GERMANY

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1. ENERGY, ECONOMICS AND ELECTRICITY INFORMATION

1.1. General Overview

The Federal Republic of Germany is situated in central Europe, in the north bordering on the North Sea, Denmark and the Baltic Sea, in the east on Poland and the Czech Republic, in the south on Austria and Switzerland and in the west on France, Luxembourg, Belgium and the Netherlands.

The climate is moderate and influenced mainly by winds from the West, the eastern part has more continental character. In the lowlands of the northern part the average July temperature is 16 - 18°C, the average precipitation amounting to 600 - 750 mm per annum. Half of the territory is used for agricultural purpose, one third is covered by woods, 12 % are taken by settlements and traffic area.

As a result of World War II Germany was split. Until 1990 two parts named Germany existed, the Federal Republic of Germany (FRG - *Bundesrepublik Deutschland*, hereafter referred to as West Germany) and the German Democratic Republic (GDR - *Deutsche Demokratische Republik*, known as East Germany). In October 1990, the GDR joined West Germany. Germany is a federal republic. This means, that unless otherwise specified, the execution of federal laws lies within the responsibility of the federal states, the 16 *Länder*.

After the reunification Berlin again became capital of Germany. Part of the Government, however, still remains in the former (provisional) capital Bonn. Area and population development is shown in Table 1 (for the country map see Figure 2).

TABLE 1: POPULATION INFORMATION

	1960	1970	1980	1991	2000	2001	2002	Average annual growth rate (%) 1980 to 2000
Population (millions)	55.4 (17.2)	60.7 (17.1)	61.1 (16.7)	80.3	82.3	82.4	82.5	0.25
Population density (inh./km²)	226 (164)	248 (163)	252 (159)	230	235	235	236	
Urban population (% of total)					82.8			
Land Area (1000 km²)	349.5							

Numbers in brackets refer to data from the former GDR.
Source: Country Information

The gross domestic product (GDP) statistics are given in Table 2. Reunification has turned out to be a lengthy and difficult process. Germany has to fund improvements in infrastructure, environment, and industry in the eastern part, while many eastern companies collapsed acting in the unaccustomed western competition.

Germany imported 62 % of its primary energy supply in 2001, including oil, which accounts for nearly 40 % of its energy consumption. There are substantial reserves of both hard coal and lignite, the amount in place is about 5 times the recoverable quantities mentioned in Table 3. However, domestic hard coal is much more expensive than imported coal and expansion of open cast lignite mining is limited by environmental considerations. Hydro energy anyway contributes only a small amount, and possible sites are already in use, so there are no considerable reserves left. Uranium extraction has tapered off since 1991 and has more or less stopped by now. Energy statistics are given in Table 4.

TABLE 2: GROSS DOMESTIC PRODUCT (GDP)

	1960	1970	1980	1991	2000 [1)]	2001 [1)]	2002 [1)]
GDP (millions of current €)	154,800 (-)	345,300 (-)	752,600 (-)	1,502,200	2,030,000	2,073,700	2,110,400
GDP (millions of current US$)		185,200 (40,063)	810,600 (134,301)	1,769,800	1,870,300	1,857,200	1,995,600
GDP per capita (current US$/capita)		3,051 (2,343)	13,159 (8,042)	22,040	22,730	22,540	24,190
GDP by sector (%)							
Agriculture	8.1 (-)	4.7 (-)	2.9 (-)	1.7	1.2	N/A	1.1
Industry	65.5 (-)	68.1 (-)	65.2 (-)	45.5	29.8	N/A	28.8
Services	26.4 (-)	27.2 (-)	31.9 (-)	52.8	69	N/A	70.1

1) preliminary data
Source: Country Information

1.2. Energy Policy

Since the 1970s, a central intention of the German energy policy has been to shift electricity production away from imported oil and gas towards (previously domestic) coal and nuclear power. The share of oil and gas in electricity production was reduced from the peak of 30 % in 1975 to 9 % in 2002, while during the same period the share of nuclear has grown from 9 % to 31 %, whereas that of coal (hard coal 22 % and lignite 29 %) has remained at around 50 %. Since the 1990s all Federal Governments promoted the utilization of renewable energies. The utilities are required by law to buy electricity generated by independent producers using renewables. In comparison with the generation price of nuclear or coal plants rather high minimum payments to the small producers are guaranteed. Also direct government subsidies for the construction of wind and photovoltaic generators are granted. In 2002, the share of electricity production from renewables comes up to 9 % - Hydro already makes 5 %, Wind another 3.5 % - and it is intended to double this share by the year 2010. Nevertheless, in the medium-term large scale electricity production will continue to come from Germany's coal and nuclear power plants.

In the past, the Federal Government encouraged the utilities to increasingly use domestic hard coal for electricity generation, this rose up to 45 million tons of hard coal per year in 1995. Subsidies were paid by the Government and amounted to € 5000 million per annum in 1994, but will be reduced continuously to € 2700 million per annum in 2005. Lignite production in Germany is not subsidized, nevertheless it accounts for nearly one third of the electricity production.

To comply with environmental regulations since the mid 1980s, German utilities implemented state of the art technologies to reduce emissions from electricity generation through coal. Also they invested in underground transmission networks. Both influenced company costs and electricity prices.

The current Federal Government (since September 1998) decided to phase out the use of nuclear power for commercial electricity production (see chapter 4).

TABLE 3: ESTIMATED RECOVERABLE ENERGY RESERVES IN 2000

	Solid	Liquid	Gas	Uranium	Hydro [1)]	Total
Total amount in place (EJ)	1,052	2.3	10.3	0	0.8	1,065

1) For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability (World Energy Council – 1998) by a factor of 10
Source: Country Information

TABLE 4: ENERGY STATISTICS

	1960	1970	1980	1991	2000	2001 [1]	2002 [1]	Annual growth rate (%) 1980 to 2000
Energy consumption (EJ)								
- Total [2]	6.3 (2.9)	9.9 (3.1)	11.6 (3.8)	14.61	14.36	14.59	14.29	- 0.4
- Solids [3]	4.9 (2.8)	4.0 (2.6)	3.5 (2.5)	4.84	3.56	3.56	3.54	- 2.7
- Liquids	1.3 (0.1)	5.1 (0.4)	5.4 (0.8)	5.55	5.50	5.58	5.36	- 0.6
- Gases	N/A	0.6 (0.0)	2.1 (0.3)	2.43	3.03	3.15	3.14	+ 1.2
- Nuclear	0.0 (0.0)	0.03 (0.01)	0.45 (0.13)	1.61	1.85	1.87	1.80	+ 6.0
- Hydro + Wind	N/A	N/A	N/A	0.05	0.12	0.12	0.15	N/A
- Others [4]	0.2 (0.0)	0.3 (0.0)	0.2 (0.0)	0.13	0.30	0.31	0.30	N/A
Energy production (EJ)								
- Total	5.7 (2.6)	5.4 (2.3)	5.3 (2.5)	6.97	5.61	5.57	5.55	- 1.7
- Solids	5.3 (2.6)	4.3 (2.3)	3.7 (2.3)	4.44	2.54	2.43	2.44	- 4.4
- Liquids	0.2 (0.0)	0.3 (0.0)	0.2 (0.0)	0.15	0.13	0.14	0.15	- 2.2
- Gases	N/A	0.5 (0.0)	0.7 (0.1)	0.58	0.66	0.68	0.68	- 0.1
- Nuclear	0.0 (0.0)	0.03 (0.01)	0.45 (0.13)	1.61	1.85	1.87	1.80	+ 6.0
- Hydro	N/A	N/A	N/A	0.05	0.09	0.08	0.09	N/A
- Wind	N/A	N/A	N/A	0.00	0.03	0.04	0.06	N/A
- Others [4]	0.2 (0.0)	0.3 (0.0)	0.2 (0.0)	0.14	0.31	0.33	0.33	N/A
Net import (EJ)								
- Total	0.7 (0.3)	4.9 (0.7)	6.9 (1.2)		8.86	9.09	8.89	+ 0.5
- Solids	-0.5 (0.2)	-0.4 (0.3)	-0.2 (0.2)		0.80	0.97	0.90	N/A
- Liquids	1.2 (0.1)	5.1 (0.4)	5.6 (0.8)		5.38	5.44	5.23	N/A
- Gases	N/A	0.1 (0.0)	1.4 (0.2)		2.65	2.68	2.75	N/A
- Electricity	+ 0.04 (-)	+ 0.08 (-)	+ 0.06 (-)	0.01	+ 0.03	0.00	0.01	N/A

[1] Preliminary data.
[2] Total energy consumption = Primary energy production + Net import of energy.
[3] Solid fuels include coal and lignite.
[4] Others are geothermal, solar energy etc.
Source: Country Information.

