlich NPP (KMK)

The Mülheim-Kärlich NPP, a PWR with a capacity of 1,302 MW_e was commissioned in March 1986. After the Federal Administrative Court had withdrawn the first partial licence it was shut down on 9 September 1988.

Those applications according to § 7 AtG for granting the first partial licence for the construction and operation of the KMK and of the partial licence (continuous operation) that had not been decided on, were withdrawn by RWE Power AG with letter dated 21 June 2001. The spent fuel elements were taken to La Hague (F) for reprocessing. New fuel elements intended for the reloading of the reactor were given back to the manufacturer in Belgium. The plant has thus been free of nuclear fuel since 29 July 2002.

The KMK is to be dismantled in three independent steps. Step 1 includes the final decommissioning of the plant. In the second step, among others, the reactor coolant system equipment is to be dismantled. Step 3 provides for, among others, the release of the buildings and the premises from nuclear supervision. The demolition of the released buildings is then to take place according to building law provisions.

On 16 July 2004, the licence for dismantling phase 1a was granted. Thus the plant went into residual operation. For further dismantling, several auxiliary systems (among others exhaust air) can be adapted to the new requirements. The modification licence to licence 1a granted on 23 February 2006 permits the dismantling of all facilities shut down during phase 1a in the controlled area, if the proof of proper waste management covers the waste arising in this process. With it all plant components no more required for residual operation can be dismantled. Exceptions to this are the primary coolant circuit, handling devices and the biological shield. With letter of 8 May 2008, RWE Power applied for suspension of the licensing procedure for the on-site interim storage facility and the treatment centre until further notice. On the basis of the first decommissioning licence further dismantling works were carried out in the period under report. The licence for downsizing the plant premises was granted on 9 June 2009. This notification regulates the procedure for the release from regulatory control of buildings and the ground area of the eastern part of the plant premises. The application for reducing in size the plant premises around the western area filed on 27 November 2009 continues to be subject to the licensing procedure. RWE filed an application for dismantling phase 2a on 23 June 2010. Subject matter is, among others, the dismantling of the steam generators, the reactor coolant pumps and the pipes of the reactor coolant loop. The licensing procedure has not yet concluded. The total dismantling of the Mülheim-Kärlich plant will still take a couple of years.

2.4 NUCLEAR POWER PLANTS DECOMMISSIONED AND RELEASED FROM REGULATORY CONTROL

In the Federal Republic of Germany three nuclear power plants have been entirely dismantled and released from regulatory control so far.

Großwelzheim Superheated Steam Reactor (HDR)

As prototype and experimental plant, the Großwelzheim Superheated Steam Reactor with a capacity of 25 MW_e served to develop this reactor design series. It was commissioned in 1969. After only 1.5 years of operation, the plant finally shut down in 1971 because of deformations at the cladding tubes of the novel superheat fuel elements. The spent fuel elements were reprocessed in the WAK. From 1974 to 1991, the reactor building and the installed systems were used for the performance of non-nuclear investigations of nuclear power plant behaviour in case of severe accidents (among others, earthquakes). The decommissioning of the reactor was licensed on 16 February 1983. The plant was entirely dismantled.

In the middle of May 1998 the plant could be released from regulatory control. The residual conventional dismantling work was completed by the middle of October 1998.

Niederaichbach NPP (KKN)

The Niederaichbach NPP is a prototype NPP with a capacity of 106 MW_e. It is characterised by the use of natural uranium and a heavy-water moderated pressure tube reactor with CO_2 gas cooling. By using the pressure tube system thick-walled pressure vessels normally required for LWR reactors should be avoided. The objective was to be able to use reactors of nearly any building size.

The commissioning licence was granted on 11 December 1972. The reactor went critical for the first time on 17 December 1972. Technical problems and the then already established light-water reactor design series contributed to the owner's decision to shut down the reactor finally. The development of this reactor type was thus stopped. With the shut-down on 31 July 1974 it was decided to decommission the KKN. Thus the nuclear power plant was in operation for 18.3 full-load days. The licence for establishing the state of safe enclosure for the plant was granted on 21 October 1975 and the licence for "safe enclosure" on 20 October 1981. The fuel elements were taken to the CEA (Commissariat à l'Energie Atomique et aux Energies Alternatives). The entire dismantling of the plant was licensed on 6 June 1986. On 17 August 1995, the decommissioning of the KKN was completed and the NPP was released from regulatory control. The ground slabs of the reactor building and of the tomb building have remained in the soil as a groundwater lowering would have been necessary for complete removal. The residual ground slabs and underground pipes were removed. The KKN was the first nuclear power plant in the world with a capacity worth mentioning whose decommissioning was completed by handing over the site as "greenfield". Thus it could be demonstrated for the first time in Germany that both the technical implementation of a complete removal and of the associated nuclear licensing procedure are feasible.

Kahl Experimental NPP (VAK)

The Kahl Experimental NPP with a 16 MW_e BWR was the first nuclear power plant for electrical energy production in Germany. It was commissioned in 1960. In 1985, the plant was shut down since all planned scientific and operational tests had been concluded according to statements by the operator. The first partial decommissioning licence was granted with notification of 5 May 1988. The fuel elements were removed from the plant by 1989 and transported to the Karlsruhe Reprocessing Plant (WAK) for reprocessing. Spent MOX fuel elements that could not be reprocessed in the WAK were transported to the Central Storage Facility for Spent Fuel Elements (CLAB) in Sweden for storage and disposal. This was done in exchange of the reprocessing of Swedish uranium fuel elements in France (COGEMA), based on an agreement for the transport of Swedish fuel elements to COGEMA between the utilities, the French enterprise COGEMA (now: AREVA) and Sweden.

The buildings and the plant site were released from regulatory control on 17 May 2010. Subsequent dismantling activities in the scope of conventional dismantling concluded on 24 September 2010. The competent authority has not yet decided as to the duties continuing in force, even after the plant has been released from regulatory control.

2.5 STOPPED NUCLEAR POWER PLANT PROJECTS

Greifswald NPP (KGR) Units 6 to 8

In the Greifswald NPP construction and assembly works at Units 6 to 8 (440-MWe PWR of the Russian WWER type, reactor W-213) were stopped in 1990. Dismantling of the already constructed facilities has already made great progress.

Unit 6 is used as technical exhibition to demonstrate reactor technology at visiting tours. The engine house of Units 5 to 8 was entirely cleared and it is planned to use it industrially afterwards (cf. chapter 2.3). Non-contaminated equipment of Units 7 and 8 was transported to Unit 5 where it was dissected. With it tools and equipment for the remote-controlled dissecting of reactor components were tested. The tested tools and equipment are used for the dismantling of all reactor pressure vessels in Units 1 to 4.

Kalkar Sodium-cooled Fast Breeder Reactor (SNR 300)

The SNR 300 with a 327 MW_e sodium-cooled fast-breeder reactor was constructed and almost completed between 1973 and 1991, and commissioning was prepared. Before the already fabricated fuel elements were loaded, it was decided in 1991 not to commission the plant. The erected systems were then dismantled, scrapped or sold. On 1 April 1996, the ownership of the site was transferred to Kern-Wasser-Wunderland Freizeitpark GmbH and the site has been used commercially since. The fuel elements were at first kept in government custody by BfS and were later delivered to France for reprocessing (cf. Chapter 4.4.2).

Stendal NPP

In 1974, the Stendal construction site was opened with the objective of erecting four 440-MW_e units of the Russian WWER type. In 1976, it was decided to construct Units A and B (PWR with 1,000 MW_e each) in the Stendal NPP. Construction and installation work which had started in 1976 was finally stopped in 1990 after several years of delay. Part of the buildings and of the equipment was dismantled or has been used otherwise.

3. RESEARCH REACTORS WITH A CONTINUOUS THERMAL POWER ABOVE 50 KW_{TH}

In Germany altogether 17 research reactors with a continuous thermal power above 50 kW_{th} have to be considered of which currently there are (as at 31 December 2011)

3 Research reactors in operation

4 Research reactors finally shut down

4 Research reactors under decommissioning and

6 Research reactors entirely dismantled and released from regulatory control.

The operational and licensing status of these research reactors is described in Chapters 3.1, 3.2, 3.3 and 3.4 and in the relevant Tables II.1, II.2 and II.3 and II.4 in Annex II – Research Reactors. A survey of still existing sites is given in Figure II.

3.1 RESEARCH REACTORS IN OPERATION

In the Federal Republic of Germany, three research reactors with a continuous thermal power above 50 kW_{th} were still in operation in 2011.

Berlin Experimental Reactor Unit II (BER II)

The BER II is a pool reactor with fuel elements of the MTR type. The thermal power is 10 MW_{th} and the thermal neutron flux is $1.5 \cdot 10^{14}$ $1/cm^2 \cdot s$. The reactor was commissioned on 9 December 1973 and mainly serves pure and applied basic research with beam pipe experiments and the generation of radioactive isotopes.

From 1985 to 1989, the plant was comprehensively expanded, doubling the thermal power from originally 5 MW_{th} to 10 MW_{th} and increasing the thermal neutron flux to $1.5 \cdot 10^{14}$ $1/cm^2 \cdot s$, which is nearly the ten-fold. To reduce the proliferation risk, the operation of the BER II with fuel elements of low-enriched uranium (LEU) and, respectively, mixed loadings with fuel elements of high-enriched uranium (HEU) and LEU was licensed on 14 June 1994. Following a number of mixed loadings a pure LEU core was built up for the first time and commissioned on 7 February 2000.

Because of rebuilding measures the BER II was shut down on 3 October 2010 and was not operated in the year under report 2011. The rebuilding measures comprise, among others, the replacement of the “conical beam tube” and the moderator barrel cell of the cold neutron source inside as well as changes to the power supply system.

Munich High-flux Neutron Source in Garching Unit II (FRM-II)

The FRM-II is the newest commissioned research reactor in Germany, a light-water cooled pool reactor with a compact core where high-enriched uranium (HEU) is used as fuel and heavy water as moderator. With a thermal neutron flux of $8 \cdot 10^{14}$ $1/cm^2 \cdot s$ the plant – having a comparatively low thermal power of 20 MW_{th} – is the most intensive German neutron source for beam pipe experiments and irradiations for scientific, industrial and medical purposes.

The first two partial licences (PL) for the construction of the plant were granted on 4 April 1996 and on 9 October 1997 by the former Bavarian State Ministry for Regional Development and Environmental Questions (today: BStMLU, Bavarian State Ministry of the Environment and Public Health) as the competent licensing authority. Nuclear commissioning and the operation of the plant are components of the operation licence (3rd partial licence) granted on 2 May 2003.

The reactor went critical for the first time on 2 March 2004. Following a comprehensive programme to commission the plant and after the regulatory authority had given its approval, routine operation of the plant was taken up on 25 April 2005.

On the basis of the operating licence of 2 May 2003 and an agreement between federal government and the Free State of Bavaria of 30 May 2003, it was originally intended to convert the reactor core from HEU to fuel

with a reduced enrichment level of 50 % uranium 235 (MEU) at maximum by 31 December 2010. However, due to unexpected delays in the international technical-scientific development of new, high-density fuels, this requirement could not be complied with. The original agreement between the federal government and Bavaria of 30 May 2003 was amended on 22 October 2010. Now the plant needs to be converted by 31 December 2018 at the latest.

Between 22 October 2010 and 29 November 2011 the FRM II was in a scheduled extended maintenance phase after conclusion of the 25th fuel element cycle. During that phase, among others, a so-called shuttle tube in the moderator tank was extended. It is planned to install an irradiation device for the production of the radioisotope molybdenum 99 in this expanded shuttle tube later on. Further rebuilding measures and the operation of the irradiation source require carrying out a nuclear licensing procedure.

TRIGA Mark II Research Reactgor of the Mainz University (FRMZ)

The Research Reactor of the Mainz University is an open pool reactor of the TRIGA Mark II type. It is a light-water cooled and moderated reactor with homogeneous fuel moderator elements of LEU and zirconium hydride. Nuclear commissioning was on 3 August 1965. In continuous operation the thermal power is 100 kW_{th} and the thermal neutron flux is $4 \cdot 10^{12}$ 1/cm^2·s. Additionally, the reactor can be operated in pulsed operation above 30 ms with a power peak of 250 MW_{th} and a thermal neutron flux of $8 \cdot 10^{15}$ 1/cm^2·s. The plant is operated for basic research in nuclear physics and is especially suitable for examining short-lived radionuclides with rabbit systems because of the high neutron flux density which can be managed in pulsed operation for short periods of time.

On the basis of a licence of 28 July 1992, a comprehensive modification of the reactor systems was carried out.

In 2011 an ultra-cold neutron source was installed in the FRMZ and put to the test in trial operation.

3.2 RESEARCH REACTORS FINALLY SHUT DOWN

With status as of 31 December 2011, four research reactors with a thermal power above 50 kW_{th} have been included under the heading “Finally shut down”. No decommissioning licence has been granted so far for these reactors.

Research Reactor Munich (FRM)

The FRM was a pool reactor of the American type with a thermal power of 4 MW_{th} and a thermal neutron flux of $7 \cdot 10^{13}$ 1/cm^2·s. The plant was commissioned on 31 October 1957 as the first reactor in Germany. The purpose of the reactor was to provide neutrons for beam pipe experiments and irradiations, such as the generation of radioisotopes, the proof of trace elements and tumour therapy.

In 1957, the plant was commissioned with LEU and a thermal power of 1 MW_{th}. However, already in 1960 it was changed over to using HEU. In the years of operation the thermal neutron flux was gradually increased from originally $1 \cdot 10^{13}$ 1/cm^2·s to $7 \cdot 10^{13}$ 1/cm^2·s by increasing the thermal power to 2.5 MW_{th} in 1966 and to 4 MW_{th} in 1968 (operation licences of 28 October 1966 and 10 May 1968); additionally, a beryllium reflector was installed in 1982. Since 1991, the core has been operated as mixed core and gradually changed over from HEU to MEU.

On 14 December 1998, the Technische Universität München (TUM) applied for the plant’s decommissioning in order to use it later on – following another procedural step – as supporting system to the new Munich High-flux Neutron source in Garching (FRM-II, cf. Chapter 3.1). On 28 July 2000 the reactor was finally shut down, on 3 June 2002 the still existing 47 fuel elements were delivered to the USA. After the FRM-II has meanwhile taken up routine operation, the TUM submitted further documents relating to its application for being granted a decommissioning licence for the FRM, which are currently being examined by the competent licensing authority.

On 22 September 2010 the monument protection service approved of the intended dismantling of the installations in the reactor building. The listed historic features are protected correspondingly.

Research Reactor Jülich (FRJ-2)

The FRJ-2 (DIDO, derived from D_2O) was a heavy-water cooled and moderated closed tank reactor of the English type. It was operated with HEU. The reactor with a thermal power of 23 MW_{th} and a thermal neutron

flux of $2 \cdot 10^{14}$ 1/cm^2·s was used for beam pipe experiments and irradiations for isotope production and neutron activation analysis.

Nuclear commissioning of the plant was on 2 November 1962. In 1967, a first capacity increase from 10 MW_{th} to 15 MW_{th} (licence of 11 December 1967) was carried out by utilising available reserves, in 1972 a second capacity increase was carried out to 23 MW_{th} by taking uprating and improvement measures (licence of 15 March 1972). Between November 1990 and April 1995, the reactor was taken out of operation to repair damage and to carry out backfitting measures. The regulatory authority approved of the plant's re-commissioning in February 1995.

On 2 May 2006, the FRJ-2 was finally shut down. It is currently in the post-operational phase. In the scope of the operation licence the spent fuel elements were transported to the USA in 2008 for disposal. An application for decommissioning and dismantling the reactor facility was filed on 27 April 2007. On 15 December 2008 a revised application was filed. The licensing procedure has made good progress.

To continue scientific work the Forschungszentrum Jülich (FZJ) installed an outstation at the new FRM-II research reactor (cf. Chapter 3.1).

Research Reactor Geesthacht Unit 1 (FRG-1)

The FRG-1 is an open pool reactor of the MTR type with a thermal power of 5 MW_{th} and a maximum thermal neutron flux of $1.4 \cdot 10^{14}$ 1/cm^2·s. It was commissioned with HEU on 23 October 1958 and was mainly used for material research with beam pipe experiments and isotope production and for carrying out neutron activation analyses.

From 1963, the FRG-1 was operated with the new FRG-2 reactor in a joint reactor hall but with different pools. Due to a subsequent joint operation licence of 6 September 1967, both reactors must be regarded as one reactor facility under licensing aspects. This also applies after the licence for taking the reactor out of operation and partial decommissioning of the FRG-2 was granted on 17 January 1995 (cf. section FRG-2).

During the more than 40 years of operation the FRG-1 was continuously upgraded. In February 1991 a modification from HEU to LEU was carried out for the first time at a German research reactor on the basis of a modification licence dated 4 May 1988. Apart form reducing the proliferation risk, it was possible to increase the thermal neutron flux by using fuels of significantly higher density. With licence of 8 March 2000, the nuclear fuel was further densified and a 3x4 compact core with twelve fuel elements was set up.

The FRG-1 was finally shut down on 28 June 2010. In the scope of the operating licence continuing to be effective, the plant is now in the post-operational phase. The operator intends to decommission the plant according to § 7 para. 3 Atomic Energy Act and is currently developing a corresponding application to be submitted to the responsible licensing authority. In the scope of the effective operating licence, 45 MTR fuel elements were transported to the USA on 10 August 2010. The last 25 fuel elements remaining in the plant are to be disposed of in the USA at the end of 2012.

The plant operator, Forschungszentrum Geesthacht GmbH (GKSS), renamed itself to Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research on 1 November 2010. Material research with neutron radiation continues at the FRM-II in Garching in the scope of the newly founded "German Engineering Materials Science Centre".

Research Reactor Geesthacht Unit 2 (FRG-2)

Just as the FRG-1, the FRG-2 was an open pool reactor of the MTR type; the thermal power was 15 MW_{th} and the maximum thermal neutron flux was $1.5 \cdot 10^{14}$ 1/cm^2·s. It was commissioned on 16 March 1963 as material test reactor and used for the further development of nuclear power plant components and reactor safety.

The FRG-2 was operated with the FRG-1 reactor in a joint reactor hall but different pools. Since a new joint operation licence dated 6 September 1967 came into effect, both reactors must be regarded as one reactor facility under licensing aspects.

With the aforementioned notification of 6 September 1967, another licence was granted for the increase of the FRG-2's thermal power from 5 MW_{th} to 15 MW_{th}. During its thirty years of operation, the reactor was continuously operated with HEU; the application of the operator Gesellschaft für Kernenergieverwertung in Schiffbau und Schifffahrt mbH (GKSS, today Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research) of 25 September 1986 for the conversion of the facility from HEU operation to LEU operation was not approved by the licensing authority.

Since orders for material testing through irradiation had decreased, GKSS, in consultation with BMFT (Federal Ministry of Research and Technology) and the industry, filed an application on 28 January 1993 for taking the FRG-2 out of operation and partially dismantling the reactor. The licence was granted on 17 January 1995. The FRG-2 and the FRG-1 representing a joint reactor facility under the licensing aspect on the basis of the operation licence of 6 September 1967. The provisions of § 7 para. 3 Atomic Energy Act do not provide for a decommissioning of plant components. Thus, the shut-down and partial dismantling of the FRG-2 must legally be considered as a modification of the operation of the entire facility according to § 7 para. 1 Atomic Energy Act. The fuel elements were at first stored intermediately in the joint fuel pool and were disposed of in the USA by 20 September 2000. The formal decommissioning and final dismantling of the FRG-2 will later on be carried out along with the dismantling of the FRG-1 which was shut down in 2010 in the scope of decommissioning the entire facility according to § 7 para. 3 Atomic Energy Act.

3.3 RESEARCH REACTORS UNDER DECOMMISSIONING

At the end of 2011, four research reactors with a continuous thermal power above 50 kW_{th} were being decommissioned in the Federal Republic of Germany.

Karlsruhe Research Reactor Unit 2 (FR 2)

The FR 2 was a closed tank reactor operated with low-enriched uranium (2 %) and moderated and cooled by heavy water. It was the first nuclear reactor facility which was developed and built according to a German concept. With 44 MW_{th} it was the German research reactor with the highest performance with respect to thermal power. With a thermal neutron flux of $1.0 \cdot 10^{14}$ $1/cm^2 \cdot s$ the FR 2 was used as neutron source for beam pipe experiments for basic research and for irradiation tests in fuel rod development and for isotope production for medical purposes.

Nuclear commissioning of the reactor with natural uranium was on 7 March 1961. To increase the original thermal neutron flux of $3.9 \cdot 10^{13}$ $1/cm^2 \cdot s$ to $1 \cdot 10^{14}$ $1/cm^2 \cdot s$, the facility was retrofitted in 1966 to be operated with fuel elements with low-enriched uranium (2 %). The maximum thermal power of the reactor was thus increased form 12 MW_{th} to 44 MW_{th} (licence of 26 January 1966).

After 2 years of operation, the plant was finally shut down on 21 December 1981 for economic reasons. By 22 October 1982, the fuel elements were delivered to WAK for reprocessing. The first of several partial licences for decommissioning, partial decommissioning, and safe enclosure for at least thirty years was granted on 3 July 1986. Since 20 November 1996, the reactor block which has remained from the facility has been in safe enclosure. Since 1997, the reactor hall has been used for a permanent exhibition about the history of nuclear engineering.

Following safe enclosure, it is intended to dismantle the plant to finally remove the reactor block. Since July 2009 the Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH, a company of the Energiewerke Nord GmbH, has been responsible for this task. A rough dismantling concept was submitted to the competent authority at the end of 2010. An application for dismantling has not been filed so far.

Research Reactor Neuherberg (FRN)

The FRN was a pool reactor of the TRIGA Mark III type with homogeneous fuel moderator elements of LEU and zirconium hydride. The thermal power was 1 MW_{th} and the thermal neutron flux was $3 \cdot 10^{13}$ $1/cm^2 \cdot s$. In pulsed operation the reactor could be operated for short periods of time above 10 ms with power peaks of up to 2,000 MW_{th}. The facility was commissioned on 23 August 1972 and was used for isotope production and beam-pipe experiments in medico-biological research.

On 16 December 1982, the reactor was finally shut down. In the scope of the operation licence the fuel elements were removed and disposed of in the USA. The decommissioning licence of 30 May 1983 comprised the decommissioning of the facility and the dismantling of plant components as well as effecting safe enclosure of the shielding block with the former reactor pool. With a separate licence notice dated 24 May 1984 it was permitted that the facility will continue to be in the state of safe enclosure.

