State and Development of Nuclear Power Utilization in the Federal Republic of Germany 2013

Department of Nuclear Safety

Ines Bredberg

Johann Hutter

Kerstin Kühn

Katarzyna Niedzwiedz

Frank Philippczyk

Julia Dose

Bundesamt für Strahlenschutz

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SUMMARY

This report describes the use of nuclear energy in the Federal Republic of Germany as of 31 December 2013. It contains the essential data of all nuclear power plants, research reactors and the facilities of the nuclear fuel cycle. At the reporting moment 31st of December in 2013, nine nuclear power plants were still in operation. The power generation from nuclear energy in 2013 amounted to 97.3 TWh (2012: 99.5 TWh). It is a share of 15.4 % of the total gross electricity production (2012: 15.8 %).[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 of the licensing and operation history and the present state of the operating condition is given. For the facilities of the nuclear fuel cycle data on purpose and capacity, the licensing history and the present state of operation and licensing are given. The current status of repository projects (ERAM and Konrad), Asse mine and the Gorleben site is presented. To give a survey, the data is summarised in tabular form in the report Annexes. The report will be updated and published once a year.

Due to the government reshuffle and the changed portfolio of some federal ministries, the former Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) was renamed to Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) on 17 December 2013.

[1] Primilary estimated values as of February 2014, source BDEW

LIST OF ABBREVIATIONS

ADIBKA	Burn-up measurement of differential fuel elements with critical assembly
AGEB	Energy Balances Working Group
AGO	Comparison of Options Working Group
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
BB	Brandenburg
BBergG	Federal Mining Law
BDEW	German Association of Energy and Water Industries 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 December 2013)
BMUB	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (previously BMU)
BNFL	British Nuclear Fuels Ltd.
Bq	Becquerel
BVerfG	Federal Constitutional Court
BVerwG	Federal Administrative Court
BW	Baden-Wurttemberg
BWE	German Wind Energy Association
BWR	Boiling water reactor
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	Centrales Interim Storage Facility for Spent Fuel Elements in Sweden
COGEMA	Compagnie Générale des Matières Nucléaires, AREVA-Group
CSD-C	High-pressure Compacted Radioactive Waste
DBE	German Company for the Construction and Operation of Waste Repositories
DBG	Permanent operating licence
DIDO	Heavy-water moderated and cooled research reactor at Jülich Forschungszentrum (FZJ)
DKFZ	German Cancer Research Center
DWK	German Company for the Reprocessing of Nuclear Fuels
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	Energieversorgungsunternehmen, 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 1
FRG-1	Research Reactor Geesthacht Unit 1
FRG-2	Research Reactor Geesthacht Unit 1

FRH	Research Reactor of the Hannover Medical School
FRJ-1	Research Reactor Jülich Unit 1
FRJ-2	Research Reactor Jülich Unit 2
FRM	Research Reactor Munich
FRM-II	Research Reactor Munich, high-flux neutron source
FRMZ	TRIGA Mark II Research Reactor of the Mainz University
FRN	Research Reactor Neuherberg
FZJ	Jülich Forschungszentrum
FZK	Karlsruhe Research Center
GDR	German Democratic Republic
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 - Centre for Materials and Coastal Research 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
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
HZB	Helmholtz-Zentrum Berlin für Materialien und Energie
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, Department Kraftwerk-Union
KWW	Würgassen NPP
LAVA	Facility for the Storage 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 Forschungszentrum (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
MWh	Megawatt hour
MW_{th}	Megawatt thermal power
MZFR	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	Physikalisch-Technische Bundesanstalt
PuO_2	Plutonium dioxide
PWR	Pressurised Water Reactor
RAKE	Rossendorf assembly for critical experiments
RDB	Reactor pressure vessel
RFR	Research Reactor Rossendorf
RP	Rhineland-Palatinate
RRR	Rossendorf ring zone reactor
RRRFR	Russian Research Reactor Fuel Return
RSK	Reactor Safety Commission
RWE	Rheinisch-Westfälische Elektrizitätsgesellschaft
SAAS	Federal Office for Nuclear Safety and Radiation Protection (of the former GDR)
SAR	Siemens Argonaut Reactor
SE	Safe enclosure
SG	Decommissioning licence
SH	Schleswig-Holstein
SL	Saarland
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
SSR	Großwelzheim, Superheated Steam Reactor
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
SZL	On-site Interim Storage Facility
TBG	Partial operating licence
TBL-A	Ahaus Transport Cask Storage Facility

TBL-G	Gorleben Transport Cask Storage Facility
TEG	Partial construction licence
TG	Partial licence
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
VEK	Karlsruhe Vitrification Facility
VGB	Technische Vereinigung der Großkraftwerksbetreiber (e.V.)
VKTA	Verein für Kernverfahrenstechnik und Analytik Rossendorf (e.V.)
VSG	Preliminary Safety Analysis for the Gorleben site
WAK	Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH
WAW	Wackersdorf Reprocessing Plant
WTI	Wissenschaftlich-Technische Ingenieurberatung GmbH
WWER	Water-cooled water-moderated energy reactor (Russian type PWR)
WWR-S (M)	Water-cooled water-moderated reactor of the Russian type, S stands for serial production and M for modification (RFR: Modifications to core and fuel)
ZLN	Interim Storage Facility North Rubenow

1 ELECTRICITY PRODUCTION FROM NUCLEAR ENERGY IN GERMANY

1.1 GENERAL

In the Federal Republic of Germany, altogether approximately 633.6 TWh (2012: ca. 629.9 TWh) of electric energy were produced in 2013 (gross electricity production including electricity transfers; source: BDEW). The total gross electricity production in Germany increased compared with the preceding year (cf. Table 1). There were increases in the field of power generation from coal, due to the construction of new coal–fired power stations, and the further expansion of renewables. Power generation from nuclear energy decreased to 97.3 TWh (2012: around 99.5 TWh). More information on the topic is included in Chapter 1.2 “Phase-out of electricity production from nuclear energy”.

Table 1. 1: Share of energy sources in the total gross electricity production in % inclusive supplies

***	2011		2012		2013*	
	TWh	%	TWh	%	TWh	%
Nuclear energy	108.0	17.7	99.5	15.8	97.3	15.4
Lignite	150.1	24.7	160.7	25.5	162.0	25.6
Hard coal	112.4	18.5	116.4	18.5	124.0	19.6
Mineral oil	6.8	1.1	7.6	1.2	6.4	1.0
Natural gas	82.5	13.5	76.4	12.1	66.8	10.5
Renewables	123.5	20.3	143.6	22.8	151.7	23.9
Others (total)**	25.6	4.2	25.7	4.1	25.4	4.0
TOTAL	608.9	100.0	629.9	100.0	633.6	100.0

* All figures relating to the years 2013 are preliminary, partly estimations
** The category “Other” energies has not been specified in the BDEW data. The category “Renewables” is described in more detail in a sub-chapter on page 11 in Table 1.2.
***all values are rounded
[Sources: BDEW, as of March 2014, AGEB]

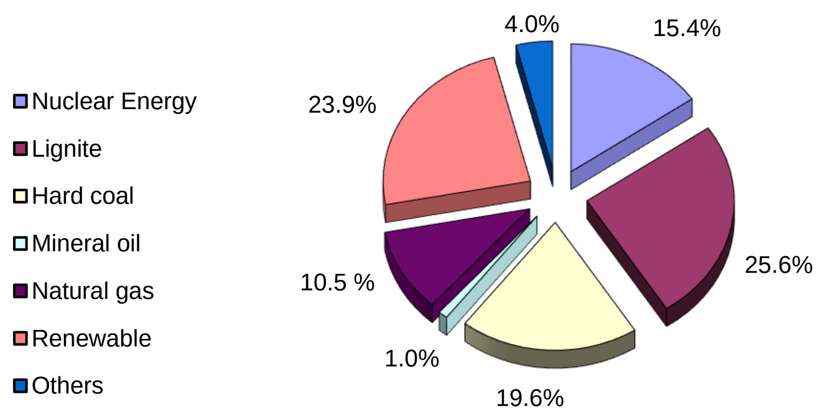

Fig. 1: Share of energy sources in the total gross electricity production (basis: 633.6 TWh)

The overall gross electricity production of the general electricity supply (i.e. without companies producing electricity or heat for self supply) amounted to 590.0 TWh in 2013 (568.4 TWh in 2012). The share of nuclear power plants in 2013 was 16.5 % (2012: 17.5 %) [source: BDEW].

Renewable sources of energy

The increased utilisation of renewables is a component of the German climate protection strategy. This is stipulated by the Renewable-Energy Law (Erneuerbare-Energien-Gesetz, EEG) of 25 October 2008 (BGBl I p. 2074), last amended in 2012 by the “Law concerning the Change of the Legal Framework for Electricity from Solar Radiation Energy and Further Changes in the Renewable Energies Law”, so-called “PV Amendment”. The Federal Cabinet deciced on 22 January 2014 the basic points of a basic EEG reform bill submitted by Federal Minister Gabriel. Accordingly, the share of renewables in power supply is to be increased to minimum 40 to 45 % until the year 2025 and to 55 to 60 % until the year 2035. The EEG amendment shall be passed in spring 2014 and become effective from 1 August 2014.

In 2013, the percentage of renewables in the gross electricity production was approximately 23.9 % according to BDEW (2012: 22.8%).

Today, wind energy, water power (renewable share, i.e. without pump storage plants), solar energy and biomass energy are the most essential renewables. Altogether, renewables produced ca. 151.7 TWh in 2013 (2012: 143.6 TWh).

In the area of solar energy, the German Solar Industry Association stated that in 2013 the development of photovoltaics was the weakest since 2008. The reason for this is the decreased demand because of the cuts in the promotion of solar power. Despite the reduced building of photovoltaics systems, its contribution to power generation from renewables has increased compared with the previous year. The expansion in the area of wind turbines continues to progress. The German Wind Energy Association says there has been a stable upwards trend in onshore wind turbines. In 2013, 48 offshore wind turbines were connected to the grid with an installed capacity of 240 MW. Further expansion of the offshore wind turbines is expected for 2014.

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

****	**2011**		**2012**		**2013***	
	TWh	%	TWh	%	TWh	%
Water**	17.7	2.9	21.8	3.5	20.5	3.2
Wind	48.9	8.0	50.7	8.0	53.4	8.4
Photovoltaic systems	19.3	3.2	26.4	4.2	30.0	4.7
Biomass	32.8	5.4	39.7	6.3	42.6	6.7
Refuse**	4.8	0.8	5.0	0.8	5.2	0.8
Geothermal energy	0.02	***	0.03	***	0.04	***
TOTAL	123.5	20.3	143.6	22.8	151.7	23.9

* All figures relating to the years 2013 are preliminary, partly estimations
** Only the regenerative share is taken into account.
*** The share is very small and is not stated here
***all values are rounded
[Sources: BDEW March 2014, AGEB]

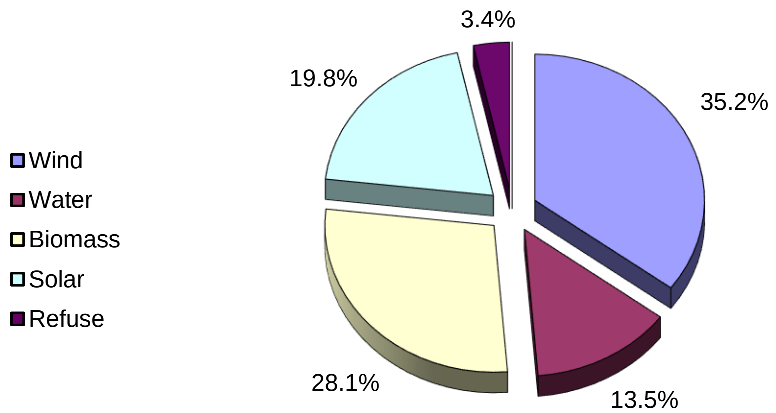

Fig. 2: Share of individual renewable energy sources in total power generation from renewable energies in 2013 (basis: 151.7 TWh)

1.2 PHASE-OUT OF ELECTRICITY PRODUCTION FROM NUCLEAR ENERGY

Using nuclear energy for commercial power generation is limited – in stages – until the end of 2022 in Germany.

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.

1.2.1 Consequences of the reactor accident in Fukushima

As a result of the reactor accident in the Fukushima Daiichi Nuclear Power Plant, Japan, of 11 March 2011, the Federal Government decided in a Moratorium on 14 March 2011 to take all German nuclear power plants (NPPs) 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 NPPs still in operation the Reactor Safety Commission (RSK) conducted a safety check. In Germany, the results and the cross-social dialogue with the participation of the Ethics Commission "Secure Supply of Energy" have led to a re-evaluation of the risks associated with the use of nuclear energy. The Federal Government decided to end the use of nuclear energy for commercial power generation in Germany.

1.2.2 Current nuclear legislation

The 13th Law amending the Atomic Energy Act of 31 July 2011 specifies that the last nuclear power plants in Germany will be shut down at the end of 2022. At the same time as the nuclear legislation was updated, also the regulatory guidelines were adapted to scientific and technological progress. In November 2012, the Federal Environment Ministry and the federal states agreed upon new safety requirements for the operation of nuclear power plants (Safety Requirements for Nuclear Power Plants). These nuclear rules and regulations contain basic rules and general safety-related requirements. As from the above date, the new nuclear rules and regulations have been applied and taken as a basis in the execution of supervision and in pending procedures. The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB, previously BMU) provides more information on this topic on its website which can be accessed at: http://www.bmub.bund.de/N49442/ (in German only).

Dates for shutting down

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

No nuclear power plant as reserve

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

The Federal Network Agency stated that one could do without using a reserve NPP, even in the event of exceptional incidents occurring, because additional conventional power plant reserves are available. Therefore, the Federal Network Agency decided on 31 August 2011 that none of the nuclear power plants shut down on 6 August 2011 will be required to constitute a reserve to guarantee electricity supply.

1.2.3 Electricity volumes generated by nuclear power plants in Germany

As early as in June 2001 the Federal Government and the utilities agreed upon a specific 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 the operating times by eight years of those nuclear power plants that had taken up power operation until and including 1980 or, respectively, to extend the operating times of the younger nuclear power plants by 14 years. Correspondingly, the Atomic Energy Act as amended in December 2010 allocated additional electricity volumes to individual nuclear power plants. In the wake of the reactor accident in Fukushima Daiichi, Japan, the Federal Government decided – as already mentioned - 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.

With the Amendment to the Atomic Energy Act in August 2011 a concrete shutdown date was set by law for each single nuclear power plant. Furthermore, the Atomic Energy Act specifies in Column 2 of Annex 3 to § 7 para. 1a the electricity volumes (previously referred to as residual electricity volumes) that can still be produced with the reference date 1 January 2000. Once they have been produced, the authorisation for operating the NPP will expire. According to the Atomic Energy Act the transfer of electricity volumes from one NPP to another is optional. They may be transferred in part or as a whole from one – usually older and smaller – NPP to another. The transfer of the remaining electricity volumes of shut downed nuclear power plants 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 NPP is subject to the approval of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (today: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety - BMUB), in agreement with the Federal Chancellery and the Ministry of Economics and Technology (today: Federal Ministry for Economic Affairs and Energy). From the Federal Environment Ministry's point of view, it is necessary in this case to compare the safety level of both NPPs involved in the transfer. Transfers of electricity volumes must be reported to the Federal Office for Radiation Protection and are taken into account when registering the electricity volumes.

In January 2011, the Neckarwestheim NPP unit 1 (GKN 1) had exhausted its electricity volume listed in Column 2 of Annex 3 to § 7 para. 1a Atomic Energy Act in the version that was effective at that point in time. Since then the plant was operated with the additional electricity volumes according to the Atomic Energy Act as of December 2010. GKN 1 was previously shut down in the scope of the Federal Government's Moratorium of 14 March 2011 and the shutdown was established by being integrated into Atomic Energy Act of 6 August 2011.

Tasks of the Federal Office for Radiation Protection (BfS)

The Federal Office for Radiation Protection registers and documents the net electricity volumes produced in any German nuclear power plants and the electricity volumes remaining according to the Atomic Energy Act. The utilities measure the generated electricity volumes and report this data monthly to the BfS since May 2002. They also arrange an annual inspection of the measuring devices by independent expert organisations and and for each year the communicated electricity volumes are certified by an independent auditing company. The functional inspection reports and the certificates by the public accountant are submitted to the BfS.

Publication of electricity volumes

Since 10 July 2002 the produced, transferred and remaining electricity volumes according to Atomic Energy Act have been published by the BfS in the Bundesanzeiger (Federal Gazette). Normally the figures are published annually. There is an exeption if the expected operating time is less than six months. Then the figures are published monthly. Table 1.3 shows the status of electricity volumes as of 31 December 2013, published in the Bundesanzeiger as annual statement 2013 on 13 May 2014.