1.3. The Electricity System

The German electricity market was opened by the new energy law in 1998. Up to that time the electricity suppliers had regional monopolies. Now, the German public electricity sector is characterized by a pluralistic structure in electricity generation, transportation and distribution. Participants are large, medium and small-sized electricity suppliers, grid operators, electricity traders (electricity spot market), numerous large and small power plants (see Table 5), and so-called "small producers" not accounted for in Table 5. In 2001, around 1 100 electricity suppliers to final consumers operated in Germany, much more than before the liberalization of the market. Among them the three largest companies supply 53 %, and the next largest only 3 % of the final electricity consumption in Germany. Shareholders of the public electricity supply companies in 2001 included both, private investors - also from abroad - as well as governmental interests. All nuclear power plants in operation are run by private corporations under commercial legislation and with their sales revenues from electricity production and trade.

The larger utilities use a mix of power producing facilities, including nuclear power. So electricity prices in general reflect this energy-mix. Few distributors offer "*Ökostrom*" - electricity only from renewables - at a slightly higher price. There is no company exclusively using nuclear power, neither in production nor in distribution.

TABLE 5: STRUCTURE OF THE ELECTRICITY SECTOR (2001)

	Number of utilities *)	Thereof from abroad *)
Electricity suppliers to final consumers	1 100	80
Grid operators	900	10
Electricity producers	520	--
"New" electricity traders	150	80
Traders on electricity spot market	110	40
Electricity distributors only from renewables	30-40	--
Services for measurement and payment	20	--

*) Partially estimated, double counting
Source: Country Information

TABLE 6: ELECTRICITY PRODUCTION AND INSTALLED CAPACITIES

	1960	1970	1980	1991	2000 [1]	2001 [1]	2002 [1]	Annual growth rate (%) 1980 to 2000
Electricity production (TWh)								
- Total gross	119.0 (40.3)	237.7 (67.7)	365.2 (98.9)	540.2	573.4	582.3	581.5	+ 1.1
- Fossil [2]	106.0 (39.7)	218.8 (65.9)	306.4 (85.3)	359.2	345.8	354.8	354.0	- 0.6
- Nuclear	0.0 (0.0)	2.7 (0.5)	41.4 (11.9)	147.4	169.6	171.3	164.8	+ 6.0
- Hydro	13.0 (0.6)	16.2 (1.3)	17.4 (1.7)	19.2	27.7	26.0	26.5	+ 1.9
- Wind	0.0	0.0	0.0	0.1	9.5	10.5	16.8	N/A
- Others [3]	N/A	N/A	N/A	14.3	20.8	19.7	19.4	N/A
Gross Capacity of electrical plants (GWe)								
- Total	28.4 (7.9)	47.6 (12.1)	82.7 (19.7)	104.2	126.9	125.0	N/A	+ 1.1
- Fossil [2]	25.0 (7.6)	42.0 (11.3)	67.5 (16.5)	72.4	84.0	82.3	N/A	± 0
- Nuclear	0.0 (0.0)	0.9 (0.1)	8.7 (1.7)	23.7	23.6	22.4	22.4	+ 4.2
- Hydro	3.4 (0.3)	4.7 (0.7)	6.5 (1.5)	6.9	9.0	8.5	N/A	+ 0.6
- Wind	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	N/A	6.1	8.8	12.0	N/A
- Others [3]	N/A	N/A	N/A	1.2	4.2	3.0	N/A	N/A

[1] Preliminary data.
[2] hard coal, lignite, gas, oil
[3] Geothermal, solar, biomass etc.
Source: Country Information.

The Federal Ministry of Economics and Labour (BMWA) outlines the national energy policy. As mentioned before, electricity supply is organized by private corporations which of course decide on economic means and follow commercial legislation. Decisions on new production facilities and similar matters are due to market forces and price competition and also have to reflect political preferences, as e.g. the obligation to accept at all times electricity produced from renewables at a fixed high price (see also chapter 1.2).

In 2002, the net generation of all power plants amounted to 504 TWh, with a net capacity of 103 GWe. In 2001, nuclear power took 22 % of the capacity, had a share of 34 % in electricity production and more than half of the base load (51 %). Electricity supply companies also purchases electricity from around 10 000 small producers using renewables for power production, predominantly hydro and wind energy as well as solar energy, biomass and waste materials. In 2002, renewables fed in 45 TWh.

Table 6 shows the statistics on electricity production and installed capacities, Table 7 shows energy related ratios.

TABLE 7: ENERGY RELATED RATIOS

	1960	1970	1980	1991	2000 [1)]	2001 [1)]	2002 [1)]
Energy consumption per capita (GJ/capita)	114 (169)	163 (181)	188 (228)	182	174	177	173
Electricity production per capita (kW·h/capita)	2,148 (2,343)	3,916 (3,959)	5,929 (5,922)	6,727	6,967	7,067	7,049
Electricity production / Energy production (%)	7.5 (5.5)	16 (6.3)	25 (14)	28	37	32	38
Nuclear / total electricity (%)	N/A	1.1 (0.7)	11.6 (12.0)	27.3	29.6	29.4	28.3
Ratio of external dependency (%) [2)]	11 (10)	49 (23)	59 (32)	N/A	62	62	62
Load factor of electricity plants (%)							
- Total	48 (58)	57 (64)	50 (57)	59	52	53	N/A
- Fossil	48 (60)	60 (67)	52 (59)	57	47	49	N/A
- Nuclear	N/A	34 (57)	54 (80)	71	82	87	84
- Hydro	44 (23)	39 (21)	31 (13)	32	35	35	N/A
- Wind	N/A	N/A	N/A	N/A	18	14	16

[1)] Preliminary data.
[2)] Net import / Total energy consumption.
Source: Country Information .

2. NUCLEAR POWER SITUATION

2.1. Historical Development and Current Nuclear Power Organizational Structure

2.1.1. Historical Development Concerning NPPs

After World War II, allied regulations prohibited any activity in nuclear research and industrial development in the two parts of Germany. After West Germany had officially renounced to produce, possess or use nuclear weapons, it was admitted, in 1955, to the western community of nations as a sovereign state. Research and development of nuclear energy for peaceful purposes could start.

By this time, some countries already had been working for ten years in nuclear technology. To close the gap, an agreement was reached between the scientific, economic and political sectors to organize an extensive international co-operation. The German Atomic Programme was formulated to coordinate the work, including the construction of a series of prototype reactors, formulating the concepts for a closed nuclear fuel cycle, and for the disposal of radioactive waste in deep geological formations.

In 1955, the Federal Government established an atomic ministry (*Bundesministerium für Atomfragen*). Germany became a founding member of the European Atomic Energy Community (EURATOM) and the present Nuclear Energy Agency (NEA) of OECD. Agreements for co-operation with France, the United Kingdom and the USA were concluded. With the assistance of US manufacturers, Germany started developing commercial nuclear power plants (Siemens/Westinghouse for PWR, AEG/General Electric for BWR). The German electric utilities supported the development.

In the following years several nuclear research centers were created in West Germany:

1956: - *Kernforschungszentrum Karlsruhe* (KfK),

- *Gesellschaft für Kernenergieverwertung in Schiffbau und Schifffahrt* (GKSS) in Geesthacht,
- *Kernforschungsanlage Jülich* (KFA),

1959: - *Hahn-Meitner-Institut für Kernforschung* (HMI) in Berlin,

- *Deutsches Elektronen-Synchrotron* (DESY) in Hamburg,

1969: - *Gesellschaft für Schwerionenforschung* (GSI) in Darmstadt.

Most of these research centres as well as university institutes were equipped with research reactors. At present most research reactors are shut down and being decommissioned. Since the late 1980s some of the research centres changed their areas of activity - and some of them also their names - to environmental issues. Due to financial conditions, nuclear research became more and more limited to basic nuclear physics.

In 1958, a 16 MWe experimental nuclear power plant (*Versuchsatomkraftwerk Kahl*, VAK) was ordered from GE/AEG and reached criticality in 1960. The domestic German nuclear development began in 1961 with the order of the 15 MWe pebble-bed high-temperature reactor (*Arbeitsgemeinschaft Versuchsreaktor* in Jülich, AVR) from BBK/BBC. Power reactors with 250-350 MWe and 600-700 MWe were ordered between 1965 and 1970. After about 15 years, the gap between the German and the international technological state of the art was closed. The German nuclear industry received the first orders from abroad, from the Netherlands (Borssele) and from Argentina (Atucha). In 1972, the construction of the world's then largest reactor, Biblis A with 1200 MWe, started in Germany. Between 1970 and 1975, on the average three units were ordered annually.

In 1969, Siemens and AEG founded *Kraftwerk Union* (KWU) by merging their respective nuclear activities. The domestic development of KWU nuclear power plants with PWRs started. On the basis of several years of operational experience, finally a standardized 1300 MWe PWR ("Konvoi") was introduced, mainly to speed up the licensing process. However, after some "pre-Konvoi" units, the construction of only three Konvoi-units was actually realized (Isar-2, Neckarwestheim-2, and Emsland). The Konvoi-units were ordered in 1982 and commissioned in 1988/89, the last NPP projects in Germany. Since then, nuclear continuously has a share of approximately one third of the electricity production in Germany.

