State and Development of Nuclear Energy Utilization in the Federal Republic of Germany 2014

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SUMMARY

This report describes the use of nuclear energy in the Federal Republic of Germany as at 31 December 2014. It contains the essential data of all nuclear power plants, research reactors and the facilities of the nuclear fuel cycle. At the reporting date 31 December 2014, nine nuclear power plants were in operation. The power generation from nuclear energy in 2014 amounted to altogether 97.1 TWh (2013: 97.3 TWh). This is a share of 15.8% of the total gross electricity production (2013: 15.4%)[1].

The report summarises the essential operational results of the nuclear power plants and information on granted licences. A short description of the present state of the nuclear power plants that have been shut down or decommissioned and of the stopped projects is given. Concerning research reactors essential data on type, characteristics (thermal power, thermal neutron flux) and purpose of the facility are represented. Furthermore, an overview is given of the licensing and operation history and the present state of the operating condition. For the facilities of the nuclear fuel cycle data on purpose and capacity and output are given. Furthermore, the licensing history and the present status of operation and licensing are represented. The works on the running repository projects ERAM and Konrad and on the Asse II mine and the Gorleben mine are presented. To give a survey, the data is summarised in tabular form at the end of in the report (Annexes). The report is updated and published once a year.

[1] Preliminary estimated values as of March 2015, source: BDEW

LIST OF ABBREVIATIONS

ADIBKA	Burn-up measurement of differential fuel elements with critical assembly
AGEB	Energy Balances Working Group
AGO	Formerly: Comparison of Options Working Group, now: Working Group Options-Retrieval
AKR-2	Training reactor Technische Universität Dresden
ANEX	Facility for homopolar power experiments
ANF (AREVA)	Advanced Nuclear Fuels GmbH, French industrial company, main line of business: nuclear technology
AtG	Atomic Energy Act
AtVfV	Nuclear Licensing Procedure Ordinance
AVR	Jülich Experimental NPP
A2 B	ASSE II consultation group
BB	Brandenburg
BBergG	Federal Mining Law
BDEW	Bundesverband der Energie- und Wasserwirtschaft e.V., Federal Association of Energy and Water Economy e.V.
BE	Berlin
BER II	Berlin Experimental Reactor Unit II
BfS	Federal Office for Radiation Protection
BGR	Federal Institute for Geosciences and Natural Resources
BLG	Gorleben Fuel Element Storage Facility
BMBF	Federal Ministry of Education and Research
BMFT	Federal Ministry of Research and Technology
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (renamed to BMUB on 17.12.2013)
BMUB	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (previously BMU)
BMWi	Federal Ministry for Economic Affairs and Energy
BNFL	British Nuclear Fuels Ltd.
Bq	Becquerel
BVerfG	Federal Constitutional Court
BVerwG	Federal Administrative Court
BW	Baden-Württemberg
BWE	Bundesverband WindEnergie e.V., German Wind Energy Association
BY	Bavaria
BZA	Ahaus Interim Storage Facility for Spent Fuel Elements
CASTOR®	Cask for Storage and Transport of Radioactive material
CEA	Commissariat à l'Energie Atomique et aux Energies Alternatives
CLAB	Centralt mellanlager för använt bränsle, Central interim storage facility for spent fuel elements in Sweden
COGEMA	Compagnie Générale des Matières Nucléaires, AREVA-Group
CSD-C	Colis Standard de Déchets Compactés
DBE	German Company for the Construction and Operation of Waste Repositories
DBG	Permanent operating licence
DDR	German Democratic Republic
DIDO	Heavy-water moderated and cooled research reactor in the Jülich Research Center
DKFZ	German Cancer Research Center
DWK	German Company for the Reprocessing of Nuclear Fuels
PWR	Pressurised Water Reactor (PWR)
E.ON	E.ON Kernkraft GmbH
EnBW	Energiewerke Baden-Württemberg AG
EnKK	EnBW Kernkraft GmbH
ERAM	Morsleben Repository for Radioactive Waste
ERU	Enriched-Uranium
ESK	Waste Management Commission
EVU	Utilities
EWN	Energiewerke Nord GmbH
FDR	Advanced Pressurised Water Reactor
FMRB	Research and Measuring Reactor Braunschweig

FR 2	Research Reactor Karlsruhe Unit 2
FRF 1	Research Reactor Frankfurt Unit 1
FRF 2	Research Reactor Frankfurt Unit 2
FRG-1	Research Reactor Geesthacht Unit 1
FRG-2	Research Reactor Geesthacht Unit 2
FRH	Research Reactor of the Hannover Medical School
FRJ-1	Research Reactor Jülich Unit 1
FRJ-2	Research Reactor Jülich Unit 2
FRM	Research Reactor Munich
FRM-II	Research Reactor Munich, high-flux neutron source
FRMZ	TRIGA Mark II Research Reactor of the Mainz University
FRN	Research Reactor Neuherberg
FZJ	Jülich Research Center
FZK	Karlsruhe Research Center
GKN 1	Neckarwestheim NPP Unit 1
GKN 2	Neckarwestheim NPP Unit 2
GKSS	Gesellschaft für Kernenergieverwertung in Schiffbau und Schifffahrt mbH, now: Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung GmbH
GNS	Gesellschaft für Nuklear Service mbH
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit mbH
GWh	Gigawatt hour
HAW	High-Active Waste
HAWC	High-Active Waste Concentrate
HB	Free Hanseatic City of Bremen
SSR	Großwelzheim, Superheated Steam Reactor
HE	Hesse
HEU	High-Enriched Uranium
HH	Free and Hanseatic City of Hamburg
HKG	Hochtemperatur-Kernkraftwerk GmbH
HM	Heavy Metal
HMGU	Helmholtz Zentrum München, German Research Center for Environmental Health GmbH
HOBEG	Hochtemperatur-Brennelement Gesellschaft
HTR	High-temperature gas-cooled reactor
HWL	High-Active Waste Storage Facility
K	Kelvin
KAHTER	Critical facility for high-temperature reactors
KBR	Brokdorf NPP
KEITER	Critical experiment on in core thermionics reactor
KGR	Kernkraftwerk Greifswald, Greifswald NPP
KIT	Karlsruhe Institute of Technology
KKB	Brunsbüttel NPP
KKE	Emsland NPP
KKG	Grafenrheinfeld NPP
KKI 1	Isar NPP Unit 1
KKI 2	Isar NPP Unit 2
KKK	Krümmel NPP
KKN	Niederaichbach NPP
KKP 1	Philippsburg NPP Unit 1
KKP 2	Philippsburg NPP Unit 2
KKR	Rheinsberg NPP
KKS	Stade NPP
KKU	Unterweser NPP
NPP	Nuclear Power Plant
KMK	Mülheim-Kärlich NPP
KNK II	Karlsruhe Sodium-cooled Reactor
KRB A	Gundremmingen NPP Unit A
KRB-II-B	Gundremmingen NPP Unit B
KRB-II-C	Gundremmingen NPP Unit C

KTA	Nuclear Safety Standards Commission
KWB A	Biblis NPP Unit A
KWB B	Biblis NPP Unit B
KWG	Grohnde NPP
KWL	Lingen NPP
KWO	Obrigheim NPP
KWU	Siemens AG, Fachbereich Kraftwerk-Union
KWW	Würgassen NPP
LAVA	Facility for the Sto-rage and Vaporisation of High-Active Waste Liquids
LAW	Low-Active Waste
LBEG	State Authority for Mining, Energy and Geology
LEU	Low-Enriched Uranium
LWR	Light Water Reactor
MERLIN	Medium Energy Research Light Water Moderated Industrial Nuclear Reactor in the Jülich Research Center (FZJ)
MEU	Medium-Enriched Uranium
MLU	Saxony-Anhalt Ministry for Agriculture and the Environment
MOX	Mixed-oxide (fuel)
MTR	Materials Testing Reactor
MV	Mecklenburg-Western Pomerania
MWe	Megawatt electrical power
MWEIMH NRW	Ministry of Economic Affairs, Energy, Industry, Middle Class and Trade of the Land of North Rhine-Westphalia
MWh	Megawatt hour
MWth	Megawatt thermal power
MZFR	Karlsruhe, Multipurpose Research Reactor Karlsruhe
NBauO	Lower Saxon Building Code
NI	Lower Saxony
NMU	Lower Saxon Ministry for the Environment, Energy and Climate Protection
NUKEM	NUKEM GmbH Alzenau
NW	North Rhine-Westphalia
OH	Otto Hahn
oHG	General Partnership
OVG	Higher Administrative Court
PFB	Plan-approval decision
PKA	Pilot conditioning plant
PTB	Federal Institute of Physics and Metrology
PuO2	Plutonium dioxide
RAKE	Rossendorf assembly for critical expe-riments
RFR	Research Reactor Rossendorf
RP	Rhineland-Palatinate
RPV	Reactor pressure vessel
RRR	Rossendorf ring zone reactor
RRRFR	Russian Research Reactor Fuel Return
RSK	Reaktor-Sicherheitskommission, Reactor Safety Commission
RWE	Rheinisch-Westfälische Elektrizitätsgesellschaft
SAAS	Federal Office for Nuclear Safety and Radiation Protection (of the former GDR)
SAR	Siemens Argonaut Reactor
SE	Safe enclosure
SG	Decommissioning licence
SH	Schleswig-Holstein
SL	Saarland
SM	Heavy metal (HM)
SMUL	Saxon State Ministry for the Environment and Agriculture
SN	Saxony
SNEAK	Fast Zero-Power Facility
FBR	Sodium-cooled Fast Breeder Reactor
SSK	German Commission on Radiological Protection

ST	Saxony-Anhalt
STARK	Fast Thermal Argonaut Reactor
StMUV	Bavarian State Ministry of the Environment and Consumer Protection
StrlSchV	Radiation Protection Ordinance
SUA	Siemens Subcritical Assembly
SUR	Siemens Training Reactor
BWR	Boiling water reactor (BWR)
SZL	On-site interim storage facilities
TBG	Partial operating licence
TBL	Transport Cask Storage Facility
TBL-A	Ahaus Transport Cask Storage Facility
TBL-G	Gorleben Transport Cask Storage Facility
TEG	Partial construction licence
TG	Partial licence
TH	Thuringia
THTR-300	Hamm-Uentrop Thorium High-temperature Reactor
TRIGA	Training Research Isotope General Atomics
TRIGA HD I	TRIGA HD I Research Reactor Heidelberg
TRIGA HD II	TRIGA HD II Research Reactor Heidelberg
TSG	Partial decommissioning licence
TUM	Technische Universität München
TWh	Terawatt hour
U-235	Uranium isotope 235
U_3O_8	Triuranium octoxide
UAG	Gronau Uranium Enrichment Plant
UF_6	Uranium hexafluoride
UNS	Independent Emergency System
UO_2	Uranium dioxide
UTA	Uranium separative work
UVP	Environmental Impact Assessment
VAK	Kahl Experimental NPP
VBA	Lost concrete shielding
VDEW	Verband der Elektrizitätswirtschaft (e.V.)
VDMA	Verband Deutscher Maschinen- und Anlagenbau e.V.
VEK	Karlsruhe Vitrification Facility
VGB	Technische Vereinigung der Großkraftwerksbetreiber (e.V.)
VKTA	Radiation Protection, Analytics and Waste Management Rossendorf (e.V.)
VSG	Preliminary safety assessment for the Gorleben site
WAK	Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH
WAW	Wackersdorf Reprocessing Plant
WWER	Water-cooled water-moderated energy reactor (Russian type PWR)
WWR-S (M)	Water-cooled water-moderated reactor of the Russian type, S stands for serial production and M for modification (RFR: Modifications to core and fuel)
ZLN	Interim Storage North Rubenow

1 ELECTRIC ENERGY PRODUCTION IN GERMANY

1.1 GENERAL

In 2014, altogether approximately 614.0 TWh (2013: ca. 633.2 TWh) of electric energy was produced in the Federal Republic of Germany (gross electricity production including electricity transfers). The total gross electricity production in Germany decreased compared with the previous year (cf. Table 1). Nearly all conventional energy sources were affected by the decrease. Particularly affected was electricity generation from hard coal. In the year under report, the hard coal power plants produced ca. 10.4 per cent less energy than in the preceding year (Source: BDEW).

The upward trend of wind power energy continued also in 2014. For example, in the year under report onshore wind energy grew by 58% (4.750 MW) compared to the previous year. Wind turbines were erected in all German Länder. The major part of these turbines was erected in Schleswig-Holstein. More than a quarter of the capacity constructed in 2014 in Germany was installed there. (Source: Deutsche WindGuard, on behalf of the BWE and VDMA)

The overall gross electricity production of the general electricity supply (i.e. without companies producing electricity or heat for self supply) amounted to 569.3 TWh in 2014. The share of nuclear power plants was 17.1% in 2014 [Source: BDEW].

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

***	2012		2013		2014*	
	TWh	**%**	**TWh**	%	**TWh**	%
Nuclear energy	99.5	15.8	97.3	15.4	97.1	15.8
Lignite	160.7	25.5	160.9	25.4	155.8	25.4
Hard coal	116.4	18.5	121.7	19.2	109.0	17.8
Mineral oil	7.6	1.2	7.2	1.1	6.0	1.0
Natural gas	76.4	12.1	67.5	10.7	58.3	9.5
Renewables, among them	143.6	22.8	152.4	24.1	160.6	26.2
Wind	50.7	8.1	51.7	8.2	56.0	9.1
Water	21.8	3.5	23.0	3.6	20.5	3.3
Biomass	39.7	6.3	41.2	6.5	43.0	7.0
Photovoltaic systems	26,4	4.2	31.0	4.9	34.9	5.7
Refuse (Regenerative share only)	5.0	0.8	5.4	0.9	6.1	1.0
Others (total) **	25.7	4.1	26.2	4.1	27.2	4.4
Total	629.,9	100.	633.2	100.0	614.0	100.0

* All figures relating to the years 2014 are preliminary, partly estimations

** The category “Others” has not been specified in the BDEW data.

*** all values are rounded

[Sources: BDEW, as at March 2015, AGEB]

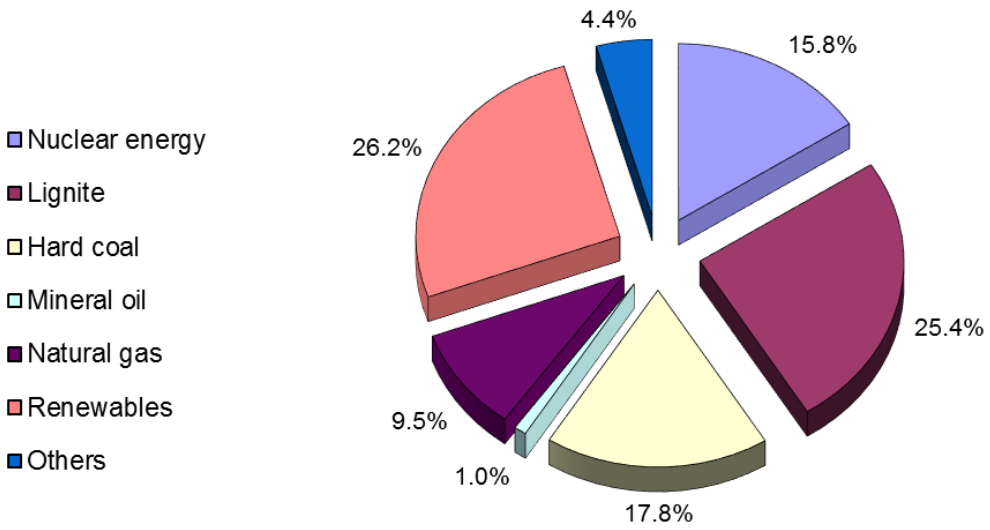


Fig. 1: Share of energy sources in the total gross electricity production in 2014 (basis: 614.0 TWh)

1.2 THE RENEWABLE ENERGY SOURCES ACT

The increased utilisation of renewables is a component of the German climate protection strategy. This is stipulated in the Renewable Energy Sources Act (EEG) that became effective in 2000 and has been continually developed further since. The EEG amendment 2014 has been effective since 1 August 2014. Accordingly, the share of renewables in power supply is to be increased to minimum 40 to 45% until the year 2025, to 55 to 60% until the year 2035, and to at least 80% until the year 2050. The objective of the EEG amendment of 2014 is still to promote the use and development of renewables. In order to be able to better steer the expansion, specific expansion corridors have been determined for the annual growth of the various renewable energy technologies.

- Solar energy: Annual growth of 2.4 to 2.6 GW (gross)
- Wind energy (onshore): Annual growth of 2.4 to 2.6 GW (net)
- Biomass: Annual growth of 100 MW (gross), and
- Wind energy (offshore): Installation of 6.5 GW until 2020 and 15 GW until 2030.

(Source: BMWi)

1.3 PHASE-OUT OF ELECTRICITY PRODUCTION FROM NUCLEAR ENERGY

The use of nuclear energy for commercial power generation will gradually phase out in Germany. It is planned to shut down the last nuclear power plant in 2022.

The end of the individual power plants' operating times has been laid down in the Atomic Energy Act. The final shutdown of a nuclear power plant is followed by the post-operational phase during which works to prepare decommissioning are carried out.

1.3.1 Consequences of the reactor accident in Fukushima

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

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

1.3.2 Current nuclear legislation in Germany

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

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

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

31 December 2015 Grafenrheinfeld NPP

31 December 2017 Gundremmingen NPP unit B

31 December 2019 Philippsburg NPP unit 2

31 December 2021 Grohnde NPP, Gundremmingen NPP unit C and Brokdorf NPP

31 December 2022 Isar NPP unit 2, Emsland NPP and Neckarwestheim NPP unit 2.

However, the operator of the Grafenrheinfeld plant (KGG) had already publicly announced in 2014 to take KGG from the grid prematurely in the first half-year 2015

1.3.3 Electricity volumes generated in Germany

Already in June 2001, the federal government and the utilities agreed upon a certain electricity volume for each nuclear power plant which the respective plant is authorised to produce with reference date 1 January 2000. This resulted in an operating time of approximately 32 years for each nuclear power plant, which was determined in the Atomic Energy Act in April 2002. In 2010, the federal government decided to extend by eight years the operating times of the nuclear power plants that had taken up power operation until and including 1980 or, respectively, to extend the operating times of the younger nuclear power plants by 14 years. Correspondingly, the Atomic Energy Act as amended in December 2010 allocated additional electricity volumes to individual nuclear power plants. In the wake of the reactor accident in Fukushima Daiichi, the federal government decided to end the use of nuclear energy for commercial power generation. As a result, the Atomic Energy Act was amended in August 2011. It does again specify exclusively the electricity volumes for each individual nuclear power plant that had already been set out in the previous version of the Atomic Energy Act of April 2002. The extension of operating times laid down in December 2010 was revoked and the additional electricity volumes were cancelled.

Due to the amendment to the Atomic Energy Act in August 2011 a concrete date was set by law for each individual nuclear power plant to shut down. Furthermore, the Atomic Energy Act specifies in Column 2 of Annex 3 to § 7 para. 1a the electricity volumes that can still be produced with reference date 01 January 2000 (cf. Column 2 of the Table in Fig. 2). Once they have been produced, the authorisation for operating the plant will expire. According to the Atomic Energy Act the transfer of electricity volumes from one nuclear power plant to another is an option. They may be transferred in part or as a whole from one – usually older and smaller – nuclear power plant to another. The transfer of the remaining electricity volumes of the nuclear power plants shut down according to Atomic Energy Act on 6 August 2011 (Biblis A, Neckarwestheim 1, Biblis B, Brunsbüttel, Isar 1, Unterweser, Philippsburg and Krümmel) is also an option. According to the Atomic Energy Act, any transfer from a newer onto an older nuclear power plant is subject to the approval of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), in agreement with the Federal Chancellery and the Federal Ministry for Economic Affairs and Energy. From the BMUB point of view, it is necessary in this case to compare the safety level of both nuclear power plants involved in the transfer. Transfers of electricity volumes must be reported to the Federal Office for Radiation Protection and are taken into account when registering the electricity volumes.

In January 2011, the Neckarwestheim NPP unit 1 (GKN 1) had exhausted its electricity amount listed in Column 2 of Annex 3 to § 7 para. 1a Atomic Energy Act in the version that was effective at that point in time. Since then the plant was operated with the additional electricity volumes according to the Atomic Energy Act as at December 2010. GKN 1 was shut down in the scope of the federal government’s Moratorium of

14 March 2011. The shut down has been regulated by the amendment of the Atomic Energy Act of 6 August 2011.

1.3.4 Tasks of the Federal Office for Radiation Protection (BfS)

The Federal Office for Radiation Protection registers and documents the net electricity volumes produced in the German nuclear power plants and the electricity volumes remaining according to Atomic Energy Act. The utilities measure the generated net electricity and, report the data to the BfS once a month since May 2002. They arrange for the measuring devices to be tested by independent expert organisations and certify the annually reported electricity volumes assisted by a certified accountant. The functional inspection reports and the certificates by the certified accountant are submitted to the BfS.

The BfS has been publishing the produced, transferred and remaining electricity volumes according to Atomic Energy Act in the Bundesanzeiger (Federal Gazette) since 10 July 2002. The figures are published annually. Fig. 2 depicts the status of the electricity volumes on 31 December 2014 which was published on 22 April 2015 as annual statement in the Bundesanzeiger. Its current version can also be viewed at the BfS website http://www.bfs.de/de/kerntechnik/KTA/kkw/laufzeiten.html.

Should an operating time of less than six months be expected due to the residual electricity volumes, the figures are published monthly. Since November 2014, this applies to the Grafenrheinfeld plant (KKG), so that publications relating to this plant will be made in the Bundesanzeiger on a monthly basis from November 2014 until the probable end of its operating time in May 2015 (cf. Chapter 1.3.2).

Announcement according to § 7para 1 c Atomic Energy Act (AtG) - annual statement 2014 -

Electricity volumes produced, transferred and remaining during the period from 1 January 2000 to 31 December 2014 [GWh net] according to § 7 para. 1a annex 3 column 2 AtG

Nuclear Power Plant	Electricity volume from 1 January 2000	1 January 2000 to 31 December 2011	Total 2012	Total 2013	Total 2014	Electricity volumes transferred until 31 December 2014	Remaining electricity volumes
1	2	3	4	5	6	7	8
Biblis A[1) 4)]	62000.00	64591.29	0.00	0.00	0.00	4785.53	2194.24
Neckarwestheim 1[4)]	57350.00	57350.00	0.00	0.00	0.00		0.00
Biblis B[3) 4)]	81460.00	81737.52	0.00	0.00	0.00	8100.00	7822.48
Brunsbüttel[4)]	47670.00	36670.33	0.00	0.00	0.00		10999.67
Isar 1[4)]	78350.00	76325.88	0.00	0.00	0.00		2024.12
Unterweser[4)]	117980.00	106777.14	0.00	0.00	0.00		11202.86
Philippsburg 1[2) 4)]	87140.00	73185.87	0.00	0.00	0.00	-5499.89	8454.24
Grafenrheinfeld	150030.00	116677.46	9996.43	9664.79	9853.99		3837.33
Krümmel[4)]	158220.00	69974.89	0.00	0.00	0.00		88245.11
Gundremmingen B	160920.00	121011.39	9862.66	9647.36	9527.08		10871.51
Philippsburg 2	198610.00	128832.36	10227.82	8714.52	9631.53		41203.77
Grohnde	200900.00	128856.95	11048.99	10420.06	9481.18		41092.82
Gundremmingen C	168350.00	119288.19	10099.09	10015.72	10031.13		18915.87
Brokdorf	217880.00	133491.99	10246.91	11146.17	10974.17		52020.76
Isar 2	231210.00	138040.67	11438.20	11402.05	10794.90		59534.18
Emsland	230070.00	131940.69	10847.68	10912.11	10954.90		65414.62
Neckarwestheim 2	236040.00	126295.94	10426.52	10218.74	10588.09		78510.71
Summe	**2484180.00**	**1711048.56**	**94194.30**	**92141.52**	**91836.97**		**502344.29**
Stade[1)]	23180.00	18394.47				-4785.53	0.00
Obrigheim[2)]	8700.00	14199.89				5499.89	0.00
Mülheim-Kärlich[3)]	107250.00					-8100.00	99150.00
Gesamtsumme	**2623310.00**						**601494.29**

The data in column 6 "Total 2014" contain the values examined by certified accountants according to § 7 para. 1a AtG.

