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 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*, 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 2001 was 82.3 million people. Area and population development is shown in Table 1.

TABLE 1. POPULATION INFORMATION

	1960	1970	1980	1990	1995	1996	1997	1998	1999	2000	2001	Growth rate (%) 1980 to 2000
Population (millions)	55.4 (17.2)	60.7 (17.1)	61.6 (16.7)	63.3 (16.1)	81.7	81.9	82.1	82.0	82.1	82.2	82.3	0.24
Population density (inh./km²)	226 (164)	248 (163)	252 (159)	259 (153)	234	234	235	235	235	235	235	0.24
Urban population (% of total)						82.2	82.5	82.4	82.8	82.9	N/A	
Land 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 [8, 9, 10].

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 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 restricted 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)

	1970	1980	1990	1996	1997a)	1998a)	1999a)	2000a)	2001a)
GDP (millions of current €)							1,974,300	2,025,500	2,063,000
GDP (millions of current US$)	185,200 (40,060)	810,600 (134,300)	1,501,200 (170,820)	2,384,620	2,113,240	2,151,450	2,098,580	1,870,750	1,847,620
GDP (millions of constant 1990 US$)	623,600 (134,900)	1,286,700 (213,200)	1,501,200 (170,820)	1,987,130	1,722,300	1,725,290			
GDP per capita (current US$/capita)	3,050 (2,340)	13,160 (8,040)	23,720 (10,610)	29,120	25,740	26,240	25,560	22,760	22,450
GDP by sector (%):									
Agriculture					1.1	1.2	1.2	1.2	1.2
Industry					32,8	30.8	30.1	30.4	29.9
Services					66.1	67.9	68.7	68.4	68.9

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 [8, 10].

TABLE 3. ESTIMATED ENERGY RESERVES

	Estimated energy reserves in 1999 (Exajoule)					
	Solid	**Liquid**	**Gas**	**Uranium (1)**	**Hydro (2)**	**Total**
Total amount in place	1,187.70	1.76	8.46	1.64	11.57	1,211.13

(1) This total represents essentially recoverable reserves.
(2) For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability (World Energy Council - 2002) by a factor of 10.
Source: IAEA Energy and Economic Database.

1.4. 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 10 % in 2001, while during the same period the share of nuclear has grown from 9 % to 30 %, whereas that of coal has remained at around 50 %. Since the 1990s 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. In comparison with the generation price of nuclear or coal plants high minimum payments to the small producers for the transactions are established. 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 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 € 5 billion per annum in 1994, but will be reduced continuously to € 2,7 billion per annum in 2005. Lignite production in Germany is not subsidized but purchasing is guaranteed for at least 50 TWh of electricity produced yearly by lignite-fired power plants.

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 company costs and electricity prices.

TABLE 4. ENERGY STATISTICS

Exajoule

	1960	1970	1980	1990	1997	1998	1999[a]	2000[a]	2001[a]	Average annual Growth rate (%) 1960 to 1980	1980 to 2000
Energy consumption											
- Total [b]	6.3(2.9)	9.9(3.1)	11.6(3.8)	14.91	14.57	14.52	14.19	14.28	14.50	2.6	-0.3
- Solids [c]	4.9(2.8)	4.0(2.6)	3.5(2.5)	5.51	3.63	3.57	3.36	3.56	3.54	-1.2	-2,6
- Liquids	1.3(0.1)	5.1(0.4)	5.4(0.8)	5.24	5.75	5.78	5.60	5.50	5.58	7.7	-0.6
- Gases	N/A	0.6(0.0)	2.1(0.3)	2.32	3.02	3.05	3.06	3.00	3.12	-	1.1
- Primary electricity [d]	0.2(0.0)	0.3(0.0)	0.6(0.1)	1.85	2.16	2.13	2.18	2.23	2.27	6.5	6.0
Energy production											
- Total	5.6(2.6)	5.2(2.4)	5.2(2.5)	7.88	5.95	5.63	5.64	5.51	5.46	-0.3	-1.7
- Solids	5.3(2.6)	4.3(2.3)	3.7(2.3)	5.23	2.96	2.72	2.64	2.54	2.43	-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	0.11	0.12	0.0	-2.8
- Gases	N/A	0.5(0.0)	0.7(0.1)	0.59	0.7	0.66	0.70	0.66	0.67	-	-0.9
- Primary electricity [d]	0.1(0.0)	0.2(0.0)	0.6(0.1)	1.85	2.17	2.13	2.18	2.20	2.24	10.2	5.9
Net import (import – export)											
- Total	0.6(0.3)	4.8(0.7)	6.8(1.2)	6.87	8.62	8.88	8.85	8.77	9.03	11.5	0.5
- Solids	-0.5(0.2)	-0.4(0.3)	-0.2(0.2)	0.15	0.67	0.84	0.71	0.79	0.96	-17.7	12.0
- Liquids	1.2(0.1)	5.1(0.4)	5.6(0.8)	4.97	5.63	5.65	5.48	5.32	5.39	8.3	-0.9
- Gases	N/A	0.1(0.0)	1.4(0.2)	1.75	2.32	2.39	2.36	2.65	2.68	-	2.6
- Primary electricity [d]	N/A	N/A	N/A	0.00	-0.01	0.00	0.00	0.01	0.00	-	-