In East Germany, nuclear power started developing with the assistance of the Soviet Union in 1955. Research in nuclear physics could begin, the Central Institute for Nuclear Physics was founded in 1956 at Rossendorf. There, in 1957, a research reactor supplied by the Soviet Union started operation. The first East German 70 MWe nuclear power plant Rheinsberg, equipped with a Russian type PWR, was connected to the grid in 1966. Between 1974 and 1979, the Greifswald NPP units 1-4 were connected to the grid, all equipped with Russian WWER-440/W-230 reactors. In 1989, unit 5, a WWER-440/W-213 reactor, was in the process of commissioning. Following the German unification, comprehensive safety assessments of the Soviet type NPPs in East Germany were carried out. These analyses showed safety deficiencies in comparison with the current West German nuclear safety requirements. Due to technical and economic reasons - in particular uncertainties in the licensing process and also decreasing electricity consumption - it was decided not to upgrade these plants. They were prepared for decommissioning. Also, work on the nuclear plants under construction (units 6, 7 and 8 at Greifswald with WWER-440/W-213 reactors and two WWER-1000 reactors near Stendal) was abandoned.

Two prototypes of advanced reactor design were developed in Germany: the pebble-bed high-temperature reactor (*Thorium-Hochtemperaturreaktor*, THTR 300) at HRB/BBC and a fast breeder reactor (*Schneller Natriumgekühlter Reaktor*, SNR 300) at Interatom/Siemens. Due to economical and political reasons, the former, after a successful commissioning and operation for some years, was shut down, and the latter was completed but never commissioned.

All nuclear power plants currently in operation in Germany were built by KWU or Siemens/AEG respectively. The second German supplier for NPPs, the company BBR, a joint venture of Brown, Boveri & Cie. and Babcock&Wilcox from the USA, meanwhile ABB, respectively sold to BNFL/UK in December 1999, now renamed Westinghouse, supplied only one PWR plant, Mülheim-Kärlich, which is shut down by court order since 1988 for procedural reasons. After signing the agreement between Government and utilities in June 2001 (see chapter 4), an application for decommissioning was made.

For several years, German utilities together with Siemens/KWU and in close co-operation with its French counterparts (EdF and Framatome) had been developing an advanced PWR, the European Pressurized Water Reactor EPR. The reactor design is "evolutionary" and shows enhanced safety features, the design includes provisions to control core meltdown accidents. German utilities also supported the Siemens/KWU development of an advanced BWR (SWR 1000) with additional passive safety features. In 2001, Siemens/KWU merged its nuclear branch with Framatome SA to Framatome ANP (Advanced Nuclear Power) GmbH, which continues both projects EPR and SWR 1000.

Since the early 1970s, the quite successful German nuclear power programme faced a steadily increasing opposition against the national use of nuclear energy. On the one hand violent demonstrations and occupation of potential sites took place, mainly at Brokdorf, Wyhl and Wackersdorf. On the other hand "concerned citizens" raised objections in administrative courts. Consequently, construction and licensing of nuclear power plants were considerably delayed due to ongoing litigation. Today, the construction of new NPPs for electricity production is forbidden by law (see chapter 4).

2.1.2. Historical Development Concerning the Nuclear Fuel Cycle

In Germany all facilities necessary for a closed nuclear fuel cycle had been erected: in the former West Germany a very small uranium mine *Ellweiler* with yellow cake production, in the former East Germany the large uranium production facility Wismut, which in the beginning also supplied uranium to the Soviet Union. Ellweiler has been closed and Wismut - with an accumulated uranium production as top 3 in the world after the USA and Canada - is being decommissioned.

The project for a reprocessing plant at Wackersdorf was abandoned in 1988, partly due to public opposition and partly also due to economic reasons. Therefore, the German utilities have contracts for reprocessing spent fuel with COGEMA/France and BNFL/UK. The contracts under private law were accompanied by governmental agreements. Radioactive waste resulting from reprocessing spent fuel in foreign facilities is brought back to Germany, the plutonium from reprocessing is used for MOX fuel fabrication. The new MOX fuel fabrication plant at Hanau was completed, but the operation license was not granted due to political complications and the plant is now being dismantled. The reprocessing pilot plant WAK is being decommissioned, a facility to vitrify the resulting high active waste concentrate meanwhile is under construction and close to commissioning.

Since the early 1960s West Germany started to set up a programme for radioactive waste management and disposal. The radioactive waste disposal policy was based on the decision that all types of radioactive waste are to be disposed of in deep geological formations. Realistically, such a decision is only acceptable if a barrier for radionuclide releases exists which remains effective over the long periods of time, which radionuclides need to decay significantly. Thus, vitrified fission product solution from reprocessing and spent fuel elements as well as spent sealed radiation sources and miscellaneous waste from small waste generators are affected by this decision. It also applies to alpha bearing waste originating in particular from reprocessing facilities, nuclear research facilities or the nuclear fuel cycle industry. Near-surface disposal or shallow land burial was excluded in Germany from the very beginning, because of the high population density and climatic conditions; furthermore appropriate deep geological formations exist.

Development work in this field started with the *Asse* research mine in a salt dom in *Niedersachsen*, where low- and medium-level radioactive waste was disposed of on an experimental basis until the end of 1978. In 1979, an agreement on the principles for NPP waste management was reached between the Federal Government and the *Länder.* The *Land Niedersachsen* agreed to assess the salt dome of Gorleben for its suitability to host a repository for all types of radioactive waste, in particular high level waste originating from reprocessing and spent fuel elements. According to the new energy policy (see chapter 4), the underground investigation of the *Gorleben* salt dome has been interrupted in October 2000, for at least three, but at most ten years (Gorleben moratorium). The former iron ore mine *Schacht Konrad* - also in *Niedersachsen* - has been licensed for low and intermediate level waste (waste with negligible heat generation), but still construction of the final repository facility could not begin due to legal restrictions.

In the late 1960s, East-German studies on disposal of radioactive waste resulted in the decision to use the abandoned salt mine *Morsleben* (ERAM) as repository for low and intermediate level waste with low concentrations of alpha emitters. In 1981, after extensive investigations, the first license for final disposal was granted. Along with the German unification in 1990, the operation license was limited until June 30, 2000, later extended to 2005. Due to court order in 1998 concerning the so-called eastern emplacement field, the waste disposal was stopped completely. Now, the licensing procedure for decommissioning is in progress.

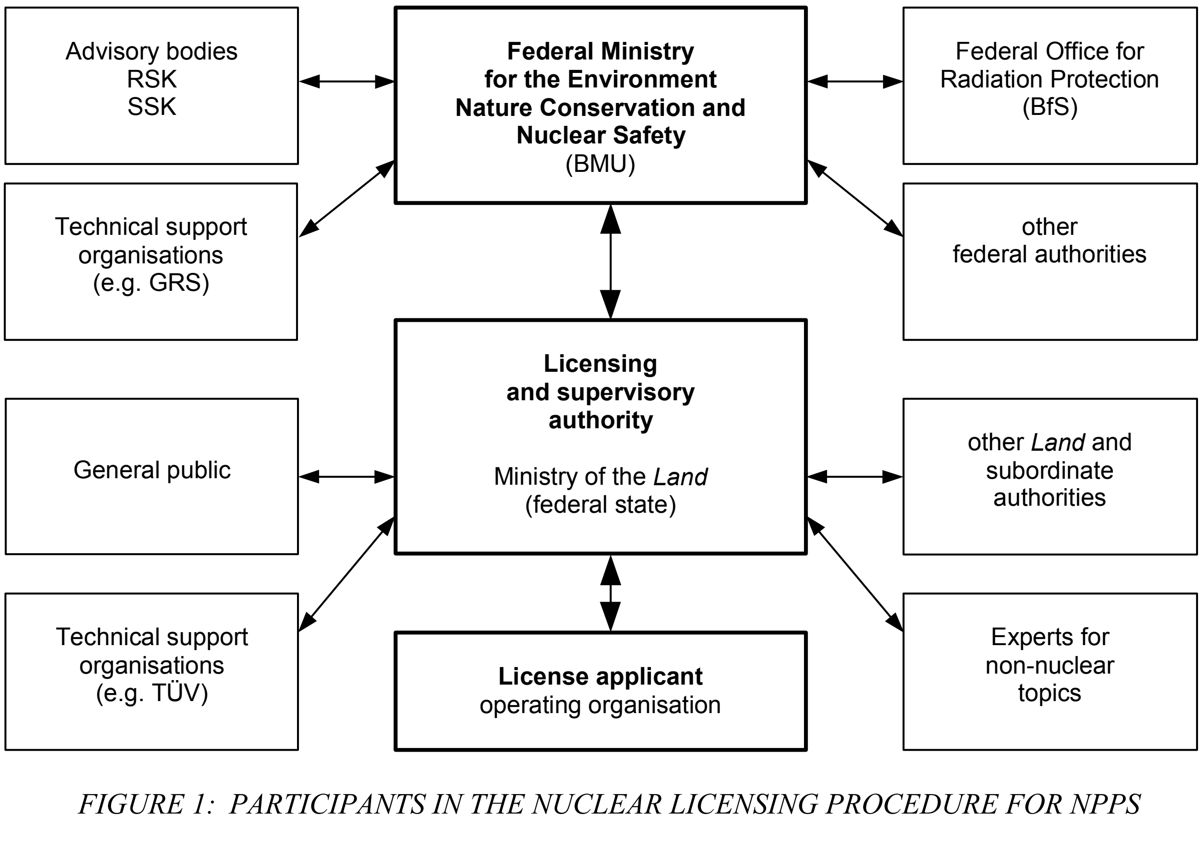


FIGURE 1: PARTICIPANTS IN THE NUCLEAR LICENSING PROCEDURE FOR NPPS

2.1.3. Organizational Charts

The interaction of the different authorities and organizations involved in the nuclear licensing procedure is shown in Figure 1. The institutions mentioned are explained in more detail in chapter 3. Table 8 shows the licensing and supervisory authorities for the individual power plants.

