GERMANY

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1. GENERAL 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 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, settlements and traffic area take 12 %.

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*, named West Germany) and the German Democratic Republic (GDR - *Deutsche Demokratische Republik*, known as East Germany). In October 1990, the GDR joined West Germany.

After the reunification Berlin again became capital of Germany. Part of the government, however, still remains in the former (provisional) capital Bonn. The estimated population for 2000 was about 82 million people. Area and population development is shown in Table 1.

TABLE 1. POPULATION INFORMATION

											Growth rate (%)
	1960	1970	1980	1990	1995	1996	1997	1998	1999	2000	1980 to 2000
Population (millions)	55.4 (17.2)	60.7 (17.1)	61.6 (16.7)	63.3 (16.1)	81.6	81.9	82.1	82.0	82.2	82.0	0.2
Population density (inh./km²)	223 (159)	244 (158)	247 (154)	254 (149)	234	235	235	235	235	235	0.2
Urban population (% of total)					86.5	86.7	86.9	87.1	87.3	N/A	
Area (1000 km²)	349.5										

Numbers in brackets refer to former GDR data
Source: IAEA Energy and Economic Database; Data & Statistics/The World Bank; Country Information [4].

1.2. Economic Indicators

The gross domestic product (GDP) statistics are given in Table 2, up to 1990 separately and later on for the unified republic. 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 unaccustomed western competition.

1.3. Energy Situation

Germany imported 60 % of its primary energy supply in 1999, including oil, which accounts for 39 % 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 restricted by environmental considerations. Hydro energy anyway contributes only a small amount, and possible places are already in use, so there are no considerable reserves left. Uranium extraction is 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)

	1970	1980	1990	1996	1997	1998	1999[a)]
GDP (millions of current DM)	675,300	1,472,000	2,426,000	3,541,500	3,666,600	3,784,200	3,877,100
GDP (millions of current US$)	185,200 (40,063)	810,600 (134,301)	1,501,200 (170,821)	2,345,700	2,113,290	2,151,340	2,110,000
GDP (millions of constant 1990 US$)	623,600 (134,900)	1,286,700 (213,200)	1,501,200 (170,821)	1,962,200	1,722,350	1,725,200	-
GDP per capita (current US$/capita)	3,051 (2,343)	13,159 (8,042)	23,716 (10,610)	28,716	25,740	26,235	25,700
GDP by sector (%):							
Agriculture				1.2	1.2	1.2	1.1
Industry				29.4	29.1	29.0	28.4
Services				69.3	69.7	69.9	70.6

[a)] preliminary data
Numbers in brackets refer to former GDR data
Source: IAEA Energy and Economic Data Base; Data & Statistics/The World Bank; Country Information [4].

TABLE 3. ESTIMATED ENERGY RESERVES

Exajoule

	Solid	Liquid	Gas	Uranium[a]	Hydro	Total
Total amount in place[c]	1222.70	1.18	11.35	0	11.57[b]	1,248.43
Total amount in place[d]	1,081.5[e]	2.1	10.9	0	0.8	1,095.3

[a] This total represents essentially recoverable reserves
[b] 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
[c] IAEA Energy and Economic Data Base
[d] Country Information [2, 10]
[e] 1998

TABLE 4. ENERGY STATISTICS

Exajoule

									Average annual Growth rate (%)	
	1960	1970	1980	1990	1997	1998 [a]	1999[a]	2000	1960 to 1980	1980 to 1999
Energy consumption										
- Total [b]	6.3(2.9)	9.9(3.1)	11.6(3.8)	14.91	14.57	14.46	14.20	14.07	2.6	-0.4
- Solids [c]	4.9(2.8)	4.0(2.6)	3.5(2.5)	5.51	3.63	3.55	3.36	3.46	-1.2	-3.0
- Liquids	1.3(0.1)	5.1(0.4)	5.4(0.8)	5.24	5.75	5.77	5.60	5.39	7.7	-0.5
- Gases	N/A	0.6(0.0)	2.1(0.3)	2.32	3.02	3.05	3.06	3.51	-	1.3
- Primary electricity [d]	0.2(0.0)	0.3(0.0)	0.6(0.1)	1.85	2.16	2.09	2.18	1.71	6.46	6.2
Energy production										
- Total	5.6(2.6)	5.2(2.4)	5.2(2.5)	7.88	5.95	5.58	5.65	4.93	-0.3	-1.6
- Solids	5.3(2.6)	4.3(2.3)	3.7(2.3)	5.23	2.96	2.71	2.64	2.33	-1.4	-4.2
- Liquids	0.2(0.0)	0.3(0.0)	0.2(0.0)	0.16	0.12	0.12	0.12	0.12	0.0	-2.7
- Gases	N/A	0.5(0.0)	0.7(0.1)	0.59	0.70	0.66	0.70	0.74	-	-0.7
- Primary electricity [d]	0.1(0.0)	0.2(0.0)	0.6(0.1)	1.85	2.17	2.09	2.18	1.74	10.2	6.2
Net import (import – export)										
- Total	0.6(0.3)	4.8(0.7)	6.8(1.2)	7.03	8.62	8.88	8.55	9.64	11.5	0.4
- Solids	-0.5(0.2)	-0.4(0.3)	-0.2(0.2)	0.23	0.67	0.84	0.71	0.92	-17.7	12.1
- Liquids	1.2(0.1)	5.1(0.4)	5.6(0.8)	5.08	5.63	5.65	5.48	5.98	8.3	-0.8
- Gases	N/A	0.1(0.0)	1.4(0.2)	1.73	2.32	2.39	2.36	2.74	-	2.1

[a] preliminary data
[b] Energy consumption = Primary energy production + Net import
[c] Solid fuels include coal, lignite and commercial wood
[d] Primary electricity = Hydro + Nuclear + Others (Geothermal, Wind, Solar energy etc.)
Numbers in brackets refer to former GDR data
Source: IAEA Energy and Economic Database and Country Information [2]

1.4. Energy Policy

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 11 % in 1999, while during the same period the share of nuclear has grown from 9 % to 31 %, whereas that of coal has remained at around 50 %. Since the 1990's all Federal Governments promoted the utilization of renewable energy. The utilities are required by law to buy energy generated by independent producers who use renewables. High minimum payments to the small producers for the transactions are determined in comparison with the generation price of nuclear or coal plants. Also direct government subsidies for the erection of wind and photovoltaic generators are paid. Nevertheless, large-scale electricity production will, for the next time, continue to come from Germany's coal and nuclear power plants.

In the past, the Federal Governments encouraged the utilities to increasingly use domestic hard coal for electricity generation, this rose to 45 million tons of hard coal per year in 1995. Subsidies were paid and amounted to 10 billion DM per annum in 1994. Since then subsidies are reduced continuously.

The current Federal Government (since September 1998) decided to phase out the use of nuclear power. The governing coalition will propose an amendment to the Atomic Act, in accordance with the agreement between the Federal Government and the utilities dated 14 June 2000, which was signed in June 2001. Basically the operation of a nuclear power plant is limited to 32 years (details see chapter 3.3). Therefore, the share of nuclear power in the national energy mix will decrease continuously within the next two decades.

The Federal Government intends to establish a new consensus in politics and society on an energy policy for the long term. It is of considerable importance to develop systems for energy supply apt for the future and to implement effective measures for improving energy efficiency and savings. Renewable energy is increasingly supported. Since April 2000, especially the remuneration for small producers for photovoltaic electricity is particularly high, around 10 times the generation price of nuclear power. Today, the share of renewable energy in gross electricity production is about 6 %, and it is intended to double this share by the year 2010. Furthermore the framing conditions for raising energy efficiency are improved, in particular by 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.

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 to reduce CO_2 emissions by 25 % compared to 1990, by the year 2005. Part of the challenge could be done 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 1999 e.g. the lowest CO_2 emission volume was recorded since 1990: 834 mt CO_2, which is 15 % less than 987 Mt CO_2 in 1990.

