PEOPLE'S REPUBLIC OF CHINA

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1. ENERGY, ECONOMIC AND ELECTRICITY INFORMATION

1.1. General Overview

The People's Republic of China (China) is the world's most populous country and the second largest energy consumer (after the United States). China has a population of about 1.3 billion people (Table1). Its land area is 9,561,000 square kilometres. China is rich in coal and water resources, which are unevenly distributed throughout the country. Coal deposits are predominant in the north and north-western regions, while water resources are mainly in the south-western region. In contrast, Southeast China is densely populated and has extensively developed industry and agriculture, but is deficient in coal and hydro resources.

Transportation of vast amounts of coal accounts for 48% of the railway capacity and 25% of the highway capacity. This adds to a high price of coal. Environmental pollution from burning coal has been a serious problem. Improvement of China’s energy infrastructure includes the development of nuclear power. During the last 40 years, a relatively complete nuclear fuel cycle system has been built in China.

On China’s mainland, there were five nuclear power plants and 7 units in operation by the end of 2002, with a capacity of 4.5 GW(e): two PWR NPPs and one PHWR NPP, 1.6 GW(e) at Qinshan, Zhejiang Province and two PWR NPPs, 2.9 GW(e) at Daya Bay and Lingao, Guangdong Province. China's nuclear electricity production was 26 TW·h in 2002.

Tests show there were no domestic nuclear radiation or environmental pollution accidents in 2002. China's nuclear fuel industry is also able to provide fuel for all domestic nuclear power plants. China has created a continuous flow of safe, clean and economic nuclear energy.

Especially, the formal commercial operation of unit 1 of Qinshan nuclear power phase 2 indicates that China has already possessed full ability in designing, constructing, managing and operating nuclear power plants of 650 MW PWR for commercial purposes. It is an indication to show that China has gone up a new stage in the domestication of nuclear power equipment and facilities, thereby laying a solid foundation for China to design and construct the nuclear power plant with a capacity of a million kilowatts by itself.

China's nuclear power capacity is expected to reach 8.7 GW by 2005.

TABLE 1. POPULATION INFORMATION

	1970	1980	1990	1996	1997	1998	1999	2000	2001	2002
Population (millions)	830.7	998.9	1,155	1,232	1,236	1,248	1,259	1,266	1,276	1,284
Population density (inhabitan/km^2)	86.9	104.5	120.8	128.9	129.3	130.5	131.7	132.4	133.5	134.4
Urban populations percent of total	-	19.4	26.4	29.3	29.9	30.4	30.9	36	37.7	39.1
Area (1000km^2) 9,561										

Source: IAEA Energy and Economic Database and National Bureau of Statistics of China.

In 2002, China's Gross Domestic Product (GDP) was 10,239.8 billion RMB Yuan, a 8% increase from 2001, or 1237 billion US$ (according to the exchange rate of 1US$=8.27 Yuan) with the per capita GDP of 963 US$. The annual growth rate of GDP reached 8.3% during the 9th Five-Year Plan Period (1996-2000). Total industrial GDP increased to 5,298.2 billion RMB Yuan with a growth rate of 9.9 % over the previous year. Agricultural sector grew to 1,488.3 billion RMB Yuan with a growth rate of 2.9 % over previous year. Service sector grew to 3,453.3 billion RMB Yuan with 7.3%. In 2002, the proportions of agriculture, industry and services were 14%, 52% and 34% of total GDP, respectively. Table 2 shows the historical Gross Domestic Product (GDP) data.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

	1970	1980	1990	1996	1997	1998	1999	2000	2001	2002
GDP[(1)]	123,424	392,056	505,750	815,412	896,933	943,383	990,459	1,081,064	1,160,012	1,237,094
GDP[(2)]	117,970	215,498	505,750	750,515	818,061					
GDP[(3)] per capita	151	400	446	662	732	772	780	848	909	963
GDP by sector (%):										
-Agriculture	35	30	27	20	19	18	18	17	15	14
-Industry	37	44	37	43	44	42	49	50	51	52
-Services	28	26	36	37	37	40	33	33	34	34

(1) Millions of current US$.
(2) Millions of constant 1990 US$.
(3) Current US$ per capita.
Source: IAEA Energy and Economic Data Base and National Bureau of Statistics of China.