[a] Preliminary data.
[b] Energy consumption = Primary energy production + Net import of secondary energy.
[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 [1, 2, 3, 4].

The current Federal Government (since September 1998) decided to phase out the use of nuclear power for commercial electricity production. In April 2002, an amendment to the Atomic Energy Act came into force, according to the respective agreement between the Federal Government and the utilities, signed in June 2001. Licenses for the construction and operation of NPPs for commercial electricity production will not be granted any more, and the lifetime of the existing plants is limited to 32 years on the average (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 energy policy for the long term. It is of considerable importance to develop an energy supply apt for the future, that is to improve energy efficiency and enhance savings. Renewable energy is increasingly supported. Supplier, according to the new law, have to buy the electricity from renewables when it is produced and at the fixed high price. Since April 2000, in particular the remuneration for small producers of photovoltaic electricity is high, around 10 times the generation price of nuclear power. Today, the share of renewable energy in gross electricity production is about 7 %, and it is intended to double this share by the year 2010. Furthermore the general framework for raising energy efficiency are 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.

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 2001 the CO_2 emission volume was 857 Mt CO_2, which is 13 % 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. According to a burden sharing of the European Union in 1998, Germany has to reduce of 21 % of its overall greenhouse gases to the 1990 level.

2. ELECTRICITY SECTOR

2.1. Structure of the Electricity Sector

The German public electricity sector now 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 socalled "small producers" not accounted for in Table 5. In 2001, around 1 100 electricity suppliers to final consumers operated in Germany, more than before the liberalization of the market. Thereof the three largest companies supply 53 %, and the next largest only 3 % of the final consumption in Germany. Shareholder 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 the nuclear power plants. 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	--

Source: Country Information [13].
*) Partially estimated, double counting.

2.2. Decision Making Process

The Federal Ministry of Economics and Technology (BMWi) 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 1.4).

Concerning the safety of nuclear power plants, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has the federal competence, whereas the execution of federal laws lies within the responsibility of the federal states, the *Länder* (see Chapter 5.1)