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 1990 level in 2012.

2. ELECTRICITY SECTOR

2.1. Structure of the Electricity Sector

The total electricity industry covers the sectors "public electricity supply", "mining, processing industry and others" and "*Deutsche Bahn*". In 1999, the net generation of all power plants amounted to 510.4 TW·h, 0.6 % less than in the previous year. Electricity supply companies also purchased electrical energy from around 10 000 small producers utilizing regenerative energy sources for power production, predominantly hydro and wind energy as well as solar energy, biomass and waste materials. In 1999, these small producers fed in 8.1 TW·h, this is around 1.6 % in relation to the net power generation mentioned above.

Germany's public electricity supply is characterized by a mixture of centralized and decentralized elements plus a pluralistic structure in electricity generation, transport and distribution. Participants are large, medium and small-sized electricity suppliers, the various capital interests and company legal forms as well as numerous large and small power plants and private producers. In 1998, around 1 000 electricity suppliers operated in Germany. The Association of German Electricity Supply Companies VDEW, carrying the statistics, dealt with 750 of these. They supplied their customers with more than 99 % of the electricity sold via the public grid. Of these 750 companies, 517 possessed their own power plant and 233 companies were engaged only in trading of electricity (see Table 5).

TABLE 5. STRUCTURE OF THE ELECTRICITY SECTOR (1998)

	Publicly owned utilities[a]		Utilities with mixed ownership[b]		Privately owned utilities[c]		Total Number
	Number	Share [%][d]	Number	Share [%][d]	Number	Share [%][d]	
Number of utilities in the VDEW statistics	455	13.6	200	52.2	95	34.2	750
Utilities producing electricity	318	61.5	134	25.9	65	12.6	517
net-maximum capacity [MW]	6 733	6.9	53 941	54.9	37 464	38.2	98 177
net production [TW·h]	21	4.6	255	56.8	173	38.6	448
Total supply to customers [TW·h]	122	278.4	280	62.9	43	9.7	445
Utilities supplying consumers with electricity	443	63.5	170	24.3	85	12.2	698

[a] With a share of at least 95 % owned by Bund, Länder, municipal associations or municipalities
[b] With a share of less than 95 % publicly owned and less than 75 % private capital
c With at least 75 % private capital
[d] Share in total supply
Source: Country Information [7]

Shareholder of the public electricity supply companies in 1998 included both governmental (mainly municipalities, municipal associations and counties and several *Länder*) as well as private investors. The group of mixed ownership companies (with shares held by the aforementioned public bodies and private investors) held the largest share in both electricity generation and total supply to consumers, 57 % in production and 63 % of supply. According to total supply to consumers, the second place was occupied by public utilities with 27 %. This group included nearly two thirds of the companies producing electricity. With 10 %, private companies held the smallest share of total supply to consumers. However, with nearly 40 % these companies held a relative large share in electricity generation.

Broken down according to supply functions, three corporate groups may be distinguished: the interconnected companies which predominantly own and operate the large power plants and ultra-high voltage transmission networks. Their key assignment is to maintain the reliability of nationwide power supply and to trade electricity supra-regional. The regional power suppliers, whose service

areas cover several municipalities, supply electricity obtained from those interconnected companies and other suppliers, as well as from small producers to local power suppliers and final consumers. Finally the local - mostly municipal - supply companies, whose service area is a municipality, several municipalities or parts thereof, predominantly supply cities and highly urbanized regions.

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

2.2. Decision Making Process

The BMWi outlines the national energy policy. The energy supplying companies are independent in their economic decisions, but of course follow commercial legislation. Decisions on expansion in energy production facilities and similar matters are due to market forces and price competition. Licensing and supervising activities are carried out by the competent *Länder* authorities, if the necessity is set by regulations. In the nuclear field the principle "safety first" has been guiding any administrative action ever since. The national energy policy - e.g. in the 1970s and 1980s using domestic coal and expanding the nuclear share, today the phase out of nuclear energy - is observed (see also Chapter 3.3).

2.3. Main Indicators

Table 6 shows the statistics on gross electricity production and installed gross capacities, here the three sectors "public electricity supply", "mining, processing industry and others" and "*Deutsche Bahn*" were added. In Table 7 energy related ratios are given.

TABLE 6. ELECTRICITY PRODUCTION AND INSTALLED CAPACITIES

								Average annual growth rate (%)	
	1960	1970	1980	1990	1997	1999	2000	1960 to 1980	1980 to 2000
Electricity production (TW·h)									
- Total [a] gross	119.0 (40.3)	237.8 (67.7)	365.3 (98.8)	444.5 (117.3)	551.2	563.58	569.42	5.77 (4.59)	2.21
- Thermal (fossil)	106.0 (39.7)	218.8 (65.9)	306.4 (85.3)	285.9 (103.5)	338.7	381.42	389.04	5.45 (3.90)	1.20
- Hydro	13.0 (0.6)	16.2 (1.3)	17.4 (1.7)	19.20 (2.0)	20.9	21.12	20.57	1.48 (5.35)	0.84
- Nuclear	N/A	2.7 (0.5)	41.4 (11.9)	139.4 (11.8)	170.3	160.84	159.60	31.12 (37.30)	6.69
- Others (Geothermal, Wind, Solar energy etc.)	N/A	N/A	N/A	N/A	21.3			-	
Gross Cap. of electrical plants (GWe)									
- Total	28.4 (7.9)	47.6 (12.1)	82.6 (19.7)	106.4 (23.4)	119.9	115.75	115.68	5.49 (4.67)	1.70
- Thermal (fossil)	25.0 (7.6)	42.0 (11.3)	67.5 (16.5)	76.6 (19.7)	85.1	85.14	85.20	5.08 (3.95)	1.17
- Hydro	3.4 (0.3)	4.7 (0.7)	6.5 (1.5)	7.1 (1.8)	8.9	8.89	8.89	3.33 (8.38)	1.62
- Nuclear	0,0 (0,0)	0.9 (0.1)	8.7 (1.7)	22.7 (1.8)	22.2	21.28	21.12	24.98 (32.75)	4.59
- Others (Geothermal, Wind, Solar energy etc.)	N/A	N/A	N/A	N/A	0.4	0.44	0.46	-	-

[a] Electricity losses are not deducted.
Numbers in brackets refer to former GDR data
Source: IAEA Energy and Economic Database and Country Information [2, 3].

TABLE 7. ENERGY RELATED RATIOS

	1960	1970	1980	1990	1997	1998[a]	1999[a]	2000
Energy consumption per capita (GJ/capita)	114(169)	163(181)	188(228)	188	177	176	173	172
Electricity per capita (kW·h/capita)	2.148 (2.343)	3.918 (3.959)	5.930 (5.916)	7.022 (7.286)	6.666	6.749	6750	N/A
Electricity production/Energy production (%)	7.6(5.6)	16(10)	25(14)	26	33	34	34	
Nuclear/Total electricity (%)		1.1(0.1)	11(12)	31(10)	31	29	31	30
Ratio of external dependency (%)[b]	9.5(10)	48(23)	59(32)	47	59	61	60	69
Load factor of electricity plants								
- Total (%)	48(58)	57(64)	50(57)	48(57)	51	52	54	56
- Thermal	48(60)	60(67)	52(59)	43(60)	45	46	48	52
- Hydro	44(23)	39(21)	31(13)	31(13)	25	26	27	26
- Nuclear		34(57)	55(80)	70(75)	87	83	87	86

[a] preliminary data
[b] Net import / Total energy consumption
Numbers in brackets refer to the former GDR
Source: IAEA Energy and Economic Database and Country Information [2, 8].

2.4. Impact of Open Electricity Market in the Nuclear Sector

In April 1998, the act on the reorganization of the power 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 in one step completely, not using the gradual opening conditions also in line with the directive. Up to this liberalization, the German electricity supply was characterized by closed supply areas. Contracts for licenses and demarcations provided a monopoly position of the utility in question. With the new regulation of April 1998 the competition started also in the electricity market, being a dynamically developing process ever since.