Table 1.3: Generated, transferred and remaining electricity volumes (net) of German nuclear power plants (annual statement, Bundesanzeiger: 13 May 2014)

Announcement according to § 7 para. 1c Atomic Energy Act (AtG) – annual statement 2013 -

Electricity volumes produced, transferred and remaining during the period from 1 January 2000 to 31 December 2013 [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 2010	Total 2011	Total 2012	Total 2013	Electricity volumes transferred until 31 December 2013	Remaining electricity volume
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Biblis A[1) 4)]	62,000.00	62,480.01	2,111.28	0.00	0.00	4,785.53	2,194.24
Neckarwestheim 1[4)]	57,350.00	57,161.34	188.66	0.00	0.00		0.00
Biblis B[3) 4)]	81,460.00	80,098.53	1,638.99	0.00	0.00	8,100.00	7,822.48
Brunsbüttel[4)]	47,670.00	36,670.33	0.00	0.00	0.00		10,999.67
Isar 1[4)]	78,350.00	74,764.78	1,561.10	0.00	0.00		2,024.12
Unterweser[4)]	117,980.00	104,407.80	2,369.34	0.00	0.00		11,202.86
Philippsburg 1[2) 4)]	87,140.00	71,770.58	1,415.29	0.00	0.00	-5,499.89	8,454.24
Grafenrheinfeld	150,030.00	108,145.15	8,532.31	9,996.43	9,664.79		13,691.32
Krümmel[4)]	158,220.00	69,974.89	0.00	0.00	0.00		88,245.11
Gundremmingen B	160,920.00	110,691.31	10,320.08	9,862.66	9,647.36		20,398.59
Philippsburg 2	198,610.00	118,105.15	10,727.21	10,227.82	8,714.52		50,835.30
Grohnde	200,900.00	119,253.76	9,603.19	11,048.99	10,420.06		50,574.00
Gundremmingen C	168,350.00	109,833.22	9,454.97	10,099.09	10,015.72		28,947.00
Brokdorf	217,880.00	123,790.73	9,701.26	10,246.91	11,146.17		62,994.93
Isar 2	231,210.00	126,384.83	11,655.84	11,438.20	11,402.05		70,329.08
Emsland	230,070.00	120,969.57	10,971.12	10,847.68	10,912.11		76,369.52
Neckarwestheim 2	236,040.00	115,488.15	10,807.79	10,426.52	10,218.74		89,098.80
Total	**2,484,180.00**	**1,609,990,13**	**101,058.43**	**94,194.30**	**92,141.52**		**594,181.26**
Stade[1)]	23,180.00	18,394.47				-4,785.53	0.00
Obrigheim[2)]	8,700.00	14,199.89				5,499.89	0.00
Mülheim-Kärlich[3)]	107,250.00					-8,100.00	99,150.00
Sum total	**2,623,310.00**						**693,331.26**

The data in column 6 "Total 2013" contains the values examined by certified accountants according to § 7 para. 1a AtG.

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

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

3) With letter of 30 June 2010 PNN/Dr.Pa the RWE Power AG reported the transfer of 8,100 GWh of the electricity volume allocated to the decommissioned plant Mülheim-Kärlich (KMK) to the Biblis B plant (KWB B) according to § 7 para. 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 and Philippsburg 1 are no longer authorised for power 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).

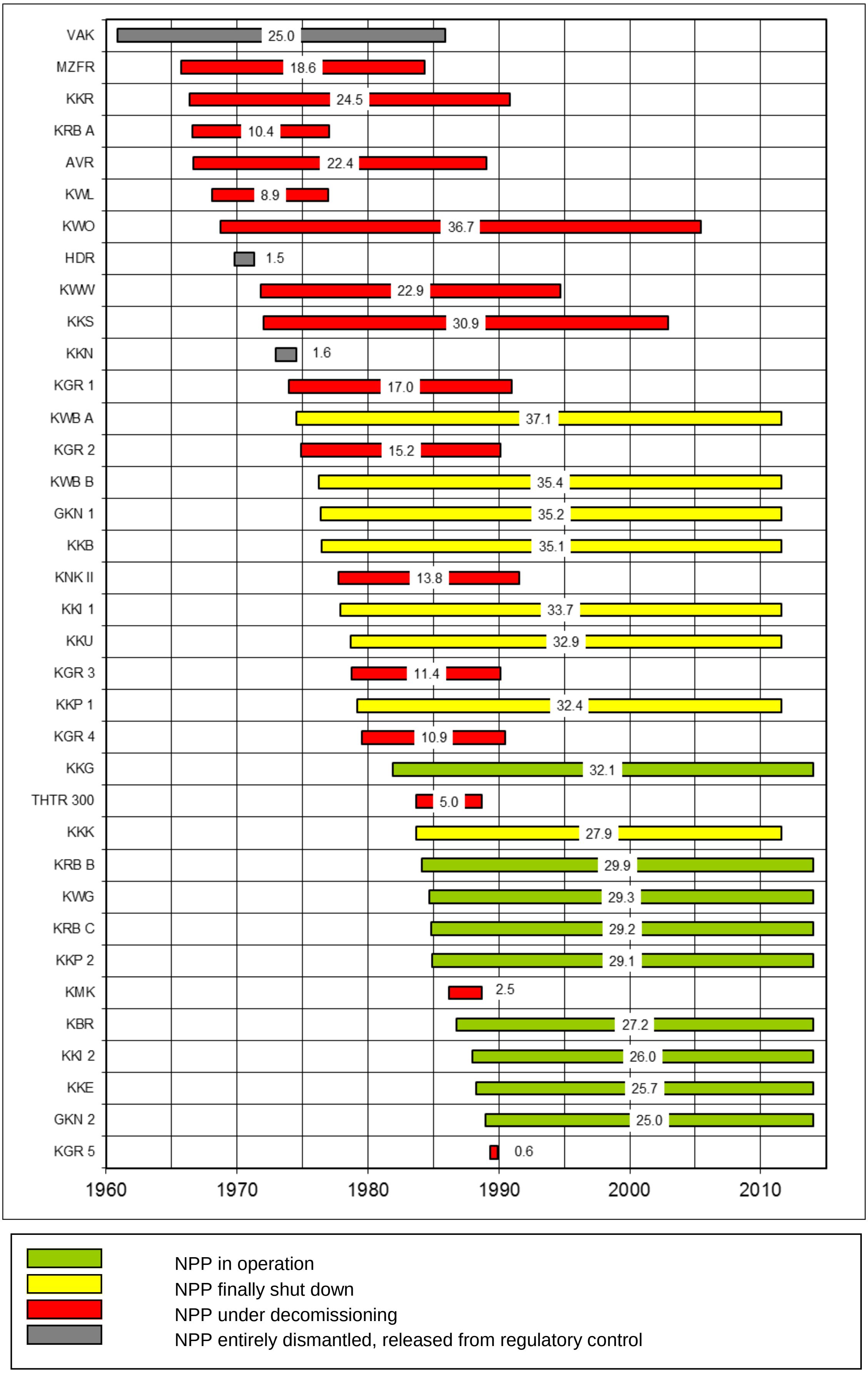

Fig. 3: Nuclear power plant operating times in Germany, given in years since first criticality, as of 31 December 2013

2 NUCLEAR POWER PLANTS IN GERMANY

As of 31 December 2013, 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 2013

Status	**PWR**		**BWR**		**Others**			
	Number	**MW_e (gross)**	**Number**	**MW_e (gross)**	**Number**	**MW_e (gross)**	**Number**	**MW_e (gross)**
In operation	7	10,008	2	2,688	—	—	9	12,696
Finally shut down	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 are described in chapters 2.1 to 2.5 and in the corresponding tables contained in Annex I.

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

2.1 NUCLEAR POWER PLANTS IN OPERATION

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

2.1.1 Availabilities and reportable events

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

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

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

Year	Time availability* [%]	Energy availability* [%]	Capacity availability* [%]	Number of reportable events
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
2004	89.8	89.2	87.4	152

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

2.1.2 Plant and licensing status of the nuclear power plants

The following section gives a short description of each nuclear power plant in operation and provides information about the essential licences according to § 7 AtG in the year under report granted by the competent federal state authorities under nuclear law as shown in Table I.1 (Annex I). Also licensing procedures in progress are dealt with if they are of special relevance to the plant and licensing status. Furthermore, details on the capacity increases carried out so far are shown in Table 1.2.b in Annex I.

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

Neckarwestheim NPP Unit 2 (GKN 2)

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

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

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

Philippsburg NPP Unit 2 (KKP 2)

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

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

Isar NPP Unit 2 (KKI 2)

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

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

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

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

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

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

Kernkraftwerk Gundremmingen GmbH withdrew the application for increasing the thermal capacity to 4,000 MW_{th} each on 17 December 2013.

Grohnde NPP (KWG)

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

For the Grohnde plant an application for the use of uranium fuel elements with an initial enrichment of up to 4.4 % uranium 235 was filed in the past. This application was withdrawn on 25 June 2013. Furthermore, an application for the modification of the safety-related parameters “hold-down capacity” for the design and the operation of the reactor core are subject to the licensing procedure according to § 7 Atomic Energy Act.

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

Emsland NPP (KKE)

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

The operator withdrew the application for increasing the thermal reactor capacity to 3,950 MW_{th} on 15 February 2013.

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

Brokdorf NPP (KBR)

The Brokdorf NPP is a PWR of the 3rd generation (pre-Convoy). The plant was commissioned in 1986 with a capacity of 1,380 MW_e. The reactor output is currently 1,480 MW_e resulting from two thermal and several electrical capacity increases.

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

2.2 NUCLEAR POWER PLANTS FINALLY SHUT DOWN

In 2011, eight nuclear power plants finally shut down on the basis of the Amendment to the Atomic Energy Act which became effective on 6 August 2011 (cf. Chapter 1.2 and Table I.3 in Annex I).

Neckarwestheim NPP Unit 1 (GKN 1)

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

A primary circuit decontamination was carried out in the year under report. The 1st licence for decommissioning and dismantling was applied for on 24 April 2013.

Philippsburg NPP Unit 1 (KKP 1)

As 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, resulting from two electrical capacity increases. The authorisation for power operation expired with the Amendment to the Atomic Energy Act on 6 August 2011 (cf. Chapter 1.2). The KKP 1 is in the post-operational phase. Since the beginning of 2012 the fuel elements are in the fuel pond.

A primary circuit decontamination was carried out in the year under report.

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.

Isar NPP 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 been permanently shut down. The authorisation for power operation expired with the Amendment to the Atomic Energy Act on 6 August 2011 (cf. Chapter 1.2). The reactor core was entirely unloaded; the fuel elements are in the fuel 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 year under report, a scoping meeting was held on 16 April 2013 as part of the environmental impact assessment.

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

The plants Biblis A and B are among the eight nuclear power plants that had to finally cease power operation in 2011 on the basis of the Amendment to the Atomic Energy Act (cf. Chapter 1.2).

Biblis A with a PWR of the 2nd generation and was commissioned in 1974 with a capacity of 1,204 MW_e. The last valid 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 11 May 2010, 4.78 TWh were transferred from the decommissioned Stade NPP to the KWB A in the scope of the electricity volume transfers according to § 7 para. 1b AtG. An electricity volume of 8.1 TWh was transferred to the KWB B on 30 June 2010. The electricity volumes came from the decommissioned Mülheim-Kärlich nuclear power plant (KMK). This contingency was made use of until the plant was shut down in 2011 (cf. Table 1.3 in Chapter 1.2.3).

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.

The decontamination of the primary circuit for Unit A was interrupted following some findings at the primary coolant pump.

A scoping meeting was held on 22 January 2013 as part of the environmental impact assessment.

Unterweser NPP (KKU)

The Unterweser NPP was commissioned in 1978 with a capacity of 1,300 MW_e. It is a nuclear power plant with PWR of the 2nd generation. The last reactor output was 1,410 MW_e. Power operation ceased on 6 August 2011 with the 13th Amendment to the Atomic Energy Act (cf. Chapter 1.2). 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.

Decontamination of the primary circuit was carried out in 2012.

In the year under report, a scoping meeting was held on 25 June 2013 as part of the environmental impact assessment. An application pursuant to § 7 Radiation Protection Ordinance 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 federal state authority on 20 June 2013.

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 1.2). 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. In the year under report, a scoping meeting was held on 18 December 2013 as part of the environmental impact assessment.

Krümmel NPP (KKK)

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

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

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

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

2.3 NUCLEAR POWER PLANTS UNDER DECOMMISSIONING

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

Rheinsberg NPP (KKR)

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

The transport of the reactor pressure vessel to the Interim Storage Facility North was carried out on 30 October 2007. Thus the activity inventory in the plant has considerably decreased.

In 2013, further decommissioning and residual operational works were carried out. In the reactor building, radiological sampling of the cooling pond started with the objective to remove the core.

Work to convert the clearance facility were completed and calibration of the facility started. In the Active Storage Facility for solid and liquid radioactive waste half of the base tray inside the protective housing was removed and radiological sampling of the soil was completed.

The licence I/2013 pursuant to § 7 para. 3 AtG was granted on 4 September 2013. Among others, it comprises the production of openings for transport and emergency exit routes, removal of surface structures and the demolition of supply lines.

Karlsruhe Sodium-Cooled Reactor (KNK II)

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

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

Currently, measures are being carried out for the dismantling of the primary shielding in the context of the 9th decommissioning licence. A lifting tool which is to lift the primary shielding segments weighing up to 15.5 Mg was taken into the reactor building and positioned in an extension to the housing located above the reactor shaft. Furthermore the necessary machine technology was taken inside and installed. Following final examinations and the elimination of malfunctions, one can start dismantling the segments.

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

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

Karlsruhe Multi-Purpose Research Reactor (MZFR)

The Karlsruhe Multi-Purpose Reactor with a 57-MW_e heavy-water cooled pressure vessel reactor was operated from 1965 to 1984. Apart from electricity production, it also served the heat supply of the 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). Since then, dismantling has been carried out separately in several steps, each of them requiring nuclear licensing (partial decommissioning licences).

With the 8th decommissioning licence of 31 January 2007 the dismantling of the activated part of the biological shield, the dismantling of all systems and equipment, the decontamination and the dismantling of all building structures were approved. The remote-controlled dismantling of parts of the MZFR concluded with the dismantling of the activated concrete of the biological shield in 2011.

Demolition and decontamination of the collection tank building as well as the assembly and storage building are continuing but have made great progress. The fuel pool building was demolished in the year under report. Furthermore, the demolition of the reactor building was prepared.

Dismantling works will probably conclude in 2015.

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

Obrigheim NPP (KWO)

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

Dismantling is to be carried out in altogether three independent licensing steps and will take approximately 10 to 15 years. The nuclear fuel was removed from the core. The fuel elements that had still been in the internal fuel pool were brought into the external wet storage facility in the emergency building. Since March 2007, all fuel elements have been removed from the internal fuel pool. 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 1st decommissioning and dismantling licence (SG) to finally and permanently shut down operation was granted on 28 August 2008. After two steam generators that had been dismantled and stored on the premises of the Obrigheim nuclear power plant were already taken to Lubmin on waterways in 2008, two further steam generators were taken to the Interim Storage Facility North (ZLN) in 2012, with the same objective of decontamination and disassembly. The 2nd licence for decommissioning and dismantling was granted on 24 October 2011. Among others, it regulates the dismantling of plant components and allocated auxiliary systems in the control area (such as reactor coolant system and steam generator) and the operating procedures for continuing decommissioning operations. Claims against the licence were filed on 27 December 2011 by four citizens. They were supported by the Aktionsbündnis Atom-Erbe Obrigheim. No decision has been taken so far. On 30 April 2013, the 3rd licence was granted for the dismantling of the lower part of the reactor pressure vessel (RDB), the reactor pressure vessel installations, the biological shield and single building components inside the reactor pressure vessel. The licence also comprises the demolition of plant components, the treatment of the accruing radioactive residues and the treatment of the accruing radioactive waste.

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 The facility's entire dismantling is carried out in three phases on the basis of the existing nuclear licences. Phase 1 comprises the machine building installations, phase 2 the contaminated systems of the reactor pressure vessel and phase 3 the activated components inside the reactor building such as reactor pressure vessel and biological shield. 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 dissection of the reactor pressure vessel has been completed; the same applies to the removal of the biological shield. The accruing radioactive waste was packaged into qualified waste packages and taken to the Mitterteich interim storage facility. The reactor building was decontaminated.

On 5 January 2006, the 13th nuclear modification licence was granted for using the technical building (excluding reactor building) in Unit A as technology centre. Decontamination and waste treatment works are carried out relating to Units KRB-II-B and KRB-II-C. Both units are 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).

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

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

On 10 August 2012, the 37th modification licence according to § 7 Atomic Energy Act was granted for the decommissioning of the entire plant and the 21st dismantling licence for the dismantling of plant components. Among others, they include the partial demolition of the underground connecting channel between the special buildings Nord I and Nord II.

In the year under report, the EWN filed a new application for a licence pursuant to § 7 para. 1 and 3 Atomic Energy Act for the modification of the licence for the decommissioning of the entire plant and for the dismantling or, respectively, demolition of the exhaust air chimney Nord I which is no longer needed and intended for other use.[2]

The dismantling of plant components of Units 1 to 6 is almost finished. About 85 % of the demolition of the plant parts of the control area including special buildings of Units 1 – 5 has been completed. Already 95 % of plant components of the monitored areas have been demolished.

Stade NPP (KKS)

The Stade NPP, a PWR with a capacity of 672 MW_e, was in operation from 1972 to 2003. The plant was finally shut down on 14 November 2003. With letter of 23 July 2001, the operator E.ON 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:

Phase one, which was licensed on 7 September 2005, describes the decommissioning, the dismantling phase 1 and the construction of the storage facility for radioactive waste (LarA).

Phase two, the second licence having been granted on 15 February 2006, regulates the dismantling of large components (steam generator) and the necessary modification of the lock. In September 2007, the steam generators were shipped to Studsvik Nuclear Dept. Radwaste AB, Sweden, for further waste management.

Phase three comprises two licensing steps. The first step (3A), comprises the dismantling of the reactor pressure vessel lid, reactor internals, the biological shield as well as other systems and components. The second step concerns the dismantling of the reactor pressure vessel. It was completed in 2010.