TABLE 6. ELECTRICITY PRODUCTION AND INSTALLED CAPACITIES

	1960	1970	1980	1990	1998	1999	2000[a]	2001[a]	Average annual Growth rate(%) 1960 to 1980	Average annual Growth rate(%) 1980 to 2000[a]
Electricity production (TWh)										
- Total [b] gross	119.0 (40.3)	237.8 (67.7)	365.3 (98.8)	444.5 (117.3)	553.6	551.5	563.1	570.0	5.77 (4.59)	0.97
- Thermal (fossil)	106.0 (39.7)	218.8 (65.9)	306.4 (85.3)	285.9 (103.5)	348.8	335.1	344.2	348.0	5.45 (3.90)	-0.64
- Hydro	13.0 (0.6)	16.2 (1.3)	17.4 (1.7)	19.20 (2.0)	21.2	23.3	26.0	25.8	1.48 (5.35)	1.55
- Nuclear	N/A	2.7 (0.5)	41.4 (11.9)	139.4 (11.8)	161.6	170.0	169.6	171.2	31.12 (37.30)	5.96
- Others (Geothermal, Wind, Solar energy etc.)	N/A	N/A	N/A	N/A	22.0	23.0	23.3	25.0	-	-
Gross Cap. of electrical plants (GWe)										
- Total	28.4 (7.9)	47.6 (12.1)	82.6 (19.7)	106.4 (23.4)	106.4	118.8	121.0	-	5.49 (4.67)	0.84
- Thermal (fossil)	25.0 (7.6)	42.0 (11.3)	67.5 (16.5)	76.6 (19.7)	72.6	82.6	84.0	81.3	5.08 (3.95)	0.00
- Hydro	3.4 (0.3)	4.7 (0.7)	6.5 (1.5)	7.1 (1.8)	8.4	8.9	9.0	8.6	3.33 (8.38)	0.62
- Nuclear	0,0 (0,0)	0.9 (0.1)	8.7 (1.7)	22.7 (1.8)	23.5	23.5	23.7	22.4	24.98 (32.75)	4.20
- Others (Geothermal, Wind, Solar energy etc.)	N/A	N/A	N/A	N/A	2.1	3.7	4.3	N/A	-	-

[a] Preliminary data.
[b] Electricity losses are not deducted.
Numbers in brackets refer to former GDR data.
Source: IAEA Energy and Economic Database and Country Information [1, 4, 5, 6].

TABLE 7. ENERGY RELATED RATIOS

	1960	1970	1980	1990	1997	1998	1999[a]	2000[a]	2001[a]
Energy consumption per capita (GJ/capita)	114(169)	163(181)	188(228)	188	177	177	173	174	176
Electricity per capita (kW·h/capita)	2,148 (2,343)	3,918 (3,959)	5,930 (5,916)	7,022 (7,286)	6,714	6,751	6,717	6,850	6,926
Electricity production/Energy production (%)	7.6(5.6)	16(10)	25(14)	26	33	35	35	37	38
Nuclear/Total electricity (%)		1.1(0.1)	11(12)	31(10)	31	29	31	30	30
Ratio of external dependency (%)[b]	9.5(10)	48(23)	59(32)	46	59	61	60	61	62
Load factor of electricity plants									
- Total (%)	48(58)	57(64)	50(57)	48(57)	52	52	55	48	N/A
- Thermal	48(60)	60(67)	52(59)	43(60)	44	46	48	40	N/A
- Hydro	44(23)	39(21)	31(13)	31(13)	25	26	27	32	N/A
- Nuclear		34(57)	55(80)	70(75)	87	83	87	82	87

[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 [1, 5, 7, 14].

2.3. Main indicators

In 2001, the net generation of all power plants amounted to 522 TWh, 1 % more than in the previous year. Electricity supply companies also purchased electrical energy 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 2001, these small producers fed in 13.8 TWh, this is around 2.6 % in relation to the net power generation mentioned above.

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

2.4. Impact of Open Electricity Market in the Nuclear Sector

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 branch 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, participations and mergers and by the appearance of additional market participants in the new business sector "electricity trade". The current situation is illustrated in Table 5. Among the new market participants there are several companies from abroad - Europe and US - 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 this extra burden on industrial prices amounted to 0.08 cent/kWh (1,4 %), whereas in 2001 already to 0.73 cent/kWh (19 %). 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 favored cost conditions.

Under these tightening financial circumstances backfitting of plant safety, maintenance and review of the nuclear power plants have to be carried out. 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.

3. NUCLEAR POWER SITUATION

3.1. Historical Development

3.1.1 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 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.

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 centers as well as University institutes were equipped with research reactors, but in the meanwhile, many research reactors are shut down and being decommissioned. Since the late 1980s some of the research centers changed their subjects - and some of them also their names - to environmental issues. Due to financial conditions, nuclear research became restricted 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 then world's largest reactor, Biblis A with 1,2000 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 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 company BBR a joint venture of Brown, Bovery & Co. (BBC) and Babcock&Wilcox USA, meanwhile ABB, respectively sold to BNFL/UK in December 1999, now renamed 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. 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, 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 litigation. Today, the construction of new NPPs for electricity production is forbidden by law.