2.2. Nuclear Power Plants: Status and Operation

In 2002, a total gross capacity of 22.4 GWe was installed in the 19 operating German nuclear power plants, 0.7 % more than in 1999. This was realized either by increasing the thermal reactor power (KKP 2, KKU) or by optimizing the steam turbine (KKE, KKI 1, KKI 2) respectively. Increasing of thermal reactor power is also foreseen for several other plants. The generated nuclear electricity (gross) amounted up to 165 TWh in 2002, 0.4 % less than in the previous year, and about one third of the electricity supplied by public utilities. This nuclear share is roughly constant since 1985, but will decrease within the next two decades due to the political decision to phase out. Table 9 shows the status of nuclear power plants by the end of 2002, Figure 2 the siting. In Table 10 the projected shutdown dates for the 19 plants are given.

TABLE 8: THE *LÄNDER* LICENSING AND SUPERVISORY AUTHORITIES FOR NPPS

<table>
<tr><th>Land</th><th>Nuclear Installation</th><th>Licensing Authority</th><th>Supervisory Authority</th></tr>
<tr><td>Baden-Württemberg</td><td>Obrigheim
Neckarwestheim 1
Neckarwestheim 2
Philippsburg 1
Philippsburg 2</td><td>Wirtschaftsministerium
after consultation with
Ministerium für Umwelt und Verkehr und Innenministerium</td><td>Ministerium für Umwelt und Verkehr</td></tr>
<tr><td>Bayern</td><td>Isar 1
Isar 2
Grafenrheinfeld
Gundremmingen B
Gundremmingen C</td><td>Staatsministerium für Landesentwicklung und Umweltfragen,
in agreement with
Staatsministerium für Wirtschaft, Verkehr und Technologie</td><td>Staatsministerium für Landesentwicklung und Umweltfragen</td></tr>
<tr><td>Hessen</td><td>Biblis A
Biblis B</td><td colspan="2">Ministerium für Umwelt, Landwirtschaft und Forsten</td></tr>
<tr><td>Niedersachsen</td><td>Stade
Unterweser
Grohnde
Emsland</td><td colspan="2">Umweltministerium</td></tr>
<tr><td>Rheinland-Pfalz</td><td>Mülheim-Kärlich</td><td colspan="2">Ministerium für Umwelt und Forsten</td></tr>
<tr><td>Schleswig-Holstein</td><td>Brunsbüttel
Krümmel
Brokdorf</td><td colspan="2">Ministerium für Finanzen und Energie</td></tr>
</table>

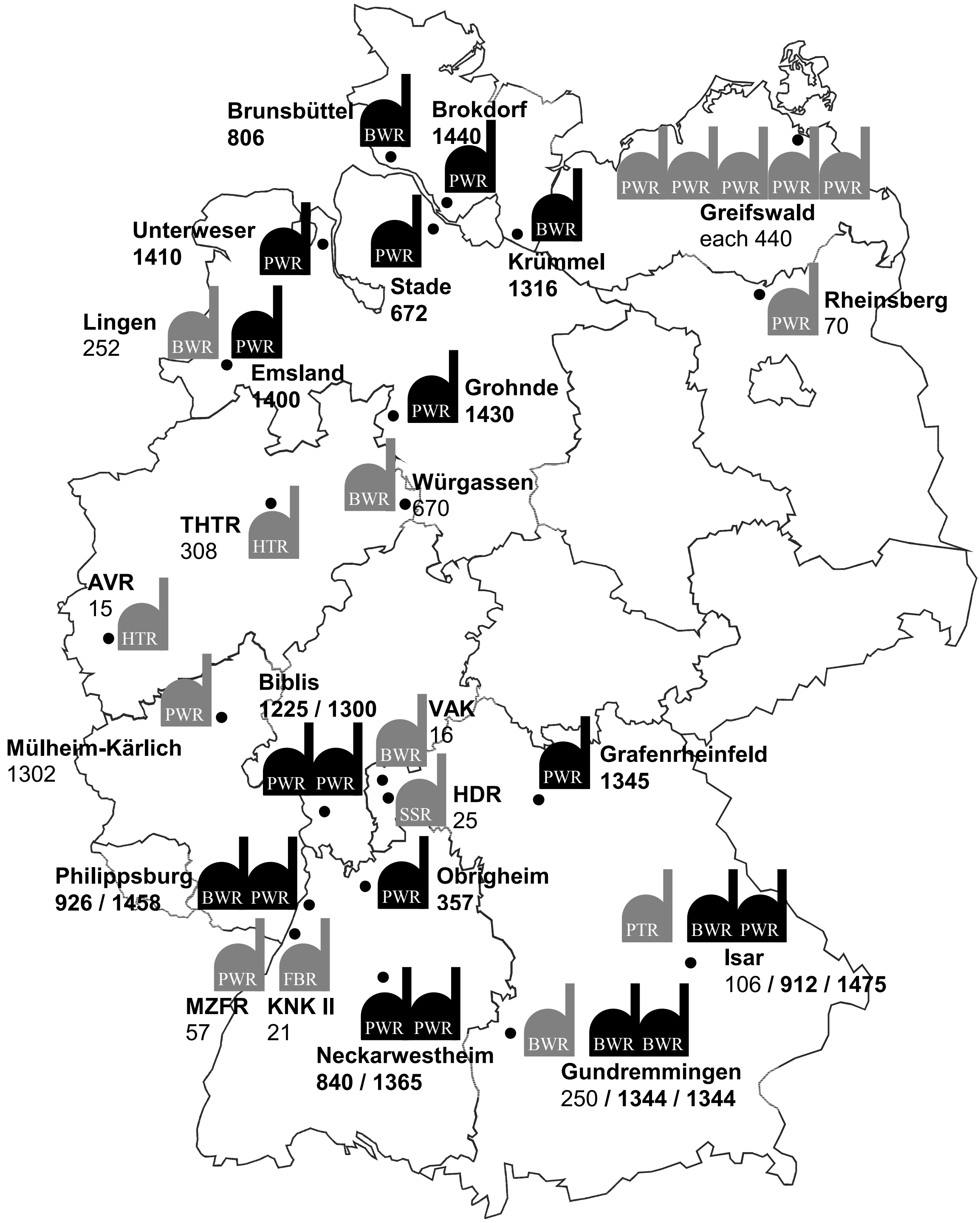
2.3. Supply of NPPs

No exclusively German supplier of NPPs has remained with the start of the 21st century. In 2001, the remaining domestic manufacturer Siemens/KWU merged its nuclear business with Framatome SA to Framatome ANP (Advanced Nuclear Power). The former nuclear branch of Siemens - KWU in Erlangen - now acts as an operational center, called Framatome ANP GmbH. The main activities are projects and engineering, nuclear services, nuclear fuel and mechanical equipment. The second German supplier for NPPs, BBR, meanwhile Westinghouse Reaktor GmbH, now concentrates on nuclear services.