After only a few months of competition, the branch already found itself in a transformation of its structures, which have developed throughout decades. The situation is characterized by reorganization of the companies according to the value creation steps "generation", "transmission" and "distribution", by co-operation agreements, participations and mergers and not least by the appearance of additional market players in the new business sector "electricity trade".

At the beginning of the development special-tariff customers - mainly industry - took advantage by remarkable price reductions. And since the middle of 1999 the normal-tariff customers - e.g. private households - take a profit from the lower prices too.

3. NUCLEAR POWER SITUATION

3.1. Historical Development

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 EURATOM and the present Nuclear Energy Agency (NEA) of OECD. Agreements for cooperation with France, the United Kingdom and the USA were signed. 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.

Several nuclear research centers were created:

1956: - *Kernforschungszentrum Karlsruhe* (KfK),

- *Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt* (GKSS) in Geesthacht,

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

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

1967: - *Kernforschungsanlage* Jülich (KFA),

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

University institutes were equipped with small reactors for instruction, research and material testing.

In 1958, a 15 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 then world's largest reactor, Biblis A, 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 1,300 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 than 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, started commissioning. Following the German unification, comprehensive safety assessments of the Soviet type NPPs in East Germany were carried out. These analyses showed safety deficiencies compared to 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 and now is used as pleasure ground.

All nuclear power plants currently in operation in Germany were built by KWU or Siemens/AEG respectively. The second German supplier for NPPs, the Brown, Bovery & Co. (BBC), meanwhile ABB, respectively sold to BNFL/UK in December 1999, now called Westinghouse, commissioned 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, 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. Today, this development is continued by Framatome ANP. German utilities also supported the Siemens/KWU development of an advanced BWR 1000 (SWR 1000). In 2001, the remaining domestic NPP supplier Siemens merged its nuclear branch with Framatome SA to Framatome ANP (Advanced Nuclear Power) GmbH.

Since the early 1970’s, 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, like in 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 litigations.

By the mid 1970’s, Germany increased its efforts to close the fuel cycle and to set up a programme for radioactive waste management and final disposal. 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 suitability as high level waste repository. Experience from the disposal of low and medium level waste had been gathered in the former salt mine Asse, also in Niedersachsen. The former iron ore mine Konrad/Niedersachsen is in the licensing process for low and medium-level radioactive waste since 1976.

In the late 1960’s, East German studies on final disposal of radioactive waste resulted in the decision to use the abandoned salt mine Morsleben as repository for low and medium 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. In the meanwhile, the emplacement was stopped due to court order in September 1998. Now, the licensing procedure for the decommissioning is in progress.

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 will be brought back to Germany (see also chapter 3.3). The plutonium from reprocessing should be used for MOX fuel elements. The new MOX fuel fabrication plant at Hanau was completed, but could not be commissioned due to political complications, and is now being dismantled.

Since the late 1980's most of the research centers changed their subjects - and some of them also the name - to environmental issues. Due to financial conditions, research became restricted to basic nuclear physics.

3.2. Status and Trends of Nuclear Power

In 2000, the total gross capacity of 22.4 GWe was installed within the 19 operating German nuclear power plants, 0.7 % more than in the previous year. This was realized either by increasing the thermal reactor power (KKI 2, KKP 2, KKU) or optimizing the steam turbine (KKE, KKI 1) respectively. Increasing of thermal reactor power is also foreseen for several other facilities. The generated nuclear electricity amounted up to 170 TW·h in 2000, as in 1999 also, and about one third of the electricity supplied by public utilities. This nuclear share is roughly constant since 1985. Table 8 shows the status of nuclear power plants by the end of 2000, Figure 1 the siting.

3.3. Current Policy Issues

In 1986, after the Chernobyl nuclear accident, political consensus on the use of nuclear energy was lost definitely in Germany. 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. Since the federal elections in September 1998, they hold the Federal Government in a coalition with the green party Bündnis90/ Die Grünen (Greens).

The political situation regarding the relation between the Federation and the *Länder* has been complicated by changing political majorities. Federation and *Länder*, both have their responsibilities in nuclear licensing and nuclear safety matters. The *Länder* are represented by 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 is to phase out the use of nuclear power as soon as possible, but in consensus with the industry and without compensation payments. There is also the request to rearrange all waste management and waste repository issues. Therefore, in June 2001, the Agreement between the Federal Government of Germany and the utility companies dated 14 June 2000 was signed. The main topics are as followed:

- *NPP*

  Basically, the operation time of NPPs is limited to 32 years. However, not the period of time of NPP operation will be limited, but the remaining amount of electricity to be produced. This amount may be shared between the different plants. The operation of the NPP Mülheim-Kärlich will not be resumed.

  The Government assures the uninterrupted operation of the NPPs during the residual operating life, if there is compliance with the requirements of atomic energy law.

- *Transport of spent fuel*

  In order to minimize transports of spent fuel, the utilities agreed to build as soon as possible interim storage facilities at the NPP sites. To account for the time until these interim storages will be operable other on-site temporary storage capabilities will be made available.