Research and Measuring Reactor Braunschweig (FMRB)

The FMRB was a light-water cooled and moderated pool reactor with two separate fission product zones of HEU which were neutron-physically coupled via a 400-l heavy-water tank. The reactor went critical for the first time on 3 October 1967. The thermal power was 1 MW_{th}, the thermal neutron flux was $6 \cdot 10^{12}$ $1/cm^2 \cdot s$. The Federal Institute of Physics and Metrology (PTB) used the facility as neutron source for irradiations and beam

pipe experiments, in particular in the area of neutron metrology and dosimetry and of condensed matter physics.

The reactor was taken out of operation for economic reasons on 19 December 1995. On 28 August 1996, the residual fuel elements were delivered to the USA for disposal. On 2 March 2001, the decommissioning licence for the plant was granted. Dismantling of the facility was completed in the middle of 2004. The radioactive waste and residues accrued during the operation and dismantling of the facility were conditioned and, by May 2005, delivered to the interim storage facility that was erected in rooms of the FMRB for this particular purpose and which continues to be subject to nuclear supervision. The reactor building and other building areas and ground surfaces were gradually released from regulatory control by 28 July 2005 and can now be used by the PTB without restrictions for other purposes.

Research Reactor Rossendorf (RFR)

The RFR was a light-water moderated and cooled tank reactor of the Russian WWR-S(M) type. The thermal power was at last 10 MW_{th} and the thermal neutron flux was $1.2 \cdot 10^{14}$ $1/cm^2 \cdot s$. Basically, the facility served as neutron source for isotope production, activation analyses, material research, and additionally for training purposes in the GDR nuclear energy programme.

On 16 December 1957, the reactor was commissioned with LEU and a thermal power of 2 MW_{th}, which was gradually increased to 10 MW_{th} until 1967, among others by a conversion from LEU operation to MEU operation. From 1987 to 1989, the RFR was extensively reconstructed, e. g. by replacing the reactor vessel, improving the emergency cooling and the cooling circuits.

The operation of the reactor was approved with temporary licences; the last licence was renewed on 8 October 1990 until 30 June 1991, by the then competent nuclear authority GEL (common institute of the federal states of Brandenburg, Mecklenburg-Western Pommerania, Saxony, Saxony-Anhalt and Thuringia). The application of the operator of 5 March 1991 for a permanent operating licence was dismissed. The reactor was finally shut down on 27 June 1991. After it had taken over competency as new nuclear authority, the Saxon State Ministry for the Environment and Agriculture (SMUL) gave supervisory order to discontinue the facility's operation which was geared to nuclear fission on 28 June 1991 according to § 19 para. 3 Atomic Energy Act.

From 30 January 1998, several partial licences for the decommissioning of the plant were granted. With the concluding 4^{th} partial licence of 1 February 2005, the dismantling of the residual facility was granted.

Dismantling has made good progress and is to conclude until 2012.

Between 30 May 2005 and 13 June 2005, the spent fuel elements were transported in altogether 18 CASTOR® casks to the Ahaus Transport Cask Storage Facility. The declared aim was to store the fuel elements intermediately until they will be disposed of directly. The plan to take the spent fuel elements to the Russian Mayak reprocessing plant was not approved by the federal government.

Already on 18 December 2006, approximately 300 kg of unirradiated nuclear fuel of LEU and MEU were transported to Russia which had been the country of origin. This was done in the scope of a return programme agreed between the USA, Russia and IAEA (RRRFR – Russian Research Reactor Fuel Return).

Dismounting the deaerator in the reactor hall concluded. The core of the basement is currently being cleared.

3.4 NUCLEAR POWER PLANTS DECOMMISSIONED AND RELEASED FROM REGULATORY CONTROL

In the Federal Republic of Germany, the decommissioning of six research reactors with a continuous thermal power above 50 kW_{th} has been terminated so far. They have been released from regulatory control.

TRIGA HD II Research Reactor Heidelberg (TRIGA HD I)

The TRIGA HD I was a pool reactor of the TRIGA Mark I type with homogeneous fuel moderator elements of LEU and zirconium hydride. The thermal power of the reactor was 250 kW_{th}, the thermal neutron flux was $1 \cdot 10^{13}$ $1/cm^2 \cdot s$. The facility was commissioned on 26 August 1966 as irradiation source for nuclear-medical applications.

As a second research reactor (TRIGA HD II, see below) was built in the German Cancer Research Center in Heidelberg (DKFZ), the reactor was finally shut down on 31 March 1977. The fuel elements were transported to the new reactor facility for further use. The licence for decommissioning the facility was granted on 30 June 1980 and comprised the dismantling of the components and the safe enclosure of the reactor tank and the biological shield, which was effected on 11 December 1980. Since it is now intended to dismantle the building, the DKFZ filed an application for dismantling of the residual facility on 25 April 2003, which was approved on 16 January 2006. The dismantling of the facility and the clearance of the building structure were carried out in the first half of 2006. The facility was released from regulatory control on 13 December 2006. The facility was conventionally dismantled in 2009 in the scope of the clearance procedure and the premises were completely rehabilitated.

TRIGA HD II Research Reactor Heidelberg (TRIGA HD II)

Just as the TRIGA HD I (see above) the TRIGA HD II was a pool reactor of the TRIGA Mark I type with homogeneous fuel moderator elements of LEU and zirconium hydride. The thermal power of the reactor was also 250 kW_{th}, the thermal neutron flux was $1 \cdot 10^{13}$ $1/cm^2 \cdot s$. The reactor went critical for the first time on 28 February 1978; it was used for neutron activation analyses and for the production of short-lived radionuclides for medical purposes in cancer research.

Since isotope production had been taken over by an accelerator of the DKFZ and it had to be expected that there was no longer a need for the reactor to be working full capacity, the facility was shut down on 30 November 1999. On 1 June 2001, the fuel elements were delivered to the USA for disposal. A licence according to § 7 para. 3 Atomic Energy Act for the decommissioning and entire dismantling of the research reactor was granted on 13 September 2004. The facility was entirely dismantled in 2005 and released from regulatory control on 13 December 2006.

Research Reactor Frankfurt Unit 2 (FRF 2)

The FRF 2 was a light-water cooled and moderated reactor of the modified TRIGA type with homogeneous fuel moderator elements of LEU and zirconium hydride. The reactor was installed in the remaining buildings (reactor hall and reactor block) of the dismantled predecessor reactor FRF 1 on the basis of the construction licence of 10 January 1973. The FRF 1 was operated from 10 January 1958 to 19 March 1968 as a homogeneous fuel solution reactor of the L54 type with a thermal power of 50 kW_{th}. It was intended to use the new FRF 2 as neutron source for basic research in nuclear physics as well as in solid-state physics and for activation analyses and isotope production. The designed thermal power was 1 MW_{th} and the designed thermal neutron flux was $3 \cdot 10^{13}$ $1/cm^2 \cdot s$. According to a decision of the Hessian Ministry of Culture of 11 July 1980, an operation licence was not granted and one abstained from the nuclear commissioning of the reactor which was ready for use.

On 25 October 1982, the licence for the decommissioning of the FRF 2 and for the dismantling of plant components was granted. Those reactor fuel elements that had not been used were delivered to a foreign research reactor facility (TRIGA MARK II in Ljubljana) in 1981. The residual activity in the facility resulted exclusively from the former operation of the FRF 1 and, after parts of the facility had been dismantled, was in a state of safe enclosure. After the reactor building had meanwhile been used as interim storage facility for low-level radioactive waste produced by the Frankfurt University, the dismantling of the residual structures of the FRF – consisting of FRF 1 and FRF 2 – was licensed on 28 December 2004. On 31 October 2006, the facility was released from regulatory control after the activated concrete structures had been dismantled and the remaining building structures and the facility site had been cleared.

Research Reactor of the Hannover Medical School (FRH)

The FRH was a pool reactor of the TRIGA Mark I type with homogeneous fuel moderator elements of LEU and zirconium hydride. The thermal power of the reactor was 250 kW_{th}, the thermal neutron flux was $8.5 \cdot 10^{12}$ $1/cm^2 \cdot s$. Nuclear commissioning of the reactor with natural uranium was on 31 January 1973. The use as neutron source mainly included neutron activation analysis and the production and activation of short-lived radionuclides for medico-biological applications.

Due to changed production processes for radiopharmaceuticals and a decreasing demand for using the reactor, it was finally shut down on 18 December 1996. The fuel elements were delivered to the USA for disposal on 9 July 1999. On 22 February 2002, an application for the decommissioning and dismantling of plant components was filed and approved on 8 May 2006. The dismantling of the facility and the clearance measurements were completed by August 2007. The regulatory supervision of the facility as specified in § 19 Atomic Energy Act was terminated on 13 March 2008.

Research Reactor Jülich 1 (FRJ-1)

The FRJ-1 (MERLIN, Medium Energy Research Light Water Moderated Industrial Nuclear Reactor) was a pool reactor of the English type operated with HEU with fuel elements of the MTR type. The thermal power was at last 10 MW_{th} and the thermal neutron flux was $1.1 \cdot 10^{14}$ $1/cm^2 \cdot s$. The reactor was commissioned on 23 February 1962 and was used for irradiations and beam pipe experiments.

In 1971, the plant was comprehensively converted for an increase in neutron flux from $6 \cdot 10^{13}$ $1/cm^2 \cdot s$ to the last available level of $1.1 \cdot 10^{14}$ $1/cm^2 \cdot s$. Among others, this concerned the use of new fuel elements with higher U-235 mass and modifications in the primary and secondary cycle for removal of the thermal power that had been doubled from 5 MW_{th} to 10 MW_{th} (licences of 3 June 1971 and 15 September 1971).

On 22 March 1985, the FRJ-1 was shut down. As a requirement of the operation licence, the fuel elements were removed from the facility and transported to the USA and Great Britain by October 1992. The licence for the decommissioning of the plant was granted on 8 June 1995. Dismantling of the plant was carried out gradually on the basis of further partial licences and supplementary notices. At last, the decontamination of the reactor hall and reactor hall fittings and the establishment of the prerequisites for clearance and release from regulatory control were approved with licence of 29 November 2004. These works were completed in 2007 and the plant was released from regulatory control on 23 November 2007. The reactor hall and reactor hall fittings were then dismantled conventionally, so that in the course of 2008 the state of “greenfield” could be achieved.

Nuclear Ship "Otto Hahn" (OH)

The nuclear ship „Otto Hahn“, the only nuclear ship operated in Germany, was formally classified as research reactor. An “Advanced Water Reactor” with low-enriched uranium dioxide with a maximum enrichment of 5.42 w/o of U-235 and a thermal power of 38 MW_{th} was used as drive source.

The principal task of the “Otto Hahn” was to gain operational experience for nuclear-powered ships for civil use. The “Otto Hahn” was commissioned as nuclear ship on 11 October 1968, and was taken out of operation ten years later on 22 March 1979. On 1 December 1980, a licence was granted for the decommissioning of the "Otto Hahn” according to § 7 Atomic Energy Act in connection with §§ 3 and 4 of the Radiation Protection Ordinance (old version). After the reactor had been dismounted, the ship was decontaminated and cleared and was released from regulatory control on 1 September 1982.

The reactor pressure vessel as a whole was taken to the operator, Gesellschaft für Kernenergieverwertung in Schiffbau und Schifffahrt mbH (GKSS, today Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research) in Geesthacht where it has been stored in a drop shaft since on the basis of a licence according to § 3 Radiation Protection Ordinance (old version) granted on 30 April 1981.

By autumn of 1979, the fuel elements were delivered to the WAK for reprocessing, except for 49 spent and three fresh fuel elements. 52 fuel elements had initially remained with the former operator of the ship and were taken to the French CEA research centre (Commissariat à l’Energie Atomique et aux Energie Alternatives) in Cadarache in July 2010. From there they were taken to the Interim Storage Facility North in the scope of a consolidated transport, along with approximately 2,500 fuel elements from the Karlsruhe Research Center (cf. Chapter 4.3.3).

4. PLANTS OF NUCLEAR FUEL SUPPLY AND WASTE MANAGEMENT

Annex III includes essential data and information on nuclear fuel supply and waste management in the form of tables, figures and enclosures. Figure III.1 shows a survey map of the nuclear fuel supply and waste management sites.

4.1 URANIUM ENRICHMENT PLANTS

Gronau Uranium Enrichment Plant (UAG)

In the Gronau uranium enrichment plant (cf. Table III.1), natural uranium in the form of uranium hexafluoride (UF_6) is enriched in centrifuge cascades to the point of a maximum concentration of the fissile U-235 isotope of 6 per cent by weight (w/o).

The plant was commissioned in the middle of August 1985 with 400 Mg of uranium separative work per year (SW/a).
An application for extending the production capacity to 4,500 Mg SW/a was filed in September 1998. The relevant licence was granted on 14 February 2005. It includes the construction and operation of a second uranium separating plant with a separation capacity of up to 2,700 Mg SW/a with a maximum enrichment of 6 w/o. The licence also includes the storage of 58,962 Mg of depleted uranium (tails) in oxidic form and 38,100 Mg as UF_6, of 10,000 Mg of natural uranium (feed) as UF_6 and 1,250 Mg of enriched uranium (product) with a maximum enrichment of 6 w/o U-235 as UF_6. The expanded plant has been under construction since the middle of 2008 and is commissioned gradually. Production capacity amounted to 4,200 Mg SW/a at the end of 2011.

The operator of the Urenco plant says that they terminated re-enrichment in Russia in 2009. The uranium hexafluoride produced in future would be converted into the triuranium octoxide (U_3O_8) – which is chemically more stable – by the French AREVA company (formerly COGEMA) in Pierrelatte, and subsequently be stored on the company premises in Gronau.

The construction of a storage hall for 50,000 Mg U_3O_8 was launched in 2011.

4.2 FUEL ELEMENT FABRICATION PLANTS

In the Federal Republic of Germany, the following fuel element fabrication plants have been in operation, decommissioned, dismantled or released from regulatory control (cf. Tables III.2; III.3):

ANF Fuel Element Fabrication Plant, Lingen

Uranium fuel elements with a maximum fraction of 5 per cent by weight (w/o) U-235 are produced in the ANF Fuel Element Fabrication Plant for major use in light-water reactors. Uranium dioxide (UO_2) powder, uranium hexafluoride (UF_6) or externally fabricated uranium dioxide pellets are used as raw material.

Fuel element fabrication started in January 1979 with externally produced uranium pellets. In March 1987, the production of up to 400 Mg of UO_2 pellets annually was licensed with the 5th partial operation licence (start of production in 1988). The operation of dry conversion with up to 5 w/o U-235 of enriched uranium was taken up in June 1994 (7^{th} partial operating licence). In June 1996, a second fuel rod production line and a building for the storage and handling of UO_2 pellets and powder were licensed. The licence for the processing of additional 250 Mg/a of externally produced uranium pellets to fuel elements was granted in March 1997. In March 2002, an increase of the annual uranium powder processing from 400 Mg to 500 Mg and in January 2005 to 650 Mg of uranium was licensed.

A licence according to § 7 Atomic Energy Act for increasing the capacity of the conversion facility to 800 Mg/a of uranium was granted on 2 December 2009. At the same time an increase of storage capacity for UF_6 to 275 Mg was approved. A hall for the storage of UF_6 containers for which a licence according to § 7 Atomic Energy Act had been granted has been taken into operation.

Siemens Fuel Element Fabrication Plant Hanau, Plant Section MOX-Processing

Since 1968 the facility served to produce mixed oxide (MOX) fuel elements on the basis of uranium dioxide/plutonium dioxide (UO_2/PuO_2), plutonium dioxide (PuO_2) or uranium dioxide (UO_2) fuel, mainly for light-water reactors.

Due to a decree issued by the Hessian Environmental Ministry according to § 19 Atomic Energy Act, the plant stopped operation in summer 1991 after an incident involving contamination had occurred. In April 1994, the operator decided not to re-commission the old plant but to run a clean-out programme.

On 7 May 1996, Siemens AG filed an application for a licence to clean up the MOX facility. The project was discussed in a hearing in October 1996. In September and November 1997 and on 28 January 1998, partial licences were granted to process the nuclear fuels in the MOX facility in such a way that they were storable and transportable.

The licensing procedure for the dismantling of the Siemens MOX facility was discussed in a hearing in March 2000 in Hanau, the dismounting of the first production facilities was licensed in December 2007. The first partial licence for the dismantling of the cleaned out facilities was granted in May 2001, the second partial licence in March 2003 and the third partial licence on 3 January 2005. It provided for some buildings and parts

of the open-air ground being already used conventionally. The fourth and concluding partial licence was granted on 16 March 2005.

In December 2005, the residual nuclear fuel was removed from the areas in the fission product storage facility used by the Federal Office for Radiation Protection for the execution of government custody according to § 5 Atomic Energy Act.

Dismantling work concluded in July 2006 and the MOX processing plant section was released from regulatory control in September 2006.

The dismantling of the non-contaminated new facility which had to be carried out separately was licensed on 7 December 1998. The building designed against air crashes was emptied and is available for other use.

There are thus no restrictions to using the facility premises for conventional new purposes.

Siemens Fuel Element Fabrication Plant Hanau, Plant Section Uranium Processing

Since 1969, the plant served to produce uranium fuel elements with a maximum fraction of 5 per cent by weight (w/o) of U-235 for major use in light-water reactors. UF_6 was used as raw material.

Due to unfavourable overall boundary conditions at the Siemens site the production of uranium fuel elements was discontinued in October 1995. To prepare decommissioning, several individual licences for the dismantling of plant components and for the removal of nuclear fuel were granted from 1996 to 1998. From 1999 to March 2001, three partial licences and several individual licences for subsequent decommissioning were granted.

The finally approved decommissioning procedure included the dismantling of the production buildings and the remediation of the premises on the basis of the 10 µSv concept. (This means that it is justifiable to release the materials, the objects or the facility from radiation protection supervision if the release leads to radiation exposures that are in the order of 10 µSv per calendar year for individuals.) After the controlled areas had been closed and the buildings dismantled one started remediating the premises. Since uranium had entered the soil and the groundwater as a result of the facility operation, it had also become necessary to remediate the soil, the existing sewers and the groundwater. After remediation work could be successfully concluded in January 2006, the facility was released from regulatory control in May 2006. Merely a groundwater remediation which had become necessary for chemico-toxic reasons and which is in the responsibility of the competent authority under water right is still continuing. The operation of the groundwater treatment plant was licensed according to § 7 StrlSchV.

Siemens Fuel Element Fabrication Plant, Plant Section Karlstein

Since 1966, the plant served to produce fuel elements made of uranium oxide with a fraction of maximum 4 per cent by weight (w/o) of uranium 235.

In the scope of the decommissioning decision for the Siemens plant sections in Hanau the comparatively small plant in Karlstein was closed, too. The removal of all radioactive operational equipment was concluded. The Siemens Fuel Element Fabrication Plant, Plant Section Karlstein, was released from regulatory control in March 1999. The released buildings have been used for the conventional fabrication of structural parts for fuel elements.

NUKEM Fuel Element Fabrication Plant, Hanau

Since 1962, the NUKEM company produced fuel elements for research and material test reactors; the fuel elements were made of uranium and thorium up to an enrichment degree of 94 per cent by weight (w/o) for uranium 235.

A first licence for the dismantling of components in the area of the fuel element fabrication was granted on 5 December 1988. On 23 December 1988 NUKEM filed an application for the decommissioning of the entire NUKEM industrial premise. The licence for decommissioning was granted on 10 March 1993. Further licences were granted for the dismantling of the non-safety relevant plant components.

The dismantling of the stationary production facility, the soil remediation or decontamination and remediation of buildings which are to be used otherwise, was discussed in a hearing in November 1997. The licence for the dismantling of the building and the remediation of the premises was granted on 19 October 2000.

It had turned out that the so-called Monostahalle located on the Degussa premises (outside the ring fence of the NUKEM-A premises), which was meanwhile used again by Degussa, had to be included in the

decommissioning procedure. Therefore, two additional licences for the dismantling of this complex of buildings were applied for and granted on 9 November 1999 and on 26 June 2001.

All buildings inside the ring fence have meanwhile been dismantled. In May 2006 the remediation of the soil concluded and the entire premises, with the exception of 1,000 m^2, were released from regulatory control. The partial area will remain under regulatory control for the operation of a groundwater restoration plant. Groundwater restoration will still take several years until the restoration level of 10 µg uranium/l required by Water Law will be achieved.

Hochtemperatur-Brennelement Gesellschaft (HOBEG)

From 1972 to 1988, the facility of Hochtemperaturreaktor Brennelement GmbH (HOBEG) located on the Hanau premises was operated to produce ball-shaped fuel elements for high-temperature reactors. The capacity was up to 200,000 fuel elements per year. Altogether approximately 1 million fuel elements were fabricated. The HOBEG plant was initially operated with several individual licences according to § 9 Atomic Energy Act. On 30 December 1974 these individual licences were combined to a temporary licence covering all individual licences. The facility was temporarily taken out of operation on 15 January 1988, and was decommissioned subsequently.

Between 5 December 1988 and 7 April 1995, altogether nine licences according to § 7 para. 3 Atomic Energy Act for the decommissioning of the facility were granted. The procedural components were dismantled and the major part of them was sold. The buildings and the surrounding terrain were decontaminated. Following relevant measurements, the remaining buildings and the associated terrain were cleared and released from regulatory control on 18 December 1995. Today, the terrain and the buildings are used by Nuclear Cargo & Service GmbH.

4.3 STORAGE OF SPENT FUEL ELEMENTS IN CENTRAL AND DECENTRALISED INTERIM STORAGE FACILITIES

4.3.1 STORAGE OF SPENT FUEL ELEMENTS IN THE NUCLEAR POWER PLANTS

Spent fuel elements are initially stored in the nuclear power plants in the wet storage pools of the reactor facility and then in interim storage facilities near the site (cf. Table III.5).

In accordance with requirements imposed in the licences for the nuclear power plants, a capacity of one core load must basically be kept free in the wet storage pools to ensure that the reactor core can be entirely unloaded at any time. In general, the internal storage capacities cannot be used by several nuclear power plants. Exceptions were approved for the double unit facilities of Neckarwestheim and Philippsburg.

For the Obrigheim NPP the operation of an already constructed additional wet storage facility in the earthquake-protected emergency building outside the reactor building was approved in 1998. The first fuel elements were stored here in 1999 (cf. Chapter 4.3.2).

4.3.2 DECENTRALISED ON-SITE INTERIM STORAGE FACILITIES

Table III.5 gives a survey of the decentralised on-site interim storage facilities in Germany.

AVR – Jülich Cask Storage Facility

The AVR cask storage facility is a dry storage facility for spent ball-shaped fuel elements originating from the AVR Jülich in transport and storage casks of the CASTOR®THTR/AVR type.

The cask storage facility is located in a partial area of waste storage hall II in the Department of Decontamination of the Forschungszentrum Jülich GmbH.