3.1.2 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 test plant WAK is being decommissioned, a facility to vitrify the resulting high active waste concentrate meanwhile is under construction.

Since the early 1960s Germany started to set up a programme for radioactive waste management and disposal. The 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 radio nuclides 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 practiced in Germany because of the high population density and climatic conditions; furthermore appropriate deep geological formations exist.

By the mid 1970s, Germany increased its efforts to close the fuel cycle and to set up a programme for radioactive waste management and 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 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 policy, 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). 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 Schacht Konrad 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 process.

3.2. Status and Trends of Nuclear Power

In 2001, as 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 1999. 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 plants. The generated nuclear electricity amounted up to 171 TWh in 2001, 1 % more 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 8 shows the status of nuclear power plants by the end of 2001, 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, SPD 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* is complicated by changing political majorities. Federation and *Länder*, both have their responsibilities in nuclear licensing and nuclear safety matters (see chapter 5.1). 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 is to phase out the use of nuclear power for commercial electricity production. In April 2002, an amendment to the Atomic Energy Act came into force, according to the respective agreement between the Federal Government and the utilities, signed in June 2001. The main purpose of the amendment is to terminate in an orderly manner the use of nuclear energy for electricity production. At the same time, safe operation of the NPPs for the remaining operating lives is to be achieved. Beside the limiting of NPP lifetime to a 32 year equivalent on the average, the erection of new NPPs is forbidden. Furthermore, consensus is looked for in the issue of radioactive waste disposal. Therefore the utilities agreed to build interim storage facilities at the NPP sites, in order to minimize transports of spent fuel, at least for the next time. Starting from July 2005, the management of spent fuel from the NPPs is restricted to direct disposal.

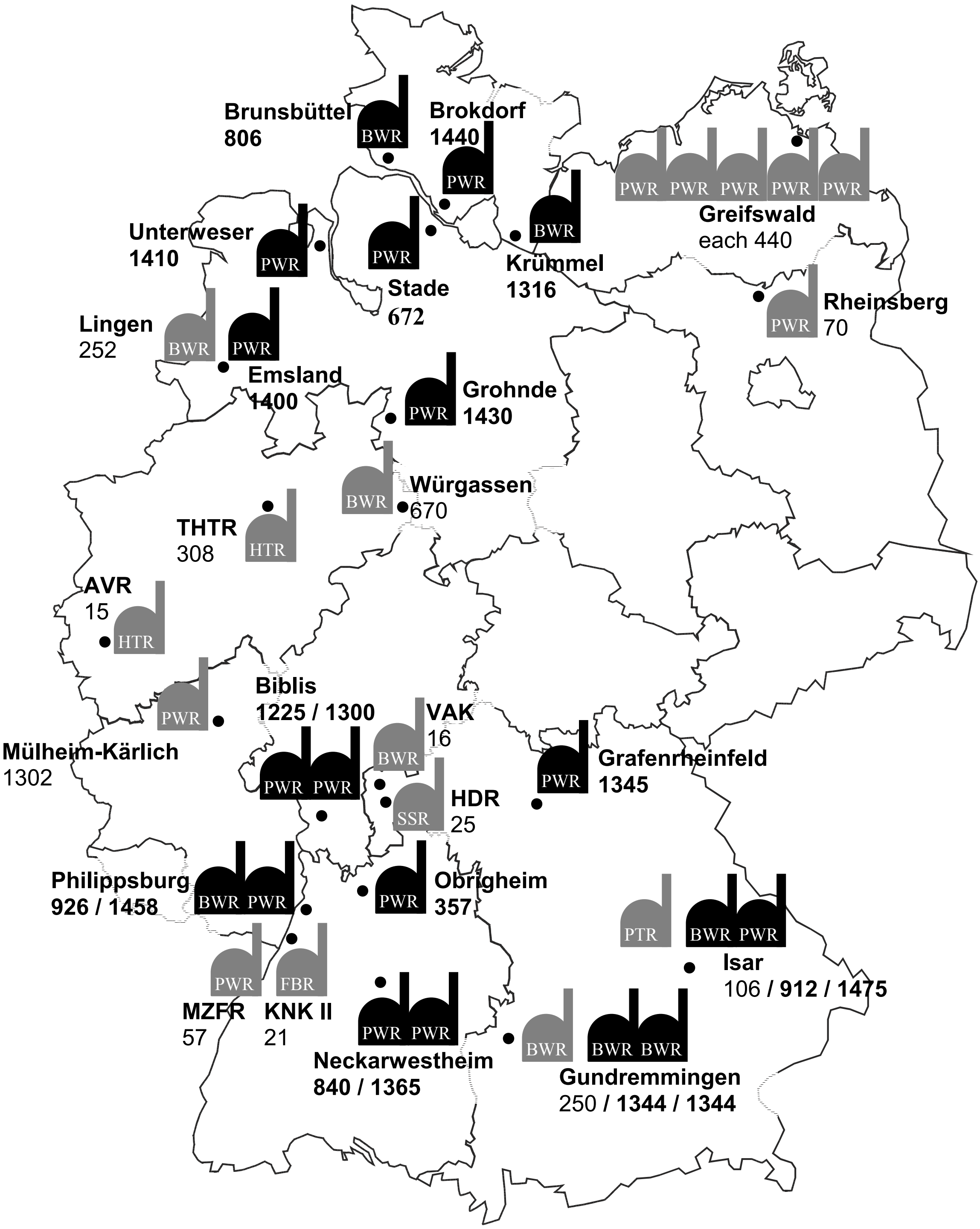
Following the new energy policy of the current Federal Government, the German radioactive disposal programme presently is re-examined. The political objective is to erect one single repository in Germany for all types of radioactive waste by 2030. According to this new approach, further sites in various host rocks will be investigated for suitability. Thus, BMU 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.