At last, phase four was authorised on 4 February 2011. It concerns the further dismantling of the plant and measures to clear buildings and ground surfaces. The clearance procedure is regulated with the notice of assessment according to § 29 Radiation Protection Ordinance of 24 June 2010.

Phase five comprises the conventional dismantling of buildings.

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[2] After editorial deadline: the notification to the 38th modification licence for the decommissioning of the entire plant and to the 22nd licence for the dismantling of plant components was granted on 28 February 2014.

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, building decontamination and building clearance measures and concept reviews for the 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. During the major plant revision, further damage became apparent, so that the licensing authority required additional comprehensive improvement measures before approving a new commissioning of the plant. However, costs were so high that the operator decided in March 1979 to decommission the nuclear part and to use the available steam turbine with a natural gas fired high-temperature gas turbine that had 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 with its 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.

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

In the nuclear licensing procedure the competent licensing authority, the Lower Saxon Ministry for the Environment, Energy and Climate Protection, initiated the participation of the public according to §§ 4 to 7 Nuclear Licensing Procedure Ordinance on 5 December 2012. The documents could be viewed from 13 December 2012 until 12 February 2013. Six objections were raised that were discussed with the objectors on 4 September 2013.

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 with ball-shaped graphite fuel elements (in which there were uranium and thorium containing coated particles). It was finally shut down at the end of 1988 when with the decommissioning of the prototype reactor THTR-300 (308 MWe) in Hamm-Uentrop the further development of this technology was no longer pursued in Germany either. When it was in operation, it 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 Forschungszentrum was completed in June 1998, leaving only maximum 197 pieces. Until the reactor containment has been dismounted it is impossible to recover the remaining ball-shaped fuel elements at reasonable cost and with sufficient radiation protection measures.

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. An application for complete dismantling according to § 7 para. 3 AtG was submitted to the responsible federal state authority on 25 February 2005 and revised with letter of 27 April 2006. The respective licence was granted on 31 March 2009. Subject matter of the notification are preparatory works to lift the reactor vessel, the lifting and putting down of the reactor vessel in the material lock and measures following the removal of the reactor vessel. It is intended to take the reactor vessel filled with pore lightweight concrete in November 2008 to an interim storage facility erected at the site. The licence for the operation of the interim storage facility was granted on 1 March 2010. The first modification licence to the licence of 31 March 2009 was granted on 18 January 2013. The modification licence provides for using a wheel-mounted Self-Propelled Modular Transporter (SPMT) and a transport and storage rack for transporting the reactor vessel.

Currently, preparatory works are carried out to build a transport opening in the biological shield to lift the reactor vessel.

Würgassen NPP (KWW)

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

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

In the year under report dismantling works for the NPP continued on the basis of the decommissioning licences granted. Dismantling has made good progress. Building surfaces are decontaminated in parts of the control area building. Clearance measurements are carried out on the outdoor area. Dismantling is expected to be completed in 2014. Two interim storage facilities for radioactive waste will remain, where solely low-level and intermediate-level radioactive waste from the dismantling and operation of the plant will be stored.

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.

The measures on safe enclosure continued to be carried out in the year under report.

Mülheim-Kärlich NPP (KMK)

The Mülheim-Kärlich NPP, a PWR with a capacity of 1.302 MW_e was commissioned in 1986. After the Federal Administrative Court had withdrawn the first partial licence it was shut down on 9 September 1988.

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

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

On 16 July 2004, the licence for dismantling phase 1a was granted. Thus the plant went into residual operation. For further dismantling, several auxiliary systems (among others exhaust air) can thus be adapted to the new requirements. The modification licence to licence 1a granted on 23 February 2006 permits the dismantling of all facilities in the controlled area that were shut down during phase 1a, if the proof of proper waste management covers the waste accruing in this process. With it all plant components no more required for residual operation can be dismantled. Exceptions to this are the primary coolant system, handling devices and the biological shield. In the year under report, further dismantling works and modifications in residual operation were carried out on the basis of this licence.

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

The licence for downsizing the plant premises was granted on 9 June 2009. This notification regulates the procedure for the release from regulatory control of buildings and the ground area of the eastern part of the plant premises. The application for reducing in size the plant premises around the western area filed on 27 November 2009 continues to be subject to the licensing procedure.

On 31 May 2013, the licence for dismantling phase 2a was granted. Subject of the licence is the removal of the primary coolant pumps and the pipelines of the main cooling system. The steam generators, which had originally been included in the measure applied for on 23 June 2010, were postponed to dismantling phase 2b with modification application of January 2012.

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 of the biological shield was filed on 12 August 2013.[3]

[3] After editorial deadline: On 31 January 2014 the licence acc.to § 7 para. 3 Atomic Energy Act was granted for a procedure to release part of the premises of the Mühlheim-Kärlich NPP from regulatory control in the scope of its dismantling (licence 3c).

2.4 NUCLEAR POWER PLANTS DECOMMISSIONED AND RELEASED FROM REGULATORY CONTROL

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

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

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

Kahl Experimental NPP (VAK)

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

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

2.5 STOPPED NUCLEAR POWER PLANT PROJECTS

Greifswald NPP (KGR) Units 6 to 8

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

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

Kalkar Sodium-cooled Fast Breeder Reactor (SNR 300)

The SNR 300 with a 327-MW_e sodium-cooled fast-breeder reactor was constructed 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 of 31 December 2013)

- 7 Research reactors are in operation
- 5 Research reactors are finally shut down
- 5 Research reactors are under decommissioning and
- 29 Research reactors have been decommissioned. They have been released from regulatory control.

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

3.1 RESEARCH REACTORS IN OPERATION

In the Federal Republic of Germany, altogether seven research reactors were in operation on 31 December 2013, among which there were three with a continuous thermal power above 50 kW_{th} and five training reactors with a thermal power of below 2 W. For one of the five training reactors an application for decommissioning and dismantling was filed in 2013. Accordingly, this reactor is described in the chapter “Research Reactors Finally Shut Down”.

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 about $2{\cdot}10^{14}$ 1/cm$^2{\cdot}$s. The reactor was commissioned on 9 December 1973 and mainly serves 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 around $2{\cdot}10^{14}$ 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.

In the year of operation 2013 the plant was in normal operation.

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

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

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

The reactor went critical for the first time on 3 March 2004. Following a comprehensive programme to commission the plant and after the regulatory authority had given its approval, routine operation of the plant was taken up on 25 April 2005.

On the basis of the operating licence of 2 May 2003 and an agreement between federal government and the Free State of Bavaria of 30 May 2003, it was originally intended to convert the reactor core from HEU to fuel with a reduced enrichment level of 50 % uranium 235 (MEU) at maximum by 31 December 2010 at latest. However, due to unexpected delays in the international technical-scientific development of new, high-density fuels, this requirement could not be complied with. The original agreement between the federal government and Bavaria of 30 May 2003 was amended on 22 October 2010. Now the plant needs to be converted by 31 December 2018 at the latest.

In the year of operation 2013 the plant was in normal operation. On 8 November 2013, a licence pursuant to § 9 AtG was granted for the handling of radioactive material in the Industrielles Anwenderzentrum (IZA) on the premises of the research neutron source Heinz Maier-Leibniz of Technische Universität München. Subject of the licence is the handling and storage of uranium molybdenum foils of enriched uranium (up to max. 50 % U-235) and the handling and storage of depleted uranium (up to 0.3 % U-235). Background is that a new fuel with a medium degree of enrichment instead of a high one is demanded to be developed. To solve the problem caused by enhanced C-14 emissions from the ion-exchange resins that had occurred in 2012, a CO_2 gas washer was installed in the mobile vacuum system used to dry the resin.

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 $4 \cdot 10^{12}$ $1/cm^2 \cdot s$. 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 $8 \cdot 10^{15}$ $1/cm^2 \cdot s$. 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/cm^3 have been achieved at the FRMZ.

In the year of operation 2013 the plant was in normal operation.

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 $3 \cdot 10^7$ $1/cm^2 \cdot s$. The AKR-2 was commissioned on 22 March 2005. It replaced the old AKR-1 plant that was operated at the TU 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 2013 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). An application for decommissioning and dismantling was filed for the fourth SUR plant, the training reactor in Hanover (SUR-H), on 22 October 2013. It is thus no longer among the plants that are in operation (cf. Chapter 3.2).

In the SUR plants, the reactor core consists of U_3O_8 with low uranium-235 enrichment (< 20 %) and with polyethylene as moderator. Both materials are pressed together in a homogeneous mixture into cylindrical fuel plates. The reactor core is surrounded by a graphite reflector on all sides. The SUR plants were mainly commissioned in the 60s and 70s in Germany. The thermal reactor capacity is 100 mW_{th} and the thermal neutron flux in the central experimental channel is generally at $5 \cdot 10^6$ $1/cm^2 \cdot s$. 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 2013 all SUR plants were in normal operation.

3.2 RESEARCH REACTORS FINALLY SHUT DOWN

As of 31 December 2013, five research reactors were included in the heading “Finally shut down”. No decommissioning licence has been granted so far for these reactors.

Research Reactor Munich (FRM)

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

In 1957, the plant was commissioned with LEU and a thermal power of 1 MW_{th}. However, already in 1960 it was changed over to using HEU. In the years of operation the thermal neutron flux was gradually increased from originally $1 \cdot 10^{13}$ $1/cm^2 \cdot s$ 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 (operation licences of 27 October 1966 and 10 May 1968); additionally, a beryllium reflector was installed in 1982. Since 1991, the core has been operated as mixed core and gradually changed over from HEU to MEU.

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

On 22 September 2010 the authority competent for listed buildings permitted the intended dismantling of the installations in the reactor building. The listed historic features are protected correspondingly.

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 $1.4 \cdot 10^{14}$ $1/cm^2 \cdot s$. 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 beam pipe experiments and isotope production and to carry out neutron activation analyses.

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

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

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-operational phase. 45 MTR fuel elements were taken to the USA on 10 August 2010. Since the end of July 2012, there is no more nuclear fuel in the reactor. The last 25 fuel elements that had remained in the plant were transported with a special ship 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.

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

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 about $2 \cdot 10^{14}$ $1/cm^2 \cdot s$. 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 at first stored intermediately in the joint fuel pool and shipped to the USA by 20 September 2000.

On 21 March 2013, decommissioning and dismantling of the FRG 1 and the research reactor facility (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 facility 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 and a thermal neutron flux of $6 \cdot 10^6$ 1/cm$^2 \cdot$s at 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 through 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 about $6 \cdot 10^6$ 1/cm^{2}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, five research reactors were under decommissioning at the end of 2013.

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 $1 \cdot 0 \cdot 10^{14}$ 1/cm$^2 \cdot$s the FR 2 was used as neutron source for beam pipe experiments for basic research and for irradiation 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 $3 \cdot 9 \cdot 10^{13}$ 1/cm$^2 \cdot$s to $1 \cdot 10^{14}$ 1/cm$^2 \cdot$s, the facility was retrofitted in 1966 to be operated with fuel elements with low-enriched uranium (2 %). The maximum thermal power of the reactor was thus increased from 12 MW$_{th}$ to 44 MW$_{th}$ (licence of 26 January 1966).

After 2 years of operation, the plant was finally shut down on 21 December 1981 for economic reasons. By 22 October 1982, the fuel elements were delivered to 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 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 medico-biological research.

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

Research and Measuring Reactor Braunschweig (FMRB)

The FMRB was a light-water cooled and moderated pool reactor with two separate fission product zones of HEU which were neutronically coupled via a 400-l heavy-water tank. The reactor went critical for the first time on 3 October 1967. The thermal power was 1 MW_{th} and the thermal neutron flux was $6 \cdot 10^{12}$ 1/cm$^2 \cdot$s. The Physikalisch-Technische Bundesanstalt (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$^2 \cdot$s was used for beam pipe experiments and irradiations for isotope production and neutron activation analysis.

Nuclear commissioning of the plant was on 14 November 1962. In 1967, a first capacity increase from 10 MW_{th} to 15 MW_{th} (licence of 11 December 1967) was carried out by utilising available reserves, in 1972 a second capacity increase was carried out to 23 MW_{th} by taking uprating and improvement measures (licence of 15 March 1972). Between November 1990 and April 1995, the reactor was taken out of operation to repair damage and to carry out backfitting measures. The regulatory authority approved of the plant's re-commissioning in February 1995.

On 2 May 2006, the 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 Forschungszentrum (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 about $1 \cdot 10^{14}$ 1/cm$^2 \cdot$s. Basically, the facility served as neutron source for isotope production, activation analyses, material research, and additionally for training purposes in the GDR nuclear energy programme.

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

The operation of the reactor was approved with temporary licences, the last licence was renewed on 8 October 1990 until 30 June 1991, by the then competent nuclear authority GEL (common institute of the federal states of Brandenburg, Mecklenburg-Vorpommern, Saxony, Saxony-Anhalt and Thuringia). The application of the operator of 5 March 1991 for a permanent operating licence was dismissed. The reactor was finally shut down on 27 June 1991. After it had taken over competency as new nuclear authority, the Saxon State Ministry for the Environment and Agriculture (SMUL) gave supervisory order to discontinue the facility's operation which was geared to nuclear fission on 28 June 1991 according to § 19 para. 3 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. With the concluding 4th partial licence dated 1 February 2005, the dismantling of the residual facility was approved. With letter of 27 March 2013, a modification to the 4th partial licence pursuant to § 7 para. 3 Atomic Energy Act was applied for for the dismantling of the residual plant.[4]

Decommissioning and dismantling works continued in the year under report. On 16 July 2013, the old reactor exhaust air chimney was dismantled. This was followed by the radiological exploration and decontamination.

3.4 RESEARCH REACTORS DECOMMISSIONED AND RELEASED FROM REGULATORY CONTROL

In the Federal Republic of Germany, the decommissioning of six research reactors with a continuous thermal power above 50 kW_{th} and of 23 research reactors with a thermal power of 50 kW_{th} or less was completed as of 31 December 2013. 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 1.10^{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. The designed thermal power was 1 MW_{th} and the designed thermal neutron flux was $3 \cdot 10^{13}$ $1/cm^2 \cdot s$. According to a decision of the Hessian Ministry of Culture of 11 July 1980, an operation licence was not granted and one abstained from the nuclear commissioning of the reactor which was ready for use.

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

Research Reactor of the Hannover Medical School (FRH)

The FRH was a pool reactor of the TRIGA Mark I type with homogeneous fuel moderator elements of LEU and zirconium hydride. The thermal power of the reactor was 250 kW_{th}, the thermal neutron flux was about

[4] After editorial deadline: On 9 January 2014 the licence to the 2nd modification of the 4th licence 4653/18 VKTA 04/2 was granted.

$9 \cdot 10^{12}$ 1/cm$^2 \cdot$s. Nuclear commissioning of the reactor 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 about $1 \cdot 10^{14}$ 1/cm$^2 \cdot$s. The reactor was commissioned on 23 February 1962 and was used for irradiations and beam pipe experiments.

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

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

Nuclear ship “Otto Hahn” (OH)

The „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.

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

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

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 ABDIKA), 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 b.

Decommissioning of the SUR-Berlin was completed on 16 April 2013 and the facility was released from regulatory control.

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 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/ (in German only).

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/a).

An application for extending the production capacity to 4,500 Mg SW/a was filed in September 1998. The relevant licence was granted on 14 February 2005. It includes the construction and operation of a second uranium separating plant with a separation capacity of up to 2,700 Mg UTA/a 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 UTA/a.

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. Start of operation is scheduled for 2014.

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 uranium dioxide pellets are used as raw material.

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

A licence according to § 7 AtG for increasing the capacity of the conversion facility to 800 Mg/a of uranium was granted on 2 December 2009. At the same time an increase of storage capacity for UF_6 to 275 Mg was approved. 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.

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.

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

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

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

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

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

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 was discontinued in October 1995. To prepare decommissioning, several single licences for the dismantling of plant components and for the removal of nuclear fuel were granted from 1996 to 1998. From 1999 to March 2001, three partial licences and several single licences for subsequent decommissioning were granted.

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

Siemens Fuel Element Fabrication Plant, Plant Section Karlstein

Since 1966, the plant served to produce 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. The released buildings have been used for the conventional fabrication of structural parts for fuel elements.

NUKEM Fuel Element Fabrication Plant, Hanau

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

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

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

All buildings inside the ring fence have meanwhile been dismantled. In May 2006 the remediation of the soil concluded and the entire premises, with the exception of 1,000 m^2, were released from regulatory control. The partial area will remain under regulatory control for the operation of a groundwater restoration plant. It will still take several years for the groundwater restoration level to reach 20 µg uranium/l, which is required by Water Law.

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 IN CENTRAL AND DECENTRALISED INTERIM STORAGE FACILITIES

4.3.1 Storage of spent fuel elements in the nuclear power plants

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

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

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

4.3.2 Decentralised interim storage facilities

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

AVR – Jülich Cask Storage Facility

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

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

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

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

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

Since 2009, on account of the limited duration of validity of the storage licence until 30 June 2013, the Jülich Forschungszentrum aimed to store the 152 casks in the transport cask storage facility Ahaus in future (cf. Chapter 4.3.3). As an alternative, the applicant has also examined since 2012 the option of transporting the AVR fuel elements to the USA.

In view of the fact that interim storage in the AVR cask storage facility will probably be required beyond 30 June 2013, a prolongation of the granted storage licence was applied for on 26 June 2007 by way of precaution.

