State and Development of Nuclear Energy Utilization in the Federal Republic of Germany 2009

Department of Nuclear Safety

Ines Bredberg

Johann Hutter

Wolf Koch

Kerstin Kühn

Frank Philippczyk

Rolf Schulz

Bundesamt für Strahlenschutz

BfS-SK-15/10

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

urn:nbn:de:0221-201009073052

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, September 2010

State and Development of Nuclear Energy Utilization in the Federal Republic of Germany 2009

Department of Nuclear Safety

Ines Bredberg

Johann Hutter

Wolf Koch

Kerstin Kühn

Frank Philippczyk

Rolf Schulz

CONTENTS

SUMMARY

This report describes the use of nuclear energy in the Federal Republic of Germany as of December, 2009. It contains the essential data of all nuclear power plants, research reactors with a continuous thermal power above 50 kW_{th} and the plants of nuclear fuel supply and waste management. At the reporting moment 31st of December in 2009, 17 nuclear power plants were in operation. With 134.9 TWh (in 2008 – 148.8 TWh) altogether they provided 22.6 % (23.4 % in 2008) of the total gross electricity production (incl. electricity transfers)*. The report summarises the essential operational results of the nuclear power plants and information on granted licenses. 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 plant 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.

ZUSAMMENFASSUNG

Der vorliegende Bericht mit dem Stand 31.12.2009 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 kW_{th} und der Anlagen der Kernbrennstoffver- und -entsorgung. Zum Berichtszeitpunkt 31.12.2009 waren 17 Kernkraftwerksblöcke in Betrieb. Sie erbrachten mit einer Stromerzeugung von insgesamt 134,9 TWh (148,8 TWh in 2008) einen Anteil von 22,6 % (23,4 % in 2008) der allgemeinen Gesamt-Brutto-Stromerzeugung (einschließlich Einspeisungen)*. 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.

* preliminary estimated values as of February 2009 / vorläufige Schätzwerte Februar 2009;
source / Quelle: Federal Association of Energy and Water Economy e.V. (BDEW – former VDEW e.V.), Bundesverband der Energie- und Wasserwirtschaft e.V.

LIST OF ABBREVIATIONS

AG	Arbeitsgemainschaft, Consortium
AGO	Arbeitsgruppe Optionenvergleich, Comparison of Options Working Group
ANF	Advanced Nuclear Fuels GmbH
AtG	Atomgesetz, Atomic Energy Act
AtVfV	Atomrechtliche Verfahrensverordnung, Nuclear Licensing Procedure Ordinance
AVR	Atomversuchskernkraftwerk Jülich, Jülich Experimental NPP
BB	Brandenburg , Brandenburg
BBergG	Bundesberggesetz, Federal Mining Law
BDEW	Bundesverband der Energie- und Wasserwirtschaft e.V., Federal Association of Energy and Water Economy e.V.
BE	Berlin
BER II	Berliner-Experimentier-Reaktor II, Berlin Experimental Reactor Unit II
BfS	Bundesamt für Strehlenschutz, Federal Office for Radiation Protection
BGR	Bundesanstalt für Geowissenschaft und Rohstoffe, Federal Institute for Geosciences and Natural Resources
BLG	Brennelementlager Gorleben GmbH, Gorleben Fuel Element Storage Facility
BMBF	Bundesministerium für Bildung und Forschung, Federal Ministry of Education and Research
BMFT	Bundesministerium für Forschung und Technologie, Federal Ministry of Research and Technology
BMU	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BNFL	British Nuclear Fuels Ltd.
BStMUG	Bayerisches Staatsministerium für Umwelt und Gesundheit, Bavarian State Ministry of the Environment and Health
BVerwG	Bundesverwaltungsgericht, Federal Administrative Court
BW	Baden-Wuerttemberg
BWR	Boiling Water Reactor
BY	Bayern, Bavaria
BZA	Brennelement-Zwischenlager-Ahaus-GmbH, Ahaus Interim Storage Facility for Spent Fuel Elements
CASTOR®	Cask for Storage and Transport of Radioactive material
CDU	Christian Democratic Union of Germany
CEA	Commissariat à l'Energie Atomique
CLAB	Zentrales Lager für abgebrannte Brennelemente in Frankreich, Central storage facility for spent fuel elements in France
COGEMA	Compagnie Générale des Matières Nucléaires
CSU	Christian Social Union of Germany
DBE	Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH, German Company for the Construction and Operation of Waste Repositories
DBG	Dauerbetriebsgenehmigung, Permanent operating licence
DIDO	Schwerwassermoderierter und -gekühlter Forschungsreaktor in Jülich, Heavy-water Moderated and Cooled Research Reactor in Jülich
DKFZ	Deutsches Krebsforschungszentrum, German Cancer Research Center
DWK	Deutsche Gesellschaft zur Wiederaufarbeitung von Kernbrennstoffen mbH, German Company for the Reprocessing of Nuclear Fuels
E.ON	E.ON Kernkraft GmbH
EnBW	Energiewerke Baden-Württemberg AG
ERAM	Endlager für radioaktive Abfälle Morsleben, Morsleben Repository for Radioactive Waste
ERU	Enriched-Uranium
EVU	Energieversorgungsunternehmen, Utilities
EWN	Energiewerke Nord GmbH
FBR	Schneller natriumgekühlter Reaktor, Sodium-cooled Fast Breeder Reactor
FDP	Free Democratic Party of Germany
FDR	Fortschrittlicher Druckwasserreaktor, Advanced Pressurised Water Reactor
FMRB	Forschungs- und Messreaktor Braunschweig, Research and Measuring Reactor Braunschweig
FR 2	Forschungsreaktor Karlsruhe 2, Research Reactor Karlsruhe Unit 2
FRF 1	Forschungsreaktor Frankfurt 1, Research Reactor Frankfurt Unit 1
FRF 2	Forschungsreaktor Frankfurt 2, Research Reactor Frankfurt Unit 1

FRG-1	Forschungsreaktor Geesthacht 1, Research Reactor Geesthacht Unit 1
FRG-2	Forschungsreaktor Geesthacht 2, Research Reactor Geesthacht Unit 1
FRH	Forschungsreaktor der Medizinischen Hochschule Hannover, Research Reactor of the Hannover Medical School
FRJ-1	Forschungsreaktor Jülich 1, Research Reactor Jülich Unit 1
FRJ-2	Forschungsreaktor Jülich 2, Research Reactor Jülich Unit 2
FRM	Forschungsreaktor München, Research Reactor Munich
FRM-II	Hochflussneutronenquelle München in Garching, Munich High-flux Neutron Source in Garching Unit II
FRMZ	Forschungsreaktor TRIGA Mark II der Universität Mainz, TRIGA Mark II Research Reactor of the Mainz University
FRN	Forschungsreaktor Neuherberg, Research Reactor Neuherberg
FZJ	Forschungszentrum Jülich GmbH, Jülich Research Center
FZK	Forschungszentrum Karlsruhe GmbH, Karlsruhe Research Center
GDR	German Democratic Republic
GKN 1	Gemeinschaftskernkraftwerk Neckar Block 1, Neckar NPP Unit 1
GKN 2	Gemeinschaftskernkraftwerk Neckar Block 2, Neckar NPP Unit 1
GKSS	Forschungszentrum Geesthacht GmbH, Research Center Geesthacht
GNS	Gesellschaft für Nuklear Service mbH
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit mbH
GWh	Gigawattstunde, Giga-Watt hour
HAW	High-Active Waste
HAWC	High-Active-Waste Concentrate
HE	Hessen, Hesse
HEU	High-Enriched Uranium
HKG	Hochtemperatur-Kernkraftwerk GmbH
HM	Heavy Metal
HMGU	Helmholtz Zentrum München, Deutsches Forschungszentrum für Gesundheit und Umwelt GmbH
HOBEG	Hochtemperatur-Brennelement Gesellschaft
HTR	Hochtemperaturreaktor, High-temperature Gas-cooled Reactor
HWL	High-Active Waste Lager, High-level Active Waste Storage Facility
IBS	Inbetriebsetzung, Commissioning
KBR	Kernkraftwerk Brokdorf, Brokdorf NPP
KGR	Kernkraftwerk Greifswald, Greifswald NPP
KIT	Karlsruher Institute für Technologie, Karlsruhe Institute of Technology
KKB	Kernkraftwerk Brunsbüttel, Brunsbüttel NPP
KKE	Kernkraftwerk Emsland, Emsland NPP
KKG	Kernkraftwerk Grafenrheinfeld, Grafenrheinfeld NPP
KKI 1	Kernkraftwerk Isar 1, Isar NPP Unit 1
KKI 2	Kernkraftwerk Isar 2, Isar NPP Unit 2
KKK	Kernkraftwerk Krümmel, Krümmel NPP
KKN	Kernkraftwerk Niederaichbach, Niederaichbach NPP
KKP 1	Kernkraftwerk Philippsburg Block 1, Philippsburg NPP Unit 1
KKP 2	Kernkraftwerk Philippsburg Block 2, Philippsburg NPP Unit 1
KKR	Kernkraftwerk Rheinsberg, Rheinsberg NPP
KKS	Kernkraftwerk Stade, Stade NPP
KKU	Kernkraftwerk Unterweser, Unterweser NPP
KMK	Kernkraftwerk Mülheim-Kärlich, Mülheim-Kärlich NPP
KNK II	Kompakte natriumgekühlte Kernreaktoranlage, Karlsruhe, Karlsruhe Sodium-cooled Reactor
KRB A	Kernkraftwerk Gundremmingen Block A, Gundremmingen NPP Unit A
KRB-II-B	Kernkraftwerk Gundremmingen Block B, Gundremmingen NPP Unit B
KRB-II-C	Kernkraftwerk Gundremmingen Block C, Gundremmingen NPP Unit C
KWB A	Kernkraftwerk Biblis Block A, Biblis NPP Unit A
KWB B	Kernkraftwerk Biblis Block B, Biblis NPP Unit B
KWG	Gemeinschaftskernkraftwerk Grohnde, Grohnde NPP
KWL	Kernkraftwerk Lingen, Lingen NPP
KWO	Kernkraftwerk Obrigheim, Obrigheim NPP
KWU	Siemens AG, Fachbereich Kraftwerk-Union
KWW	Kernkraftwerk Würgassen, Würgassen NPP

LAVA	Anlage zur Lagerung und Verdampfung hochaktiver Abfallflüssigkeiten, Facility for the Storage and Vaporisation of High-level Waste Liquids
LAW	Low-Active Waste
LBEG	Landesamt für Bergbau, Energie und Geologie in Hannover, State Office for Mining, Energy and Geology in Hannover
LEU	Low-Enriched Uranium
LWR	Leichtwasserreaktor, Light Water Reactor
MERLIN	Medium Energy Research Light Water Moderated Industrial Nuclear Reactor in the Jülich Research Center (FZJ)
MEU	Medium-Enriched Uranium
MLU	Ministerium für Landwirtschaft und Umwelt des Landes Sachsen-Anhalt, Saxony-Anhalt Ministry for Agriculture and the Environment
MOX	Mischoxid (-Brennstoff), Mixed-oxide (fuel)
MTR	Materials Testing Reactor
MV	Mecklenburg-Vorpommern, Mecklenburg-Western Pomerania
MW_e	Megawatt elektrische Leistung, Megawatt electrical power
MWh	Megawattstunde, Megawatt Hour
MW_{th}	Megawatt thermische Leistung, Megawatt Thermal Power
MZFR	Mehrzweckforschungsreaktor, Karlsruhe, Multipurpose Research Reactor Karlsruhe
NI	Nidersachsen, Lower Saxony
NMU	Niedersächsiche Ministerium für Umwelt und Klimaschutz, Lower Saxony Ministry for the Environment and Climate Protection
NPP	Nuclear Power Plant
NRW	Nordrhein-Westfalen, North Rhine-Westphalia
NUKEM	NUKEM GmbH Alzenau
OH	Otto Hahn
oHG	Offene Handelsgesellschaft, General Partnership
OVG	Oberverwaltungsgericht, Higher Administrative Court
PFB	Planfeststellungsbeschluss, Plan-approval Decision
PKA	Pilotkonditionierungsanlage, Pilot Conditioning Plant
PTB	Physikalisch-Technische Bundesanstalt, Federal Institute of Physics and Metrology
PWR	Pressurised Water Reactor
RDB	Reaktordruckbehälter, Reactor Pressure Vessel
RFR	Rossendorfer Forschungsreaktor, Research Reactor Rossendorf
RP	Rheinland Pfalz, Rhineland-Palatinate
RRRFR	Russian Research Reactor Fuel Return
RSK	Reaktor-Sicherheitskommission, Reactor Safety Commission
RWE	Rheinisch-Westfälische Elektrizitätsgesellschaft
SAAS	Staatliches Amt für Atomsicherheit und Strahlenschutz (der ehemaligen DDR), Federal Office for Nuclear Safety and Radiation Protection (of the former GDR)
SE	Sicherer Einschluss, Safe Enclosure
SG	Stilllegungsgenehmigung, Decommissioning Licence
SH	Schleswig-Holstein , Schleswig-Holstein
SMUL	Sächsische Staatsministerium für Umwelt und Landwirtschaft, Saxony State Ministry for the Environment and Agriculture
SN	Sachsen, Saxony
SSK	Strahlenschutzkommission, German Commission on Radiological Protection
SSR	Heißdampfreaktor, Großwelzheim, Großwelzheim Superheated Steam Reactor
ST	Sachsen-Anhalt, Saxony-Anhalt
StrlSchV	Strahlenschutzverordnung, Radiation Protection Ordinance
SZL	Standort- Zwischenlager, On-site Interim Storage Facilities
TBG	Teilbetriebsgenehmigung, Partial Operating Licence
TBL-A	Transportbehälterlager Ahaus, Ahaus Transport Cask Storage Facility
TBL-G	Transportbehälterlager Gorleben, Gorleben Transport Cask Storage Facility
TEG	Teilerrichtungsgenehmigung, Partial Construction Licence
TG	Teilgenehmigung, Partial Licence
THTR-300	Thorium-Hochtemperaturreaktor, Hamm/Uentrop, Hamm-Uentrop Gas-cooled High-temperature Pebble Bed Reactor
TRIGA	Training Research Isotope General Atomics
TRIGA HD I	Forschungsreaktor TRIGA HD I Heidelberg, TRIGA HD I Research Reactor Heidelberg
TRIGA HD II	Forschungsreaktor TRIGA HD II Heidelberg, TRIGA HD II Research Reactor Heidelberg

TSG	Teilstilllegungsgenehmigung, Partial Decommissioning Licence
TUM	Technische Universität München
TWh	Terawattstunde, Tera Watt hour
U-235	Uranisotop 235, Uranium Isotope 235
UAG	Urananreicherungsanlage Gronau, Gronau Uranium Enrichment Plant
UNS	Unabhängiges Notstandssystem, Independent Emergency System
UTA	Urantrennarbeit, Uranium Separative Work
UVP	Umweltverträglichkeitsprüfung, Environmental Impact Assessment
VAK	Versuchsatomkraftwerk, Kahl, Kahl Experimental NPP
VBA	Verlorene Betonabschirmung, Lost Concrete Shielding
VDEW	Verband der Elektrizitätswirtschaft e.V., now BDEW e.V.
VEK	Verglasungseinrichtung Karlsruhe, Karlsruhe Vitrification Facility
VGB	Technische Vereinigung der Großkraftwerksbetreiber e.V.
VKTA	Verein für Kernverfahrenstechnik und Analytik Rossendorf e.V.
w/o	Gewichtsprozent, Weight Percent
WAK	Wiederaufarbeitungsanlage Karlsruhe, Karlsruhe Reprocessing Plant
WAW	Wiederaufarbeitungsanlage Wackersdorf, Wackersdorf Reprocessing Plant
WTI	Wissenschaftlich-Technische Ingenieursberatung GmbH
WWER	Wassergekühlter, wassermoderierter Energiereaktor (DWR russischen Typs), Water-cooled Water-moderated Energy Reactor (Russian Type PWR)
WWR-S (M)	Wassergekühlter, wassermoderierter Reaktor (DWR russischen Typs), 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	Zwischenlager Nord, Rubenow, Interim Storage Facility North Rubenow

1. ELECTRICITY PRODUCTION FROM NUCLEAR ENERGY IN GERMANY

Altogether 596.8 TWh (2008: 637.3 TWh) of electric energy were produced in the Federal Republic of Germany in 2009 (gross electricity production including electricity transfers, BDEW February 2010). Nuclear power plants contributed approximately 134.9 TWh to the total gross electricity production, which corresponds to 22.6% (2008: 23.4%, corresponding to 148.8 TWh). In comparison with the previous year, the share of nuclear energy has, thus, slightly decreased. This is mainly due to the nearly one-year lasting shutdown of the Biblis A plant (10 months), Biblis B (9 months) and Krümmel (11 months) and the complete shutdown of Brunsbüttel lasting one year. The total gross electricity production in Germany decreased by approximately 40.5 TWh compared with the preceding year (cf. Table 1.1). This has also been influenced by the global economic crisis since the end of 2008.