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 NPPs will be operating in Germany.

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	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 and Country Information [11, 12] year-end 2001.



Legend

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

Numbers indicate Gross Capacity [MWe], 12/2001

FIG. 1. Nuclear Power Plants 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 more detail in chapter 5.1.

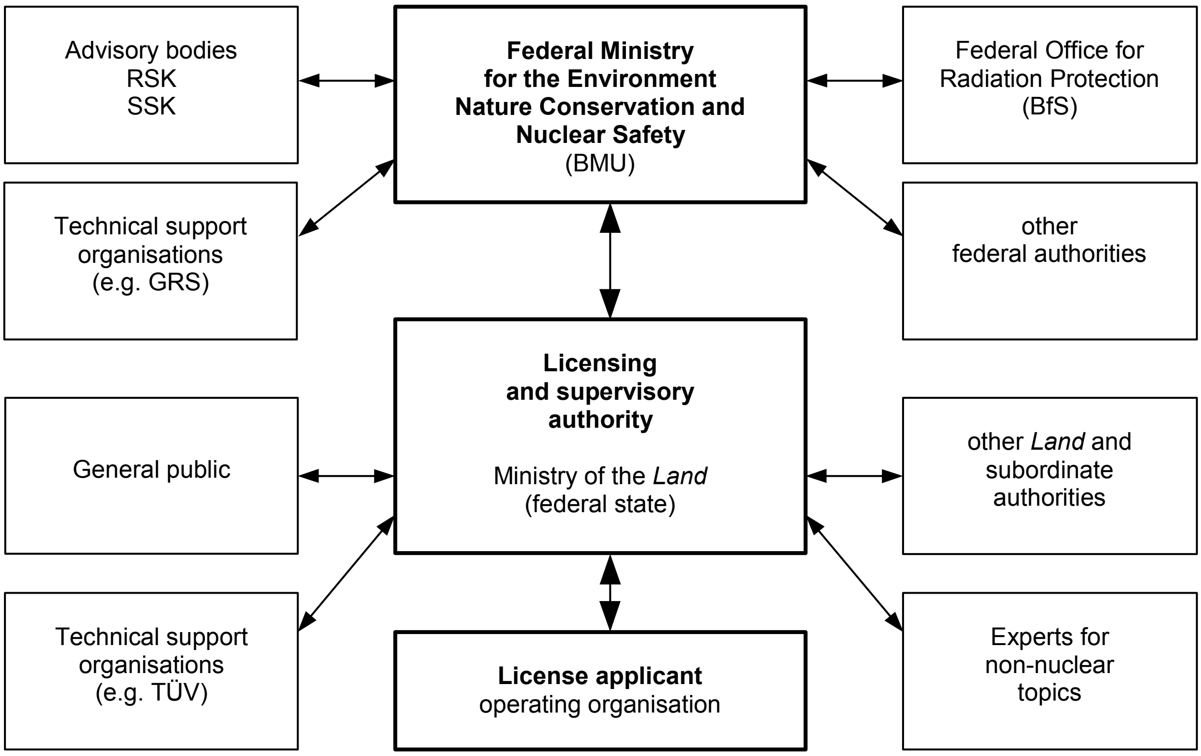


FIG.2. Participants in the Nuclear Licensing Procedure

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/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.

4.2. Operation of NPPs

The different companies operating the NPPs are owned by only few main utilities. Also these were in a process of concentration and reorder within the last years (see chapter 2.1). 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 policy to phase out the use of nuclear power and diminishing interest in a nuclear education in Germany. For maintenance, the operator receives support from manufacturers and service suppliers specialized in this field.

4.3. Fuel Cycle and Waste Management Service Supply

All facilities necessary for a closed nuclear fuel cycle had been erected in Germany. Today, only a few of them are in operation, most of them are shut down and being decommissioned or did not receive an operation license (chapter 3.1.2).

At Gronau, the enrichment plant of URENCO expanded from a capacity of 400 SWU/year to 1300 SWU/year step by step within the last years and intends to increase further the capacity to 4500 SWU/year. At Lingen, the fuel fabrication facility ANF is in operation and produces uranium fuel elements for LWR, recently the capacity was increased.

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 interim storage facilities for spent fuel are erected on the NPP sites.

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.

A selection of services are mentioned in the appendix.

4.4. Research and Development Activities

Basic nuclear research is supported by the BMWi, the more practical nuclear research is supported by the BMU, within this also national research on disposal. Universities and research centers, technical support organizations and others perform the research mainly under federal contracts.

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

As member 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 research issues, e.g.:

- PHEBUS-FP programme covering severe accidents on PWR;
- PHARE and TACIS programs, 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; 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 program.