TABLE 9: STATUS OF NUCLEAR POWER PLANTS

Station	Type	Net Capacity	Status	Operator	Reactor Supplier	Construction Date	Criticality Date	Grid Date	Commercial Date	Shutdown Date
BIBLIS-A (KWB A)	PWR	1167	Operational	RWE	KWU	01-Jan-70	16-Jul-74	25-Aug-74	26-Feb-75	
BIBLIS-B (KWB B)	PWR	1240	Operational	RWE	KWU	01-Feb-72	25-Mar-76	25-Apr-76	31-Jan-77	
BROKDORF (KBR)	PWR	1370	Operational	E.ON	KWU	01-Jan-76	08-Oct-86	14-Oct-86	22-Dec-86	
BRUNSBUETTEL (KKB)	BWR	771	Operational	KKB	KWU	15-Apr-70	23-Jun-76	13-Jul-76	09-Feb-77	
EMSLAND (KKE)	PWR	1329	Operational	KLE	SIEM, KWU	10-Aug-82	14-Apr-88	19-Apr-88	20-Jun-88	
GRAFENRHEINFELD (KKG)	PWR	1275	Operational	E.ON	KWU	01-Jan-75	09-Dec-81	30-Dec-81	17-Jun-82	
GROHNDE (KWG)	PWR	1360	Operational	KWG	KWU	01-Jun-76	01-Sep-84	04-Sep-84	01-Feb-85	
GUNDREMMINGEN-B (KRB B)	BWR	1284	Operational	KGB	KWU	20-Jul-76	09-Mar-84	16-Mar-84	19-Jul-84	
GUNDREMMINGEN-C (KRB C)	BWR	1288	Operational	KGB	KWU	20-Jul-76	26-Oct-84	02-Nov-84	18-Jan-85	
ISAR-1 (KKI 1)	BWR	878	Operational	E.ON	KWU	01-May-72	20-Nov-77	03-Dec-77	21-Mar-79	
ISAR-2 (KKI 2)	PWR	1400	Operational	E.ON	KWU	15-Sep-82	15-Jan-88	22-Jan-88	09-Apr-88	
KRUEMMEL (KKK)	BWR	1260	Operational	KKK	KWU	05-Apr-74	14-Sep-83	28-Sep-83	28-Mar-84	
NECKARWESTHEIM-1 (GKN 1)	PWR	785	Operational	GKN	KWU	01-Feb-72	26-May-76	03-Jun-76	01-Dec-76	
NECKARWESTHEIM-2 (GKN 2)	PWR	1269	Operational	GKN	SIEM, KWU	09-Nov-82	29-Dec-88	03-Jan-89	15-Apr-89	
OBRIGHEIM (KWO)	PWR	340	Operational	KWO	SIEM, KWU	15-Mar-65	22-Sep-68	29-Oct-68	01-Apr-69	
PHILIPPSBURG-1 (KKP 1)	BWR	890	Operational	EnBW	KWU	01-Oct-70	09-Mar-79	05-May-79	26-Mar-80	
PHILIPPSBURG-2 (KKP 2)	PWR	1392	Operational	EnBW	KWU	07-Jul-77	13-Dec-84	17-Dec-84	18-Apr-85	
STADE (KKS)	PWR	640	Operational	E.ON	KWU	01-Dec-67	08-Jan-72	29-Jan-72	19-May-72	
UNTERWESER (KKU)	PWR	1345	Operational	E.ON	KWU	01-Jul-72	16-Sep-78	29-Sep-78	06-Sep-79	
AVR JUELICH (AVR)	HTGR	13	Shut Down	AVR	BBK	01-Aug-61	16-Aug-66	17-Dec-67	19-May-69	31-Dec-88
GREIFSWALD-1(KGR 1)	WWER	408	Shut Down	EWN	AEE, KAB	01-Mar-70	03-Dec-73	17-Dec-73	12-Jul-74	18-Dec-90
GREIFSWALD-2 (KGR 2)	WWER	408	Shut Down	EWN	AEE, KAB	01-Mar-70	03-Dec-74	23-Dec-74	16-Apr-75	14-Feb-90
GREIFSWALD-3 (KGR 3)	WWER	408	Shut Down	EWN	AEE, KAB	01-Apr-72	06-Oct-77	24-Oct-77	01-May-78	28-Feb-90
GREIFSWALD-4 (KGR 4)	WWER	408	Shut Down	EWN	AEE, KAB	01-Apr-72	22-Jul-79	03-Sep-79	01-Nov-79	02-Jun-90
GREIFSWALD-5 (KGR 5)	WWER	408	Shut Down	EWN	AEE, KAB	01-Dec-76	26-Mar-89	24-Apr-89	-	30-Nov-89
GUNDREMMINGEN-A (KRB A)	BWR	237	Shut Down	KGB	AEG, GE	12-Dec-62	14-Aug-66	01-Dec-66	12-Apr-67	13-Jan-77
HDR GROSSWELZHEIM	BWR	23	Shut Down	FZK	AEG, KWU	01-Jan-65	14-Oct-69	14-Oct-69	02-Aug-70	20-Apr-71
KNK II	FBR	17	Shut Down	FZK	IA	01-Sep-74	10-Oct-77	09-Apr-78	03-Mar-79	23-Aug-91
LINGEN (KWL)	BWR	240	Shut Down	KWL	AEG	01-Oct-64	31-Jan-68	01-Jul-68	01-Oct-68	05-Jan-77
MUELHEIM-KAERLICH (KMK)	PWR	1219	Shut Down	RWE	BBR	15-Jan-75	01-Mar-86	14-Mar-86	01-Oct-87	09-Sep-88
MZFR	PHWR	52	Shut Down	FZK	SIEMENS	01-Dec-61	29-Sep-65	09-Mar-66	19-Dec-66	03-May-84
NIEDERAICHBACH (KKN)	HWGCR	100	Shut Down	FZK	SIEM, KWU	01-Jun-66	17-Dec-72	01-Jan-73	01-Jan-73	31-Jul-74
RHEINSBERG (KKR)	PWR	62	Shut Down	EWN	AEE, KAB	01-Jan-60	11-Mar-66	06-May-66	11-Oct-66	01-Jun-90
THTR-300	HTGR	296	Shut Down	HKG	HRB	01-May-71	13-Sep-83	16-Nov-85	01-Jun-87	29-Apr-88
VAK KAHL	BWR	15	Shut Down	VAK	GE, AEG	01-Jul-58	13-Nov-60	17-Jun-61	01-Feb-62	25-Nov-85
WUERGASSEN (KWW)	BWR	640	Shut Down	E.ON	AEG, KWU	26-Jan-68	20-Oct-71	18-Dec-71	11-Nov-75	26-Aug-94

Source: IAEA Power Reactor System year-end 2002.



Legend

PWR Pressurized Water Reactor
BWR Boiling Water Reactor
FBR Fast Breeder Reactor
HTR High Temperature Reactor
PTR Pressure Tube Reactor
SSR Superheated Steam-Cooled Reactor
Numbers indicate Gross Capacity [MWe], 12/2002

in operation

shut down

Source: Country Information

FIGURE 2: NUCLEAR POWER PLANTS IN GERMANY

2.4. Operation of NPPs

The companies operating the NPPs are owned by only a few major utilities. These are, since some years, in a process of concentration and reordering. Operating personnel is in sufficient supply at the moment, regularly retrained for their job at plant specific full scope simulators at the *Kraftwerksschule* in Essen. But personnel may become a difficult issue due to the policy to phase out the use of nuclear power and diminishing interest in nuclear education in Germany. For maintenance, the operator receives support from manufacturers and service suppliers specialized in this field (for operation data see chapter 2.2).

2.5. Fuel Cycle and Waste Management

All facilities necessary to close the nuclear fuel cycle have been realized in Germany. Today, only a few of them are in operation, several are shut down and being decommissioned or did not receive an operation license (see chapter 2.1.2). According to the new energy policy and the respective amendment of the Atomic Energy Act, the waste management of nuclear power plants comprises

- transport of spent fuel for reprocessing only until June 30, 2005 at the latest and utilisation of recovered nuclear fuel;
- from July 1, 2005, use of the local interim storage facilities for spent fuel until a final repository will be commissioned;
- interim storage of spent fuel at central (external) interim storage facilities and, as soon as possible, at local interim storage facilities; and
- conditioning and interim storage of radioactive waste from operation and decommissioning of the nuclear power plants until a final repository will be commissioned.

At Gronau, the **enrichment** plant of URENCO expanded from a capacity of originally 400 SWU/year to 1 400 SWU/year within the last years and it is intended to increase the capacity further to 4 500 SWU/year.

At Lingen, the **fuel fabrication** facility ANF is in operation and produces uranium fuel elements for LWRs. In 2002, the increase of the throughput capacity up to 500 t Uranium per year was licensed.

Three **central interim storage** facilities for spent fuel are in operation: The transport flask store *Ahaus* (TBLA) for irradiated fuel, the transport flask store *Gorleben* (TBLG) for both, irradiated fuel and vitrified reprocessing products and the interim storage facility *Zwischenlager Nord* (ZLN) exclusively for spent fuel from decommissioning the NPPs in Greifswald and Rheinsberg.

According to the new German energy policy additional **local interim storage** facilities for spent fuel are to be built on the NPP sites. License applications have been introduced for 13 sites; meanwhile one storage is in operation.

At the beginning of 2002, the licensed **storage pond** capacity, erected within the NPPs, amounted to 6 327 t HM, of which 751 t were not occupied (additional empty space for one core load each not counted).

The **waste conditioning** facility PKA at the Gorleben site is now completed, but only a limited operation license to repair damaged containers was granted by the competent *Länder* authority in 2000.

Concerning the **final repository**, the Federal Government has in mind that a future facility for all types of radioactive waste will be available around 2030. A working group on the site selection for a possible repository, set up by BMU, has produced a report on a comprehensive and suitable site selection procedure.

2.6. Research and Development Activities

Basic nuclear research is supported by the BMBF (Federal Ministry of Education and Research), the applied nuclear research - especially nuclear reactor safety and repository research - by the BMWA (Federal Ministry of Economics and Labour), and regulatory nuclear investigations by BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety). The national development activities on disposal are refinanced by the utilities. Research in nuclear matters at universities and research centers is decreasing. Nothing more is done on future nuclear reactors because of the political decision to phase out nuclear for commercial electricity production (see also chapter 2.1).

2.7. International Co-operation and Initiatives

As member state of the EU, OECD/NEA, and IAEA, Germany supports various international programmes in nuclear safety and nuclear waste management. In direct international co-operation Germany also supports projects and organizations, e.g. the licensing and supervisory authorities, technical support organizations and also research institutes.