	2007		2008*		2009*	
	TWh	%	TWh	%	TWh	%
Nuclear energy	140.5	22.0	148.8	23.4	134.9	22.6
Lignite	155.1	24.3	150.6	23.6	146.5	24.5
Hard coal	142.0	22.3	124.6	19.5	109.0	18.3
Mineral oil	9.6	1.5	9.2	1.4	12.5	2.1
Natural gas	75.9	11.9	86.7	13.6	77.0	12.9
Water	28.1	4.4	26.5	4.2	24.5	4.1
Wind	39.7	6.2	40.6	6.4	37.8	6.3
Others (total)	46.4	7.3	50.3	7.9	54.6	9.1
TOTAL	637.3	100.0	637.3	100.0	596.8	100.0

* all data relating to the years 2008 and 2009 are preliminary estimations
[Source: BDEW e.V. February 2009]

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

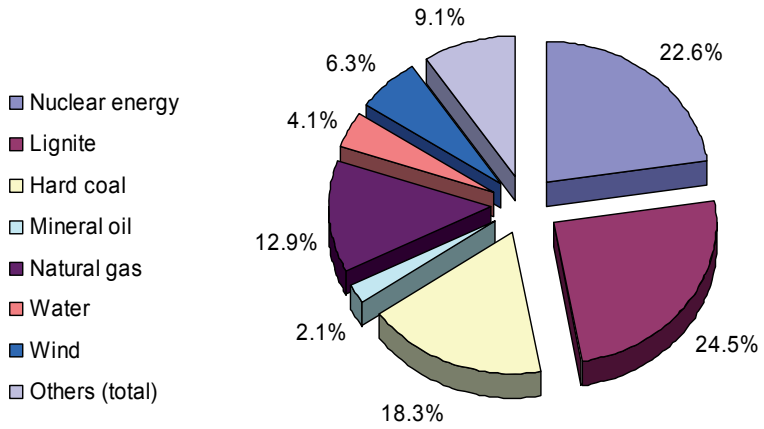


Figure 1: Total gross electricity production in 2009

The share of nuclear power plants in the total gross electricity production in the general (public) electricity supply (i.e. without private suppliers such as industry, railways etc.) amounted to 27.7% in 2009 (28.4% in 2008) [source: BDEW]. The share of nuclear energy in the total final energy consumption is estimated to have been approximately 5 % in 2008.

Renewable Energy

The increased utilisation of renewable energy is a component of the German climate protection strategy. The amended Renewable Energy Sources Act (EEG) became effective on 1 January 2009. According to §1 EEG the share of renewables in power supply is to be increased to minimum 30% until the year 2020. In 2009, the percentage of renewable energies in the gross electricity production was approximately 15.6% according to BDEW (2008: 14.5%).

Today, wind energy, water power (regenerative contribution, i.e. without pump storage plant), and biomass energy are the most essential renewables. Altogether, energy production from renewable energy such as wind, water, biomass, photovoltaics and biogenic waste amounted to approximately 93.0 TWh in 2009 (92.7 TWh in 2008).

The installed capacity of the windmill-powered plants was increased by 1,870 MW to 25,780 MW. Despite of the increased number of windmill-powered plants, the percentage of power generated by wind remained the same. This result is due to the small amount of wind in the year under report (all data BDEW).

	2007		2008*		2009*	
	TWh	%	TWh	%	TWh	%
Water**	21.2	3.3	20.4	3.2	19.0	3.2
Wind	39.7	6.2	40.6	6.4	37.8	6.3
Solar	3.1	0.5	4.4	0.7	6.2	1.0
Biomass	19.1	3.0	22.3	3.5	25.0	4.2
Refuse**	4.5	0.7	4.9	0.8	5.0	0.8
TOTAL	87.5	13.7	92.7	14.5	93.0	15.6

* all data are preliminary values, part of them have been estimated [source: BDEW February 2009]

** only regenerative share

[Source: BDEW February 2009]

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

Phase-out of Electricity Production from Nuclear Energy

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

One central item of the amendment is that the authorisation for power operation of the existing electricity producing reactors expires when certain electricity volumes have been produced. The electricity volumes that can still be produced from 1 January, 2000 (residual electricity volumes) have been laid down in Annex 3 column 2 to § 7 para. 1a Atomic Energy Act (AtG) for each single nuclear power plant. In the provisions of this Annex it has also been set out that the electricity volume given for the Mülheim-Kärlich NPP can only be transferred to the NPPs Emsland, Neckarwestheim 2, Isar 2, Brokdorf, Gundremmingen B and C as well as Biblis B. According to § 7 para. 1b AtG, it is possible to transfer electricity volumes from older plants to newer plants without consent given by the Federal Minister for the Environment, Nature Conservation and Nuclear Safety (BMU). The other way around, this can only be done with the approval of BMU in consultation with the Federal Chancellery and the Federal Ministry of Economics and Technology.

So far the utilities have not made use of the option to transfer electricity volumes from “old” to “new” or from Mülheim-Kärlich to the mentioned facilities. Instead they applied for the approval of a transfer of production rights of three more recent to older nuclear power plants and from Mülheim-Kärlich to two plants other than those formally mentioned. The BMU rejected these applications. All applications are or have been object of administrative court claims.

For details click on http://www.bmu.de/atomenergie_sicherheit/strommengenuebertragung/doc/42281.php.

Starting in the month under report May 2002, the licencees of the German nuclear power plants have reported once a month the produced electricity volumes to the Federal Office for Radiation Protection (BfS) according to the provisions set out in § 7 para. 1c AtG.

At least once a year, the BfS announces the residual electricity volumes in the Bundesanzeiger (Federal Gazette). The BfS announcements can be found in the Bundesanzeiger or on the BfS website at www.bfs.de/kerntechnik/strommengen.html. Table 1.3 shows the state of the produced net electricity volumes and the remaining residual electricity volumes on 31 December 2009.

The coalition agreement on the 17th legislative period was signed on 26 October 2009 by the new government parties of CDU, CSU and FDP. The agreement states the following on the topic nuclear energy:

“Nuclear energy is a bridge technology until it can be replaced reliably by renewables. Otherwise we will not achieve our climate goal, tolerable power tariffs and less dependence of other countries. To achieve this goal we are ready to extend the operating times of German nuclear power plants in compliance with the strict German and international safety standards. The ban on constructing new nuclear power plants laid down in the Atomic Energy Act will persist.”

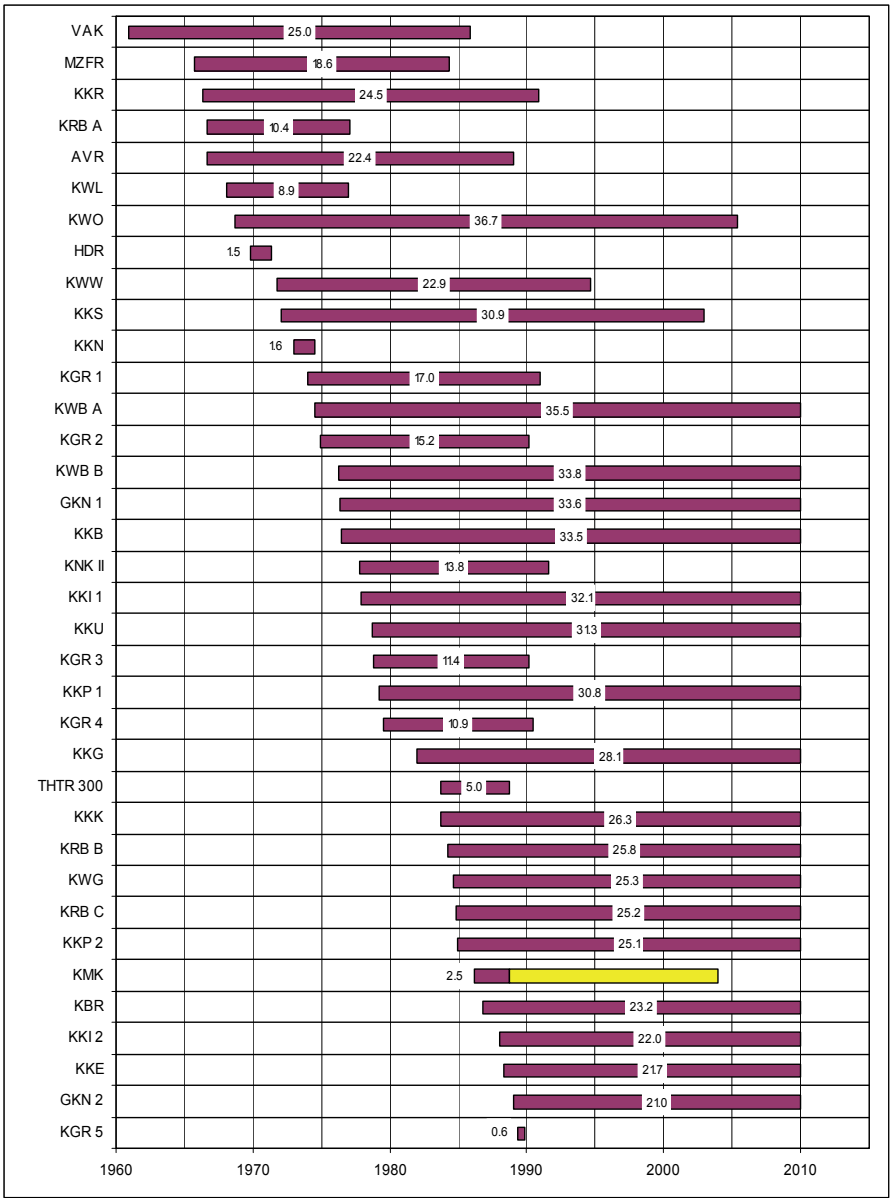
Net electricity volumes and residual electricity volumes generated between 1 January 2000 and 31 December 2009 [GWh] - Annual report 2009							
Nuclear Power Plant	**Residual electricity volume from 1 Jan. 2000 acc. to § 7 para. 1a AtG**	**1. Jan. 2000 until 31 Dec. 2006**	**Total 2007**	**Total 2008**	**Total 2009*** **	**Residual electricity volumes transferred so far**	**Remaining residual electricity volume**
Stade*	23,180.00	18,394.47					4,785.53
Obrigheim**	8,700.00	14,199.89				5,499.89	0.00
Biblis A	62,000.00	48,319.02	0.00	8,472.13	1,012.98		4,195.87
Neckarwestheim 1	57,350.00	42,388.54	4,713.53	3,786.95	4,361.98		2,099.00
Biblis B	81,460.00	57,620.92	884.46	10,355.20	1,511.33		11,088.09
Brunsbüttel	47,670.00	34,182.47	2,487.86	0.00	0.00		10,999.67
Isar 1	78,350.00	47,345.20	6,755.77	7,582.63	6,796.00		9,870.40
Unterweser	117,980.00	65,308.20	9,076.27	9,295.52	10,028.91		24,271.10
Philippsburg 1	87,140.00	46,017.85	6,966.11	6,148.10	6,149.84	-5,499.89	16,358.21
Grafenrheinfeld	150,030.00	70,130.84	10,311.47	9,763.01	10,447.26		49,377.42
Krümmel	158,220.00	64,185.06	5,454.86	0.00	334.97		88,245.11
Gundremmingen B	160,920.00	70,674.24	10,496.50	9,669.91	10,389.87		59,689.48
Philippsburg 2	198,610.00	73,918.74	11,180.64	10,844.03	10,969.60		91,696.99
Grohnde	200,900.00	76,239.50	10,818.40	10,545.95	10,867.47		92,428.68
Gundremmingen C	168,350.00	69,345.99	9,888.31	9,928.98	10,275.18		68,911.54
Brokdorf	217,880.00	78,094.81	11,425.65	11,450.40	11,459.42		105,449.72
Isar 2	231,210.00	80,691.06	11,377.49	11,456.15	11,484.85		116,200.45
Emsland	230,070.00	77,257.05	10,989.22	10,896.15	10,849.24		120,078.34
Neckarwestheim 2	236,040.00	73,414.88	10,411.09	10,702.15	10,779.73		130,732.15
Total	**2,516,060.00**	**1,107,728.73**	**133,237.63**	**140,897.26**	**127,718.63**	**5,499.89**	**1,006,477.75**
Mülheim-Kärlich	107,250.00						**107,250.00**
Sum total	**2,623,310.00**						**1,113,727.75**

* The Stade NPP was shut down on 14 November 2003 and was decommissioned on 7 September 2005. A decision on the remaining residual electricity volume for KKS has not yet been made.

** The Obrigheim NPP was shut down on 11 May 2005 and was decommissioned on 28 August 2008.

*** The data in column 6 "Total 2009" contain the values checked by certified accountants according to § 7 para. 1a AtG.

Table 1.3: Produced electricity volumes (net) of the German nuclear power plants, transfer of production rights, and compilation of residual electricity volumes



Shortcuts used in the diagram:

VAK	Kahl Experimental NPP	**KWB A**	Biblis NPP Unit A	**THTR**	Hamm-Uentrop Gas-cooled High-temperature Pebble Bed Reactor
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 Unit A	**GKN 1**	Neckarwestheim 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 2
KWO	Obrigheim NPP	**KKI 1**	Isar NPP Unit 1	**KMK**	Mülheim-Kärlich NPP
HDR	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 NPP Unit 1	**KKE**	Emsland NPP
KKN	Niederaichbach NPP	**KGR 4**	Greifswald NPP Unit 4	**GKN 2**	Neckarwestheim NPP Unit 2
KGR 1	Greifswald NPP Unit 1	**KKG**	Grafenrheinfeld NPP	**KGR 5**	Greifswald NPP Unit 5

Figure 2: Operating times of nuclear power plants in Germany since first criticality, as at 31 December 2009

2. NUCLEAR POWER PLANTS IN GERMANY

In the Federal Republic of Germany there are currently (as at 31 December 2009)

17 Nuclear power plants in operation

17 Nuclear power plant units under decommissioning or decommissioning was decided

2 Nuclear power plants entirely dismantled and released from regulatory control

6 Nuclear power plant projects that were stopped.

Status	PWR		BWR		Others		Total	
	Number	MW_e (gross)	Number	MW_e (gross)	Number	MW_e (gross)	Number	MW_e (gross)
In operation	11	14,773	6	6,734	—	—	17	21,507
Under decommissioning, decommissioning decided	10	4,658	4	1,188	3	344	17	6,190
Entirely dismantled	—	—	—	—	2	131	2	131
Project stopped	5	3,320	—	—	1	327	6	3,647

Table 2.1: Nuclear power plants in Germany in 2009

The individual NPPs are described according to their operational status in chapters 2.1 to 2.4 and in the corresponding tables 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 17 nuclear power plants in operation with their essential features is given in Table I.2a in Annex I.

2.1.1 OPERATIONAL CHARACTERISTICS AND AVAILABILITY OF NUCLEAR POWER PLANTS

Compared with the preceding years, the nuclear power plant units operated in 2009 in Germany showed the following availabilities:

Year	Time availability [%]	Energy availability [%]	Capacity availability [%]
2009	73.2	74.2	71.2
2008	80.0	80.9	78.4
2007	76.0	76.4	74.4
2006	91.1	90.8	89.1

Source: Technische Vereinigung der Großkraftwerksbetreiber e.V. (VGB 2009)

Table 2.2: Average availabilities of nuclear power plants in %

In 2009, nuclear power plant availabilities were below those of the preceding year. The Brunsbüttel NPP continued to be shut down. On account of technical problems in the Krümmel NPP the plant had to be taken from the grid again on 4 July 2009, after a short period of operation in June 2009. It has continued to be shut down since. The plants Biblis A and Biblis B were shut down for nearly the whole year due to comprehensive revisions and the implementation of modification measures.

2.1.2 PLANT AND LICENSING STATUS OF THE NUCLEAR POWER PLANTS

In the following section a short description is given of the nuclear power plants in operation and the essential licences according to § 7 AtG – granted by the competent federal state authorities under nuclear law according to Table I.1 (Annex I) – are dealt with. Also licensing procedures in progress are dealt with if they are of special relevance to the plant and licensing state. Furthermore, details on the capacity increases carried out so far are shown in Table 1.2b 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 concrete particular 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. In the scope of this overall complex also applications for hampering the targeting precision in case of a targeted terrorist air crash (camouflage protection through artificial smokescreen) were filed, apart from a number of in-plant measures which could be implemented immediately. For some plants the corresponding licences have already been granted and been implemented. For reasons of protection of classified information further details could not be made public.

Neckarwestheim NPP Unit 1 (GKN 1) and Unit 2 (GKN 2)

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 current reactor output of 840 MW_e results from a power decrease due to an exchange of condenser pipes in 1990.

The Neckarwestheim NPP Unit 2 is a 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 (from January 2007) results from several thermal and electric power changes.