The storage licence 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), 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. The order pursuant to § 19 para. 3 AtG entitles the FZJ to further own the nuclear fuel. As the Forschungszentrum Jülich GmbH has not achieved to be granted a licence in this period of time, the MWEIMH gave order on 17 December 2013 to continue the storage of the AVR fuel elements. This order becomes effective on 1 January 2014 and is limited to seven months until 31 July 2014.

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 1999. Once the Obrigheim NPP (KWO) had shut down on 11 May 2005, altogether 342 fuel elements were stored in the external wet storage facility until the end of 2007. On 22 April 2005, Kernkraftwerk Obrigheim GmbH submitted an application to the BfS for storage of the 342 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. The Federal Ministry of the Interior (BMI) is of the opinion that, as a consequence of the events of 11 September 2001 in the USA, a target crash of a passenger plane onto a nuclear installation can no longer be ruled out. 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 not yet been decided. In 2013, 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 defendant has filed a complaint against the denial of leave to appeal. Until the decision becomes legally binding, the licence for the Brunsbüttel on-site interim storage facility continues to be valid.

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

With the exception of the Lingen on-site interim storage facility, the building permits for the on-site interim storage facilities were granted complementarily to the nuclear licences. The storage building in Lingen was licensed according to building law on 27 September 2000 and completed in April 2002. Thus the Lingen interim storage facility was already operable when the nuclear licence was granted. It was only possible to begin the construction of the remaining on-site interim storage facilities in 2003/2004, after the Environmental Impact Assessment had come to an end and the building permits had been granted by the respective Federal State building authorities.

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

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 2013)	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 (21)	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 (41)	23.08.2004	25.08.2006
SZL Isar	22.09.2003	1.500	152 (31)	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 (41)	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 (8)	19.01.2004	18.06.2007

On 22 April 2005, Kernkraftwerk Obrigheim 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 year 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. An operational building is attached to the east side of the storage hall. Furthermore, it is planned to erect a separate guardhouse (security centre) together with technical equipment for security services. The Obrigheim interim storage facility is to be designed for self-sustaining operation and is to be operated in a nearly self-sustained way as soon as it has been commissioned.

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. As opposed to the originally planned WTI concept with wall thicknesses of ca. 85 cm for the outer walls and ca. 55 cm for the thickness of the concrete roof of the cask storage hall, wall thicknesses of the outer walls and of the concrete roof were increased to ca. 1.2 m in the current plans for the building. Thus, wall thicknesses in the planned on-site interim storage facility Obrigheim now correspond with the wall thicknesses of the interim storage facilities in Northern Germany which was also constructed according to the so-called STEAG concept.

Since 2013, the EnKK has been examining if the 342 spent fuel elements from the Obrigheim NPP can be stored alternatively in the Neckarwestheim on-site interim storage facility. 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 mvK type is to be maintained.

The Neckarwestheim on-site interim storage facility is situated ca. 40 km from the Obrigheim site (air-line distance). The EnKK is currently examining in a transport study which transport route (road, rail, river Neckar) the CASTOR® casks can be taken to the Neckarwestheim on-site interim storage facility. Once the transport route has been chosen, the EnKK needs to file a separate application to the BfS for a transport licence according to § 4 AtG. With the application for the storage of the KWO fuel elements in the Neckarwestheim on-site interim storage facility 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 Central Interim Storage Facilities

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

For the transport cask storage facilities of Ahaus, 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 operations started in June 1992.

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

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

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

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

From 2000 until 2010, altogether six modification licences pursuant to § 6 AtG were also granted (cf. Table III.4). Details are available in the Status Report on Nuclear Energy Utilisation in the Federal Republic of Germany 2012.

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 2 April 2013 the GNS and the BZA applied for the replacement of the storage hall crane in order to comply with the enhanced requirements according to Section 4.3 of KTA Standard 3902.

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, apart from the increase to altogether 3,800 Mg of HM and the storage of solidified high-level radioactive fission product solutions. The storable activity was limited to $2 \cdot 10^{20}$ Bq. Prior to this decision a public participation procedure was carried out on the basis of the amendment to § 6 Atomic Energy Act.

From 2000 until 2010, altogether four modification licences pursuant to § 6 AtG were granted (cf. Table III.4). Details are available in the Status Report on Nuclear Energy Utilisation in the Federal Republic of Germany 2012.

Thus, on 31 December 2013, 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 storage facility.

The application for the storage of the HAW vitrified waste block canisters from reprocessing at the British Sellafield Ltd. plant has been examined since 2012. Altogether, a waste volume of further ca. 21 casks of the CASTOR® HAW28M containing HAW vitrified waste block canisters must be assumed. These HAW vitrified waste block canisters are to be returned, probably starting in 2015.

With letters of 2 February 2012 and of 10 February 2012, the GNS and the Brennelementlager Gorleben GmbH (BLS) 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. The MAW vitrified glass block canisters are to be returned in 2015.

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 to be transported to the Interim Storage Facility Gorleben will be taken to on-site interim storage facilities in future. A decision about the sites is to be taken by the middle of 2014, in co-ordination 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 to the storage of other radioactive materials at the TBL-G pursuant to § 7 para. 2 StrlSchV. 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 Facility North Rubenow (ZLN)

The Transport Cask Storage Facility in the Interim Storage Facility North is a dry storage facility for spent fuel elements in transport and storage casks. It is situated in hall no. 8 of the Interim Storage Facility North on the premises of EWN. The ZLN 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 operations of CASTOR® casks started on 11 December 1999.

From 2001 until 2010, altogether seven modification licences were granted (cf. Table III.4). Details are available in the Status Report on Nuclear Energy Utilisation in the Federal Republic of Germany 2012.

On the appointed date of 31 December 2013, 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 (waste storage facility Esenshamm),
- The decentralised on-site interim storage facility Biblis (the period of interim storage is limited to ten years, starting at the first emplacement of a waste package),
- The TBL Ahaus (the period of interim storage is also limited to ten years, starting at the first emplacement of a waste package),
- The waste storage facility Gorleben (ALG),
- The EVU hall of the interim storage facility Mitterteich,
- The interim storage facilities of Nuclear + Cargo Service GmbH (NCS) in Hanau,
- The interim storage facility North (ZLN) near Greifswald, 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 authority competent for federal custody is the Federal Office for Radiation Protection.

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 installations for this purpose is disproportionate.

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

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

4.5 REPROCESSING OF NUCLEAR FUELS

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

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

With 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 for a German reprocessing plant were carried out on an industrial scale. The WAK resumed operation in 1971 under the leadership of the WAK Betriebsgesellschaft mbH. The operation 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.

A volume 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 evaporisation of high-level radioactive waste liquids). The low-level and intermediate-level operational waste of the WAK was conditioned in the Karlsruhe Research Center (later on FZK and today KIT). Until today, additional conditioned operational waste has remained with the WAK Rückbau- und Entsorgungs-GmbH (in short WAK GmbH), after radioactive waste emplacement into the Asse mine had stopped in 1978.

Operation finally ceased on 30 June 1991. At the end of 1991 the Federal Government, the Land of Baden-Wurttemberg and the utilities decided to decommission and dismantle the reprocessing plant. On 22 March 1993, the first partial decommissioning licence for the WAK was granted. On behalf of the research centre the WAK Betriebsgesellschaft mbH carried out the residual operation and dismantling of the plant on its own responsibility until 2005. Since 1 January 2006, the WAK GmbH is responsible. WAK GmbH is a daughter of the state owned corporation Energiewerke Nord GmbH (EWN).

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 has been completed in 2010. The HAWC storage facilities and the vitrification plant Karlsruhe (VEK, details see below) has been adapted to the reduced overall operation. 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 needed to be conditioned in a way that it was suitable for disposal and to be disposed of. For this special purpose the VEK was constructed. On 20 December 1996, an application for granting a licence according to § 7 Atomic Energy Act was filed for the erection and operation of the VEK. The first partial building licence for the VEK was granted on 30 December 1998. The construction of the VEK started at the beginning of 2000 and the interior fitting was completed until 2005. This was followed by functional tests of single components and the respective plant components and an inactive test operation of the entire plant from April to July 2007. The second partial operation licence for hot (nuclear) operation was granted on 24 February 2009. Between September 2009 and June 2010 the approx. 60 m^3 of HAWC were processed in the VEK into 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. With the filling of 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 17 August 2012, the operator filed an application for "manual unloading of the equipment in the VEK which was already taken out of operation in step 4". The 140 waste block canisters were placed into 5 transport and storage casks of the CASTOR® HAW 2028 type and were taken to the Interim Storage Facility North of EWN GmbH in Lubmin near Greifswald in February 2011 (cf. Chapter 4.3.3).

Two emptied HAWC casks each are in the buildings "LAVA" (storage casks) and "HWL" (reserve casks) in thick-walled concrete cells. They 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 they had been rinsed several times after having been emptied, solid HAWC residues were detected in the reserve cask (8aB21) 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.

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

The 23rd decommissioning licence was granted on 14 December 2011. It concerns 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 government and federal state 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 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 FOR DIRECT DISPOSAL

Gorleben Pilot Conditioning Plant (PKA)

(Cf. Table III.8 in Annex III)

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

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

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

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

All three partial licences are definitive.

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

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

4.7 DISPOSAL

A survey of radioactive waste repositories and decommissioning projects in the Federal Republic of Germany is given in Table III.9. The course of licensing procedures and procedures according to Mining Law 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).

The Federal Office for Radiation Protection (BfS) is responsible for the implementation of the site-selection procedure according to the Repository Site Selection Act (StandAG), the construction, operation and decommissioning of repositories. A site-selection procedure for a repository for heat-generating radioactive waste is reinitiated and implemented on the basis of the Repository Site Selection Act which became effective on 27 July 2013.
Following the decision of the federal government concerning the phase-out of nuclear energy in 2011, the state and the Länder agreed on extending the achieved consensus regarding the termination of power generation with nuclear energy (cf. Chapter 1.2.2) to the still open issue of high-level radioactive waste management. In order to place the search for a repository for high-level radioactive waste on a broad, politically and socially supported basis, the Bundestag and Bundesrat passed the Law Concerning the Search and Selection of a Site for a Repository for Heat-Generating Radioactive Waste (Repository Site Selection Act – StandAG). It entered into force on 27 July 2013. In all phases of the site selection procedure, a formal public participation and active public relations work are provided for by the StandAG. For technical reasons, BfS has been opting for years for an exploration of alternative sites and for a transparent search procedure based on scientific search criteria that have been laid down previously. When the StandAG became effective, the exploration works in the Gorleben salt dome were terminated officially. The mine needs to be kept open for as long as the Gorleben site has not been ruled out in the site selection procedure. The BfS implements the search and exploration of new sites in the context of the search procedure. A new Federal Office for the Regulation of Nuclear Waste Management to be founded in 2014 is to regulate site-selection procedure.

Pursuant to § 9a para. 3 Atomic Energy Act the federation must establish facilities for the safekeeping and disposal of radioactive waste, The BfS is the responsible authority (§ 23 para. 1 no. 2 Atomic Energy Act). The BfS is assigned to the portfolio of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) – previously Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)[5] – 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) consisting of eleven scientists has given advice to the BMU in terms of nuclear waste management issues. Before that, the Repository Committee of the Reactor Safety Commission was responsible for rendering this advice.

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 Economic Affairs and Energy (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 Atomic Energy Act the state 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 %). The DBE currently supports the BfS in terms of the construction of the Konrad repository, the operation of the Morsleben repository and the keeping of the Gorleben exploratory mine operable. 100-% federal Asse GmbH has been tasked with the operational management and the decommissioning of the Asse II mine. On behalf of the BfS, the company for the operation and decommissioning of the Asse II mine carries out tasks relating to the planning, construction and operation of federal facilities for the safekeeping and disposal of radioactive waste. It is also a third party in the context of § 9a para. 3 Atomic Energy Act. The overall responsibility for the construction and operation of federal repositories is with the BfS. The DBE and the Asse-GmbH are supervised by the BfS. The BfS also initiates and co-ordinates facility-related research and development projects.

On behalf of the 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 Reaktorsicherheit mbH (GRS), the Karlsruhe Institute of Technology (KIT) and the Jülich Forschungszentrum (FZJ).

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[5] The Federal Ministry of Environment, Nature Conservation and Nuclear Safety (BMU) was renamed as Federal Ministry of Environment, Nature Conservation, Building and Nuclear Safety (BMUB) in December 2013 because of the new tasks.

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. This examination has not yet been completed.

Currently no statement can be given on the suitability of the Gorleben salt dome to host a repository for radioactive waste. Essential parts of the required examination procedure such as a plant and site-specific safety assessment or a statement on long-term storage are still outstanding. The mining exploration of the Gorleben salt dome was officially terminated when the Repository Site Selection Act - StandAG entered into force (cf. Chapter 4.7.1). Like any other eligible site, the Gorleben site will be included in the 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 that all legal requirements are met and the necessary maintenance measures are carried out that are necessary for its operation.

A decision about a site for a repository for heat-generating radioactive waste still needs to be taken (cf. Chapter 4.7.1).

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

For this purpose, according to BMU plans, it was to be examined at first whether Gorleben could be suitable as a repository. This was to be done in a multi-stage procedure based on a safety assessment, an updated disposal concept and an international expert report by independent scientists (International Peer Review). The BMU, now BMUB, commissioned the GRS with the implementation of a preliminary safety assessment for the Gorleben site (VSG) on the basis of the available exploration results. The focus of the VSG was on the issue of long-term safety, i.e. it should be predicted in a comprehensible way on the basis of today’s state of knowledge if and, if necessary, under what conditions it will be possible to operate a safe repository on this site. Furthermore an updated repository concept was to be developed taking into account operational safety, and the future need for investigation and exploration was to be determined.

Accompanying and supporting the VSG, the underground exploration works in the Gorleben salt dome were to continue. The BfS had filed an application for the extension of the overall operating plan for the geo-scientific exploration of the Gorleben salt dome until 30 September 2020 and for a new main operating plan for further exploration works in the period of application from 1 October 2010 to 30 September 2012 to the competent mining authority, Landesamt für Bergbau, Energie und Geologie (LBEG). Either operating plans were approved in September 2010. After legal proceedings had been initiated against either approvals and thus a suspensive effect had come into effect for the approvals of the operating plans, the LBEG ordered immediate enforcement of the operating plans. Exploration works were then resumed.
In view of the on-going communication about a waste management consensus – also involving the exploration of Gorleben – between the Federal Government and the federal states (cf. above), the BfS was ordered to postpone driving operations in exploration area 3 with decree by the BMUB issued on 6 December 2011. One could continue to carry out the planned exploration drillings. The validity of the main operating plan approval having expired on 30 September 2012, an application for the extension of the main operating plan approval until 31 December 2012 was filed to the mining authority in June 2012 in co-ordination with the Federal Environment Ministry. The mining authority approved the extension of the main operating plan on 27 September 2012. On 31 October 2012, actions were brought against this approval with the Lüneburg Administrative Court. The mining authority then ordered on 6 November 2012 that only necessary operational works according to § 7a BBergG be carried out which serve in particular the precaution against hazards to life and health of employees or third parties and the protection of material goods. Further exploration works were thus not permitted.

On 30 November 2012, the Federal Environment Minister declared that the exploration of the Gorleben salt dome would stop until the legislative period ended in autumn 2013. Another extension of the main operating plan approval from 1 January 2013 until 30 June 2013 was applied for at the LBEG, with a restriction to measures to keep the mine open excluding the performance of exploration works. The mining authority gave its consent with notification of 27 December 2012. On 30 April 2013, another application for a main operating plan for the validity period from 1 July 2013 until 31 December 2015 was submitted to the mining authority. The mining authority limited the validity period with notification of 28 June 2013 to the period from 1 July 2013 until 31 December 2013. Furthermore, the mining authority demanded the submission of a new main operating plan by 31 October 2013. This new main operating plan was submitted to the mining authority for approval on 30 October 2013 and covered the period from

1 January 2014 until 31 December 2015. This main operating plan contains only measures that are required for the mine being brought into a state that it can be kept operable to keep it in that state. Exploration measures are no longer permitted according to this main operating plan. With notification of 19 December 2013, the mining authority limited the approval of the main operating plan for a period from 1 January 2014 to 30 September 2014.

With the cross-party consensus in terms of a Repository Site Selction Act, which has been aimed at since autumn 2011, the tasks of the VSG changed, too. It was now no longer necessary to develop a preliminary suitability prognosis for the Gorleben site. Instead, it was to be examined whether the developed repository concepts, together with the geological barrier at the Gorleben site or a site in rock salt which is comparable in terms of the geological situation, appear to be suitable from today's point of view for fulfilling the safety requirements for the disposal of heat-generating radioactive waste. It was to be examined which methodical approaches for a future site-selection procedure developed in the VSG could also be applied to a comparison of repository sites. Furthermore, the applicability of the technical concepts developed in the VSG in terms of radioactive waste storage and sealing of the repository mine in salt host rock is to be examined as to whether it can be transferred to other repository systems in a different geological surrounding (other host rocks). Works on the VSG were terminated in the first quarter 2013. Results of the preliminary Gorleben safety assessment can be found on the GRS website (http://www.grs.de/endlagersicherheit/gorleben/ergebnisse). It was no longer planned to carry out the Peer Review by an international expert organisation.