As EU member Germany takes part in many European nuclear researchactivities, e.g.:

- PHEBUS-FP programme covering severe accidents on PWR;
- PHARE and TACIS programmes, general projects to support Central Europe and the CIS countries in nuclear safety.

As NEA member, Germany participates, among other things, in:

- the ICDE project on collection and analysis of data on common cause failure event;
- the HALDEN project on fuel and material issues;
- the MASCA project on in-vessel phenomena during a servere accident as a follow up of the RASPLAV project;
- the CABRI project on the behaviour of high burn-up and MOX fuel elements under RIA conditions;
- the MCCI project on melt coolability and concrete interaction;
- the PSB-VVER project on VVER-1000 code validation; and in
- the SETH project on thermal-hydraulic experiments in support of accident management.

The Framatome ANP directly participates in several international projects, e.g.:

- HALDEN, the NEA project on fuel and material issues;
- PKL3, partly financed by the OECD, on boron dilution scenarios at the PKL large scale test facility in Erlangen;
- PANDA, an investigation at PSI of the function and reliability of passive condensers under servere accident conditions;
- PHARE/TACIS, the EU project to support Central Europe and the CIS countries in nuclear safety;
- INPRO, an IAEA project on innovative nuclear reactors and fuel cycles; and

- CAMP, an USNRC organized improvement of a code analysis and maintenance programme.

3. NATIONAL LAWS AND REGULATIONS

3.1. Safety Authority and the Licensing Process

In accordance with the federal structure of Germany, its Constitution (Basic Law) bestows upon the Federal Government the responsibility for legislation and regulation regarding "production and utilization of nuclear energy for peaceful purposes, construction and operation of facilities serving such purposes, protection against hazards arising from the release of nuclear energy or ionizing radiation and disposal of radioactive substances."

The Atomic Energy Act was promulgated December 23, 1959, right after the Federal Republic of Germany had officially renounced any acquisition, development or use of nuclear weapons. Before unification its scope of application was restricted to West Germany (within its boundaries up to 1990) and to the *Land* Berlin.

In Germany the legislation and its execution must also take into account any binding requirement from regulations of the European Union. With respect to radiation protection there are, e.g., the EURATOM Basic Safety Standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation. These were issued on the basis of Articles 30 to 33 of the EURATOM Treaty. In accordance with Chapter 7 of the EURATOM Treaty any use of ores, source material and special fissile material is subject to the Safeguards of the European Atomic Energy Community.

With respect to nuclear safety and waste management, the Atomic Energy Act is the core of national regulations in Germany. Its primary purpose is to protect life, health and property against the hazards of nuclear energy and the detrimental effects of ionizing radiation and, furthermore, to provide for the compensation for any damage and injuries incurred. And according to the amendment of 2002, another purpose is to phase out the use of nuclear energy for commercial electricity production: "No further licenses will be issued for the construction and operation of installations for the fission of nuclear fuel for the commercial generation of electricity or of facilities for the reprocessing of irradiated nuclear fuel." The Atomic Energy Act is supplemented by the Precautionary Radiation Protection Act, which came about in the wake of the reactor accident at Chernobyl.

These regulations are put into concrete terms by ordinances, by general administrative provisions, by regulatory guidelines, by safety standards of the Nuclear Safety Standards Commission (KTA), by recommendations from the Reactor Safety Commission (RSK) and the Commission on Radiological Protection (SSK) and by conventional technical standards (e.g. DIN). The NUSS Code is not implemented into national regulations, but national regulations are at least comparable.

According to the Atomic Energy Act, a license is required for the construction, operation or any other holding of a stationary installation for the production, treatment, processing or fission of nuclear fuel or reprocessing or irradiated fuel (but no further license for commercial NPPs will be granted). A license is also required for essentially modifying such installation or its operation and for decommissioning. The applicant can only be granted a license if he meets the individual requirements spelled out in § 7 Atomic Energy Act as license prerequisites:

- trustworthiness and qualification of the responsible personnel;
- necessary knowledge of the otherwise engaged personnel regarding safe operation of the installation;

- necessary precautions against damage in the light of the state of the art in science and technology;
- necessary financial security with respect to legal liability for paying damage compensation;
- protection against disruptive actions or other interference by third parties; and
- consideration of public interests with respect to environmental impact.

The Radiation Protection Ordinance regulates in a legally binding way the reporting by name of the responsible persons for the radiation protection of the licensee, the dose limits of radiation exposure during operating conditions for the personnel engaged at the plant and for the general public. Furthermore, it contains planning values for doses from potential exposure in case of design basis accidents of NPPs.

Concerning the safety of nuclear power plants, the Federal Environmental Ministry (BMU) has the federal competence, whereas the execution of federal laws lies within the responsibility of the federal states, the *Länder*. So the licensing of nuclear installations is carried out by the *Länder*, where different ministries are responsible for licensing of construction, operation, essential modification and decommissioning of nuclear power plants. For technical matters in the licensing procedure and the supervision of nuclear facilities, the regulatory authorities of the *Länder* are supported by independent technical support organizations, in general the nuclear departments of the Technical Inspection Agencies (TÜV).

The actual details and procedure of licensing are specified in the Nuclear Licensing Procedure Ordinance. It deals specifically with the application procedure, with the submission of supporting documents and with the participation of the general public. It deals, furthermore, with the assessment of any environmental impact and with the consideration of other licensing requirements (e.g. regarding the possible release or discharge of non-radioactive pollutants into air or water).

To preserve the legal uniformity for the entire territory of the Federal Republic of Germany, the BMU supervises the licensing and supervisory activities of the *Länder* authorities (so-called "federal executive administration"). Supervision by BMU includes the right to issue binding directives.

In performing its federal supervision, the BMU is supported by the Federal Office for Radiation Protection (BfS) in all matters concerning nuclear safety and radiation protection. The BfS is responsible – inter alia - for the construction and operation of nuclear waste repositories, subcontracting for this task with the *Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe* mbH (DBE). Further advisory support for the BMU comes from the RSK, the SSK and the GRS, a central technical support organization (see Figure 1).

As in licensing, the prime objective of the regulatory supervision of nuclear installations is to protect the general public and workers in these installations against the hazards connected with the operation of the installation. Officials of the supervisory authorities as well as the authorized experts working on behalf of the supervisory authority have access to the nuclear installation at all times and are authorized to perform the necessary examinations and to request any pertinent information. Nuclear installations are subject to continuous regulatory supervision. However, the *Länder* perform this supervisory procedure on behalf of the Federal Government.

In the case of non-compliance with legal provisions or requirements of the license permit, and whenever it must be suspected that life, health or property of third parties is endangered, the competent supervisory authority of the *Land* is authorized by § 19 Atomic Energy Act to issue orders stating:

- that protective measures must be applied and, if so, which ones;

- that radioactive materials must be stored at a place prescribed by the authority; and
- that the handling of radioactive materials, the construction and operation of nuclear installations must be interrupted or temporarily or - in case of a revocation of the license - permanently be suspended.

The high safety standards already applied make it highly improbable that serious damage would be caused by nuclear power plants. Nevertheless and with due respect for the potential degree of such a damage, it has always been an essential licensing prerequisite in Germany that sufficient financial security is provided for covering possible claims for damage compensation. Current liability regulations take the Paris Convention (on Third Party Liability in the Field of Nuclear Energy) and the Brussels Supplementary Convention into account. Both conventions have been incorporated into the Atomic Energy Act. The corresponding details are regulated by the Nuclear Financial Security Ordinance. The licensees are required to take out liability insurance policies for a maximum financial sum that is specified in the individual nuclear licensing procedure. The Federal Government and the *Land* issuing the license jointly carry an additional indemnity which may be claimed by the damaged party. The maximum required financial security from liability insurances is limited to € 2 500 million.

The individual power utilities or their subsidiaries are the licensees of the NPPs. They build up financial reserves to be prepared for the follow-up costs connected with the operation of a nuclear power plant such as the decommissioning and dismantling of the installations, and the treatment and disposal of radioactive material including spent fuel. So far, reserves amounting to € 35 000 million have been set aside, of which about 45 % are earmarked for decommissioning and dismantling and about 55 % for waste management.

The responsibility for the disposal of radioactive waste lies with the Federation, the BfS is the legally responsible authority. All other radioactive waste management facilities, i.e. spent fuel interim storage, are within the responsibility of the waste producers. The *Länder* have to construct and operate regional state collecting facilities for the interim storage of radioactive waste originating, in particular, from radioactive applications in medicine, industry, or universities. The protection objective of disposal of radioactive waste in a repository is laid down in the Atomic Energy Act and the Radiation Protection Ordinance. The Federal Mining Act regulates the aspects concerning the operation of a disposal mine. The Safety Criteria for the Disposal of Radioactive Waste in a Mine specify the measures to be taken in order to achieve that this objective has been reached. In addition, environmental legislation must be taken into account, in particular an environmental impact assessment has to be performed.