On 25 April 2000, the operator filed further applications according to § 7 AtG for thermal capacity increases for both plants. Furthermore applications for licences concerning the improvement of electrical engineering, instrumentation and control and systems engineering, and the replacement of the reactor protection instrumentation and control by a digital system are currently in the nuclear licensing procedure.

Commissioned in December 1988, the Neckarwestheim NPP Unit 2 is the youngest NPP operated in Germany. Similar to the Neckarwestheim NPP Unit 1, electricity is also produced for Deutsche Bahn AG in the Neckarwestheim NPP Unit 2, apart from electricity for the national grid.

Two nuclear licences according to § 7 AtG for the further development of the organisational structure in the EnBW Kernkraft GmbH (EnKK) were granted on 12 November 2009 for the GKN 1 and GKN 2 plants.

Philippsburg NPP Unit 1 (KKP 1) and Unit 2 (KKP 2)

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 current reactor output of 926 MW_e is a result of two electrical capacity increases.

The adjacent unit 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 1,458 MW_e by several thermal and electrical capacity increases. Furthermore an increase in efficiency was achieved by exchanging the high-pressure turbine in the process of the 2008 revision. In the year under report 2009 the new nominal capacity of 1,468 MW_e was measured which the operator has taken as a basis since 1 January 2010.

As for the GKN 1 and GKN 2 plants, nuclear licences according to § 7 AtG were also granted on 12 November 2009 for the KKP 1 and KKP 2 plants for the further development of the organisational structure in the EnKK.

Isar NPP Unit 1 (KKI 1) and Unit 2 (KKI 2)

Isar 1 also belongs to the BWR of design series 69 and was commissioned in 1977 with an electrical output of 907 MW_e. On account of an electrical capacity increase, the reactor output is now 912 MW_e. Application for an increase in thermal reactor capacity to 2,704 MW_{th} has been filed but is not further pursued by the operator.

Isar 2 is one of the five dual-unit plants in the Federal Republic of Germany. It is a PWR of the fourth generation at the site, a Convoy plant which was commissioned as the first one of the three Convoy plants (Neckarwestheim 2, Emsland) 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. KKI 2 is thus currently the most powerful plant in Germany.

No licences according to § 7 AtG were granted for either plant in the year under report.

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

No licence according to § 7 AtG was granted in the year under report.

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, which are of identical design. Each of them is a 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. With respect to electrical capacity, the Gundremmingen NPP is the largest German nuclear power plant. Application for an increase in thermal reactor capacity for both units to 4,000 MW_{th} has been filed to the licensing authority on 19 December 2001 and is currently in the licensing procedure.

No licence according to § 7 AtG was granted for the Gundremmingen plant in the year under report 2009.

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

The Biblis A NPP is a PWR of the 2nd generation and was commissioned in 1974 with a capacity of 1,204 MW_e. The current reactor output of 1,225 MW_e results from the last electrical capacity increase carried out in 1995. 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. The electrical capacity was reduced to initially 1,238 MW_e in the first years following commissioning and then again increased to the original value of 1,300 MW_e which is still effective today.

Four licences according to § 7 AtG were granted for the Biblis plant Unit A and five licences for Biblis Unit B in the year under report 2009.

In detail Biblis A was granted the following licences:

- Licence for the introduction of emergency manual chapter NHG 05 “Reactor Coolant System – Pressure Relief via Pressure Control Valves” – primary side pressure relief of 23 February 2009
- Licence for the improvement and the normal use of load chains LK 5 “lift rig”, LK 9 “lift rig for small slot gate (refuelling slot gate)” and LK 10 “lift rig for biological contactor (shielding slab)” of 29 May 2009
- Licence for the construction and operation of the fuel pool cooling system partial licence of 14 July 2009

and the

- Licence for the construction and operation of components for backwashing the sump sieves and reducing the mesh size of the sump sieves 10TH00 N001-2 from 3x3 mm to 2x2 mm of 22 December 2009.

The following licences according to § 7 AtG were granted for Biblis B:

- Licence for the separation of the operational and safety-related power consuming devices from the demineralised water system RY of 2 February 2009
- Licence for the cutting off of leakages in the operational part of the closed cooling water system for reactor services TF of 16 February 2009
- Licence for the implementation of fuel element repairs in the storage rack of the fuel pool in the KWB-B of 18 March 2009
- Licence for the construction and operation of components for backwashing the sump sieves of 31 July 2009

and the

- Licence for the reduction of the mesh size of the sump sieves 20TH00 N002-005 from 3x3 mm to 2x2 mm of 31 August 2009.

For nearly the whole year under report 2009 both nuclear power plant units were shut down (revisions and refuelling and implementation of licensed modification measures).

Unterweser NPP (KKU)

The Unterweser NPP is a PWR of the 2nd generation. It was commissioned in 1978 with a capacity of 1,300 MW_e. The current reactor output resulting from one thermal capacity increase and several electrical capacity increases is 1,410 MW_e.

No licence according to § 7 AtG was granted in 2009.

Changes of the safety-related parameters for the core design and the exchange of the reactor protection have been applied for. One licence for the application of a standard earthquake design specification for installations and modifications in the KKU is currently being examined.

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.

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 was granted on 11 March 2009.

For the Grohnde plant, applications were filed in the past years for the utilisation of uranium fuel elements with an initial enrichment of up to 4.4 weight percent U-235 and for increasing the thermal reactor capacity to 4,000 MW_{th}. Furthermore, one application for the introduction of digital instrumentation and control systems in the area of neutron ex-core instrumentation is in the licensing procedure.

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.

Currently an application of 16 December 2002 for an increase in thermal reactor capacity to 3,950 MW_{th} is in the licensing procedure.

No nuclear licence according to § 7 AtG was granted in the year under report 2009.

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.

The licence for an increase in enrichment up to 4.45 percent by weight uranium 235 was granted on 19 February 2009 (10th amended licence).

Brunsbüttel NPP (KKB)

The Brunsbüttel NPP is the oldest BWR of design series 69 and 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.

No licence according to § 7 AtG was granted for the Brunsbüttel NPP in the operating year 2009.

An application was filed on 11 August 2009 for dropping the switching operations of the fault identification and de-meshing of the emergency power supply including use of another emergency Diesel unit.

The plant continued to be shut down in 2009, among others because construction anchoring (anchor bolts) had to be checked.

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. The current reactor output of 1,402 MW_e results from an improvement of the steam turbine's efficiency which was carried out in the major plant revision in 2005.

Running licensing procedures apply to the use of mixed oxide fuel elements and the use of Svea 96 Optima (3) fuel elements.

No nuclear licence according to § 7 AtG was granted for Krümmel in 2009.

Following a short circuit period of operation in June 2009 the reactor scram was triggered in the plant on 4 July 2009 as a result of a short circuit in a generator transformer. The plant has continued to be shut down since. It is now intended to replace both generator transformers of the plant by new transformers before the plant will be taken to the grid again.

2.2 NUCLEAR POWER PLANTS UNDER DECOMMISSIONING OR DECOMMISSIONING WAS DECIDED

In Germany there are currently 17 nuclear power plant units under decommissioning or decommissioning was decided (cf. Table I.3). Two of them are in the phase of safe enclosure, the others are being dismantled with the objective of entire 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 was 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. 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.

In the period under report the works on decommissioning and dismantling the plant were continued. Noteworthy is that the dismantling of the wet disassembly station has been concluded.

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 the 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 26 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 been concluded. Further steps should be the remote-controlled dismantling of the thermal insulation, the primary shielding and the activated part of the biological shield. In the year under report one also dealt with disassembling the sodium cold trap which was licensed in 2007.

It is intended to dismantle the remaining buildings conventionally and to recultivate the premises after the plant has been released from the scope of the AtG. 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. Due to the combined heat and power generation, it also served the heat supply of the Karlsruhe Research Center, apart from electricity production. After it had been 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, all nuclear licences are now available for the entire dismantling of the plant. One continued to carry out retrofitting measures inside the reactor building required for the dismantling of the activated part of the biological shield. The testing of the handling equipment for the remote-controlled dismantling of the liner could be successfully concluded in the year under report.

The work will probably be concluded in 2013.

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 (gross) 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 was finally shut down on 11 May 2005, since the licence for power operation according to § 7 para. 1a AtG had expired.

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 on 22 April, 2005 was filed to the BfS. The licensing procedure has not yet been concluded (cf. chapter 4.3.2).

The first decommissioning licence on the final and permanent shut-down of 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 dismantling works in the turbine house continued in the year under report. On 1 December 2008 application was filed for amending the 1st decommissioning licence. Among others, this application includes the exchange of the material lock of the reactor building. On 15 December 2008, application was filed for amending the 2nd decommissioning licence, which, apart from an adjustment of the licensing procedure, also provides for the dismantling of components in the control area and of further components in the monitored area.

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

In 2009, the focus of dismantling works was on the decontamination of the reactor building and the dismantling of residual systems and components of the plant.

Work on the conversion of the remaining residual structures into a technology centre has been continued. It is to serve for decontamination and waste treatment purposes for the two still running units KRB-II-B and KRB-II-C. The relevant nuclear licence was granted on 5 January 2006.

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, according to statements made by the operator, all planned scientific and operational tests had been concluded.

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 between the utilities, COGEMA and Sweden for the transport of Swedish fuel elements to COGEMA.

The control areas were raised and the exhaust air balancing was discontinued in the year under report. It was possible to conclude the clearance of the premises in August 2009.

Release of the VAK from the scope of the AtG is planned for 2010. Subsequently, cleared buildings are to be dismantled and the plant premises are to be recultivated with the objective "Greenfield".

Greifswald NPP (KGR)

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 8 PWR units 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 were 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 there has been no more nuclear fuel in the Greifswald NPP.

The first decommissioning licence according to § 7 para. 3 AtG for the decommissioning of the entire plant and for the dismantling of plant components was granted on 30 June 1995. The 35th modification licence and the 1st modification licence to the 4th partial licence to the before mentioned decommissioning licence were granted on 16 August 2007. Among others, they comprise the modification of the waste management strategy for the dismantling of the reactor components of KGR Units 1 to 4. According to this concept, shielded large components can be stored intermediately in an undissected state in the Interim Storage Facility North (ZLN). The reactor pressure vessels of Units 1 and 2 were delivered to the ZLN in November 2007. Together with the reactor shaft and the shaft bottom the reactor pressure vessel of unit 3 was transported to the ZLN for interim storage on 14 September 2009 and of Unit 4 on 22 September 2009.

On the basis of the 36th modification licence granted on 7 May 2008 relating to the licence of 30 June 1995 and the 20th licence for the dismantling of plant components, plants and components in the control and monitored area continue to be dismantled.

The dismantling of the residual plant will probably be concluded in 2012.

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 for the decommissioning and dismantling of the plant according to § 7 para. 3 AtG. Direct dismantling of the plant was applied for.

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

The first licence for the decommissioning of the KKS according to § 7 para. 3 AtG 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 already granted licences. Among others, the reactor internals of the reactor pressure vessel were removed.

The licence for phase 3 part B for the dismantling of the reactor pressure vessel was granted with notification 1/2009 on 14 May 2009.

The operator of the KKS applied for the dismantling phase 4 on 19 December 2008. This application was put into more precise terms with letter of 4 September 2009. Dismantling phase 4 includes, among others, the removal of contaminated concrete structures, the release of buildings and premises from regulatory control and the operation of the storage facility for radioactive waste.

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, those improvement measures were so expensive 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 the dismantling of 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.

On 26 September 2008, the licence was granted for dismantling the existing chimney which is in need of rehabilitation above a height of 10 m and for building a 60-m high exhaust air chimney. The new exhaust air chimney was erected and has been connected. In the year under report the existing chimney was dismantled and removed.

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 Center was completed in June 1998.

For some years the operator has dealt with a concept modification – direct dismantling instead of safe enclosure. Application for entire dismantling according to § 7 AtG was applied for by 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. The reactor vessel which was filled with pore lightweight concrete in November 2008 will be taken to an interim storage facility still to be erected on the site. This will probably take place in 2011. Groundwork for the construction of this interim storage facility started in March 2009. Due to a contamination of the concrete chamber water in the base plate of the reactor building – probably a result of the operational malfunction "steam generator leakage" in 1978 – contaminated water got into the surrounding soil in the immediate vicinity of the reactor building. If necessary, these areas need to be rehabilitated after the buildings have been dismantled.

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 Preussen Elektra decided to finally shut down the plant. Since October 1996, the plant has been free of nuclear fuel. The fuel elements were delivered to La Hague (F) for reprocessing.

The first decommissioning licence was granted on 14 April 1997. Three further decommissioning licences for the plant have been granted since.

In the period under report one started to dissect the reactor pressure vessel. It is planned to clear the buildings by 2014.

Two interim storage facility buildings (UNS building and the 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 Hamm-Uentrop THTR-300 with a helium-cooled 308 MW_e pebble-bed high-temperature reactor 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, reloading 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. 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 1986. After the Federal Administrative Court had withdrawn the first partial licence it was shut down on 9 September 1988.

With letter dated 21 June 2001, RWE Power AG withdrew the applications according to § 7 AtG for granting the first partial licence for the construction and operation of the KMK – insofar as they had not been notified – and of the partial licence (continuous operation). 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 of buildings and the ground area of the eastern part of the plant premises from regulatory control. The total dismantling of the Mülheim-Kärlich plant will take approximately 10 years.

2.3 NUCLEAR POWER PLANTS ENTIRELY DISMANTLED AND RELEASED FROM REGULATORY CONTROL

Großwelzheim Superheated Steam Reactor (SSR)

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 was 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 (such as 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 and 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. On 21 October 1975, the licence for establishing the state

of safe enclosure for the plant and, on 20 October 1981, the licence for “safe enclosure” were granted. The fuel elements were delivered to the CEA (Commissariat à l’Energie Atomique). 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 the feasibility of both the technical implementation of a complete removal and of the associated nuclear licensing procedure could be demonstrated for the first time in Germany.

2.4 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 MW_e 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 2.2). 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 form 1973 to 1991, largely completed 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 since been used commercially. 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 WW_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 n1976 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

In Germany altogether 17 research reactors with a continuous thermal power above 50 kW have to be considered of which currently (as at 31 December 2009)

4 research reactors are in operation

7 research reactors are under decommissioning or decommissioning was decided, and

6 research reactors have entirely been dismantled and released from regulatory control.

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

3.1 RESEARCH REACTORS IN OPERATION

In Germany, altogether four research reactors with a continuous thermal power above 50 kW were still in operation in 2009.

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

At the end of 2004, the entire operational instrumentation and control of the BER II was renewed and upgraded to digital technology after this had been permitted by the nuclear regulatory authority. After shortly four months of structural alteration works, the reactor was re-commissioned in January 2005.

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. According to a requirement of the operating licence (3rd partial licence of 2 May 2003), the reactor core must be converted by 31 December 2010 from HEU to fuel with a reduced enrichment level of 50 % U-235 (MEU) at maximum. 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 for the construction of the plant were granted on 4 April 1996 and 9 October 1997 by the Bavarian State Ministry of Environment and Health as the competent licensing authority. Nuclear commissioning and the operation of the plant are part of the 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.

In 2008, the nuclear regulatory authority approved of an increase in the maximum U-235 burnup from originally 1,040 MWd to 1,200 MWd. Thus an operation cycle can be extended from 52 full-load days up to 60 full-load days. In the year under report the operator filed an application according to § 7 AtG on 27 March 2009 for expanding the operating permit of the FRM II by the operation of an ultra-cold neutron source.

TRIGA Mark II Research Reactor 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 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 fast pneumatic delivery 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.

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 is 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 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. chapter 3.2).

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. To prevent the core from falling dry in case of a leakage in the reactor coolant system, watertight partitions were built into the radioactive basement below the pools (licence of 21 May 2001). In 2003 and 2004, a new emergency power facility was installed with licence of 5 March 2002, and commissioned at the beginning of 2005.

Despite it is state of the art of science and technology it is intended to shut down the FRG-1 finally in 2010 because of new structures in neutron research in Germany (commissioning FRM II, ch. 3.1).

3.2 RESEARCH REACTORS UNDER DECOMMISSIONING OR DECOMMISSIONING WAS DECIDED

At the end of 2009, seven research reactors with a continuous thermal power above 50 kW were being decommissioned in the Federal Republic of Germany or it had been decided to decommission them.

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·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·s to $1 \cdot 10^{14}$ 1/cm^2·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 20 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 dismantling 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.

A concept for finally dismantling the reactor is to be presented by 2010.

Since July 2009 the Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH, a company of the Energiewerke Nord GmbH, has been responsible for dismantling the FR 2 plant.

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. As the first reactor in Germany the plant was commissioned on 31 October 1957. 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 27 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.

On14 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.

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 continuous thermal power was 1 MW_{th} and the thermal neutron flux was $3 \cdot 10^{13}$ 1/cm^2·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. 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. Within 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 neutronically 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} and the thermal neutron flux was $6 \cdot 10^{12}$ 1/cm^2·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 surfaces were gradually released from regulatory control by 28 July 2005 and can now be used without restrictions for other purposes by the PTB.