The nuclear licence for the storage of spent AVR ball-shaped fuel elements was granted on 17 June 1993 for a period of 20 years. It comprises the storage of maximum 300,000 fuel element balls in maximum 158 casks.

On 7 July 2005, the modification licence for the storage of the last 2,400 fuel element balls was granted.

Storage operation was taken up on 23 August 1993. At the end of 2009, altogether 152 loaded casks of the CASTOR®THTR/AVR type were stored in the AVR cask storage facility.

As further interim storage in the AVR cask storage facility beyond 30 June 2013 will possibly be required, a prolongation of the granted storage licence was applied for on 26 June 2007 by way of precaution. The licensing procedure was though suspended in October 2010 upon request by the Forschungszentrum Jülich GmbH, the applicant favouring the transport of the 152 casks into the Transport Cask Storage Facility Ahaus (cf. Chapter 4.3.3).

Interim Storage Facility in the Obrigheim NPP

Based on licences dating from 1979 to 1983, Kernkraftwerk Obrigheim GmbH constructed an interim storage facility for spent fuel elements of the KWO. It is an external wet storage facility for 980 fuel elements (approx. 286 Mg of HM) which was erected in the emergency building until 1984.

The operation licence of this storage facility comprises the storage of 980 fuel elements exclusively from the KWO and of core components. It was granted according to § 7 Atomic Energy Act on 26 October 1998.

Emplacement of fuel elements started mid 1999. Once the Obrigheim NPP (KWO) had shut down on 11 May 2005, altogether 342 fuel elements were stored in the external wet storage facility until the end of 2007. On 22 April 2005, the BfS was submitted an application by Kernkraftwerk Obrigheim GmbH for storage of the spent fuel elements in a dry storage facility (cf. the following section "On-site interim storage facilities").

On-site Interim Storage Facilities

From 1998 to 2000, applications for the storage of nuclear fuel in the form of spent fuel elements in on-site interim storage facilities (SZL) were filed for altogether 13 sites by the NPP operators. The application for an on-site interim storage facility in Stade was withdrawn after one had decided to decommission the NPP.

The Federal Office for Radiation Protection (BfS) is the competent authority for granting licences according to § 6 Atomic Energy Act. Apart from the nuclear licence for the storage of nuclear fuel, the construction of the building especially requires a building licence according to the building regulations of the relevant federal state. In the licensing procedures relating to the applications of 1999 a joint Environmental Impact Assessment (EIA) was carried out. This was based on the European Directive 97/11/EG that was effective until 16 February 2012 and was replaced by the Directive 2011/92/EU and the Environmental Impact Assessment Act. Possible effects of the respective projects on man, animals, plants and their habitat, and on soil, water, air, and climate were examined.

After the terrorist attacks of 11 September 2001, the Federal Office for Radiation Protection also examined the effects of a targeted air crash on the on-site interim storage facilities applied for within the scope of the licensing procedures. For the licensed on-site interim storage facilities the examinations carried out by BfS came to the result that in case of a targeted air crash, the lives and health of the population and the environment would not be jeopardised by the release of considerable amounts of radioactive substances and that it would not be necessary to take drastic disaster control measures.

The on-site interim storage facilities are dry storage facilities for spent fuel elements packed into transport and storage casks that are kept in storage halls or tunnel sections, respectively. In all already licensed storage facilities, CASTOR®V/19 or CASTOR®V/52 type casks are used initially. The granted licences for all on-site interim storage facilities applied for until 2000 permit the storage of spent fuel elements with a mass of heavy metal amounting to altogether 14,025 Mg on 1,435 storing positions for transport and storage casks of the CASTOR® type. Capacity has been dimensioned in such a way that all spent fuel elements that would have accrued on the basis of the electricity volumes determined in 2002 (former: residual electricity volumes) until nuclear power plant operation will finally stop, could have been accepted until nuclear power plant operation has been discontinued and that they could have remained there beyond the time the nuclear power plant has been decommissioned and until a repository will be taken into operation. As the authorisation for power operation for altogether eight nuclear power plants expired on 6 August 2011 after the 13th Amendment to the Atomic Energy Act had become effective of 31 July 2011 had become effective and as, at the same time, the remaining operating times of the other nuclear power plants will end in 2022 at the latest, the storage capacities of the on-site interim storage facilities will no longer be exhausted by the storage of spent fuel elements accruing in future.

By the end of 2003, storage of spent fuel elements was granted for 12 on-site interim storage facilities. The BfS initially granted partial licences for those parts of the application whose examination had been concluded, so that the applications filed between 1998 and 2000 have not yet been decided. In 2011, the BfS continued the examinations in the scope of supplementary licences and amending licences for the on-site interim storage facilities. Focal points in 2011 were the examinations for the use of a modified transport and storage cask CASTOR®V/19 type and the examinations for an upgrade of the crane installations according to the

increased requirements of KTA Safety Standard 3902 in the on-site interim storage facilities. Altogether three licences could be granted on this topic in 2011. In the licensing procedures for modifications it was examined individually whether supplementary examinations had to be carried out for the Environmental Impact Assessment in individual cases.

With the exception of the Lingen on-site interim storage facility, the building permits for the on-site interim storage facilities were granted complementarily to the nuclear licences. The storage building in Lingen was licensed according to building law on 27 September 2000 and completed in April 2002. Thus the Lingen interim storage facility was already operable when the nuclear licence was granted. The erection of the remaining on-site interim storage facilities could only be started in 2003/2004, after the Environmental Impact Assessment had come to an end and the building permits had been granted by the respective federal state building authorities. A survey of the respective first licences, the licensed masses of heavy metal (HM) and storing positions, start of erection and taking into operation (i.e. the first emplacement of a loaded cask) of the on-site interim storage facilities is given in Table 4.1. Further details on the on-site interim storage facilities carried out so far are shown in Table III.5 in Annex III.

Table 4.1: On-site Interim Storage Facilities

On-site interim storage facility (SZL)	Granting the 1st licence according to § 6 Atomic Energy Act	Mass HM [Mg]	Storing positions TOTAL (Taken at the end of 2011)	Start of construction	Taken into operation
SZL Biblis	2003-09-22	1,400	135 (51)	2004-03-01	2006-05-18
SZL Brokdorf	2003-11-28	1,000	100 (14)	2004-04-05	2007-03-05
SZL Brunsbüttel	2003-11-28	450	80 (6)	2003-10-07	2006-02-05
SZL Grafenrheinfeld	2003-02-12	800	88 (13)	2003-09-22	2006-02-27
SZL Grohnde	2002-12-20	1,000	100 (13)	2003-11-10	2006-04-27
SZL Gundremmingen	2003-12-19	1,850	192 (34)	2004-08-23	2006-08-25
SZL Isar	2003-09-22	1,500	152 (22)	2004-06-14	2007-03-12
SZL Krümmel	2003-12-19	775	80 (19)	2004-04-23	2006-11-14
SZL Lingen	2002-11-06	1,250	125 (32)	2000-10-18	2002-12-10
SZL Neckarwestheim	2003-09-22	1,600	151 (41)	2003-11-17	2006-12-06
SZL Philippsburg	2003-12-19	1,600	152 (36)	2004-05-17	2007-03-19
SZL Unterweser	2003-09-22	800	80 (8)	2004-01-19	2007-06-18

On 22 April 2005, the BfS was submitted an application by Kernkraftwerk Obrigheim GmbH for storage of spent fuel elements in an on-site interim storage facility. On 1 January 2007, KWO GmbH was replaced by EnBW Kernkraft GmbH (EnKK) as applicant. Storage of altogether 342 spent fuel elements from the pressurised water reactor of the Obrigheim NPP was applied for, which had already been shut down in May 2005 and is now under decommissioning. The fuel elements are currently being stored in an already existing wet storage facility at the site (see above). As the external wet storage facility impedes the planned dismantling works for the Obrigheim NPP, the applicant has planned to operate a separate on-site interim storage facility with dry interim storage of spent fuel elements on the premises of the Obrigheim NPP for 40 years at maximum. The EnKK concept provides for the storage of the spent fuel elements in altogether 15 transport and storage casks of the CASTOR®440/84 type. Storage of the nuclear fuels is applied for in a storage hall made from reinforced concrete with unloading and storage area. An operational building is attached to the east side of the storage hall. Furthermore, it is planned to erect a separate guardhouse (security centre) together with technical equipment for security services. The Obrigheim interim storage facility is to be designed for self-sustaining operation and be operated in a nearly self-sustained way immediately after having been commissioned. With the laying out of the application documents to public inspection between 8 May and 7 July 2008 the BfS meanwhile initiated the public participation procedure. In this period, altogether 897 persons raised objections against the project. From 8 October to 10 October 2008, the objections were discussed in detail with the applicant, experts and authority representatives as well as the objectors. A verbatim transcript was made of the course and results of the hearing. The results of the hearing will be taken into account in the further course of the procedure when the licensing requirements will be examined.

With letter of 6 December 2011 the EnKK added further details to the application of 22 April 2005 in terms of construction and plant inspection. In order to meet new requirements in terms of plant security, it is now planned to store the nuclear fuel in a storage hall (approx. 36.6 m long, 19.7 m wide and 19.0 m high) according to the concept of a so-called STEAG storage facility. As opposed to the originally planned WTI concept with wall thicknesses of approx. 85 cm for the outer walls and approx. 55 cm for the thickness of the concrete roof of the cask storage hall, wall thicknesses of the outer walls and of the concrete roof were increased to approx. 1.2 m in the current plans for the building. Thus, wall thicknesses in the planned on-site interim storage facility Obrigheim now correspond with the wall thicknesses of the interim storage facilities in Northern Germany which was also constructed according to the so-called STEAG concept.

4.3.3 CENTRAL INTERIM STORAGE FACILITIES OUTSIDE NUCLEAR POWER PLANT SITES

A survey of the central interim storage facilities outside nuclear power plant sites is given in Table III.4.

For the transport cask storage facilities of Ahaus (TBL-A), Gorleben (TBL-G), and the transport cask storage facility of the Interim Storage Facility North (ZLN), investigations into the possible impacts of a targeted air crash were carried out in the scope of investigations into a possible subsequent requirement according to § 17 Atomic Energy Act. Expert results have shown that in case of an assumed targeted air crash the lives and health of the population in the vicinity would not be jeopardised by the release of considerable amounts of radioactive substances and that no drastic disaster control measures need to be taken.

Ahaus Transport Cask Storage Facility (TBL-A)

The Ahaus Transport Cask Storage Facility is a dry storage facility for spent fuel elements in transport and storage casks of the CASTOR® type.

The nuclear licence for the storage of fuel elements from light-water reactors according to § 6 Atomic Energy Act for a capacity of 1,500 Mg of heavy metal (HM) was granted on 10 April 1987, after a corresponding application had been filed on 2 August 1984. Storage operations started in June 1992.

The TBL-A was granted a licence for the storage of spent ball-shaped fuel elements from the THTR-300 in transport and storage casks of the CASTOR®THTR/AVR type; it was granted on 17 March 1992. By the end of April 1995, all 305 CASTOR®THTR/AVR casks containing the fuel elements from the THTR-300 were stored.

On the basis of a comprehensive new application a new licence was granted on 7 November 1997. It comprises the storage of maximum 3,960 Mg of HM in the previously licensed casks and in the new casks of the CASTOR®V/19, CASTOR®V/19SN06, and CASTOR®V/52 types on 420 storing positions until 31 December 2036. In the licence the maximum storable activity is set out to be $2 \cdot 10^{20}$ Bq and the heat output limit of all casks in the hall 17 MW.

In addition to the already stored 305 CASTOR® THTR/AVR casks, 2 CASTOR® V/19 casks, 1 CASTOR® V/19 SN06 cask and 3 CASTOR®V/52 casks with LWR fuel elements were transported to the Ahaus Transport Cask Storage Facility on 20 March 1998.

In a first modification licence of 17 May 2000 for the TBL-A, the fuel inventory was adapted to the modified conditions. Among others, different fuel element types (mixed loading) may in future also be stored in casks of the CASTOR® V/19 SN06 type. The maximum heat output for this type and for the CASTOR® V/19 type is limited to 25 kW, compared to 39 kW before. It is no longer permitted to store the older CASTOR® types Ia, Ic, and IIa.

On 24 April 2001, a second modification licence was granted. It comprises the recovery of the maximum permissible heat output of 39 kW or 40 kW for the CASTOR®V/19SN06 and CASTOR®V/52 cask types (which had been reduced with the first modification licence), the handling procedure when using a silver-coated large metal seal in the primary lid (wet compaction) as well as the modification of the technical acceptance requirements and the storage facility occupation (assembly of casks with enhanced heat output).

On 30 March 2004, the third modification licence was granted. It provides for the storage of nuclear fuel in the form of spent fuel elements from the Rossendorf Research Reactor in 18 transport and storage casks of the CASTOR®MTR2 type. In 2005, the 18 casks were transported from Rossendorf to Ahaus where they have been stored. Thus altogether 329 loaded transport and storage casks have been stored in the TBL Ahaus since 2005.

On 4 July 2008, the fourth modification licence relating to the sealing of the ventilation openings and a modified storage facility occupation was granted.

On 22 December 2008, the fifth modification licence relating to the modification of security installations was granted.

After completion of the complaint and appeal proceedings the storage licence for the TBL Ahaus has meanwhile become definitive.

On 30 October 2006, Gesellschaft für Nuklear Service mbH (GNS) and Brennelement-Zwischenlager-Ahaus-GmbH (BZA) filed an application according to § 7 Radiation Protection Ordinance (StrlSchV) at the Münster regional government for the interim storage of radioactive waste from the operation and decommissioning of German nuclear power plants in the TBL Ahaus. The licence of 9 November 2009 granted according to § 7 StrlSchV by the Münster regional government provides for a limited interim storage of the radioactive waste with a total activity of maximum 10^{17} Bq for a period of maximum ten years. The operational and decommissioning waste are to be stored in the western half of the hall, placed in different casks made from concrete, cast-iron and steel. This waste is later on to be taken to the licensed federal repository, Konrad near Salzgitter, which is currently being converted.

The use of the TBL Ahaus for the temporary interim storage of radioactive operational waste is linked with modifications of the operation of the 1,400-kN-storage hall crane and modifications of the storage cask monitoring system of the TBL Ahaus. On 26 May 2010 the required 6th modification licence was granted.

The GNS and the BZA filed an application according to § 6 Atomic Energy Act for the storage of high-pressure compacted radioactive waste from the reprocessing of spent fuels in transport and storage casks of the TGC36 type on 20 December 2006. From today's point of view this waste is to be stored in up to 152 casks, starting in 2020. Examinations have been initiated on the basis of the first documents submitted. The GNS decided in December 2011 to revise the cask concept (formerly TGC36).

With letter of 24 September 2009 the GNS and the BZA additionally applied for the storage of the AVR ball-shaped fuel elements from the Jülich AVR cask storage facility in the TBL Ahaus. This is due to the expiry of the licence for the AVR cask storage facility in 2013 (cf. Chapter 4.3.2). The altogether 152 casks of the CASTOR®THTR/AVR type are to be stored in the eastern half of the hall beside the already stored 305 casks of the CASTOR®THTR/AVR type with fuel elements from the THTR.

Gorleben Transport Cask Storage Facility (TBL-G)

The Gorleben Transport Cask Storage Facility is a dry storage facility for spent fuel elements from nuclear power plants with light-water reactors and for HAW vitrified waste containers from reprocessing in transport and storage casks.

The nuclear licence according to § 6 Atomic Energy Act for the storage of fuel elements from light-water reactors for a capacity of 1,500 Mg of heavy metal (HM) was granted on 5 September 1983, after a corresponding application had been filed in September 1980. Storage operations started on 25 April 1995.

In a new licence of 2 June 1995, especially the storage of mixed oxide (MOX) containing fuel elements and the storage of nuclear fuels in the form of waste as well as of nuclear fuel containing waste and other radioactive substances was permitted, apart from the increase to altogether 3,800 Mg of HM and the storage of solidified high-level radioactive fission product solutions. The storable activity was limited to $2 \cdot 10^{20}$ Bq. Prior to this decision a public participation procedure was carried out on the basis of the amendment to § 6 Atomic Energy Act.

On 1 December 2000, the TBL-G was granted a first modification licence to the licence of 2 June 1995. The licence concerned the modification of the Technical Acceptance Requirements for the casks. It also comprised the involvement of GNS as licencee as well as the use of other cask types for the fuel element types already licensed in 1995 and slight modifications of these fuel elements. On 18 January 2002, the second modification licence was granted. The approved modifications only concern the CASTOR®HAW 20/28CG, starting from serial number 16.

On 23 May 2007, with a third modification licence the use of the new cask type TN85 was permitted for the storage of high-level radioactive vitrified waste block canisters from the reprocessing of spent fuel elements from German nuclear power plants. The TN85 cask of the French AREVA NC (formerly COGEMA) enables a higher heat output of the vitrified waste block containers to be stored of maximum 56 kW compared to the heat output of maximum 45 kW previously permitted for the CASTOR® casks. The return of the vitrified waste block canisters to Germany has been set out in international contracts between the Federal Republic of Germany and the Republic of France.

With letters of 29 February 2000 and 2 March 2000, Brennelementlager Gorleben GmbH (BLG) and GNS, respectively, filed an application for HAW vitrified waste block canisters from reprocessing also being stored in casks of the CASTOR HAW28M type with a thermal capacity of up to 56 kW per cask. With letter of 20 September 2006, this application was initially restricted to the storage of HAW vitrified waste block canisters from reprocessing at AREVA NC. On 29 January 2010 this application was approved with the 4th modification licence.

In 2010, one transport to the TBL Gorleben was carried out with altogether 11 casks (10 CASTOR®HAW28M und 1 TN85) containing HAW vitrified waste block canisters from reprocessing in France. Further 11 casks of the CASTOR® HAW 28M containing HAW vitrified waste block canisters were returned from France to the TBL Gorleben at the end of 2011. There are no more transports with HAW vitrified glass block canisters from France required. On 31 December 2010, 5 casks containing spent fuel elements (1 CASTOR® Ic, 1 CASTOR® IIa, 3 CASTOR® V/19) and 97 casks containing HAW vitrified waste block canisters (1 TS28V and 74 CASTOR® HAW 20/28 CG, 10 CASTOR® HAW 28 M and 12 TN85) were stored in the storage facility.

The application for the storage of the HAW vitrified waste block canisters from reprocessing in the British Sellafield Ltd. Plant is to be examined in another licensing step later on. Altogether, a waste volume of further ca. 21 casks of the CASTOR®HAW28M containing HAW vitrified waste block canisters must be assumed.

Transport Cask Storage Facility in the Interim Storage Facility North Rubenow (ZLN)

The Transport Cask Storage Facility in the Interim Storage Facility North is a dry storage facility for spent fuel elements in transport and storage casks. It is situated in hall no. 8 of the Interim Storage Facility North on the premises of EWN. The ZLN serves to store spent fuel elements, nuclear fuel, and other radioactive waste from the reactors of Rheinsberg and Greifswald.

On 5 November 1999, the licence according to § 6 Atomic Energy Act was granted, after a corresponding application had been filed in April 1993. The licence was granted for a capacity of maximum 585 Mg of HM in maximum 80 casks of the CASTOR®440/84 type. The maximum storable activity inventory has been limited to $7.5 \cdot 10^{18}$ Bq. The licence involved immediate enforcement. Claims were filed against it but it is now definitive. Emplacement operations of CASTOR® casks started on 11 December 1999.

Modifications applied for by the operator were licensed in a first modification licence on 14 March 2001. Among others, the modifications comprise the storage of nuclear fuel in a cask of the CASTOR®440/84 type with modified basket (among others, special fuel elements and plutonium containing sources) and in six casks of the CASTOR®440/84 type that had already been loaded before the licence was granted.

Alternatively to dry compaction, the compaction of the primary lid metal sealing prior to drying (wet compaction) was also licensed in a second modification licence of 7 July 2003.

In a fourth modification licence for the ZLN dated 17 February 2006, the storage of casks of the CASTOR®440/84 type with supplemented inventories, of 3 casks of the CASTOR®KRB-MOX type (among others with special fuel elements), and of maximum 10 empty casks with contaminated inner surfaces was permitted. Thus the original extent of the licence has been achieved and the entire fuel from the facilities in Rheinsberg and Greifswald can be intermediately stored in the ZLN.

On 17 December 2008, the fifth modification licence relating to the modification and supplementation of security installations was granted.

On 24 February 2009, the storage of VEK canisters from the Karlsruhe reprocessing plant in five casks of the CASTOR®HAW 20/28 CG SN 16 was granted with the sixth modification licence. The casks were stored in the ZLN in February 2011.

With the seventh modification licence granted on 30 April 2010, storage was authorised of four casks of the CASTOR®KNK type containing spent and fresh fuel elements originating, among others, from the decommissioned compacted sodium-cooled reactor (KNK) of the Forschungszentrum Karlsruhe (cf. chapter 2.3) and from the operation of the decommissioned Nuclear Ship “Otto Hahn” (cf. chapter 3.4). This included a slight increase in the mass of heavy metal to 585.4 Mg. The four casks CASTOR®KNK were stored in the ZLN at the end of 2010.

On the appointed date of 31 December 2011, there were thus altogether 74 loaded CASTOR® casks in the ZLN (62 CASTOR®440/84, 3 CASTOR®KRB-MOX, 5 CASTOR®HAW 20/28 SN 16 and 4 CASTOR®KNK).

4.4 INTERIM STORAGE OF RADIOACTIVE WASTE AND NUCLEAR FUELS

4.4.1 INTERIM STORAGE OF RADIOACTIVE WASTE

A survey of external waste interim storage facilities in Germany is given in Table III.6.

Apart from facilities on the nuclear power plant sites, the following facilities are currently available for storing the waste:

- The external storage hall Unterweser,
- The decentralised on-site interim storage facility Biblis (the period of interim storage is limited to ten years, starting at the first emplacement of a waste package),
- The TBL Ahaus (the period of interim storage is also limited to ten years, starting at the first emplacement of a waste package),
- The waste storage facility Gorleben (ALG),
- The transport cask storage facility Gorleben (TBL-G), which is to provide storage capacity in the scope of a licensing procedure according to § 6 Atomic Energy Act, extending to the handling of other radioactive material according to § 7 Radiation Protection Ordinance,
- The EVU (utilities) hall of the interim storage facility Mitterteich,
- The interim storage facilities of Nuclear + Cargo Service GmbH (NCS) in Hanau,
- The interim storage facility North (ZLN) near Greifswald,
- The interim storage facility Rossendorf (ZLR) and
- The interim storage facility of the Hauptabteilung Dekontaminationsbetriebe (HDB) in Karlsruhe.

Based on the licences for these interim storage facilities there are restrictions in delivery.