3.2. Main National Laws and Regulations on Nuclear Power and Waste Management

- Atomic Energy Act (*Atomgesetz*)
- Precautionary Radiation Protection Act *(Strahlenschutzvorsorgegesetz)*
- Environmental Impact Assessment Act *(Umweltverträglichkeitsprüfungsgesetz)*
- Federal Mining Act *(Bundesberggesetz)*
- Radiation Protection Ordinance *(Strahlenschutzverordnung)*
- Nuclear Licensing Procedure Ordinance *(Atomrechtliche Verfahrensverordnung)*
- Nuclear Financial Security Ordinance *(Atomrechtliche Deckungsvorsorge-Verordnung)*
- Repository Financing Ordinance *(Endlagervorausleistungsverordnung)*
- Ordinance on the Verification of Trustworthiness *(Atomrechtliche Zuverlässigkeitsüberprüfungs-Verordnung)*

- Nuclear Safety Commissioner and Reporting Ordinance *(Atomrechtliche Sicherheitsbeauftragten- und Meldeverordnung)*
- Ordinance on Nuclear Waste Transboundary Movement *(Atomrechtliche Abfallverbringungsverordnung)*
- Nuclear Power Plant Safety Criteria *(Sicherheitskriterien für Kernkraftwerke)*
- Safety Criteria for Disposal of Radioactive Wastes in a Mine *(Sicherheitskriterien für die Endlagerung radioaktiver Abfälle in einem Bergwerk)*

4. CURRENT ISSUES AND DEVELOPMENT ON NUCLEAR POWER

4.1. Energy Policy

In 1986, after the Chernobyl nuclear accident, political consensus on the use of nuclear energy was lost in Germany. Up to that time, all three parties in parliament had more or less supported the increasing use of nuclear power. Now, society split into two parts, one in favour and one against using nuclear power. The Social Democratic Party (SPD), at that time in opposition to the Federal Government coalition of Christian Democratic Party (CDU) and Free Democratic Party (FDP), adopted a resolution to phase out nuclear power within ten years. It took another twelve years until in September 1998 SPD and the green party *Bündnis90/Die Grünen* (Greens) won the federal election and together took over the Federal Government.

The political situation regarding the relation between the Federation and the *Länder* is complicated by changing political majorities. Federation and *Länder*, both have their responsibilities in nuclear licensing and nuclear safety matters (see chapter 3.1). The *Länder* are represented in the second parliament chamber (*Bundesrat*). Since 1982 CDU/FDP led the Federal Government, but the following elections for the *Länder* resulted in a SPD majority in the *Bundesrat*. At present, SPD/Greens are leading the Federal Government, but meanwhile the majority of SPD-governed *Länder* in the *Bundesrat* got lost.

The intention of the current Federal Government still is to phase out the use of nuclear power for commercial electricity production. Finally an agreement between the Federal Government and the utilities on the matter was signed in June 2001. In April 2002, the respective amendment to the Atomic Energy Act came into force. The main purpose of the amendment is to terminate in an orderly manner the use of nuclear energy for commercial electricity production. At the same time, safe operation of the NPPs for their remaining operative life-times is to be achieved. Beside the limiting of NPP lifetime to a 32 year equivalent on the average (Table 9), the erection of new NPPs is forbidden. Therefore, the share of nuclear power in the national energy mix will decrease continuously within the next two decades. Furthermore, consensus is sought in the issue of radioactive waste disposal. The utilities agreed to build interim storage facilities at the NPP sites, in order to minimize transports of spent fuel, at least for the near future. Starting from July 2005, the management of spent fuel from the NPPs will be restricted to direct disposal; reprocessing will no longer be permitted.

Following the new energy policy, the German programme for the disposal of radioactive waste is presently under review The political objective is to erect one single repository in Germany for all types of radioactive waste by 2030. Further sites in various host rocks will be investigated for suitability. Thus, BMU has set up an expert group to develop new repository site selection criteria and respective procedures on a scientific basis and on thorough discussions with public participation. In 2002 a final report was issued on a comprehensive and suitable site selection procedure.

The new German energy policy will not affect Germany's responsibility regarding its international obligations and does not reduce the efforts towards nuclear safety.

TABLE 10: PROJECTED SHUTDOWN OF NUCLEAR POWER PLANTS

BWR		PWR	
Brunsbüttel	2/2009	Obrigheim	12/2004
Isar 1	3/2011	Stade	2003
Philippsburg 1	3/2011	Biblis A	2/2007
Krümmel	3/2016	Biblis B	1/2009
Gundremmingen B	7/2016	Neckarwestheim 1	12/2008
Gundremmingen C	1/2017	Unterweser	9/2011
		Grafenrheinfeld	6/2014
		Grohnde	2/2017
		Philippsburg 2	4/2017
		Brokdorf	12/2018
		Isar 2	4/2020
		Emsland	6/2020
		Neckarwestheim 2	4/2021

Source: Country Information

The Federal Government intends to establish a new consensus in politics and society on energy policy for the long term. It is of considerable importance to foster a forward-looking and sustainable energy supply policy through improved energy efficiency and enhanced energy savings. Renewable energy is increasingly supported. Suppliers, according to the new energy law, have to buy the electricity from renewables when it is produced and at the fixed high price. Furthermore the general framework for raising energy efficiency is improved, in particular for combined heat and power production. Nevertheless, within the changing scope of global markets and European energy trade, the liberalization of markets for electricity and natural gas and the commitments to reduce the emission of greenhouse gases have to be taken into account.

4.2. Privatization and Deregulation

In April 1998, the act on the reorganization of the electricity supply industry came into force in Germany. By this act the European domestic market directive "Electricity" was implemented into German law. The German electricity market was liberalized completely in one step, not using the gradual opening conditions also in line with the directive. Up to this liberalization, the German electricity market had been characterized by closed supply areas. Demarcation areas and supply contracts provided a monopoly position of the respective utility. With the new regulation of April 1998 the competition also started in the electricity market, a dynamically developing process ever since.

After only a few months of competition, the sector already found itself in a transformation of its structures, which had developed throughout decades. The situation was characterized by reorganization of the companies according to "generation", "transportation" and "distribution", by co-operation agreements, transfers of shares in companies and mergers of companies and by the appearance of additional market participants in the new business sector "electricity trade". The current situation is illustrated in Table 5 (see chapter 1.3). Among the new market participants there are several companies from abroad - Europe and USA - with financial participations up to 100 %.

At the beginning only special-tariff customers - mainly industry - took advantage of price reductions, and since the middle of 1999 also private households took advantages. The total price reduction for industrial and commercial customers reached up to 40 % comparing 1995 and 2000, for private customers up to 20 %. Since 2000, the special measures resulting from governmental decisions on environmental policy (e.g. taxes like "*Ökosteuer*" and subsidies to increase the share of renewables) made prices rise again. In 1998 the governmental share in all electricity cost amounted to 2 300 million €, whereas in 2002 it already rose to 9 440 million €. With the liberalization of the market the closed supply areas where obsolete, customer now can choose their power supplier. But only just over 2 % of the 43 million private and commercial customers have changed the supplier. However, at the same time 12 million new contracts have been signed, mostly with the previous supplier and under more favorable cost conditions. Under these tightening financial circumstances backfitting of plant safety, maintenance and review of the nuclear power plants have to be carried out.

4.3. Role of the Government in Nuclear R&D

For activities supported by the Federal Government see chapter 2.6. Besides that, the Association of Major Power Utilities (VGB), of which all German and several foreign licensees of nuclear power plants are members, annually spends between approximately € 2 and 3 millions for the evaluation and feed-back of operating experience. In addition, VGB has financed about 350 projects over the past ten years, three-quarters of which - for a total amount of about € 70 million - were directly aimed at improving safety.

4.4. Nuclear Energy and Climate Change

The position of the German Government with respect to CO_2 emissions creates a new challenge for the electricity supply industry. In the course of the climate debate, Germany committed itself in 1995 to reduce CO_2 emissions by 25 % compared to 1990, by the year 2005. Part of the challenge could be achieved by closing down aged and inefficient industries and power productions in the former GDR and erection of new facilities. But in the meantime it is no longer sufficient to replace old devices by current technologies. A strong reduction in the burning of hydrocarbon fuels will be necessary. The options for the electricity supply industry are to increase energy efficiency, both in electricity generation and end-use consumption, and to switch to generating technologies which do not burn fossil fuel. For the public it means to reduce energy consumption in general. In 2000 the CO_2 emission volume was 858 Mt CO_2, which is 15 % less than the 1 014 Mt CO_2 in 1990. But for the electricity supply industry alone, which makes around one third of the CO_2 emission in Germany, numbers have increased again by 8 % from 1999 - the least emissions - to 2002.

Furthermore, in the Kyoto Protocol to the Convention on Climate Change in 1997, the European Union ensured that their overall emission of greenhouse gases will be at least 8 % below the 1990 level in 2012. According to a burden sharing of the European Union in 1998, Germany has to reduce of 21 % of its overall greenhouse gases compared to the 1990 level.