Research Reactor Jülich Unit 2 (FRJ-2)

The FRJ-2 (DIDO, derived from D_2O) was a heavy-water cooled and moderated closed tank reactor of the English type and was operated with HEU. The reactor with a thermal power of 23 MW_{th} and a thermal neutron flux of $2 \cdot 10^{14}$ $1/cm^2 \cdot s$ was used for beam pipe experiments and irradiations for isotope production and neutron activation analysis.

Nuclear commissioning of the plant was on 14 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. Within 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 Jülich Research Center (FZJ) installed an outstation at the new FRM-II research reactor (cf. Chapter 3.1).

Research Reactor Geesthacht Unit 2 (FRG-2)

Just as the FRG-1 (Chapter 3.1) 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 $1.5 \cdot 10^{14}$ $1/cm^2 \cdot s$. It was commissioned on 16 March 1963 as material test reactor and used for irradiation experiments and 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 (cf. Chapter 3.1).

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 (today Research Center Geesthacht, GKSS) 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 and the industry, filed an application on 28 January 1993 for taking the FRG-2 out of operation and for a partial dismantling of the reactor. The licence was granted on 17 January 1995. Since on the basis of the operation licence of 6 September 1967 the FRG-2 and the FRG-1 represent a joint reactor facility under the aspect of licensing and since the provisions of § 7 para. 3 AtG do not provide for a decommissioning of plant components, the shut-down and partial dismantling of the FRG-2 must legally be considered a modification of the operation of the entire facility according to § 7 para. 1 AtG. The fuel elements were at first intermediately stored 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 together with the dismantling

of the FRG-1 which will probably be shut down in 2010 within the scope of decommissioning the entire facility according to § 7 para. 3 AtG.

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.

The reactor was commissioned on 16 December 1957, with LEU and a thermal power of 2 MW_{th}, which was gradually increased to 10 MW_{th} by 1967, among others by a conversion from LEU operation to MEU operation. From 1987 to 1989, the RFR was extensively reconstructed, e. g. by exchanging 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 (Gemeinsame Einrichtung der Länder Brandenburg, Mecklenburg-Vorpommern, Sachsen, Sachsen-Anhalt und Thüringen). 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 Saxonian State Ministry for the Environment and Agriculture (SMUL) decreed on 28 June 1991 according to § 19 para. 3 AtG to discontinue the facility's operation which was geared to nuclear fission.

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

Between 30 May 2005 and 13 June 2005, the spent fuel elements were transported to the Ahaus Transport Cask Storage Facility in altogether 18 CASTOR® casks. 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 within the scope of a return programme agreed between the USA, Russia, and IAEA (RRRFR – Russian Research Reactor Fuel Return). Dismantling is to be concluded by 2011 with the objective of "greenfield".

3.3 RESEARCH REACTORS ENTIRELY DISMANTLED AND RELEASED FROM REGULATORY CONTROL

In the Federal Republic of Germany, six research reactors with a continuous thermal power above 50 kW have been entirely dismantled and 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 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 within 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 1 (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 10^{13} $1/cm^2 \cdot s$. The reactor went critical for the first time on 28 February 1978 and 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. On 13 September 2004, a licence according to § 7 para. 3 AtG for the decommissioning and entire dismantling of the research reactor was granted. 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 form 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 entire dismantling of the facility and the clearance measurements were completed by August 2007. The regulatory supervision of the facility as defined in § 19 AtG was terminated on 13 March 2008.

Research Reactor Jülich Unit 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·s to the last available level of $1.1 \cdot 10^{14}$ 1/cm^2·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 afterheat removal of the thermal power that had been doubled from 5 MW_{th} to 10 MW_{th} (licence notices 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 „Otto Hahn“ was the only nuclear ship operated in Germany and was formally classified as research reactor. An “Advanced Water Reactor” with low-enriched uranium dioxide with a maximum enrichment of 5.42 % 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. By autumn of 1979, the fuel elements were delivered to the WAK for reprocessing, except for 49 spent and three fresh fuel elements.

On 1 December 1980, a licence was granted for the decommissioning of the "Otto Hahn” according to § 7 AtG 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.

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 percent 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 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 constructed since the middle of 2008 and will be commissioned gradually. Production capacity was 2,750 Mg SW/a at the end of 2009. Approximately 2,320 Mg of depleted uranium were taken to Russia in 2009 for reprocessing. Approximately 1,730 Mg of depleted uranium were taken to a French enrichment client for deconversion – i.e. for chemical conversion into the stable uranium oxide – as well as additional 840 Mg for being kept there.

4.2 FUEL ELEMENT FABRICATION PLANTS

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

ANF Fuel Element Fabrication Plant, Lingen

In the ANF Fuel Element Fabrication Plant, uranium fuel elements with a maximum fraction of 5 percent by weight (w/o) U-235 are produced for major use in light-water reactors. UO_2 powder, UF_6, or externally produced UO_2 pellets are used as basic materials.

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 started in June 1994 (7th partial operating licence). In June 1996, a second fuel rod production line and a storage and handling building for UO_2 pellets and powder was licensed. The licence for the processing of additional 250 Mg annually 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 AtG 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 uranium hexafluoride to 275 Mg was approved of.

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

Since 1968, the plant has served to produce mixed-oxide fuel elements on the basis of UO_2/PuO_2, PuO_2 or UO_2 fuel, mainly for light-water reactors.

Since the Hessian Environmental Ministry issued a decree according to § 19 AtG, 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 public 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 public hearing in March 2000 in Hanau, the dismounting of the first production facilities was licensed in December 2000. 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 nuclear fuel storage facility used by the Federal Office for Radiation Protection for the execution of government custody according to § 5 AtG. At the end of December 2005, the BfS committed the storage facility areas free of contamination to the nuclear responsibility of Siemens for further dismantling.

Dismantling work was 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 which was designed against air crashes was emptied and is available for other use.

There are thus no restrictions to using the facility premises for industrial 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 percent by weight (w/o) of U-235 for major use in light-water reactors. UF_6 was used as base 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 single 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 single 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 special fuel elements made of uranium oxide with a fraction of maximum 4 percent by weight (w/o) of U-235.

Within 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.

NUKEM Fuel Element Fabrication Plant, Hanau

Since 1962, NUKEM produced special fuel elements for research reactors of uranium and thorium up to an enrichment degree of 94 percent by weight (w/o) for U-235.

On 23 December 1988, NUKEM filed an application for decommissioning the entire NUKEM plant. The licence for the 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, soil remediation or decontamination and remediation of buildings which were to be used otherwise, was discussed in a public 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 was 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 was concluded and the entire premises, with the exception of 1000 m^2 used for groundwater remediation, were released from regulatory control. Groundwater remediation will probably continue for some years.

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 facility which had been licensed according to § 9 AtG on 30 December 1974 was temporarily taken out of operation on 15 January 1988 and was decommissioned later on.

Between 30 January 1990 and 7 April 1995, altogether six licences 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 form 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 at first 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, basically at least a capacity of one core load must 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 Jülich Research Center.

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 operations started 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 possibly further interim storage in the AVR cask storage facility beyond 30 June 2013 will be required, a prolongation of the granted storage licence was applied for on 26 June 2007 by way of precaution.

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 by 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 AtG on 26 October 1998.

Emplacement of fuel elements started mid 1999. After the Obrigheim NPP (KWO) had been 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 is the competent authority for granting licences according to § 6 AtG. 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 is based on the European Directive 97/11/EG and the Law on Environmental Impact Assessments. 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 in 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 accruing can be accepted until nuclear power plant operation has been discontinued and that they can remain there beyond the time the nuclear power plant has been decommissioned and until a repository will be taken into operation.

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 on. In 2009, the BfS continued the examinations within the scope of supplementary licences and amending licences for the on-site interim storage facilities. In the supplementary and amending licensing procedures it was examined if in individual cases supplementary examinations have to be carried out for the Environmental Impact Assessment.

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 capacity increases carried out so far are shown in Table III.5.

On-site interim storage facility (SZL)	Granting the 1st licence according to § 6 AtG	Mass HM [Mg]	Storing positions Total (Taken at the end of 2009)	Start of construction	Taken into operation
SZL Biblis	22.09.2003	1400	135 (41)	01.03.2004	18.05.2006
SZL Brokdorf	28.11.2003	1000	100 (12)	05.04.2004	05.03.2007
SZL Brunsbüttel	28.11.2003	450	80 (6)	07.10.2003	05.02.2006
SZL Grafenrheinfeld	12.02.2003	800	88 (13)	22.09.2003	27.02.2006
SZL Grohnde	20.12.2002	1000	100 (12)	10.11.2003	27.04.2006
SZL Gundremmingen	19.12.2003	1850	192 (25)	23.08.2004	25.08.2006
SZL Isar	22.09.2003	1500	152 (16)	14.06.2004	12.03.2007
SZL Krümmel	19.12.2003	775	80 (17)	23.04.2004	14.11.2006
SZL Lingen	06.11.2002	1250	125 (28)	18.10.2000	10.12.2002
SZL Neckarwestheim	22.09.2003	1600	151 (32)	17.11.2003	06.12.2006
SZL Philippsburg	19.12.2003	1600	152 (31)	17.05.2004	19.03.2007
SZL Unterweser	22.09.2003	800	80 (5)	19.01.2004	18.06.2007

Table 4.1: On-site Interim Storage Facilities

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 plans the operation of 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 (approximately 35.3 m long, 17.8 m wide and 16.7 m high). The wall thickness of the outer walls in this area is to be approximately 85 cm and the thickness 55 cm. Thus, the wall thicknesses of the Obrigheim on-site interim storage facility correspond to the wall thicknesses in interim storage facilities in southern Germany, which were constructed

according to the so-called WTI-concept. 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 from 8 May to 7 July 2008 the BfS has meanwhile initiated the public participation procedure. In this period altogether 897 persons raised objections against the project. From 8 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 public hearing. The results of the public hearing will be taken into account in the further course of the procedure when the licensing requirements will be examined.

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 within the scope of investigations into a possible subsequent requirement according to § 17 AtG. 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 AtG 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 nuclear 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/19 SN06, 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/19 SN06 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 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 different casks made from concrete, cast-iron and steel in the western half of the hall. Probably from 2014 this waste will be taken to the licensed federal repository, Konrad near Salzgitter, which is currently being converted.

Furthermore, GNS and BZA filed an application according to § 6 AtG 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 one intends to store up to 150 casks. In the current state of handing in documents no examinations have been initiated.

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 AtG 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 AtG.

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 20/28 CG as from serial number 16.

On 23 May 2007, a third modification licence was granted, which permitted the use of the new cask type TN85 for the storage of high-level radioactive vitrified waste 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 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 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 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 canisters from reprocessing at AREVA NC. This application is currently being dealt with.[1] The application for the storage of the HAW vitrified waste canisters from reprocessing in the British Sellafield Ltd. Plant is to be examined in another licensing step later on.

No transports of HAW vitrified waste canisters from reprocessing to the TBL Gorleben were carried out in 2009. On 31 December 2009, 5 casks with spent fuel elements (1 CASTOR® Ic, 1 CASTOR® IIa, 3 CASTOR® V/19) and 86 casks with HAW vitrified waste canisters (1 TS 28 V and 74 CASTOR® HAW 20/28 CG and 11 TN85) were stored in the storage facility.

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 AtG 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 licence.

No decision has been made so far on the application filed by EWN in 2005 for the storage of four casks of the CASTOR® KNK type with spent and fresh fuel elements originating, among others, from the decommissioned compacted sodium-cooled reactor (KNK) of the Karlsruhe Research Center (cf. chapter 2.2) and from the operation of the decommissioned Nuclear Ship “Otto Hahn” (cf. chapter 3.3).

On the appointed date of 31 December 2009, altogether 65 loaded CASTOR® casks were stored in the ZLN.

[1] After editorial deadline:
The licensing procedure was concluded on 29 January 2010 with the 4th amendment being granted.

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. Radioactive waste with negligible heat generation originating from NPP operation is currently intermediately stored on the sites of the nuclear power plants and in the external interim storage facilities in Gorleben, Mitterteich, Esenshamm and Lubmin/Rubenow.

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 federal states 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 AtG, 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 AtG in future, storage space a will be rented and containers and paraphernalia 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 a national waste management centre (Gorleben Nuclear Waste Management Center) 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 through interim storage and reprocessing in other EC member countries was accepted as part of the integrated waste management concept and thus of the proof of precautionary measures to dispose of radioactive waste through the decision of the federal government of 6 June 1989. The construction of an industrial German reprocessing plant in Wackersdorf (WAW) that had been started was stopped in the same year and the spent fuel elements were transported to France (COGEMA, 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 for reprocessing, a ban was imposed on transports for reprocessing abroad after 30 June 2005 with the amendment to the Atomic Energy Act of 27 April 2002. 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 Research Center 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 (today reduced to 60 m^3) of high-level radioactive liquid waste concentrate (HAWC) with an activity of $7.7 \cdot 10^{17}$ Bq arose in reprocessing. The low-level and intermediate-level operational waste of the WAK was conditioned in the Karlsruhe Research Center (formerly FZK and today KIT) and its major part (approx. 25,000 m^3 of waste package volume) was taken to the Asse mine until the end of 1978. After the Asse waste management path had been closed further conditioned operational waste has remained at the WAK-GmbH until today.

Operations finally ended on 30 June 1991. At the end of 1991 the federal government, the federal state of Baden-Württemberg 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 Rückbau- und Entsorgungs-GmbH, a daughter of the federally owned company Energiewerke Nord GmbH (EWN) has been responsible.

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

The process building which had contained the reprocessing process installations has been nearly empty since 2006 (steps 1-3).
Only after the waste solution will have been vitrified will it be possible to adapt the HAWC storage facility installations to the reduced plant operation and to dismantle them (steps 4-5). Also the vitrification facility VEK which was specially constructed for this purpose will be adapted to the reduced plant operation and dismantled immediately after vitrification has been completed.
The conventional dismantling of all buildings (step 6) will only be carried out after the entire plant will have been released from regulatory control.

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.

Prior to the dismantling of the storage buildings the approx. 60 m^3 of HAWC stored in 2 tanks need to be conditioned and disposed of in compliance with the waste acceptance requirements. For this purpose the Karlsruhe Vitrification Plant (VEK) has been constructed. By means of vitrification the liquid waste is converted into a solid, transport and storage-consistent form.

On 20 December 1996, an application for granting a licence according to § 7 AtG 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. Since 16 September 2009 the plant has been in routine operation. Until the end of 2009 48 canisters were filled with waste glass. During the vitrification of the HAWC originating from the operating period of the WAK altogether approx. 130 canisters are being produced each one containing 400 kg of waste glass. It is planned to conclude the works at the end of 2010. The canisters are placed into transport and storage casks of the CASTOR® HAW 20/28 type. These CASTOR® casks are later to be stored in the Interim Storage Facility North of the EWN GmbH in Lubmin (cf. chapter 4.3.3).

Two HAWC casks are in the "LAVA" building (storage casks) and two HAWC casks are 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 which can probably not be dissolved and vitrified. Currently the planning for a residue recovery during remote-handled cask dismantling is being continued.

Apart from the HAWC casks there are also collecting casks for intermediate-level radioactive waste (MAW) in the HWL. These casks are no longer required and can 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 20th decommissioning licence dated 31 January 2006.

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 government of the federal government and the federal states in 1979, which considered the reprocessing including recirculation of the utilisable nuclear fuels and the disposal of radioactive waste from the reprocessing process to be realisable according to the state of the art of science and technology 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 Center in Gorleben not 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 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 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 notification of 21 July 1994, the Lower Saxony 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. Damaged transport and storage casks are generally repaired in the respective nuclear power plants.

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 systems are being operated in the PKA that are required for the repair of a casks and the maintenance of the plant including periodic review and expertise of the staff.

4.7 DISPOSAL

A survey of repositories for radioactive waste and repository projects in Germany is given in Table III.9. Competences 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.

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

The investigation of the Gorleben salt dome in the Lower Saxony administrative district of Lüchow-Dannenberg for its suitability to host a repository for all types of solid and solidified radioactive waste started in 1979.

Within the scope of the above-ground exploration, the above-ground measuring programme in the area of Dömitz-Lenzen north to the river Elbe was completed. Underground, the first exploration area (EB1) was driven in the north-eastern part of the Gorleben salt dome and investigated.

As a consequence of the agreement of 14 June 2000 between the federal government and the utilities concerning an energy consensus, the underground exploration of the Gorleben salt dome was discontinued for minimum 3 years to maximum 10 years (Gorleben Moratorium), as the exploration can currently not contribute to clarifying conceptual and safety-related issues. The Gorleben Moratorium does not imply that the site will be given up. Not until the questions which the Moratorium is based on have been answered and it has become possible to compare it with other sites can it be decided if the exploration of the Gorleben salt dome will be continued. Until then the geological findings gained so far will be saved and the exploration mine above ground and underground will be maintained in a state which will make it possible to resume operation. According to these boundary conditions, the relevant effective main operating plan regulates the phase of keeping the mine open and the measures required for maintaining the value.