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 and waste management, 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. And according to the latest amendment another purpose is to phase out the use of nuclear energy for electricity production. 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. A license is also required for essentially modifying such installation or its operation and for decommissioning. With the mentioned amendment of the Atomic Energy Act, further NPPs for commercial production of electricity will not be licensed any more. Up to than, the applicant could only be granted a license if he met 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 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 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 technical support organization.

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 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. 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 elements. These reserves are tax-free. 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 steps, 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 industry, universities or medicine. 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 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.

5.2 Main National Laws and Regulations on Nuclear Power and Waste Management

- Atomic Energy Act (*Atomgesetz*)
- Radiation Protection Ordinance (*Strahlenschutzverordnung*)
- Precautionary Radiation Protection Act (*Strahlenschutzvorsorgegesetz*)
- Environmental Impact Assessment Act (*Umweltverträglichkeitsprüfung*)
- Nuclear Licensing Procedure Ordinance (*Atomrechtliche Verfahrensverordnung*)
- Nuclear Financial Security Ordinance (*Atomrechtliche Deckungsvorsorge-Verordnung*)
- Repository Financing Ordinance (*Endlagervorausleistungsverordnung*)
- Federal Mining Act (*Bundesberggesetz*)
- 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 Abfallverbringungs-verordnung*)
- 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*)

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	In general, national regulations are consistent with codes	letter of 6 March 1989
• Nuclear Suppliers Group		Member

BILATERAL AGREEMENTS CONCERNING THE SAFETY OF NUCLEAR INSTALLATIONS AND RADIATION PROTECTION

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	
	Exchange of information	13 October 1987	30 September 1988
	Mutual assistance in case of an emergency	17 March 1988	1 August 1988
Finland	Early notification in case of an emergency and exchange of information	21 December 1992	28 May 1993
France	Exchange of information	12 Jan./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	
	Exchange of information	21 May 1981	
	Mutual assistance in case of an emergency	7 June 1988	1 March 1997
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

Agreement with	Major agreement content	date signed	effective date
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
	Third party liability	22 October 1986	28 June 1988
	Mutual assistance in case of an emergency	28 November 1984	1 December 1988
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	19 October 1995	19 October 1995

REFERENCES

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[6] VDEW, Jahresbericht 2001, Frankfurt 2002.