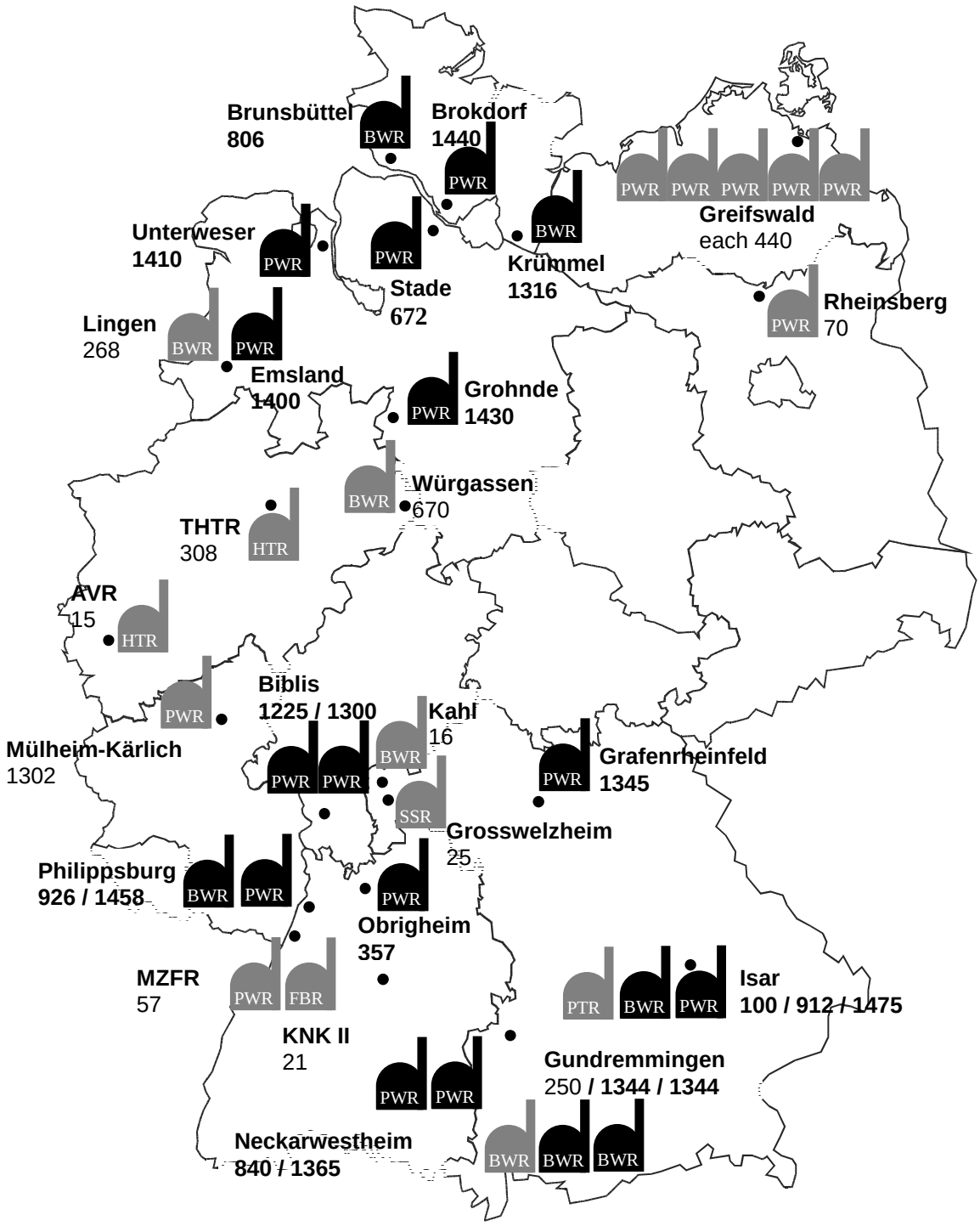
- Reprocessing/Direct Disposal

  Starting from July 2005, the waste management of spent fuel from the NPPs shall be restricted to direct disposal. Until then, transports to reprocessing facilities are permitted.

TABLE 8. 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	06-Apr-76	31-Jan-77	
BROKDORF (KBR)	PWR	1370	Operational	EON	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	EON	KWU	01-Jan-75	09-Dec-81	21-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	EON	KWU	20-Jul-76	26-Oct-84	02-Nov-84	18-Jan-85	
ISAR-1 (KKI 1)	BWR	878	Operational	BAG	KWU	01-May-72	20-Nov-77	03-Dec-77	21-Mar-79	
ISAR-2 (KKI 2)	PWR	1400	Operational	EON	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	31-Mar-69	
PHILIPPSBURG-1 (KKP 1)	BWR	890	Operational	EnBW	KWU	01-Oct-70	09-Mar-79	07-May-79	26-Mar-80	
PHILIPPSBURG-2 (KKP 2)	PWR	1392	Operational	EnBW	KWU	07-Jul-77	13-Dec-84	17-Dec-84	17-Apr-85	
STADE (KKS)	PWR	640	Operational	EON	KWU	01-Dec-67	08-Jan-72	29-Jan-72	19-May-72	
UNTERWESER (KKU)	PWR	1345	Operational	EON	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	15-Dec-73	17-Dec-73	12-Jul-74	14-Feb-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	16-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	22-Jul-90
GREIFSWALD-5 (KGR 5)	WWER	408	Shut Down	EWN	AEE, KAB	01-Dec-76	26-Mar-89	24-Apr-89	01-Nov-89	24-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	HDR	AEG, KWU	01-Jan-65	14-Oct-69	14-Oct-69	02-Aug-70	20-Apr-71
KNK II	FBR	17	Shut Down	KBG	IA	01-Sep-74	10-Oct-77	09-Apr-78	03-Mar-79	23-Aug-91
LINGEN (KWL)	BWR	250	Shut Down	KWL	AEG	01-Oct-64	31-Jan-68	01-Jul-68	01-Oct-68	05-Jan-79
MUELHEIM-KAERLICH (KMK)	PWR	1219	Shut Down	RWE	BBR	15-Jan-75	01-Mar-86	14-Mar-86	01-Aug-87	09-Sep-88
MZFR	PHWR	52	Shut Down	KBG	SIEMENS	01-Dec-61	01-Sep-65	09-Mar-66	19-Dec-66	03-May-84
NIEDERAICHBACH (KKN)	HWGCR	100	Shut Down	KKN	SIEM, KWU	01-Jun-66	17-Dec-72	01-Jan-73	01-Jan-73	21-Jul-74
RHEINSBERG (KKR)	PWR	62	Shut Down	EWN	AEE, KAB	01-Jan-60	01-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	20-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	PE	AEG, KWU	26-Jan-68	20-Oct-71	18-Dec-71	11-Nov-75	26-Aug-94

Source: IAEA Power Reactor System year-end 2000



Legend

PWR	Pressurized Water Reactor		
BWR	Boiling Water Reactor	in operation	
FBR	Fast Breeder Reactor		
HTR	High Temperatur Reactor		
PTR	Pressure Tube Reactor	shut down	
SSR	Superheated Steam-Cooled Reactor		

Numbers indicate Gross Capacity [MWe], 12/2000

FIG. 1. Nuclear Power Plants in Germany

- *Disposal Sites*

  The underground investigation of the Gorleben salt dome (intended to host a repository for all types of radioactive waste, mainly for heat-generating radioactive waste originating from reprocessing and spent fuel elements) will be postponed up to 10 years at maximum (moratorium). The German waste management policy will be reconsidered and new criteria for the selection of appropriate disposal sites will be established.

  The responsible authorities shall conclude the plan approval for Schacht Konrad (radioactive waste with negligible heat generation) according to the legal provisions.

- *Costs*

  Government and utilities understand that there will be no compensation claims.

- *Atomic Act*

  The Government will propose an amendment to the Atomic Act in accordance with the agreement.

The new German energy policy will not affect Germany's responsibility regarding its international obligations and does not reduce the efforts towards nuclear safety, at least as long as nuclear power plants will be operating in Germany.

3.4. Organizational Charts

The interaction of the different authorities and organizations involved in the nuclear licensing procedure is shown in Figure 2. The institutions mentioned are explained in chapter 5.1 in more detail.