In 2008 the competent mining authority was submitted the 5th amendment – updating and extension - to the main operating plan according to § 52 Federal Mining Law (BbergG) for the mine for the exploration of the Gorleben salt dome (main operating plan for keeping the mine open). The validity period of the authorisation of the 4th amendment was extended until 31 December 2008, the authorisation of the 5th amendment was granted in December 2008 (validity period 1 January 2009 – 30 September 2010).

The federal government’s intention to legally support the Gorleben site and its position as applicant during the Moratorium and to protect the project against interventions of third parties, has led to an extension of the overall operating plan for the exploration mine until 30 September 2010. Furthermore, the project was ensured through the Ordinance on a Ban on Development according to § 9g AtG imposed by a Local Authority to Safeguard the Planned Development of the Gorleben Zone (Gorleben-Veränderungssperren-Verordnung, GorlebenVSpV). The GorlebenVSpV became effective one day after it had been announced on 26 July 2005.

With the beginning of the Moratorium, the underground exploration by heading, exploration drillings, and geotechnical measurements was stopped. Geotechnical measurements are only carried out to preserve evidence and/or to monitor the shape of drift near the contour in order to ensure mining safety.

Since 1 October 2000, only measures and works have been carried out that are necessary for reasons of mining safety and for operational reasons to maintain the exploration mine in a reliable state, even for a longer period of time, and to not invalidate the previous investments and work results.

In October 2009, the coalition parties supporting the new federal government laid down in the coalition agreement: “We will therefore lift the moratorium on the exploration of the Gorleben salt dome immediately in

order to continue the exploration without predefined outcome. It is our wish that an international peer review group accompany the works and examine if Gorleben complies with the latest international standards.[2]

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 (Physikalisch-Technische Bundesanstalt, PTB) filed the application for the initiation of a plan-approval (licensing) procedure according to § 9b AtG 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.

The radioactive waste to be disposed of mainly accrues in nuclear energy use for electricity generation, in the decommissioning and dismantling of nuclear facilities, in radioisotope application in craft, research, medicine, and at the Federal Armed forces as well as in research and development work. The volume of this waste is about 90 % but only 0.1 % of the activity of all radioactive waste is to be disposed of permanently in deep geological formations.

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 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.

With decision of 21 February 2008 of the 3rd Chamber of the First Senate of the Federal Constitutional Court, the city of Salzgitter's constitutional complaint was not accepted for a decision for lack of admissibility. With decision of the same Chamber the constitutional complaint of a citizen was not accepted for decision on 10 November 2009 because it did not have a positive perspective.

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 on schedule was continued in 2009. The updating of plannings was continued taking into account requirements of the federal government's Meseberg decisions, the stipulations of the Energy Saving Ordinance and the Regulations on Sustainable Building.

Within the scope of converting the hoisting plant Konrad 1 South several buildings have been dismantled. Hoisting installations were reconstructed. First above-ground construction measures at Konrad 1 and the reconstruction of the north-western area in shaft Konrad 1 were started. Start of reconstruction of the southern area is imminent.

Apart from the shaft hall all buildings at shaft Konrad 2 were dismantled. A temporary hoisting plant has been constructed.

The reconstruction works in shaft Konrad 2 that had already started in 2007 were concluded in 2009.

Furthermore, galleries underground were reconstructed and the main cable route was set up. One started to drive the first emplacement chamber.

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

[2] Currently works for developing a first interim safety assessment and updating the repository concept are being structured and pepared to the extent that required tenders can be initiated on short notice.

operations had discontinued, it was used until 1998 for the disposal of low-level and medium-level radioactive waste with negligible heat generation. 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 $6 \cdot 10^{14}$ Bq (appointed date: 30 June 2005). 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. As regards 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 § 57a AtG were modified to the extent that the permanent operation licence continues to be effective as plan-approval decision in the sense of § 9b AtG for an indefinite period, except for the regulations relating to the acceptance and disposal of further radioactive waste. The acceptance of radioactive waste for disposal has been excluded. Since 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. 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.

Since October 2003, selected mine openings of the central part where no radioactive waste is stored have been backfilled with a pumpable salt concrete within the scope of measures to prevent mining hazards and to improve the geo-mechanic state of the ERAM's central part. Through interaction with the salt rock, additional bearing arches and pillars have been 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. Until the end of 2009, about 790,000 m^3 of salt concrete were pumped into 24 out of 27 cavities on levels 1, 2a, 2, 3a and 3. Until the beginning of 2011 another 140,000 m^3 of salt concrete will be pumped into a cavity which is prone for pieces of rock falling from the roof.

The application for further operation of the ERAM filed on 13 October 1992 to the Ministry for Agriculture and the Environment (MLU) of Saxony-Anhalt was restricted to the decommissioning of the ERAM on 9 May 1997. 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.

Works for the licensing procedure are focussed on the decommissioning concept and on safety assessments. Decommissioning of the ERAM is done in such a way that it is ensured that the radiation protection goals are complied with. Even if it cannot be entirely prevented in the long term that radionuclides are released from a sealed repository, only such amounts of these radionuclides may reach the biosphere that the protection goals are complied with in the long run. This is done with the help of long-term safety assessments. Additional parts of the underground facilities and the shafts are to be backfilled with sealing and stabilising building materials. The emplacement areas are sealed by sealing dams in the access galleries. Altogether, the concept provides for an amount of backfill of about 4.8 million cubic metres of salt concrete. The shafts are sealed with shaft sealings.

In February 2009 the BfS submitted those documents to the MLU that are according to § 6 Nuclear Licensing Procedure Ordinance (AtVfV) required for the public participation procedure within the scope of the nuclear licensing procedure for the final decommissioning of the repository.

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

In addition to the plan, BfS also submitted an Environmental Impact Assessment study in which all results gained in the environment investigations have been presented and evaluated, and a survey of different technical decommissioning variants examined. These documents were laid open to public inspection from October to December 2009 within the scope of the public participation procedure. 12,000 objections relating to the decommissioning of the ERAM have been submitted to the licensing authority by concerned citizens. The objections have been forwarded to the BfS for further processing and preparation of the public hearing within the scope of the public participation procedure.

The decision for the plan-approval procedure for the project "Decommissioning of the ERAM" will be granted following the public participation and after the plan has been evaluated by the licensing authority. In case of a positive decision, following a conversion phase, the implementation of the licensed decommissioning measures for the ERAM can be started. The actual decommissioning of the repository, after the plan-approved decision will be available, will take about 15 years. The decommissioning costs will probably amount to at least 1.2 billion (+/- 30 %) euros (construction costs according to § 3 Cost Ordinance under the Atomic Energy Act). The total costs until decommissioning works have been completed are estimated to amount to about 2.3 billion euros (including operating costs).

ASSE repository for radioactive waste

The Asse II mine near Wolfenbüttel was used for producing potash and rock salt from 1909 until 1964. During this period one carnallitite panel and two rock salt panels were driven. From 1966 until 1995 the Asse II mine was used as "research mine" for radioactive waste disposal in salt formations by Helmholtz Zentrum München – Deutsches Forschungszentrum für Gesundheit und Umwelt (HMGU), formerly Gesellschaft für Strahlen- und Umweltforschung (GSF).

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. Within the scope of the test and demonstration programmes around 124,500 drums with low-level radioactive waste were emplaced in 12 chambers on the 725-m level and on the 750-m level and around 1,300 drums with intermediate-level radioactive waste in a chamber on the 511-m level. The sum of the activity inventory was $6.96 \cdot 10^{15}$ Bq on 1 January 1980.

Within the scope of an agreement between BMU, BMBF and NMU it was decided on 4 September 2008 that the decommissioning of the Asse II mine be treated like the decommissioning of a repository for radioactive waste and that the further operation of the mine be carried out under the responsibility of the BfS. Following a decision of the federal cabinet in this regard of 5 November 2008 responsibility was transferred from the HMGU to the BfS on 1 January 2009.

Since then the BfS has been responsible for the operation of the Asse II mine. Thus the responsibility for the Asse II mine according to both Mining Law and Atomic Energy Act is entirely with the BfS as the operator of the mine. The BfS commissioned the newly founded Asse-GmbH with the management of the mine, starting on 1 January 2009.

The decommissioning concept that had been developed by the former operator HMGU and the selection and justification of this concept, which was not comprehensible from the public's point of view, was heavily criticised by the public. Thereupon the BfS as the new operator decided to carry out a comparison of options prior to commit itself to a decommissioning concept which now has to be licensed in a nuclear plan-approval procedure according to § 9b AtG. In this comparison of options the decommissioning concept that is best suitable for ensuring compliance with protection goals is to be selected.

Since the BfS has the operator responsibility for the Asse mine it has only acted as a consultant in the Comparison of Options Working Group (AGO) which was established by the BMU to examine and evaluate possible decommissioning options. The lead-management is with the project executing organisation, Karlsruhe Institute of Technology (KIT).

At the beginning of 2009 the AGO suggested in an interim report for further examination the decommissioning options retrieval, relocation and complete backfilling. On behalf of the BfS feasibility studies for the three options were carried out. The studies were developed by different expert companies with regard to the purely technical feasibility and to radiation protection aspects.

The results of the feasibility studies were published on 2 October 2009. Their result was that basically all three options are technically feasible.

The options were compared according to criteria that had been discussed in 2009 with the AGO, the Asse II Accompanying Group and with the BMU and that were established by the BfS. Following the completion of the evaluation procedure, the BfS and the BMU arrived at the conclusion that, according to the present state of knowledge, the best variant of how to further deal with the radioactive waste emplaced in the Asse II mine was retrieving the waste, because a proof of long-term safety could only be furnished for the option of retrieval.

While the planning works for a selected decommissioning concept and the required licensing procedure 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 Atomic Energy Act and the Mining Law.

From the point of view of operation the following topics were in the fore in 2009:

- Implementation of immediately required measures to prevent mining hazards (among others backfilling of roof clefts),
- Improvement of brine management,
- Maintaining and improving site monitoring,
- Ensuring operational radiation protection,
- Developing an application according to § 7 StrlSchV for the regulation of the handling of radioactive substances,
- Implementation of an operational security check,
- Developing an emergency planning according to the requirements of the mining law and the atomic law and
- Health monitoring.

After having taken over the operation of the mine, the BfS discovered several potential danger situations. Among others they concerned the emplacement chambers 4 and 5 on the 750-m level and the former "visitors' chamber" on the 725-m level. These potential danger situations had not been classified as safety-relevant by the former operator with regard to the running advanced closing measures. The danger situations have been removed by appropriate measures (improvement or construction of chamber sealings, removal of rock that had scaled off and covering of uncovered waste packages).

Parallel to the acute measures to prevent mining hazards the backfilling of roof clefts was prepared and started in 2009 to reduce the deformations at the southern flank of the mine. This involves the backfilling of residual cavities with a special type of concrete in about 80 out of the more than 100 mining districts, to begin with. On 7 December 2009 one started backfilling the first roof cleft in mining district 6/532.

Due to the fact that it has been interdicted since summer 2008 to use influent saline solution contaminated with tritium outside the mine, the solution had to be stored in emergency reservoirs underground and above ground. Through this measure the capacity limits of the facility were nearly reached and the safety reserves were massively impeded. By developing an improved brine management among others with auxiliary ventilation of the selecting point and the storage reservoir it was possible to reduce the tritium exposure to levels < 10 Bq/l. On the basis of the acceptance gained by the parties responsible for waste management the external use of the influent saline solution could be resumed on 6 February 2009. The influent saline solution stored among others in the emergency reservoirs which cannot be removed has been and is used internally for the production of a special type of concrete for backfilling measures.

The rock-mechanic monitoring of the mine has been intensified by the BfS. Currently the devices for measuring the deformation of the rock are converted from discontinuous measurements to online registration. All inflow-prone parts of the mine are inspected once a week. The chemical monitoring of the influent saline solution's composition has been intensified. By introducing a reporting order it has been ensured that all responsible persons and authorities are informed in due time.

Already in the run-up to taking over operation, the BfS had improved the operational radiation protection in autumn 2008 by introducing a new radiation protection regime.

With letter of 21 April 2009 the BfS filed an application for handling other radioactive substances according to § 7 Radiation Protection Ordinance (StrlSchV) to the NMU. The BfS has thus realised a central requirement of the NMU status report of 1 September 2008.

The BfS arranged for a security check of the mine under mining and radiological aspects to be carried out. The security check of normal operation showed that sufficient precaution according to the state of the art has been taken against releases or discharges of radioactive substances to above ground during the operational phase. The security check relating to incident precaution carried out on behalf of the BfS showed, however, that a design-exceeding inflow of saline solution into the Asse II mine cannot be ruled out and that further precautions need to be taken.

The BfS has examined and published the basic strategic options resulting from this situation. It has started to develop an emergency planning going beyond the requirements of the mining emergency planning. The Asse-GmbH was commissioned to implement plans of execution for a part of the precautions and to carry out

measures to further improve the influent saline solution management. This includes especially measures to improve the collection, storage and transport of the influent saline solution.

Within the scope of the radiological monitoring of the Asse staff the Asse health monitoring was started in 2009. The objective is to determine the occupational radiation exposure of all former and current staff members. The health monitoring will be concluded at the end of 2010 with a publicly accessible report which a summary of the presentation and evaluation of the staff members' radiation exposure.

Under precautionary aspects and as a confidence-building measure the project "Incorporation monitoring of the population in the vicinity of the Asse II mine" has been planned. It will start in 2010 and run for 5 years.

ANNEXES - SURVEY

ANNEX I – NUCLEAR POWER PLANTS –

Status: as at 31.12.2009

Table I.1: Licensing and supervisory authorities of the federal government and the federal states for storage licences according to § 6 AtG and facilities according to § 7 AtG

	Authority for licences according to § 6 AtG	**Supervisory authority according to § 19 in conjunction with § 6 AtG § 6 AtG**
Federal Republic of Germany	Federal Office for Radiation Protection	federal states supervisory authorities
federal state	**Licensing authority for facilities according to § 7 AtG**	**Supervisory authority according to § 19 in conjunction with § 6 AtG and § 7 AtG**
Baden-Württemberg	Environment Ministry in consultation with Ministry of Economics and Ministry of the Interior	Environment Ministry Baden-Württemberg
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-Western-Pomerania	Ministry of the Interior in consultation with Ministry of Economics, Labour and Tourism	Ministry of the Interior
Lower Saxony	Lower Saxony Ministry for the Environment and Climate Protection	
Northrhine-Westphalia	Ministry of Economic Affairs, Middle Class and Energy of the federal state of Northrhine-Westphalia	
Rhineland-Palatinate	Ministry for the Environment, Forests and Consumer Protection	
Saarland	Ministry for the Environment, Energy and Traffic	
Saxony	Saxony State Ministry for the Environment and Agriculture	
Saxony-Anhalt	Ministry for Agriculture and Environment	
Schleswig-Holstein	Ministry of Justice, Equality and Integration of federal state Schleswig-Holstein	
Thuringia	Ministry for Agriculture, Forestry, Environment and Nature Conservation	

Table I.2a: Nuclear power plants in operation
As at 31.12.2009

Nuclear Power Plant	Site	Federal state	Operator	Type	Capacity gross [MW_e]	Capacity net [MW_e]	1st partial licence	Start of construction	Initial criticality
Neckarwestheim 1	Neckarwestheim	BW	EnBW Kernkraft GmbH (EnKK)	PWR	840	785	24.01.1972	02/1972	26.05.1976
Neckarwestheim 2	Neckarwestheim	BW	EnBW Kernkraft GmbH (EnKK)	PWR	1,400	1,310	09.11.1982	11/1982	29.12.1988
Philippsburg 1	Philippsburg	BW	EnBW Kernkraft GmbH (EnKK)	BWR	926	890	09.10.1970	10/1970	09.03.1979
Philippsburg 2	Philippsburg	BW	EnBW Kernkraft GmbH (EnKK)	PWR	1,458	1,392	06.07.1977	07/1977	13.12.1984
Isar 1	Essenbach	BY	E.ON Kernkraft GmbH	BWR	912	878	16.05.1972	05/1972	20.11.1977
Isar 2	Essenbach	BY	E.ON Kernkraft GmbH	PWR	1,485	1,410	12.07.1982	09/1982	15.01.1988
Grafenrheinfeld	Grafenrheinfeld	BY	E.ON Kernkraft GmbH	PWR	1,345	1,275	21.06.1974	01/1975	09.12.1981
Gundremmingen B	Gundremmingen	BY	Kernkraftwerk Gundremmingen GmbH	BWR	1,344	1,284	16.07.1976	07/1976	09.03.1984
Gundremmingen C	Gundremmingen	BY	Kernkraftwerk Gundremmingen GmbH	BWR	1,344	1,288	16.07.1976	07/1976	26.10.1984
Biblis A	Biblis	HE	RWE Power AG	PWR	1,225	1,167	31.07.1970	01/1970	16.07.1974
Biblis B	Biblis	HE	RWE Power AG	PWR	1,300	1,240	06.04.1972	02/1972	25.03.1976
Unterweser	Esenshamm	NI	E.ON Kernkraft GmbH	PWR	1,410	1,345	28.06.1972	07/1972	16.09.1978
Grohnde	Grohnde	NI	E.ON Kernkraft GmbH	PWR	1,430	1,360	08.06.1976	06/1976	01.09.1984
Emsland	Lingen	NI	Kernkraftwerke Lippe-Ems GmbH	PWR	1,400	1,329	04.08.1982	08/1982	14.04.1988
Brokdorf	Brokdorf	SH	E.ON Kernkraft GmbH	PWR	1,480	1,410	25.10.1976	01/1976	08.10.1986
Brunsbüttel	Brunsbüttel	SH	Kernkraftwerk Brunsbüttel GmbH & Co. oHG	BWR	806	771	02.04.1970	04/1970	23.06.1976
Krümmel	Krümmel	SH	Kernkraftwerk Brunsbüttel GmbH & Co. oHG	BWR	1,402	1,346	18.12.1973	04/1974	14.09.1983