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

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

3) With letter of 30 June 2010 PNN/Dr. Pa the RWE Power AG reported the tranfer of 8,100 GWh of the electricity volume allocated to the decommissioned plant Mülheim-Kärlich (KMK) to the Biblis B (KWB B) plant according to § 7 Absatz 1c Atomic Energy Act. Prior to the transfer on 30 June 2010 the remaining electricity volume of the KWB B amounted to 5,889.11 GWh.

4) Since the 13th Law concerning the Amendment to the Atomic Energy Act became effective on 6 August 2011, the nuclear power plants Biblis A, Biblis B, Brunsbüttel, Neckarwestheim 1, Isar 1, Unterweser, Krümmel und Philippsburg 1 are no longer authorised for porwer operation and have been exempted from the reporting obligation according to § 7 para. 1c sent. 1 no. 1 and 2 of the Atomic Energy Act (AtG).

Fig. 2: Generated, transferred and remaining electricity volumes (net) of German nuclear power plants (annual statement, Bundesanzeiger: 22 April 2015)

2 NUCLEAR POWER PLANTS IN GERMANY

As at 31 December 2014, the status of the nuclear power plants in Germany was as follows:

9 Nuclear power plants in operation

8 Nuclear power plants finally shut down,

16 Nuclear power plants under decommissioning

3 Nuclear power plants decommissioned and released from regulatory control, and

6 Nuclear power plant projects stopped.

Table 2.1: Nuclear power plants in Germany 2014

Status	DWR		SWR		Others		Total	
	Num-ber	MWe (gross)	Num-ber	MWe (gross)	Num-ber	MWe (gross)	Num-ber	MWe (gross)
In Operation	7	10,014	2	2,688	—	—	9	12,702
Finally shut dowm	4	4,775	4	4,046	—	—	8	8,821
Under decommis-sioning	10	4,658	3	1,172	3	344	16	6,174
Entirely dismantled	—	—	1	16	2	131	3	147
Project stopped	5	3,320	—	—	1	327	6	3,647

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

An overview 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.

Furthermore, the operating times of the nuclear power plants in Germany since their first criticality are shown in the following Figure 3.

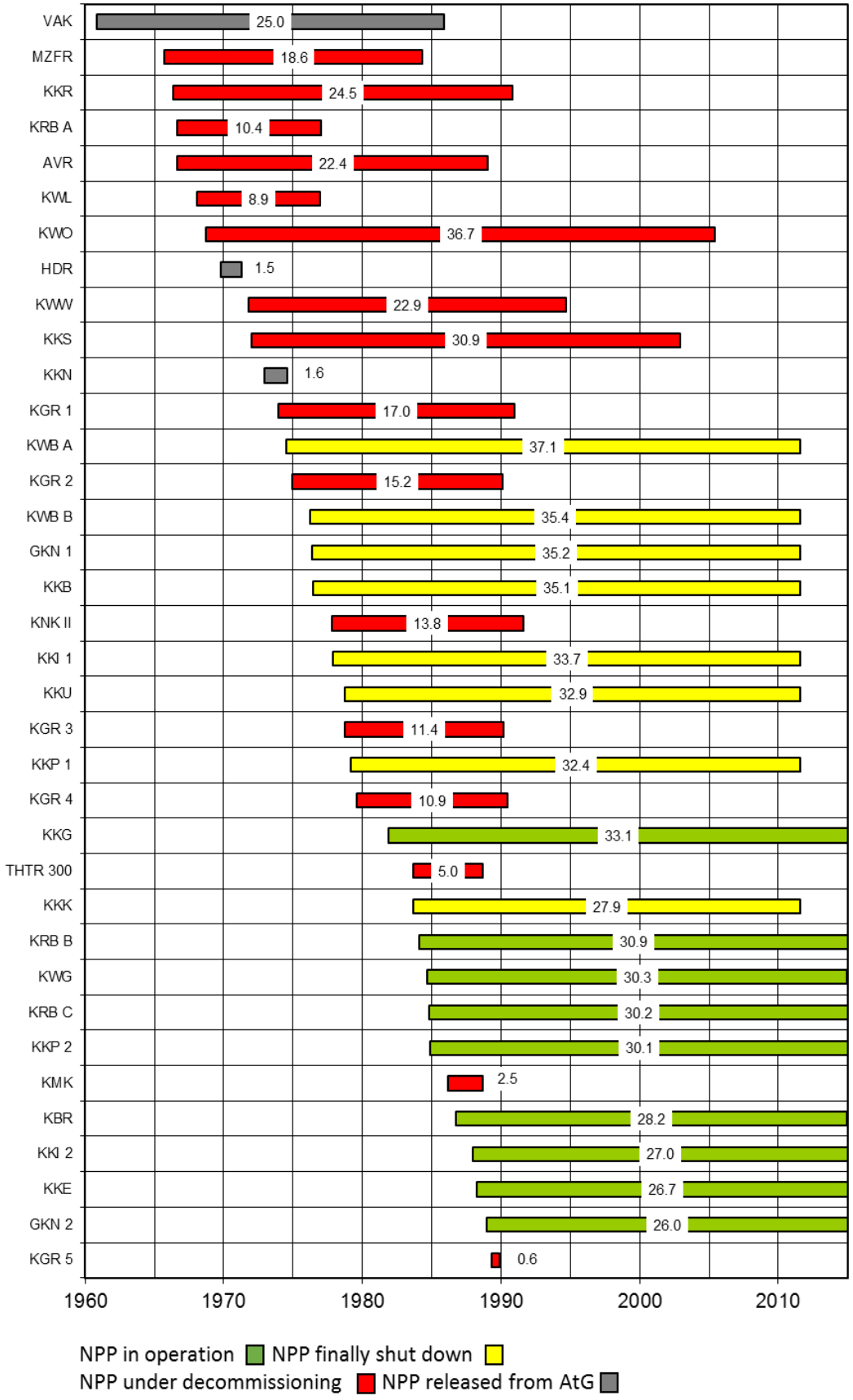


Fig. 3: Nuclear power plant operating times in Germany, given in years since first criticality, as at 31 December 2014

2.1 NUCLEAR POWER PLANTS IN OPERATION

A list of the nine nuclear power plants in operation with their essential features is given in Table 1.2 in Annex I.

2.1.1 Availabilities and reportable events

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

Details and more information on reportable events can be found on the BfS website by clicking http://www.bfs.de/de/kerntechnik/ereignisse.

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

Year	Time availabilty* [%]	Energy availability* [%]	Capacity availability* [%]	Number of reportable events
2014	90.6	89.1	86.8	67
2013	89.2	88.7	87.2	78
2012	91.0	90.5	88.9	79
2011	82.1	81.9	68.2	103
2010	76.4	77.5	74.0	81
2009	73.2	74.2	71.2	104
2008	80.0	80.9	78.4	92
2007	76.0	76.4	74.4	118
2006	91.1	90.8	89.1	130
2005	88.8	88.0	86.3	134

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

2.1.2 Plant and licensing status

The following section gives a short description of the nuclear power plants in operation and provides information about the licences according to § 7 AtG granted in the year under report by the competent federal state authorities under nuclear law as shown in Table I.1 (Annex I). Also licensing procedures in progress are dealt with if they are of special relevance to the plant and licensing status.

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

Neckarwestheim nuclear power plant Unit 2 (GKN 2)

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

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

To conform to the 13th amendment to the Atomic Energy Act, the operator, EnBW Kernkraft GmbH (EnKK), was granted a licence for the modification of the EnKK structural organisation at the sites Philippsburg, Neckarwestheim and Obrigheim according to § 7 para. 1 Atomic Energy Act on 21 November 2014.

Philippsburg nuclear power plant Unit 2 (KKP 2)

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

To conform to the 13th amendment to the Atomic Energy Act, EnBW Kernkraft GmbH (EnKK) was granted a licence for the modification of the EnKK structural organisation at the sites Philippsburg, Neckarwestheim and Obrigheim according to § 7 para. 1 Atomic Energy Act on 21 November 2014.

Isar nuclear power plant Unit 2 (KKI 2)

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

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

Grafenrheinfeld nuclear power plant (KKG)

The Grafenrheinfeld nuclear power plant 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 a result of two electrical capacity increases.

The operator filed an application for the decommissioning and dismantling of the plant on 28 March 2014. Accordingly, it is planned to terminate the operating time of the KKG already 7 months before the legally prescribed end of its operating time (cf. Chapters 1.3.2 and 1.3.4).

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

Gundremmingen nuclear power plant Unit B and Unit C (KRB-II-B and KRB-II-C)

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

The operator filed an application for the dismantling of plant components in Unit B on 11 December 2014. This application was filed as a preparatory measure, power operation of Unit B ceasing in 2017.

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

Grohnde nuclear power plant (KWG)

The Grohnde nuclear power plant 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 application according to § 7 Atomic Energy Act for the modification of the safety-related parameter “Hold-down force for fuel elements” for the design and the operation of the reactor core was withdrawn with letter dated 26 August 2014.

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

Emsland nuclear power plant (KKE)

The Emsland plant is a PWR of the 4th generation and thus 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 1,406 MW_e results from one thermal and several electrical capacity increases. The last capacity increase by 6 MW occurred in May 2014 by exchanging the high-pressure turbine.

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

Brokdorf nuclear power plant (KBR)

The Brokdorf nuclear power plant 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 application according to § 7 Atomic Energy Act for the modification of the safety-related parameter “Hold-down force for fuel elements” was withdrawn with letter dated 31 March 2014.

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

2.2 NUCLEAR POWER PLANTS FINALLY SHUT DOWN

In the following Chapter, the nuclear power plants are described that were shut down finally on 6 August 2011, when the Amendment to the Atomic Energy Act became effective (cf. Chapter 1.3 and Table I.3 in Annex I).

Neckarwestheim nuclear power plant Unit 1 (GKN 1)

The Neckarwestheim nuclear power plant Unit 1 is a pressurised water reactor (PWR) of the 2nd generation and was commissioned in 1976 with a capacity of 855 MW_e. The reactor output was at last 840 MW_e resulting from a power decrease due to an exchange of condenser pipes in 1990. On 16 March 2011, the federal government gave order to shut down the plant, which has been in the post-operational phase since. The authorisation for power operation expired due to the amendment to the Atomic Energy Act of 6 August 2011 (cf. Chapter 1.3). The fuel elements were removed from the reactor and taken into the fuel pond.

The 1st licence for decommissioning and dismantling was applied for on 24 April 2013.

To conform to the 13th amendment to the Atomic Energy Act, EnBW was granted a licence for the modification of the EnKK structural organisation at the sites Philippsburg, Neckarwestheim and Obrigheim according to § 7 para. 1 Atomic Energy Act on 21 November 2014.

The EnBW energy company, operator of the GKN 1, brought an action against the Federal Republic of Germany and the federal state of Baden-Württemberg on 23 December 2014. From the EnBW point of view, the reason for this was the damage resulting from the moratorium against eight nuclear power plants (cf. Chapter 1.3.1) adopted in 2011.

Philippsburg nuclear power plant Unit 1 (KKP 1)

Just like the Isar NPP Unit 1, Brunsbüttel NPP and Krümmel NPP, the Philippsburg NPP Unit 1 is a boiling water reactor (BWR) of design series 69 and was commissioned in 1979 with a capacity of 900 MW_e. The reactor output valid when the reactor shut down in 2011 was 926 MW_e, and resulted from two electrical capacity increases. The authorisation for power operation expired due to the amendment to the Atomic Energy Act on 6 August 2011 (cf. Chapter 1.3). The KKP 1 is in the post-operational phase. Since the beginning of 2012 the fuel elements are in the fuel pond.

On 24 April 2013, application pursuant to § 7 para. 3 Atomic Energy Act was filed for a 1st decommissioning and dismantling licence. Furthermore, application for modification of the fuel pool cooling and emergency power supply of the facility was filed on 24 May 2013.

To conform to the 13th Amendment to the Atomic Energy Act, EnBW was granted a licence for the modification of the EnKK structural organisation at the sites Philippsburg, Neckarwestheim and Obrigheim according to § 7 para. 1 Atomic Energy Act on 21 November 2014.

The EnBW energy company, operator of the KKP 1, brought an action against the Federal Republic of Germany and the federal state of Baden-Württemberg on 23 December 2014. From the operator's point of view, the reason for this was the damage resulting from the moratorium against eight nuclear power plants (cf. Chapter 1.3.1) adopted in 2011.

Isar nuclear power plant Unit 1 (KKI 1)

Isar 1 is also among the BWR of design series 69 and was commissioned in 1977 with an electrical output of 907 MW_e. The last valid electrical reactor output was 912 MW_e. Since 17 March 2011 Isar Unit 1 has permanently shut down. The authorisation for power operation expired due to the amendment to the Atomic Energy Act on 6 August 2011 (cf. Chapter 1.3). The reactor core was entirely unloaded; the fuel elements are in the fuel pond.

On 4 December 2012, an application was filed according to § 7 para. 3 Atomic Energy Act for the decommissioning and dismantling of the KKI 1 plant. In the scope of public participation in the licensing procedure, a public hearing took place on 22 July 2014.

The E.ON energy company brought an action for damages against the Federation and the Free State of Bavaria on 1 October 2014. The reason for this is the moratorium adopted in 2011 as a result of the reactor accident in Fukushima.

Biblis nuclear power plant – Unit A (KWB A) and B (KWB B)

The plants Biblis A and B are among the eight nuclear power plants that had to finally cease power operation in 2011 on the basis of the Amendment to the Atomic Energy Act (cf. Chapter 1.3).

Biblis A with a PWR of the 2nd generation was commissioned in 1974 with a capacity of 1,204 MW_e. The last valid electrical reactor output was 1,225 MW_e. The Biblis nuclear power plant was designed as dual-unit

plant. Unit B, which is also a PWR of the 2nd generation, was commissioned in 1976 with an electrical capacity of 1,300 MW_e. This output was also the last effective one. The fuel elements of both units have already been unloaded and are in the fuel pond.

On 6 August 2012, applications were filed according to § 7 para. 3 Atomic Energy Act for the decommissioning and dismantling of Units A and B of the Biblis nuclear power plant. In the scope of the licensing procedure a public hearing took place in Biblis from 11 until 12 November 2014.

The decontamination of the primary circuit for Unit A which had started in 2013 was interrupted as a result of some findings at the primary coolant pump and it has not been continued.

On 25 August 2014, the RWE Power brought an action for damages at the district court of Essen that were caused by the moratorium provisions of March 2011.

Unterweser nuclear power plant (KKU)

The Unterweser NPP was commissioned in 1978 with a capacity of 1,300 MW_e. It is a nuclear power plant with PWR of the 2nd generation. The last reactor output was 1,410 MW_e. Power operation stopped on 6 August 2011 when the 13th Amendment to the Atomic Energy Act became effective (cf. Chapter 1.3). The fuel elements were removed from the reactor and are now in the fuel pond.

On 4 May 2012, application pursuant to § 7 para. 3 Atomic Energy Act was filed for the decommissioning and dismantling the KKU plant. The application was extended with letter of 20 December 2013, to the extent that the dismantling of the KKU was to begin already when some fuel elements were still inside the plant.

An application pursuant to § 7 Radiation Protection Ordinance (StrlSchV) for the construction of a storage facility for radioactive waste (LUnA) for the interim storage of low-level and intermediate-level radioactive waste was submitted to the competent federal state authority on 20 June 2013.

The E.ON energy company brought an action for damages against the Federation and the Federal State of Lower Saxony on 1 October 2014. The reason for this is the moratorium adopted in 2011 as a result of the reactor accident in Fukushima.

Brunsbüttel NPP (KKB)

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

Brunsbüttel is one of the eight nuclear power plants in Germany that were finally shut down in 2011 as a result of the Amendment to the German Atomic Energy Act (cf. chapter 1.3). The NPP is in the post-operational phase. Part of the reactor has been unloaded.

On 1 November 2012, an application was filed according to § 7 para. 3 Atomic Energy Act for the decommissioning and dismantling of the KKB plant.

On 5 May 2014 an application pursuant to § 7 StrlSchV was filed for the handling of radioactive substances in the storage facility for radioactive waste and residues (LasmA) to be built.

In October 2014, the Swedish Vattenfall energy company brought an action against the Federal Republic of Germany to an international court of arbitration. This was done against the background of the expiry of the licence for power operation of the nuclear power plants of Brunsbüttel and Krümmel in 2011 due to the amendment to the Atomic Energy Act.

Krümmel NPP (KKK)

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

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

As a result of the Amendment to the Atomic Energy Act in 2011 the plant ultimately ceased power operation (cf. Chapter 1.3). The reactor was unloaded. The fuel elements are in the fuel pool.

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

In October 2014, the Swedish Vattenfall energy company brought an action against the Federal Republic of Germany to an international court of arbitration. This was done against the background of the expiry of the licence for power operation of the nuclear power plants of Brunsbüttel and Krümmel in 2011 due to the amendment to the Atomic Energy Act.

2.3 NUCLEAR POWER PLANTS UNDER DECOMMISSIONING

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

Rheinsberg NPP (KKR)

The Rheinsberg NPP with a capacity of 70 MW_e (WWER reactor type) was commissioned in 1966. It served the autonomous development of reactors in the GDR. The produced electric energy was fed into the state grid. After 24 years of operation, the plant finally shut down in 1990. Since 9 May 2001, all nuclear fuel has been removed from the site, the fuel elements were delivered to the Interim Storage 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 North (ZLN) was carried out on 30 October 2007. Thus the activity inventory in the plant has considerably decreased.

The licensing procedure concerning the application for a modification licence to licence I/95 for the decommissioning and partial dismantling of the KKR pursuant to § 7 Atomic Energy Act, which was filed on 3 July 2013, is still pending.

On 14 February 2014, an application was filed for a licence pursuant to § 7 para. 3 Atomic Energy Act for the construction and operation of an external ventilation system with exhaust air monitoring

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 finally shut down on 23 August 1991.

The decommissioning concept provides for a dismantling of the plant in ten steps eight of which having already been carried out. The first 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).

Currently, measures are being carried out for the dismantling of the primary shielding in the context of the 9th decommissioning licence. The preparatory measures to lift single segments of the primary shielding were terminated. A first segment, the so-called filler piece, was dismounted.

It is intended to dismantle the remaining buildings conventionally and to recultivate the premises once the plant has been released from regulatory control.

Karlsruhe Multi-Purpose Research Reactor (MZFR)

The Karlsruhe Multi-Purpose Reactor with a 57 MW_e heavy-water cooled pressure vessel reactor was operated from 1965 to 1984. Apart from electricity production, it also served the heat supply of the Karlsruhe Research Center on account of the combined heat and power generation. After it had finally shut down, it was decided to dismantle the plant immediately and entirely. The spent fuel elements were reprocessed in the Karlsruhe Reprocessing Plant (WAK). Dismantling has since been carried out gradually, each stage with an extra nuclear licence (partial decommissioning licences).

With the 8th decommissioning licence of 31 January 2007 the dismantling of the activated part of the biological shield, the dismantling of all systems and equipment, the decontamination and the dismantling of all building structures were approved. The remote-controlled dismantling of parts of the MZFR concluded with the dismantling of the activated concrete of the biological shield in 2011. Decontamination and demolition works in the nuclear auxiliary building and the filter house are well advanced.

Demolition and decontamination works of the collection tank house as well as the assembly and storage building have also made great progress.

In the year under report preparatory works for the demolition of the reactor building were carried out.

Obrigheim NPP (KWO)

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

Dismantling is to be carried out in altogether four independent licensing steps. 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. On the Obrigheim site, dry storage in CASTOR® casks was planned and an application for a licence according to § 6 AtG was filed to the BfS on 22 April 2005. Currently

the procedure is suspended, since taking the KWO fuel elements to the Neckarwestheim interim storage facility is being pursued alternatively. The application for the modification to the storage licence was submitted to the BfS on 10 December 2013 (cf. Chapter 4.3.2).

The first decommissioning and dismantling licence (SG) to finally and permanently shut down operation was granted on 28 August 2008. The 2nd licence for decommissioning and dismantling was granted on 24 October 2011. Among others, it regulates the dismantling of plant components and allocated auxiliary systems in the control area (such as reactor coolant system and steam generator) and the operating procedures for continuing decommissioning operation. Four citizens brought action against the licence. The Mannheim Administrative Court dismissed the action on 30 October 2014.

On 30 April 2013, the 3rd licence was granted for the dismantling of the lower part of the reactor pressure vessel (RPV), the reactor pressure vessel installations, the biological shield and single building components inside the reactor building. The licence also comprises the demolition of plant components, the treatment of the accruing radioactive residues and the treatment of the accruing radioactive waste. Inside the reactor building, about 90 per cent of the material has been removed.

To conform to the 13th amendment to the Atomic Energy Act, EnBW was granted a licence for the modification of the EnKK structural organisation at the sites Philippsburg, Neckarwestheim and Obrigheim according to §7 para. 1 Atomic Energy Act on 21 November 2014.

Gundremmingen NPP Unit A (KRB A)

The Gundremmingen NPP Unit A (BWR) was commissioned in August 1966 with a capacity of 250 MW_e. Characteristic of this plant was a water-steam separating and steam-drying plant in the reactor which was used for the first time in a BWR. After an incident in 1977, the operator decided in 1980 not to repair the plant but to shut it down finally for economic reasons. The last fuel elements were removed from the plant by 1989 and were subsequently reprocessed. The decommissioning licence according to § 7 para. 3 AtG was granted on 26 May 1983, followed by the facility's entire dismantling in three phases on the basis of the existing nuclear licences. Dismantling has made good progress. The systems and components inside the machine building and the reactor building that are no longer needed have been dismantled.

The former technical building (not including reactor building) of Unit A is used as technology centre. Decontamination and waste treatment works are carried out there relating to Units KRB-II-B and KRB-II-C, both units still operating.

Greifswald NPP (KGR) Units 1 to 5

The construction of the Greifswald NPP (PWR) traces back to a decision made in 1955 by the government of the former GDR to use nuclear energy for electrical energy production. Of the eight PWR units of the KGR of the Russian WWER type (Reactor W-230 and W-213) with 440 MW_e each, unit 1 was commissioned in 1973. Units 2 to 4 were commissioned in 1974, 1977 and 1979. Units 1 to 4 shut down on the basis of a safety assessment made by Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) and the Federal Office for Nuclear Safety and Radiation Protection (SAAS) of the former GDR. It was furthermore decided to decommission Unit 5, too, which went critical for the first time in 1989 and whose commissioning was stopped by the SAAS, the regulatory authority at that time. Due to the dual-unit construction, Unit 5 is connected to Unit 6. All six units are to be dismantled without a longer period of prior safe enclosure. Units 6 to 8 were still under construction at that time (cf. Chapter 2.5).