The major part of the radioactive waste produced by nuclear industry and research institutions is intermediately stored on the waste producers' sites. Radioactive waste produced in the medical field and by small waste producers is intermediately stored in Länder collecting depots.

In the Morsleben Repository for Radioactive Waste (ERAM) one drum with radium radiation sources and seven special containers with mainly Co-60 radiation sources are intermediately stored. The BfS plans to dispose of these radiation sources in the ERAM within the scope of its closure. The BfS filed the respective application for disposal of this waste on 12 September 2005.

4.4.2 GOVERNMENT CUSTODY OF NUCLEAR FUELS

According to § 5 Atomic Energy Act, nuclear fuels (such as fresh fuel elements, fuel rods, and UO_2-pellets) must be kept in government custody if the operator does not have a valid licence. The Federal Office for Radiation Protection is responsible for the enforcement of government custody. For this case the government has to take precautions.

Should, contrary to expectations, there be larger amounts of nuclear fuels to be kept in government custody, they are stored in situ. Maintaining an own installations for this purpose is disproportionate.

For smaller amounts of nuclear fuel accruing which have to be kept in government custody according to § 5 Atomic Energy Act in future, storage space will be rented and containers and equipment will be developed and purchased. The objective is to prepare container storage for emergencies which is to a great extent maintenance-free.

A plutonium-beryllium neutron source (Pu-Be source) is still in government custody in the BfS branch office in Berlin Karlshorst.

4.5 REPROCESSING OF NUCLEAR FUELS

In the sixties of the 20th century, Germany started developing the technology of reprocessing spent fuel elements to complete the so-called nuclear fuel cycle. The Karlsruhe Reprocessing Pilot Plant (WAK) served to achieve this objective. There were plans for the construction of a national waste management centre (Gorleben Nuclear Waste Management Centre) where interim storage, industrial reprocessing, and disposal were to be dealt with on one site.

After this plan and domestic reprocessing had been given up, the management of spent fuel elements from German nuclear power plants by interim storage and reprocessing in other EU Member States was accepted – by the decision of the federal government of 6 June 1989 – as it was part of the integrated waste management concept and thus of the proof of precautionary measures to dispose of radioactive waste. The construction of an industrial German reprocessing plant in Wackersdorf (WAW) was stopped in the same year and the spent fuel elements were taken to France (AREVA, La Hague) or England (BNFL, Sellafield) for reprocessing.

As a result of an amendment to the Atomic Energy Act of 1994, direct disposal was put on a par with reprocessing as a waste management alternative, so that fuel elements were also intermediately stored in the Gorleben and Ahaus interim storage facilities for direct disposal later on.

To minimise the risk associated with reprocessing and transports to reprocessing plants, a ban was imposed on transports to reprocessing plants abroad with the Amendment to the Atomic Energy Act of 27 April 2002, starting on 30 July 2005. Since then, the management of fuel elements has exclusively been restricted to direct disposal.

Karlsruhe Reprocessing Plant (WAK)

The WAK (cf. Table III.7) on the premises of the Forschungszentrum Karlsruhe (FZK) – today Karlsruhe Institute of Technology (KIT) – was a test facility for the reprocessing of spent fuels from research, prototype and power reactors. Apart from the objective to gain operational experience, development projects for a German reprocessing plant were carried out on an industrial scale. The WAK resumed operation in 1971 under the leadership of the WAK Betriebsgesellschaft mbH. The operation ended in 1990 following a decision to do without a large-scale reprocessing plant. During this period approximately 200 Mg of nuclear fuels originating from numerous reactors were reprocessed. The uranium and plutonium obtained in this process was taken to nuclear fuel supply companies for reprocessing.

An amount of 70 m^3 (later on reduced to 60 m^3) of high-level radioactive liquid waste concentrate (HAWC) with an activity of $7.7 \cdot 10^{17}$ Bq accrued from reprocessing. The low-level and intermediate-level operational waste of the WAK was conditioned in the Forschungszentrum Karlsruhe (later on FZK and today KIT). After radioactive waste emplacement into the Asse mine had stopped in 1978, additional conditioned operational waste has remained with the WAK Rückbau- und Entsorgungs-GmbH (in short WAK GmbH) until today.

Operations finally ended on 30 June 1991. At the end of 1991 the federal government, the Land of Baden-Wurttemberg and the utilities decided to decommission and dismantle the reprocessing plant. On behalf of the research centre the WAK Betriebsgesellschaft mbH carried out the residual operation and dismantling of the plant on its own responsibility until 2005. Since 1 January 2006 the WAK GmbH, a daughter of the federally owned company Energiewerke Nord GmbH (EWN), has been responsible.

At the end of the reprocessing operation the plant consisted of

- The process building with the installations for the reprocessing of spent fuels,
- The storage buildings with containers and processing units for the interim storage of HAWC and intermediate-level liquid waste (MAW) as well as
- Facilities and buildings for media supply and technical infrastructure.

The objective is to dismantle all buildings completely and to achieve the state of "greenfield" by 2023. One intends to achieve this overall objective in six technically independent steps.

The process building which had contained the reprocessing process installations has been nearly empty since 2006 (steps 1-3). Following the completion of HAWC vitrification in 2010, one started to adapt the HAWC storage facilities and the Karlsruhe vitrification plant (VEK, details see below) to the reduced operation that was approved with the licence of 23 April 2010 (step 4). Step 5 includes the dismantling of the HAWC storage

facilities and the VEK. The conventional dismantling of all buildings (step 6) will only be carried out after the entire plant will have been released from regulatory control.

Prior to dismantling the storage facilities the HAWC that was last stored in two containers in the LAVA building (facility for the storage and evaporation of high-level radioactive liquids) needs to be conditioned in a way that it is suitable for disposal and to be disposed of. For this special purpose the VEK was constructed. By means of vitrification the liquid waste was converted into a solid, transport and storage-consistent form.

On 20 December 1996, an application for granting a licence according to § 7 Atomic Energy Act was filed for the erection and operation of the VEK. The first partial building licence for the VEK was granted on 30 December 1998. The construction of the VEK started at the beginning of 2000 and the interior fitting was completed until 2005. This was followed by functional tests of single components and the respective plant components and an inactive test operation of the entire plant from April to July 2007. The second partial operation licence for hot (nuclear) operation was granted on 24 February 2009. Between September 2009 and June 2010 the approx. 60 m^3 of HAWC were processed in the VEK into 122 vitrified waste block canisters containing altogether 49 Mg of waste glass. Additional 18 waste block canisters were produced during the subsequent rinsing process, so that altogether 56 Mg of waste glass were produced. With the filling of the 140^{th} and last waste block canister the operation of the Karlsruhe vitrification plant finally terminated on 25 November 2010; it is now in the post-operational phase. The furnace has been emptied and switched off. The 140 waste block canisters were placed into 5 transport and storage casks of the CASTOR®HAW 2028 type and were taken to the Interim Storage Facility North of EWN GmbH in Lubmin near Greifswald in February 2011 (cf. Chapter 4.3.3).

Two emptied HAWC casks are each in the "LAVA" building (storage casks) and in the "HWL" building (reserve casks) in thick-walled concrete cells which are only accessibly by remote-handling. For carrying out the remote-handling and for the residue logistics a new access building south to the HWL was constructed and taken into operation in May 2008. One of the reserve casks (81B21) was in operation and filled with HAWC for approx. 15 years. Despite of the fact that the cask was rinsed several times after it had been emptied there were approx. 100 kg of solid HAWC residues in this cask. One intends to recover these residues in the scope of the remote-handled dismantling of the HAWC storage casks approved on 8 December 2010.

Apart from the HAWC casks there were also collecting casks for intermediate-level radioactive waste (MAW) in the HWL. These casks were no longer required and could therefore be dismantled irrespective of the HAWC vitrification. The remote-controlled dismounting of the empty MAW storage casks in the HWL has been approved with the 20^{th} decommissioning licence dated 31 January 2006. These works concluded in 2011.

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

Wackersdorf Reprocessing Plant (WAW)

In 1982, Deutsche Gesellschaft zur Wiederaufarbeitung von Kernbrennstoffen mbH (DWK) filed an application to the Bavarian State Ministry of Regional Development and the Environment for the construction of a reprocessing plant at the Wackersdorf site (Oberpfalz/Bavaria).

This application resulted from the decision made by the heads of federal and Land governments in 1979, which considered reprocessing to be feasible in terms of safety according to the state of the art of science and technology, including the recirculation of the utilisable nuclear fuels and the disposal of radioactive waste from the reprocessing process, and demanded to rapidly construct a reprocessing plant. It was also a result from Lower Saxony Prime Minister Ernst Albrecht's (CDU) attitude: he considered the National Waste Management Centre in Gorleben not to be politically enforceable.

The first partial building licence was granted in September 1985. The Bavarian Administrative Court considered the development plan contrary to law in January 1988. Construction had started in December 1985. Modifications of the concept then made it necessary to develop a new safety report, to perform another public hearing and to examine the safety of the facility as a whole.

Offers made by COGEMA (now: AREVA) and later on by BNFL to take over the reprocessing of spent fuel elements from German nuclear power plants for the long term and to do this at reasonable prices, persuaded the German utilities to reconsider the Wackersdorf project and to give it up. The procedure was formally completed by the DWK withdrawing the building application in December 1989.

4.6 CONDITIONING OF FUEL ELEMENTS FOR DIRECT DISPOSAL

Gorleben Pilot Conditioning Plant (PKA)

(Cf Table III.8 in Annex III)

In order to advance methods for direct disposal, a pilot conditioning plant for spent fuel elements and radioactive waste was erected at the Gorleben site (Lower Saxony). The plant is a multi-purpose facility, where, apart from fuel elements, all types of radioactive waste from nuclear facilities can be reloaded or conditioned in such a way that they are suitable for disposal. The plant has been designed for a capacity of 35 Mg of HM per year.

In January 1990, the first nuclear partial licence was granted for the erection of the building shells and the fence and earth wall surrounding the plant and the preliminary positive overall judgement of the plant concept.

With decision of 21 July 1994, the Lower Saxon Environment Ministry granted the second partial licence for the erection of the PKA. It concerns the entire technical and electro-technical part as well as the PKA's instrumentation and control.

The third partial licence, which includes the operation licence, was granted in December 2000. Until the federal government will nominate a repository site, PKA operation is restricted to repairing defective transport and storage casks on the basis of a collateral clause to the granted licence. This was a component of the agreement of 14 June 2000 between the federal government and the leading utilities using nuclear power which was signed on 11 June 2001. It guarantees the use of the PKA "hot cell" in case one of the transport and storage casks stored on the same site in the transport cask storage facility Gorleben needs repairing.

All three partial licences are definitive.

On 18 December 2001, the Lower Saxony Environment Ministry issued a subsequent requirement to the second partial licence of 21 July 1994 that certain systems and plant components be operated in "cold operation". This serves to maintain the PKA in its tested state and ensures that a defective cask can be accepted at any time.

Currently only those systems are being operated in the PKA that are required for repairing a cask and maintaining the plant (including periodic reviews) and the expertise of the staff.

4.7 DISPOSAL

A survey of repositories for radioactive waste and repository projects in the Federal Republic of Germany is given in Table III.9. Responsibilities in radioactive waste disposal are shown in Figure III.2 and the course of plan-approval (licensing) procedures and procedures according to Mining Law are presented in Figure III.3.

4.7.1 RESPONSIBILITIES REGARDING DISPOSAL

The legal basis for radioactive waste disposal is the Atomic Energy Act. Through talks with the federation and the federal states about the question of radioactive waste management a joint working group is currently developing a procedure to find a site for a repository for heat-generating waste. The result is to be set out in a law concerning the search for a repository. First key points were determined on 15 December 2011.

The objective of the discussions is to define a procedure according to which a repository site is selected in a comprehensible and transparent process with participation of the public. Central items still to be addressed concern the number of sites to be explored in terms of mining, the issue concerning the further handling of the Gorleben exploration mine and the institutional organisation of establishing selection criteria, conducting the search for a site, operating the repository and implementing the licensing and/or supervisory function.

The following responsibilities for radioactive waste disposal have been regulated in the Atomic Energy Act: according to § 9a para. 3 Atomic Energy Act the federation must establish facilities for the long-term storage and disposal of radioactive waste. The Federal Office for Radiation Protection (BfS) is the authority competent for these issues (§ 23 para. 1 no. 2 Atomic Energy Act). The BfS is assigned to the portfolio of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The BfS is subject to the functional and legal control of the BMU in terms of the implementation of repository-related tasks. Since 2008, the BMU has been advised in nuclear waste management issues by the Nuclear Waste Management

Commission (ESK) consisting of eleven scientists. Prior to this the Repository Committee of the Reactor Safety Commission was responsible for advising the BMU.

In geo-scientific and geo-technical issues associated with the planning, construction, operation and decommissioning of repositories, the BfS collaborates with the Federal Institute for Geosciences and Natural Resources (BGR), the latter being part of the portfolio of the Federal Ministry of Economy and Technology (BMWi). The collaboration is done on the basis of a corresponding agreement.

According to § 9 para. 3 Atomic Energy Act the federation – or in this case the BfS – may use the services of third parties to comply with its obligations. Under a contract of 1984 the German Company for the Construction and Operation of Repositories for Waste (DBE) has been tasked with the planning and construction of federal facilities for the long-term storage and disposal of radioactive waste. DBE's shares are held by the GNS mbH (75 %) and the EWN GmbH (25 %). The DBE is currently supporting the BfS in terms of the construction of the Konrad repository, the operation of the Morsleben repository and the operation of the Gorleben exploratory mine. The 100 % federal Asse GmbH has been tasked with the operational management and the decommissioning of the Asse II mine. On behalf of the BfS, the company for the operation and decommissioning of the Asse II mine carries out tasks relating to the planning, construction and operation of federal facilities for the safekeeping and disposal of radioactive waste. It is also a third party according to § 9a para. 3 Atomic Energy Act.

The overall responsibility for the construction and operation of federal repositories is with the BfS. The DBE and the Asse-GmbH are supervised by the BfS. The BfS also initiates and co-ordinates facility-related research and development projects.

On behalf of the Federal Ministry of Education and Research (BMBF) large research institutions do basic research in the field of disposal of radioactive materials and carry out facility-related research and development works on behalf of the BfS. Contractors are, among others, Helmholtz Zentrum München – German Research Center for Environmental Health (formerly GSF), Gesellschaft für Reaktorsicherheit mbH (GRS), the Karlsruhe Institute of Technology (KIT) and the Forschungszentrum Jülich (FZJ).

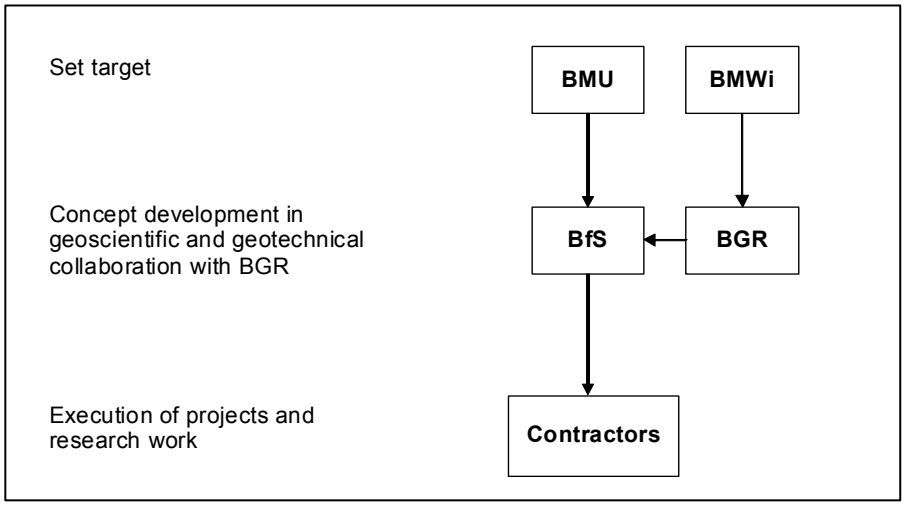


Fig. 4: Responsibilities regarding radioactive waste disposal

4.7.2 REPOSITORIES

Mine for the Exploration of the GORLEBEN Salt Dome (Project)

The exploration of the Gorleben salt dome for its suitability to host a repository for all types of radioactive waste started in 1979.

Currently no statement can be given on the suitability of the Gorleben salt dome to host a repository for radioactive waste. Essential parts of the required examination procedure such as a plant and site-specific

safety assessment or a statement on long-term storage are still outstanding. A final statement on the suitability of the Gorleben site would be achieved in a nuclear plan-approval procedure.

The site for a repository for heat-generating radioactive waste has not been determined so far. The discussions currently (as of July 2012) taking place between the federal government and the federal states about the wording of a law concerning the search for a repository also include the issue of how to deal further with the Gorleben exploration mine in the scope of a site-selection procedure.

Due to a moratorium agreed with the power utilities, exploration works had stopped between 1 October 2000 and 30 September 2010. During this period only works to maintain the mine and to keep it open were carried out in order to keep the exploratory mine in a safe-to-operate state and not to devaluate the investments made and work results achieved. On 15 March 2010, Federal Environment Minister informed the public that the moratorium for the exploration of the Gorleben salt dome as a radioactive waste repository would be lifted and one would resume an open-ended exploration.

The BMU defined on the further approach: In a first step a preliminary safety assessment for the Gorleben site is to be carried out by the end of 2012 on the basis of the available exploration results. The focus is on the issue of long-term safety, i.e. one needs to predict in a comprehensible way on the basis of the state of knowledge if and, if necessary, under what conditions it will be possible to operate a safe repository on this site. Furthermore an updated repository concept is to be developed taking into account operational safety and the future need for investigation and exploration is to be determined.

Until the middle of 2013, an International Peer Review Group is to examine on the basis of the available exploration results and the preliminary safety assessment whether the common international standards and the state of the art of science and technology are complied with. The result of exploration, preliminary safety assessment and peer review will be a decision in favour of or against the Gorleben site. On the basis of this suitability prognosis for the Gorleben site the federal government is then to decide whether the Gorleben repository project will be pursued any further.

Following a subsequent further exploration, the BfS as the operator of the exploratory mine has to make a basic statement on the suitability. On this basis a decision can then be taken about the initiation of a nuclear plan-approval procedure.

The exploration works in exploration area 1 will continue, accompanying and supporting the preliminary safety assessment. The BfS submitted to the competent mining authority, Landesamt für Bergbau, Energie und Geologie (LBEG), an application for the renewal of the overall operating plan for the geo-scientific exploration of the Gorleben salt dome until 30 September 2020 and for a new main operating plan for further exploration works in the period of application between 1 October 2010 and 30 September 2012. Either operating plans were approved in September 2010. After legal proceedings had been initiated against either approvals and a suspensive effect had come into effect for the approval of the operating plans, the LBEG ordered immediate enforcement of the operating plans. The BfS then gave order to the operator, “Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH” (DBE), to resume the exploration works. With decree issued by the Federal Minister for the Environment, Nature Conservation and Nuclear Safety of 6 December 2011 the BfS was ordered to postpone driving operations in exploration area 3. This was done in view of the on-going communication about a waste management consensus – also involving the exploration of Gorleben – between the federal government and the federal states (cf. above). The planned exploration drillings are to be carried out.

KONRAD Repository

The Konrad mine in Salzgitter developed the iron ore deposit known since 1933 in depths between 800 m and 1,300 m. Sinking of shaft Konrad 1 started in 1957. Iron ore production already stopped in 1976 for economic reasons. Since it is extraordinarily dry, the mine was initially investigated for its basic geo-scientific suitability to host a repository for radioactive waste. After these investigations had been concluded with a positive result, the then competent Federal Institute of Science and Metrology filed an application for the initiation of a plan-approval (licensing) procedure according to § 9b Atomic Energy Act on 31 August 1982. The plan provided for the disposal of up to 650,000 m^3 of radioactive waste with negligible heat generation. Compared with these estimations, the waste volume expected today has clearly decreased. The volume licensed for disposal has been restricted to 303,000 m^3 of waste for the national need. Until 2050, approximately 290,000 m^3 of radioactive waste will accrue for the Konrad repository. The radioactive waste to be disposed of mainly accrues in the use of nuclear energy for electricity generation, in the decommissioning and dismantling of nuclear facilities. Other waste originates from radioisotope application in craft, research, medicine, the Federal Armed Forces as well as from research and development work Altogether the volume of the waste with

negligible heat generation amounts to about 90 %. It is, however, only 0.1 % of the activity of all radioactive waste.

The licensing procedure pending since 1982 was completed through the plan-approval decision of 22 May 2002. According to the agreement between federal government and power utilities the application for immediate enforcement was withdrawn by the BfS on 17 July 2000. In March 2006, the pending actions against the plan-approval decision were rejected by the Lüneburg Higher Administrative Court; revision was not admitted. The complaints against the non-admission of the revision to the decisions of the Higher Administrative Court filed by the claimants were rejected by the Federal Administrative Court with decision of 26 March 2007. The plan-approval decision is thus legally binding. Since that date the Konrad repository has been under construction.

The Mining Law licence of the competent mining authority which is required in addition to the (nuclear) plan-approval decision was granted on 15 January 2008 with the approval of the main operating plan for a term of six years.

The necessary planning for implementing the project continued in 2011. In particular the more than 500 ancillary clauses in the plan-approval decision and the fact that the major part of the plans was developed in the nineties make it necessary to comprehensively up-date the plans taking into account the current need to re-build the installations, the state of the art of the technical rules and regulations, the stipulations of the federal government's "Meseberger Beschlüsse", the stipulations of the energy saving regulations and the provisions on sustainable building.

Taking into account present conditions, all construction operations are currently being examined and revised.

The process of revising the plant shows that the assumptions made in the nineties were incorrect and have raised unrealistic expectations. Works being carried out in an optimum way in the present structures, it is therefore expected that the Konrad repository will not be completed before 2019.

A media channel is being established in the Konrad 1 mine. The construction of the hoist building south (without machine engineering) was concluded.

Shaft construction works were taken up in Konrad 1. Scaling works concluded. Shaft reconstruction works are on-going.

In Konrad 2, the construction site installations above ground are being established. Security fencing in the planned areas concluded.

The mine restorations, the underground strengthening of galleries and the driving of emplacement chambers in field 5/1 started. The emplacement transport gallery has already been restored, additional restorations and driving of galleries are according to schedule. Overhauling of several road headers concluded and serves to further prepare the driving of emplacement chambers and to expand the final crosscut. Furthermore, assembly and maintenance works at large mining vehicles were carried out. The set-up of the main cable route will follow. Extensometers were installed to measure the rock pressure.