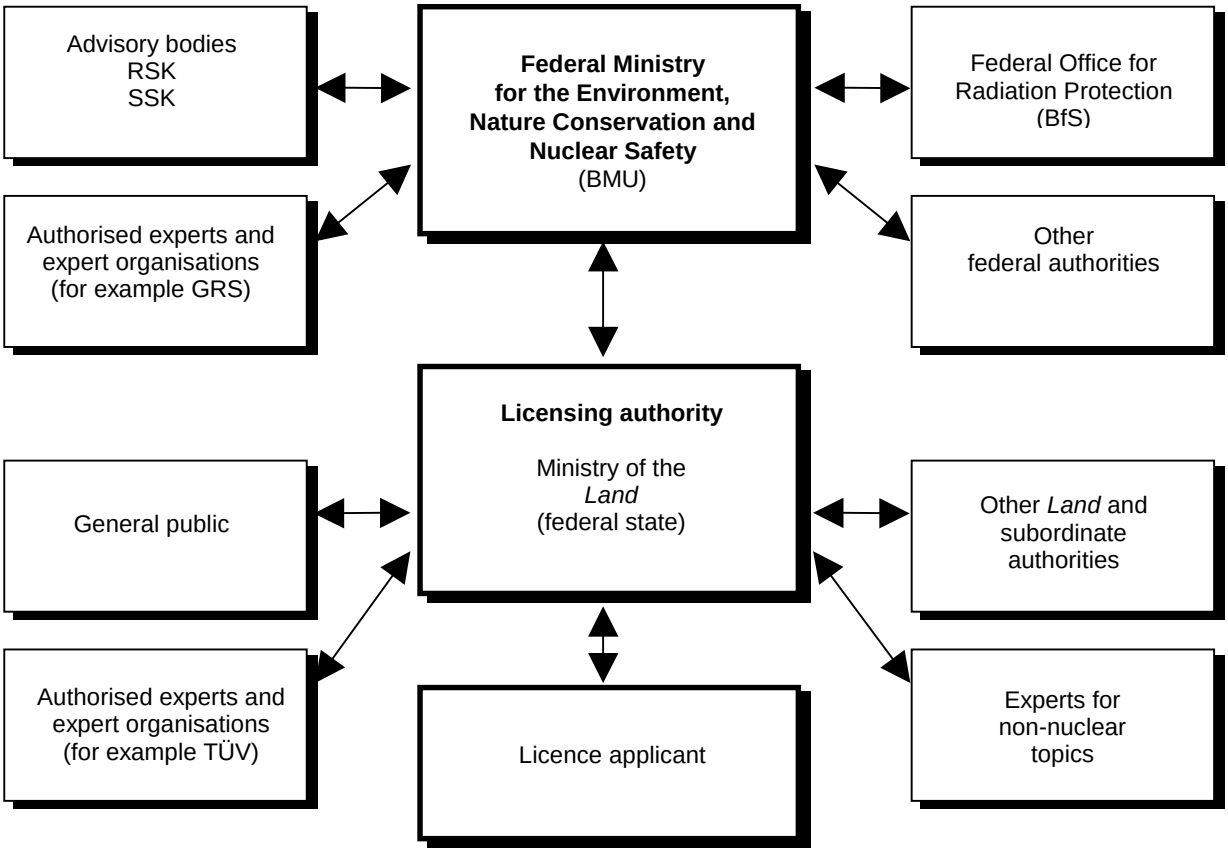


FIG.2. Participants in the Nuclear Licensing Procedure

3.5. Radioactive Waste Management and Disposal

Since the early sixties, i.e. from the very beginning of use of nuclear energy, the German radioactive waste disposal policy has been 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 effected 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 is not practised in Germany because of the high population density and climatic conditions; furthermore appropriate deep geological formations exist.

Responsibility for the disposal of radioactive waste lies with the Federation, the *Bundesamt für Strahlenschutz* (Federal Office for Radiation Protection) is the legally responsible authority. All other radioactive waste management, i.e. spent fuel storages, 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 industry, universities or medicine.

The disposal of radioactive waste in a final repository is governed by the following regulations:

- *Atomgesetz* (Atomic Energy Act);
- *Strahlenschutzverordnung* (Radiation Protection Ordinance);
- *Bundesberggesetz* (Federal Mining Act);
- *Sicherheitskriterien für die Endlagerung radioaktiver Abfälle in einem Bergwerk* (Safety Criteria for the Disposal of Radioactive Waste in a Mine);
- *Umweltverträglichkeitsgesetz* (Environmental Impact Assessment Act).

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 all aspects concerning the operation of a disposal mine. The Safety Criteria 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.

According to the political aims of the Federal Government being in favour of phasing out the use of nuclear energy for electricity production, the German radioactive waste management and disposal programmes are presently re-examined and revised programmes are to be developed. The new policy will be enforced by changes of the legislative basis, necessary amendments are in preparation.

4. NUCLEAR POWER INDUSTRY

4.1. 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/SNP GmbH 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 called Westinghouse Reaktor GmbH, now concentrates on Nuclear Services.

4.2. Operation of NPPs

The different companies operating the NPP sites are owned by only few main utilities. Also these were in a process of concentration within the last years. So Bayernwerk AG and Preussen Elektra AG came together in the new E.ON Energie AG, also RWE AG and VEW AG merged their activities in the new RWE AG. Operating personnel is sufficiently supplied at the moment, regularly retrained for their job at plant specific simulators. But personnel may become a difficult issue due to the agreement to phase out the use of nuclear power and diminishing interest in a nuclear education in Germany.

4.3. Fuel Cycle and Waste Management Service Supply

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.

One fuel fabrication facility is operating in Lingen, the Hanau fuel fabrication facilities are either being decommissioned or never received an operating license. The enrichment plant of URENCO extended from a capacity of 400 t/year to 1300 t/year step by step within the last years. It is also intended to increase the capacity to 4000 t/year, the application was made in 1998.

In Germany there are three central interim storage facilities for spent fuel in operation. The transport flask store Ahaus (TBLA) serves for the interim storage of irradiated fuel elements, the transport flask store Gorleben (TBLG) provides both the interim storage of irradiated fuel elements and the interim storage of vitrified fission products solutions from reprocessing. The interim storage facility Nord (ZLN) was erected for the storage of spent fuel from decommissioning the NPPs in Greifswald and Rheinsberg. According to the mentioned agreement between the Federal Government an the utilities additional applications have been filed to built interim storage facilities and temporary storage place for spent fuel at the site of nuclear power plants. Now, the licensing procedures are in progress.

The waste conditioning facility PKA is now completed; a limited operation license to repair damaged containers was granted by the competent *Länder* authority in 2000.

The reprocessing test plant WAK is being decommissioned, a facility to vitrify high active waste concentrate is in the licensing procedure. The project on industrial reprocessing Wackersdorf has been abandoned in Germany partly due to economic reasons. Therefore, the German utilities have contracts for reprocessing spent fuel with COGEMA/France and BNFL/UK. But starting from July 2005, the disposal of spent fuels shall be restricted to direct final storage (see Section 3.3).

The repository for low and medium active waste ERAM stopped emplacement on court decision in 1998. Now the licensing procedure for the decommissioning is in process. Schacht Konrad is planed for disposal of all types of radioactive waste with negligible heat generation; the licensing procedure is still in progress. The underground investigation of the Gorleben salt dome (intended to host a repository for all types of radioactive waste, mainly for heat-generating radioactive waste originating from reprocessing and spent fuel elements) is postponed since October 2000 up to 10 years at maximum, in accordance to the agreement between the Federal Government and the utility companies (see Section 3.3).

A selection of services are mentioned in the appendix.

4.4. Research and Development Activities

Basic nuclear research is supported by BMWi and conducted at several governmental and few industrial institutions and sometimes, but less and less, at the - former nuclear - research centers (see Section 3.1). Reactor type development is also covered on Section 3.1. The *Gesellschaft für Anlagen- und Reaktorsicherheit* (GRS) performs scientific research in the field of nuclear safety mainly under federal contracts, and assists the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) in technical issues. Also the Federal Government, represented this time by the two ministries BMWi and BMU, supports national research on direct disposal and final repositories.

4.5. International Co-operation in the Field of Nuclear Power Development and Implementation

Germany as member of the EU, OECD/NEA, and IAEA supports various international programmes in nuclear safety and nuclear waste management.

As EU member Germany takes part in the PHEBUS project and in many other European nuclear research issues. Also Germany participates in the PHARE and TACIS programs, which are general projects to support Central Europe and the CIS countries and include the field of nuclear safety and development.

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 SANDIA project on the lower head failure; and in
- the MASCA project on in-vessel phenomena during a servere accident as a follow up of the RASPLAV project.

In direct international co-operation Germany also supports projects or organizations respectively, e.g. the MACE/ACEX project on corium spreading and iodine behavior at EPRI/USA.

Framatome ANP GmbH participates in several international R&D Projects, e.g.:

- HALDEN
- PKL3 (OECD)
- PANDA (PSI)
- PHARE/TACIS (EU)
- INPRO (IAEA)
- CAMP (USNRC).

5. REGULATORY FRAMEWORK

5.1. 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 use of atomic weapons. Originally - prior to the unification - its application scope was restricted to the Federal Republic of Germany within the 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 Article 30 ff. of the EURATOM Treaty. In accordance with Article 77 ff. of the EURATOM Treaty any utilization of ores, source material and special fissile material is subject to surveillance by the European Atomic Energy Community.

With respect to nuclear safety, the Atomic Energy Act is the central 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. It 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 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 for essentially modifying such installation or its operation. The applicant may only be granted a license if he meets the individual requirements that are spelled out in Section 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;
- consideration of public interests with respect to environmental impacts.

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 dose planning values for the design of nuclear power plants against design basis accidents.

The licensing of nuclear installations lies within the responsibility of the individual *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 expert 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 submittal of supporting documents and with the participation of the general public. It deals, furthermore, with the assessment of environmental impacts 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 region of the Federal Republic of Germany, the BMU supervises the licensing and supervisory activities of the *Länder* authorities (so-called ”federal executive administration”). This also 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 as a central expert organization.