On 22 May 2006, all nuclear fuel was removed from the Greifswald NPP.

The first licence according to § 7 para. 3 Atomic Energy Act for the decommissioning of the entire plant and for the dismantling of plant components was granted on 30 June 1995. The licensing notice to the 38th modification licence for the decommissioning of the entire plant and to the 22nd licence for the dismantling of plant components pursuant to § 7 para. 1 and 3 Atomic Energy Act was granted on 28 February 2014. It includes the dismantling or, respectively, demolition of vent stack Nord I including air duct of special building 1 which is no longer needed and is to be used elsewhere. The application pursuant to § 7 para. 1 and 3 Atomic Energy Act for the demolition and dismantling of no longer needed plant components of special building Nord I which was filed on 29 November 2013 is being examined.

Dismantling is well advanced. About 85% of the dismantling of the plant parts of the controlled areas has been completed, including special buildings of Units 1 – 5. Already 95% of plant components from the monitored areas have been dismantled.

Stade NPP (KKS)

The Stade NPP, a PWR with a capacity of 672 MW_e, was in operation from 1972 to 2003. Final shut-down was on 14 November 2003. With letter of 23 July 2001, the operator E.ON applied for the direct dismantling

of the plant. The fuel elements were transported to France for reprocessing at the end of April 2005. Dismantling is planned in five phases. The last phase (phase four) was authorised on 4 February 2011. It concerns the further dismantling of the plant and measures to clear buildings and ground surfaces. In the context of the demolition activities, contamination was detected at the bottom of the containment. It is assumed that this contamination stems from the phase the plant was in power operation. As a result, it is not possible to release the corresponding concrete area by a clearance measurement of the standing building structure following a rough decontamination; instead it must be dismantled. Depending on the activity content, the originating building rubble has to be managed as radioactive waste or to be released pursuant to § 29 StrlSchV, either for disposal on heaps or without restrictions.

In the year under report adaptations were made for the residual operation and dismantling works were carried out on the basis of the licences already granted. Furthermore, measures for clearance of buildings and clearance of grounds were carried out.

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, in order to install new ones. More serious damages were detected, so that the operator decided in March 1979 to decommission the nuclear part and to use the existing 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 (UK). The safe enclosure is monitored by the adjacent Emsland NPP (KKE).

In December 2007, Kernkraftwerk Lingen GmbH withdrew the application of 21 December 2004 for continuation of safe enclosure. On 15 December 2008, the operator filed an application according to § 7 para. 3 AtG for dismantling the plant. The dismantling of the residual plant is to be carried out in three partial projects. In the first licensing step initially applied for (Partial Project 1), all non-contaminated and contaminated plant components are to be dismantled. A second licensing step to be applied for later on (Partial Project 2) is to include the dismantling of the reactor pressure vessel including installations, the biological shield, the residual dismantling, decontamination, and the plant's release from nuclear regulatory control. The third partial project comprises the conventional dismantling of buildings.

Arbeitsgemeinschaft Versuchsreaktor Jülich (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 – which had started in Germany - with ball-shaped graphite fuel elements containing uranium and thorium containing coated particles. It was finally shut down at the end of 1988 when the further development of this technology was no longer pursued in Germany as a result of the decommissioning of the prototype reactor THTR-300 (308 MW_e) in Hamm-Uentrop. When it was in operation, the AVR fed ca. 1,500 GWh electric energy into the public grid. 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, leaving only a maximum of 197 pieces. Until the reactor containment has been dismounted it is impossible to recover the remaining ball-shaped fuel elements at reasonable cost and with sufficient radiation protection measures.

After the EWN GmbH had taken over the AVR GmbH in 2003, the operator dealt with a modification of the concept. This provided for terminating the safe enclosure and applying for direct dismantling. The licence for the entire dismantling of the plant was granted on 31 March 2009. Subject matter of the licence notification are preparatory works to lift the reactor vessel, the lifting and putting down of the reactor vessel in the material lock and measures following the removal of the reactor vessel. It is intended to take the reactor vessel filled with pore lightweight concrete in November 2008 to an interim storage facility erected at the site. The licence for the operation of the interim storage facility was granted on 1 March 2010. The first modification licence to the licence of 31 March 2009 was granted on 18 January 2013. For the transport of the reactor vessel, a wheel-mounted Self-Propelled Modular Transporter (SPMT) heavy-load vehicle with a steel transport rack is to be used according to this licence. The handling licence required pursuant to § 7 para. 1 StrlSchV for the transport of the AVR reactor vessel from the AVR material lock to the interim storage facility on the business premises of the Jülich Research Center was granted on 15 October 2014.

Once the preparatory works for lifting the reactor vessel had concluded, the reactor vessel was lifted from its previous position in November 2014. Then it was placed and aligned on the storage rack of the material lock. The transport into the interim storage facility located 600 m away is planned to take place in 2015.

Würgassen NPP (KWW)

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

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

In the year under report, the works on the dismantling of the reactor building, engine house and the neighbouring components in the control area were completed on the basis of the granted decommissioning licences. On 28 August 2014, the exhaust air system was withdrawn from service. Clearance measurements on the outdoor grounds continue. The technical infrastructure is to be adapted to the requirements before the two interim storage facilities for radioactive waste where solely low-level and intermediate-level radioactive waste from the dismantling and operation of the plant is to be stored will be fully operable.

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

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

Mülheim-Kärlich NPP (KMK)

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

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

The 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.

Dismantling measures continued in the year under report on the basis of the licence for dismantling phase 1a granted on 16 July 2004 and the modification licence to licence 1a granted on 23 February 2006.

The application for dismantling phase 2b for the dismantling of the two steam generators, the reactor pressure vessel including its core components and the activated areas at the biological shield was filed on 12 August 2013. In the year under report the documents were displayed and a public hearing took place.

The notification of 31 January 2014 pursuant to § 7 para. 3 Atomic Energy Act regulates the clearance and release of ground areas and the buildings erected there (licence 3c). On this basis the supervisory procedure to clear and release the buildings has been proceeding since for the monitoring area south of the reactor building. The licence pursuant to § 7 para. 3 for downsizing the plant premises was granted on 16 September 2014 (licence West 3b).

The licensing procedure for the on-site storage facility and the treatment centre for radioactive waste discontinued after RWE Power AG had withdrawn the construction application in December 2014.

2.4 NUCLEAR POWER PLANTS RELEASED FROM REGULATORY CONTROL

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

Großwelzheim Superheated Steam Reactor (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 finally shut down in 1971 because of deformations at the cladding tubes of the novel superheat fuel elements. The spent fuel elements were reprocessed in the WAK. From 1974 to 1991, the reactor building and the installed systems were used for the performance of non-nuclear investigations of nuclear power plant behaviour in case of severe accidents (among others, earthquakes). The decommissioning of the reactor was licensed on 16 February 1983. The plant was entirely dismantled.

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

Niederaichbach NPP (KKN)

The Niederaichbach NPP was a prototype NPP with a capacity of 106 MW_e. It was 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. The licence for establishing the state of safe enclosure for the plant was granted on 21 October 1975 and the licence for "safe enclosure" on 20 October 1981. The fuel elements were taken to the CEA (Commissariat à l'Energie Atomique et aux Energies Alternatives) in France. The entire dismantling of the plant was licensed on 6 June 1986. On 17 August 1995, the decommissioning of the KKN was completed and the NPP was released from regulatory control. The ground slabs of the reactor building and of the tomb building have remained in the soil as a groundwater lowering would have been necessary for complete removal. The residual ground slabs and underground pipes were removed. The KKN was the first nuclear power plant in the world with a capacity worth mentioning whose decommissioning was completed by handing over the site as "greenfield". Thus it could be demonstrated for the first time in Germany that both the technical implementation of a complete removal and of the associated nuclear licensing procedure are feasible.

Kahl Experimental NPP (VAK)

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

The buildings and the plant site were released from regulatory control on 17 May 2010. Dismantling activities in the scope of conventional dismantling concluded on 24 September 2010.

2.5 STOPPED NUCLEAR POWER PLANT PROJECTS

Greifswald NPP (KGR) Units 6 to 8

In the Greifswald NPP construction and assembly works on Units 6 to 8 (440-MW_e PWR of the Russian WWER type, reactor W-213) were stopped in 1990.

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 is now used industrially (cf. Chapter 2.3). Non-contaminated equipment of Units 7 and 8 was transported to Unit 5 where it was dissected. With it tools and equipment for the remote-controlled dissecting of reactor components were tested.

Kalkar Sodium-cooled Fast Breeder Reactor (SNR 300)

The SNR 300 with a 327-MWe sodium-cooled fast-breeder reactor was constructed between 1973 and 1991. It was almost 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, ownership of the site was transferred to Kern-Wasser-Wunderland Freizeitpark GmbH. The site has been used commercially since. The fuel elements were at first kept in government custody by BfS and were later delivered to France for reprocessing.

Stendal NPP

Construction of a nuclear power plant with four units was planned near Stendal. In 1979 it was decided to construct pressurised water reactors of the Russian WWER type with 1.000 MW_e each on the site. The former Federal Office for Nuclear Safety and Radiation Protection of the GDR (SAAS) granted the first construction licence for two units on 10 September 1982. The works for units A and B of the Stendal nuclear power plant that were started discontinued in 1990 after they had been delayed for several years. Part of the buildings and of the equipment was dismantled or has been used otherwise.

3 RESEARCH REACTORS

Research reactors are nuclear installations that do not serve to generate power on a commercial basis. They are used in research centres and universities, among other things for scientific experiments.

In the Federal Republic of Germany altogether 46 research reactors have to be considered of which currently (as at 31 December 2014):

7 Research reactors are in operation

4 Research reactors are finally shut down

6 Research reactors are under decommissioning and

29 Research reactors have been decommissioned. They have been released from regulatory control.

The operational and licensing state of the research reactors is described in chapters 3.1, 3.2, 3.3 and 3.4, and in the relevant Tables in Annex II – Research Reactors. An overview of still existing sites is given in Figure II.

3.1 RESEARCH REACTORS IN OPERATION

In the Federal Republic of Germany, altogether seven research reactors were in operation on 31 December 2014, among which there were three with a continuous thermal power above 50 kW_{th} and five training reactors with a thermal power of max. 2 W_{th}.

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 ca. $2 \cdot 10^{14}$ $1/cm^2 \cdot s$. The reactor was commissioned on 9 December 1973 and mainly serves pure and applied basic research with beam pipe experiments and the generation of radioactive isotopes.

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

To carry out maintenance and repair works the BER II was shut down on 29 November 2013. Amongst these are the remediation of a defective sealing weld between the suction pipe of the primary circuit and the separating wall between the two reactor pool halves. On this occasion also the new high field magnet was installed. The emergency manual and a study on air crashes were developed as further issues relating to the plant-specific safety inspection of German research reactors of the RSK (RSK-SÜ).

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

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

the most intensive German neutron source for beam pipe experiments and irradiations for scientific, industrial and medical purposes.

Nuclear commissioning and plant operation were regulated in the operation licence granted on 2 May 2003. The reactor went critical for the first time on 3 March 2004. On 25 April 2005, the plant's routine operation started.

On the basis of the operating licence of 2 May 2003 and of an agreement between the federal government and the Free State of Bavaria of 30 May 2003, it was originally intended to convert the reactor core from HEU to fuel with a reduced enrichment level of max. 50% uranium- 235 (MEU) by 31 December 2010. However, due to unexpected delays in the international technical-scientific development of new, high-density fuels, one failed to comply with this requirement. The original agreement between the federal government and Bavaria of 30 May 2003 was amended on 22 October 2010. Now the plant needs to be converted by 31 December 2018 at the latest.

After 10 years of operation, the FRM-II was shut down on 9 February 2014 for a longer, scheduled maintenance phase. This maintenance was mainly carried out to perform the prescribed, comprehensive, periodic inspections. The reactor was started again on 21 August 2014 for its 35th cycle. On 12 September 2014, it was shortly shut down and properly restarted on 15 September 2014, the motor of one of the two secondary pumps had failed.

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 of the plant was on 3 August 1965. In continuous operation the thermal power is 100 kW_{th} and the thermal neutron flux is $4 \cdot 10^{12}$ 1/cm^2•s. Additionally, the reactor can be operated in pulsed operation above 30 ms with a power peak of 250 MW_{th} and a thermal neutron flux of $8 \cdot 10^{15}$ 1/cm^2•s. The plant is operated for basic research in nuclear physics and is especially suitable for examining short-lived radionuclides with rabbit systems because of the high neutron flux density which can be managed in pulsed operation for short periods of time.

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

Following the installation of an ultra-cold neutron source in 2011, peak values with neutron velocities of 5 m/s and neutron densities of 10 n/cm3 have been achieved at the FRMZ.

In the year of operation 2014 the plant was in normal operation. There were restrictions on the operation on account of the absence of a certificate of specialised knowledge of the new manager.

Training Reactor of the Technische Universität Dresden (AKR-2)

The AKR-2 is a homogeneous, solids-moderated zero-power reactor. The fuel plates consist of a homogeneous mixture of low-enriched uranium oxide (enrichment < 20% uranium-235) and polyethylene as moderator material. The reactor core is surrounded on all sides by a reflector from graphite. The maximum continuous thermal power of the reactor is 2 W_{th} and the thermal neutron flux is about $3 \cdot 10^7$ 1/cm^2•s. The AKR-2 was commissioned on 22 March 2005. It replaced the old AKR-1 plant that was operated by the TU Dresden (Technical University of Dresden) from July 1978 to March 2004. The AKR-2 mainly serves for training purposes but it is also an instrument for research activities in national and international projects.

In the year of operation 2014 the plant was in normal operation.

Siemens Training Reactors (SUR) 100

In Germany, three Siemens training reactors are currently in operation (Furtwangen, Stuttgart and Ulm). In the SUR plants, the reactor core consists of U_3O_8 with low uranium-235 enrichment (< 20%) and with polyethylene as moderator. In a homogeneous mixture, both materials are pressed into cylindrical fuel plates. The reactor core is surrounded by a graphite reflector on all sides. The SUR plants were commissioned in Germany mainly the 60s and 70s. The thermal reactor capacity is 100 mW_{th} and the thermal neutron flux in the central experimental channel is generally at $5 \cdot 10^6$ 1/cm^2•s. Details are given in Tab. II.1. The SUR plants are mainly used as training devices for training and tuition in the field of nuclear energy.

In the year of operation 2014 all SUR plants were in normal operation.

3.2 RESEARCH REACTORS FINALLY SHUT DOWN

As at 31 December 2014, four research reactors have been included in the heading "Finally shut down". No decommissioning licence has been granted so far for these reactors.

Research Reactor Geesthacht Unit 1 (FRG-1)

The FRG-1 was an open pool reactor of the MTR type with a thermal power of 5 MW_{th} and a maximum thermal neutron flux of ca. $1 \cdot 10^{14}$ $1/cm^2 \cdot s$. It was commissioned on 23 October 1958 with HEU. Originally the FRG-1 served to explore nuclear ship propulsion. Later on it was mainly used for material research with steel pipe experiments and isotope production and to carry out neutron activation analyses.

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

During the more than 40 years of operation the FRG-1 was continuously upgraded. In February 1991, a modification from HEU to LEU was carried out for the first time at a German research reactor on the basis of a modification licence dated 4 May 1988. Apart from reducing the proliferation risk, it was possible to increase the thermal neutron flux by using fuels of significantly higher density.

On 28 June 2010, the FRG-1 was shut down finally. In the context of the operating permit which continues to be effective the plant is now in the post-closure phase. 45 MTR fuel elements were taken to the USA on 10 August 2010. Since the end of July 2012, there has been no more nuclear fuel in the reactor. On a special ship, the last 25 fuel elements that had remained in the plant were transported to the USA. The testing equipment of the research reactor was taken to research institutions in Delft (Netherlands) and St. Petersburg (Russia) for further use.

On 21 March 2013, decommissioning and dismantling of the FRG 1 and the research reactor (consisting of FRG-1 and still existing plant components of the FRG-2) as well as the release of the plant from regulatory control were applied for. It is planned to dismantle the research reactor in the scope of a single decommissioning and dismantling licence pursuant to § 7 para. 3 Atomic Energy Act.

Research Reactor Geesthacht Unit 2 (FRG-2)

Just as the FRG-1, the FRG-2 was an open pool reactor of the MTR type; the thermal power was 15 MW_{th} and the maximum thermal neutron flux was ca. $2 \cdot 10^{14}$ $1/cm^2 \cdot s$. It was commissioned on 16 March 1963 as material test reactor and used for irradiation tests 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. This licence permitted at the same time the increase of the FRG-2's thermal capacity from 5 MW_{th} to 15 MW_{th}. During its 30 years of operation, the reactor was permanently operated with HEU.

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 partially dismantling the reactor. The licence was granted on 17 January 1995. The fuel elements were taken to the USA until 20 September 2000.

On 21 March 2013, decommissioning and dismantling of the FRG 1 and the research reactor (consisting of FRG-1 and still existing plant components of the FRG-2) as well as the release of the plant from regulatory control were applied for. It is planned to dismantle the research reactor in the scope of a single decommissioning and dismantling licence pursuant to § 7 para. 3 Atomic Energy Act.

Siemens Training Reactor Hanover (SUR-H)

The SUR-H was a training reactor with a thermal capacity of 100 mW_{th} and a thermal neutron flux of $6 \cdot 10^6$ $1/cm^2 \cdot s$ by the Leibniz Universität Hannover at the Institute of Nuclear Engineering and Non-Destructive Testing. The construction of the SUR reactors is described in Chapter 3.1. On 11 October 1971, the licence for the construction and operation of the SUR-H was granted by the Lower Saxon Ministry for Social Affairs. The reactor was operated from 1971 until 2008. In 2008, the fuel plates were removed according to the operating permit and taken to the Technische Universität München, Institute for Radiochemistry in Garching for conditioning and disposal. The start-up neutron source was removed in 2013 and given to Eckert & Ziegler Nuclitec GmbH for further use. The operator filed an application for decommissioning and dismantling the Siemens Training Reactor SUR 100 Hannover on 22 October 2013. Because of the low performance of the reactor, there is no need to carry out an environmental impact assessment and a public participation procedure.

Siemens Training Reactor Aachen (SUR-AA)

The Siemens Training Reactor Aachen was operated by the Rheinisch-Westfälische Technische Hochschule Aachen (RWTH Aachen). It was constructed by Siemens-Schuckertwerke AG in 1963 and became critical for the first time on 22 September 1965. The thermal power of the reactor was 100 mW_{th}, the thermal neutron flux was ca. $6 \cdot 10^6$ $1/cm^2 \cdot s$. The research reactor served as training reactor in the scope of training in nuclear technology and was also used for conducting experiments in the scope of seminar papers and diploma theses. The reactor was shut down in 2002. In 2008, the fuel consisting of plates from enriched uranium 235 was taken to the Technische Universität München for disposal and conditioning. In 2010, the operator filed an application for the decommissioning and dismantling of the plant to the competent federal state authority. The licensing procedure is under way. Because of the low performance of the reactor, there is no need to carry out an environmental impact assessment and a public participation procedure.

3.3 RESEARCH REACTORS UNDER DECOMMISSIONING

In the Federal Republic of Germany, six research reactors were under decommissioning at the end of 2014.

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 with 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 $1 \cdot 10^{14}$ $1/cm^2 \cdot s$ the FR 2 was used as neutron source for beam pipe experiments for basic research and for irradiation experiments in fuel rod development and for the production of isotopes for medical purposes.

Nuclear commissioning of the reactor with natural uranium was on 7 March 1961. To increase the original thermal neutron flux of $3.9 \cdot 10^{13}$ $1/cm^2 \cdot s$ to $1 \cdot 10^{14}$ $1/cm^2 \cdot s$ the facility was retrofitted in 1966 to be operated with fuel elements with low-enriched uranium (2%). The reactor's maximum thermal power was thus increased from 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 the WAK for reprocessing. The first of several partial licences for decommissioning, partial decommissioning, and safe enclosure for at least thirty years was granted on 3 July 1986. Since 20 November 1996, the reactor block as the still remaining part of the plant has been in safe enclosure. Since 1997, the reactor hall has been used for a permanent exhibition about the history of nuclear engineering.

Following safe enclosure, it is intended to dismantle the plant to finally remove the reactor block. Since July 2009, the Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH, a company of the Energiewerke Nord GmbH, has been responsible for this task. A rough dismantling concept was submitted to the competent authority at the end of 2010. No application for dismantling has been filed so far.

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 $7 \cdot 10^{13}$ $1/cm^2 \cdot s$. The plant was commissioned as the first reactor in Germany 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} but was changed over to using HEU already in 1960. In the years of operation the thermal neutron flux was gradually increased from originally $1 \cdot 10^{13}$ $1/cm^2 \cdot s$ to $7 \cdot 10^{13}$ $1/cm^2 \cdot s$ by increasing the thermal power to 2.5 MW_{th} in 1966 and to 4 MW_{th} in 1968; additionally, a beryllium reflector was installed in 1982. Since 1991, the core has been operated as mixed core and gradually changed over from HEU to MEU.

On 14 December 1998, the Technische Universität München (TUM) applied for the plant's decommissioning in order to use it later on – following another procedural step – as supporting system to the new Munich High-flux Neutron source in Garching (FRM-II, cf. Chapter 3.1). On 28 July 2000, the reactor was finally shut down, on 3 June 2002, the still existing 47 fuel elements were delivered to the USA. On 3 April 2014, the licence pursuant to § 7 Atomic Energy Act for the dismantling of the FRM Garching reactor was granted. Dismantling has started.

The FRM dome, known as Garching Atomic Egg, has been designated a listed building.

Research Reactor Neuherberg (FRN)

The FRN was a pool reactor of the TRIGA Mark III type with homogeneous fuel moderator elements of LEU and zirconium hydride. The thermal power was 1 MW_{th} and the thermal neutron flux was $3 \cdot 10^{13}$ $1/cm^2 \cdot s$. In

pulsed operation the reactor could be operated above 10 ms for short periods of time, with power peaks of up to 2,000 MW_{th}. The plant was commissioned on 23 August 1972 and was used for isotope production and beam-pipe experiments in medical-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 plant 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 on 19 December 1995 for economic reasons. On 28 August 1996, the residual fuel elements were delivered to the USA. The decommissioning licence for the plant was granted on 2 March 2001. 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, which continues to be subject to nuclear supervision. The reactor building and other building areas and ground surfaces were gradually released from regulatory control by 28 July 2005 and can now be used by the PTB without restrictions for other purposes. The premises which the PTB operates interim storage facilities on, was legally transferred to the Bundesanstalt für Immobilienaufgaben (BIMA) on 1 January 2012.

Research Reactor Jülich (FRJ-2)

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

Nuclear commissioning of the plant was on 14 November 1962. On account of the available resources being exhausted, a first capacity increase from 10 MW_{th} to 15 MW_{th} was carried out in 1967. A second capacity increase to 23 MW_{th} was achieved through conversion and retrofitting measures in 1972.