MORSLEBEN Repository for Radioactive Waste (ERAM)

By the Unification Treaty of 1990, the Federal Republic of Germany has become responsible for the Morsleben Repository for Radioactive Waste (ERAM) installed by the former GDR in the former potash and rock salt mines of Bartensleben and Marie. Except for the period from 1991 to 1994, when emplacement operations had discontinued, it was used until 1998 for the disposal of low-level and intermediate-level radioactive waste containing mainly radionuclides with short half-lives. Through the legal transfer the Federal Office for Radiation Protection has been the holder of the permanent operation licence since 1990.

Between 1971 and 1998, altogether about 37,000 m^3 of low-level and medium-level radioactive waste were disposed of in the ERAM with a total activity of less than 3.3 10^{14} Bq (appointed date: 30 June 2010). As regards time the amount of emplaced waste can be classified as follows: approx. 14,500 m^3 until 1991, approx. 22,500 m^3 from 1994 to 1998. In terms of the geographical origin of the waste one can differentiate between approx. 20,550 m^3 from East Germany and approx. 16,200 m^3 from West Germany. On 21 May 1999, the BfS announced that, for safety reasons, emplacement operations in the ERAM would not be resumed. On the basis of the Amendment to the Atomic Energy Act of 2002, the provisions of § 57 a Atomic Energy Act were modified to the extent that the permanent operation licence for the ERAM of 22 April 1986 continues to be effective as plan-approval decision within the meaning of § 9 b Atomic Energy Act for an indefinite period, except for the regulations relating to the acceptance and disposal of further radioactive waste. Therefore, the acceptance of radioactive waste of third parties for disposal has been excluded. As the

emplacement of radioactive waste has been finally terminated, repository operation is to be converted into operation with the purpose of keeping the mine open. For this purpose, a corresponding plan for converting the ERAM and keeping it open was submitted to the competent licensing authority of the federal state of Saxony-Anhalt in 2003.

Between 2003 and 2011, 27 rock salt workings where no radioactive waste is stored have been backfilled with ca. 935,000 m^3 of salt concrete in the scope of measures to prevent mining hazards and to improve the geo-mechanic state of the ERAM's central part. Given the interaction with the salt rock, additional bearing arches and pillars are thus being erected to ensure that the mine is suitable for the implementation of the decommissioning measures. The salt concrete, a mixture of salt grit, limestone meal, sand, concrete, and water, is a hydraulically setting stowing material which already sets after a few days and unfolds the planned supporting effect. The measure to prevent mining hazards concluded in February 2011. The objective to stabilise the central part of the Bartensleben mine was achieved. This has been shown by the measurement data. The BfS restricted the application for further operation of the ERAM that it had filed to the Ministry for Agriculture and the Environment (MLU) of Saxony-Anhalt on 13 October 1992, to the decommissioning of the ERAM on 9 May 1997. In the scope of the plan-approval procedure for decommissioning, apart from decommissioning the ERAM, the radioactive waste intermediately stored until that time and the operational radioactive waste accruing in the process of decommissioning operation is to be disposed of in the process of decommissioning.

In the course of the work for the plan-approval procedure carried out so far, about 400 procedure qualification records on the decommissioning concept and the safety assessments have been submitted to the competent licensing authority for examination. The ERAM is decommissioned in such a way that it is ensured that the protection goals are complied with according to both radiation protection law and Mining Law. Even if the release of radionuclides from a sealed repository cannot be entirely prevented in the long term, only a certain amount of these radionuclides may reach the biosphere in order for the protection goals to be complied with in the long run. This proof is furnished on the basis of long-term safety assessments. In the course of decommissioning, additional parts of the underground facilities and the shafts are to be backfilled with sealing and stabilising building materials. The emplacement areas eastern field and western-southern field are sealed with the help of sealing structures in the access galleries. Altogether, 4 million cubic metres of salt concrete still have to be pumped into the ERAM on the basis of the decommissioning concept. The shafts are subsequently sealed with shaft sealing constructions.

The plan documents required according to § 6 Nuclear Licensing Procedure Ordinance (AtVfV) were submitted to the competent licensing authority, the Ministry for Agriculture and Environment (MLU) of the federal state of Saxony-Anhalt on 13 September 2005. After the plan documents had been completely revised upon request of the licensing authority, the authority declared in September 2009 that the documents be suitable for the public participation procedure. The plan documents for the decommissioning of the ERAM were then laid out to public inspection between October and December 2009 in the scope of the public participation procedure which is part of the plan-approval procedure.

The plan for the decommissioning of the ERAM presents comprehensively and in detail the initial situation, the decommissioning concept with the planned backfilling and sealing measures up to the shaft sealing constructions, the planned works relating to the conversion and dismantling of the facilities and the radiological consequences for the environment. These possible radiological consequences of the sealed repository for the biosphere are assessed in the long-term safety assessments. For this purpose, various climatic, geological and mining scenarios are considered for a period of 1 million years.

In addition to the plan, the BfS also submitted an Environmental Impact Assessment study in which all results gained in the environment investigations are presented and evaluated, the accompanying landscape conservation plan (LBP) and a survey of different technical decommissioning variants examined.

Between 13 October and 25 October 2011, a hearing was conducted of the ca. 15,000 objections against the "Plan to decommission the ERAM". The hearing took place in the Motorpark Oschersleben. In addition to questions as to retrievability and alternative projects and the inventory of the ERAM, key issues were questions relating to the decommissioning concept and the proof of long-term safety. In the ERAM plan-approval procedure the decision will be taken after the public participation procedure and after the in-depth planning for the preparation of the decommissioning measures has been surveyed and evaluated by the licensing authority. The licensing authority MLU strives to achieve a plan-approval decision in 2014. After the plan-approval decision has become definitive and following a conversion phase, the implementation of the licensed decommissioning measures for the ERAM can then start. The actual implementation of the approved decommissioning works is currently being estimated to take 15 years.

ASSE Repository for radioactive waste

The Asse II mine near Wolfenbüttel was operated by Burbach AG for the production of potash and rock salt from 1909 until 1964. One carnallitite panel and two rock salt panels were driven.

In 1965, Gesellschaft für Strahlen- und Umweltforschung (GSF, today Helmholtz Zentrum München German Research Center for Environmental Health; HMGU) bought the Asse II mine in order to use it as "research mine" for the disposal of radioactive waste in salt formations. Low-level and intermediate-level radioactive waste was emplaced in the Asse II mine between 1967 and 1978. Emplacement of radioactive waste ended on 31 December 1978. In the scope of the trial and demonstration programmes about 124,500 drums containing low-level radioactive waste were emplaced in 12 chambers on the 725-m level and on the 750-m level and about 1,300 drums containing intermediate-level radioactive waste in a chamber on the 511-m level. According to the present state of knowledge, the sum of the activity inventory was $1.13 \cdot 10^{16}$ Bq on 1 January 1980.

Following a decision of the federal cabinet of 5 November 2008 to treat the mine as a radioactive waste repository in future, responsibility was transferred from the HMGU to the BfS on 1 January 2009, the BfS being responsible for repositories according to § 23 Atomic Energy Act.

Operating the Asse II mine involves the responsibility according to both mining and nuclear law being with the BfS. The BfS commissioned the newly founded Asse-GmbH with the management of the mine, starting on 1 January 2009.

The decommissioning of the Asse II mine is accompanied by the Asse II Accompanying Group of the rural district of Wolfenbüttel consisting, among others, of representatives of the local stakeholders, environmental and conservation organisations and citizens' initiatives. The Asse II Accompanying Group receives expert advice from the Comparison of Options Working Group (AGO). Until the BfS took over the operator responsibility for the Asse mine, it had been prominently involved in this working group; it is now only acting in an advisory role in the AGO. The AGO is now being managed by the Karlsruhe Institut für Technologie (KIT) as the project executing organisation.

At the beginning of 2009, the AGO suggested in an interim report the further examination of the decommissioning options retrieval, relocation and complete backfilling.

Once the evaluation procedure was terminated, the BfS and the BMU came to the conclusion that a proof of long-term storage for the waste that is conforming to the law can be only furnished after the waste has been retrieved. Thus retrieval was selected as best option to handle the waste.

Prior to retrieval one intends to carry out an enquiry of facts (fact finding). The fact finding has the objective to clarify uncertainties and to enable an evaluation of the actual radiation exposures occurring when all the waste is retrieved.

Three steps have been planned for the fact finding:

Step 1: Drilling into the chambers and first examinations via the drillings,

Step 2: Opening of the chambers and evaluation of the waste package state,

Step 3: Recovering of first waste packages or waste.

Orders were given to DMT GmbH & Co. KG (DMT) and to TÜV-NORD Systec GmbH & Co. KG (TÜV NORD) for the conceptual works for the fact finding. For the purpose of fact finding, chamber 7/750 will be the first chamber to be examined, followed by chamber 12/750. The approval for drilling into chamber 7/750 required according to Mining Law has been granted.

The licence for step 1 of the works that is required according to § 9 Atomic Energy Act was granted by the Lower Saxon Environment Ministry (NMU) on 21 April 2011. Each step of the fact-finding procedure requires an individual licence according to § 9 Atomic Energy Act.

The licence for step 1 contains 32 requirements that need to be complied with before drilling works can be taken up.

Regarding retrieval, plans for a new shaft, an interim storage facility and retrieval techniques are currently in the planning process.

While the planning works for a selected decommissioning concept and the required licensing procedure for decommissioning are carried out, the mine needs to be kept open in a state that is safe to operate and

sufficient precaution against damage needs to be taken according to the standards set out in the provisions of the AtG and the Mining Law (BBergG).

The BfS has invited experts to a two-day workshop in order to evaluate the previous procedure of decommissioning the Asse II mine. This workshop took place at the end of January 2012 with participation of broad external expertise (AGO, TU Clausthal, ERCOSPLAN, IFT, Colenco).

The operations that are necessary to keep the mine open are carried out on the basis of the nuclear licence by NMU according to § 7 Radiation Protection Ordinance which was granted in July 2010. Apart from brine management, which is performed continuously, the operational focal points in 2011 were the backfilling of roof clefts, the planning and realisation of precautionary measures and the planning of emergency measures and the preparation of investigations relating to the fact-finding.

Backfilling of roof clefts

To reduce the deformations at the mine's southern flank one intends to backfill residual cavities with Sorel concrete in more than approximately 90 mining districts. The purpose of this measure is to reduce the rock deformation in the southern flank. After the pilot phase started in December 2009, the roof clefts of 17 mining districts have been backfilled so far. 10 other mining districts have been backfilled in part. They still need to be explored with the help of drillings and the remaining cavities need to be backfilled. Altogether ca. 27,100 m^3 of special concrete has been used for the backfilling of roof clefts so far.

Emergency preparedness

The objective of the BfS' emergency preparedness is to limit the occurrence of events that would lead to a situation where the mine could neither be operated nor decommissioned, or, respectively, to limit its consequences in case such an event occurred. Among others, the emergency preparedness measures aim to reduce the probability of occurrence of an enhanced inflow of brine and to minimise the radiological consequences as a result of such drowning.

To achieve emergency preparedness, measures need to be implemented by way of precaution and measures that can only be taken in the event of an emergency need to be planned and prepared in a way that they are ripe for implementation.

Precautionary measures that have already been implemented include, for example, the increase of production capacity of the influent brine, the establishment of emergency storage facilities to secure the replacement of devices and equipment having failed in case of emergency and technical devices. To increase the underground storage capacity, the driving of sumps was advanced in 2011.

Various structural precautionary measures are being implemented in succession according to their dependencies and effectiveness with work capacities still to be created. For instance, cavities no longer needed are backfilled and sealing structures are constructed on the levels and underneath the emplacement chambers, in order to minimise and delay the release of radionuclides in the event of an emergency. The implementation of precautionary measures started in summer 2010 with the insertion of Sorel concrete as supporting backfill into cavities on the 775-m level. In summer 2011, sealing structures were constructed in the western area of the 750-m level. It will take several years to carry out the works relating to the precautionary measures.

The effectiveness of the sealing structures implemented as precaution can only be entirely ensured if the mine is counter-flooded with $MgCl_2$ solution which cannot affect the potash salt located around the sealing structures. Therefore, the acquisition and storage of sufficient amounts of counter-flooding solution was prepared in 2011. Furthermore, plans and works are carried out in the mine to improve the infrastructure conditions (such as place where the salt can be unloaded, reception facility for solutions).

In view of the works on retrieval the emergency preparedness is being updated and adapted.

Fact finding

Drilling into chamber 7/750 is being prepared. Already before the licence according to § 9 Atomic Energy Act had been granted, works were carried out on the setting-up of a drilling site (setting-up of a planum, scaling works etc.) in front of the sealing structure to chamber 7/750 in mining district 5/750 in the scope of the approval according to Mining Law. In the course of the year, the drilling site underground was completely set up with all radiation protection devices (housing, cuttings bunker, radiological exhaust air filter, radiation protection laboratory etc.). A larger amount of inert gas (nitrogen) must be available, which will be directed to the drilling place via a standpipe in case of a fire. Given that larger amounts of nitrogen cannot be held available, technical devices for nitrogen production still need to be planned and produced.

Before works for the fact-finding process in chamber 12/750 can be taken up, a sump with contaminated brine must be dried. Appropriate options are being examined.

Health monitoring

The BfS health monitoring concluded at the end of 2010 has shown that the former Asse staff was exposed to a total occupational life dose of 11 millisievert and maximum 110 millisievert on average. These values are below the currently effective limit for the occupational life dose of 400 millisievert. A value of 18.7 millisievert was observed as highest total annual dose in one employee in 1972. This value is below the limit of 50 millisievert per year that was effective at the time of emplacement and below the limit of 20 millisievert per year effective today.

Each former and current employee and their dependants – in case the former employee has deceased meanwhile – had the opportunity in 2011 to contact the BfS in order to get an individual dose estimation. This has been carried out for 22 applicants who signed a declaration of consent developed by the BfS.

ANNEXES - SURVEY

Annex I – Nuclear power plants –

As of 31 December 2011

Table I.1: Licensing and supervisory authorities of the federal government and the Länder for storage licences according to § 6 Atomic Energy Act (AtG) and facilities according to § 7 AtG

	Authority for licences according to § 6 AtG	**Supervisory authority according to § 19 in conjunction with § 6 AtG**
Federal Republic of Germany	Federal Office for Radiation Protection	Länder supervisory authorities
Land	**Licensing authority for facilities according to § 7 AtG**	**Supervisory authority according to § 19 in conjunction with § 6 AtG and § 7 AtG**
Baden-Wurttemberg	Ministry of the Environment, Climate Protection and the Energy Sector in agreement with the Ministry of Economy and the Ministry of the Interior	Ministry of the Environment, Climate Protection and the Energy Sector
Bavaria	Bavarian State Ministry of the Environment and Health	Bavarian State Ministry of the Environment and Health
Berlin	Berlin Senate Department of the Environment, Health and Consumer Protection	
Brandenburg	Brandenburg State Ministry of the Environment, Health and Consumer Protection	
Bremen	Senator for the Environment, Building, Transport and Europe, in consultation with the Senator for Labour, Women, Public Health, Adolescents and Social Affairs	
Hamburg	Authority for Urban Development and Environment	
Hesse	Hessian Ministry for the Environment, Energy, Agriculture and Consumer Protection	
Mecklenburg-Vorpommern	Ministry of the Interior in consultation with Ministry of Economics, Labour and Tourism	Ministry of the Interior
Lower Saxony	Lower Saxon Ministry for the Environment, Energy and Climate Protection	
Northrhine-Westphalia	Ministry of Economic Affairs, Energy, Building, Living and Traffic of the Land of Northrhine-Westphalia	
Rhineland-Palatinate	Ministry of Economy, Climate Protection, Energy and Regional Planning	
Saarland	Ministry for the Environment, Energy and Traffic	
Saxony	Saxon State Ministry for the Environment and Agriculture	
Saxony-Anhalt	Ministry for Agriculture and Environment	
Schleswig-Holstein	Ministry of Justice, Equality and Integration of Land Schleswig-Holstein	
Thuringia	Ministry for Agriculture, Forestry, Environment and Nature Conservation	

Table I.2a: Nuclear power plants in operation
As of 31 December 2011

Nuclear Power Plant	Site	Land	Operator	Type	Capacity gross [MW_e]	Capacity net [MW_e]	1st partial licence	Start of construc-tion	Initial criticality
GKN 2	Neckarwestheim	BW	EnBW Kernkraft GmbH (EnKK)	PWR	1,400	1,310	1982-11-09	11/1982	1988-12-29
KKP 2	Philippsburg	BW	EnBW Kernkraft GmbH (EnKK)	PWR	1,468	1,402	1977-07-06	07/1977	1984-12-13
KKI 2	Essenbach	BY	E.ON Kernkraft GmbH	PWR	1,485	1,410	1982-07-12	09/1982	1988-01-15
KKG	Grafenrheinfeld	BY	E.ON Kernkraft GmbH	PWR	1,345	1,275	1974-06-21	01/1975	1981-12-09
KRB-II-B	Gundremmingen	BY	Kernkraftwerk Gundremmingen GmbH	BWR	1,344	1,284	1976-07-16	07/1976	1984-03-09
KRB-II-C	Gundremmingen	BY	Kernkraftwerk Gundremmingen GmbH	BWR	1,344	1,288	1976-07-16	07/1976	1984-10-26
KWG	Grohnde	NI	E.ON Kernkraft GmbH	PWR	1,430	1,360	1976-06-08	06/1976	1984-09-01
KKE	Lingen	NI	Kernkraftwerke Lippe-Ems GmbH	PWR	1,400	1,329	1982-08-04	08/1982	1988-04-14
KBR	Brokdorf	SH	E.ON Kernkraft GmbH	PWR	1,480	1,410	1976-10-25	01/1976	1986-10-08

Table I.2b: Survey of thermal and electrical capacity increases in the German nuclear power plants in operation
As of 31 December 2011

Nuclear Power Plant	Licenced thermal power at initial criticality [MW_{th}]	Thermal power increase [MWth]	Electricity output in MWe gross (in the year of initial criticality)	Year the electricity output was modified	Current electrical power [MW_e]	Capacity increase applied for [MW_{th}]
GKN 2	3,765 (4th partial operation licence of 28 Dec. 1988)	3,850 (3rd modification licence of 13 May 1991, application of 24 Oct. 1990)	1,316 (1988)	1,314 [1989] 1,316 (1990) 1,365 (1992) 1,395 (08/2004) 1,400 (01/2007)	1,400	3,965 (application of 25 April 2000)
KKP 2	3,765 (1st partial building licence of 6 July 1977)	3,803 (5th modification licence of 26 Nov. 1991, application of 5 Sep. 1991) 3,850 (8th modification licence of 8 May 1992, application of 7 March 1991) 3,950 (modification licence of 29 March 2000, application of 30 April 1998)	1,349 (1984)	1,357 (1991) 1,390 (1992) 1,402 (1993) 1,424 (1996) 1,458 (11/2000) 1,468 (01/2010)	1,468	-
KKI 2	3,765 (4th partial building licence of 12 July 1982)	3,850 (1st modification licence of 25 Feb. 1991, application of 16 Oct. 1990) 3,950 (5th modification licence of 20 Nov. 1998, application of 7 April 1998)	1,370 (1988)	1,390 (1989) 1,400 (1991) 1,410 (1993) 1,420 (1995) 1,440 (1996) 1,455 (1998) 1,475 (2000) 1,485 (2009)	1,485	-
KKG	3,765 (5th partial building licence of 10 Nov. 1981)	-	1,299 (1981)	1,300 (1984) 1,345 (1993)	1,345	3,950 (application of 16 May 2000)

Nuclear Power Plant	Licenced thermal power at initial criticality [MW_{th}]	Thermal power increase [MWth]	Electricity output in MWe gross (in the year of initial criticality)	Year the electricity output was modified	Current electrical power [MW_e]	Capacity increase applied for [MW_{th}]
KRB-II-B	3,840 (11th partial building licence of 18 Oct. 1984)	-	1,310 (1984)	1,300 (1987) 1,344 (1994)	1,344	4.100 (application of 14 Sep. 1999 for units B and C, withdrawn on 21 Dec. 2001) 4,000 (new application of 19 Dec. 2001 for units B and C)
KRB-II-C	Cf. KRB-II-B	-	1,310 (1984)	1,308 (1987) 1,344 (1995)	1,344	Cf. KRB-B
KWG	3,765 (1st partial building licence of 8 June 1976)	3,850 (modification licence of 9 Feb. 1990 (application of 27 June 1989) 3,900 (modification licence of 29 June 1999, application of 13 June 1997)	1,365 (1984)	1,394 (1990) 1,430 (1995)	1,430	4,000 (application of 24 Sep. 2007)
KKE	3,765 (4th partial licence of 30 March 1988)	3,850 (1st modification licence of 9 Feb. 1990, application of 6 June 1989)	1,316 (1988)	1,314 (1988) 1,341 (1990) 1,363 (1992) 1,400 (08/2000)	1,400	3,950 (application of 16 Dec. 2002)
KBR	3,765 (1st partial operation licence of 30 Dec. 1985)	3,850 (modification licence of 15 Feb. 1994 to 2. operation licence of 3 Oct. 1986) 3,900 (7th amending licence to 2. operation licence of 23 May 2006, application of 16 Dec. 2002)	1,380 (1986)	1,400 (1987) 1,395 (1988) 1,440 (1997) 1,480 (2008)	1,480	-

Table I.3: Nuclear power plants finally shut down

Nuclear Power Plant	Site	Land	Operator	Type	Capacity gross [MW_e]	Start of construc-tion	Initial criticality	Final shut-down
GKN 1	Neckarwestheim	BW	EnBW Kernkraft GmbH (EnKK)	PWR	840	02/1972	1976-05-26	2011-08-06
KKP 1	Philippsburg	BW	EnBW Kernkraft GmbH (EnKK)	BWR	926	10/1970	1979-03-09	2011-08-06
KKI 1	Essenbach	BY	E.ON Kernkraft GmbH	BWR	912	05/1972	1977-11-20	2011-08-06
KWB A	Biblis	HE	RWE Power AG	PWR	1,225	01/1970	1974-07-16	2011-08-06
KWB B	Biblis	HE	RWE Power AG	PWR	1,300	02/1972	1976-03-25	2011-08-06
KKU	Esenshamm	NI	E.ON Kernkraft GmbH	PWR	1,410	07/1972	1978-09-16	2011-08-06
KKB	Brunsbüttel	SH	Kernkraftwerk Brunsbüttel GmbH & Co. oHG	BWR	806	04/1970	1976-06-23	2011-08-06
KKK	Krümmel	SH	Kernkraftwerk Brunsbüttel GmbH & Co. oHG	BWR	1,402	04/1974	1983-09-14	2011-08-06