The individual power utilities or their subsidiaries are the license applicants for the construction and operation of a nuclear power plant. They submit a written license application to the competent licensing authority of that *Land* in which they intend to erect the nuclear installation. The license application is accompanied by documents that are specified by the Nuclear Licensing Procedure Ordinance as well as in collateral guidelines. An important document is the safety analysis report which describes the plant, its operation and the related effects, and also includes descriptions of the design basis accidents as well as the associated precautionary measures. It contains site plans and overview drawings. In fulfilment of the licensing prerequisites, further documents are submitted. In addition, with respect to public participation, a brief description of the planned installation is submitted with the application that includes information on the probable effects on the general public and environment in the direct vicinity of the installation. A license is also required for the decommissioning of a nuclear installation and substantial modifications of the plant or its operation. On the basis of the submitted documents and after having involved all competent institutions and also the general public, the licensing authority evaluates whether or not the license prerequisites have been met. Prerequisite for the legality of the decision is that all procedural requirements of the Nuclear Licensing Procedure Ordinance are fulfilled. Licenses for the operation of nuclear power plants are issued with no time limitation. Actions against the decision of the licensing authority can be brought forth in the administrative courts.

Over their entire lifetime, from the start of construction to the end of decommissioning with the corresponding licenses, nuclear installations are subject to continuous regulatory supervision. However, the *Länder* perform this supervisory procedure on behalf of the Federal Government, the Federal Government supervises the *Länder*.

As in licensing, the supreme objective of the regulatory supervision of nuclear installations is to protect the general public and the people engaged in these installations against the hazards connected with the operation of the installation. Authority officials 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 necessary examinations and to demand pertinent information.

In the case of non-compliance with respect to legal provisions or to requirements of the license permit and also if it must be suspected that the life, health or property of third parties is endangered, the competent supervisory authority of the *Land* is authorized by Section 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 to the potential magnitude of such 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 account for the Paris Convention on nuclear liability amended by the Brussels Supplementary Convention. Both conventions have, in the meantime, been incorporated into the Atomic Energy Act. The corresponding details are regulated by the Nuclear Financial Security Ordinance. In Germany this means that 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. Currently, the maximum required financial security from liability insurances is limited to DM 500 million and that of the additional (federal) indemnity to twice this amount. With the pending amendment of the Atomic Act, this financial security will be increased to € 2500 millions.

5.2. Main National Laws and Regulations

- Atomic Energy Act (*Gesetz über die friedliche Verwendung der Kernenergie und den Schutz gegen ihre Gefahren - Atomgesetz*) of December 23, 1959, as amended and promulgated on July 15, 1985, last amendment by the act of March 05, 2001
- Precautionary Radiation Protection Act (*Gesetz zum vorsorgenden Schutz der Bevölkerung gegen Strahlenbelastung - Strahlenschutzvorsorgegesetz*) of December 19, 1986, last amendment by the act of June 24, 1994
- Act of the Assessment of Environmental Impacts (*Gesetz über die Umweltverträglichkeits-prüfung*) of February 12, 1990, last amendment by the act of August 18, 1997
- Radiation Protection Ordinance (*Verordnung über den Schutz vor Schäden durch ionisierende Strahlen - Strahlenschutzverordnung*) as promulgated on June 30, 1989, last amendment of August 18, 1997
- Nuclear Licensing Procedure Ordinance (*Verordnung über das Verfahren bei der Genehmigung von Anlagen nach § 7 des Atomgesetzes - Atomrechtliche Verfahrensverordnung*) of February 18, 1977, last amendment of February 3, 1995
- Nuclear Financial Security Ordinance (*Verordnung über die Deckungsvorsorge nach dem Atomgesetz - Atomrechtliche Deckungsvorsorge-Verordnung*) of January 25, 1977, last amendment by the act of September 25, 1990
- Repository Financing Ordinance (*Verordnung über Vorausleistungen für die Einrichtung von Anlagen des Bundes zur Sicherstellung und zur Endlagerung radioaktiver Abfälle - Endlager-vorausleistungsverordnung*) of April 28, 1982, last amendment by the act of September 25, 1990
- Ordinance on the Verification of Trustworthiness (*Verordnung für die Überprüfung der Zuverlässigkeit zum Schutz gegen Entwendung oder erhebliche Freisetzung radioaktiver Stoffe nach dem Atomgesetz - Atomrechtliche Zuverlässigkeitsüberprüfungs-Verordnung*) of July 1, 1999
- Nuclear Safety Commissioneer and Reporting Ordinance (*Verordnung über den kerntechnischen Sicherheitsbeauftragten und die Meldung von Störfällen und sonstigen Ereignissen - Atomrechtliche Sicherheitsbeauftragten- und Meldeverordnung*) of October 14, 1992

- Ordinance on Nuclear Waste Transboundary Movement (*Verordnung über die Verbringung radioaktiver Abfälle in das oder aus dem Bundesgebiet - Atomrechtliche Abfallverbringungs-verordnung*) of July 27, 1998
- X-ray Ordinance (*Verordnung über den Schutz vor Schäden durch Röntgenstrahlen - Röntgen Verordnung*) of January 8, 1987, last amendment of July 20, 2000

5.3. International, Multilateral and Bilateral Agreements

AGREEMENTS WITH THE IAEA

• NPT related safeguards agreement INFCIRC/193	Entry into force:	21 February 1977
• Additional protocol (GOV/1998/28)	Signature:	22 September 1998
• Improved procedures for designation of safeguards	Proposal rejected by EURATOM but special procedures agreed upon	letter of 16 February 1989
• Agreement on privileges and immunities; INFCIRC/9/Rev.2	Entry into force:	4 August 1960

MULTILATERAL SAFEGUARDS AGREEMENTS

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

OTHER RELEVANT INTERNATIONAL TREATIES

• NPT INFCIRC/140	Entry into force:	2 May 1975
• EURATOM		Member
• Agreement on privileges and immunities; INFCIRC/9/Rev.2	Entry into force:	4 August 1960
• Convention on physical protection of nuclear material; INFCIRC/274/Rev.1	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 civil liability for nuclear damage; INFCIRC/402	Entry into force:	30 September 1975

• Joint protocol	Ratified: Entry into force:	13 June 2001 13 September 2001
• Protocol to amend the Vienna convention for civil liability for nuclear damage		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	Entry into force:	18 June 2001
• ZANGGER Committee		Member
• Nuclear Export Guidelines		Adopted
• Acceptance of NUSS Codes	National regulations are generally consistent with codes	letter of 6 March 1989
• Nuclear Suppliers Group		Member

BILATERAL AGREEMENTS CONCERNING THE SAFETY OF NUCLEAR INSTALLATIONS AND RADIATION PROTECTION (12/2000)

Agreement with	**Major agreement content**	**date signed**	**effective date**
Argentina	Exchange of information and co-operation	8 October 1981	8 October 1981
Austria	Mutual assistance in case of an emergency	23 December 1988	1 October 1992
	Exchange of information	1 July/3 August 1993	1 December 1994
Belgium	Mutual assistance in case of an emergency	30 November 1982	1 May 1984
Brazil	Co-operation	27 June 1975	18 November 1975
	Exchange of information and co-operation	10 March 1978	10 March 1978
Bulgaria	Exchange of information	26 March 1993	28 June 1993
China	Promotion of co-operation	12 April 1992	14 June 1993
	Co-operation	09 Mai 1984	09 Mai 1984
Czechoslovakia	Exchange of information	30 May 1990	2 August 1990
Denmark	Mutual information on close border nuclear installations	4 July 1977 13 October 1987	30 September 1988
	Exchange of information	17 March 1988	1 August 1988
Finland	Mutual assistance in case of an emergency Early notification in case of an emergency and exchange of information	21 December 1992	28 May 1993