On 2 May 2006, the FRG-2 was shut down finally. Within the scope of the operation licence the spent fuel elements were transported to the USA in 2008. An application for decommissioning and dismantling the reactor facility was filed on 27 April 2007. On 20 September 2012, the North Rhine-Westphalia state authority granted the licence for the decommissioning and dismantling of the plant, whereupon dismantling started.

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 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 ca. $1 \cdot 10^{14}$ 1/cm^2•s. Basically, the facility served as neutron source for isotope production, activation analyses, material research, and additionally for training purposes in the GDR nuclear energy programme.

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

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

Between 30 May 2005 and 13 June 2005, the spent fuel elements were transported in altogether 18 CASTOR® casks to the Ahaus Transport Cask Storage Facility.

From 30 January 1998, several partial licences for the decommissioning of the plant were granted. On 9 January 2014, the licence pursuant to § 7 para. 3 Atomic Energy Act was granted for the second modification of the fourth licence 4653/18 VKTA 04/2. The modification concerns the expansion of the previous scope of the licence for the total demolition of the residual plant under radiation protection conditions.

3.4 RESEARCH REACTORS RELEASED FROM REGULATORY CONTROL

In the Federal Republic of Germany, the decommissioning of six research reactors with a continuous thermal power above 50 kW_{th} and of 23 research reactors with a thermal power of 50 kW_{th} or less was completed as at 31 December 2014. They have been released from regulatory control.

TRIGA HD II Research Reactor Heidelberg (TRIGA HD I)

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

As a second research reactor (TRIGA HD II, see below) was built in the German Cancer Research Center in Heidelberg (DKFZ), the reactor was finally shut down on 31 March 1977. The fuel elements were transported to the new reactor facility for further use. The licence for decommissioning the facility was granted on 30 June 1980 and comprised the dismantling of the components and the safe enclosure of the reactor tank and the biological shield, which was effected on 11 December 1980. Since it was planned 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 I (see above) the TRIGA HD II was a pool reactor of the TRIGA Mark I type with homogeneous fuel moderator elements of LEU and zirconium hydride. The thermal power of the reactor was also 250 kW_{th}, the thermal neutron flux was $1 \cdot 10^{13}$ $1/cm^2 \cdot s$. The reactor went critical for the first time on 28 February 1978; it was used for neutron activation analyses and for the production of short-lived radionuclides for medical purposes in cancer research.

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

Research Reactor Frankfurt Unit 2 (FRF 2)

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

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

Research Reactor of the Hannover Medical School (FRH)

The FRH was a pool reactor of the TRIGA Mark I type with homogeneous fuel moderator elements of LEU and zirconium hydride. The thermal power of the reactor was 250 kW_{th}, the thermal neutron flux was ca. $9 \cdot 10^{12}$ $1/cm^2 \cdot s$. 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. On 9 July 1999, the fuel elements were shipped to the USA. On 22 February 2002, an application for the decommissioning and dismantling of plant components was filed and approved on 8 May 2006. The dismantling of the facility and the clearance measurements were completed by August 2007. The regulatory supervision of the facility as specified in § 19 AtG was terminated on 13 March 2008.

Research Reactor Jülich 1 (FRJ-1)

The FRJ-1 (MERLIN, Medium Energy Research Light Water Moderated Industrial Nuclear Reactor) was a pool reactor of English design 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 ca. $1 \cdot 10^{14}$ $1/cm^2 \cdot s$. The reactor was commissioned on 23 February 1962 and was used for irradiations and beam pipe experiments.

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

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 the UK 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. 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.

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

Research Reactors with a Capacity of 50 kW_{th} or less

Among the already dismantled research reactors with a capacity of 50 kW_{th} or less or, respectively already released from regulatory control, are 23 reactors. Of these plants, one was not licensed according to § 7 Atomic Energy Act but § 9 Atomic Energy Act (SUAK). The reactors were based on different reactor concepts. Among them are e.g. training reactors (such as SUR-KI), reactors with fuel solution (such as AB-DIKA), critical assemblies (such as ANEX) or Argonaut reactors (such as RRR). The individual reactors need not be further elaborated here. A survey of this category is given in Annex II, Tab. II. 4.

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.

On behalf of the Federal Environment Ministry, the Nuclear Waste Management Commission carried out a safety assessment (stress test) of the plants of nuclear fuel supply and waste management in Germany. The results of the stress test were published in March 2013 (part 1) and in October 2013 (part 2) and can be accessed on the website of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB): http://www.bmub.bund.de/N49919/.

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 %.

The plant was commissioned in the middle of August 1985 with 400 Mg of uranium separative work per year (SW/y).

An application for extending the production capacity to 4,500 Mg SW/y 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/y with a maximum enrichment of 6%. The licence also includes the storage of 58,962 Mg of depleted uranium (tails) in oxidic form and 38,100 Mg as UF_6, of 10,000 Mg of natural uranium (feed) as UF_6 and1,250 Mg of enriched uranium (product) with a maximum enrichment of 6% of uranium-235 as UF_6. Apart from completion of the uranium oxide storage facility, the final stage of completion of the extended facility has been reached. The UAG is operated by Urenco Deutschland GmbH with a licensed capacity of nominally 4,500 Mg SW/y.

According to Urenco's own information, the re-enrichment of depleted uranium in Russia was terminated in 2009. The uranium hexafluoride produced in future would be converted into the triuranium octoxide (U_3O_8) – which is chemically more stable – by the French AREVA company (formerly COGEMA) in Pierrelatte, and subsequently be stored on the company premises in Gronau.

The construction of a storage hall for 50,000 Mg U_3O_8 was launched in 2011. According to information given by the operator, start of operation is planned for 2015.

4.2 FUEL ELEMENT FABRICATION PLANTS

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

ANF Fuel Element Fabrication Plant, Lingen

In the ANF Fuel Element Fabrication Plant uranium fuel elements with a maximum fraction of 5% of uranium-235 are produced for major use in light-water reactors. Uranium dioxide (UO_2) powder, uranium hexafluoride (UF_6) or externally fabricated UO_2 pellets are used as raw material. The fuel element fabrication process includes the following procedural steps: Conversion, pellet fabrication, fuel rod fabrication and fuel element fabrication.

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 the dry conversion with uranium-235 enriched to up to 5% was started in June 1994. In June 1996, a second fuel rod production line and a building for the storage and handling of UO_2 pellets and powder were licensed. The currently licensed processing performance has been laid down to be 800 Mg/y for dry conversion and 600 Mg/y for other partial plants.

The licensed storage capacity of uranium hexafluoride is 275 Mg. A hall for the storage of UF_6 containers for which a licence according to § 7 AtG had been granted has been taken into operation.

On 26 June 2014, a licence pursuant to § 7 Atomic Energy Act was granted for the expansion of the storage areas for nuclear fuel by integrating the storage hall for the storage of radioactive waste that had previously been licensed pursuant to § 6 Atomic Energy Act.

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

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

Due to a decree issued by the Hessian Environmental Ministry according to § 19 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.

The licensing procedure for the dismantling of the Siemens MOX facility was discussed in a hearing in March 2000 in Hanau, the dismounting of the first production facilities was licensed in December 2007. The first partial licence for the dismantling of the cleaned out facilities was granted in May 2001, the second partial licence in March 2003 and the third partial licence on 3 January 2005. It provided for some buildings and parts of the open-air ground being already used conventionally. The fourth and concluding partial licence was granted on 16 March 2005.

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

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

The facility premises can now be used conventionally as industrial site.

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% uranium-235 for major use in light-water reactors. UF_6 was used as raw material.

Due to unfavourable overall boundary conditions at the Siemens site the production of uranium fuel elements stopped 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 fuel elements made of uranium oxide with a fraction of maximum 4% of uranium-235.

In the scope of the decommissioning decision for the Siemens plant sections in Hanau the comparatively small plant in Karlstein was closed, too. The removal of all radioactive operational equipment was concluded. The Siemens Fuel Element Fabrication Plant, Plant Section Karlstein, was released from regulatory control in March 1999.

Non-nuclear operation carried on and is used for the fabrication of structural components for fuel elements (ANF Karlstein). Since 2001, the Karlstein site is a subsidiary of Framatome ANP, later renamed AREVA NP.

NUKEM Fuel Element Fabrication Plant, Hanau

Since 1962, the NUKEM company produced fuel elements for research and material test reactors; the fuel elements were made of uranium and thorium up to an enrichment degree of 94% of uranium 235.

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

It had turned out that the so-called Monostahalle located on the Degussa premises (outside the ring fence of the NUKEM-A premises), which was meanwhile used again by Degussa, had to be included in the decommissioning procedure. Therefore, two additional licences for the dismantling of this complex of buildings were applied for and granted on 9 November 1999 and on 26 June 2001.

All buildings inside the ring fence have meanwhile been dismantled. In May 2006 the remediation of the soil concluded and the entire premises, with the exception of 1.000 m^2, were released from regulatory control. On this ground a groundwater treatment plant is operated which is subject to nuclear surveillance. A test shut-down of the groundwater treatment plant has been carried out since January 2014. Release from regulatory control has been applied for at the federal state authority.

Hochtemperatur-Brennelement Gesellschaft (HOBEG)

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

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

4.3 STORAGE OF SPENT FUEL ELEMENTS

4.3.1 Storage in nuclear power plants

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

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

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

4.3.2 Storage in 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 part of the waste storage hall II in the Department of Decontamination of the Jülich Research Center (FZJ).

On 17 June 1993, the BfS granted a nuclear licence pursuant to § 6 Atomic Energy Act (AtG) for the storage of maximum 300,000 spent AVR fuel elements for a period of 20 years. Storage operation was taken up on 23 August 1993. At the end of 2009, altogether 152 loaded casks of the CASTOR®THTR/AVR type were stored in the AVR cask storage facility.

Since the storage licence was limited until 30 June 2013, the FZJ GmbH initially applied in 2007 for the licence for storage in Jülich to be extended. With letter of 29 April 2009 the FZJ declared that the extension would have to be effective for three years.

Furthermore, the FZJ requested Gesellschaft für Nuklear-Service mgH (GNS) on 24 September 2009 to submit an application to the BfS for being permitted to store the 152 casks in the GNS interim storage facility in Ahaus (TBL Ahaus). The FZJ requested Nuclear Cargo + Service GmbH (NCS) on 4 October 2010 to apply

a transport licence for the transport to the TBL Ahaus. As a result, the FZJ asked on 16 July 2010 to suspend the licensing procedure for the extension of storage in Jülich.

In 2012 the FZJ changed its plans again and applied on 16 May 2012, for resuming the procedure for further storage of the AVR fuel elements in Jülich. On behalf of the FZJ the GNS applied on 11 January 2013 for the suspension of the procedure for the storage of the AVR fuel elements in Ahaus; the NCS also applied on 17 January 2013 for the suspension of the procedure for the transport to Ahaus.

On 15 December 2014, the FZJ announced that it now again wished to pursue the option of a transport to the TBL Ahaus. For this purpose the GNS resumed the licensing procedure for the storage of the fuel elements in the TBL Ahaus with letter of 6 January 2015.
Since the middle of 2012 the FZJ furthermore examines the feasibility of shipping the AVR fuel elements to the USA.

The storage licence pursuant to § 6 AtG meanwhile expired on 30 June 2013. On 27 June 2013, the Ministry of Economic Affairs, Energy, Industry, Middle Class and Trade of the federal state of North Rhine Westphalia (MWEIMH NRW), being responsible as nuclear supervisory authority, ordered that the AVR fuel elements continue to be stored in the Jülich Interim Storage Facility, initially until 31 December 2013. This decision was limited to six months and continued to entitle the FZJ GmbH to the nuclear fuels. It was followed by a corresponding decision of 17 December 2013 which was limited to seven months.

Once it was clear that proof of earthquake safety, which needs to be furnished by the applicant and is required for a licence pursuant to § 6 AtG, would be delayed indefinitely should the storage in Jülich be prolonged, the MWEIMH imposed an injunction pursuant to § 19 para. 3 AtG according to which the nuclear fuels must be removed from the AVR cask storage facility with immediate effect and it must be guaranteed that the nuclear fuels remain with a person entitled to them pursuant to § 5 para. 1, sentence 1 AtG. At the same time the injunction regulates the further storage until evacuation and it is assumed that the licensing procedure pursuant to § 6 AtG will continue. The FZJ GmbH presented a concept for the removal of the nuclear fuels from the AVR cask storage facility on 31 October 2014, which is currently being examined by the MWEIMH. The alternative options mentioned in the concept are shipping the AVR fuel elements to the USA, to the TBL Ahaus or to an interim storage facility on the premises of the Jülich Research Center, which would still have to be constructed.

Interim Storage Facility in the Obrigheim NPP

Based on licences dating from 1979 to 1983, Kernkraftwerk Obrigheim GmbH (KWO) constructed an interim storage facility for spent fuel elements from the KWO on the nuclear power plant premises. It is an external wet storage facility for 980 fuel elements (approx. 286 Mg of HM) which was erected in the emergency building until 1984. The operation licence of this storage facility comprises the storage of 980 fuel elements exclusively from the KWO and of core components. It was granted according to § 7 AtG on 26 October 1998.

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

On-site interim storage facilities

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

The Federal Office for Radiation Protection (BfS) is the competent authority for granting licences according to § 6 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 was based on the European Directive 97/11/EG that was effective until 16 February 2012 and was replaced by the Directive 2011/92/EU and the Environmental Impact Assessment Act. Possible effects of the respective projects on man, animals, plants and their habitat, and on soil, water, air, and climate were examined.

In the context of the licensing procedures pursuant to § 6 para. 2 no. 4 AtG, the BfS has to examine in particular whether the required protection against disruptive actions or other interference by third parties (SEWD) is guaranteed. Since the terrorist attacks of 11 September 2001, air traffic is a prime target for terrorist attacks, despite of the known high safety standards. Despite the fact that no new findings have become known in the past years and more recently that indicate a concrete risk of stationary nuclear facilities, the BfS has examined the consequences of a targeted crash of a large passenger plane onto an interim storage facility,

in addition to the consequences of terrorist attacks and acts of sabotage. This has been done in the context of examinations pursuant to § 6 para. 2 no. 4 AtG. As a result of its examinations, the BfS has noted that the evacuation-related intervention reference levels of 100 millisierverts (mSv) effective dose (required in the case of disaster control) would not be reached.

The on-site interim storage facilities are dry storage facilities for spent fuel elements placed into transport and storage casks that are kept in storage halls or tubes, 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 had originally been dimensioned such that all spent fuel elements that would have accrued until nuclear power plant operation finally stopped (on the basis of the electricity volumes determined in 2002), could have been accepted until nuclear power plant operation had discontinued and could have been stored there, also beyond decommissioning, until a repository would be taken into operation. As the authorisation for power operation for altogether eight nuclear power plants expired on 6 August 2011 on the basis of the 13th Amendment to the Atomic Energy Act that became effective on 31 July 2011 and as, at the same time, the remaining operating times of the other nuclear power plants will end in 2022 at the latest, the storage capacities of the on-site interim storage facilities will no longer be exhausted by the storage of spent fuel elements accruing in future.

By the end of 2003, storage of spent fuel elements was granted for twelve on-site interim storage facilities (cf. Table III.5). 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 as yet not been decided. In 2014, the BfS continued the examinations in the context of modification licences for the on-site interim storage facilities. The focus was on examinations of the use of a modified type of transport and storage casks CASTOR® V/19 and CASTOR® V/52 and the new cask type TN 24 E, examinations of an upgrade of the cranes according to the increased requirements of the KTA Safety Standard 3902, and examinations in connection with an extension of the protection of the on-site interim storage facilities against disruptive actions or other intervention of third parties, see above. In the licensing procedures for modifications it was examined individually whether supplementary examinations had to be carried out for the Environmental Impact Assessment in individual cases.

In June 2013, the OVG Schleswig upheld the action against the licence for the Brunsbüttel on-site interim storage facility. The licence of November 2003 was unlawful and to be annulled since it did not fulfil the requirements set out in § 6 para. 2 no. 4 AtG. The defendant had wrongly determined and evaluated the necessary level of protection against terrorist impacts in the form of a targeted crash of a passenger plane as well as the risks of the scenario of a terrorist attack on the on-site interim storage facility with anti-tank weapons in the licensing procedure. The OVG Schleswig did not grant the right to further appeals. The Federal Republic of Germany - as the defendent - lodged a complaint against the denial of leave to appeal to the Federal Administrative Court (BVerwG). With decision of 8 January 2015 the BVerwG dismissed the complaint against the denial of leave to appeal in the decision of the OVG Schleswig of 19 June 2013. With the decision of the BVerwG the revocation of the licence for the SZL Brunsbüttel has become effective. Until recovery of a legal licence, the nuclear supervisory authority of the Federal State of Schleswig-Holstein gave order on 16 January 2015, to carry on storing the altogether nine stored CASTOR® casks in the SZL Brunsbüttel until January 2018.

Another legal proceeding is pending at the OVG Lüneburg concerning the licence for the Unterweser on-site interim storage facility.

Table 4.1 gives a survey of the respective first licences, the licensed masses of heavy metal (HM) and storing positions, start of construction and taking into operation (i.e. the first emplacement of a loaded cask) of the on-site interim storage facilities. Further details about the on-site interim storage facilities are given in Table III.5.

Table 4.1: On-site interim storage facilities (SZL)

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 2014)	Start of construction	Taken into operation
SZL Biblis	22.09.2003	1,400	135 (51)	01.03.2004	18.05.2006
SZL Brokdorf	28.11.2003	1,000	100 (26)	05.04.2004	05.03.2007
SZL Brunsbüttel	28.11.2003	450	80 (9)	07.10.2003	05.02.2006
SZL Grafenrheinfeld	12.02.2003	800	88 (21)	22.09.2003	27.02.2006
SZL Grohnde	20.12.2002	1,000	100 (22)	10.11.2003	27.04.2006
SZL Gundremmingen	19.12.2003	1,850	192 (42)	23.08.2004	25.08.2006
SZL Isar	22.09.2003	1,500	152 (34)	14.06.2004	12.03.2007
SZL Krümmel	19.12.2003	775	80 (19)	23.04.2004	14.11.2006
SZL Lingen	06.11.2002	1,250	125 (32)	18.10.2000	10.12.2002
SZL Neckarwestheim	22.09.2003	1,600	151 (44)	17.11.2003	06.12.2006
SZL Philippsburg	19.12.2003	1,600	152 (36)	17.05.2004	19.03.2007
SZL Unterweser	22.09.2003	800	80 (16)	19.01.2004	18.06.2007

On 22 April 2005, Kernkraftwerk Obrigheim GmbH (KWO GmbH) submitted an application to the BfS for the storage of spent fuel elements in the Obrigheim on-site interim storage facility. On 1 January 2007, KWO GmbH as the applicant was replaced by EnBW Kernkraft GmbH (EnKK). Storage of altogether 342 spent fuel elements was applied for which came from the pressurised water reactor of the Obrigheim NPP that had already been shut down in May 2005 and is now under decommissioning. The fuel elements are currently stored in an already existing wet storage facility on the site (see above). The external wet storage facility impeding the planned dismantling works for the Obrigheim NPP, the applicant intends to operate a separate on-site interim storage facility with dry interim storage of spent fuel elements on the premises of the Obrigheim NPP for 40 years at most. The EnKK concept provides for the storage of spent fuel elements in altogether 15 transport and storage casks of the CASTOR® 440/84 type. Applied for is the storage of the nuclear fuel in a storage hall made of reinforced concrete with a loading and storage area. It is planned to design the Obrigheim interim storage facility for self-sustained operation. With letter of 6 December 2011 the EnKK added further details to the application of 22 April 2005 in terms of construction and plant inspection. In order to meet new requirements in terms of plant security, it is now planned to store the nuclear fuel in a storage hall (ca. 36.6 m long, ca. 19.7 m wide and ca. 19.0 m high) according to the concept of a so-called STEAG storage facility.

Since 2013, the EnKK has also been examining the alternative storage of the 342 spent fuel elements from the Obrigheim NPP in the SZL Neckarwestheim. With letter of 10 December 2013 it filed a corresponding application to the BfS according to § 6 AtG. The EnKK concept for the storage of the spent fuel elements in altogether 15 casks of the CASTOR® 440/84 type is to be maintained.

The Neckarwestheim on-site interim storage facility is situated ca. 40 km from the Obrigheim site (air-line distance). In a transport study, the EnKK is currently examining on which transport route (road, rail, river Neckar) the CASTOR® casks could be transported to the Neckarwestheim on-site interim storage facility. The EnKK has come to the conclusion that transport on an inland water vessel on the river Neckar should be prioritised. The so-called “Roll-on/Roll-off procedure” with a transport vehicle should be prioritised for loading/unloading the vessel. As an alternative, the EnKK also pursues direct transport by road. On behalf of the EnKK, the NCS GmbH filed a corresponding application to the BfS for a transport licence under § 4 AtG on 27 March 2014. With this application the EnKK’s considers to do without the construction of another interim storage facility and to stop using the Obrigheim site as a nuclear site considerably earlier.

4.3.3 Storage in central interim storage facilities

An overview 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, Gorleben and the transport cask storage facility of the Interim Storage Facility North, investigations into the possible impacts of a targeted air crash were carried out

in the scope of investigations into a possible subsequent requirement according to § 17 AtG. Expert results have shown that in the 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 Transport Cask Storage Facility Ahaus is a dry storage facility for spent fuel elements in transport and storage casks of the CASTOR® type.

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

On 17 March 1992, the TBL-A was granted a licence for the storage of spent ball-shaped fuel elements from the THTR-300 in transport and storage casks of the CASTOR® THTR/AVR type. 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. The licence stipulates the maximum storable activity to be $2 \cdot 10^{20}$ Bq and the heat output limit of all casks in the hall 17 MW.

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

After the complaint and appeal proceedings had concluded, the storage licence for the TBL Ahaus became definitive.

On 9 November 2009, the Bezirksregierung Münster granted the licence pursuant to § 7 StrlSchV for the limited interim storage of radioactive waste from the operation and decommissioning of German nuclear power plants with a maximum total activity of 10^{17} Bq for a period of 10 years maximum. The operational and decommissioning waste is to be stored in the western half of the hall, placed in different casks made from concrete, cast-iron and steel. This waste is later on to be taken to the licensed federal Konrad repository, which is located near Salzgitter and is currently being converted.

Furthermore, altogether six modification licences pursuant to § 6 AtG were granted from 2000 until 2010 (cf. Table III.4).

The GNS and the BZA filed an application according to § 6 AtG for the storage of high-pressure compacted intermediate-level radioactive waste (CSD-C – Colis Standard de Déchet Compactés) from the reprocessing of spent fuels in transport and storage casks of the TGC36 type on 20 December 2006. A new transport and storage cask of the TGC27 type is being developed for the storage of this CSD-C waste. From today's point of view one plans to store this waste in up to 150 casks.

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 was done because the licence for the AVR cask storage facility expired 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. With letter of 20 April 2012, the GNS requested notification of storage of initially 76 of these casks at ground level set-up. In a second licensing step, the storage of the remaining 76 casks is to be decided, along with the two-layer stacking of the 152 casks.

With letter of 30 September 2014, the GNS requested the nuclear licensing procedure for the storage of the spent fuel elements of the research neutron source Heinz Maier-Leibnitz of the Technische Universität München in the TBL Ahaus to be reopened. It is planned to store the fuel elements in ca. 21 casks of the new cask type CASTOR®MTR3 in storage facility area II of the TBL Ahaus. The storage of spent fuel elements from German research reactors applied for is part of the comprehensive joint application of the BZA and the GNS of 15 September 1995, for which a decision has so far only been made for the fuel elements of the Rossendorf research reactor with respect to research reactor fuel elements.