KONRAD repository

The Konrad mine in Salzgitter developed the iron ore deposit in depths between 800 m and 1,300 m. The deposit has been known since 1933. Sinking of shaft Konrad 1 started in 1957. For economic reasons, iron ore production already stopped in 1976. Since it is extraordinarily dry, the mine was initially investigated for its basic geo-scientific suitability to host a repository for radioactive waste. After these investigations had concluded with a positive result, the then competent Federal Institute of Science and Metrology filed an application for the initiation of a plan-approval (licensing) procedure according to § 9b Atomic Energy Act on 31 August 1982. The plan provided for the disposal of up to 650,000 m^3 of radioactive waste with negligible heat generation. Compared with these estimations, the waste volume expected today has clearly decreased. The volume licensed for disposal has been restricted to 303,000 m^3 of waste for the national need. 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 been pending since 1982 was completed through the plan-approval decision of 22 May 2002. According to the agreement between the Federal Government and utilities the application for immediate enforcement was withdrawn by the BfS on 17 July 2000. In March 2006, the pending actions against the plan-approval decision were rejected by the Lüneburg Higher Administrative Court; revision was not admitted. The complaints against the non-admission of the revision to the decisions of the Higher Administrative Court filed by the claimants were rejected by the Federal Administrative Court with decision of 26 March 2007. The plan-approval decision is thus legally binding. Since 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 2013. Especially the over 500 collateral clauses in the plan-approval decision and the fact that the major part of the plans was developed in the nineties of the 20th century make it necessary to comprehensively up-date the plans. The current remediation requirements of the facilities, the status of the technical rules and regulations, the stipulations of the federal government's "Meseberger Beschlüsse" and the specifications of the Energy Saving Ordinance and the regulations on sustainable building are taken into consideration. These comprehensive changes to the plans require building permits, too. Following a longer discussion regarding competences between the city of Salzgitter and the federal state, Lower Saxony acknowledged the project-related privileged status of the BfS in terms of the simplified approval procedure of the building authorities according to § 74 Lower Saxon Building Code (NBauO, former § 82 NBauO). The first application for approval was submitted by the BfS in September 2011 and approved by the highest building authority of the federal state of Lower Saxony in December 2011. In 2012, the BfS filed four further applications for approval, all of which were decided positive. The procedure is still used during the construction of the repository.
In the process of revising the plans it has shown that the assumptions made in the nineties were incorrect and have raised unrealistic expectations. Provided that the works will continue to be carried out with the present structures under optimal conditions, it can be expected that the Konrad repository will not be completed before 2019.

The so-called "construction in existing contexts" has proven to be a fundamental project risk. The state of some existing buildings and installations is 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 guidance devices anchoring 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, which is to be supported by exact dimensioning with the help of geo-technical calculations. Already available results show that considerably more cavities need to be driven, which makes scheduling more uncertain.

As in shaft Konrad 1, more necessity for remediation is expected for shaft Konrad 2.

Currently, the construction measures for the erection of the transformer house at Konrad 1 continue. In November 2013, the 30 kV feed line was switched to the new transformer. The two old transformers are taken off the grid. Besides, construction of the extension to the shaft hall started. The security fence at the Konrad 1 mine is under construction.

Construction of the external traffic connections of Konrad 2 started including conversion and redevelopment of district road 39. Verkehrsbetriebe Peine-Salzgitter constructed the rail connection to the area of the railway siding Konrad 2.

Works on the underground strengthening of galleries and the driving of emplacement chambers in the first planned emplacement field are currently underway. Two emplacement galleries have already been driven up to the planned final length. Finishing works are carried out in a third emplacement gallery. Driving of the return air collection roadway goes according to plan. Works on cable routes and cable-laying are continuing in different areas underground.

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. Except for the period from 1991 to 1994 when emplacement operations had discontinued, it was used for the disposal of low-level and intermediate-level radioactive waste with mainly short half-lives until 1998. Through the legal transfer the Federal Office for Radiation Protection has been the holder of the permanent operation licence since 1990.

Between 1971 and 1998, altogether about 37,000 m^3 of low-level and intermediate-level radioactive waste were disposed of in the ERAM with a total activity of less than $3.3 \cdot 10^{14}$ Bq (appointed date: 30 June 2010). In terms of time, the volume of the stored waste is structured as follows: Approx. 14,500 m^3 to 1991, ca. 22, 500 m^3 in the period from 1994 until 1998. In terms of the geographical origin of the waste, one can differentiate between approx. 20,550 m^3 from East Germany and approx. 16,200 m^3 from West Germany. On 21 May 1999, the BfS announced that for safety reasons, the emplacement of radioactive waste in the ERAM would not be resumed. On the basis of the Amendment to the Atomic Energy Act of 2002, the provisions of § 57 a Atomic Energy Act were modified to the extent that the permanent operation licence for the ERAM 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 operations 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 continues, it is planned to change repository operation to keeping the mine operable. 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. The MLU submitted the draft licence in November 2013 and intends to grant the licence in 2014.

Between 2003 and 2011, 27 rock salt workings where no radioactive waste is stored were backfilled with ca. 935,000 m^3 of salt concrete as part of measures to prevent mining hazards and to improve the geo-mechanic state of the ERAM’s central part. Measurements currently available of the rock movements show that the aim of stabilising the central part of the Bartensleben mine has been achieved. During the year 2012, the waste stored in mining district 2 of the eastern field was covered with salt grit in accordance with the provisions of the permanent operating licence. The 1.2-m thick cover protects the stored waste containers from pieces of rock potentially falling from the roof. Additionally, this measure serves to improve the radiological situation and fire protection.

Key works in the repository's surface area included in particular the complete renewal of the security system. On account of its age and susceptibility to faults, the old security system strongly needed remediation.

In the course of the work for the plan-approval procedure for the decommissioning of the ERAM, about 450 procedure qualification reports on the decommissioning concept and the safety assessments have been submitted to the competent licensing authority for examination since the middle of the nineties of the 20^{th} century. The decommissioning concept applied for aims to comply with the protection goals both in terms of radiological protection and according to 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. Proof that these protection goals are kept is furnished on the basis of long-term safety assessments.

A key component of the decommissioning concept is the backfilling of major parts of the underground installations 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. The planned backfilling measures will comprise filling the ERAM with altogether ca. 4.2 million cubic metres of salt concrete. Likewise, the several-hundred-metre-deep shafts will be sealed with especially developed structures to complete the works.

Already in 2005, the plan documents that are required according to § 6 Nuclear Licensing Procedure Ordinance (AtVfV) were submitted to the competent licensing authority, the MLU. Following a long examination of the submitted plan documents by the licensing authority and the subsequent revision of the documents, the MLU declared in September 2009 that the documents were suitable for the public participation procedure. The plan documents relating to the decommissioning of the ERAM were then laid out to public inspection between October and December 2009 in the scope of the public participation procedure.

The plan for the decommissioning of the ERAM that has been developed for the participation of the public explains in detail and comprehensively the initial situation, the decommissioning concept including the planned backfilling and sealing measures up to the shaft sealing structures. The planned works involving the conversion and dismantling of the facilities and the radiological consequences to the environment are explained, as well. Furthermore, the sealed repository's possible radiological effects on the biosphere are assessed with the help of long-term safety assessments. For this purpose, various climatic, geological and mining scenarios are considered for a period of 1 million years.

Apart from the plan, the documents to be laid out also comprise an environmental impact study in which all findings from the environmental investigations are presented and evaluated, the accompanying landscape conservation plan (LBP) including the presentation of planned measures to compensate the actions associated with decommissioning, and a survey of different examined technical alternative procedures to the decommissioning. The about 15,000 objections and concerns against the project that were raised on the basis of the documents required for the public participation procedure were discussed in October 2011. In 2012, the results of the hearing were submitted to the BfS a verbatim report and subsequently evaluated in terms of open issues or questions. The BfS takes into account the evaluation results in the context of in-depth plans.

In 2013, the works on the in-depth plans of the measures provided for in the decommissioning concept have basically been completed. The examination results of the licensing procedure for the decommissioning concept that have been submitted to the BfS so far have been taken into account. Due to the fact that the examinations of the decommissioning concept have not been completed yet, it is planned to consider subsequent examination results in the final revision of the documents (following the examination of the in-depth plans). Subsequent to the hearing, the Federal Environment Ministry ordered the Waste Management Commission (ESK) to prepare an opinion on the question as to whether the proof of long-term safety (LZSN) for the ERAM complies 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 are necessary with regard to building material, building concept and the required safety proof. The time required for the developing additional works in connection with the aforementioned audit of the ESK was assessed. The additional time required will be at least five years.

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 panel and two rock salt panels were driven.

In 1965, Gesellschaft für Strahlen- und Umweltschung (GSF, today Helmholtz-Zentrum German Research Center of Health and Environment - 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. The emplacement of radioactive waste ended on 31 December 1978. In the scope of the trial and demonstration programmes altogether around 124,500 drums with low-level radioactive waste were emplaced in 12 chambers on the 725-m level and on the 750-m level (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 April 2013 it has been stipulated by law that the radioactive waste must be retrieved before the Asse II mine will be decommissioned. To speed up the process, the measures required for the preparation were carried out in parallel. On 25 April 2013, the “Law on Speeding up the Retrieval of Radioactive Waste and the Decommissioning of the Asse II Mine”, the so-called “Lex Asse”, became effective. § 57b AtG was redrafted. According to the redrafted paragraph, the radioactive waste is to be retrieved before the Asse II mine will be decommissioned, as long as this is not safety-relevant. The legal mandate of retrieving the waste replaces the final evaluation as to whether retrieval is justified according to § 4 StrlSchV. This allows for the parallel implementation of all measures necessary for retrieval without having to wait for the results from the trial phase (fact-finding). Under certain conditions, preparatory activities can already be carried out during the licensing procedure, before the actual licence has been granted. The “Lex Asse” permits the implementation of a joint environmental impact assessment for different licensing procedures. If possible and appropriate, several procedures can thus be summarised, each of which lasting at least two years. According to “Lex Asse”, radioactively contaminated saline solutions and salt grit, whose activity does not exceed the ten-fold of the limit values set out in the Radiation Protection Ordinance, can be handled, processed, stored or used underground. For as long as these conditions are complied with, it is no longer necessary to dispose of contaminated saline solutions in the federal state collecting depot. According to “Lex Asse” it is basically possible for the accident planning levels for retrieval and decommissioning measures deviating from the legal provisions (50 mSv) for the individual case to be determined in the licence. According to StrlSchV, all technical options to reduce radiation exposure must be taken.

Operation

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.

Management of influent saline solutions

Since summer 2012, a brine inflow from an operational drilling has been observed on the 658-m level, which is adjacent to the existing main point of brine inflow. At the end of May 2013, there was a strong increase in the volume of brine in the bore hole. Additional drip points were detected on the 574-m, 553-m and the 511-m levels in June and July 2013. In September 2013, an inflow of brine of over 13 m^3/day altogether (all collecting points) was measured temporarily. Comparable brine volumes were detected in 2002 and 2005, also temporarily. The inflow shows that the system has changed recently. The development cannot be prognosticated.

Approximately 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 which is being flooded. The contract with K+S was extended in January 2013 until max. 2016. At the same time, the search for further options (such as caverns) is taking place.

On the 750-m level there are also contaminated solutions, currently ca. 16 l/day in front of emplacement chamber 8 in the west and 17 m^3 from a swamp in front of chamber 12 in the east, the latter having meanwhile been solidified with concrete.

The BfS plans to use the contaminated solution which is currently stored in radiation protection areas on the 750-m level and the 725-m level to backfill no longer needed cavities with salt concrete. According to “Lex Asse”, radioactive materials whose radioactivity does not exceed the ten-fold of the limits according to Annex II Table 1 Column 3 of the StrlSchV may also be processed underground (see above).

Backfilling of Residual Cavities

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 39 mining districts have been backfilled with ca. 41,000 m^3 since December 2009.

Emergency Preparedness

Among others, the emergency preparedness measures aim to reduce the probability of occurrence of an enhanced inflow of brine and to minimise the radiological consequences as a result of such drowning. As a precaution, measures to increase the facility design have already been implemented (increase of production capacity, emergency storage facilities to maintain additional pumps and equipment). With the completion of swamp galleries on the 800-m level, the underground storage capacity was increased significantly in 2013 by ca. 7,500 m^3.

To minimise and delay the release of radionuclides in the event of an emergency, sealing structures continue to be constructed on the levels and underneath the emplacement chambers and cavities no longer needed are backfilled. Limitations in the mine's suitability for use and their remedying delayed the backfilling measures in 2012. In 2013, gallery sections in front of chambers 12 and 10 were backfilled for stabilisation purposes. It is planned to carry out further backfilling measures to stabilise and seal galleries on the 750-m level. The backfilling measures on the 750-m level are discussed in detail in the support process. There are concerns that the backfilling measures on the 750-m level could impede the retrieval of the waste. The BfS does not share these concerns and considers the performance of emergency precaution measures essential.

Furthermore, by backfilling the upper section of blind shaft 1 (725m to 574-m level) of the complete blind shaft 2a (553-m to 490-m level) and the lower section of day shaft 2 up to the 800-m level, vertical paths were sealed and the mine workings were stabilised at these locations in 2013.

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 2024.

Fact finding

The upwards running drilling through the sealing of chamber 7/750, which had started on 1 June 2012, was completed at the end of December 2012 at a depth of 35 m in the salt rock above the chamber. Radar measurements were carried out to explore the shape of the chamber roof and possibly existing cavities. Based on these results, another bore hole was sunk on 30 April 2013, which reached the chamber on 7 June 2013 at a depth of 23 m and the concrete shielding of a waste package on 12 June 2013 at a depth of 23.2 m. First radiological examinations showed no contamination of the stowing material. More drillings to explore the state of the pillar above the chamber are in preparation. It is examined whether chamber 12 can be explored from the 700-m level, in order to further stabilise the area in front of chamber 12 on the 750-m level and to be able to speed up the fact-finding parallel for both chambers (7 and 12).

Maintaining the mine's suitability for use

At the end of May 2013, parts of the damaged mine working 6a on the 532-m level were backfilled and a bypass was completed to enable accessibility of the infrastructure rooms located to the east of the working.

An increasingly bad condition of the other infrastructure areas of the mine workings begins to emerge (among others on the 490-m level, in the mine bottom area of surface shaft 2 on the 750-m level, in the spiral gallery between the 750-m level and the 775-m level). Time and cost consuming measures to maintain the mine's suitability for use also have to be expected in the future.

Decommissioning

The decommissioning of the Asse II mine is monitored by the Asse II Monitoring Group of the rural district of Wolfenbüttel 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 managed by the project executing organisation, the Karlsruhe Institut für Technologie (KIT).

At the beginning of 2009, the AGO suggested at the beginning of 2009 to further examine the decommissioning options of retrieval, relocation and complete backfilling (comparison of options). The result of the comparison of options was that the complete retrieval of the waste was considered the best decommissioning option, as, according to present knowledge, no proof of long-term safety could be furnished for the location of the waste. The waste retrieved from the facility would at first have to be stored intermediately and subsequently be taken to a suitable repository.

Prior to retrieval, a fact-finding is carried out by drilling at first into two selected chambers (chamber 7/750 and chamber 12/750). According to planning, the chambers are to be opened and single packages are to be recovered by way of trial in a second and third step. The objective of the fact-finding is to clarify current uncertainties and to enable an evaluation of the actual radiation exposures during the retrieval of all the waste and of conservativities, to enable an approvable planning.

Experiences made so far have shown that already the fact-finding phase will last longer than expected (8 to 10 years instead of three years as originally planned). An evaluation of the retrieval process in January 2012 showed that retrieval will also take more time than originally expected. According to a general schedule (RTP) developed by the ARCADIS company in May 2012 on behalf of the BfS states the year 2036 as the date for retrieval operations to start. This date is not acceptable to the BfS. Therefore, involving the Asse 2 Monitoring Group and other experts involved in the project, speeding-up potentials (BP) were developed in several workshops in 2012.

Based on the speeding-up potentials developed in the workshops and further own speeding-up potentials, the BfS has revised the general schedule. The new general schedule takes into account delays and options resulting from the “Lex Asse” that have meanwhile occurred. In particular the immediate start and parallelisation of partial projects (interim storage facility, shaft 5, recovery techniques) and the early start of partial measures are considered speeding-up potentials; the same applies to the cancelling of the dependency of step 2 of the fact-finding (opening of chambers) on the completion of emergency preparedness. The risk is that planning may have been in vain and investments could be lost in case retrieval is carried out not at all or in a different way than originally planned. On account of the “Lex Asse”, there is no need for an economic justification of the measures. According to the revised general schedule retrieval operations will start in 2033.

In terms of retrieval, plans for a new shaft, an interim storage facility and retrieval techniques were taken up.

In 2013, extensive discussions took place with the bodies of the monitoring process about the site criteria and 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 has decided to search also a site for an interim storage facility located near the Asse mine.

For the surface exploration of a new shaft located 500 m to the east of the existing company site an exploration drilling (planned final depth 790 m) was started on 5 June 2013, which had reached a depth of 259 m at the end of 2013.