Agreement with	Major agreement content	date signed	effective date
France	Exchange of information	12 January/29 March 1976	29 March 1976
	Mutual assistance in case of an emergency	3 February 1977	1 December 1980
	Exchange of information in case of an emergency	28 January 1981	6 August 1981
Hungary	Exchange of information	26 September 1990	7 February 1991
	Mutual assistance in case of an emergency	9 June 1997	7 July 1998
Japan	Exchange of information	5 July/1 September 1989	
Lithuania	Mutual assistance in case of an emergency	15 March 1994	1 September 1996
Luxembourg	Mutual assistance in case of an emergency	2 March 1978	1 December 1981
Netherlands	Mutual information on close border nuclear installations	27 Sept./28 October 1977	
		21 May 1981	
	Exchange of information	7 June 1988	1 March 1997
	Mutual assistance in case of an emergency		
Norway	Exchange of information	10 May 1988	30 August 1988
Poland	Mutual assistance in case of an emergency	10 April 1997	7 July 1998
Russian Federation	Early information in case of an emergency and exchange of information	25 October 1988	08 January 1990
	Mutual assistance in case of an emergency	16 December 1992	11 July 1995
	Third party liability	8 June 1998	8 June 1998
	Application of nuclear material	2 June 1998	2 June 1998
	Supply of highly enriched uranium for use in FRM II	8 June 1998	13 January 1999
Spain	co-operation	23 Nov. 87/14 March 88	
Sweden	Early notification in case of an emergency and exchange of information	25 September 1990	5 December 1990
Switzerland	Radiological emergency preparedness	31 May 78/25 July 86	25 March 1988
	Mutual information on close border nuclear installations	10 August 1982	19 September 1983
		22 October 1986	28 June 1988
	Third party liability	28 November 1984	1 December 1988
	Mutual assistance in case of an emergency		
United Kingdom	Exchange of information and co-operation in drafting safety standards	14 March/4 April 1979	4 April 1979
Ukraine	Exchange of information	10 June 1993	5 November 1993
USA	Exchange of information and co-operation (until 19 October 2000)	19 October 1995	19 October 1995
	Exchange of information (until 13 December 2000)	13 December 1995	13 December 1995

REFERENCES, BIBLIOGRAPHY

[1] Report under the Convention on Nuclear Safety by the Government of the Federal Republic of Germany for the First Review Meeting in April 1999, www.bfs.de.

[2] Zahlen und Fakten, Energie Daten 2000, BMWi, Bonn 2000.

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[4] Statistisches Jahrbuch für die Bundesrepublik Deutschland, Metzler-Poeschel, Stuttgart, September 2000.

[5] Jahrbuch Atomwirtschaft 2001, INFORUM Verlags- und Verwaltungsgesellschaft mbH, Bonn 2001.

[6] Nuclear Power in Germany, Annual Report 1999, Deutsches Atomforum, Bonn.

[7] Electricity Market Germany 1998, VDEW, Verlag VWEW, Frankfurt, Oktober 1999.

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[9] Handbuch Reaktorsicherheit und Strahlenschutz, BMU, loose-leaf edition, 27th update 12/99.

[10] Wirtschaftsverband Erdöl- und Erdgasgewinnung e.V., Schätzung der deutschen Erdgas- und Erdölreserven, www.erdoel-erdgas.de, Hannover, Juni 2001.

[11] IAEA Energy and Economic database.

[12] Data & Statistics, the World Bank, www.worldbank.org/data.

[13] IAEA Power Reactor Information System.

Appendix 1

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 Technologie (BMWi)
D-10109 Berlin
www.bmwi.de

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU)
Postfach 12 06 29
D-53048 Bonn
www.bmu.de

Bundesministerium für Bildung und Forschung (BMBF)
53170 Bonn
http://www.bmbf.de

Bundesamt für Strahlenschutz (BfS)
Postfach 10 01 49
D-38201 Salzgitter
www.bfs.de

Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)
Postfach 51 01 53
D-30631 Hannover
www.bgr.de

Physikalisch-Technische Bundesanstalt (PTB)
Postfach 33 45
D-38023 Braunschweig
www.ptb.de

Wirtschaftsministerium Baden-Württemberg
Theodor-Heuss-Str. 4
D-70174 Stuttgart
www.baden-wuerttemberg.de

Ministerium für Umwelt und Verkehr Baden-Württemberg
Kernerplatz 9
D-70182 Stuttgart
www.uvm.baden-wuerttemberg.de

Bayerisches Staatsministerium für Wirtschaft, Verkehr und Technologie
D-80525 München
www.stmwft.bayern.de

Bayerisches Staatsministerium für Landesentwicklung und Umweltfragen
Postfach 81 01 40
D-81901 München
www.stmlu.bayern.de

Ministerium für Landwirtschaft, Umweltschutz und Raumordnung
Postfach 60 11 64
D-14411 Potsdam
www.brandenburg.de/land/mlur

Senatsverwaltung für Stadtentwicklung, Umweltschutz und Technologie
D-10173 Berlin
www.sensut.berlin.de

Senator für Frauen, Gesundheit, Jugend, Soziales und Umweltschutz der Freien Hansestadt Bremen
Postfach 10 78 68, D-28078 Bremen
www.bremen.de

Senator für Arbeit der Freien Hansestadt Bremen
Contrescarpe 73
D-28195 Bremen
www.bremen.de

Umweltbehörde der Freien und Hansestadt Hamburg
Billstr. 84
D-20539 Hamburg
www.hamburg.de/behoerden/umweltbehoerde

Hessisches Ministerium für Umwelt, Landwirtschaft und Forsten
Mainzer Str. 80
D-65189 Wiesbaden
www.mulf.hessen.de

Innenministerium Mecklenburg-Vorpommern
D-19048 Schwerin
www.mv-regierung.de/im

Wirtschaftsministerium Mecklenburg-Vorpommern
D-19048 Schwerin
www.wm.mv-regierung.de

Niedersächsisches Umweltministerium
Postfach 41 07
D-30041 Hannover
www.mu.niedersachsen.de

Ministerium für Wirtschaft und Mittelstand, Energie und Verkehr des Landes Nordrhein-Westfalen
D-40190 Düsseldorf
www.nrw.de

Ministerium für Umwelt und Forsten
Postfach 31 60
D-55021 Mainz
www.rheinland-pfalz.de

Ministerium für Umwelt
Postfach 10 24 61
D-66024 Saarbrücken
www.saarland.de

Sächsisches Staatsministerium für Umwelt und Landwirtschaft
Postfach 10 05 10
D-01075 Dresden
www.sachsen.de

Ministerium für Raumordnung und Umwelt des Landes Sachsen-Anhalt
Postfach 37 69
D-39012 Magdeburg
www.mu.sachsen-anhalt.de

Ministerium für Finanzen und Energie des Landes Schleswig-Holstein
Postfach
D-24019 Kiel
www.schleswig-holstein.de

Thüringisches Ministerium für Landwirtschaft, Naturschutz und Umwelt
Postfach 10 03
D-99021 Erfurt
www.thueringen.de/natur

MAIN POWER UTILITIES

EnBW Energie Baden-Württemberg AG
Postfach 2349
D-76011 Karlsruhe
www.enbw.de

E.ON Energie AG
Brienner Straße 40
80333 München
www.eon-energie.de

Hamburgische Electricitätswerke AG (HEW)
Überseering 12
D-22297 Hamburg
www.hew.de

RWE Energie AG
Opernplatz 5
D-45128 Essen
www.rwe.de

MANUFACTURER, SERVICES AND OTHER NUCLEAR ORGANIZATIONS

Advanced Nuclear Fuels GmbH (ANF)
Postfach 14 65
D-49784 Lingen

Babcock Noell Nuclear GmbH
Alfred-Nobel-Straße 20
D-97080 Würzburg
www.babcockborsigpower.de