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 storage licence according to § 6 Atomic Energy Act for a capacity of 1,500 Mg of heavy metal (HM) was granted on 5 September 1983. Storage operation 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, in addition to the increase to altogether 3,800 Mg of HM and the storage of solidified high-level radioactive fission product solutions. The storable activity was limited to $2 \cdot 10^{20}$ Bq. Prior to this decision a public participation procedure was carried out on the basis of the amendment to § 6 Atomic Energy Act.

On 31 December 2014, 5 casks containing spent fuel elements (1 CASTOR® Ic, 1 CASTOR® IIa, 3 CASTOR® V/19) and 108 casks containing HAW vitrified waste block canisters (1 TS 28 V and 74 CASTOR® HAW 20/28 CG, 21 CASTOR®HAW 28 M and 12 TN85) were stored in the TBL Gorleben.

The application for the storage of the HAW vitrified waste block canisters from reprocessing at the British Sellafield Ltd. plant has been under examination since 2012. Altogether, a waste volume of further ca. 21 casks of the CASTOR® HAW HAW28M containing HAW vitrified waste block canisters must be assumed.

With letters of 2 February 2012 and of 10 February 2012, the GNS and the Brennelementlager Gorleben GmbH (BLG) also applied for the storage of solidified intermediate-level radioactive waste (MAW vitrified waste block canisters) from the reprocessing of spent fuel elements at AREVA NC in France in casks of the CASTOR®HAW28M type. The GNS predicts storage of up to five casks.

According to an Amendment to the Atomic Energy Act in connection with the Repository Site Selection Act (StandAG) of 23 July 2013, the waste that was originally to be transported to the Interim Storage Facility Gorleben will now be taken to on-site interim storage facilities. It is planned to make a decision about the sites in consultation with the affected federal states and the utilities.

With letters of 5 December 2013 and 12 December 2013, the GNS and the BLG applied for extending the storage licence pursuant to § 7 para. 2 StrlSchV to the storage of other radioactive materials at the TBL-G. In the framework of this combined utilisation it is now planned to store in a part of the storage facility waste suitable for disposal which was conditioned previously on the site, in a still to be constructed attachment to the waste storage facility Gorleben.

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

The Transport Cask Storage Facility in the Interim Storage 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 North on the premises of EWN. The ZLN mainly serves to store spent fuel elements, nuclear fuel, and other radioactive waste from the reactors of Rheinsberg and Greifswald.

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

On the appointed date of 31 December 2014, there were altogether 74 loaded CASTOR® casks in the ZLN (62 CASTOR®440/84, 3 CASTOR®KRB-MOX, 5 CASTOR® HAW 20/28 SN 16 and 4 CASTOR®KNK).

4.4 INTERIM STORAGE OF RADIOACTIVE WASTE AND NUCLEAR FUELS

4.4.1 Interim storage of radioactive waste

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

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

- the external storage hall Unterweser,
- the decentralised interim storage facility Biblis,
- the TBL Ahaus,
- the waste storage facility Gorleben (ALG),
- the EVU hall of the interim storage facility Mitterteich,
- the interim storage facilities of Nuclear + Cargo Service GmbH (NCS) in Hanau,
- the Interim Storage North (ZLN) near Greifswald,
- the interim storage facility Rossendorf (ZLR) and

- the interim storage facility of the Hauptabteilung Dekontaminationsbetriebe (HDB) in Karlsruhe.

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

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

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

4.4.2 Government custody of nuclear fuels

According to § 5 Atomic Energy Act, nuclear fuels (such as fresh fuel elements, fuel rods, and UO_2-pellets) must be kept in government custody if the operator does not have a valid licence. According to § 5 Atomic Energy Act, the Federal Office for Radiation Protection is the competent authority for federal custody.

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

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

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 60's of the 20th century, Germany started developing the technology used for the reprocessing of spent fuel elements. For this purpose the Karlsruhe reprocessing plant (WAK) was constructed as pilot plant. There were plans for the construction of a national waste management centre (Gorleben Nuclear Waste Management Centre) where interim storage, industrial reprocessing, and disposal were to be dealt with on one site.

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

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

Due to the Amendment to the Atomic Energy Act of 27 April 2002, a ban was imposed on transports to reprocessing plants abroad after 30 June 2005, in order to minimise the risk associated with reprocessing and transports to reprocessing plants. 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 relating to 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 finally ended in 1991 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 60 m^3 of high-level radioactive liquid waste concentrate (HAWC) with an activity of $7.7 \cdot 10^{17}$ Bq accrued from reprocessing, which was last stored inside the LAVA building (facility for the storage and evaporation of high-level radioactive waste liquids). The low-level and intermediate-level operational wastes of the WAK were conditioned in the Karlsruhe Nuclear Research Center. After radioactive waste emplacement into

the Asse mine stopped in 1978, additional conditioned operational waste remained with the WAK Rückbau- und Entsorgungs-GmbH.

Operation finally ended on 30 June 1991. At the end of 1991 the federal government, the Land of Baden-Württemberg and the utilities decided to decommission and dismantle the reprocessing plant. On 22 March 1993, the first partial decommissioning licence for the WAK was granted.

At the end of the reprocessing operation the plant consisted of

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

The objective is to dismantle all buildings completely and to achieve the state of "greenfield" by 2023. 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). The vitrification of the HAWC was completed in 2010. The adaptation of the HAWC storage facilities and the vitrification plant Karlsruhe (VEK, details see below) to the reduced overall operation has been achieved. Step 4 has thus been completed. Step 5 consists of the dismantling of the HAWC storage facilities and the VEK. The conventional dismantling of all buildings (step 6) will only be carried out after the entire plant has been released from regulatory control.

Prior to dismantling the storage facilities, the HAWC that was last stored in 2 containers in the LAVA building had to be conditioned in a way suitable for disposal and to be disposed of. For this special purpose the VEK was constructed. The first partial construction licence for the VEK was granted on 30 December 1998. The construction of the VEK started at the beginning of 2000. The second partial operation licence for hot (nuclear) operation was granted on 24 February 2009. Between September 2009 and June 2010 the approx. 60 m^3 of HAWC were processed in the VEK into 123 vitrified waste block canisters containing altogether 49 Mg of waste glass. Additional 17 waste block canisters were produced during the subsequent rinsing process, so that altogether 56 Mg of waste glass were produced. After having filled the 140th and last waste block canister, the operation of the Karlsruhe vitrification plant finally terminated on 25 November 2010; it has been in the post-operational phase since. The furnace has been emptied and switched off. On 28 April 2014, the operator was granted a licence for manually emptying the installations in the VEK that had already been finally shut down. An application for remote-controlled dismounting of the VEK process technology was filed on 24 March 2014. The 140 waste block canisters were placed into 5 transport and storage casks of the CASTOR®HAW 20/28 type and were taken to the Interim Storage North of EWN GmbH in Lubmin near Greifswald in February 2011 (cf. Chapter 4.3.3).

Two emptied HAWC casks each are in the buildings “LAVA” (storage casks) and “HWL” (reserve casks) in thick-walled concrete cells which are only accessibly by remote-handling because of the high dose rate. 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. Despite having been rinsed several times after being emptied, solid HAWC residues were detected in the reserve cask (81B21) and in the two LAVA casks. In the scope of the remote-handled dismantling of the HAWC storage casks which has been permitted by the 22nd decommissioning licence of 8 December 2010, these solid residues are to be recovered.

The 23rd decommissioning licence was granted on 14 December 2011. It includes the dismounting of the LAVA-high-active laboratory and the LAVA (hot) cells. The high-active laboratory has been dismantled in the meantime. The dismantling of the LAVA cells is being prepared.

Wackersdorf Reprocessing Plant (WAW)

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

This application resulted from the decision made by the heads of the federal and Länder governments made in 1979, which considered reprocessing, including the recirculation of the utilisable nuclear fuels and the disposal of radioactive waste from the reprocessing process, to be feasible in terms of safety 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 Centre in Gorleben not to be politically enforceable.

The first partial building licence was granted in September 1985. The Bavarian Administrative Court considered the development plan contrary to law. Construction had started in December 1985. Modifications of the

concept then made it necessary to develop a new safety report, to perform another public hearing and to examine the safety of the facility as a whole.

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

4.6 CONDITIONING OF FUEL ELEMENTS

Gorleben Pilot Conditioning Plant (PKA)

(Cf Table III.8 in Annex III)

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

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

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

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

All three partial licences are definitive.

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

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

4.7 DISPOSAL

An overview of radioactive waste repositories and decommissioning projects in the Federal Republic of Germany is given in Table III.9. The course of approval procedures for repositories for radioactive waste pursuant to § 9b Atomic Energy Act is shown in Fig. III.2.

4.7.1 Responsibilities regarding disposal

The legal basis for the disposal of radioactive waste is the Atomic Energy Act (AtG).

Following the decision of the federal government of 2011 concerning the phase-out of nuclear energy until 2022, the federation and the Länder agreed on extending the achieved consensus regarding the termination of power generation with nuclear energy (cf. Chapter 1.3) to the issue of high-level radioactive waste management which is still open. In order to place the search for a repository for high-level radioactive waste on a broad, political and social basis, the Bundestag and Bundesrat passed the Act Concerning the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste (Site Selection Act – StandAG). It became effective on 27 July 2013. The StandAG provides for a legally binding, formal public participation and active public relations work in all phases of the repository site selection procedure.

The Federal Office for Radiation Protection (BfS) is responsible for the implementation of the repository site-selection procedure according to StandAG, the construction, operation and decommissioning of repositories. A site-selection procedure for a repository for heat-generating radioactive waste is newly initiated and implemented on the basis of the Repository Site-Selection Act.

Pursuant to § 9a para. 3 Atomic Energy Act (AtG) the federation must establish facilities for the safekeeping and disposal of radioactive waste, The BfS is the responsible authority (§ 23 para. 1 no. 2 AtG). The BfS is part of the portfolio of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and is subject to the BMUB's functional and legal control in terms of the implementation of repository-related tasks. Since 2008, the Nuclear Waste Management Commission (ESK) has given advice to the Federal Environment Ministry in terms of nuclear waste management issues.

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

According to § 9 para. 3 AtG the federation or the BfS, respectively, may use the services of third parties to comply with its obligations. Under a contract of 1984, the German Company for the Construction and Operation of Repositories for Waste (DBE) has been tasked with the planning and construction of federal facilities for the long-term storage and disposal of radioactive waste. DBE's shares are held by the GNS mbH (75%) and the EWN GmbH (25%). Currently, the DBE as the plant-managing company, is in charge of the construction of the Konrad repository, the operation of the Morsleben repository and the transfer of the Gorleben mine into a state where it is kept open but not operated. The 100-% federal Asse GmbH has been tasked with the operational management and the decommissioning of the Asse II mine. On behalf of the BfS, the company for the operation and decommissioning of the Asse II mine carries out tasks relating to the planning, construction and operation of federal facilities for the safekeeping and disposal of radioactive waste. Like the DBE, it is also a third party in the context of § 9a para. 3 AtG. The overall responsibility for the construction and operation of federal repositories is with the BfS. The DBE and the Asse-GmbH are supervised by the BfS. The BfS also initiates and co-ordinates facility-related research and development projects.

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

In 2013 the German Bundestag passed the act concerning the search and selection of a site for a repository for heat-generating radioactive waste (Repository Site Selection Act). According to the StandAG, the site selection procedure is prepared by the "Commission High-level Radioactive Waste Storage" (Commission). This Commission is part of the Environment Committee of the German Bundestag and consists of 33 members comprising representatives from society, politics and science. In the public meetings, the Commission will e.g. deal with the question as to whether, for a proper waste management, other options than the immediate disposal of high-level radioactive waste in deep geological formations should be investigated scientifically. Furthermore, the Commission develops decision criteria for the selection procedure, criteria for correction possibilities (e.g. retrieval), requirements for the organisation and the performance of the selection process and the participation and information provided to the public. The Commission should complete its work by the end of 2015, in the case of an optional extension, by mid 2016. Currently an extension until 31 December 2016 is being discussed.

At the end of 2014/beginning of 2015, the Commission discussed a possible reorganisation of responsibilities. Part of these considerations is to combine the disposal-related tasks and parts of the BfS with the so-called administrative helpers (Asse-GmbH and DBE GmbH) as project developer, applicant and operator, in an organisation still to be founded, in order to minimise interfaces and increase efficiency. The plan is that the federation will be the sole owner of this new private-sector company.

The repository site selection procedure is to be regulated by the Federal Office for Nuclear Waste Management currently under development, which is also to take over regulatory tasks relating to the repository projects.

4.7.2 Repository and decommissioning projects

GORLEBEN mine (project)

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

The mining exploration of the Gorleben salt dome was terminated when the StandAG entered into force (cf. Chapter 4.7.1). Like any other eligible site, the Gorleben site will be included in the repository site-selection

procedure in accordance with the criteria and requirements proposed by the “Commission High-level Radioactive Waste Storage” pursuant to the StandAG. Until a decision will be taken about the site and as to whether the Gorleben site will be discarded pursuant to the StandAG, the mine will be kept operable, ensuring compliance with all legal requirements and that the necessary maintenance measures are carried out required for its operation.

On 30 October 2013, an application was submitted to the mining authority for a main operating plan which contains only measures required to bring the mine into a state where it will be kept open, and then to keep it in that state. The approval of the main operating plan was granted by the mining authority on 18 December 2013 and limited until 30 September 2014.

On 29 July 2014, the BMUB and the Lower Saxon Ministry for the Environment, Energy and Climate Protection agreed as to how the operation of the Gorleben mine would have to be reduced until the mine is just kept open. The two shafts and the parts of the infrastructure area necessary for mining reasons will continue to be operated. During a transitional phase lasting about 2 years, the mine openings, facilities and buildings no longer needed will be taken out of operation and, if necessary, dismantled. According to this agreement, the main operating plan including the transition measures was submitted to the LBEG on 30 September 2014 for approval. Until this approval will be available, the LBEG issued an information injunction pursuant to § 72 para. 1 BBergG, stating that works and measures would be tolerated that have been listed in the main operating plan and that have already been approved by licensed special operating plans. The new main operating plan was approved on 26 November 2014.

KONRAD repository

The Konrad mine in Salzgitter developed the iron ore deposit in depths between 800 m and 1,300 m. The deposit had been known since 1933. Construction of the Konrad mine started in 1957. Iron ore production already stopped in 1976, for economic reasons. From 1977, the mine was initially investigated as to whether it would be basically suited to host a repository for radioactive waste. After these investigations had concluded with a positive result, the then competent Physikalisch-Technische Bundesanstalt filed an application for the initiation of a plan-approval (licensing) procedure according to § 9b Atomic Energy Act on 31 August 1982. The plan provided for the disposal of up to 650,000 m^3 of radioactive waste with negligible heat generation. Subsequently, the estimations of the waste volume to be expected reduced considerably. Therefore, 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 the use of nuclear energy for electricity generation, in the decommissioning and dismantling of nuclear power plants and other nuclear installations. Other, comparatively small amounts of waste originate from radioisotope application in craft, research, medicine, the Federal Armed forces as well as from research and development works. Referring to the volume, the waste with negligible heat generation amounts to about 90% but has only 0.1% of the activity of all radioactive waste.

The licensing procedure that had started in 1982 was completed through the plan-approval decision of 22 May 2002. 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 then the Konrad mine has been converted into a repository. The mining licence of the competent mining authority which is required in addition to the nuclear plan-approval decision was granted with the approval of the main operating plan.

The necessary planning for implementing the project continued in 2014. Especially the over 500 collateral clauses in the plan-approval decision and the fact that the major part of the plans originate from the nineties make it necessary to comprehensively up-date the plans. The current remediation requirements of the existing facilities, today’s market availability of licensed components, the status of the technical code, the requirements of the energy saving regulations and the provisions on sustainable and barrier-free building are taken into account. Among others, building permits become necessary through these comprehensive changes to the plans. In the context of the BfS’ privileged status regarding the Konrad project that has been recognised by the federal state of Lower Saxony, the simplified building approval procedure pursuant to § 74 Lower Saxon Building Ordinance (NBauO) has been applied.

In the process of revising the plans it has shown that the assumptions made in the nineties were incorrect at the time the Konrad repository was taken into operation and have raised unrealistic expectations. The BfS has requested the DBE to develop an updated schedule for the completion of the Konrad mine which takes into account the most recent findings. In October 2013, the DBE gave an estimation as to when the Konrad repository will be completed. According to the DBE, the new estimated date of completion of Konrad is the

year 2022. However, this date is not reliable and there are considerable uncertainties attached to it that cannot be quantified. Therefore no reliable new date of completion can currently be given. At present, the DBE cannot say when these uncertainties will have overcome finally. The DBE has indicated that it can present a reliable schedule only after it has contractually agreed anew the deadlines and periods for services of key subcontractors.

The so-called “construction in existing contexts” has proven to be a fundamental project risk. The state of some existing buildings and installations has turned out to be worse than expected. New hoisting installations need to be installed in shafts Konrad 1 and Konrad 2 for the approved conversion into a repository. While the anchoring of the guidance devices for the shaft hoisting system Konrad 1 south was installed, it turned out that further remediation measures need to be carried out at the existing shaft masonry. This will delay the conversion. The extent of the unavoidable delays and the effects on the individual construction processes cannot be quantified at present. The contractor can only present a resilient scheduling once the deadlines for the performance of their sub-contractors have been contractually agreed upon. In addition to commercial agreements with sub-contractors, this also requires pending approvals according to Mining Law.

For the construction of the Konrad repository, new chambers need to be driven underground, which is to be supported by exact dimensioning with the help of geo-technical calculations. Already available results lead to a considerable increase in costs and efforts, whose re-evaluation in terms of schedule is associated with even more uncertainties.

As in shaft Konrad 1, more efficiency-boosting measures are expected for shaft Konrad 2.

MORSLEBEN Repository for Radioactive Waste (ERAM)

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

In the ERAM, altogether ca. 14,432 m^3 of low-level and intermediate-level radioactive waste with a total activity of ca. $1.8 \cdot 10^{14}$ Bq was disposed of from 1971 until February 1991 (in relation to 1 July 1991). 22,320 m^3 of low-level and intermediate-level radioactive waste with a total activity at time of emplacement of ca. $9.1 \cdot 10^{13}$ Bq was disposed of from January 1994 until September 1998. Furthermore, radiation sources and other waste with a total activity at time of emplacement of ca. $2.9 \cdot 10^{15}$ Bq were stored intermediately in the ERAM.

On 21 May 1999, the BfS announced that for safety reasons, the emplacement of radioactive waste in the ERAM would not be resumed after operation was stopped by court order in September 1998. On the basis of the Amendment to the Atomic Energy Act of 2002, the provisions of § 57 a Atomic Energy Act were modified to the extent that the permanent operation licence for the ERAM dated 22 April 1986 continues to be effective for an indefinite period as plan-approval decision in the context of § 9 b Atomic Energy Act, except for the regulations relating to the acceptance and disposal of further radioactive waste. The acceptance for disposal of radioactive waste from third parties has been ruled out since.

On 9 May 1997, the BfS limited the application for further operation of the ERAM to the scope of its decommissioning. The application was filed to the Ministry for Agriculture and the Environment (MLU) of Saxony-Anhalt on 13 October 1992. In the context of the plan-approval procedure for decommissioning, the radioactive waste intermediately stored until that time and the operational radioactive waste accruing during decommissioning operation is to be disposed of while the ERAM is being decommissioned.

Given that the emplacement of radioactive waste has permanently ended and the procedure for the decommissioning applied for is pending, it is planned to change repository operation to keeping the mine open. For this purpose, an appropriate plan for converting the ERAM and keeping it operable was submitted to the competent licensing authority of the federal state of Saxony-Anhalt in 2003. However, fundamental questions have arisen about what has to be done, so that the procedure has been suspended until further notice since 11 June 2014.

To improve the geo-mechanical state in the central part of the ERAM, altogether 27 rock salt mining districts were stabilised with ca. 935,000 m^3 of salt concrete between 2003 and 2011. With this measure the mining security objective has been achieved.

Plans in the plan-approval procedure for the decommissioning of the ERAM aim at keeping the protection goals both in the context of radiation protection and mining law. Even if the release of radionuclides from a

sealed repository cannot be entirely prevented in the long term, only so small amounts of these radionuclides may reach the biosphere that the protection goals will be complied with in the long run.

A key component of the decommissioning concept is the wide backfilling of major parts of the underground cavities and shafts with building materials that have a sealing and stabilising effect. The emplacement areas in the repository's eastern field and western-southern field are additionally sealed with building materials and structures that have been especially developed for the conditions. This is done at selected sites in the access galleries. Altogether more than 4 million cubic metres of salt concrete will have to be filled into the ERAM for the planned backfilling measures. Likewise, the several-hundred-metre-deep shafts will be sealed with especially developed structures to complete the works.

From October to December 2009, the necessary documents were displayed to the public in the scope of public participation of the plan-approval procedure "Decommissioning of the ERAM". The public hearing relating to the objections to the project was held in October 2011.

Subsequent to the hearing, the Federal Environment Ministry tasked the Waste Management Commission (ESK) with the preparation of an opinion on the question as to whether the proof of long-term safety (LZSN) for the ERAM complied with the state of the art of science and technology in terms of methodology. The ESK statement was published on 31 January 2013 and includes six main requirements to supplement the long-term safety assessments which require very much additional work.

Large-scale tests underground relating to the sealing structures in rock salt and in anhydrite and the in-depth planning have shown that more investigations and planning adjustments are necessary with regard to building material, building concept and the required safety proof. In 2013, the works on the in-depth plans of the measures provided for in the decommissioning concept have basically been completed. As a result of the amended plans relating to the sealing structures and the comprehensive works on the recommendations of the ESK, a large number of the documents that were already submitted needs revising, taking into account already available audit findings of the MLU.

These additional works are estimated to take at least five years. Subsequently it must be evaluated whether another public participation procedure will be required.

Asse II mine

Between 1909 and 1964, the Asse II mine located near Wolfenbüttel was operated by Burbach AG for the production of potash and rock salt. One carnallitite mining field and two rock salt mining fields were developed.

In 1965, Gesellschaft für Strahlen- und Umweltforschung (GSF, today Helmholtz-Zentrum für Umwelt und Gesundheit München; HMGU) bought the Asse II mine for use as research mine for the disposal of radioactive waste in salt formations. In the period from 1967 to 1978, low-level and intermediate-level radioactive waste was emplaced in the Asse II mine. In the scope of the trial and demonstration programmes altogether around 124,500 drums were emplaced as low-level radioactive waste in 12 chambers on the 725-m level and on the 750-m level (14,779 packages of which with lost concrete shielding) and around 1,300 drums with intermediate-level radioactive waste were emplaced in a chamber on the 511-m level. According to the present state of knowledge, the sum of the activity inventory on 1 January 1980 was $1.13 \cdot 10^{16}$ Bq.

Following a decision of the federal cabinet of 5 November 2008 to treat the mine in future as a radioactive waste repository, responsibility was transferred from the HMGU to the BfS on 1 January 2009, the BfS being responsible for repositories according to § 23 AtG. As the operator of the Asse II mine, the BfS is responsible in terms of both mining and nuclear law. The BfS commissioned the newly founded Asse-GmbH with the management of the mine, starting on 1 January 2009.