Table I.2b: Survey of thermal and electrical capacity increases in the German nuclear power plants
As at 31.12.2009

Nuclear Power Plant	Licenced thermal power At initial criticality [MW_{th}]	Thermal power increase [MW_{th}]	Electricity output in MW_e gross (in the year of initial criticality)	Modification of electricity output (year)	Current electrical power [MW_e]	Capacity increase applied for [MW_{th}]
Neckarwestheim 1	2,362 (1. partial building licence of 24.01.1972)	2,497 (2. partial operation licence of application of 02.04.1971)[1)]	855 (1976)	840 (1990)	840	2,597 (application of 25.04.2000)
Neckarwestheim 2	3,765 (4. partial operation licence of 28.12.1988)	3,850 (3. modification licence of application of 24.10.1990)	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 25.04.2000)
Philippsburg 1	2,575 (1. partial building licence of 09.10.1970)	-	900 (1979)	912 (1994) 926 (1996)	926	-
Philippsburg 2	3,765 (1. partial building licence of 06.07.1977)	3,803 (5. modification licence of 26.11.1991,application of 05.09.1991) 3,850 (8. modification licence of 08.05.1992,application of 07.03.1991) 3,950 (modification licence of 29.03.2000,application of 30.04.1998)	1,349 (1984)	1,357 (1991) 1,390 (1992) 1,402 (1993) 1,424 (1996) 1,458 (11/2000)	1,458	-
Isar 1	2,575 (4. partial building licence of 18.11.1977)		907 (1977)	912 (06/2000)	912	2,755 (application of 04.04.2000) Application suspended

Nuclear Power Plant	Licenced thermal power At initial criticality [MW_{th}]	Thermal power increase [MW_{th}]	Electricity output in MW_e gross (in the year of initial criticality)	Modification of electricity output (year)	Current electrical power [MW_e]	Capacity increase applied for [MW_{th}]
Isar 2	3,765 (4. partial building licence of 12.07.1982)	3,850 (1. modification licence of 25.02.1991,application of 16.10.1990) 3,950 (5. modification licence of 20.11.1998, application of 07.04.1998)	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	-
Grafenrheinfeld	3,765 (5. partial building licence of 10.11.1981)	-	1,299 (1981)	1,300 (1984) 1,345 (1993)	1,345	3,950 (application of 16.05.2000)
Gundremmingen B	3,840 (11. partial building licence of 18.10.1984)	-	1,310 (1984)	1,300 (1987) 1,344 (1994)	1,344	4,100 (application of 14.09.1999 for units B and C, withdrawn on 21.12.2001) 4,000 (new application of 19.12.2001 for units B and C)
Gundremmingen C	Cf. KRB-B	-	1,310 (1984)	1,308 (1987) 1,344 (1995)	1,344	Cf. KRB-B
Biblis A	3,540 (6. partial building licence of 14.12.1973)	-	1,204 (1974)	1,147 (1978) 1,204 (1980) 1,225 (1995)	1,225	-
Biblis B	3,733 (1. partial building licence of 06.04.1972)	-	1,300 (1976)	1,238 (1978) 1,300 (1980)	1,300	-
Unterweser	3,733 (3. modification licence of 15.03.1982)	3,900 (modification licence of 16.08.2000, application of 19.9.1997)	1,300 (1978)	1,320 (1991) 1,350 (1996) 1,410 (11/2000)	1,410	-

Nuclear Power Plant	Licenced thermal power At initial criticality [MW_{th}]	Thermal power increase [MW_{th}]	Electricity output in MW_e gross (in the year of initial criticality)	Modification of electricity output (year)	Current electrical power [MW_e]	Capacity increase applied for [MW_{th}]
Grohnde	3,765 (1. partial building licence of 08.06.1976)	3,850 (modification licence of 09.02.1990, Application of 27.06.1989) 3,900 (modification licence of 29.06.1999, Application of 13.06.1997)	1,365 (1984)	1,394 (1990) 1,430 (1995)	1,430	4,000 (application of 24.09.2007)
Emsland	3,765 (4. partial licence of 30.03.1988)	3,850 (1. modification and supplement licence of 09.02.1990,application of 06.06.1989)	1,316 (1988)	1,314 (1988) 1,341 (1990) 1,363 (1992) 1,400 (08/2000)	1,400	3,950 (application of 16.12.2002)
Brokdorf	3,765 (1. partial operation licence of 30.12.1985)	3,850 (modification licence of 15.02.1994 to 2. operation licence of 03.10.1986) 3,900 (7. amending licence to 2. operation licence of 23.05.2006, application of 16.12.2002)	1,380 (1986)	1,400 (1987) 1,395 (1988) 1,440 (1997) 1,480 (2008)	1,480	-
Brunsbüttel	2,292 (1. operation licence of 22.06.1976)	-	806 (1976)	-	806	-
Krümmel	3,690 (1. operation licence of 14.09.1983)	-	1,316 (1983)	1,376 (2005) 1,402 (2007)	1,402	-

[1)] As to GKN I: The second partial operation licence of 26.05.1976 comprises, among others, zero power and power tests up to 30 % of the thermal reactor output.
Supplements: 1. Amendment to the 2. partial operation licence of 02.08.1976: zero power and power tests up to 80 % of the thermal reactor output
2. Amendment to the 2. partial operation licence of 05.10.1976: zero power and power tests up to 100 % of the thermal reactor output
3. Amendment to the 2. partial operation licence of 15.06.1977: test operation up to 100 % of the thermal reactor output

Table I.3: Nuclear power plants under decommissioning or decommissioning was decided

Nuclear Power Plant	Site	Federal state	Operator	Type	Gross capacity [MW_e]	Start of construction	Initial criticality	Final shut-down	Status
Rheinsberg	Rheinsberg	BB	Energiewerke Nord GmbH	PWR	70	01/1960	11.03.1966	01.06.1990	Dismantling licence of 28.04.1995 ff.
Compact sodium-cooled reactor	Eggenstein-Leopoldshafen	BW	Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH	FBR	21	09/1974	10.10.1977	23.08.1991	Dismantling licence of 26.08.1993 ff.
Multi-purpose research reactor	Eggenstein-Leopoldshafen	BW	Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH	PWR	57	12/1961	29.09.1965	03.05.1984	Dismantling licence of 17.11.1987 ff.
Obrigheim	Obrigheim	BW	EnBW Kernkraft GmbH (EnKK)	PWR	357	03/1965	22.09.1968	11.05.2005	1. decomm. licence of 28.08.2008
Gundremmingen A	Gundremmingen	BY	Kernkraftwerk Gundremmingen GmbH	BWR	250	12/1962	14.08.1966	13.01.1977	Dismantling licence of 26.05.1983 ff.
Kahl Test Nuclear Power Plant	Kahl, Main	BY	Versuchsatomkraftwerk Kahl GmbH	BWR	16	07/1958	13.11.1960	25.11.1985	Dismantling licence of 05.05.1988 ff.
Greifswald Unit 1	Lubmin	MV	Energiewerke Nord GmbH	PWR	440	03/1970	03.12.1973	18.12.1990	Licence of 30.06.1995 ff. for decomm./ dismantl. entire plant
Greifswald Unit 2	Lubmin	MV	Energiewerke Nord GmbH	PWR	440	03/1970	03.12.1974	14.02.1990	Licence of 30.06.1995 ff. for decomm./ dismantl. entire plant
Greifswald Unit 3	Lubmin	MV	Energiewerke Nord GmbH	PWR	440	04/1972	06.10.1977	28.02.1990	Licence of 30.06.1995 ff. for decomm./ dismantl. entire plant

Nuclear Power Plant	Site	Federal state	Operator	Type	Gross capacity [MW_e]	Start of construction	Initial criticality	Final shut-down	Status
Greifswald Unit 4	Lubmin	MV	Energiewerke Nord GmbH	PWR	440	04/1972	22.07.1979	02.06.1990	Licence of 30.06.1995 ff. for decomm./ dismantl. entire plant
Greifswald Unit 5	Lubmin	MV	Energiewerke Nord GmbH	PWR	440	12/1976	26.03.1989	30.11.1989	Licence of 30.06.1995 ff. for decomm./ dismantl. entire plant
Stade	Stade	NI	Kernkraftwerk Stade GmbH & Co. oHG	PWR	672	12/1967	08.01.1972	14.11.2003	Licence for decomm./ dismantl. phase 1 of 07.09.2005, phase 2 of 15.02.2006 Phase 3 14.05.2009
Lingen	Lingen, Ems	NI	Kernkraftwerk Lingen GmbH	BWR	252	10/1964	31.01.1968	05.01.1977	Licence for Safe Enclosure on 21.11.1985; application for dismantling of facility of 15.12.2008
Jülich Experimental Nuclear Power Plant	Jülich	NRW	Arbeitsgemeinschaft Versuchsreaktor GmbH	HTR	15	08/1961	26.08.1966	31.12.1988	1. decomm. licence for Safe Enclosure on 09.03.1994 Licence for entire dismantl. Of the plant 31.03.2009

Nuclear Power Plant	Site	Federal state	Operator	Type	Gross capacity [MW_e]	Start of construction	Initial criticality	Final shut-down	Status
Würgassen	Würgassen	NRW	E.ON Kernkraft GmbH	BWR	670	01/1968	22.10.1971	26.08.1994	1. decomm. licence of 14.04.1997 ff.
Hamm-Uentrop Gas-cooled High-temperature Pebble Bed Reactor	Hamm-Uentrop	NRW	Hochtemperatur-Kernkraftwerk GmbH	HTR	308	05/1971	13.09.1983	29.09.1988	Licence for operation of Safe Enclosure of 21.05.1997
Mülheim-Kärlich	Mülheim-Kärlich	RP	RWE Power AG	PWR	1,302	01/1975	01.03.1986	09.09.1988	Licence for decomm./ dismantl. phase 1a 16.07.2004, supplemented 23.02.2006, lic. for reduc. the plant premises 09.06.2009

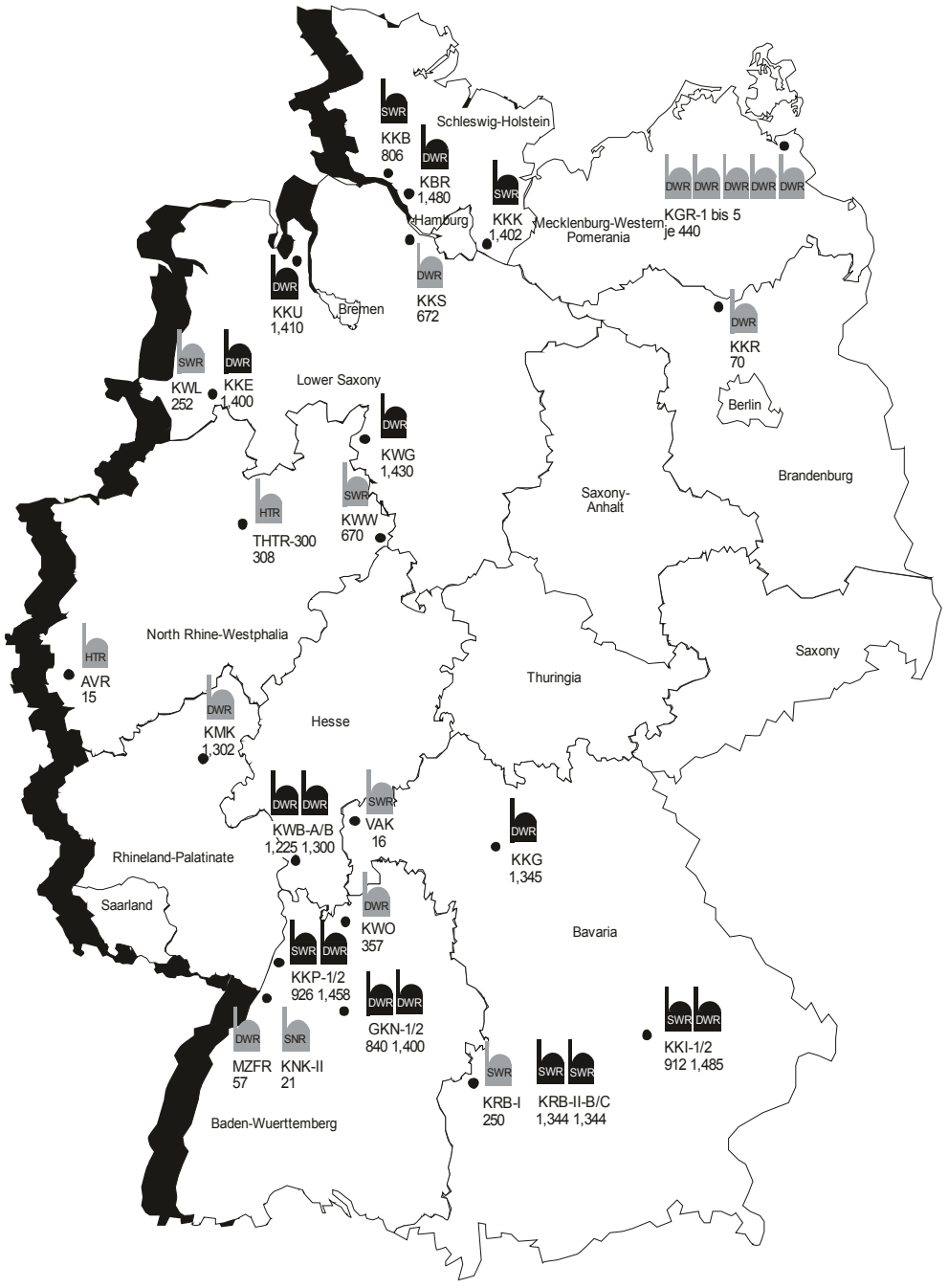
Table I.4: Nuclear power plants entirely dismantled and released from regulatory control

Nuclear Power Plant	Site	Federal state	Operator	Type	Gross capacity [MW_e]	Start of construction	Initial criticality	Final shut-down	Status
Superheated Steam Reactor	Großwelzheim	BY	Karlsruhe Institute of Technology (KIT), formerly Karlsruhe Research Center GmbH	SSR	25	01/1965	14.10.1969	20.04.1971	Entirely dismantled
Nieder-aichbach	Niederaichbach	BY	Karlsruhe Institute of Technology (KIT), formerly Karlsruhe Research Center GmbH	PTR	106	06/1966	17.12.1972	31.07.1974	Entirely dismantled

.