Table I.4: Nuclear power plants under decommissioning

Nuclear Power Plant	Site	Land	Operator	Type	Gross capacity [MW_e]	Start of construction	Initial criticality	Final shut-down	Status
KKR	Rheinsberg	BB	Energiewerke Nord GmbH	PWR	70	01/1960	1966-03-11	1990-06-01	Dismantling licence of 28 April 1995 ff.
KNK II	Eggenstein-Leopoldshafen	BW	Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH	FBR	21	09/1974	1977-10-10	1991-08-23	Dismantling licence of 26 Aug. 1993 ff.
MZFR	Eggenstein-Leopoldshafen	BW	Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH	PWR	57	12/1961	1965-09-29	1984-05-03	Dismantling licence of 17 Nov. 1987 ff.
KWO	Obrigheim	BW	EnBW Kernkraft GmbH (EnKK)	PWR	357	03/1965	1968-09-22	2005-05-11	1. Decomm. licence 28 Aug. 2008 2. Decomm. licence 24 Oct. 2011
KRB A	Gundremmingen	BY	Kernkraftwerk Gundremmingen GmbH	BWR	250	12/1962	1966-08-14	1977-01-13	Dismantling licence of 26 May 1983 ff.
KGR 1	Lubmin	MV	Energiewerke Nord GmbH	PWR	440	03/1970	1973-12-03	1990-12-18	Licence of 30 June 1995 ff. for decomm./dismantl. Entire plant
KGR 2	Lubmin	MV	Energiewerke Nord GmbH	PWR	440	03/1970	1974-12-03	1990-02-14	Licence of 30 June 1995 ff. for decomm./dismantl. Entire plant
KGR 3	Lubmin	MV	Energiewerke Nord GmbH	PWR	440	04/1972	1977-10-06	1990-02-28	Licence of 30 June 1995 ff. for decomm./dismantl. entire plant
KGR 4	Lubmin	MV	Energiewerke Nord GmbH	PWR	440	04/1972	1979-07-22	1990-06-02	Licence of 30 June 1995 ff. for decomm./dismantl. entire plant

Nuclear Power Plant	Site	Land	Operator	Type	Gross capacity [MW_e]	Start of construction	Initial criticality	Final shut-down	Status
KGR 5	Lubmin	MV	Energiewerke Nord GmbH	PWR	440	12/1976	1989-03-26	1989-11-30	Licence of 30 June 1995 ff. for decomm./dismantl. entire plant
KKS	Stade	NI	Kernkraftwerk Stade GmbH & Co. oHG	PWR	672	12/1967	1972-01-08	2003-11-14	Licence for decomm./dismantl. phase 1 of 7 Sep. 2005, phase 2 of 15 Feb. 2006 Phase 3 14 May 2009 Phase 4 4 Feb. 2011
KWL	Lingen, Ems	NI	Kernkraftwerk Lingen GmbH	BWR	252	10/1964	1968-01-31	1977-01-05	Licence for Safe Enclosure on 21 Nov. 1985; application for dismantling of facility of 15 Dec. 2008
AVR	Jülich	NW	Arbeitsgemeinschaft Versuchsreaktor GmbH	HTR	15	08/1961	1966-08-26	1988-12-31	1st Decomm. licence for Safe Enclosure on 9 March 1994 Licence for entire dismantl. of 31 March 2009
KWW	Würgassen	NW	E.ON Kernkraft GmbH	BWR	670	01/1968	1971-10-22	1994-08-26	1. Decomm. licence of 14 April 1997 ff.
THTR	Hamm-Uentrop	NW	Hochtemperatur-Kernkraftwerk GmbH	HTR	308	05/1971	1983-09-13	1988-09-29	Licence for operation of Safe Enclosure of 21 May 1997

Nuclear Power Plant	Site	Land	Operator	Type	Gross capacity [MW_e]	Start of construction	Initial criticality	Final shut-down	Status
KMK	Mülheim-Kärlich	RP	RWE Power AG	PWR	1,302	01/1975	1986-03-01	1988-09-09	Licence for decomm./dismantl. phase 1a 16 July 2004, supplemented 23 Feb. 2006, lic. for reduc. the plant premises 9 June 2009

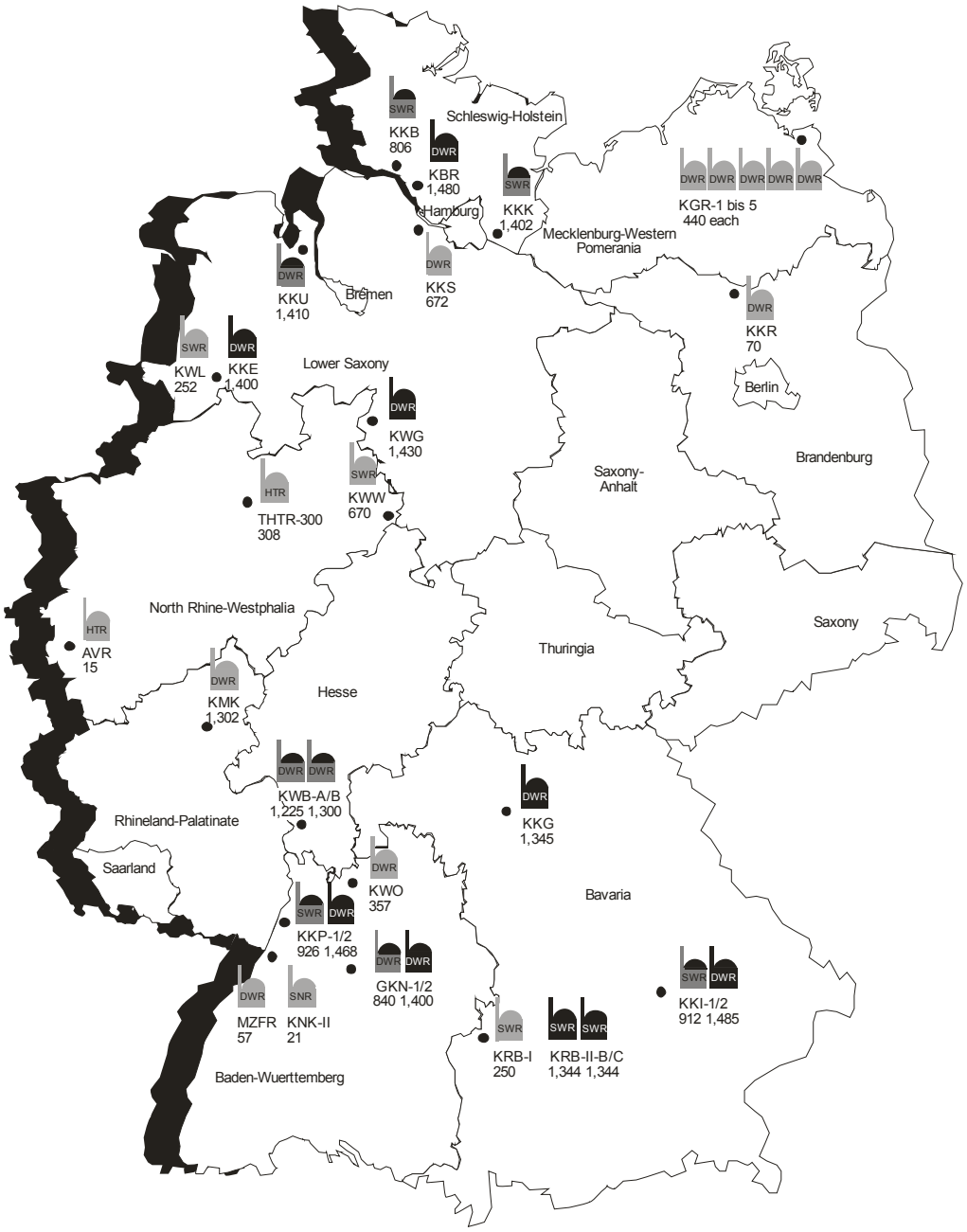
Table I.5: Nuclear power plants entirely dismantled and released from regulatory control

NPP	Site	Land	Operator	Type	Gross capacity [MW_e]	Start of construction	Initial criticality	Final shut-down	Status
HDR	Großwelzheim	BY	Karlsruhe Institute of Technology (KIT), formerly Forschungszentrum Karlsruhe GmbH	SSR	25	01/1965	1969-10-14	1971-04-20	Entirely dismantled
KKN	Niederaichbach	BY	Karlsruhe Institute of Technology (KIT), formerly Forschungszentrum Karlsruhe GmbH	PTR	106	06/1966	1972-12-17	1974-07-31	Entirely dismantled
VAK	Kahl, Main	BY	Versuchsatomkraftwerk Kahl GmbH	BWR	16	07/1958	1960-11-13	1985-11-25	Building and site released from regulatory control on 17 May 2010, dismantling concluded on 24 Sep. 2010

.

Table I.6: Stopped nuclear power plant projects

NPP	Site	Land	Operator	Type	Gross capacity [MW_e]	Start of construction	Final shut-down	Status
KGR 6	Lubmin	MV	Energiewerke Nord GmbH	PWR	440	1976	1989-11-30	Licence of 30 June 1995 ff. for decomm./dismantl. entire plant
KGR 7	Lubmin	MV	Energiewerke Nord GmbH	PWR	440	1976		Project stopped
KGR 8	Lubmin	MV	Energiewerke Nord GmbH	PWR	440	1976		Project stopped
SNR 300	Kalkar	NW	Schnell-Brüter-Kernkraftwerksgesellschaft mbH	FBR	327	1973		Project stopped 20 March 1991
Stendal A	Stendal	ST	Altmark Industrie GmbH	PWR	1,000	1976		Project stopped
Stendal B	Stendal	ST	Altmark Industrie GmbH	PWR	1,000	1976		Project stopped



Legend

In operation

Finally shut down

Under Decomminssioning

Data: Capacity gross MW_e

Status: As at 31.12.2011

Figure I: Nuclear power plants in Germany

ANNEX II – RESEARCH REACTORS –

As of 31 December 2011

Table II.1: Research reactors in operation (continuous thermal power above 50 kW_{th})

RR	Site	Land	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Status
BER II	Berlin	BE	Helmholtz-Zentrum Berlin (HMI)	Pool, MTR	10	$1.5 \cdot 10^{14}$	1973-12-09	In operation
FRM-II	Garching	BY	Technische Universität München (TUM)	Pool, Compact core	20	$8 \cdot 10^{14}$	2004-03-02	In operation
FRMZ	Mainz	RP	Universität Mainz Institut für Kernchemie	Pool, Triga Mark II	0.1	$4 \cdot 10^{12}$	1965-08-03	In operation

Table II.2: Research reactors finally shut down (continuous thermal power above 50 kW_{th})

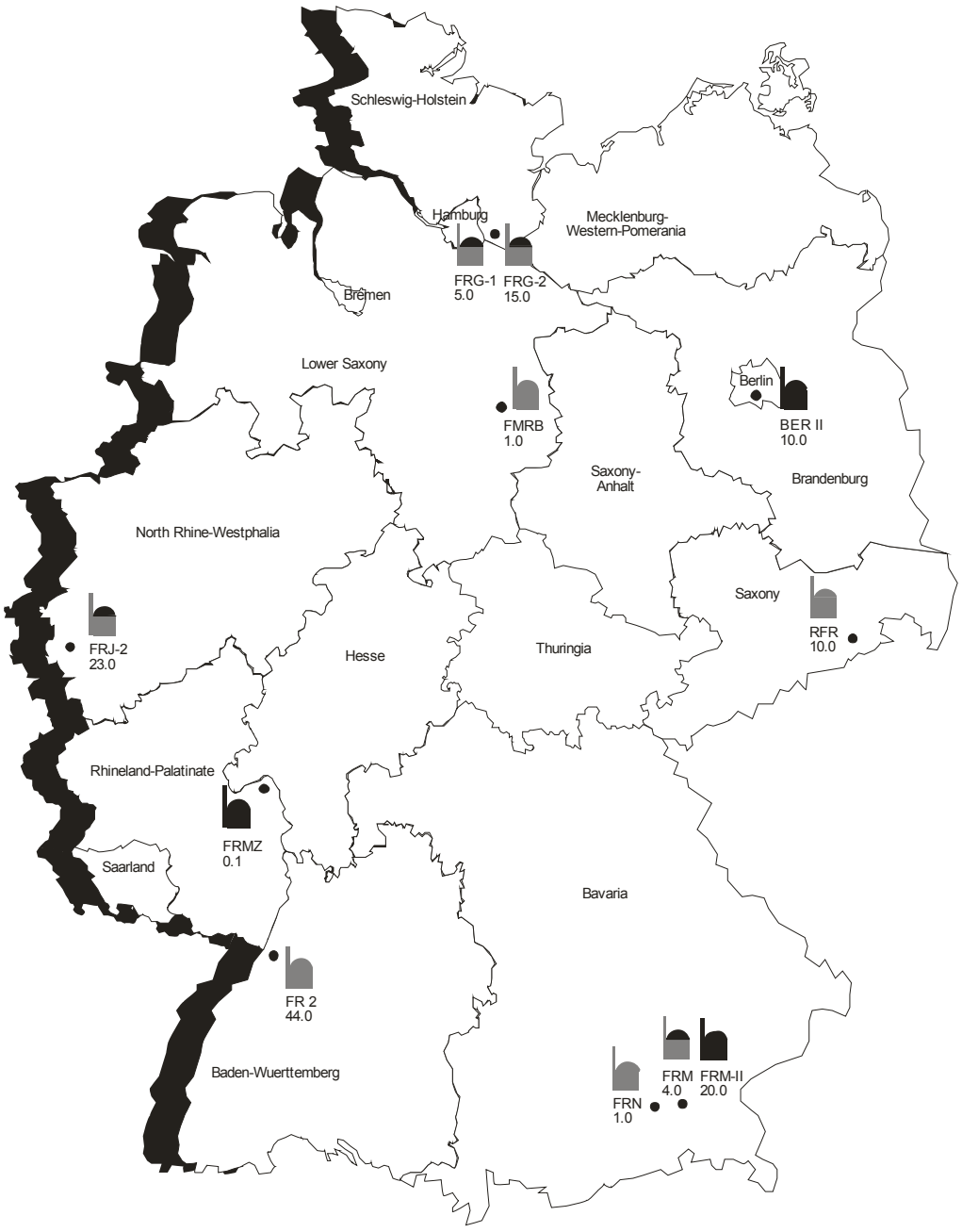
RR	Site	Land	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Status
FRM	Garching	BY	Technische Universität München (TUM)	Pool, MTR	4	$7 \cdot 10^{13}$	1957-10-31	2000-07-28	Application for decommissioning of 14 Dec. 1998
FRJ-2 (DIDO)	Jülich	NW	Forschungszentrum Jülich GmbH (FZJ)	Tank type D2O reactor	23	$2 \cdot 10^{14}$	1962-11-14	2006-05-02	Application for decommissioning of 27 April 2007
FRG-1	Geesthacht	SH	Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (GKSS)	Pool, MTR	5	$1.4 \cdot 10^{14}$	1958-10-23	Finally shut down on 28 June 2010	Application for decommissioning being prepared
FRG-2	Geesthacht	SH	Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (GKSS)	Pool, MTR	15	$1.5 \cdot 10^{14}$	1963-03-16	1993-01-28	Licence for shutting down and partial dismantling of 17 Jan. 1995, decommissioning together with FRG-1

Table II.3: Research reactors under decommissioning (continuous thermal power above 50 kW_{th})

RR	Site	Land	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Status
FR 2	Egg.-Leo-poldshafen	BW	Wiederaufarbeitungs-anlage Karlsruhe Rückbau- und Entsorgungs-GmbH	Tank type D_2O reactor	44	$1 \cdot 10^{14}$	1961-03-07	1981-12-21	Decommissioning licence of 3 July 1986 ff., Safe Enclosure since 20 Nov. 1996
FRN	Ober-schleißheim	BY	Helmholtz Zentrum München, German Research Centre for Environmental Health (HMGU)	Pool, Triga Mark III	1	$3 \cdot 10^{13}$	1972-08-23	1982-12-16	Decommissioning licence of 30 May 1983, Safe Enclosure since 24 May 1984
FRMB	Braunschweig	NI	Federal Institute of Physics and Metrology (PTB)	Pool, MTR	1	$6 \cdot 10^{12}$	1967-10-03	1995-12-19	Decommissioning licence of 2 March 2001, facility released from regulatory control by 28 July 2005, except for interim storage facility
RFR	Rossendorf	SN	Verein für Kernverfahrenstechnik und Analytik Rossendorf e.V. (VKTA)	Tank type WWR-S(M)	10	$1.2 \cdot 10^{14}$	1957-12-16	1991-06-27	Decommissioning licence of 30 Jan. 1998 ff. final partial licence for residual dismantling of 1 Feb. 2005

Table II.4: Research reactors entirely dismantled and released from regulatory control (continuous thermal power above 50 kW_{th})

RR	Site	Land	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Status
TRIGA HD I	Heidel-berg	BW	German Cancer Research Centre (DKFZ)	Pool, Triga Mark I	0.25	$1 \cdot 10^{13}$	1966-08-26	1977-03-31	Released from regulatory control on 13 Dec. 2006, within the scope of the clearance procedure the plant was conventionally dismantled in 2009 and the premises were completely rehabilitated.
TRIGA HD II	Heidel-berg	BW	German Cancer Research Centre (DKFZ)	Pool TRIGA Mark I	0.25	$1 \cdot 10^{13}$	1978-02-28	1999-11-30	Released from regulatory control on 13 Dec. 2006
FRF 2	Frankfurt	HE	Johann Wolfgang Goethe Universität Frankfurt	Modified TRIGA	1	$3 \cdot 10^{13}$ (designed)	No criticality	Not operated	Released from regulatory control on 31 Oct. 2006
FRH	Hannover	NI	Hannover Medical School	Pool TRIGA Mark I	0.25	$8.5 \cdot 10^{12}$	1973-01-31	1996-12-18	Released from regulatory control on 13 March 2008
FRJ-1 (MERLIN)	Jülich	NW	Forschungszentrum Jülich GmbH (FZJ)	Pool MTR	10	$1.1 \cdot 10^{14}$	1962-02-24	1985-03-22	Released from regulatory control on 23 Nov. 2007
OH	Geest-hacht	SH	Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (GKSS)	FDR Ship reactor	38	$2{,}8 \cdot 10^{13}$	1968-08-26	1979-03-22	Released from regulatory control on 1 Sep. 1982, storage of reactor pressure vessel according to StrlSchV



Legend

In operation

Finally shut down

Under Decomminssioning

Data: Thermal power MW_{th}

Status: As at 31.12.2011

Figure II: Research reactors with a continuous thermal power above 50 kW_{th}

ANNEX III – PLANTS OF NUCLEAR FUEL SUPPLY AND WASTE MANAGEMENT

As of 31 December 2011

Table III.1: Uranium enrichment plants

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
GRONAU URANIUM ENRICHMENT PLANT (UAG) **Gronau** **NW**	Uranium enrichment	4,500 Mg of uranium separative work per year (SW/a) according to notification of 14 Feb. 2005	3rd partial licence of 4 June 1985 (operation licence) 9. partial licence of 31 Oct. 1997; capacity increase to 1,800 Mg SW/a 7th partial/modification licence of 27 Nov. 1998, modification licence for two additional separation halls, Notification no. 7/6 of 14 Feb. 2005 on increase of production capacity to 4,500 Mg of SW/a	The licence of 14 Feb. 2005 also comprises the handling of depleted and enriched uranium (up to max. 6 w/o U-235). The expanded plant has been under construction since the middle of 2008 and is commissioned gradually. Production capacity was 4,200 Mg UTA/a at the end of 2011. Construction of a storage hall for 50,000 Mg U_3O_8 was taken up in 2011.

Table III.2: Fuel element fabrication plants

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
ANF FUEL ELEMENT FABRICATION PLANT **Lingen** **Lingen** **NI**	Fabrication of mainly LWR fuel elements of low-enriched uranium dioxide	Handling and processing of annually altogether 800 Mg of uranium in the form of uranium powder or uranium pellets with up to 5 w/o U-235	Operation licence of 18 Jan. 1979, 7th partial operation licence of 8 June 1994 (operation of conversion plant with enriched uranium) 7 March 1997: Capacity increase of fuel element fabrication by 250 Mg of externally produced uranium pellets per year 11 Jan. 2005: Increase of uranium powder throughput rate to 650 Mg/a 2 Dec. 2009: Increase of capacity to 800 Mg/a	ANF stores according to § 6 AtG certain types of radioactive waste determined for disposal from its own fuel element fabrication and UF_6 for third parties on its premises. A hall for the storage of UF6 containers has been taken into operation.

Table III.3: Fuel element fabrication plants (under decommissioning or released from regulatory control)

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
SIEMENS FUEL ELEMENT FABRICATION PLANT, PLANT SECTION KARLSTEIN **Karlsruhe** **BY**	Fabrication of fuel elements of low-enriched uranium dioxide	Annual throughput of 400 Mg of UO_2 up to max. 4.0 w/o U-235	Operation licence according to § 9 AtG: 2 Sep. 1966 Operation licence according to § 7 AtG: 30 Dec. 1977 Licence according to § 7 AtG for dismantling of plant components: 16 Aug. 1994 and 18 March 1996 Released from regulatory control March 1999	Fuel element fabrication has been discontinued; conventional fabrication of ends.
SIEMENS FUEL ELEMENT FBRICATION PLANT HANAU PLANT SECTION: MOX-PROCESSING **Hanau** **HE**	Fabrication of MOX fuel elements of plutonium and uranium mainly for use in LWR	Throughput of about 35 Mg HM/a, expansion to 120 Mg of HM/a was planned	Operation licence according to § 9 AtG: 16 Aug. 1968 Last comprehensive licence according to § 9 AtG of 30 Dec. 1974 6. Partial building licence acc. to § 7 AtG of 12 March 1991 Several partial licences for removing the fuel from the production line and dismantling of the plant for MOX fuel from 1997 to 2005 Released from regulatory control Sep. 2006	In April 1994, the operator decided to not re-commission the old plant. The fabrication facilities have been dismantled. Government custody has been terminated. Dismantling work completed in July 2006.
SIEMENS FUEL ELEMENT FABRICATION PLANT, HANAU PLANT SECTION: URANIUM-PROCESSING **Hanau** **HE**	Fabrication of LWR fuel elements of low-enriched uranium	Throughput 1,350 Mg U/a	Operation licence according to § 9 AtG: 22 July 1969 Operation licence according to § 7 AtG: 31 Aug. 1990 Several individual and partial licences for removing the fuel of the production line and for dismantling the facility from 1996 to 2001 Released from regulatory control May 2006	Fabrication of uranium fuel elements stopped in October 1995. Dismantling work incl. remediation of the premises was completed in January 2006. Groundwater decontamination still continues (licence according to § 7 StrlSchV).