Since January 2008, the decommissioning of the Asse II mine is monitored by the Asse II Monitoring Group of the rural district of Wolfenbüttel (A2 B) consisting, among others, of representatives of the local stakeholders, environmental associations and citizens' initiatives. Since March 2008, the Asse II Monitoring Group has been receiving expert advice by the Comparison of Options Working Group (AGO, meanwhile renamed in Working Group Options-Retrieval). Until the BfS took over the operator's responsibility for the Asse mine, it had been prominently involved in this working group; it is now only acting in an advisory role in the AGO. The AGO is now being managed by the Karlsruhe Institut für Technologie (KIT).

Since April 2013, it has been legally binding to retrieve the radioactive waste prior to decommissioning the mine (Act on Speeding up the Retrieval of Radioactive Waste and the Decommissioning of the Asse II Mine ("Lex Asse")). The "Lex Asse" permits that all measures associated with retrieval be carried out in parallel. The results of the examinations for the feasibility of retrieval (fact-finding) need not be waited for. Furthermore, the "Lex Asse" contains regulations on licensing procedures, utilisation/reclamation of contaminated materials and updating of accident planning values. These are to make retrieval easier.

Until it will be decommissioned, the mine has to be kept operable in a condition for safe operation and precautions have to be taken against damages according to the standards of the Atomic Energy Act and the Federal Mining Act (BBergG).

The operations that are necessary to keep the mine operable and the fact-finding are carried out on the basis of the nuclear licences granted by NMU according to § 7 StrlSchV in July 2010 and according to § 9 AtG granted in April 2011. Apart from the brine management, the backfilling of roof clefts, the implementation of precautionary measures to establish emergency preparedness and the works for the fact-finding procedure, works to maintain the mine's suitability for use and the mining infrastructure are matters of priority.

Brine management

An inflow of brine from the adjoining rock has been observed at the mine's southern flank since at least 1988. Altogether, a gradual increase has been registered until today. The measured values at the collecting points show that the volumes flowing in are not constant and partly show strong fluctuations. There are also places of brine inflow that used to be dry over long periods of time, where liquids were again collected later on. The most recent fluctuations were detected between July 2012 and September 2014 and were especially noticeable through strong fluctuations at the main collecting point on the 658-m level. An inflow of brine occurred on the 658-m level beside the existing main inflow point. It occurred via a drilling that is connected with an old collecting point on the 637-m level. The increase in volume of the inflowing brine at both collecting points on the 658-m level was more than 0.5 m^3/day. The brine inflow via the drilling to the 637-m level dried up again in September 2014. There has been an enhanced inflow from the main dripping point since. The volume inflowing brine at all collecting points in the southern flank is ca. 12.5 m^3/day.

On the 750-m level of the mine's northern flank the inflow rate has increased by < 0.2 m^3/day to ca. 0.8 m^3/day since October 2014. On account of their chemism, the brines' origin can be attributed to brine occurrences as a result of mining (potash mining field) or inside the salt dome. The inflow shows that the system has changed recently. The development cannot be prognosticated.

About every 1.5 months, the brine from the 658-m level is transported to the abandoned Maria-Glück mine of Kali + Salz (K+S) near Celle, where it is used to flood the mine. The contract with K+S was extended in January 2013 until 2016. The BfS intends to apply for a licence for discharging inflowing volumes in an emergency (up to 500 m^3/day) into a suitable surface water.

On the 750-m level there are also contaminated solutions, currently ca. 12 l/day in front of emplacement chamber 8 in the west. Contamination in the brines has so far been in a range (below the ten-fold of the exemption limit according to Annex II Table 1, Column 3 of the Radiation Protection Ordinance) that permits internal utilisation according to the "Lex Asse".

Stabilisation (e.g. backfilling of roof clefts) and emergency preparedness

To reduce the deformations at the mine's southern flank one intends to backfill residual cavities (roof clefts) with Sorel concrete in more than approximately 90 mining districts. The roof clefts of 49 mining districts have been backfilled with ca. 48,500 m^3 since December 2009.

As a preventive structural measure, sealing structures are constructed on the levels and underneath the emplacement chambers and cavities no longer needed are backfilled to minimise and delay the release of radionuclides in the event of an emergency.

Limitations in the mine's suitability for use and their remedying delayed the backfilling measures in 2014. The loading station of shaft 2 on the 750-m level had to be remediated and the spiral gallery section between the 750-m and the 775-m level had to be backfilled and newly driven.

To stabilise the southern and western side of the construction field on the 750-m level, mining district 3 (between emplacement chambers 4 and 5) and gallery sections in the area of blind shaft 1 were backfilled, among others. Furthermore, possible vertical pathways were closed by backfilling blind shaft 1 between the 700-m and the 750-m level. At the eastern side of the construction field, backfilling of blind shaft 3 was prepared.

More backfilling measures were carried out in the gallery behind blind shaft 2. Brine collection points in the backfilling area have been bordered with shaft rings. The brine monitoring and the brine collection have so far been operated successfully via drillings from the 700-m level.

Detailed discussions about the backfilling measures on the 750-m level in the support process continue. The A2 B and the AGO have expressed concerns that the backfilling measures on the 750-m level could impede the retrieval of the waste because the brine might retain in the emplacement chambers. The BfS does not share these concerns and draws attention to the emergency preparedness which is a key prerequisite for

retrieval. The BfS developed a concept for maintaining the existing brine collection method and the monitoring on the 750-m level. In the gallery behind blind shaft 2 the functional demonstration of the planned brine collecting points was given. As the operator, the BfS is responsible and must take decisions, if necessary also in disagreement with the Monitoring Group.

In view of the works on retrieval the emergency preparedness is being updated and adapted. According to preliminary plans, it will be possible to establish the best possible emergency preparedness by 2025.

Fact finding

Since the fact-finding started, three drill holes into or, respectively into the area surrounding chamber 7/750 were sunk. More information was gained in this process about the sealing structure and the chamber's geometry, the state of the rock, the occurrence of explosive gases and radiological findings. No explosive gas concentrations were detected. The radiological findings (radon, tritium) have so far been within the expected range and are controllable.

The fact-finding originally served two purposes: To investigate the necessity of retrieval and to determine data for the planning and licensing of retrieval.

Through the amendment of the so-called "Lex Asse" (§ 57 b AtG), the objective of the fact-finding has changed such that retrieval has now been defined as a legal task. The objective of proving the necessity of retrieval is therefore obsolete.

Therefore, the fact-finding is being evaluated, examining its necessity and extent. This comprises also the issues relating to the necessity of the fact-finding for each emplacement chamber (e.g. also the MAW chamber), the chamber-specific extent of a basic evaluation for the retrieval and the transferability of compiled data.

Decommissioning

According to the "Lex Asse", the radioactive waste is to be retrieved prior to decommissioning. In terms of retrieval, plans for a new shaft, an interim storage facility and retrieval techniques were advanced.

The surface exploratory drilling for a new shaft 500 m to the east of the existing premises reached a final depth of 900 m. In January 2015, the underground exploration on the 574-m level has been started. More underground drillings are planned to be carried out on the 700-m level. A decision about the suitability of the shaft site can only be made after the underground drillings have been evaluated.

In 2014, extensive discussions took place with the bodies of the monitoring process about the site selection for an interim storage facility. It is recognised that the conditioning of the retrieved waste must take place on site. To avoid transports, the BfS continues to pursue the objective to search initially for an interim storage facility site located near the Asse mine. On the other hand, the Monitoring Group demands the search be extended to interim storage facility sites located farther away from the mine.

The DMT GmbH developed a draft concept of possible variants of access to the emplacement chambers in 2013. Basically, the concept study is assessed positively by the scientific advisory board of the Monitoring Group, the Working Group Options-Retrieval.

A European-wide tender procedure in the form of a competition started for the concept plans relating to the retrieval of the waste from the 750-m and 725-m level. Planning work is to start in 2015.

The retrieval techniques identified in the scope of a market research are currently being evaluated in view of their possible application in the Asse mine. It cannot be ruled out that there is more need for research and development in terms of the retrieval techniques.

ANNEXES - SURVEY

ANNEX I – NUCLEAR POWER PLANTS

As of 31 December 2014

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

	Authority for licences according to § 6 AtG	**Supervisory authority according to § 19 in conjunction with § 6 AtG**
Federal Republic of Germany	Federal Office for Radiation Protection	Länder supervisory authorities
Land	**Licencing authority for facilities according to § 7 AtG**	**Supervisory authority according to § 19 in conjunction with §§ 6 and 7 AtG**
Baden-Württemberg (BW)	Ministry for the Environment, Climate Protection and the Energy Sector, in agreement with the Ministry for the Finances and Economy and the Ministry of the Interior	Ministry for the Environment, Climate Protection and the Energy Sector
Bavaria (BY)	Bavarian State Ministry of the Environment and Consumer Protection	
Berlin (BE)	Berlin Senate Department for Urban Development and the Environment	
Brandenburg (BB)	Ministry of Justice and for Europe and Consumer Protection	
Bremen (HB)	Senator for the Environment, Building, Traffic in consultation with Senator for Health	
Hamburg (HH)	Authority for Urban Development and Environment	
Hesse (HE)	Hessian Ministry for the Environment, Climate Protection, Agriculture and Consumer Protection	
Mecklenburg-Western-Pomerania (MV)	Ministry for the Interior and Sport	
Lower Saxony (NI)	Lower Saxon Ministry for the Environment, Energy and Climate Protection	
North Rhine-Westphalia (NW)	Ministry of Economic Affairs, Energy, Industry, Middle Class and Trade of the Land of North Rhine-Westphalia	
Rhineland-Palatinate (RP)	Ministry of Econmy, Climate Protection, Energy and Regional Planning	
Saarland (SL)	Ministry for the Environment, Energy and Traffic	
Saxony (SN)	Saxon State Ministry for the Environment and Agriculture	
Saxony-Anhalt (ST)	Ministry for the Environment and Agriculture	
Schleswig-Holstein (SH)	Ministry for a Turnaround in Energy Policy, Agriculture, Environment and Rural Areas Schleswig-Holstein	
Thuringia (TH)	Ministry for Agriculture, Forestry, Environment and Nature Conservation	

Table I.2: Nuclear power plants in operation

Name of facility and site	Operator	Type	Capacity gross [MW_e]	Capacity net [MW_e]	1st partial licence	Start of construction	Initial criticality
GKN 2 Neckarwestheim, BW	EnBW Kernkraft GmbH (EnKK)	PWR	1,400	1,310	09.11.1982	11/1982	29.12.1988
KKP 2 Philippsburg, BW	EnBW Kernkraft GmbH (EnKK)	PWR	1,468	1,402	06.07.1977	07/1977	13.12.1984
KKI 2 Essenbach, BY	E.ON Kernkraft GmbH	PWR	1,485	1,410	12.07.1982	09/1982	15.01.1988
KKG Grafenrheinfeld, BY	E.ON Kernkraft GmbH	PWR	1,345	1,275	21.06.1974	01/1975	09.12.1981
KRB-II-B Gundremmingen, BY	Kernkraftwerk Gundremmingen GmbH	BWR	1,344	1,284	16.07.1976	07/1976	09.03.1984
KRB-II-C Gundremmingen, BY	Kernkraftwerk Gundremmingen GmbH	BWR	1,344	1,288	16.07.1976	07/1976	26.10.1984
KWG Grohnde, NI	E.ON Kernkraft GmbH	PWR	1,430	1,360	08.06.1976	06/1976	01.09.1984
KKE Lingen, NI	Kernkraftwerke Lippe-Ems GmbH	PWR	1,406	1,335	04.08.1982	08/1982	14.04.1988
KBR Brokdorf, SH	E.ON Kernkraft GmbH	PWR	1,480	1,410	25.10.1976	01/1976	08.10.1986

Table I.3: Nuclear power plants finally shut down

Name of facility and site	Operator	Type	Capacity gross [MW_e]	Start of construction	Initial criticality	Final shut-down/ application for decom-missioning
GKN 1 Neckarwestheim, BW	EnBW Kernkraft GmbH (EnKK)	PWR	840	02/1972	26.05.1976	06.08.2011/ 24.04.2013
KKP 1 Philippsburg, BW	EnBW Kernkraft GmbH (EnKK)	BWR	926	10/1970	09.03.1979	06.08.2011/ 24.04.2013
KKI 1 Essenbach, BY	E.ON Kernkraft GmbH	BWR	912	05/1972	20.11.1977	06.08.2011/ 04.05.2012
KWB A Biblis, HE	RWE Power AG	PWR	1,225	01/1970	16.07.1974	06.08.2011/ 06.08.2012
KWB B Biblis, HE	RWE Power AG	PWR	1,300	02/1972	25.03.1976	06.08.2011/ 06.08.2012
KKU Esenshamm, NI	E.ON Kernkraft GmbH	PWR	1,410	07/1972	16.09.1978	06.08.2011/ 04.05.2012
KKB Brunsbüttel, SH	Kernkraftwerk Brunsbüttel GmbH & Co. oHG	BWR	806	04/1970	23.06.1976	06.08.2011/ 01.11.2012
KKK Krümmel, SH	Kernkraftwerk Krümmel GmbH & Co. oHG	BWR	1,402	04/1974	14.09.1983	06.08.2011/ -

Table I.4: Nuclear power plants under decommissioning

Name of facility and site	Operator	Type	Capacity gross [MW_e]	Start of construction	Initial criticality	Final shutdown	Status
KKR Rheinsberg, BB	Energiewerke Nord GmbH	PWR	70	01/1960	11.03.1966	01.06.1990	Dismantling licence 28.04.1995 et seq. Last licence of 04.09.2013
KNK II Eggenstein-Leopoldshafen, BW	Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH	SNR	21	09/1974	10.10.1977	23.08.1991	Dismantling licence 26.08.1993 et seq.
MZFR Eggenstein-Leopoldshafen, BW	Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH	PWR	57	12/1961	29.09.1965	03.05.1984	Dismantling licence 17.11.1987 et seq.
KWO Obrigheim, BW	EnBW Kernkraft GmbH (EnKK)	PWR	357	03/1965	22.09.1968	11.05.2005	1st decommissioning and dismantling licence 28.08.2008 2nd decommissioning and dismantling licence 24.10.2011 3rd dismantling licence 30.04.2013
KRB A Gundremmingen, BY	Kernkraftwerk Gundremmingen GmbH	BWR	250	12/1962	14.08.1966	13.01.1977	Dismantling licence 26.05.1983 et seq.
KGR 1 Lubmin, MV	Energiewerke Nord GmbH	PWR	440	03/1970	03.12.1973	18.12.1990	Licence of 30.06.1995 et seq. for decomm./dismantling entire plant
KGR 2 Lubmin, MV	Energiewerke Nord GmbH	PWR	440	03/1970	03.12.1974	14.02.1990	Licence of 30.06.1995 et seq. for decomm./dismantling entire plant
KGR 3 Lubmin, MV	Energiewerke Nord GmbH	PWR	440	04/1972	06.10.1977	28.02.1990	Licence of 30.06.1995 et seq. for decomm./dismantling entire plant

Name of facility and site	Operator	Type	Capacity gross [MW_e]	Start of construction	Initial criticality	Final shutdown	Status
KGR 4 Lubmin, MV	Energiewerke Nord GmbH	PWR	440	04/1972	22.07.1979	02.06.1990	Licence of 30.06.1995 et seq. for decomm./dismantling entire plant
KGR 5 Lubmin, MV	Energiewerke Nord GmbH	PWR	440	12/1976	26.03.1989	30.11.1989	Licence of 30.06.1995 et seq. for decomm./dismantling entire plant
KKS Stade, NI	Kernkraft Stade GmbH & Co. oHG	PWR	672	12/1967	08.01.1972	14.11.2003	Licence for dec./dism. Phase 1 - 07.09.2005 Phase 2 - 15.02.2006 Phase 3 -14.05.2009 Phase 4 - 04.02.2011
KWL Lingen (Ems), NI	Kernkraftwerk Lingen GmbH	BWR	252	10/1964	31.01.1968	05.01.1977	Licence for safe enclosure of 21.11.1985; application for dismantling of the facility of 15.12.2008
AVR Jülich, NW	Arbeitsgemeinschaft Versuchsreaktor GmbH	HTR	15	08/1961	26.08.1966	31.12.1988	1st decommissioning licence for safe enclosure of 09.03.1994, licence for complete dismantling 31.03.2009, modification lic. on 18.01.2013
KWW Würgassen, NW	E.ON Kernkraft GmbH	BWR	670	01/1968	22.10.1971	26.08.1994	1st decommissioning licence of 14.04.1997 et seq.
THTR Hamm-Uentrop, NW	Hochtemperatur-Kernkraftwerk GmbH	HTR	308	05/1971	13.09.1983	29.09.1988	Licence for operation of safe enclosure on 21.05.1997

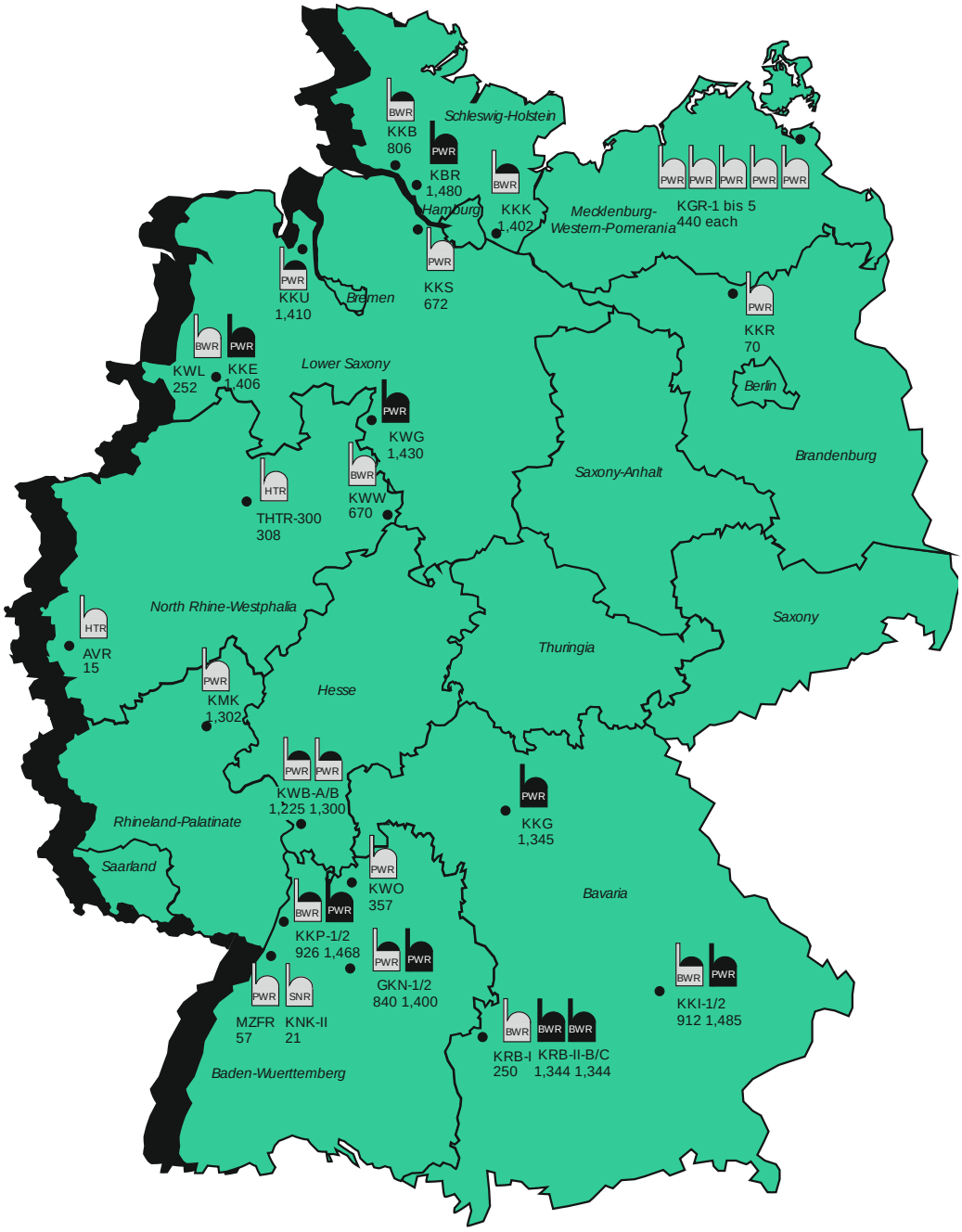
Name of facility and site	Operator	Type	Capacity gross [MW_e]	Start of construc-tion	Initial critica-lity	Final shut-down	Status
KMK Mülheim-Kärlich, RP	RWE Power AG	PWR	1,302	01/1975	01.03.1986	09.09.1988	Licence for dec./dism. phase 1a 16.07.2004, supplement 23.02.2006, lic. 3b for reducing the size of the premises of 16.09.2014, lic. 3c for release and clear-ance of ground area of 31.01.2014

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

Name of the facility and site	Operator	Type	Capacity gross [MW_e]	Start of construction	Initial criticality	Finally shutdown	Status
HDR Großwelzheim, BY	Karlsruhe Institute of Technology (KIT), formerly Forschungszentrum Karlsruhe GmbH	SSR	25	01/1965	14.10.1969	20.04.1971	Entirely dismantled
KKN Niederaichbach, BY	Karlsruhe Institute of Technology (KIT), formerly Forschungszentrum Karlsruhe GmbH	PTR	106	06/1966	17.12.1972	31.07.1974	Entirely dismantled
VAK Kahl (Main), BY	Versuchsatomkraftwerk Kahl GmbH	BWR	16	07/1958	13.11.1960	25.11.1985	The buildings and the plant site were released from regulatory control on 17.05.2010, dismantling completed on 24.09.2010

Table I.6: Stopped nuclear power plants projects

Name of the facility and site	Operator	Type	Capacity gross [MW_e]	Start of construction	Status
KGR 6 Lubmin, MV	Energiewerke Nord GmbH	PWR	440	1976	Final shut-down: 30.11.1989 licence on decomm./dism. of the entire plant 30.06.1995 et seq.
KGR 7 Lubmin, MV	Energiewerke Nord GmbH	PWR	440	1976	Project stopped
KGR 8 Lubmin, MV	Energiewerke Nord GmbH	PWR	440	1976	Project stopped
SNR 300 Kalkar, NW	Schnell-Brüter-Kernkraftwerksgesellschaft mbH	FBR	327	1973	Project stopped 20.03.1991
Stendal A Stendal, ST	Altmark Industrie GmbH	PWR	1,000	1st construction licence: 10.09.1982	Project stopped
Stendal B Stendal, ST	Altmark Industrie GmbH	PWR	1,000	1st construction licence: 10.09.1982	Project stopped



Legend:

NPP, in operation

NPP, finally shut down

NPP, under decommissioning

Data: Gross capacity MWe
As of 31 December 2014

Figure I: Nuclear Power Plants in the Federal Republic of Germany

ANNEX II – RESEARCH REACTORS

As of 31 December 2014

Table II.1: Research reactors in operation

Name of the facility and site	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Status
BER II Berlin, BE	Helmholtz-Zentrum Berlin für Materialien und Energie GmbH (HZB)	Pool, MTR	10	$1 \cdot 10^{14}$	09.12.1973	In operation
SUR Stuttgart Stuttgart, BW	University of Stuttgart, Institutes for Nuclear Energy and Energy Systems	Siemens Training reactor SUR 100	$1 \cdot 10^{-7}$	$6 \cdot 10^{6}$	24.08.1964	In operation
SUR Ulm Ulm, BW	Hochschule Ulm, Institute of Radiation Measurement (ISM)	Siemens Training reactor SUR 100	$1 \cdot 10^{-7}$	$5 \cdot 10^{6}$	01.12.1965	In operation
SUR Furtwangen Furtwangen, BW	Hochschule Furtwangen	Siemens Training reactor SUR 100	$1 \cdot 10^{-7}$	$6 \cdot 10^{6}$	28.06.1973	In operation
FRM-II Garching, BY	Technische Universität München (TUM)	Pool, Compact core	20	$8 \cdot 10^{14}$	02.03.2004	In operation
FRMZ Mainz, RP	Universität Mainz Institute for Nuclear Chemistry	Pool, TRIGA Mark II	0.1	$4 \cdot 10^{12}$	03.08.1965	In operation
AKR-2 Dresden, SN	Technische Universität Dresden, Institute of Power Engineering	Training reactor, AKR 2	$2 \cdot 10^{-6}$	$3 \cdot 10^{7}$	22.03.2005 (AKR-1: 28.07.1978)	In operation

Table II.2: Research reactors finally shut down

Name of the facility and site	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Status
SUR Hannover Hannover, NI	Leibniz Universität Hannover Institute of Nuclear Engineering and Non-Destructive Testing	Siemens Training reactor SUR 100	$1 \cdot 10^{-7}$	$6 \cdot 10^{6}$	09.12.1971	Since 2008 free from nuclear fuel	Application for decommssioning of 22.10.2013
SUR Aachen Aachen, NW	Rheinisch-Westfälische Technische Hochschule (RWTH)	Siemens Training reactor SUR 100	$1 \cdot 10^{-7}$	$6 \cdot 10^{6}$	22.09.1965	In 2002	Application for decommssioning in 2010
FRG-1 Geesthacht, SH	Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research GmbH	Pool MTR	5	$1 \cdot 10^{14}$	23.10.1958	Final shutdown on 28.06.2010	Application for dismantling of FRG-1 and the remaining plant of FRG-2 of 21.03.2013
FRG-2 Geesthacht, SH	Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research GmbH	Pool MTR	15	$2 \cdot 10^{14}$	16.03.1963	28.01.1993	Licence for taking out of operation and partial dismantling of 17.01.1995, application for dismantling of FRG-1 and the remaining plant of FRG-2 of 21.03.2013

Table II.3: Research reactors under decommissioning

Name of the facility and site	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Status
FR 2 Egg.-Leopoldshafen, BW	Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH	Tank type D_2O-Reaktor	44	$1 \cdot 10^{14}$	07.03.1961	21.12.1981	Decommissioning licence of 03.07.1986 ff, Safe enclosure since 20.11.1996
FRM Garching, BY	Technische Universität München (TUM)	Pool MTR	4	$7 \cdot 10^{13}$	31.10.1957	28.07.2000	Decommissioning licence of 03.04.2014
FRN Oberschleißheim, BY	Helmholtz Zentrum München – German Research Centre for Environmental Health (GmbH)	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
FRMB Braunschweig, NI	Physikalisch-Technische Bundesanstalt Braunschweig (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
FRJ-2 (DIDO) Jülich, NW	Forschungszentrum Jülich (FZJ)	Tank type D_2O-Reaktor	23	$2 \cdot 10^{14}$	14.11.1962	02.05.2006	Decommissioning licence of 20.09.2012
RFR Rossendorf, SN	VKTA-Radiation, Analytic and Disposal Inc.	Tank type WWR-S(M)	10	$1 \cdot 10^{14}$	16.12.1957	27.06.1991	Decommissioning licence of 30.01.1998 ff, second modification of the 4th licence of 01.02.2005 on 09.01.2014

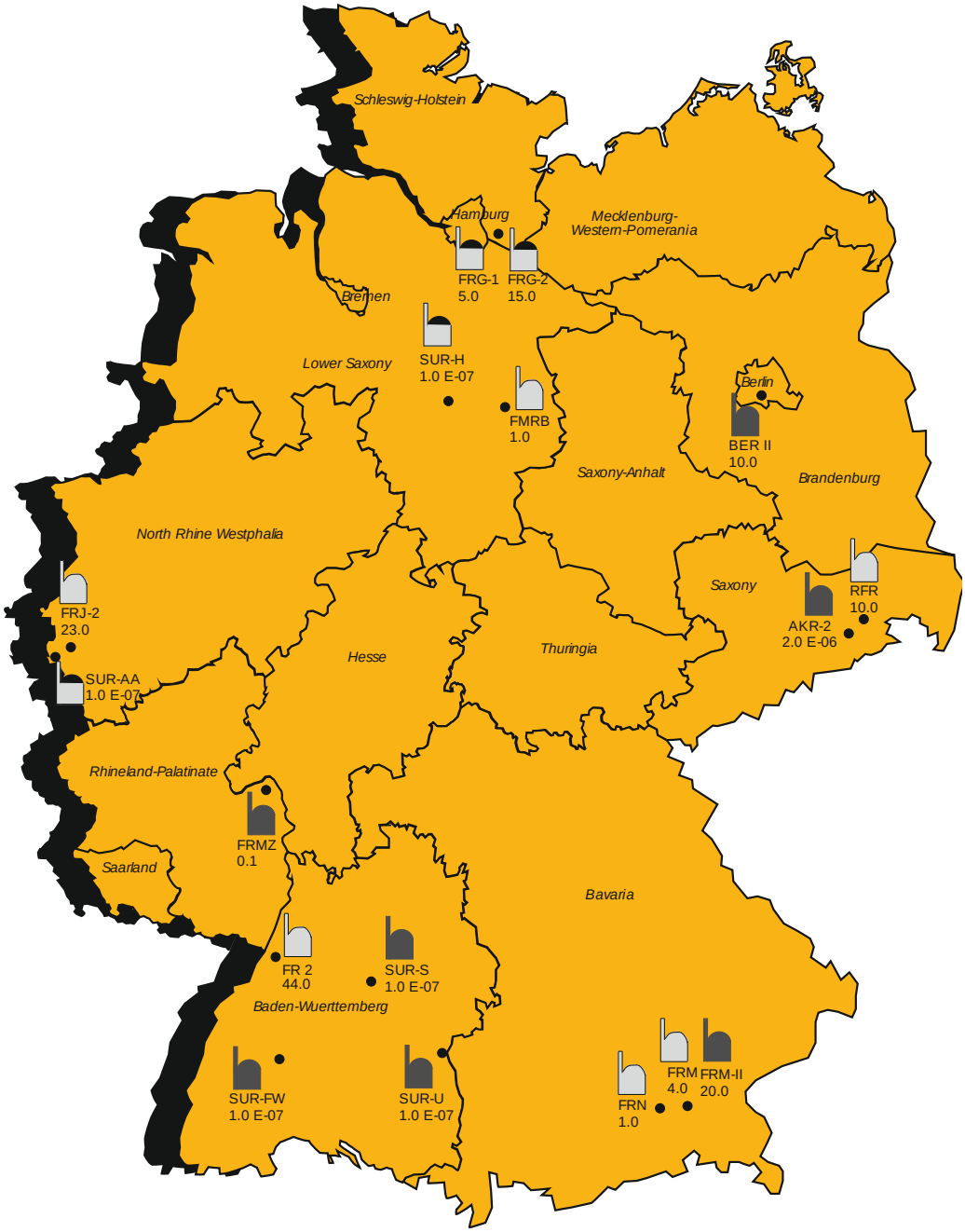
Table II.4: Research reactors released from regulatory control

Name of the facility and site	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Status
Research reactors > 50 kW_{th}							
TRIGA HD I Heidelberg, BW	German Cancer Research Centre (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 remediated.
TRIGA HD II Heidelberg, BW	German Cancer Research Centre (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
FRF 2 Frankfurt, HE	Johann Wolfgang Goethe Universität Frankfurt	Modified TRIGA	1	$3 \cdot 10^{13}$ (designed)	No criticality	No operation	Released from regulatory control on 31.10.2006
FRH Hannover, NI	Hannover Medical School	Pool, TRIGA Mark I	0,25	$9 \cdot 10^{12}$	31.01.1973	18.12.1996	Released from regulatory control on 13.03.2008
FRJ-1 (MERLIN) Jülich, NW	Forschungszentrum Jülich (FZJ)	Pool MTR	10	$1 \cdot 10^{14}$	24.02.1962	22.03.1985	Released from regulatory control on 23.11.2007
OH Geesthacht, SH	Helmholtz-Centre for Materials and Coastal Research GmbH	FDR Ship reactor	38	$3 \cdot 10^{13}$	26.08.1968	22.03.1979	Released from regulatory control on 01.09.1982, storage of reactor pressure vessel according to StrlSchV
Research reactors ≤ 50 kW_{th}							
BER I Berlin, BE	Helmholtz-Zentrum Berlin für Materialien und Energie GmbH	Homogeneous reactor	$5 \cdot 10^{-2}$	$2 \cdot 10^{12}$	24.07.1958	Summer 1972	23.04.1974 Decommissioning completed

Name of the facility and site	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Status
SUR Berlin Berlin, BE	Technische Universität Berlin	Siemens Training Reactor SUR 100	$1 \cdot 10^{-7}$	$5 \cdot 10^{6}$	26.07.1963	15.10.2007	16.04.2013 Released from regulatory control
SNEAK Eggenstein-Leopoldshafen BW	Karlsruhe Research Centre	Homogeneous reaktor	$1 \cdot 10^{-3}$	$7 \cdot 10^{6}$	15.12.1966	11/1985	06.05.1987 (notice of assessment)
SUAK Eggenstein-Leopoldshafen BW	Karlsruhe Research Centre	Fast subcritical system	No capacity		Taken into operation 20.11.1964	07.12.1978	
STARK Eggenstein-Leopoldshafen BW	Karlsruhe Research Centre	Argonaut	$1 \cdot 10^{-5}$	$1 \cdot 10^{8}$	11.01.1963	03/1976	1977 Released from regulatory control
SUR Karlsruhe Eggenstein-Leopoldshafen BW	Karlsruhe Research Centre	Siemens Training Reactor SUR-100	$1 \cdot 10^{-7}$	$6 \cdot 10^{6}$	07.03.1966	09/1996	26.06.1998 Released from regulatory control
AEG Nullenergiereaktor Karlstein, BY	Kraftwerk Union	Tank-Type/ critical system	$1 \cdot 10^{-4}$	$1 \cdot 10^{8}$	23.06.1967	1973	21.12.1981 Decommissioning completed
AEG Prüfreaktor PR 10 Karlstein, BY	Kraftwerk Union	Argonaut	$1{,}8 \cdot 10^{-4}$	$3 \cdot 10^{10}$	27.01.1961	1976	22.02.1978 Decommissioning completed
SAR Garching, BY	Technische Universität München	Argonaut	$1 \cdot 10^{-3}$	$2 \cdot 10^{11}$	23.06.1959	31.10.1968	20.03.1998 Decommissioning completed

Name of the facility and site	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Status
SUA München Garching, BY	Technische Universität München	Sub-critical system	No capacity		Taken into operation 06/1959	1968	20.03.1998 Decommissioning completed
SUR München Garching, BY	Technische Universität München	Siemens Training Reactor SUR-100	$1 \cdot 10^{-7}$	$6 \cdot 10^{6}$	28.02.1962	10.08.1981	20.03.1998 Decommissioning completed
SUR Bremen Bremen, HB	Hochschule Bremen	Siemens Training Reactor SUR-100	$1 \cdot 10^{-7}$	$6 \cdot 10^{6}$	10.10.1967	17.06.1993	03/2000 Decommissioning completed
SUR Hamburg Hamburg, HH	Fachhochschule Hamburg	Siemens Training Reactor SUR-100	$1 \cdot 10^{-7}$	$6 \cdot 10^{6}$	15.01.1965	08/1992	12/1999 Decommissioning completed
FRF 1 Frankfurt, HE	Johann Wolfgang Goethe Universität Frankfurt	Homogeneous reactor	$5 \cdot 10^{-2}$	$1 \cdot 10^{12}$	10.01.1958	19.03.1968	31.10.2006 Released from regulatory control
SUR Darmstadt Darmstadt, HE	Technische Hochschule Darmstadt	Siemens Training Reactor SUR-100	$1 \cdot 10^{-7}$	$6 \cdot 10^{6}$	23.09.1963	22.02.1985	29.11.1996 Decommissioning completed
ADIBKA Jülich, NW	Forschungszentrum Jülich	Homogeneous reactor	$1 \cdot 10^{-4}$	$3 \cdot 10^{8}$	18.03.1967	30.10.1972	Ende 1977 Decommissioning completed
KAHTER Jülich, NW	Forschungszentrum Jülich	Critical system	$1 \cdot 10^{-4}$	$2 \cdot 10^{8}$	02.07.1973	03.02.1984	06/1988 Decommissioning completed
KEITER Jülich, NW	Forschungszentrum Jülich	Critical system	$1 \cdot 10^{-6}$	$2 \cdot 10^{7}$	15.06.1971	1982	06/1988 Decommissioning completed

Name of the facility and site	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Status
ANEX Geesthacht, SH	Helmholtz- Centre for Materials and Coastal Research GmbH	Critical system	$1 \cdot 10^{-4}$	$2 \cdot 10^{8}$	05/1964	05.02.1975	01/1980 Decommissioning completed
SUR Kiel Kiel, SH	Fachhochschule Kiel	Siemens Training reactor SUR-100	$1 \cdot 10^{-7}$	$6 \cdot 10^{6}$	29.03.1966	11.12.1997	02.04.2008 Released from regulatory control
RAKE Rossendorf, SN	VKTA-Radiation, Analytic and Disposal Inc.	Tank-Type/critical system	$1 \cdot 10^{-5}$	$1 \cdot 10^{8}$	03.10.1969	26.11.1991	28.10.1998 Released from regulatory control
RRR Rossendorf, SN	VKTA-Radiation, Analytic and Disposal Inc.	Argonaut	$1 \cdot 10^{-3}$	$2 \cdot 10^{11}$	16.12.1962	25.09.1991	11.05.2000 Released from regulatory control
ZLFR Zittau, SN	Hochschule Zittau/Görlitz Fachbereich Maschinenwesen	Tank-Type/WWRM	$1 \cdot 10^{-5}$	$2 \cdot 10^{8}$	25.05.1979	24.03.2005	03.05.2006 Released from regulatory control



Legend:

RR, in Operation

RR, finally shut down

RR, under decommissioning

Data: Thermal power MW
As of 31 December 2014

Figure II: Research reactors in the Federal Republic of Germany

ANNEX III – PLANTS OF NUCLEAR FUEL SUPPLY AND WASTE MANAGEMENT

As of 31 December 2014

Table III.1: Uranium enrichment plants

Name of the facility and site	Purpose of the facility	Capacity according to the licence	Licence	Notes
Uranium-Enrichment plant Gronau (UAG) NW	Uranium enrichment	4,500 Mg of uranium separative work per year (SW/y) according to the notification of 14.02.2005	3rd partial licence of 04.06.1985 (operation licence) 9th partial licence of 31.10.1997 capacity increase to 1,800 Mg SW/y Notification no. 7/Ä2 of 27.11.1998 2nd modification licence for two further separating halls, Notification no. 7/6 of 14.02.2005 on increase of production capacity to 4,500 Mg SW/y	The licence of 14.02.2005 also comprises the handling of depleted and enriched uranium (up to max. 6 % U-235) The expanded plant has been under construction since the midlle of 2008 and is commissioned gradually. The plant is operated with a nominal capacity of 4,500 Mg SW/y. Construction of a storage hall for 50,000 Mg U_3O_8 was completed in 2014. The start of operation is planned for 2015.

Table III.2: Fuel element fabrication plants

Name of the facility and site	Purpose of the facility	Capacity according to the licence	Licence	Notes
ANF fuel element fabrication plant **Lingen** **NI**	Fabrication of mainly LWR fuel elements of low-enriched uranium dioxide	Handling and processing of annually altogether 800 Mg uranium in the form of uranium powder or uranium pellets with up to 5 % U-235-fraction.	Operation licence of 18.01.1979, 7th 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 fabricated uranium pellets per year 11.01.2005: Increase of uranium powder throughput rate to 650 Mg/y 02.12.2009: Capacity increase to 800 Mg/y 26.06.2014: Extension of the storage areas for fuel elements	ANF stores on ist premises certain types of radioactive waste determined for disposal according to § 6 AtG from its own fuel element fabrication and UF_6 for third parties. A hall for the storage of UF_6-containers has been taken into operation.

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

Name of the facility and site	Purpose of the facility	Capacity according to the licence	Licence	Notes
SIEMENS fuel element fabrication plant, Plant section Karlstein BY	Fabrication of fuel elements of low-enriched uranium dioxid	Annual throughput of 400 Mg UO_2 up to max. 4,0 % U-235 fraction	Operation licence according to § 9 AtG vom 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 Release from AtG: March 1999	Fuel element fabrication has been discontinued, conventional fabrication of ends (ANF Karlstein).
SIEMENS fuel element fabrication plant Hanau Plant section: MOX- processing HE	Fabrication of MOX-fuel elements of plutonium and uranium mainly for use in LWR	Throughput of about 35 Mg HM/y, expansion to 120 Mg HM/y was planned	Operation licence according to § 9 AtG: 16.08.1968 last comprehensive licence according to § 9 AtG of 30.12.1974 6th partial building licence according to § 7 AtG of 12.03.1991 Several partial licences for removing the fuel from the production line and for dismantling of the plant for MOX-fuel from 1997 to 2005 Release from AtG: Sept. 2006	In April 1994 the operator decided to not recommission 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 HE	Fabrication of LWR-fuel elements of low-enriched uranium	Throughput 1,350 Mg U/y	Operation licence according to § 9 AtG of 22.07.1969 operation licence according to § 7 AtG of 31.08.1990 Several individual and partial licences for removing the fuel from the production line and for dismantling of the plant from 1996 to 2001 Release from AtG: 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 the facility and site	Purpose of the facility	Capacity according to the licence	Licence	Notes
Fuel element fabrication plant NUKEM Hanau-Wolfgang, HE	Fabrication of 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 the site between 1988 bis 2001 Released from regulatory control in May 2006, except for a partial area of 1,000 m^2 for further groundwater decontamination	Operation licence discontinued on 15.01.1988; the fuel was removed from the production line by 31.12.1988. Dismantling works and soil remediation have been completed. Groundwater remediation is still continuing. A test phase to finish the remediation is running.
Hochtemperatur-Brennelement-Gesellschaft (HOBEG) Hanau, HE	Fabrication of ball-shaped fuel elements for HTR on the basis of uranium (up to 94 % U-235) and thorium	200,000 fuel elements/y 11.7 Mg HM (during operation time)	Operation licence according to § 9 AtG: 30.12.1974. 9 licences for dismantling and decommissioning between 05.12.1988 and 07.04.1995. Release from AtG: 18.12.1995.	The facility was temporarily taken out of operation on 15.01.1988 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: Central fuel element interim storage facilities

Name of the facility and site	Purpose of the facility	Capacity according to the licence	Licence	Notes
Transport cask storage facility in the Interim Storage North (ISN) Rubenow (near Greifswald), MV	Storage of spent fuel elements from Rheinsberg and Greifswald in transport and storage casks (dry storage)	585.4 Mg HM in max. 80 storage casks Max storable activity: $7.5 \cdot 10^{18}$ Bq	According to § 6 AtG of 05.11.1999 1th modification of 14.03.2001 2th modification of 07.07.2003 3th modification of 19.12.2005 4th modification of 17.02.2006 5th modification of 17.12.2008 6th modification of 24.02.2009 7th modification of 30.04.2010	On 31.12.2014 74 casks were stored in the ZLN: - 62 CASTOR® 440/84 - 3 CASTOR® KRB-MOX - 4 CASTOR® KNK - 5 CASTOR® HAW 20/28 CG.
Transport cask storage facility Gorleben (TBL-G) 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	According to § 6 AtG of 05.09.1983, order for immediate enforcement of 06.09.1988 new licence of 02.06.1995 for spent fuel elements and vitrified fission product solutions 1th modification of 01.12.2000 2th modification of 18.01.2002 3th modification of 23.05.2007 4th modification of 29.01.2010	On 31.12.2014 alltogether 113 casks were stored in the TBL-G, - 5 cask with spent fuel elements, of which - 1 CASTOR® Ic - 1 CASTOR® IIa, - 3 CASTOR® V/19 and 108 casks with HAW-vitrified waste block canisters, of which - 1 TS 28 V, - 74 CASTOR® HAW 20/28 CG, - 21 CASTOR® HAW28M - 12 TN85.

Name of the facility and site	Purpose of the facility	Capacity according to the licence	Licence	Notes
Ahaus Transport Cask Facility (TBL-A) **NW**	Storage of spent fuel elements in transport and storage casks of the CASTOR® type (dry storage)	420 cask storing positions (LWR), capacitiy up to alltogether max. 3,960 Mg HM max. storable activity $2 \cdot 10^{20}$ Bq	10.04.1987 according to § 6 AtG Amended version of the storage licence of 07.11.1997 (increase of the mass of heavy metal and licence for further cask types) 1th modification of 17.05.2000 2th modification of 24.04.2001 3th modification of 30.03.2004 4th modification of 04.07.2008 5th modification of 22.12.2008 6th modification of 26.05.2010	In April 1995 the emplacement of 305 CASTOR® THTR/AVR-casks with fuel elements of the type THTR-300 was terminated. On 20.03.1998 additionally - 2 CASTOR® V/19 - 1 CASTOR® V/19 SN06 and - 3 CASTOR® V/52 with LWR-fuel elements were taken to the TBL-A. In 2005 18 CASTOR® MTR 2 casks were stored which were transported from Rossendorf to Ahaus.