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[8] Statistisches Jahrbuch 2001 für die Bundesrepublik Deutschland, Metzler-Poeschel, Stuttgart, September 2001.

[9] Statistisches Bundesamt, Reihe 5.1, Bodenflächen nach Art der tatsächlichen Nutzung, Wiesbaden, April 2002.

[10] Statistisches Bundesamt, Wiesbaden, http://www.statistik-bund.de.

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

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[13] VDEW, Wettbewerb im deutschen Strommarkt, A-01/2002, Frankfurt, Mai 2002.

[14] Electricity Market Germany 1999, VDEW, Verlag VWEW, Frankfurt, September 2000.

[15] Report under the Convention on Nuclear Safety by the Government of the Federal Republic of Germany for the Second Review Meeting in April 2002, http://www.bfs.de.

Appendix

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
http://www.bmwi.de

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

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

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

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

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

Bayerisches Staatsministerium für Wirtschaft, Verkehr und Technologie
D-80525 München
http://www.stmwvt.bayern.de

Niedersächsisches Umweltministerium

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

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

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

Senator für Bau und Umwelt der Freien Hansestadt Bremen
Ansgaritorstraße 2
D-28195 Bremen
http://www.bremen.de

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

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

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

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

Sächsisches Staatsministerium für Umwelt und

Postfach 41 07
D-30041 Hannover
http://www.mu.niedersachsen.de

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

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

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

Landwirtschaft
Postfach 10 05 10
D-01075 Dresden
http://www.sachsen.de

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

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

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

MAIN POWER UTILITIES

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

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

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

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

MANUFACTURE, SERVICES AND OTHER NUCLERA ORGANIZATIONS

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

Babcock Noell Nuclear GmbH
Alfred-Nobel-Straße 20
D-97080 Würzburg
http://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
http://www.canberra.de

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

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

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

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

Electrowatt Engineering Mannheim GmbH
Mallaustraße 59
D-68219 Mannheim
http://www.ewe-mannheim.de

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

Framatome-ANP GmbH
Postfach 32 20
D-91050 Erlangen
http://www.framatome-anp.com

Gesellschaft für Anlagen- und Reaktorsicherheit mbH (GRS)
Society for Reactor Safety
Schwertnergasse 1
D-50667 Köln
http://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
http://www.gnb-nuklearbehaelter.de

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

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

Kerntechnische Gesellschaft e.V.
http://www.ktg.org

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

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

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

Kraftanlagen Nukleartechnik GmbH (KNT)
Postfach 10 32 24
D-69022 Heidelberg
http://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
http://www.ksb.de

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

Nuclear Cargo + Service GmbH (NCS)
Rodenbacher Chaussee 6
63457 Hanau
http://www.ncsg.de

RWE NUKEM GmbH
Industriestr. 13
D-63754 Alzenau
http://www.nukem.de

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

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

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

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

Sulzer Pumpen Deutschland GmbH
Ernst-Blickle-Straße 29
D-76646 Bruchsal
http://www.sulzerpumps.com

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

TÜV Süddeutschland
Postfach 21 04 20
D-80674 München
http://www.tuev-sued.de

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

VGB Power Tech e.V.
Postfach 10 39 32
D-45039 Essen
http://www.vgb.org

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

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

Westinghouse Reaktor GmbH
Dudenstraße 44
68167 Mannheim
http://www.westinghouse.com

Wismut GmbH
Postfach 30 03 52
D-09034 Chemnitz
http://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
http://www.wak-karlsruhe.de

NUCLEAR RESEARCH INSTITUTES

Forschungszentrum Jülich
http://www.kfa-juelich.de/

Forschungszentrum Karlsruhe GmbH
http://www.fzk.de/

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

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

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

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

OTHER RESEARCH INSTITUTES

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

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

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

Dortmunder Elektronen Testspeicherring Anlage (DELTA)
http://www.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/

UNIVERSITIES

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

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

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

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
http://www.fiz-karlsruhe.de/

GENIOS Wirtschaftsdatenbanken
http://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/