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
NUKEM FUEL ELEMENT FABRICATION PLANT **Hanau-Wolfgang** **HE**	Fabrication of fuel elements of enriched uranium and thorium for research reactors	100 kg U-235 enrichment up to 20 w/o; 1,700 kg U-235 enrichment between 20 w/o and 94 w/o; 100 Mg natural uranium; 100 Mg depleted uranium; 200 Mg thorium	Operation licence according to § 9 AtG: 30 July 1962 Several licences for decommissioning, dismantling and remediation of the site between 1988 and 2001 Released form regulatory control in May 2006, except for a partial area of 1,000 m2 for further groundwater decontamination	Operation licence discontinued on 15 Jan. 1988; by 31 Dec. 1988 the fuel was removed from the production line Dismantling works and soil remediation have been completed. Groundwater remediation is still continuing.
HOCHTEMPERATUR-BRENNELEMENT-GESELLSCHAFT (HOBEG) **Hanau** **HE**	Fabrication of ball-shaped fuel elements for HTR on the basis of uranium (up to 94 w/o of uranium 235) and thorium	200,000 Fuel elements/a 11.7 Mg HM (during operation time)	Operation licence according to § 9 AtG: 30 Dec. 1974. 9 licences for dismantling and decommissioning between 5 Dec. 1988 and 7 April 1995. On 18 Dec. 1995 released from regulatory control.	The facility was temporarily taken out of operation on 15 Jan. 1988, and was decommissioned later on. The components relating to process engineering were dismantled. Decontamination of premises and building has been completed. Premises and buildings are used by Nuclear Cargo & Service GmbH.

Table III.4: Fuel element interim storage facilities

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
TRANSPORT CASK STORAGE FACILITY IN THE INTERIM STORAGE FACILITY NORTH (ZLN) **Rubenow** **MV**	Storage of spent fuel elements from the Rheinsberg and Greifswald reactors in transport and storage casks (dry storage).	585.4 Mg HM in max. 80 storage casks Max. storable activity: $7.5 \cdot 10^{18}$ Bq	According to § 6 AtG of 5 Nov. 1999 1st modification licence of 14 March 2001 2nd modification licence of 7 July 2003 3rd modification licence of 19 Dec. 2005 4th modification licence of 17 Feb. 2006 5th modification licence of 17 Dec. 2008 6th modification licence of 24 Feb. 2009 7th modification licence of 30 April 2010	On 31 Dec. 2011, 74 casks were stored in the ZLN: - 62 CASTOR® 440/84 - 3 CASTOR® KRB-MOX - 4 CASTOR® KNK. - 5 CASTOR HAW 20/28 CG.
TRANSPORT CASK STORAGE FACILITY GORLEBEN (TBL-G) **Gorleben** **NI**	Storage of spent fuel elements in transport and storage casks and of solidified HAW fission product solutions and other radioactive waste (dry storage).	3,800 Mg HM or 420 cask storing positions; Max. storable activity: $2 \cdot 10^{20}$ Bq	5 Sep. 1983 according to § 6 AtG; order for immediate enforcement of 6 Sep. 1988 New licence of 2 June 1995 for spent fuel elements and vitrified fission product solutions 1st modification licence of 1 Dec. 2000 2nd modification licence of 18 Jan. 2002 3rd modification licence of 23 May 2007 4th modification licence of 29 Jan. 2010	On 31. Dec. 2011, altogether 113 casks were stored in the TBL-G, - 5 casks with spent fuel elements, of which - 1 CASTOR® Ic - 1 CASTOR® IIa, - 3 CASTOR® V/19 and 108 casks with HAW vitrified waste block canisters, of which - 1 TS 28 V, - 74 CASTOR® HAW 20/28 CG, - 21 CASTOR® HAW 28M - 12 TN85.

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
TRANSPORT CASK STORAGE FACILITY AHAUS (TBL-A) **Ahaus** **NW**	Storage of spent fuel elements in transport and storage casks of the CASTOR® type (dry storage).	420 cask storing positions (LWR) Capacity up to altogether max. 3,960 Mg HM Max. storable activity: $2 \cdot 10^{20}$ Bq	10 April 1987 acc. to § 6 AtG amended version of the storage licence of 7 Nov. 1997 (increase of the mass of HM and licence for further cask types) 1st modification licence of 17 May 2000 2nd modification licence of 24 April 2001 3rd modification licence of 30 March 2004 4th modification licence of 4 July 2008 5th modification licence of 22 Dec. 2008 6th modification licence of 26 May 2010	In April 1995 the emplacement of 305 CASTOR® THTR/AVR casks with fuel elements of the THTR-300 was terminated. In 1998 additionally - 2 CASTOR® V/191 CASTOR® V/19 SN06 and - 3 CASTOR® V/52 were taken to the TBL-A. In 2005, 18 CASTOR® MTR 2 casks were stored which were transported from Rossendorf to Ahaus

Table III.5: On-site interim storage facilities

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
ON-SITE INTERIM STORAGE FACILITY NECKARWESTHEIM **Gemmrigheim** **BW**	Storage of spent fuel elements from units GKN 1 and GKN II of the Neckar Joint NPP	1,600 Mg of heavy metal in up to 151 transport and storage casks with up to $8.3 \cdot 10^{19}$ Bq activity and 3.5 MW heat release	According to § 6 AtG of 22 Sep. 2003 1st modification licence of 22 March 2006 2nd modification licence of 28 Sep. 2006 1st amendment to the licence of 3 Sep. 2007 2nd amendment to the licence of 18 Feb. 2010 3rd modification licence of 11 May 2010	Start of construction 17 Nov. 2003 First emplacement 6 Dec. 2006 At the end of 2011 41 casks were stored in the interim storage facility
ON-SITE INTERIM STORAGE FACILITY PHILIPPSBURG **Philippsburg** **BW**	Storage of spent fuel elements from units 1 and 2 of the Philippsburg NPP	1,600 Mg of heavy metal in up to 152 transport and storage casks with up to $1.5 \cdot 10^{20}$ Bq activity and 6.0 MW heat release	According to § 6 AtG of 19 Dec. 2003 1st modification licence of 5 Oct. 2006 2nd modification licence of 21 Dec. 2006	Start of construction 17 May 2004 First emplacement 19 March 2007 At the end of 2011 36 casks were stored in the interim storage facility
INTERIM STORAGE FACILITY OBRIGHEIM NPP **Obrigheim** **BW**	Storage of spent fuel elements and core components from the Obrigheim NPP (wet storage)	980 fuel elements (ca. 286 Mg HM)	26 Oct. 1998 acc. to § 7 AtG	Since the end of 2007 342 fuel elements have been in the fuel pool

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
ON-SITE INTERIM STORAGE FACILITY GRAFENRHEINFELD **Grafenrheinfeld** **BY**	Storage of spent fuel elements from the Grafenrheinfeld NPP	800 Mg of heavy metal in up to 88 transport and storage casks with up to $5 \cdot 10^{19}$ Bq activity and 3.5 MW heat release	According to § 6 AtG of 12 Feb. 2003 Order for immediate enforcement of 10 Sep. 2003 1st modification licence of 31 July 2007 2nd modification licence of 6 Oct. 2011 3rd modification licence of 3 Nov. 2011	Start of construction 22 Sep. 2003 First emplacement 27 Feb. 2006 At the end of 2011 13 casks were stored in the interim storage facility
ON-SITE INTERIM STORAGE FACILITY GUNDREMMINGEN **Gundremmingen** **BY**	Storage of spent fuel elements from units B and C of the Gundremmingen NPP	1,850 Mg of heavy metal in up to 192 transport and storage casks with up to $2.4 \cdot 10^{20}$ Bq activity and 6.0 MW heat release	According to § 6 AtG of 19 Dec. 2003 Order for immediate enforcement on 28 July 2004 1st modification licence of 2 June 2006	Start of construction 23 Aug. 2004 First emplacement 25 Aug. 2006 At the end of 2011 34 casks were stored in the interim storage facility
ON-SITE INTERIM STORAGE FACILITY ISAR **Niederaichbach** **BY**	Storage of spent fuel elements from Isar 1 and Isar 2 NPPs	1,500 Mg of heavy metal in up to 152 transport and storage casks with up to $1.5 \cdot 10^{20}$ Bq activity and 6.0 MW heat release	According to § 6 AtG of 22 Sep. 2003 Order for immediate enforcement of 28 May 2004 1st modification licence of 11 Jan. 2007 2nd modification licence of 29 Feb. 2008 3rd modification licence of 16 Nov. 2011	Start of construction 14 June 2004 First emplacement 12 March 2007 At the end of 2011 22 casks were stored in the interim storage facility
ON-SITE INTERIM STORAGE FACILITY BIBLIS **Biblis** **HE**	Storage of spent fuel elements from units A and B of the Biblis NPP	1,400 Mg of heavy metal in up to 135 transport and storage casks with up to $8.5 \cdot 10^{19}$ Bq activity and 5.3 MW heat release	According to § 6 AtG of 22 Sep. 2003 1st modification licence of 20 Oct. 2005 1st amendment to the licence of 20 March 2006 2nd modification licence of 27 March 2006	Start of construction 1 March 2004 First emplacement 18 May 2006 At the end of 2011 51 casks were stored in the interim storage facility

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
ON-SITE INTERIM STORAGE FACILITY GROHNDE **Grohnde** **NI**	Storage of spent fuel elements from the Grohnde NPP	1,000 Mg of heavy metal in up to 100 transport and storage casks with up to $5.5 \cdot 10^{19}$ Bq activity and 3.75 MW heat release	According to § 6 AtG of 20 Dec. 2002 Order for immediate enforcement of 19 Sep. 2005 1st modification licence of 17 April 2007	Start of construction 10 Nov. 2003 First emplacement 27 April 2006 At the end of 2011 13 casks were stored in the interim storage facility
ON-SITE INTERIM STORAGE FACILITY LINGEN (EMSLAND) **Bramsche (near Lingen)** **NI**	Storage of spent fuel elements from the Emsland NPP	1,250 Mg of heavy metal in up to 125 transport and storage casks with up to $6.9 \cdot 10^{19}$ Bq activity and 4.7 MW heat release	According to § 6 AtG of 6 Nov. 2002 with order for immediate enforcement 1st amendment to the licence of 31 July 2007 1st modification licence of 1 Feb. 2008	Start of construction 18 Oct. 2000 First emplacement 10 Dec. 2002 At the end of 2011, 32 casks were stored in the interim storage facility
ON-SITE INTERIM STORAGE FACILITY UNTERWESER **Rodenkirchen** **NI**	Storage of spent fuel elements from the Unterweser NPP	800 Mg of heavy metal in up to 80 transport and storage casks with up to $4.4 \cdot 10^{19}$ Bq activity and 3.00 MW heat release	According to § 6 AtG of 22 Sep. 2003 Order for immediate enforcement of 5 Feb. 2007 1st modification licence of 27 May 2008	Start of construction 19 Jan. 2004 First emplacement 18 June 2007 At the end of 2011 8 casks were stored in the interim storage facility
AVR CASK STORAGE FACILITY IN THE FZJ **Jülich** **NW**	Storage of spent AVR fuel elements in transport and storage casks of the CASTOR® type	Up to 300,000 AVR fuel elements in max. 158 CASTOR® THTR/AVR casks	Notification according to § 6 AtG of 17 June 993 1st modification licence of 27 April 1995 modification licence of 7 Juliy 2005	On 31. Dec. 2010, 152 casks of the CASTOR® THTR/AVR type were stored in the interim storage facility.
ON-SITE INTERIM STORAGE FACILITY KRÜMMEL **Krümmel (near Geesthacht)** **SH**	Storage of spent fuel elements from the Krümmel NPP	775 Mg of heavy metal in up to 80 transport and storage casks with up to $9.6 \cdot 10^{19}$ Bq activity and 3.00 MW heat release	According to § 6 AtG of 19 Dec. 2003 1st modification licence of 16 Nov. 2005 Order for immediate enforcement of 28 April 2006 2nd modification licence of 17 Oct. 2007	Start of construction 23 April 2004 First emplacement 14 Nov. 2006 At the end of 2011 19 casks were stored in the interim storage facility

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
ON-SITE INTERIM STORAGE FACILITY BROKDORF **Brokdorf SH**	Storage of spent fuel elements from the Brokdorf NPP	1,000 Mg of heavy metal in up to 100 transport and storage casks with up to $5.5 \cdot 10^{19}$ Bq activity and 3.75 MW heat release	According to § 6 AtG of 28 Nov. 2003 1st modification licence of 24 May 2007	Start of construction 5 April 2004 First emplacement 5 March 2007 At the end of 2011 14 casks were stored in the interim storage facility
ON-SITE INTERIM STORAGE FACILITY BRUNSBÜTTEL **Brunsbüttel SH**	Storage of spent fuel elements from the Brunsbüttel NPP	450 Mg of heavy metal in up to 80 transport and storage casks with up to $6.0 \cdot 10^{19}$ Bq activity and 2.0 MW heat release	According to § 6 AtG of 28 Nov. 2003 Order for immediate enforcement of 28 Oct. 2005 1st modification licence of 14 March 2008	Start of construction 7 Oct. 2003 First emplacement 5 Feb, 2006 At the end of 2011, 6 casks were stored in the interim storage facility

Table III.6: External waste interim storage facilities

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
HAUPTABTEILUNG DEKONTAMINATIONS-BETRIEBE **Eggenstein-Leopoldshafen** **BW**	1.) Waste with negligible heat generation, 2.) Heat-generating waste incl. waste produced by some clients	1.) 77,424 m³ (storage volume) 2.) 1,240 m³ (storage volume)	Licence for use and manipulation according to § 9 AtG of 25 Nov. 1983, replaced by licence according to § 9 AtG of 29 June 2009	In operation since December 1964.
COLLECTING DEPOT OF THE UTILITIES MITTERTEICH **Mitterteich** **BY**	Interim storage of waste with negligible heat generation from Bavarian nuclear facilities	40,000 waste packages (200-l, 400-l, or cast-iron casks)	Licences for use and manipulation according to § 3 StrlSchV of 7 July 1982	In operation since July 1987.
ON-SITE INTERIM STORAGE FACILITY BIBLIS **Biblis** **HE**	Interim storage of other radioactive substances in the scope of a combined utilisation of the on-site interim storage facility	Up to a total activity of $1 \cdot 10^{17}$ Bq	Licence for use and manipulation according to § 7 StrlSchV of 13 Dec. 2006	Max. ten years starting at the beginning of emplacement
INTERIM STORAGE FACILITY NORTH (ZLN) **Rubenow** **MV**	Interim storage of operational and decommissioning waste of the Greifswald and Rheinsberg NPPs with interim storage of the dismantled large components	200,000 m^3	Licence for use and manipulation according to § 3 StrlSchV of 20 Feb. 1998	In operation since March 1998. Since 11 Dec. 2007 the ZLN is licencee of storage of radioactive substances from other nuclear facilities with LWR with five years prior to and after a treatment/conditioning each.
WASTE STORAGE FACILITY ESENSHAMM **Esenshamm** **NI**	Storage of waste with negligible heat generation from the Unterweser and Stade NPPs	200-l and 400-l drums, concrete casks, steel-plate casks, concrete containers, cast-iron casks with a total activity of up to $1.85 \cdot 10^{15}$ Bq	Licences for use and manipulation according to § 3 StrlSchV of 24 June 1981, 29 Nov. 1991, and 6 Nov. 1998	In operation since autumn of 1981.

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
WASTE STORAGE FACILITY GORLEBEN (DRUM STORAGE FACILITY) **Gorleben** **NI**	Storage of waste with negligible heat generation from NPPs, medicine, research, and crafts	200-l, 400-l-drums, possibly with lost concrete shielding, type-III concrete casks, type-I-II cast-iron casks, type-I-IV casks with a total activity of up to $5 \cdot 10^{18}$ Bq	Licences for use and manipulation according to § 3 StrlSchV of 27 Oct. 1983, 13 Oct. 1987, and 13 Sep. 1995	In operation since October 1984.
TRANSPORT CASK STORAGE FACILITY AHAUS (TBL-A) **Ahaus** **NW**	Interim storage of other radioactive substances in the scope of a combined utilisation of the TBL-A	Up to a total activity of $1 \cdot 10^{17}$ Bq	Licence for use and manipulation according to § 7 StrlSchV of 9 Nov. 2009	Max. ten years starting at the beginning of emplacement

Table III.7: Reprocessing plants (under decommissioning)

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
KARLSRUHE REPROCESSING PLANT (WAK) **Eggenstein-Leopoldshafen BW**	Experimental plant for reprocessing and technology development	0.175 Mg HM/day; ca. 40 Mg UO_2/a	Operation WAK: 1st partial operation licence according to § 7 AtG of 2 Jan. 1967 Decommissioning WAK: 1st decommissioning licence, March 1993 21st decommissioning licence and dismantling of the WAK (step 4) of 23 April 2010 for deregulation after end of vitrification 22nd decommissioning licence acc. to § 7 AtG of 8 Dec. 2010 for remote-handled dismounting of the HAWC storage casks in the HWL and in the LAVA. 23rd decommissioning licence of 14 Dec. 2011 for the dismounting of the LAVA high-active laboratory and the LAVA (hot) cells. Operation VEK: 1st partial operating licence (TBG) for the VEK of 20 Dec. 2005 (inactive commissioning) 2nd partial operating licence for the VEK of 24 Feb. 2009 (nuclear [hot] commissioning)	The plant was in operation from 1971 to 1990. During this period approximately 200 Mg of nuclear fuels originating from test and power reactors were reprocessed. Decommissioning and dismantling with the objective of "Greenfield" until 2023 have made progress. The major part of the equipment of the process building has been removed. Dismantling of the MAW collecting containers concluded in 2011. A vitrification plant (VEK) for 60 m^3 of HAWC was constructed and operated until November 2010. The HAWC was entirely vitrified, producing 140 vitrified waste block canisters (56 Mg), which were packed into 5 transport and storage casks of the CASTOR HAW 20/28 type. Since February 2011, the CASTOR casks have been stored in the Interim Storage Facility North of the EWN GmbH. Thus essential prerequisites have been created for the dismantling of the VEK and the HAWC storage facilities.

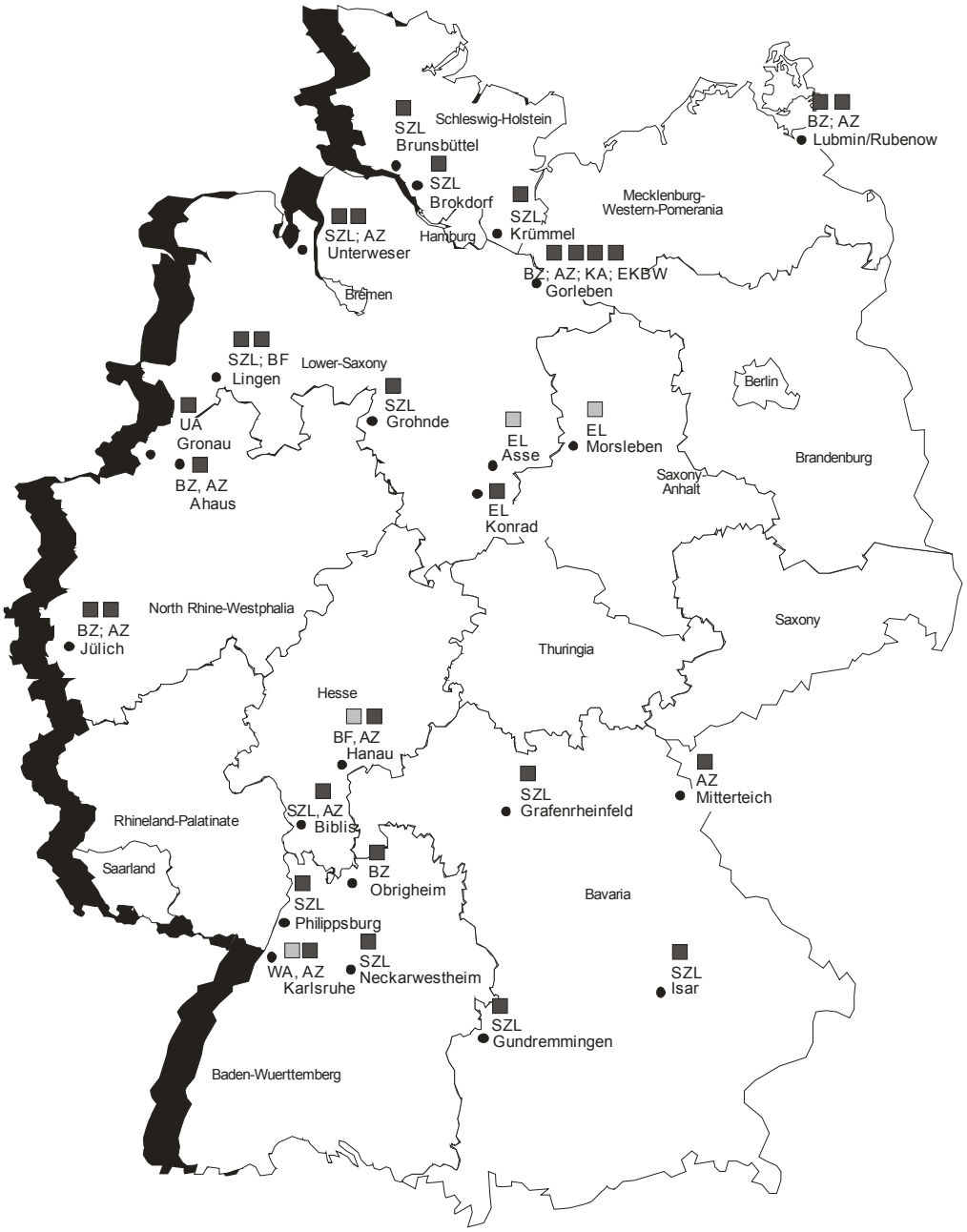
Table III.8: Conditioning plants for fuel elements

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
PILOT CONDITIONING PLANT (PKA) **Gorleben** **NI**	Repair of defective casks, conditioning of radioactive residues and waste (among others, spent fuel elements, fuel rods and fuel element components) for interim storage and disposal	Heavy metal throughput applied for: 35 Mg/a Capacity of operational buffer storage facility: 12 Mg HM	Acc. to § 7 AtG 1st partial licence of 30 Jan. 1990 2nd partial licence of 21 July 1994 (Subsequently imposed obligation of 18 Dec. 2001) 3rd partial licence: 19 Dec. 2000 (includes operation licence)	According to the 3rd partial licence the use of the plant is at first restricted to the repair of defective storage casks. An additional requirement to the 2nd partial licence ensures that one is ready to accept defective casks at any time.