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Appendix 1

INTERNATIONAL, MULTILATERAL AND BILATERAL AGREEMENTS

AGREEMENTS WITH THE IAEA

• NPT related safeguards agreement EURATOM/IAEA, INFCIRC/193	Entry into force:	21 February 1977
• Protocol Additional to the Euratom Agreement, INFCIRC/193(GOV/1998/28)	Signed:	22 September 1998
• Improved procedures for designation of safeguards	Proposal rejected by EURATOM but special procedures agreed upon	16 February 1989
• Agreement on privileges and immunities, INFCIRC/9	Entry into force:	4 August 1960

MULTILATERAL SAFEGUARDS AGREEMENTS

• Brazil/Germany/IAEA, INFCIRC/237	Entry into force:	26 February 1976
• application suspended, INFCIRC/237/Add.1	Entry into force:	21 October 1999
• Spain/Germany/IAEA, INFCIRC/305	Entry into force:	29 September 1982

OTHER RELEVANT INTERNATIONAL TREATIES

• NPT, INFCIRC/140	Entry into force:	2 May 1975
• Convention on the physical protection of nuclear material, INFCIRC/274	Entry into force:	6 October 1991
• Convention on early notification of a nuclear accident, INFCIRC/335	Entry into force:	15 October 1989
• Convention on assistance in the case of a nuclear accident or radiological emergency, INFCIRC/336	Entry into force:	15 October 1989
• Paris convention on third party liability in the field of nuclear energy	Entry into force:	30 September 1975
• Convention relating to civil liability in maritime carriage of nuclear materials	Entry into force:	30 December 1975
• Joint protocol relating to the application of the Vienna and Paris conventions, INFCIRC 402	Entry into force:	13 September 2001
• Vienna convention on civil liability for nuclear damage, INFCIRC/500		Not signed
• Convention on supplementary compensation for nuclear damage		Not signed
• Convention on nuclear safety, INFCIRC/449	Entry into force:	20 April 1997

• Joint Convention on the safety of spent fuel management and on the safety of radioactive waste management, INFCIRC /546	Entry into force:	18 June 2001
• ESPOO-Convention	Entry into force:	8 August 2002
• Aarhus-Convention	Signed	21 December 1998
• European Atomic Energy Community (EURATOM)		Member
• ZANGGER Committee		Member
• Nuclear Export Guidelines		Adopted
• Nuclear Suppliers Group		Member
• Acceptance of NUSS Codes	In general, national regulations are consistent with codes	letter of 6 March 1989

BILATERAL AGREEMENTS CONCERNING THE SAFETY OF NUCLEAR INSTALLATIONS AND RADIATION PROTECTION

Agreement with	Major agreement content
Argentina	Exchange of information and co-operation
Austria	Mutual assistance in case of an emergency Exchange of information
Belgium	Mutual assistance in case of an emergency
Brazil	Co-operation
	Exchange of information and co-operation
Bulgaria	Exchange of information
China	Promotion of co-operation
Czechoslovakia	Exchange of information
Denmark	Mutual information on close border nuclear installations Exchange of information Mutual assistance in case of an emergency
Finland	Early notification in case of an emergency and exchange of information
France	Exchange of information Mutual assistance in case of an emergency Exchange of information in case of an emergency
Hungary	Exchange of information Mutual assistance in case of an emergency
Japan	Exchange of information
Lithuania	Mutual assistance in case of an emergency
Luxembourg	Mutual assistance in case of an emergency
Netherlands	Mutual information on close border nuclear installations Exchange of information Mutual assistance in case of an emergency
Norway	Exchange of information
Poland	Mutual assistance in case of an emergency
Russian Federation	Early information in case of an emergency and exchange of information Mutual assistance in case of an emergency Third party liability Application of nuclear material Supply of highly enriched uranium for use in FRM II
Spain	Co-operation
Sweden	Early notification in case of an emergency and exchange of information
Switzerland	Radiological emergency preparedness Mutual information on close border nuclear installations Third party liability Mutual assistance in case of an emergency
United Kingdom	Exchange of information and co-operation in drafting safety standards
Ukraine	Exchange of information
USA	Exchange of information and co-operation

Appendix 2

DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

NATIONAL ATOMIC ENERGY AUTHORITIES, FEDERATION AND LÄNDER

Bundesministerium für Wirtschaft und Arbeit (BMWA)	Berlin	http://www.bmwi.de
Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU)	Bonn	http://www.bmu.de
Bundesministerium für Bildung und Forschung (BMBF)	Berlin	http://www.bmbf.de
Bundesamt für Strahlenschutz (BfS)	Salzgitter	http://www.bfs.de
Wirtschaftsministerium Baden-Württemberg	Stuttgart	http://www.wm.baden-wuerttemberg.de
Ministerium für Umwelt und Verkehr Baden-Württemberg	Stuttgart	http://www.uvm.baden-wuerttemberg.de
Bayerisches Staatsministerium für Wirtschaft, Verkehr und Technologie	München	http://www.stmwvt.bayern.de
Bayerisches Staatsministerium für Landesentwicklung und Umweltfragen	München	http://www.umweltministerium.bayern.de
Hessisches Ministerium für Umwelt, ländlichen Raum und Verbraucherschutz	Wiesbaden	http://www.nmulv.hessen.de
Niedersächsisches Umweltministerium	Hannover	http://www.mu1.niedersachsen.de
Ministerium für Umwelt und Forsten, Rheinland-Pfalz	Mainz	http://www.muf.rlp.de
Ministerium für Finanzen und Energie, Schleswig-Holstein	Kiel	http://www.landesregierung. schleswig-holstein.de

MAIN POWER UTILITIES

EnBW Energie Baden-Württemberg AG	Karlsruhe	http://www.enbw.com
E.ON Energie AG	München	http://www.eon-energie.com
Hamburgische Electricitätswerke AG (HEW)	Hamburg	http://www.websrv01.hew.de
RWE Energie AG	Essen	http://www.rwe.com

MANUFACTURER, SERVICES AND OTHER NUCLEAR ORGANIZATIONS

Babcock Noell Nuclear	Würzburg	http://www.bb-powersystems.de
Brennelementlager Gorleben (BLG)	29475 Gorleben	Lüchower Str. 8
Brennelement-Zwischenlager Ahaus (BZA)	48683 Ahaus	Ammeln 59
Brenk-Systemplanung	Aachen	http://www.brenk.com
Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)	Hannover	http://www.bgr.de
Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe (DBE)	Peine	http://www.dbe.de
Deutsche Kernreaktor-Versicherungsgemeinschaft (DVKG)	50950 Köln	Postfach 52 01 29

Deutsches Atomforum (DAtF) Kerntechnische Gesellschaft (KTG) Informationskreis Kernenergie (IK) INFORUM Verlag	Bonn	http://www.kernenergie.de
Fachverband für Strahlenschutz	Berlin	http:/www.fs.fzk.de
Fichtner	Stuttgart	http://www.fichtner.de
Framatome-ANP (Germany)	Erlangen	http://www.framatome-anp.com
Gesellschaft für Anlagen- und Reaktorsicherheit (GRS)	Köln	http://www.grs.de
Gesellschaft für Nuklear-Behälter (GNB)	Essen	http://www.gnb-nuklearbehaelter.de
Gesellschaft für Nuklear-Service (GNS)	Essen	http://www.gns.de
Internationale Länderkommission Kerntechnik (ILK)		http://www.ilk-online.org
Kerntechnischer Ausschuß (KTA)	Salzgitter	http://www.kta-gs.de
Kerntechnischer Hilfsdienst	Eggenstein-Leopoldshafen	http://www.khgmbh.de
Kraftanlagen Nukleartechnik	Heidelberg	http://www.nukleartechnik.de
Kraftwerksschule	Essen	http://www.kraftwerksschule.de
KSB Pumpen + Armaturen		http://www.ksb.de
Physikalisch-Technische Bundesanstalt (PTB)	Braunschweig	http://www.ptb.de
Reaktor-Sicherheitskommission (RSK)	Bonn	http://www.rskonline.de
RWE NUKEM Group		http://www.nukem.de
Siempelkamp Nukleartechnik (SNT)	Krefeld	http://www.siempelkamp.de
STEAG Energie- und Kerntechnik	Essen	http://www.steag.de
Strahlenschutzkommission (SSK)	Bonn	http://www.ssk.de
Studsvik SINA Industrieservice	Pforzheim	http://www.sina.de
TÜV Nord Gruppe	Hamburg	http://www.tuev-nord.de
TÜV Süddeutschland	München	http://www.tuev-sued.de
Urenco Deutschland	Jülich	http://www.urenco.com
Verband der Elektrizitätswirtsschaft (VDEW)	Frankfurt/Main	http://www.strom.de
Vereinigung der Großkraftwerksbetreiber (VGB)	Essen	http://www.vgb.org
Westinghouse Electric Company		http://www.westinghouse.com
Wismut	Chemnitz	http://www.wismut.de

NUCLEAR RESEARCH INSTITUTES

Forschungszentrum Jülich	Jülich	http://www.kfa-juelich.de/
Forschungszentrum Karlsruhe	Karlsruhe	http://www.fzk.de/
Hahn-Meitner-Institut Berlin (HMI)	Berlin	http://www.hmi.de/
Max-Planck-Institut für Kernphysik	Heidelberg	http://www.mpi-hd.mpg.de/
Gesellschaft für Schwerionenforschung (GSI)	Darmstadt	http://www.gsi.de/
Deutsches Elektronen-Synchrotron (DESY)	Hamburg	http://www.desy.de/