Annexes - Survey

Annex I – Nuclear power plants

As of 31 December 2013

Table I.1: Licensing 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 § 6 AtG**
Federal Republic of Germany	Federal Office for Radiation Protection	Länder supervisory authorities
Land	**Licensing authority for facilities according to § 7 AtG**	**Supervisory authority according to § 19 in conjunction with § 6 AtG and § 7 AtG**
Baden-Wurttemberg (BW)	Ministry of the Environment, Climate Protection and the Energy Sector, in agreement with the Ministry for Finances and Economy and the Ministry of the Interior	Ministry of 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)	Brandenburg State Ministry of the Environment, Health and Consumer Protection	
Bremen (HB)	Senator for the Environment, Building and Traffic, in consultation with the 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-Vorpommern (MV)	Ministry of 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 Economy, 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 Agriculture and Environment	
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.2a: Nuclear power plants in operation

As of 31 December 2013

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	1,400	1,329	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.2b: Survey of thermal and electrical capacity increases in the German nuclear power plants in operation

As of 31 December 2013

Name of facility and site	Licensed thermal power at initial criticality [MW_{th}]	Thermal power increase [MW_{th}]	Electricity output (gross) in the year of initial criticality [MW_e]	Year of modification of electricity output	Current electrical gross power [MW_e]	Capacity increase applied for [MW_{th}]
GKN 2 Neckarwestheim BW	3,765 (4th partial operation licence of 28.12.1988)	To 3,850 (3rd modification licence of 13.05.1991, application of 24.10.1990)	1,316 (1988)	1,314 [1989] 1,316 (1990) 1,365 (1992) 1,395 (08/2004) 1,400 (01/2007)	1,400	To 3,965 (application of 25.04.2000) Since 2010 the operator has no longer pursued the application.
KKP 2 Philippsburg BW	3,765 (1st partial building licence of 06.07.1977)	To 3,803 (5th modification licence of 26.11.1991, application of 05.09.1991) To 3,850 (8th modification licence of 08.05.1992, application of 07.03.1991) To 3,950 Modification licence of 29.03.2000, application of 30.04.1998)	1,349 (1984)	1,357 (1991) 1,390 (1992) 1,402 (1993) 1,424 (1996) 1,458 (11/2000) 1,468 (01/2010)	1,468	-
KKI 2 Essenbach BY	3,765 (4th partial building licence of 12.07.1982)	To 3,850 (1st modification licence of 25.02.1991, application of 16.10.1990) To 3,950 (5th modification licence of 20.11.1998, application of 07.04.1998)	1,370 (1988)	1,390 (1989) 1,400 (1991) 1,410 (1993) 1,420 (1995) 1,440 (1996) 1,455 (1998) 1,475 (2000) 1,485 (2009)	1,485	-

Name of facility and site	Licensed thermal power at initial criticality [MW_{th}]	Thermal power increase [MW_{th}]	Electricity output (gross) in the year of initial criticality [MW_e]	Year of modification of electricity output	Current electrical gross power [MW_e]	Capacity increase applied for [MW_{th}]
KKG Grafenrheinfeld BY	3,765 (5th partial building licence of 10.11.1981)	-	1,299 (1981)	1,300 (1984) 1,345 (1993)	1,345	To 3,950 (application of 16.05.2000) The application was withdrawn on 16.05.2012.
KRB-II-B Gundremmingen BY	3,840 (11th partial building licence of 18.10.1984)	-	1,310 (1984)	1,300 (1987) 1,344 (1994)	1,344	To 4,100 (application of 14.09.1999 for units B and C, withdrawn on 21.12.2001) To 4,000 (new application of 19.12.2001 for units B and C) The application was withdrawn on 17.03.2013.
KRB-II-C Gundremmingen BY	Cf. KRB-II-B	-	1,310 (1984)	1,308 (1987) 1,344 (1995)	1,344	Cf. KRB-B
KWG Grohnde NI	3,765 (1st partial building licence of 08.06.1976)	To 3,850 (modification licence of 09.02.1990, application of 27.06.1989) To 3,900 (modification licence of 29.06.1999, application of 13.06.1997)	1,365 (1984)	1,394 (1990) 1,430 (1995)	1,430	To 4,000 (application of 24.09.2007) The application was withdrawn in 2012.

Name of facility and site	Licensed thermal power at initial criticality [MW_{th}]	Thermal power increase [MW_{th}]	Electricity output (gross) in the year of initial criticality [MW_e]	Year of modification of electricity output	Current electrical gross power [MW_e]	Capacity increase applied for [MW_{th}]
KKE Lingen NI	3,765 (4th partial licence of 30.03.1988)	To 3,850 (1st modification and supplementing licence of 09.02.1990, application of 06.06.1989)	1,316 (1988)	1,314 (1988) 1,341 (1990) 1,363 (1992) 1,400 (08/2000)	1,400	To 3,950 (application of 16.12.2002) The application was withdrawn on 15.02.2013.
KBR Brokdorf SH	3,765 (1st partial operation licence of 30.12.1985)	To 3,850 (modification licence of 15.02.1994 to 2nd operation licence of 03.10.1986) To 3,900 (7th amending licence to 2nd operation licence of 23.05.2006, application of 16.12.2002)	1,380 (1986)	1,400 (1987) 1,395 (1988) 1,440 (1997) 1,480 (2008)	1,480	-

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 decommissioning
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 Brunsbüttel 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	Gross capacity [MW_e]	Start of construction	Initial criticality	Final shut-down	Status
KKR Rheinsberg BB	Energiewerke Nord GmbH	PWR	70	01/1960	11.03.1966	01.06.1990	Dismantling licence 28.04.1995 ff. Last licence of 04.09.2013
KNK II Eggenstein-Leopoldshafen BW	Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH	FBR	21	09/1974	10.10.1977	23.08.1991	Dismantling licence 26.08.1993 ff.
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 ff.
KWO Obrigheim BW	EnBW Kernkraft GmbH (EnKK)	PWR	357	03/1965	22.09.1968	11.05.2005	1st decommissioning licence 28.08.2008 2nd decommissioning 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 ff.
KGR 1 Lubmin MV	Energiewerke Nord GmbH	PWR	440	03/1970	03.12.1973	18.12.1990	Licence of 30.06.1995 ff. for decomm./dismantl. entire plant
KGR 2 Lubmin MV	Energiewerke Nord GmbH	PWR	440	03/1970	03.12.1974	14.02.1990	Licence of 30.06.1995 ff. for decomm./dismantl. entire plant
KGR 3 Lubmin MV	Energiewerke Nord GmbH	PWR	440	04/1972	06.10.1977	28.02.1990	Licence of 30.06.1995 ff. for decomm./dismantl. entire plant
KGR 4 Lubmin MV	Energiewerke Nord GmbH	PWR	440	04/1972	22.07.1979	02.06.1990	Licence of 30.06.1995 ff. for decomm./dismantl. entire plant

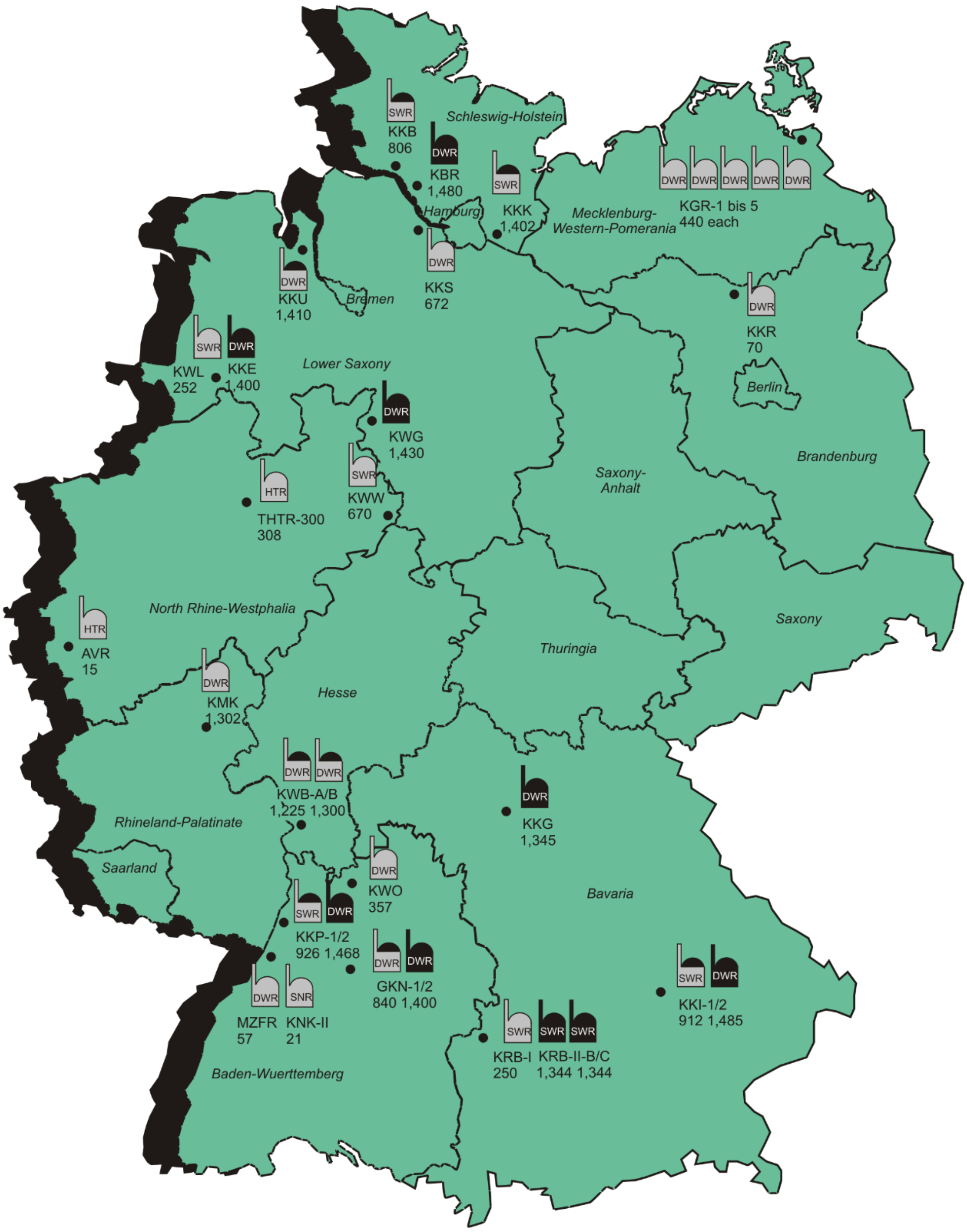
Name of facility and site	Operator	Type	Gross capacity [MW_e]	Start of construction	Initial criticality	Final shut-down	Status
KGR 5 **Lubmin** **MV**	Energiewerke Nord GmbH	PWR	440	12/1976	26.03.1989	30.11.1989	Licence of 30.06.1995 ff. for decomm./dismantl. entire plant
KKS **Stade** **NI**	Kernkraft Stade GmbH & Co. oHG	PWR	672	12/1967	08.01.1972	14.11.2003	Lic. decomm./dism. Phase 1 - 7.09.2005 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 on 21.11.1985; application for dismantling of 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 on 09.03.1994, lic. for complete dism. 31.03.2009, ÄG of 18.01.2013
KWW **Würgassen** **NW**	E.ON Kernkraft GmbH	BWR	670	01/1968	22.10.1971	26.08.1994	1st decommissioning licence 14.04.1997 ff.
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
KMK **Mülheim-Kärlich** **RP**	RWE Power AG	PWR	1,302	01/1975	01.03.1986	09.09.1988	Lic. decomm./dism. phase 1a 16.07.2004, supplement 23.02.2006, lic. for reducing the size of the premises 09.06.2009 dismantling licence 2a 33.05.2013

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

Name of facility and site	Operator	Type	Gross capacity [MW_e]	Start of construction	Initial criticality	Final shut-down	Status
SSR 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 plant projects

Name of facility and site	Operator	Type	Gross capacity [MW_e]	Start of construction	Status
KGR 6 **Lubmin** **MV**	Energiewerke Nord GmbH	PWR	440	1976	Final shut-down 30.11.1989 Licence of 30.06.1995 ff. for decomm./dismantl. entire plant
KGR 7 **Lubmin** **MV**	Energiewerke Nord GmbH	PWR	440	1976	Project stopped
KGR 8 **Lubmin** **MV**	Energiewerke Nord GmbH	PWR	440	1976	Project stopped
SNR 300 **Kalkar** **NW**	Schnell-Brüter-Kernkraftwerksgesellschaft mbH	FBR	327	1973	Project stopped 20.03.1991
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

In operation

Finally shut down

Under decommissioning

Figures: Gross capacity MWe

As of: 31 December 2013

Figure I: Nuclear power plants in the Federal Republic of Germany

Annex II – Research reactors

As of 31 December 2013

Table II.1: Research reactors in operation

Name of 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 (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, Laboratory for Radiation Measurement and Reactor Technology	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 Institut für Kernchemie	Pool, Triga Mark II	0.1	$4 \cdot 10^{12}$	03.08.1965	In operation
AKR-2 **Dresden** **SN**	Technische Universität Dresden, Institute for Energy Technology	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 facility and site	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Status
FRM Garching BY	Technische Universität München (TUM)	Pool, MTR	4	$7 \cdot 10^{13}$	31.10.1957	28.07.2000	Application for decommissioning of 14.12.1998
SUR Hannover Hannover NI	Leibniz Universität Hannover, Institute of Nuclear Engineering and Non-Destructive Testing	Siemens Training Reactor	$1 \cdot 10^{-7}$	$6 \cdot 10^{6}$	09.12.1971	Since 2008 free from nuclear fuel	Application for decommissioning of 22.10.2013
SUR Aachen Aachen NW	Rheinisch-Westfälische Technische Hochschule (RWTH)	Siemens Training Reactor	$1 \cdot 10^{-7}$	$6 \cdot 10^{6}$	22.09.1965	In 2002	Application for decommissioning of 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 shut-down on 28.06.2010	Application 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 remaining plant components of FRG-2 of 21.03.2013

Table II.3: Research reactors under decommissioning

Name of facility and site	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Status
FR 2 Eggenstein-Leopoldshafen BW	Wiederaufarbeitungs-anlage Karlsruhe Rückbau- und Entsorgungs-GmbH	Tank type D_2O reactor	44	$1 \cdot 10^{14}$	07.03.1961	21.12.1981	Decommissioning licence of 03.07.1986 ff., Safe Enclosure since 20.11.1996
FRN Oberschleißheim BY	Helmholtz Zentrum München, German Research Center for Environmental Helath 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 GmbH (FZJ)	Tank type D_2O reactor	23	$2 \cdot 10^{14}$	14.11.1962	02.05.2006	Decomm. licence of 20.09.2012
RFR Rossendorf SN	Verein für Kernforschungs-technik und Analytik Rossendorf (VKTA)	Tank type WWR-S(M)	10	$1 \cdot 10^{14}$	16.12.1957	27.06.1991	Decommissioning licence of 30.01.1998 ff., final partial licence for residual dismantling of 01.02.2005

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

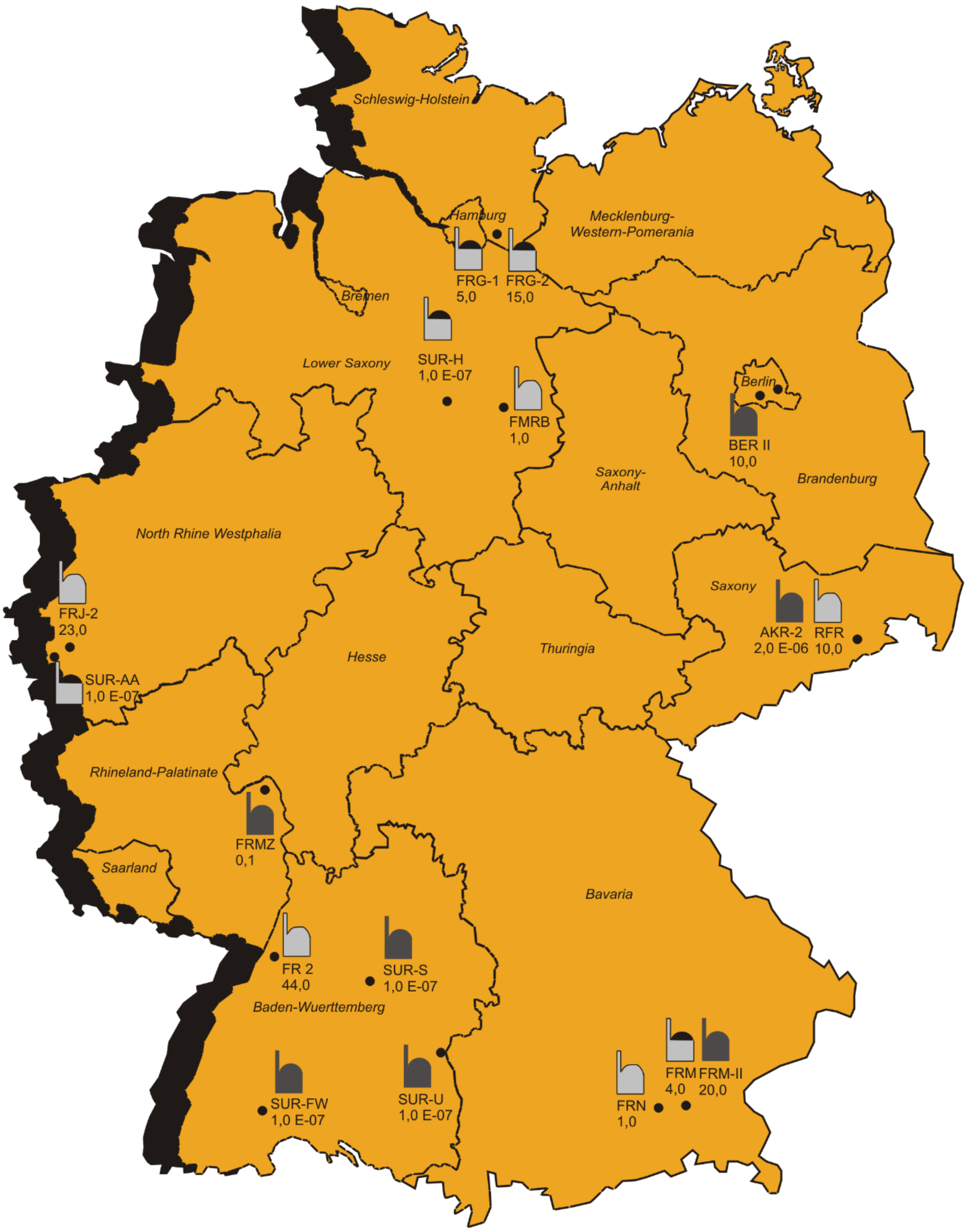
Name of facility and site	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Status
TRIGA HD I Heidelberg BW	German Cancer Research Center (DKFZ)	Pool, Triga Mark I	0.25	$1\cdot10^{13}$	26.08.1966	31.03.1977	Released from regulatory control 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 Center (DKFZ)	Pool TRIGA Mark I	0.25	$1\cdot10^{13}$	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	$3\cdot10^{13}$ (designed)	No Criticality	Not operated	Released from regulatory control on 31.10.2006
FRH Hannover NI	Hannover Medical School	Pool TRIGA Mark I	0.25	$9\cdot10^{12}$	31.01.1973	18.12.1996	Released from regulatory control on 13.03.2008
FRJ-1 (MERLIN) Jülich NW	Forschungszentrum Jülich GmbH (FZJ)	Pool MTR	10	$1\cdot10^{14}$	24.02.1962	22.03.1985	Released from regulatory control on 23.11.2007
OH Geesthacht SH	Helmholtz-Zentrum Geesthacht - Centre for Materials and Coastal Research GmbH	FDR Ship reactor	38	$3\cdot10^{13}$	26.08.1968	22.03.1979	Released from regulatory control on 01.09.1982, storage of reactor pressure vessel according to StrlSchV