Table III.9: Disposal

Name of facility and site	Purpose of the facility	Amounts disposed of / activity	Licence	Notes
MINE FOR THE EXPLORATION OF THE GORLEBEN SALT DOME **Gorleben** **NI**	Proof that the site is suitable for the disposal of all types of radioactive waste		The application for a plan-approval decision according to § 9b AtG was filed in 1977. The exploration mine is operated on the basis of the approved main operating plan (effective until 30 Sep. 2012) and the overall operating plan (effective until 30 Sep. 2020).	The geological host formation is rock salt.
KONRAD REPOSITORY **Salzgitter** **NI**	Disposal of radioactive waste with negligible heat generation		Application according to § 9b AtG in 1982 (plan-approval application) Withdrawal of the application for immediate enforcement with BfS letter of 17 July 2000. The plan-approval decision (licence) was granted on 22 May 2002. After legal remedies have been exhausted following claims against the plan-approval decision, it has been legally binding since 26 March 2007 and can be implemented. Pending constitutional complaints have not been admitted or have not been accepted for decision. With approval of the main operating plan on 15 Jan. 2008, this licence was granted for a term of six years. Thus also the required second licence for the construction is available.	The geological host rock formation is coral oolite (iron ore) undeneath an impermeable barrier of the Cretaceous.

Name of facility and site	Purpose of the facility	Amounts disposed of / activity	Licence	Notes
ASSE REPOSITORY FOR RADIOACTIVE WASTE **Remlingen** **NI**	Research and development work for the disposal of radioactive and chemico-toxic waste Disposal of low-level and intermediate-level radioactive waste	Between 1967 and 1978 ca. 124,500 LAW and ca. 1,300 MAW waste packages were emplaced. According to current knowledge, total activity $2.89 \cdot 10^{15}$ Bq (1 Jan. 2010), 20 % of which are contained in the MAW	Licences according to § 3 StrlSchV as amended on 15 Oct. 1965. Storage licences for nuclear fuels according to § 6 AtG. Licence acc. to § 7 StrlSchV granted on 8 July 2010 for the handling of other radioactive substances outside the emplacement chambers up to the 100-fold of the exemption limit. Licence according to § 9 AtG for the use and manipulation of nuclear fuels and other radioactive materials in the scope of the fact-finding procedure step 1 of 21 April 2011.	The geological host rock formation is rock salt. Since 1 Jan. 2009, the BfS has been operator. Conversion into operation according to Atomic Energy Act.
MORSLEBEN REPOSITORY FOR RADIOACTIVE WASTE (ERAM) **Morsleben** **ST**	Disposal of low-level and medium-level radioactive waste with mainly short-lived radionuclides	Disposal of altogether 36,753 m^3 of low-level and intermediate-level radioactive waste, total activity of all radioactive waste stored is in the order of magnitude of less than $3.3 \cdot 10^{14}$ Bq, the activity of the alpha-emitters is in the order of magnitude of 10^{11} Bq (as of 31 Dec. 2010).	22 April 1986: Continuous operating licence (DBG) granted. According to § 57a AtG it continued to be effective until 30 June 2005; through amendment to the AtG in 2002, the DBG is effective for an unlimited period of time as plan-approval decision, except for the regulations relating to the acceptance of further radioactive waste or its emplacement for the purpose of disposal. 12 April 2001: Declaration of the BfS to waive the acceptance of further radioactive waste for disposal	The geology of the emplacement areas is determined by potash and rock salt formations. Emplacement operations stopped on 25 Sep. 1998. Conversion of the mine and keeping it open were applied for on 10 July 2003. Decommissioning was applied for on 9 May 1997. The documents required for the public participation procedure were submitted to the licensing authority (MLU) in February 2005; they were revised subsequently and submitted in February 2009. The documents were laid open to public inspection from October to December 2009 within the scope of the public participation procedure. Approximately 15,000 objections were raised. The objections were discussed in October 2011.



Legend

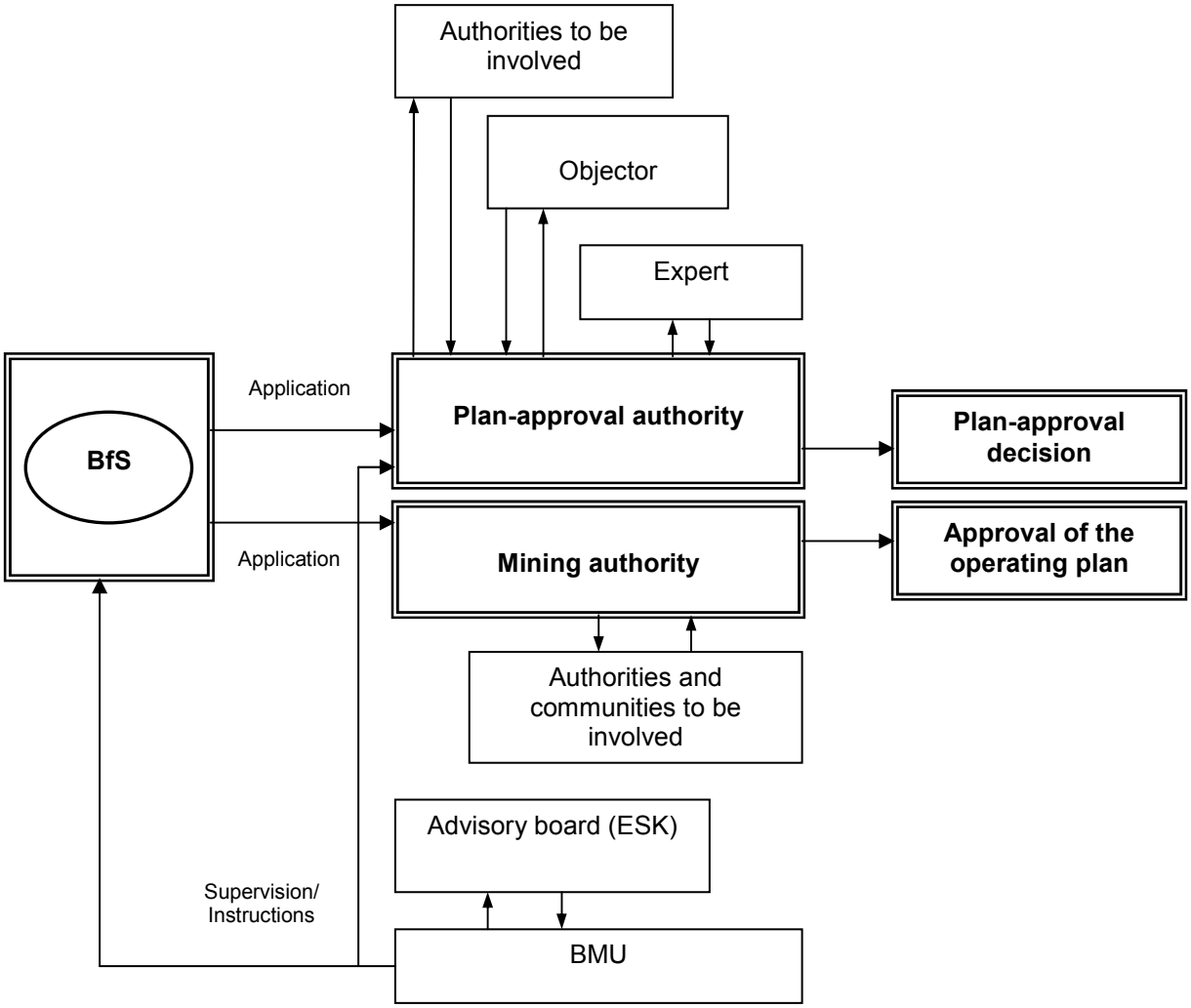
AZ	Rad. waste interim storage facility	KA	Pilot conditioning plant
BF	Fuel element fabrication plant	SZL	On-site interim storage facility
BZ	Fuel element interim storage facility	UA	Uranium enrichment plant
EKBW	Exploration mine	WA	Radioactive waste repository
EL	Radioactive waste repository		

In operation/ being planned

Under Decommissioning

Status: As at 31.12.2011

Figure III.1: Plant sites of nuclear fuel supply and waste management



Legend:

BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BfS	Federal Office for Radiation Protection
ESK	Nuclear Waste Management Commission

Figure III.2: Cource of the plan-approval (licensing) procedure and the procedures according to Mining Law for radioactive waste repositories

Bisher erschienene BfS-SK-Berichte (vorher BfS-KT-Berichte)

BfS-KT-1/92
Gersinska, R.; Hennig, R.; Kociok, B. (Hrsg.)
Zweites Expertengespräch zum BMU/BfS-Konzept Mensch-Maschine-Wechselwirkung in Kernkraftwerken am 5. und 6. März 1992 beim Bundesamt für Strahlenschutz in Salzgitter
Salzgitter, April 1992

BfS-KT-2/92
Berg, H.P.; Schott, H.
Stand von Wissenschaft und Technik auf dem Gebiet der Quantifizierung der menschlichen Zuverlässigkeit - Dezember 1991 -
Salzgitter, Februar 1992

BfS-KT-3/92
Berg, H.P.; Schott, H.
Probabilistische Sicherheitsanalysen
Aktueller Status, Weiterentwicklung von Methoden und Modellen, Anwendungen
Salzgitter, Dezember 1992

BfS-KT-3/92-REV-1
Berg, H.P.; Schott, H.
Probabilistische Sicherheitsanalysen
Aktueller Status, Weiterentwicklung von Methoden und Modellen, Anwendungen
Salzgitter, April 1993

BfS-KT-4/93
Ziegenhagen, J.
Zusammenstellung der Genehmigungswerte für Ableitungen radioaktiver Stoffe mit der Fortluft und dem Abwasser aus den Kernkraftwerken der Bundesrepublik Deutschland – Dezember 1992
Salzgitter, April 1993

BfS-KT-5/93
Philippczyk, F.; Ziegenhagen, J.
Stand und Entwicklung der Kernenergienutzung in der Bundesrepublik Deutschland
Stand: Mai 1993.
Salzgitter, Mai 1993

BfS-5/93-REV-1
Philippczyk, F.; Ziegenhagen, J.
Stand und Entwicklung der Kernenergienutzung in der Bundesrepublik Deutschland
Stand: Mai 1993.
Salzgitter, Juli 1993

BfS-5/93-REV-2
Philippczyk, F.; Ziegenhagen, J.
Stand und Entwicklung der Kernenergienutzung in der Bundesrepublik Deutschland. Stand: Mai 1993.
Salzgitter, Oktober 1993

BfS-5/93-REV-3
Philippczyk, F.; Ziegenhagen, J.
Stand und Entwicklung der Kernenergienutzung in der Bundesrepublik Deutschland
Stand: Mai 1993.
Salzgitter, Mai 1994

Bisher erschienene BfS-SK-Berichte (vorher BfS-KT-Berichte)

BfS-KT-6/93
KT/KTA-Winterseminar 1993 – 28. und 29. Januar 1993 in Salzgitter
Kerntechnik in der Bundesrepublik Deutschland im Jahre 1993. Aufgaben, Probleme, Perspektiven aus der Sicht der Beteiligten
Salzgitter, Juli 1993

BfS-KT-7/94
Gersinska, R.; Hennig, R.; Kociok, B.
Drittes Expertengespräch zum BMU/BfS-Konzept "Mensch-Maschine-Wechselwirkung in Kernkraftwerken" am 28. und 29. April 1994 beim Bundesamt für Strahlenschutz in Salzgitter
Salzgitter, April 1994

BfS-KT-8/94
2. KT/KTA-Winterseminar 20. und 21. Januar 1994 in Salzgitter
Erhaltung und Verbesserung der Reaktorsicherheit
Salzgitter, Juli 1994

BfS-KT-9/95
Meldepflichtige Ereignisse in der Wiederaufarbeitungsanlage Karlsruhe im Zeitraum 1. Januar bis 31. Dezember 1993
Salzgitter, März 1995

BfS-KT-10/95
Philippczyk, F.; Hutter, J.
Stand und Entwicklung der Kernenergienutzung 1994 in der Bundesrepublik Deutschland
Salzgitter, Mai 1995

BfS-KT-11/95
3. KT/KTA-Winterseminar. 19. und 20. Januar 1995 in Salzgitter
EDV in der Kerntechnik
Salzgitter, Juli 1995

BfS-KT-12/96
Krüger, F. W.
Quality assurance of a regulatory body
Salzgitter, April 1996

BfS-KT-13/96
4. KT/KTA-Winterseminar. 25. und 26. Januar 1996 in Salzgitter
Alterungsmanagement in Kernkraftwerken
Salzgitter, Mai 1996

BfS-KT-14/96
Philippczyk, F, Hutter, J.
Stand und Entwicklung der Kernenergienutzung 1995 in der Bundesrepublik Deutschland
Salzgitter, Juni 1996

BfS-KT-15/96
Berg, H.P., Görtz, R., Schaefer, T., Schott, H.
Quantitative probabilistische Sicherheitskriterien für Genehmigung und Betrieb kerntechnischer Anlagen: Status und Entwicklung im internationalen Vergleich
Salzgitter, September 1996

Bisher erschienene BfS-SK-Berichte (vorher BfS-KT-Berichte)

BfS-KT-16/97
Facharbeitskreis Probabilistische Sicherheitsanalyse.
Methoden zur probabilistischen Sicherheitsanalyse für Kernkraftwerke – Dezember 1996
Salzgitter, Juni 1997

BfS-KT-17/97
Arbeitsgruppe Schutzzielkonzept.
Schutzzielorientierte Gliederung des kerntechnischen Regelwerks
Übersicht über die übergeordneten Anforderungen, Dezember 1996
Salzgitter, Juni 1997

BfS-KT-18/97
Facharbeitskreis Probabilistische Sicherheitsanalyse.
Daten zur Quantifizierung von Ereignisablaufdiagrammen und Fehlerbäumen – März 1997
Salzgitter, Juni 1997

BfS-KT-19/97
Gelfort, E.; Krüger, F.W.
Wiederaufarbeitungsanlagen für Kernbrennstoff in der Russischen Föderation
Salzgitter, Juni 1997

BfS-KT-19/97-REV-1
Gelfort, E.; Krüger, F.W.
Wiederaufarbeitungsanlagen für Kernbrennstoff in der Russischen Föderation
- Statusbericht 1999 -
Salzgitter, November 1999

BfS-KT-20/97
Philippczyk, F.; Hutter, J.
Stand und Entwicklung der Kernenergienutzung 1996 in der Bundesrepublik Deutschland
Salzgitter, Juni 1997 ***(nicht im Internet)***

BfS-KT-21/98
Philippczyk, F.; Hutter, J.
Stand und Entwicklung der Kernenergienutzung 1997 in der Bundesrepublik Deutschland
Salzgitter, April 1998 ***(nicht im Internet)***

BfS-KT-22/99
Engel, K.; Gersinska, R.; Kociok, B.
Viertes Expertengespräch zum BMU/BfS-Konzept "Mensch-Maschine-Wechselwirkung in Kernkraftwerken" am 14. und 15. April 1999 beim Bundesamt für Strahlenschutz in Salzgitter
Salzgitter, April 1999

BfS-KT-23/99
Berg, H.P.; Schaefer, Th.
Current Level 1 PSA
Practices in Germany
Salzgitter, Oktober 1999

BfS-KT-24/00
Krüger, F.-W.; Spoden, E.
Untersuchungen über den Luftmassentransport von Standorten Kerntechnischer Anlagen Ost nach Deutschland
Salzgitter, Mai 2000

Bisher erschienene BfS-SK-Berichte (vorher BfS-KT-Berichte)

BfS-KT-25/00
Klonk, H.; Hutter, J.; Philippczyk, F.; Wittwer, C.
Zusammenstellung der Genehmigungswerte für Ableitungen radioaktiver Stoffe mit der Fortluft und dem Abwasser aus kerntechnischen Anlagen der Bundesrepublik Deutschland (Stand Juli 2000)
Salzgitter, Oktober 2000

BfS-KT-26/01
Philippczyk, F.; Hutter, J.; Schmidt, I.
Statusbericht zur Kernenergie in der Bundesrepublik Deutschland 2000
Salzgitter, Mai 2001

BfS-KT-27/02
Philippczyk, F.; Hutter, J.; Schneider,M.
Statusbericht zur Kernenergie in der Bundesrepublik Deutschland 2001
Salzgitter, Oktober 2002

Ab 1. Februar 2003 SK

BfS-SK-01/03
Berg, H.-P.; Fröhmel,T.; Görtz, R.; Schimetschka, E.; Schott, H.
Quantitative probabilistische Sicherheitskriterien für Genehmigung und Betrieb kerntechnischer Anlagen:
Status und Entwicklung im internationalen Vergleich
Salzgitter, Juni 2003

BfS-SK-02/03
Philippczyk, F.; Hutter, J.; Schneider,M.
Statusbericht zur Kernenergie in der Bundesrepublik Deutschland 2001
Salzgitter, November 2003

BfS-SK-03/03
Berg, H.-P.; Görtz, R.; Schimetschka, E.
Quantitative Probabilistic Safety Criteria for Licensing and Operation of Nuclear Plants
Comparison of the International Status and Development
Salzgitter, November 2003

BfS-SK-04/04
Philippczyk, F.; Hutter, J.; Rehs, B.; Schneider, M.
Statusbericht zur Kernenergienutzung in der Bundesrepublik Deutschland 2003
Salzgitter, August 2004

BfS-SK-05/05
Philippczyk, F.; Borrmann, F.; Hutter, J.; Schneider, M.
Statusbericht zur Kernenergienutzung in der Bundesrepublik Deutschland 2004
Salzgitter, Juli 2005

BfS-SK-06/06
Bredberg, I.; Borrmann, F.; Hutter, J.; Schell, H.; Schneider, M.; Wähning, R.; Hund, W.
Statusbericht zur Kernenergienutzung in der Bundesrepublik Deutschland 2005
Salzgitter, August 2006

BfS-SK-07/07
Bredberg, I.; Hutter, J.; Schell, H.; Schneider, M.; Wähning, R.
Statusbericht zur Kernenergienutzung in der Bundesrepublik Deutschland 2006
Salzgitter, Juli 2007

Bisher erschienene BfS-SK-Berichte (vorher BfS-KT-Berichte)

BfS-SK-08/08
Görtz, R.
An Identity on Alternating Sums of Squares of Binomial Coefficients
Salzgitter, Februar 2008

BfS-SK-09/08
Bredberg, I.; Hutter, J.; Schell, H.; Schneider, M.; Wähning, R.
Statusbericht zur Kernenergienutzung in der Bundesrepublik Deutschland 2007
Salzgitter, August 2008

BfS-SK-10/08
Berg, H.P.: Görtz, R.; Mahlke, J.; Reckers, J.; Scheib, P.; Weil, L.
The POS Model for Common Cause Failure Quantification
Draft Aug-21-2008
Fachbereich Sicherheit in der Kerntechnik
Salzgitter, November 2008

BfS-SK-11/08
Hutter, J.; Koch, W.; Rehs, B.; Schell, H.; Schneider, M.; Schulz, R.
State and Development of Nuclear Energy Utilization in the Federal Republic of Germany 2007
Department of Nuclear Safety
Salzgitter, November 2008

BfS-SK-12/09
urn:nbn:de:0221-2009082104
Bredberg, I.; Hutter, J.; Koch, W.; Rehs, B; Schneider, M.; Schulz, R.
Statusbericht zur Kernenergienutzung in der Bundesrepublik Deutschland 2008
Fachbereich Sicherheit in der Kerntechnik
Salzgitter, September 2009

BfS-SK-13/10
urn:nbn:de:0221-2010011203
Bredberg, I.; Hutter, J.; Koch, W.; Rehs, B.; Schneider, M.; Schulz, R.
State and Development of Nuclear Energy Utilization in the Federal Republic of Germany 2008
Department of Nuclear Safety
Salzgitter, Januar 2010

BfS-SK-14/10
urn:nbn:de:0221-201007052619
Bredberg, I.; Hutter, J.; Koch, W.; Kühn, K.; Philippczyk, F.; Schulz, R.
Statusbericht zur Kernenergienutzung in der Bundesrepublik Deutschland 2009
Fachbereich Sicherheit in der Kerntechnik
Salzgitter, Juli 2010

BfS-SK-15/10
urn:nbn:de:0221-201009073052
Bredberg, I.; Hutter, J.; Koch, W.; Kühn, K.; Philippczyk, F.; Schulz, R.
State and Development of Nuclear Energy Utilization in the Federal Republic of Germany 2009
Salzgitter, September 2010

BfS-SK-16/11
urn:nbn:de:0221-201105105856
Bredberg, I.; Hutter, J.; Kühn, K.; Philippczyk, F.; Schulz, R.
Statusbericht zur Kernenergienutzung in der Bundesrepublik Deutschland 2010
Fachbereich Sicherheit in der Kerntechnik
Salzgitter, Mai 2011

Bisher erschienene BfS-SK-Berichte (vorher BfS-KT-Berichte)

BfS-SK-17/11
urn:nbn:de:0221-201108016010
Bredberg, I.; Hutter, J.; Kühn, K.; Philippczyk, F.; Schulz, R.
State and Development of Nuclear Energy Utilization in the Federal Republic of Germany 2010
Salzgitter, August 2011

BfS-SK-18/12
urn:nbn:de:0221-201203027611
Bejdakic, E.; Fischer, B.; Hellmich, M.; Hutter, J.; Kopisch, Ch.; Krauß,M.; Link, L.; Mahlke, J.; Meiß, S.; Niedzwiedz, K.; Philipps, K.; Reiner, M.; Sachse, A.; Schaper, A.; Scheib, P.; Schneider, M.; Seidel, F.
Die Katastrophe im Kernkraftwerk Fukushima nach dem Seebeben vom 11. März 2011
Beschreibung und Bewertung von Ablauf und Ursachen
Fachbereich Sicherheit in der Kerntechnik
Salzgitter, März 2012

BfS-SK-19/12
urn:nbn:de:0221-201207259011
Bredberg, I.; Hutter, J.; Kühn, K.; Philippczyk, F.; Dose, J.
Statusbericht zur Kernenergienutzung in der Bundesrepublik Deutschland 2011
Fachbereich Sicherheit in der Kerntechnik
Salzgitter, August 2012

BfS-SK-20/12
urn:nbn:de:0221-2012102610019
Bredberg, I.; Hutter, J.; Kühn, K.; Philippczyk, F.; Dose, J.
State and Development of Nuclear Energy Utilization in the Federal Republic of Germany 2011
Department of Nuclear Safety
Salzgitter, November 2012

| Verantwortung für Mensch und Umwelt |

Kontakt:
Bundesamt für Strahlenschutz
Postfach 10 01 49
38201 Salzgitter
Telefon: + 49 (0)3018 333-0
Telefax: + 49 (0)3018 333-1885
Internet: www.bfs.de
E-Mail: ePost@bfs.de
Gedruckt auf Recyclingpapier aus 100 % Altpapier.

Bundesamt für Strahlenschutz