Table I.5: Stopped nuclear power plant projects

Nuclear Power Plant	Site	Federal state	Operator	Type	Gross capacity [MW_e]	Start of construction	Final shut-down	Status
Greifswald Unit 6	Lubmin	MV	Energiewerke Nord GmbH	PWR	440	1976	30.11.1989	Licence of 30.06.1995 ff. for decomm./dismantl. entire plant
Greifswald Unit 7	Lubmin	MV	Energiewerke Nord GmbH	PWR	440	1976		Project stopped
Greifswald Unit 8	Lubmin	MV	Energiewerke Nord GmbH	PWR	440	1976		Project stopped
Sodium-cooled Fast Breeder Reactor 300	Kalkar	NRW	Schnell-Brüter-Kernkraftwerksgesellschaft mbH	FBR	327	1973		Project stopped 20.03.1991
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

Under decommissioning or decommissioning was decided

Data: Capacity gross MW_e

Status: As at 31.12.2009

Figure I: Nuclear power plants in Germany

ANNEX II – RESEARCH REACTORS –

As at 31.12.2009

Table II.1: Research reactors in operation (continuous thermal power above 50 kW)

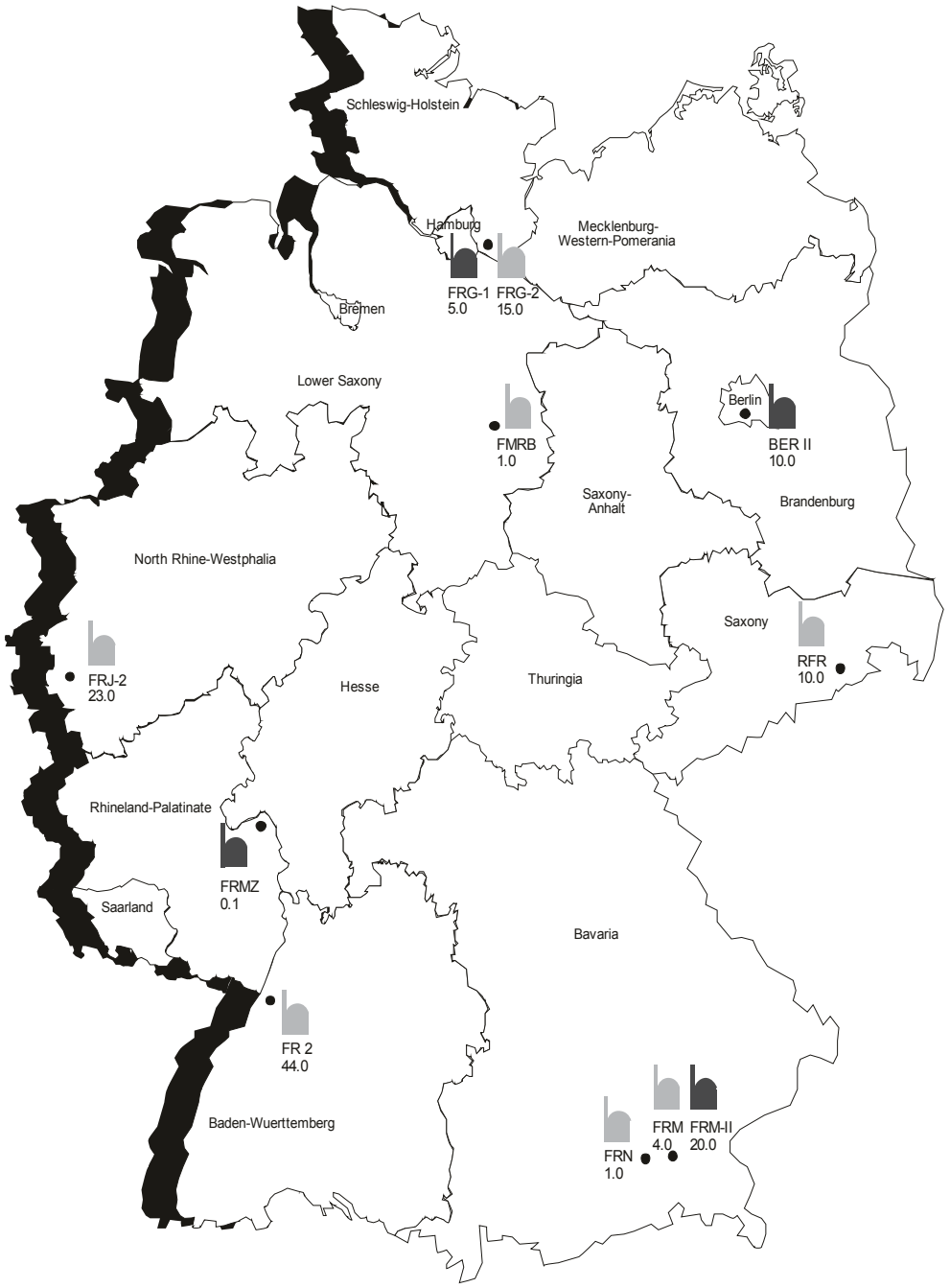
Research Reactor	Site	Federal state	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Status
Berlin Experimental Reactor Unit II	Berlin	BE	Helmholtz-Zentrum Berlin (HMI)	Pool, MTR	10	$1.5 \cdot 10^{14}$	09.12.1973	In operation
Munich High-flux Neutron Source	Garching	BY	Technische Universität München (TUM)	Pool, Compact core	20	$8 \cdot 10^{14}$	02.03.2004	In operation
Research Reactor Mainz	Mainz	RP	Universität Mainz Institut für Kernchemie	Pool, Triga Mark II	0.1	$4 \cdot 10^{12}$	03.08.1965	In operation
RR Geesthacht Unit 1	Geesthacht	SH	Research Center Geesthacht (GKSS)	Pool, MTR	5	$1.4 \cdot 10^{14}$	23.10.1958	In operation

Table II.2: Research reactors under decommissioning or decommissioning was decided (continuous thermal power above 50 kW)

Research Reactor	Site	Federal state	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Status
RR Karlsruhe Unit 2	Egg.-Leo-poldshafen	BW	Wiederaufarbeitungs-anlage Karlsruhe Rückbau- und Entsorgungs-GmbH	Tank type D_2O reactor	44	$1 \cdot 10^{14}$	07.03.1961	21.12.1981	Decommissioning licence of 03.07.1986 ff., Safe Enclosure since 20.11.1996
Munich RR	Garching	BY	Technische Universität München (TUM)	Pool, MTR	4	$7 \cdot 10^{13}$	31.10.1957	28.07.2000	Application for decommissioning of 14.12.1998
RR Neuherberg	Ober-schleißheim	BY	Helmholtz Zentrum München, German Research Center for Environmental Health	Pool, Triga Mark III	1	$3 \cdot 10^{13}$	23.08.1972	16.12.1982	Decommissioning licence of 30.05.1983, Safe Enclosure since 24.05.1984
Research and Measuring Reactor Braun-schweig	Braunschweig	NI	Federal Institute of Physics and Metrology (PTB)	Pool, MTR	1	$6 \cdot 10^{12}$	03.10.1967	19.12.1995	Decommissioning licence of 02.03.2001, facility released from regulatory control by 28.07.2005, except for interim storage facility
RR Jülich Unit 2 (DIDO)	Jülich	NRW	Jülich Research Center (FZJ)	Tank type D2O reactor	23	$2 \cdot 10^{14}$	14.11.1962	02.05.2006	Application for decommissioning of 27.04.2007
RR Geesthacht Unit 2	Geesthacht	SH	Research Center Geesthacht (GKSS)	Pool, MTR	15	$1.5 \cdot 10^{14}$	16.03.1963	28.01.1993	Licence for taking out of operation and partial dismantling of 17.01.1995, decommissioning later on with FRG-1
RR Rossendorf	Rossendorf	SN	Verein für Kernverfahrenstechnik und Analytik Rossendorf e.V. (VKTA)	Tank type WWR-S(M)	10	$1.2 \cdot 10^{14}$	16.12.1957	27.06.1991	Decommissioning licence of 30.01.1998 ff. final partial licence for residual dismantling of 01.02.2005

Table II.3: Research reactors entirely dismantled and released from regulatory control (continuous thermal power above 50 kW)

Research Reactor	Site	Federal state	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Status
TRIGA HD I RR Heidelberg	Heidelberg	BW	German Cancer Research Center (DKFZ)	Pool, Triga Mark I	0.25	$1 \cdot 10^{13}$	26.08.1966	31.03.1977	Released from regulatory control on 13.12.2006, within the scope of the clearance procedure the plant was conventionally dismantled in 2009 and the premises were completely rehabilitated.
TRIGA HD II RR Heidelberg	Heidelberg	BW	German Cancer Research Center (DKFZ)	Pool TRIGA Mark I	0.25	$1 \cdot 10^{13}$	28.02.1978	30.11.1999	Released from regulatory control on 13.12.2006
RR Frankfurt Unit 2	Frankfurt	HE	Johann Wolfgang Goethe Universität Frankfurt	Modified TRIGA	1	3·1013 (designed)	No criticality	Not operated	Released from regulatory control on 31.10.2006
RR of the Hannover Medical School	Hannover	NI	Hannover Medical School	Pool TRIGA Mark I	0.25	$8.5 \cdot 10^{12}$	31.01.1973	18.12.1996	Released from regulatory control on 13.03.2008
RR Jülich Unit 1	Jülich	NRW	Jülich Research Center (FZJ)	Pool MTR	10	$1.1 \cdot 10^{14}$	24.02.1962	22.03.1985	Released from regulatory control on 23.11.2007
"Otto Hahn" Nuclear Ship	Geesthacht	SH	Research Center Geesthacht (GKSS)	FDR Ship reactor	38	$2.8 \cdot 10^{13}$	26.08.1968	22.03.1979	Released from regulatory control on 01.09.1982, storage of reactor pressure vessel according to StrlSchV



Legend

In operation

Under decommissioning or decommissioning was decided

Data: Thermal power MW_{th}

Status: As at 31.12.2009

Figure II: Research reactors with a continuous thermal power above 50 kW

ANNEX III – PLANTS OF NUCLEAR FUEL SUPPLY AND WASTE MANAGEMENT

As at 31.12.2009

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, NRW**	Uranium enrichment up to a fraction of max. 6 % U-235	4,500 Mg of uranium separative work per year (SW/a) according to notification of 14.02.2005	3. partial licence of 04.06.1985 (operation licence) 9. partial licence of 31.101997; capacity increase to 1800 t UTA/a 7. partial/modification licence of 27.11.1998, modification licence for 2 additional separation halls Notification no. 7/6 of 14.02.2005 on increase of production capacity to 4500 Mg of SW/y	The licence of 14.02.2005 also comprises the handling of depleted and enriched uranium (up to max. 6 percent by weight U-235). The expanded plant has been constructed since mid 2008 and will be gradually commissioned. Production capacity was 2,750 Mg UTA/a at the end of 2009.

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 % U-235-fraction	Operation licence of 18.01.1979, 7. partial operation licence of 08.06.1994 (operation of conversion plant with enriched uranium) 07.03.1997: Capacity increase of fuel element fabrication by 250 Mg of externally produced uranium pellets per year 11.01.2005: Increase of uranium powder throughput rate to 650 Mg/a 02.12.2009: 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.

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 **Karlstein** **BY**	Fabrication of special fuel elements of low-enriched uranium dioxide	Annual throughput of 400 Mg of UO2 up to max. 4.0 % U-235 fraction	Operation licence according to § 9 AtG: 02.09.1966 Operation licence according to § 7 AtG: 30.12.1977 Licence according to § 7 AtG for dismantling of plant components: 16.08.1994 and 18.03.1996 Released from regulatory control March 1999	Fuel element fabrication has been discontinued; conventional fabrication of structural parts
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: 15.08.1968 Last comprehensive licence according to § 9 AtG of 30.12.1974 Operation licence according to § 7 AtG: 11.03.1991 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: Sept. 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: 22.07.1969 Operation licence according to § 7 AtG: 31.08.1990 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 special fuel elements of enriched uranium and thorium for research reactors	100 kg U-235 enrichment up to 20 %; 1,700 kg U-235 enrichment between 20 % and 94 %; 100 Mg natural uranium; 100 Mg depleted uranium; 200 Mg thorium	Operation licence according to § 9 AtG: 30.07.1962 Several licences for decommissioning, dismantling and remediation of premises between 1993 and 2001 Released form regulatory control in May 2006, except for a partial area of 1000 m^2 for further groundwater decontamination	Operation licence discontinued on 15.01.1988; by 31.12.1988 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 high-temperature reactors (HTR) on the basis of uranium (up to 94 % of U-235) and thorium	200,000 fuel elements/a 11.7 Mg HM (during operation time)	Operation licence according to § 9 AtG: 30.12.1974 six licences for decommissioning between 30.01.1990 and 07.04.1995 On 18.12.1995 released from regulatory control	The facility was temporarily taken out of operation on 15 January 1988, and was decommissioned later on. The components relating to process engineering were dismantled. Decontamination of premises and building structures 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 license	License	Notes
TRANSPORT CASK STORAGE FACILITY IN THE INTERIM STORAGE FACILITY NORTH (ZLN) **Rubenow (near Greifswald), MV**	Storage of spent fuel elements from the Rheinsberg and Greifswald reactors in transport and storage casks (dry storage).	585 Mg HM in max. 80 storage casks Max. storable activity: $7.5 \cdot 10^{18}$ Bq	According to § 6 AtG of 05.11.1999 1. modification licence of 14.03.2001 2. modification licence of 07.07.2003 3. modification licence of 19.12.2005 4. modification licence of 17.02.2006 5. modification licence of 17.12.2008 6. modification licence of 24.02.2009	On 31.12.2009 65 casks of the CASTOR® 440/84 type were stored in the ZLN.
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	05.09.1983 according to § 6 AtG; order for immediate enforcement of 06..09.1988 New licence of 02.06.1995 for spent fuel elements and vitrified fission product solutions 1. modification licence of 01.12.2000. 2. modification licence of 18.01.2002 3. modification licence of 23.05.2007	On 31.12.2009, altogether 91 casks were stored in the TBL-G - 5 casks of which contained spent fuel elements, - 86 casks HAW vitrified waste block canisters

Name of facility and site	Purpose of the facility	Capacity according to license	License	Notes
TRANSPORT CASK STORAGE FACILITY AHAUS (TBL-A) **Ahaus, NRW**	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	10.04.1987 acc. to § 6 AtG amended version of the storage licence of 07.11.1997 (increase of the mass of HM and licence for further cask types) 1. modification licence of 17.05.2000 2. modification licence of 24.04.2001 3. modification licence of 30.03.2004 4. modification licence of 04.07.2008 5. modification licence of 22.12.2008	In April 1995 the emplacement of 305 CASTOR® THTR/AVR casks with fuel elements of the THTR-300 was terminated. In 1998, 3 CASTOR® V/19 and 3 CASTOR® V/52 were additionally transported 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 (in operation or licensed)

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 22.09.2003 1. modification licence of 22.03.2006 2. modification licence of 28.09.2006 1. amendment to the licence of 03.09.2007	Start of construction 17.11.2003 First emplacement 06.12.2006 At the end of 2009, altogether 32 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 $1.5 \cdot 10^{20}$ activity and 6.0 MW heat release	According to § 6 AtG of 19.12.2003 1. modification licence of 05.10.2006 2. modification licence of 21.12.2006	Start of construction 17.05.2004 First emplacement 19.03.2007 At the end of 2009, 31 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)	26.10.1998 acc. to § 7 AtG	Since the end of 2007, 342 fuel elements have been in the fuel pool
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 12.02.2003 Order for immediate enforcement of 10.09.2003 1. modification licence of 31.07.2007	Start of construction 22.09.2003 First emplacement 27.02.2006 At the end of 2009, 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 $2.4 \cdot 10^{20}$ activity and 6.0 MW heat release	According to § 6 AtG of 19.12.2003 Order for immediate enforcement of 28.07.2004 1. modification licence of 02.06.2006	Start of construction 23.08.2004 First emplacement 25.08.2006 At the end of 2009, 25 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 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 $1.5 \cdot 10^{20}$ activity and 6.0 MW heat release	According to § 6 AtG of 22.09.2003 Order for immediate enforcement of 28.05.2004 1. modification licence of 11.01.2007 2. modification licence of 29.02.2008	Start of construction 14.06.2004 First emplacement 12.03.2007 At the end of 2009, 16 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 $8.5 \cdot 10^{19}$ activity and 5.3 MW heat release	According to § 6 AtG of 22.09.2003 1. modification licence of 20.10.2005 1. amendment to the licence of 20.03.2006 2. modification licence of 27.03.2006	Start of construction 01.03.2004 First emplacement 18.05.2006 At the end of 2009, altogether 41 casks were stored in the interim storage facility
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 $5.5 \cdot 10^{19}$ activity and 3.75 MW heat release	According to § 6 AtG of 20.12.2002 Order for immediate enforcement of 19.09.2005 1. modification licence of 17.04.2007	Start of construction 10.11.2003 First emplacement 27.04.2006 At the end of 2009, altogether 12 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 $6.9 \cdot 10^{19}$ activity and 4.7 MW heat release	According to § 6 AtG of 06.11.2002 with order for immediate enforcement 1. amendment to the licence of 31.07.2007 1. modification licence of 01.02.2008	Start of construction 18.10.2000 First emplacement 10.12.2002 At the end of 2009, 28 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 3.0 MW heat release	According to § 6 AtG of 22.09.2003 Order for immediate enforcement of 05.02.2007 1. modification licence of 27.05.2008	Start of construction 19.01.2004 First emplacement 18.06.2007 At the end of 2009, 5 casks were stored in the interim storage facility

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
AVR CASK STORAGE FACILITY IN THE FZJ **Jülich** **NRW**	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 17.06.1993 1. modification licence of 27.04.1995 2. modification licence of 07.07.2005	On 31.12.2009, 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 3.0 MW heat release	According to § 6 AtG of 19.12.2003 1. modification licence of 16.11.2005 Order for immediate enforcement of 28.04.2006 2. Modification licence of 17.10.2007	Start of construction 23.04.2004 First emplacement 14.11.2006 At the end of 2009, 17 casks were stored in the interim storage facility
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 28.11.2003 1. modification licence of 24.05.2007	Start of construction 05.04.2004 First emplacement 05.03.2007 At the end of 2009, 12 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 28.11.2003 Order for immediate enforcement of 28.10.2005 1. modification licence of 14.03.2008	Start of construction 07.10.2003 First emplacement 05.02.2006 At the end of 2009, 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
COLLECTING DEPOT OF THE UTILITIES 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 07.07.1982	In operation since July 1987.
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 20.02.1998	In operation since March 1998. Since 11.12.2007 the ZLN is licence 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 **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 24.06.1981, 29.11.1991, and 06.11.1998	In operation since autumn of 1981.
WASTE STORAGE FACILITY GORLEBEN (DRUM STORAGE FACILITY) **NI**	Storage of waste with negligible heat generation from NPPs, medicine, research and crafts	200-l, 400-l, 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 27.10.1983, 13.10.1987, and 13.09.1995	In operation since October 1984.