Brennelementlager Gorleben GmbH (BLG)
Lüchower Str. 8
D-29475 Gorleben

Brennelement-Zwischenlager Ahaus GmbH (BZA)
Ammeln 59
D-48683 Ahaus

Brenk-Systemplanung
Ingenieurbüro für wissenschaftlich technischen Umweltschutz (BS)
Heider-Hof-Weg 23
D-52080 Aachen-Verlautenheide

Canberra-Packard GmbH
Robert-Bosch-Str. 32
D-63303 Dreieich
www.canberra.de

DBE mbH
Endlager für radioaktive Abfälle Morsleben (ERAM)
Am Schacht 105
D-39343 Morsleben
www.dbe.de

Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH (DBE)
Postfach 11 69
D-31201 Peine
www.dbe.de

Deutsche Kernreaktor-Versicherungsgemeinschaft (DVKG)
Postfach 52 01 29
D-50959 Köln

Deutsches Atomforum e.V. (DAtF)
Tulpenfeld 10
D-53113 Bonn
www.atomforum.de

Electrowatt Engineering Mannheim GmbH
Mallaustraße 59
D-68219 Mannheim

Fichtner GmbH & Co. KG
Postfach 10 14 54
D-70013 Stuttgart
www.fichtner.de

Framatome-ANP GmbH
Postfach 32 20
D-91050 Erlangen
www.frameatome-anp.com

Gesellschaft für Anlagen- und Reaktorsicherheit mbH (GRS)
Society for Reactor Safety
Schwertnergasse 1
D-50667 Köln
www.grs.de

Gesellschaft zur Zwischenlagerung schwach- und mittelradioaktiver Abfälle mbH (GZA)
Postfach 20 05 53
D-80005 München

GNB Gesellschaft für Nuklear-Behälter mbH
Postfach 10 12 53
D-45012 Essen
www.gnb-nuklearbehaelter.de

GNS Gesellschaft für Nuklear-Service mbH
Postfach 10 12 53
D-45012 Essen
www.gns.de

Hansa Projekt Anlagentechnik GmbH
Tarpenring 6
D-22419 Hamburg
www.hansa-projekt.de

Kerntechnische Gesellschaft
http://hbksun17.fzk.de:8080/KTG/

Kerntechnischer Ausschuß (KTA)
Geschäftsstelle im BfS
Postfach 10 01 49
D-38201 Salzgitter
www.kta-gs.de

Kerntechnischer Hilfsdienst GmbH
Am Schröcker Tor 1
D-76344 Eggenstein-Leopoldshafen
www.khgmbh.de

Kernwasser Wunderland Freizeitpark GmbH
Griether Str. 110-1120
D-47546 Kalkar
www.hospitality.nl

Kraftanlagen Nukleartechnik GmbH (KNT)
Postfach 10 32 24
D-69022 Heidelberg
www.nukleartechnik.de

Kraftwerks-Simulator-Gesellschaft mbH (KSG)
Gesellschaft für Simulatorschulung mbH (GfS)
Postfach 15 02 51
D-45242 Essen

KSB Armaturen GmbH & Co. KG
Bahnhofsplatz 1
D-91257 Pegnitz
www.ksb.de

NIS Ingenieurgesellschaft mbH
Donaustr. 23
D-63452 Hanau
www.nukem.de

NTL Nukleare Transportleistungen GmbH
Postfach 110050
D-63434 Hanau

Nuclear Cargo + Service GmbH (NCS)
Rodenbacher Chaussee 6
63434 Hanau

NUKEM Nuklear GmbH
Industriestr. 13
D-63754 Alzenau
www.nukem.de

Siemens Nuclear Power Generation (SNPG)
http://www.pg.siemens.com/en/index.cfm

Siempelkamp Nukleartechnik (SNT)
Postfach 2570
D-47725 Krefeld
www.siempelkamp.de

SINA Industrieservice GmbH & Co. KG
Postfach 449
D-75104 Pforzheim
www.sina.de

Steag Energie- und Kerntechnik GmbH
Rüttenscheider Straße 1-3
D-45128 Essen
www.steag.de

Sulzer Pumpen GmbH
Postfach 30 28
D-76642 Bruchsal
www.sulzer-weise.de

TÜV Nord Gruppe
Postfach 54 02 20
D-22502 Hamburg
www.tuev-nord.de

TÜV Süddeutschland
Postfach 21 04 20
D-80674 München
www.tuevs.de

NUCLEAR RESEARCH INSTITUTES

Forschungszentrum Jülich
www.kfa-juelich.de/

Forschungszentrum Karlsruhe GmbH
www.fzk.de/

Verband der Elektrizitätswirtsschaft e.V.
(VDEW)
D-60591 Frankfurt/Main
www.strom.de

VGB Power Tech e.V.
Postfach 10 39 32
D-45039 Essen
www.vgb-power.de

Urangesellschaft mbH (UG)
Postfach 90 04 28
D-60444 Frankfurt am Main

Urenco Deutschland GmbH
Postfach 14 11
D-52409 Jülich
www.urenco.com

Westinghouse Reaktor GmbH
Dudenstraße 44
68167 Mannheim
www.westinghouse.de

Wismut GmbH
Postfach 30 03 52
D-09034 Chemnitz
www.wismut.de

Wissenschaftlich-Technische Ingenieurberatung
GmbH (WTI)
Karl-Heinz-Beckurts-Straße 8
52478 Jülich

Wiederaufarbeitungsanlage Karlsruhe (WAK)
Betriebsgesellschaft mbH
Postfach 1263
76339 Eggenstein-Leopoldshafen
www.wak-karlsruhe.de

Global High-Temperature Gas-Cooled Reactor
R&D Network (GHTRN)
www-is.ike.uni-stuttgart.de/ghtrn/

Hahn-Meitner-Institut Berlin (HMI)
www.hmi.de/

Hermann von Helmholtz-Gemeinschaft
Deutscher Forschungszentren:
www.helmholtz.de/

Max-Planck-Institut für Kernphysik
Heidelberg, Germany
www.mpi-hd.mpg.de/

OTHER RESEARCH INSTITUTES

Ångströmquelle Karlsruhe (ANKA):
www.fzk.de/anka/

Berliner Elektronenspeicherring-Gesellschaft
für Synchrotronstrahlung m.b.H. (BESSY)
www.bessy.de/

DESY (electron synchotron, Germany)
www.desy.de/

Dortmunder Elektronen Testspeicherring
Anlage (DELTA)
http://prian.physik.uni-dortmund.de/

Electron Stretcher Accelerator (ELSA):
http://www-elsa.physik.uni-bonn.de/

Gesellschaft für Schwerionenforschung
(GSI, Darmstadt)
http://www.gsi.de/

Institut für Experimentelle Kernphysik
Universität Karlsruhe
http://www-ekp.physik.uni-karlsruhe.de/

Max Planck Institute for Plasma Physics
Greifswald branch
http://www.ipp.mpg.de/ipp/greifswald.html

Max-Planck-Institut für Plasmaphysik Garching,
Germany
http://www.ipp.mpg.de/ipp/ipp.eng.html

UNIVERSITIES

Bonn University
(Friedrich-Wilhelms-Universität)
http://www.uni-bonn.de/

Dortmund University
http://www.uni-dortmund.de/UniDo/

Technical University Darmstadt
Institute for Laser and Plasma Physics
http://www.physik.th-darmstadt.de/lpp/

University of Greifswald
Institute for Physics
http://www.physik.uni-greifswald.de/

University of Heidelberg - Faculty of Physics:
http://www.physi.uni-heidelberg.de/
University of Stuttgart
http://www.uni-stuttgart.de/

OTHER ORGANIZATIONS

FIZ Karlsruhe
www.fiz-karlsruhe.de/

GENIOS Wirtschaftsdatenbanken
www.genios.de/

International Solar Energy Society (ISES)
http://www.ises.org/

Seismograms of Nuclear Explosions
Federal Institute for Geosciences and Natural
Resources, Germany
http://www-
seismo.hannover.bgr.de/nucimg/nuctest.html