Table II.4 b: Research reactors entirely decommissioned and released from regulatory control (continuous thermal power 50 kW_{th} or below)

Name of facility and site	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Decommissioning completed
BER I Berlin BE	Helmholtz-Zentrum Berlin für Materialien und Energie	Homogeneous reactor	$5 \cdot 10^{-2}$	$2 \cdot 10^{12}$	24.07.1958	Summer 1972	23.04.1974
SUR Berlin Berlin BE	Technische Universität Berlin	Siemens Training Reactor	$1 \cdot 10^{-7}$	$5 \cdot 10^{6}$	26.07.1963	15.10.2007	16.04.2013
SNEAK Eggenstein-Leopoldshafen BW	Karlsruhe Research Center	Homogeneous reactor	$1 \cdot 10^{-3}$	$7 \cdot 10^{6}$	15.12.1966	11/1985	06.05.1987 (notice of assessment)
SUAK Eggenstein-Leopoldshafen BW	Karlsruhe Research Center	Fast sub-critical system	No capacity		Taken into operation 20.11.1964	07.12.1978	
STARK Eggenstein-Leopoldshafen BW	Karlsruhe Research Center	Argonaut	$1 \cdot 10^{-5}$	$1 \cdot 10^{8}$	11.01.1963	03/1976	1977
SUR Karlsruhe Eggenstein-Leopoldshafen BW	Karlsruhe Research Center	SUR-100	$1 \cdot 10^{-7}$	$6 \cdot 10^{6}$	07.03.1966	09/1996	26.06.1998
AEG Zero Energy Reactor Karlstein BY	Kraftwerk Union	Tank type/critical system	$1 \cdot 10^{-4}$	$1 \cdot 10^{8}$	23.06.1967	1973	21.12.1981
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
SAR Garching BY	Technische Universität München	Argonaut	$1 \cdot 10^{-3}$	$2 \cdot 10^{11}$	23.06.1959	31.10.1968	20.03.1998

Name of facility and site	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Decommissioning completed
SUA München Garching BY	Technische Universität München	Sub-critical Assembly	No capacity		Taken into operation 06/1959	1968	20.03.1998
SUR München Garching BY	Technische Universität München	SUR-100	$1\cdot10^{-7}$	$6\cdot10^{6}$	28.02.1962	10.08.1981	20.03.1998
SUR Bremen Bremen HB	Hochschule Bremen	SUR-100	$1\cdot10^{-7}$	$6\cdot10^{6}$	10.10.1967	17.06.1993	03/2000
SUR Hamburg Hamburg HH	Fachhochschule Hamburg	SUR-100	$1\cdot10^{-7}$	$6\cdot10^{6}$	15.01.1965	08/1992	12/1999
FRF 1 Frankfurt HE	Johann Wolfgang Goethe Universität Frankfurt	Homoge-neous reactor	$5\cdot10^{-2}$	$1\cdot10^{12}$	10.01.1958	19.03.1968	31.10.2006 Released from regulatory control
SUR Darmstadt Darmstadt HE	Technische Hochschule Darmstadt	SUR-100	$1\cdot10^{-7}$	$6\cdot10^{6}$	23.09.1963	22.02.1985	29.11.1996
ADIBKA Jülich NW	Jülich Forschungszentrum	Homoge-neous reactor	$1\cdot10^{-4}$	$3\cdot10^{8}$	18.03.1967	30.10.1972	End of 1977
KAHTER Jülich NW	Jülich Forschungszentrum	Critical Assembly	$1\cdot10^{-4}$	$2\cdot10^{8}$	02.07.1973	03.02.1984	06/1988
KEITER Jülich NW	Jülich Forschungszentrum	Critical Assembly	$1\cdot10^{-6}$	$2\cdot10^{7}$	15.06.1971	1982	06/1988
ANEX Geesthacht SH	Helmholtz-Zentrum Geesthacht - Centre for Materials and Coastal Research GmbH	Critical Assembly	$1\cdot10^{-4}$	$2\cdot10^{8}$	05/1964	05.02.1975	01/1980
SUR Kiel Kiel SH	Fachhochschule Kiel	SUR-100	$1\cdot10^{-7}$	$6\cdot10^{6}$	29.03.1966	11.12.1997	02.04.2008 Released from regulatory control

Name of facility and site	Operator	Type	Thermal power [MW_{th}]	Thermal neutron flux [$cm^{-2}s^{-1}$]	Initial criticality	Out of operation	Decommissioning completed
RAKE Rossendorf SN	Verein für Kernverfahrenstechnik und Analytik Rossendorf e.V. (VKTA)	Tank type/critical assembly	$1\cdot10^{-5}$	$1\cdot10^{8}$	03.10.1969	26.11.1991	28.10.1998 Released from regulatory control
RRR Rossendorf SN	Verein für Kernverfahrenstechnik und Analytik Rossendorf e.V. (VKTA)	Argonaut	$1\cdot10^{-3}$	$2\cdot10^{11}$	16.12.1962	25.09.1991	11.05.2000 Released from regulatory control
ZLFR Zittau SN	Hochschule Zittau/Görlitz Fachbereich Maschinenwesen	Tank type WWR-M	$1\cdot10^{-5}$	$2\cdot10^{8}$	25.05.1979	24.03.2005	03.05.2006 Released from regulatory control



Legend

In operation

Finally shut down

Under decommissioning

Figures: Thermal capacity in MW

As of: 31 December 2013

Figure II: Research reactors in the Federal Republic of Germany

Annex III – Plants of nuclear fuel supply and waste management

As of 31 December 2013

Table III.1: Uranium enrichment plants

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
GRONAU Uranium enrichment plant (UAG) **NW**	Uranium enrichment	4,500 Mg of uranium separative work per year (SW/y) according to 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, 2. modification licence for 2 further separating halls, Notification no. 7/6 of 14.02.2005 on increase of production capacity to 4,500 Mg of 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 middle of 2008 and is commissioned gradually. The plant is operated with a nominal capacity of 4,500 Mg SW/a. Construction of a storage hall for 50,000 Mg U_3O_8 was taken up in 2011.

Table III.2: Fuel element fabrication plants

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
ANF fuel element fabrication plant Lingen NI	Fabrication of mainly LWR fuel elements of low-enriched uranium dioxide	Handling and processing of annually altogether 800 Mg of uranium in the form of uranium powder or uranium pellets with up to 5 % U-235-fraction	Operation licence of 18.01.1979, 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/a 02.12.2009: Capacity increase to 800 Mg/a	ANF stores on its 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 decommissioning or released from regulatory control)

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
SIEMENS fuel element fabrication plant, plant section Karlstein BY	Fabrication of fuel elements of low-enriched uranium dioxide	Annual throughput of 400 Mg of UO_2 up to max. 4.0 % U-235 fraction	Operation licence according to § 9 AtG: 02.09.1966 Operation licence according to § 7 AtG: 30.12.1977 Licence according to § 7 AtG for dismantling of plant components: 16.08.1994 and 18.03.1996 Released from regulatory control March 1999	Fuel element fabrication has been discontinued; conventional fabrication of ends
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/a, expansion to 120 Mg of HM/a 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 acc. to § 7 AtG of 12.03.1991 Several partial licences for removing the fuel from the production line and dismantling of the plant for MOX fuel from 1997 to 2005 Released from regulatory control Sept. 2006	In April 1994, the operator decided to not re-commission the old plant. The fabrication facilities have been dismantled. Government custody has been terminated. Dismantling work completed in July 2006.
SIEMENS fuel element fabrication plant Hanau Plant section: Uranium processing HE	Fabrication of LWR fuel elements of low-enriched uranium	Throughput 1,350 Mg U/a	Operation licence according to § 9 AtG: 22.07.1969 Operation licence according to § 7 AtG: 31.08.1990 Several individual and partial licences for removing the fuel of the production line and for dismantling the facility from 1996 to 2001 Released from regulatory control May 2006	Fabrication of uranium fuel elements stopped in October 1995. Dismantling work incl. remediation of the premises was completed in January 2006. Groundwater decontamination still continues (licence according to § 7 StrlSchV).

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
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 and 2001 Released form 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; by 31.12.1988 the fuel was removed from the production line Dismantling works and soil remediation have been completed. Groundwater remediation is still continuing.
Hochtemperatur-Brennelement-Gesellschaft (HOBEG) Hanau HE	Fabrication of ball-shaped fuel elements for HTR on the basis of uranium (up to 94 % of uranium-235) and thorium	200,000 fuel elements/a 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. On 18.12.1995 released from regulatory control.	The facility was temporarily taken out of operation on 15 January 1988, and was decommissioned later on. The components relating to process engineering were dismantled. Decontamination of premises and building has been completed. Premises and buildings are used by Nuclear Cargo & Service GmbH.

Table III.4: Central fuel element interim storage facilities

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
Transport cask storage facility in the interim storage facility North (ZLN) Rubenow (near Greifswald) MV	Storage of spent fuel elements from the Rheinsberg and Greifswald reactors in transport and storage casks (dry storage).	585.4 Mg HM in max. 80 storage casks Max. storable activity: $7.5 \cdot 10^{18}$ Bq	According to § 6 AtG of 05.11.1999 1st modification of 14.03.2001, 2nd modification of 7.07.2003 3rd 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 31.12.2013, 74 casks were stored in the ZLN: - 62 CASTOR® 440/84 - 3 CASTOR® KRB-MOX - 4 CASTOR® KNK. - 5 CASTOR® HAW 20/28 CG.
Gorleben Transport Cask Storage Facility (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	05.09.1983 according to § 6 AtG; order for immediate enforcement of 06.09.1988 New licence of 02.06.1995 for spent fuel elements and vitrified fission product solutions 1st modification of 01.12.2000 2nd modification of 18.01.2002 3rd modification of 23. 05.2007 4th modification of 29.01.2010	On 31.12.2013, altogether 113 casks were stored in the TBL-G, - 5 casks with spent fuel elements, of which - 1 CASTOR® Ic - 1 CASTOR® IIa - 3 CASTOR® V/19 and 108 casks with HAW vitrified waste block canisters, of which - 1 TS 28 V - 74 CASTOR® HAW 20/28 CG - 21 CASTOR® HAW28M - 12 TN85.

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
Ahaus Transport Cask Storage 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), Capacity up to altogether max. 3,960 Mg HM Max. storable activity: $2{\cdot}10^{20}$ Bq	10.04.1987 acc. to § 6 AtG Amended version of the storage licence of 07.11.1997 (increase of the mass of heavy metal and licence for further cask types) 1st modification of 17.05.2000, 2nd modification of 24.04.2001, 3rd 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 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 facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
On-site interim storage facility Neckarwestheim Gemmrigheim BW	Storage of spent fuel elements from units GKN 1 and GKN 2 of the Neckar Joint NPP	1,600 Mg of heavy metal in up to 151 transport and storage casks with up to $8.3 \cdot 10^{19}$ Bq activity and 3.5 MW heat release	According to § 6 AtG of 22.09.2003 1st modification of 22.03.2006 2nd modification of 28.09.2006 1st supplement of 03.09.2007 2nd supplement of 18.02.2010 3th modification of 11.05.2010 4th modification of 13.12.2013	Start of construction 17.11.2003 First emplacement 06.12.2006 At the end of 2013 41 casks were stored in the interim storage facility
On-site interim storage facility Philippsburg BW	Storage of spent fuel elements from unit 1 and unit 2 of the Philippsburg NPP	1,600 Mg of heavy metal in up to 152 transport and storage casks with up to $1.5 \cdot 10^{20}$ Bq activity and 6.0 MW heat release	According to § 6 AtG of 19.12.2003 1st modification of 05.10.2006 2nd modification of 21.12.2006	Start of construction 17.05.2004 First emplacement 19.03.2007 At the end of 2013 36 casks were stored in the interim storage facility
Interim storage facility Obrigheim NPP BW	Storage of spent fuel elements and core components from the Obrigheim NPP (wet storage)	980 fuel elements (ca. 286 Mg HM)	26.10. 1998 acc. to § 7 AtG	Since the end of 2007 342 fuel elements have been in the fuel pool
On-site interim storage facility Grafenrheinfeld BY	Storage of spent fuel elements from the Grafenrheinfeld NPP	800 Mg of heavy metal in up to 88 transport and storage casks with up to $5 \cdot 10^{19}$ Bq activity and 3.5 MW heat release	According to § 6 AtG of 12.02.2003 Order for immediate enforcement of 10.09.2003 1st modification of 31.07.2007 2nd modification of 06.10.2011 3rd modification of 03.11.2011	Start of construction 22.09.2003 First emplacement 27.02.2006 At the end of 2013 21 casks were stored in the interim storage facility
On-site interim storage facility Gundremmingen BY	Storage of spent fuel elements from units B and C of the Gundremmingen NPP	1,850 Mg of heavy metal in up to 192 transport and storage casks with up to $2.4 \cdot 10^{20}$ Bq activity and 6.0 MW heat release	According to § 6 AtG of 19.12.2003 Order for immediate enforcement of 28.07.2004 1st modification of 02.06.2006	Start of construction 23.08.2004 First emplacement 25.08.2006 At the end of 2013 41 casks were stored in the interim storage facility

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
On-site interim storage facility Isar Niederaichbach BY	Storage of spent fuel elements from Isar 1 and Isar 2 NPPs	1,500 Mg of heavy metal in up to 152 transport and storage casks with up to $1.5 \cdot 10^{20}$ Bq activity and 6.0 MW heat release	According to § 6 AtG of 22.09.2003 Order for immediate enforcement of 28.05.2004 1st modification of 11.01.2007 2nd modification of 29.02.2008 3rd 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 2013 31 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 of heavy metal in up to 135 transport and storage casks with up to $8.5 \cdot 10^{19}$ Bq activity and 5.3 MW heat release	According to § 6 AtG of 22.09.2003 1st modification of 20.10.2005 1st supplement of 20.03.2006 2nd modification of 27.03.2006	Start of construction 01.03.2004 First emplacement 18.05.2006 At the end of 2013 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 of heavy metal in up to 100 transport and storage casks with up to $5.5 \cdot 10^{19}$ Bq activity and 3.75 MW heat release	According to § 6 AtG of 20.12.2002 Order for immediate enforcement of 19.09.2005 1st modification of 17.04.2007 2nd modification of 23.05.2012 3rd modification of 25.06.2012	Start of construction 10.11.2003 First emplacement 27.04.2006 At the end of 2013 22 casks were stored in the interim storage facility
On-site interim storage facility Lingen (Emsland) Bramsche (near Lingen) NI	Storage of spent fuel elements from the Emsland NPP	1,250 Mg of heavy metal in up to 125 transport and storage casks with up to $6.9 \cdot 10^{19}$ Bq activity and 4.7 MW heat release	According to § 6 AtG of 06.11.2002 with order for immediate enforcement 1st supplement of 31.07.2007 1st modification of 01.02.2008	Start of construction 18.10.2000 First emplacement 10.12.2002 At the end of 2013, 32 casks were stored in the interim storage facility
On-site interim storage facility Unterweser Rodenkirchen NI	Storage of spent fuel elements from the Unterweser NPP	800 Mg of heavy metal in up to 80 transport and storage casks with up to $4.4 \cdot 10^{19}$ Bq activity and 3.0 MW heat release	According to § 6 AtG of 22.09.2003 Order for immediate enforcement of 05.02.2007 1st modification of 27.05.2008 2nd modification of 05.01.2012 3rd modification of 18.12.2012	Start of construction 19.01.2004 First emplacement 18.06.2007 At the end of 2013 8 casks were stored in the interim storage facility