Table III.5: On-site interim storage facilities

Name of the facility and site	Purpose of the facility	Capacity according to the licence	Licence	Notes
On-site interim storage facility Neckar-westheim Gemmrigheim, BW	Storage of spent fuel elements from units GKN 1 and GKN 2 of the Neckar Joint NPP	1,600 Mg heavy metal in up to 151 transport and storage casks with an activity up to $8.3 \cdot 10^{19}$ Bq and 3.5 MW heat release	According to § 6 AtG of 22.09.2003 1th modification of 22.03.2006 2th modification of 28.09.2006 1th supplement of 03.09.2007 2th supplement of 18.02.2010 3th modification of 11.05.2010 4th modification of 13.12.2013 5th modification of 16.04.2014	Start of construction: 17.11.2003 First emplacement: 06.12.2006 At the end of 2014 44 casks were stored in the interim storage facility
On-site interim storage facility Philippsburg BW	Storage of spent fuel elements from units 1 and 2 of the Philippsburg NPP	1,600 Mg heavy metal in up to 152 transport and storage casks with an activity up to $1.5 \cdot 10^{20}$ Bq and 6.0 MW heat release	According to § 6 AtG of 19.12.2003 1th modification of 05.10.2006 2th modification of 21.12.2006 3th modification of 13.06.2014 4th modification of 18.12.2014	Start of construction: 17.05.2004 First emplacement: 19.03.2007 At the end of 2014 36 casks were stored in the interim storage facility
Interim storage facility on the site of the Obrigheim NPP BW	Storage of spent fuel elements and core components of the Obrigheim NPP (wet storage)	980 fuel elements (approx. 286 Mg HM)	26.10.1998 according to § 7 AtG	Since the end of 2007 342 fuel elements have been in the fuel pool.
On-site interim storage facility Grafenrheinfeld BY	Storage of spent fuel elements from the Grafenrheinfeld NPP	800 Mg heavy metal in up to 88 transport and storage casks with an activity up to $5 \cdot 10^{19}$ Bq and 3.5 MW heat release	According to § 6 AtG of 12.02.2003 Order for immediate enforcement of 10.09.2003 1th modification of 31.07.2007 2th modification of 06.10.2011 3th modification of 03.11.2011	Start of construction: 22.09.2003 First emplacement: 27.02.2006 At the end of 2014 21 casks were stored in the interim storage facility

Name of the facility and site	Purpose of the facility	Capacity according to the licence	Licence	Notes
On-site interim storage facility Gundremmingen BY	Storage of spent fuel elements from units B and C of the Gundremmingen NPP	1,850 Mg heavy metal in up to 192 transport and storage casks with an activity up to $2.4 \cdot 10^{20}$ Bq and 6.0 MW heat release	According to § 6 AtG of 19.12.2003 Order for immediate enforcement of 28.07.2004 1th modification of 02.06.2006 2th modification of 07.01.2014	Start of construction: 23.08.2004 First emplacement: 25.08.2006 At the end of 2014 42 casks were stored in the interim storage facility
On-site interim storage facility Isar Niederaichbach BY	Storage of spent fuel elements from Isar 1 and Isar 2 NPPs	1,500 Mg heavy metal in up to 152 transport and storage casks with an activity up to $1.5 \cdot 10^{20}$ Bq and 6.0 MW heat release	According to § 6 AtG of 22.09.2003 Order for immediate enforcement of 28.05.2004 1th modification of 11.01.2007 2th modification of 29.02.2008 3th modification of 16.11.2011 4th modification of 07.02.2012	Start of construction: 14.06.2004 First emplacement: 12.03.2007 At the end of 2014 34 casks were stored in the interim storage facility
On-site interim storage facility Biblis HE	Storage of spent fuel elements from units A and B of the Biblis NPP	1,400 Mg heavy metal in up to 135 transport and storage casks with an activity up to $8.5 \cdot 10^{19}$ Bq and 5.3 MW heat release	According to § 6 AtG of 22.09.2003 1th modification of 20.10.2005 1th supplement of 20.03.2006 2th modification of 27.03.2006 3th modification of 16.06.2014 4th modification of 22.07.2014	Start of construction: 01.03.2004 First emplacement: 18.05.2006 At the end of 2014 51 casks were stored in the interim storage facility.
On-site interim storage facility Grohnde NI	Storage of spent fuel elements from the Grohnde NPP	1,000 Mg heavy metal in up to 100 transport and storage casks with an activity up to $5.5 \cdot 10^{19}$ Bq and 3.75 MW heat release	According to § 6 AtG of 20.12.2002 Order for immediate enforcement of 19.09.2005 1th modification of 17.04.2007 2th modification of 23.05.2012 3th modification of 25.06.2012	Start of construction: 10.11.2003 First emplacement: 27.04.2006 At the end of 2014 22 casks were stored in the interim storage facility.

Name of the facility and site	Purpose of the facility	Capacity according to the licence	Licence	Notes
On-site interim storage facility Lingen (Emsland) Bramsche NI	Storage of spent fuel elements from the Emsland NPP	1,250 Mg heavy metal in up to 125 transport and storage casks with an activity up to $6.9 \cdot 10^{19}$ Bq and 4.7 MW heat release	According to § 6 AtG of 06.11.2002 mit Order for immediate enforcement 1th supplement of 31.07.2007 1th modification of 01.02.2008 2th modification of 19.12.2014	Start of construction: 18.10.2000 First emplacement: 10.12.2002 At the end of 2014 32 casks were stored in the interim storage facility.
On-site interim storage facility Unterweser Rodenkirchen NI	Storage of spent fuel elements from the Unterweser NPP	800 Mg heavy metal in up to 80 transport and storage casks with an activity up to $4.4 \cdot 10^{19}$ Bq and 3.0 MW heat release	According to § 6 AtG of 22.09.2003 Order for immediate enforcement of 05.02.2007 1th modification of 27.05.2008 2th modification of 05.01.2012 3th modification of 18.12.2012	Start of construction: 19.01.2004 First emplacement: 18.06.2007 At the end of 2014 16 casks were stored in the interim storage facility.
AVR cask storage facility in the FZJ Jülich NW	Storage of spent AVR fuel elements in transport and storage casks from 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 1th modification of 27.04.1995 2th modification of 07.07.2005	Since 2009, 152 ot the CASTOR® THTR/AVR type have been stored in the interim storage facility.
On-site interim storage facility Krümmel (near Geesthacht), SH	Storage of spent fuel elements from the Krümmel NPP	775 Mg heavy metal in up to 80 transport and storage casks with an activity up to $9.6 \cdot 10^{19}$ Bq and 3.0 MW heat release	According to § 6 AtG of 19.12.2003 1th modification of 16.11.2005 Order for immediate enforcement of 28.04.2006 2th modification of 17.10.2007 3th modification of 09.07.2014	Start of construction: 23.04.2004 First emplacement: 14.11.2006 At the end of 2014 19 casks were stored in the interim storage facility.
On-site interim storage facility Brokdorf SH	Storage of spent fuel elements from the Brokdorf NPP	1,000 Mg heavy metal in up to 100 transport and storage casks with an activity up to $5.5 \cdot 10^{19}$ Bq and 3.75 MW heat release	According to § 6 AtG of 28.11.2003 1th modification of 24.05.2007 2th modification of 19.07.2012 3th modification of 29.08.2012	Start of construction: 05.04.2004 First emplacement: 05.03.2007 At the end of 2014 26 casks were stored in the interim storage facility.

Name of the facility and site	Purpose of the facility	Capacity according to the licence	Licence	Notes
On-site interim storage facility Brunsbüttel SH	Storage of spent fuel elements from the Brunsbüttel NPP	450 Mg heavy metal in up to 80 transport and storage casks with an activity up to $6.0 \cdot 10^{19}$ Bq and 2.0 MW heat release	According to § 6 AtG of 28.11.2003 Order for immediate enforcement of 28.10.2005 1th modification of 14.03.2008 2th modification of 21.07.2014	Start of construction: 07.10.2003 First emplacement: 05.02.2006 At the end of 2014 9 casks were stored in the interim storage facility.

Table III.6: External waste interim storage facilities

Name of the facility and site	Purpose of the facility	Capacity according to the licence	Licence	Notes
Hauptabteilung Dekontaminationsbetriebe (HDB) **Karlsruhe** **BW**	Interim storage of waste with negligible heat generation from FZK, WAK, ITU, federal state collecting facility of BW and restricted used or for buffering used by third parties	Handling (conditioning and interim storage) with radioactive residual material and fuel contained waste up to a total activity of $4.5 \cdot 10^{17}$ Bq	Licence for use and manipulation according to § 9 AtG of 25.11.1983, replaced by licence according to § 9 AtG of 29.06.2009	In operation since December 1964.
Interim storage facility 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 iron casks)	Licences for use and manipulation according to § 3 StrlSchV of 07.07.1982	In operation since July 1987.
On-site interim storage facility **Biblis** **HE**	Interim storage of other radioactive substances in the scope of a combined utilisation of the on-site interim storage facility	Up to a total activity of $1 \cdot 10^{17}$ Bq	Licence for use and manipulation according to § 7 StrlSchV of 13.12.2006	In operation since June 2008.
NCS interim storage facility **Hanau** **HE**	Interim storage of waste with negligible heat generation mainly produced by the nuclear industry	1.) 1,250 Konrad containers (KC) and 2.) 800 m^2 utility space	Licence for use and manipulation according to § 7 StrlSchV of 11.06.2002 Licence for use and manipulation according to § 3 StrlSchV of 02.04.1982	1.) In operation since October 2002. 2.) In operation since1982.
Interim storage North (ZLN) **Rubenow** **MV**	Interim storage of operational and decommissioning waste of the Greifswald and Rheinsberg NPPs with interim storage of dismantled large components	165,000 m^3	Licence for use and manipulation according to § 3 StrlSchV of 20.02.1998	In operation since March1998.

Name of the facility and site	Purpose of the facility	Capacity according to the licence	Licence	Notes
Waste storage facility Unterweser NI	Storage of waste with negligible heat generation from 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 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 drums, type III concrete casks, type I-II cast-iron casks, type I-IV casks with a total activity 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.
Waste storage facility Ahaus NW	Storage of radioactive waste from NPPs	Konrad packages, 20' containers and plant components, up to a total activity of $1 \cdot 10^{17}$ Bq (storage area I)	Licence for use and manipulation according to § 7 StrlSchV of 09.11.2009	In operation since July 2010.
Interim storage facility Rossendorf (ZLR) SN	Interim storage of operational and decommissioning waste of the research site	Total storage volume of 2,770 m³ (gross)	Licence for use and manipulation according to § 3 StrlSchV of 10.02.1999	In operation since February 1999.

Table III.7: Reprocessing plants

Name of the facility and site	Purpose of the facility	Capacity according to the 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/y	Operation WAK: 1th partial operation licence according to § 7 AtG of 02.01.1967 Decommissioning WAK: 1th decommissioning licence, March 1993 21th licence for decommissioning and dismantling (step 4) of 23.04.2010 for deregulation after end of vitrification 22th decommissioning licence according to § 7 AtG of 08.12.2010 for remote-handled dismounting of the HAWC storage casks in the HWL and in the LAVA 23th decommissioning licence of 14.12.2011 for dismounting of the LAVA high-active lab and the LAVA hot cells 24th decommissioning licence of 28.04.2014 to bring forward manual dismounting in the VEK Operation VEK 1th partial operation licence for the VEK of 20.12.2005 (inactive commissioning) 2th 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 approx. 200 Mg of nuclear fuels originating from test and power reactors were reprocessed. Decommissioning and dismantling with the objective of "Greenfield until 2023 have made progress. The major part of the equipment of the process building has been removed. A vitrification plant (VEK) for 60 m^3 HAWC was constructed and operated until November 2010. The HAWC was entirely vitrified, producing 140 vetrified waste block canisters (56 Mg) which were packed into 5 transport and storage casks of the CASTOR®HAW 20/28 type. Since February 2011, the CASTOR® casks have been stored in the Interim Storage North of the EWN GmbH. Thus essential prerequisites have been created for the dismantling of the VEK and the HAWC storage facilities.

Table III.8: Conditioning plants for fuel elements

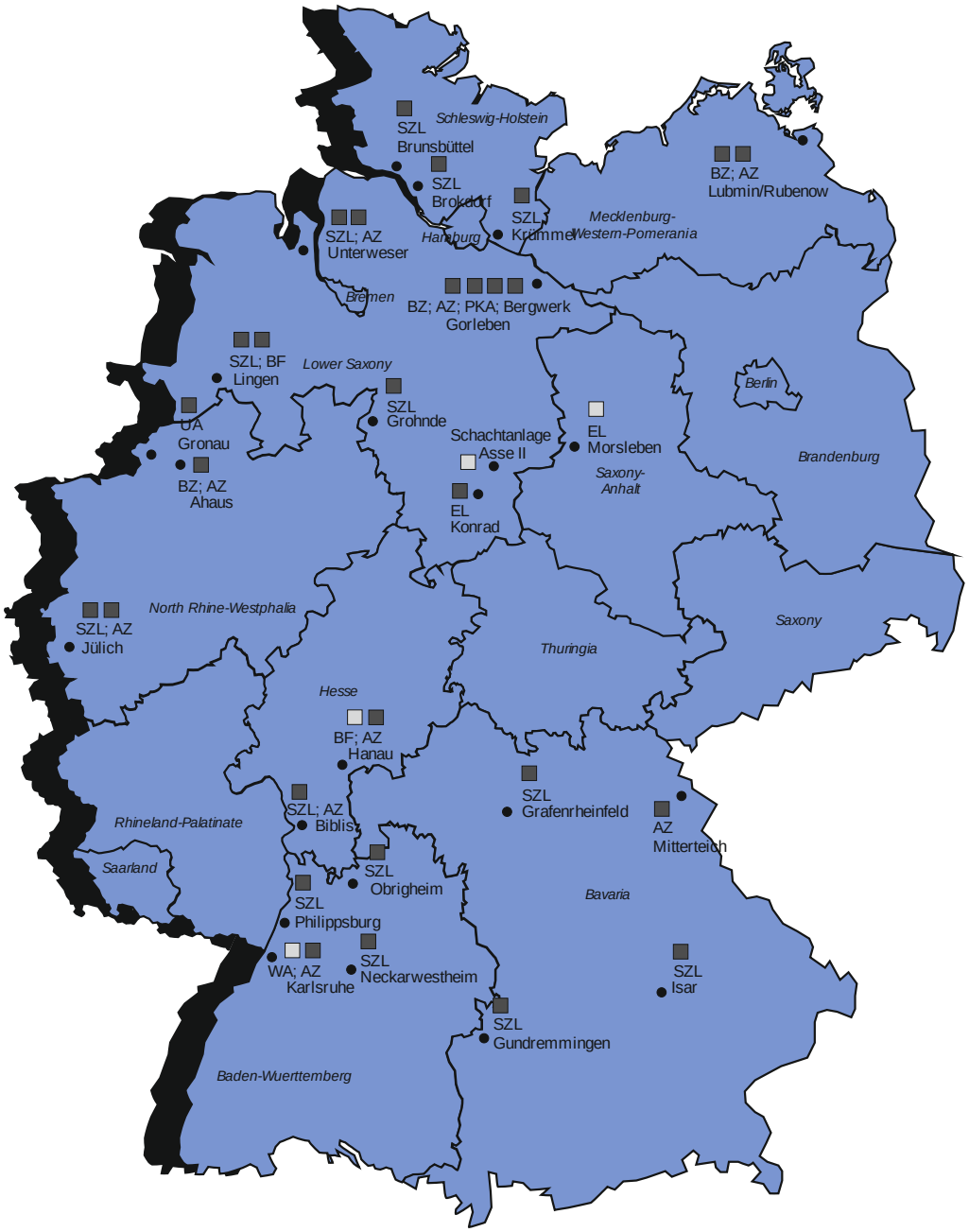
Name of the facility and site	Purpose of the facility	Capacity according to the licence	Licence	Notes
Pilot conditioning plant (PKA) Gorleben, NI	Repair of defective casks, conditioning of radioactive residues and waste (among others spent fuel elements, fuel rods and fuel element mounting parts) for interim storage and disposal	Heavy metal throutput applied for: 35 Mg/y Capacity of operational buffer storage facility: 12 Mg HM	Acc. to § 7 AtG: 1st partial licence of 30.01.1990 2nd partial licence of 21.07.1994 (Subsequently imposed of 18.12.2001) 3rd partial licence of 19.12.2000 (includes operation licence)	According to the 3rd partial licence the use of the plant is restricted to repairing 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 and decommissioning projects

Name of the facility and site	Purpose of the facility	Amounts disposed of / activity	Licence	Notes
Gorleben mine Gorleben, NI	Proof that the site is suitable for hosting a repository for all types of radioactive waste		The application for plan-approval according to § 9b AtG was filed in 1977. The mine is kept operable on the basis of the approved main operating plan according to § 52 BBergG for operating of the Gorleben mine in the period of validity from 01.10.2014 to 30.09.2016 (main operating plan: keeping the operational state).	The geological host rock formation is rock salt. The mining exploration of the Gorleben salt dome was officially terminated when the StandAG entered into force (cf. Chapter 4.7.1.).
Konrad repository Salzgitter, NI	Disposal of radioactive waste with negligible heat generation		Application according to § 9b AtG in 1982 (plan-approval application) Withdrawal of the application for immediate enforcement with BfS letter of 17.07.2000. 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 admitted or have not been accepted for decision. On 15.01.2008 the competent mining authority approved the main operating plan.	The geological host rock formation is coral oolite (iron ore) underneath an impermeable barrier of the Cretaceous.

Name of the facility and site	Purpose of the facility	Amounts disposed of / activity	Licence	Notes
ASSE II mine Remlingen, NI	Research and development work for the disposal of radioactive and chimico-toxic waste, disposal of low-level and intermediate-level waste	Between 1967 and 1978 approx. 124,500 LAW- and approx. 1,300 MAW-waste packages were emplaced. According to current knowledge $2.89 \cdot 10^{15}$ Bq (01.01.2010), 20 % of which are contained in the MAW packages	Licence according to § 3 StrlSchV as amended on 15.10.1965. Storage licences for nuclear fuels according to § 6 AtG. Licence according to § 7 StrlSchV granted on 08.07.2010 for the handling of other radioactive substances outside the emplacement chambers up to the 100-fold of the exemption limit. Licence according to § 9 AtG for the use and manipulation of nuclear fuels and other radioactive materials in the scope of the fact-finding procedure step 1 of 21.04.2011. Additional licence according to § 7 StrlSchV of 20.09.2011 for use and manipulation of sealed and unsealed radioactive materials (radiation protection lab).	The geological host rock formation is rock salt. Since 01.01.2009 the BfS has been the operator of the Asse II mine. Conversion into operation according to AtG. Since the „LEX Asse“ became effective in April 2013, the radioactive waste is to be retrieved before the ASSE II mine will be decommissioned as long as this is not safety-relevant.

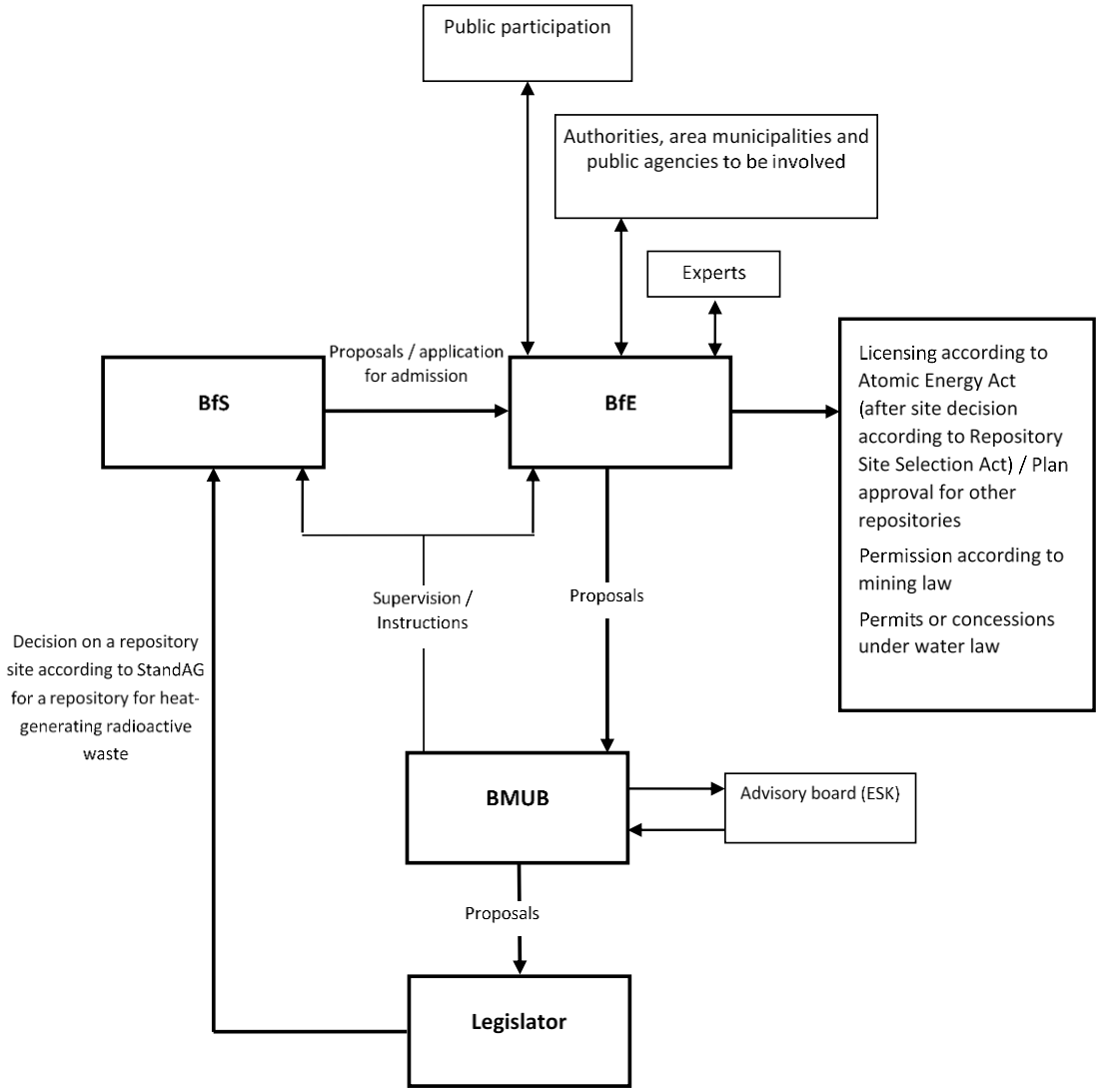
Name of the facility and site	Purpose of the facility	Amounts disposed of / activity	Licence	Notes
Morsleben repository for radioactive waste (ERAM) **ST**	Disposal of low-level and medium-level radioactive waste with mainly shortlived radionuclides	Disposal of altogether 36,753 m^3 of low-level and intermediate-level radioactive waste, total activity of all radioactive waste stored is in the order of magnitude of $1 \cdot 10^{14}$ Bq, the activity of the alpha-emitters is in the order of magnitude of 10^{11} Bq (appointed date: 31.12.2013). Furthermore, waste with an activity of $1.8 \cdot 10^{14}$ Bq has been stored intermediately (appointed date: 31.12.2013).	22.04.1986 Permanent operating licence. According to § 57a AtG it continued to be effective until 30.06.2005; through amendment to the AtG in 2002 the permanent operating licence 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 the BfS to waive the acceptance of further radioactive waste for disposal.	The geology of the emplacement areas is determined by potash and rock salt formations. On 25.09.1998 emplacement operation was stopped. Conversion and keeping the mine operable were applied for on 10.07.2003. Since 11.06.2014 the procedure has been suspended. Decommissioning was applied for on 09.05.1997. Following the public hearing in October 2012, the MLU examines the objections in terms of their relevance to the plan-approval decision. The ESK recommendation of 31.01.2013 on the state of the art of science and technology in the long-term safety assessment is available.



Legend:

AZ	Rad. waste interim storage facility	SZL	On-site interim storage facility
BF	Fuel element fabrication plant	UA	Uranium enrichment plant
BZ	Central interim storage facility	WA	Reprocessing plant
EL	Radioactive waste repositiory		
PKA	Pilot conditioning plant	■	In operation/ being planned
As of 31 December 2014		□	Under decommissioning

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



Legend:

BMUB Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

BfS Federal Office for Radiation Protection

BfE Federal Office for the Regulation of Nuclear Waste Management

ESK Nuclear Waste Management Commission

Figure III.2: Approval procedures for repositories for radioactive waste according to § 9b AtG

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