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: 1. partial operation licence according to § 7 AtG of 02.01.1967 Decommissioning WAK: 1. decommissioning licence, March 1993 20. decommissioning licence according to § 7 AtG: 31.01.2006 Construction VEK 1. partial licence according to § 7 AtG for modification work at the WAK in the process of constructing the vitrification plant (VEK) of 30.12.1998 3. partial building licence according to § 7 AtG (complete finishing of the VEK) of 15.11.2001 Modification licence to the 3. partial building licence, 19.07.2005 (Construction of a transport preparation place for loaded CASTOR® casks) Operation VEK partial operation licence for the VEK 20.12.2005 (inactive commissioning) partial operation licence for the VEK of 24.02.2009 (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” have advanced. The installations of the process building have been largely removed. The dismantling of the MAW collecting containers started in May 2008. A vitrification plant for 60 m^3 of HAWC was constructed and commissioned in 2009. Until the end of 2009 48 canisters were filled with waste glass.

Table III.8: Conditioning plants for fuel elements

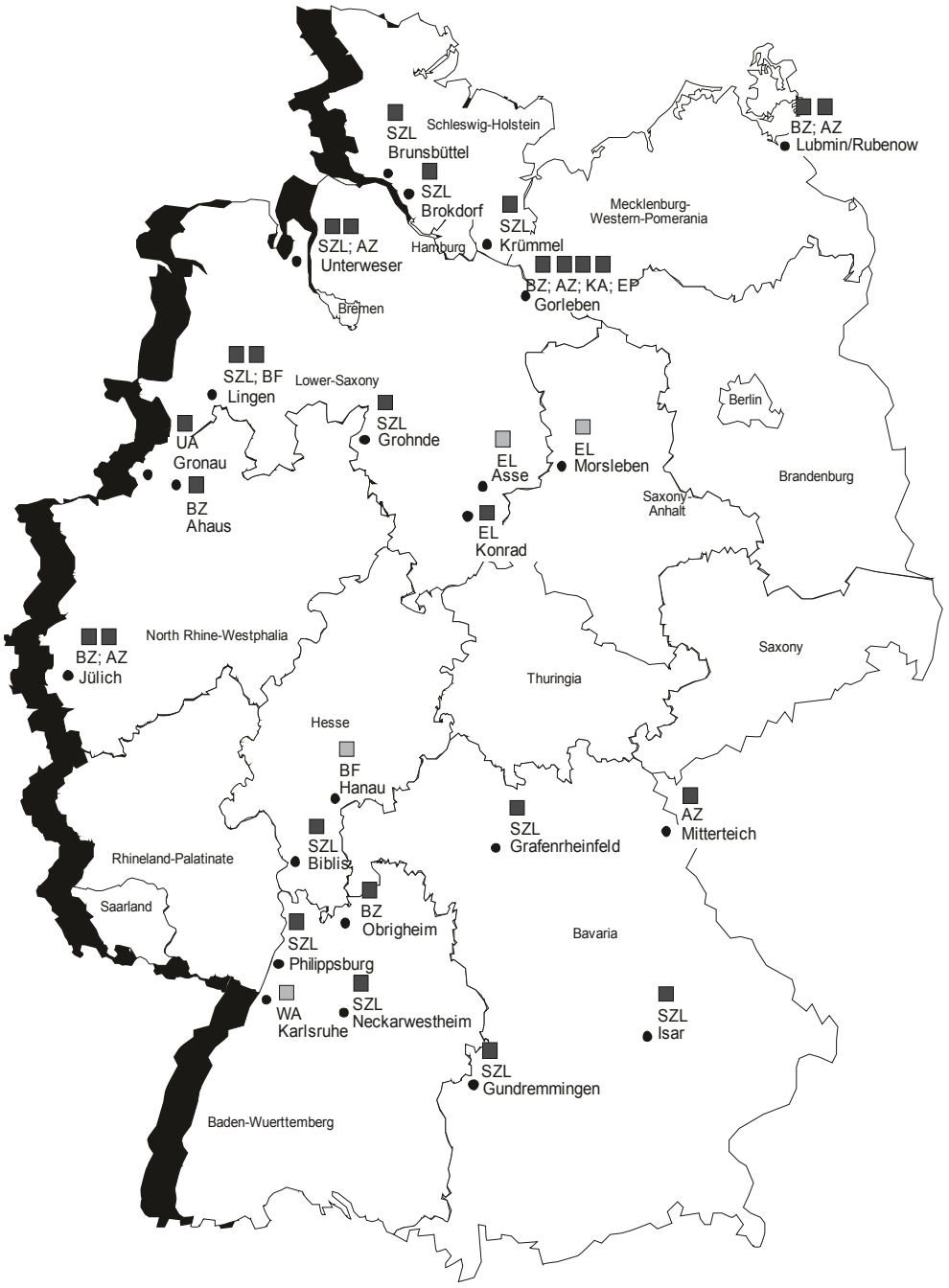
Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
PILOT CONDITIONING PLANT (PKA) **Gorleben, NI**	Repair of defective casks, conditioning of radioactive residues and waste (among others, spent fuel elements, fuel rods and fuel element components) for interim storage and disposal	Heavy metal throughput applied for: 35 Mg/a Capacity of operational buffer storage facility: 12 Mg HM	Acc. to § 7 AtG 1. Partial licence of 30.01.1990 2. partial licence of 21.07.1994 (Subsequently imposed obligation of 18.12.2001) 3. partial licence: 19.12.2000 (includes operation licence)	According to the 3. 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	License	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 exploratory mine has been operated on the basis of the licensed main and overall operating plan for keeping the mine open, either of them valid until 30.09.2010.	The geological host rock formation is rock salt. To clarify conceptual and safety-related questions the exploration of the Gorleben salt dome was since 01.10.2000 discontinued for a period between 3 years (minimum) and 10 years (maximum) (Gorleben Moratorium).

Name of facility and site	Purpose of the facility	Amounts disposed of / activity	License	Notes
KONRAD REPOSITORY **Salzgitter,** **NI**	Disposal of radioactive waste with negligible heat generation		Application according to § 9b AtG in 1982 (plan-approval application) Withdrawal of application for immediate enforcement with BfS letter of 17.07.2000. The plan-approval decision (licence) was granted on 22.05.2002. After legal remedies have been exhausted following claims against the plan-approval decision, it has been legally binding since 26.03.2007 and can be implemented. Pending constitutional complaints have not been accepted or not been accepted for decision. With approval of the main operating plan on 15 January 2008, the main operating plan was granted by the competent mining authority for a term of six years. Thus also the second licence required for construction is available.	The geological host rock formation is coral oolite (iron ore) underneath an impermeable barrier of the Cretaceous.
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. Total activity $3.1 \cdot 10^{15}$ Bq (01.01.2002), 40 % of which are contained in the MAW	Licences according to § 3 StrlSchV as amended on 15.10.1965. Storage licences for nuclear fuels according to § 6 AtG.	The geological host rock formation is rock salt. Since 01.01.2009 BfS has been operator. Conversion into operation according to Atomic Energy Act.

Name of facility and site	Purpose of the facility	Amounts disposed of / activity	License	Notes
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 $6 \cdot 10^{14}$ Bq, the activity of the alpha-emitters is in the order of magnitude of 10^{11} Bq.	22.04.1986: Continuous operating licence (DBG) granted. According to § 57a AtG it continued to be effective until 30.06. 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. 12.04.2001: Declaration of renunciation of accepting further radioactive waste for disposal	The geological host rock formation is rock salt. Emplacement operations stopped on 25.09.1998. Conversion of the mine and keeping it open were applied for on 10.07.2003. Decommissioning was applied for on 09.05.1997. The documents required for the public participation procedure were entirely revised and submitted to the licensing authority (MLU) in February 2009. These documents were laid open to public inspection from October to December 2009 within the scope of the public participation procedure. Approximately 12,000 objections were raised on this issue that are currently being dealt with.



Legend

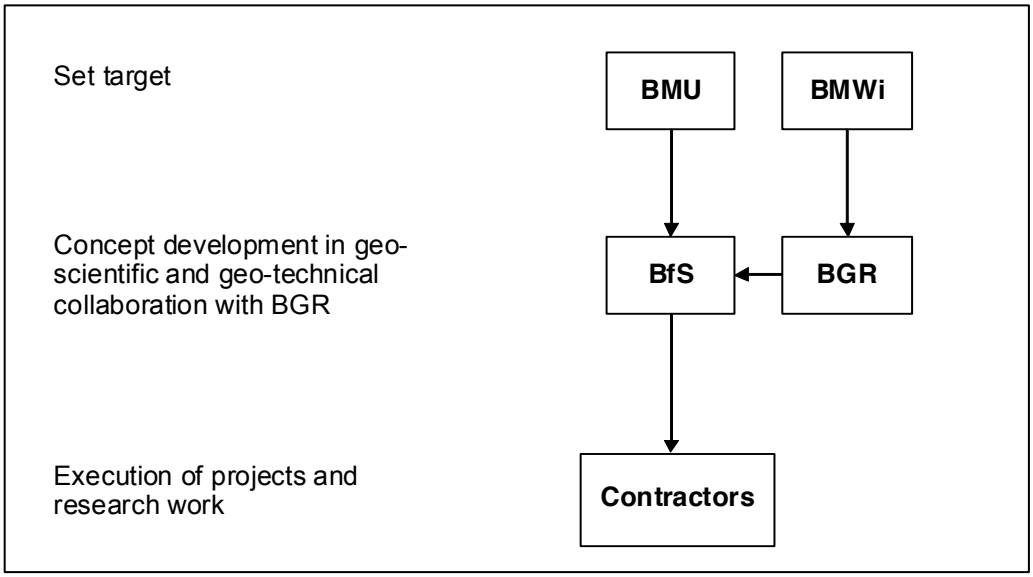
AZ	Rad. waste interim storage facility	KA	Pilot conditioning plant
BF	Fuel element fabrication plant	SZL	On-site interim storage facility
BZ	Fuel element interim storage facility	UA	Uranium enrichment plant
EL	Radioactive waste repository	WA	Reprocessing plant
EP	Repository project		

Status: 31.12.2009

In operation/ being planned

Under Decommissioning

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



BMU

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) is the federal ministry competent for nuclear safety and radiation protection according to the Atomic Energy Act. It supervises BfS.

BMWi

The Federal Ministry of Economics and Technology (BMWi) is responsible for the personnel/manpower of the BGR as Superior Federal Authority in its portfolio.

BfS

The Federal Office for Radiation Protection (BfS) is responsible for the construction and operation of federal facilities for the long-term storage and disposal of radioactive waste.
It initiates and coordinates facility-related research and development work. For implementing its tasks the BfS can avail itself of third parties (§ 9a para. § 3 AtG). It imposes prepayments/contributions and costs on the parties liable to pay.

BGR

The Federal Institute for Geosciences and Natural Resources (BGR) has the task to support BfS in geoscientific and geotechnical questions associated with the planning, construction, operation and decommissioning of repositories.

Contractors

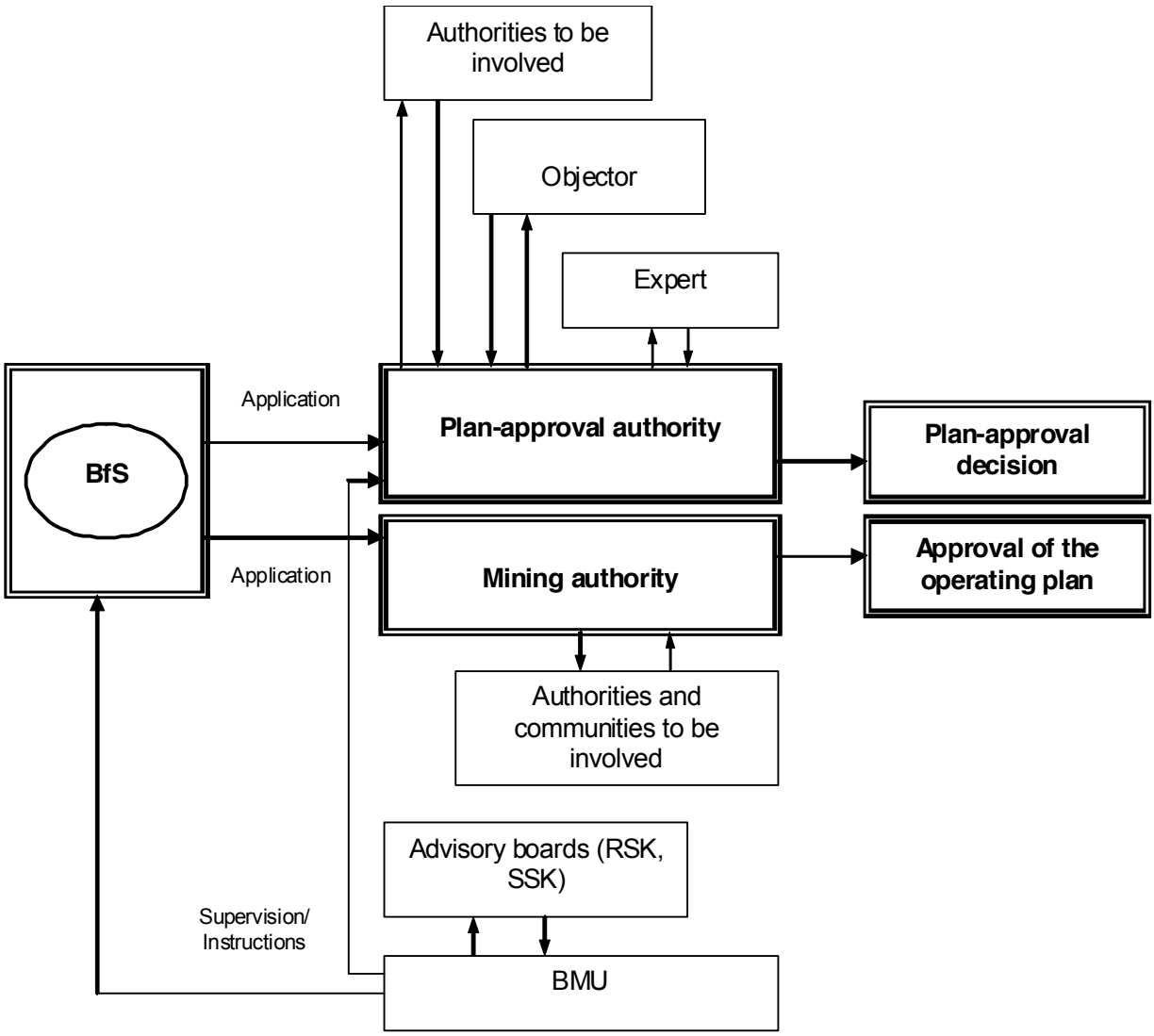
a) Large research institutions

On behalf of the BMBF they perform basic research and, on behalf of BfS, facility-related research and development work. Contractors of BfS are, among others, the Helmholtz Zentrum München – Deutsches Forschungszentrum für Gesundheit und Umwelt GmbH (formerly GSF), Gesellschaft für Reaktorsicherheit (GRS), the Karlsruhe Institute of Technology (KIT) and the Jülich Research Center (FZJ).

b) DBE mbH

On behalf of BfS, the German Company for the Construction and Operation of Waste Repositories (DBE; GNS mbH holds 75 % of the shares, EWN GmbH holds 25 % of the shares) performs tasks on the planning, construction and operation of federal facilities for the long-term storage and disposal of radioactive waste. DBE is third party in the sense of the provisions set out in § 9a para. 3 AtG.

Figure III.2: Competencies in radioactive waste disposal



The diagram shows the links between the parties in the nuclear plan-approval procedure and in mining law procedures.

Legend:

BMU	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)
BfS	Bundesamt für Strahlenschutz (Federal Office for Radiation Protection)
RSK	Reaktorsicherheitskommission (Reactor Safety Commission)
SSK	Strahlenschutzkommission (Commission on Radiological Safety)

Figure III.3: Course of the nuclear plan-approval (licensing) procedure and the procedures according to Mining Law

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

| Verantwortung für Mensch und Umwelt |

Kontakt:
Bundesamt für Strahlenschutz
Postfach 10 01 49
38201 Salzgitter
Telefon: + 49 30 18333-0
Telefax: + 49 30 18333-1885
Internet: www.bfs.de
E-Mail: ePost@bfs.de
Gedruckt auf Recyclingpapier aus 100 % Altpapier.

Bundesamt für Strahlenschutz