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
AVR cask storage facility in the FZJ Jülich NW	Storage of spent AVR fuel elements in transport and storage casks of the CASTOR® type	Up to 300,000 AVR fuel elements in max. 158 CASTOR® THTR/AVR casks	Notification according to § 6 AtG of 17.06.1993 1st modification of 27.04.1995 2nd modification of 07.07.2005	Since 2009, 152 casks of the CASTOR® THTR/AVR type have been stored in the interim storage facility.
On-site interim storage facility Krümmel Krümmel (near Geesthacht) SH	Storage of spent fuel elements from the Krümmel NPP	775 Mg of heavy metal in up to 80 transport and storage casks with up to $9.6 \cdot 10^{19}$ Bq activity and 3.0 MW heat release	According to § 6 AtG of 19.12.2003 1st modification of 16.11.2005 Order for immediate enforcement of 28.04.2006 2nd modification of 17.10.2007	Start of construction 23.04.2004 First emplacement 14.11.2006 At the end of 2013 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 of heavy metal in up to 100 transport and storage casks with up to $5.5 \cdot 10^{19}$ Bq activity and 3.75 MW heat release	According to § 6 AtG of 28.11.2003 1st modification of 24.05.2007 2nd modification of 19.07.2012 3rd modification of 29.08.2012	Start of construction 05.04.2004 First emplacement 05.03.2007 At the end of 2013 21 casks were stored in the interim storage facility
On-site interim storage facility Brunsbüttel SH	Storage of spent fuel elements from the Brunsbüttel NPP	450 Mg of heavy metal in up to 80 transport and storage casks with up to $6.0 \cdot 10^{19}$ Bq activity and 2.0 MW heat release	According to § 6 AtG of 28.11.2003 Order for immediate enforcement of 28.10.2005 1st modification of 14.03.2008	Start of construction 07.10.2003 First emplacement 05.02.2006 At the end of 2013, 9 casks were stored in the interim storage facility

Table III.6: External waste interim storage facilities

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
Hauptabteilung Dekontaminations-betriebe (HDB) **BW**	Interim storage of waste with negligible heat generation, interim storage of heat-generating waste incl. waste produced by some clients	1st : 9,684 m^3; 2nd : 9,750 lost concrete shieldings and 8,076 containers; 3rd : 2,600 drums (corresponding to 77,424 m^3 & 1,240 m^3)	Licence for use and manipulation according to § 9 AtG of 25 November 1983, replaced by licence according to § 9 AtG of 29 June 2009	In operation since December 1964.
Collecting depot of the Mitterteich utilities **BY**	Interim storage of waste with negligible heat generation from Bavarian nuclear facilities	40,000 waste packages (200-l, 400-l, or cast-iron casks)	Licences for use and manipulation according to § 3 StrlSchV of 07.07.1982	In operation since July 1987.
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	Max. ten years starting at the beginning of emplacement
NCS interim storage facility **Hanau** **HE**	Interim storage of waste with negligible heat generation mainly produced by the nuclear industry	1,250 Konrad containers (KC) and 800 m^2 utility space	Licence for use and manipulation according to § 7 StrlSchV of 09.11.2009 Licence for use and manipulation according to § 3 StrlSchV of 17.05.2000	
Interim storage facility North (ZLN) **Rubenow** **MV**	Interim storage of operational and decommissioning waste of the Greifswald and Rheinsberg NPPs with interim storage of the dismantled large components	165,000 m^3	Licence for use and manipulation according to § 3 StrlSchV of 20.02.1998	In operation since March 1998. Since 11.12.2007 the ZLN is licencee of storage of radioactive substances from other nuclear facilities with LWR with five years prior to and after a treatment/conditioning each.
Waste storage facility Esenshamm **NI**	Storage of waste with negligible heat generation from the Unterweser and Stade NPPs	200-l and 400-l drums, concrete casks, steel-plate casks, concrete containers, cast-iron casks with a total activity of up to $1.85 \cdot 10^{15}$ Bq	Licences for use and manipulation according to § 3 StrlSchV of 24.06.1981, 29.11.1991, and 06.11.1998	In operation since autumn of 1981.

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
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, possibly with lost concrete shielding, type-III concrete casks, type-I-II cast-iron casks, type-I-IV casks with a total activity of up to $5 \cdot 10^{18}$ Bq	Licences for use and manipulation according to § 3 StrlSchV of 27.10.1983, 13.10.1987, and 13.09.1995	In operation since October 1984.
Ahaus Transport Cask Storage Facility (TBL-A) **NW**	Interim storage of other radioactive substances in the scope of a combined utilisation of the TBL-A	Up to a total activity of $1 \cdot 10^{17}$ Bq	Licence for use and manipulation according to § 7 StrlSchV of 09.11.2009	Max. ten years starting at the beginning of emplacement

Table III.7: Reprocessing plants

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
Karlsruhe Reprocessing Plant (WAK) **Eggenstein-Leopoldshafen** **BW**	Experimental plant for reprocessing and technology development	0.175 Mg HM/day; ca. 40 Mg UO_2/a	Operation WAK: 1st partial operation licence according to § 7 AtG of 02.01.1967 Decommissioning WAK: 1st decommissioning licence, March 1993 21st decommissioning licence and dismantling of the WAK (step 4) of 23.04.2010 for deregulation after end of vitrification 22nd decommissioning licence acc. to § 7 AtG of 08.12.2010 for remote-handled dismounting of the HAWC storage casks in the HWL and in the LAVA. 23rd decommissioning licence of 14.12.2011 for the dismounting of the LAVA high-active laboratory and the LAVA (hot) cells. Operation VEK: 1st partial operating licence (TBG) for the VEK of 20.12.2005 (inactive commissioning) 2nd partial operating licence for the VEK of 24.02.2009 (nuclear [hot] commissioning)	The plant was in operation from 1971 to 1990. During this period approximately 200 Mg of nuclear fuels originating from test and power reactors were reprocessed. Decommissioning and dismantling with the objective of “Greenfield” until 2023 have made progress. The major part of the equipment of the process building has been removed. Dismantling of the MAW collecting containers concluded in 2011. A vitrification plant (VEK) for 60 m^3 of HAWC was constructed and operated until November 2010. The HAWC was entirely vitrified, producing 140 vitrified waste block canisters (56 Mg), which were packed into 5 transport and storage casks of the CASTOR HAW 20/28 type. Since February 2011, the CASTOR casks have been stored in the Interim Storage Facility North of the EWN GmbH. Thus essential prerequisites have been created for the dismantling of the VEK and the HAWC storage facilities.

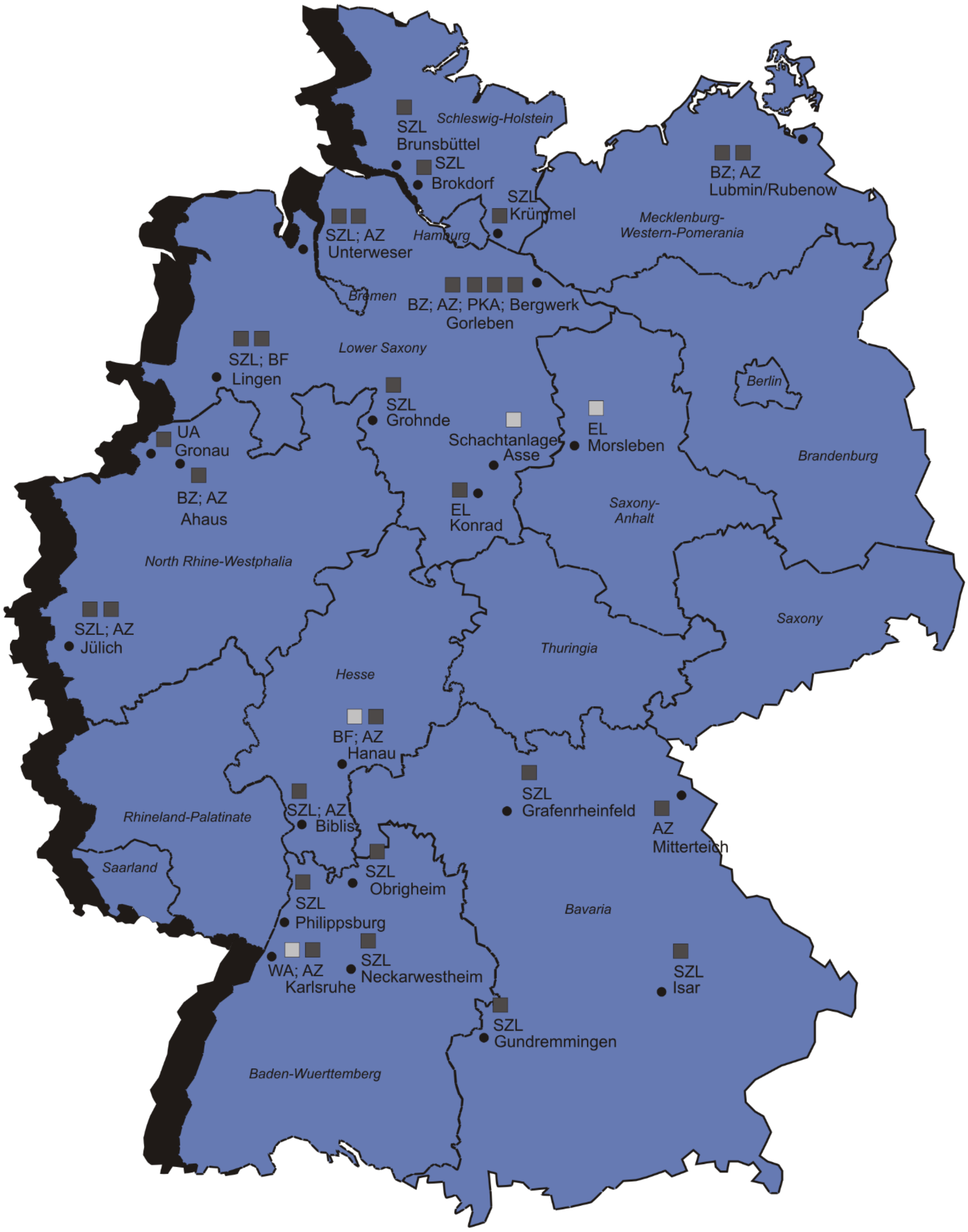
Table III.8: Conditioning plants for fuel elements

Name of facility and site	Purpose of the facility	Capacity according to licence	Licence	Notes
Pilot conditioning plant (PKA) **Gorleben** **NI**	Repair of defective casks, conditioning of radioactive residues and waste (among others, spent fuel elements, fuel rods and fuel element mounting parts) for interim storage and disposal	Heavy metal throughput applied for: 35 Mg/a Capacity of operational buffer storage facility: 12 Mg HM	Acc. to § 7 AtG 1st partial licence of 30.01.1990 2nd partial licence of 21.07.1994 (Subsequently imposed obligation of 18.12.2001) 3rd partial licence: 19.12.2000 (includes operation licence)	According to the 3rd partial licence the use of the plant is at first restricted to the repair of defective storage casks. An additional requirement to the 2nd partial licence ensures that one is ready to accept defective casks at any time.

Table III.9: Disposal and decommissioning projects

Name of 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 acc.to § 9b AtG was filed in 1977. The mine is kept operable on the basis of the approved main operating plan (effective until 30.09.2014) and the overall operating plan (effective until 30.09.2020). The mining exploration of the Gorleben salt dome was officially terminated when the StandAG entered into force (cf. Chapter 4.7.1).	The geological host rock formation is rock salt.
Konrad repository **Salzgitter** **NI**	Disposal of radioactive waste with negligible heat generation		Application according to § 9b AtG in 1982 (plan-approval application) Withdrawal of 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) undeneath an impermeable barrier of the Cretaceous.

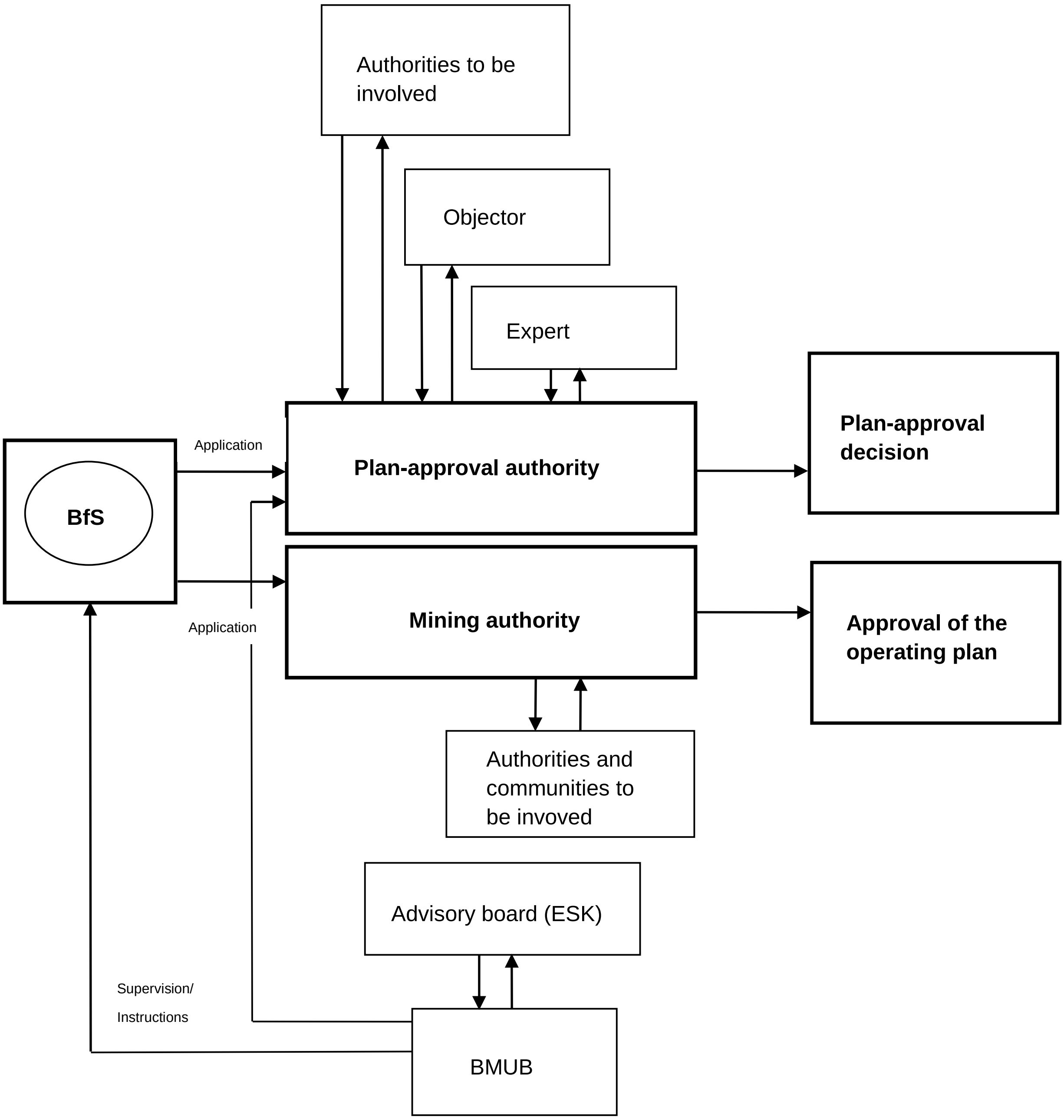
Name of facility and site	Purpose of the facility	Amounts disposed of / activity	Licence	Notes
ASSE II mine Remlingen NI	Research and development work for the disposal of radioactive and chemico-toxic waste, Disposal of low-level and intermediate-level radioactive waste	Between 1967 and 1978 ca. 124,500 LAW and ca. 1,300 MAW waste packages were emplaced. According to current knowledge, total activity $2.89 \cdot 10^{15}$ Bq (01.01.2010), 20 % of which are contained in the MAW packages	Licences according to § 3 StrlSchV as amended on 15.10.1965. Storage licences for nuclear fuels according to § 6 AtG. Licence acc. 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.	The geological host rock formation is rock salt. Since 1 January 2009, the BfS has been the operator of the Asse II mine. Conversion into operation according to Atomic Energy Act. Since the “Lex Asse” became effective in April 2013, the radioactive waste is to be retrieved before the Asse II mine will be decommissioned immediately, as long as this is not safety-relevant.
MORSLEBEN repository for radioactive waste (ERAM) ST	Disposal of low-level and medium-level radioactive waste with mainly short-lived radionuclides	Disposal of altogether 36,753 m^3 of low-level and intermediate-level radioactive waste, total activity of all radioactive waste stored is in the order of magnitude of 1.10^{14}, the activity of the alpha-emitters is in the order of magnitude of 10^{11} Bq. 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 (DBG) granted. According to § 57a AtG it continued to be effective until 30.06.2005; through amendment to the AtG in 2002, the DBG is effective for an unlimited period of time as plan-approval decision, except for the regulations relating to the acceptance of further radioactive waste or its emplacement for the purpose of disposal. 12.04.2001: Declaration of 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. 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	Interim storage facility for rad. waste	PKA	Pilot conditioning plant
BF	Fuel element fabrication plant	SZL	On-site interim storage facility
BZ	Central interim storage facility for spent fuel elements	UA	Uranium enrichment plant
WA	Reprocessing plant		
EL	Radioactive waste repository		
		■	In operation / planned
As of:	31 December 2013	□	Under decommissioning

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



Legend:

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

Fig. III.2: Course of the nuclear plan-approval (licensing) procedure and the procedures according to Mining Law

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

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

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Berg, H.P.; Schott, H.
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Kontakt:
Bundesamt für Strahlenschutz
Postfach 10 01 49
38201 Salzgitter
Telefon: + 49 (0)3018 333 0
Telefax: + 49 (0)3018 333 1885
Internet: www.bfs.de
E-Mail: ePost@bfs.de
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