China has abundant coal and hydro resources. Total coal deposits are estimated to be 5,059 billion metric tons, and hydroelectricity is about 380,000 MW. Table 3 shows the reserves of all energy sources in the country.

TABLE 3. ESTIMATED ENERGY RESERVES

Exajoule

	Solid	Liquid	Gas	Uranium[(1)]	Hydro[(2)]	Total
Total amount in place	3020.05	221.42	45.61		570.88	3857.97

(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 - 1998) by a factor of 10.
Source: IAEA Energy and Economic Data Base and Country Information.

Production and consumption of coal, its dominant fuel, is the highest in the world. China was the world's third largest consumer of petroleum products in 2002, following the United States and Japan. Rising oil demand and imports have made China a significant factor in world oil markets.

In 2002, the total energy production was 40.97 Exajoule. The solids production accounted for 70.3% of total energy production while the production of liquids, gases and primary electricity accounted respectively for 17.1%, 3.2% and 9.5% of total energy production.

In 2002, the total energy consumption amounted to 43.6 Exajoule. The rates of solids, liquids, gases and primary electricity in energy consumption were 65.7%, 23.3%, 2.7% and 8.3%, respectively. Statistical energy data are given in Table 4. The per capita energy consumption in 2002 was 34 GJ.

1.2. Energy Policy

China's energy policy adheres to the following principles:

- Laying equal stress on both energy development and energy conservation;
- Harmonizing development with environmental protection:
- Considering power sources construction in accordance with local conditions;
- Optimising structure of fossil power and developing clean coal technologies:
- Developing hydraulic power extensively;
- Developing nuclear power moderately;
- Promoting development of new energy resources in accordance with local condition, and spreading the technologies of energy save and energy integrated use.

TABLE 4. ENERGY STATISTICS

Exajoule

	1970	1980	1990	1997	1998	1999	2000	2001	2002	Average annual growth rate (%) 1980 to 2000
Energy consumption										
-Total [1]	10.22	19.02	28.90	40.48	38.74	40.89	41.09	38.83	43.60	3.93
- Solids [2]	8.62	14.18	22.26	28.95	26.96	29.06	28.49	25.90	28.65	3.55
- Liquids	1.29	3.73	4.80	8.26	8.33	8.70	9.33	9.12	10.14	4.70
- Gases	0.11	0.56	0.60	0.69	0.85	0.91	0.95	0.97	1.17	2.71
-Primary electricity [3]	0.20	0.56	1.24	2.57	2.60	2.22	2.32	2.83	3.64	7.34
Energy production										
- Total	10.26	19.81	32.05	38.80	36.41	40.21	40.00	34.43	40.97	3.58
- Solids	8.67	14.26	24.44	28.75	26.18	29.97	29.40	23.20	28.78	3.68
- Liquids	1.28	4.44	5.79	6.71	6.73	6.91	7.07	7.06	7.00	2.36
- Gases	0.11	0.56	0.60	0.81	0.91	1.08	1.18	1.17	1.30	3.83
-Primary electricity [3]	0.20	0.56	1.22	2.58	2.60	2.25	2.35	3.01	3.88	7.42
Net import (import - export)										
- Total	-0.05	-0.79	-1.29	0.67	0.39	-2.19	-62.51		1.51	24.41
- Solids	-0.06	-0.08	-0.34			-1.08	-1.16		-1.53	14.21
- Liquids	0.01	-0.71	-0.95			1.78	2.31		2.73	15.32[4]
- Gases						-2.89	-63.65		0.31	

[1] Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.

[2] Solid fuels include coal, lignite and commercial wood.

[3] Primary electricity = Hydro + Geothermal + Nuclear + Wind.

[4] From 1999 to 2002.

Source: IAEA Energy and Economic Database and National Bureau of Statistics of China.

1.3. The Electricity System

The current power developing policy of the Chinese government is to deepen the reform in the power system and to implement the separation of power generating plants and transmission grids. Power plants are to bid for power supply contracts through an auction system to foster a fairly competitive market. Meanwhile, more attentions are paid to strengthen grid construction, to actively development of hydroelectric power, to build large coal-fired units with high performance parameters and to moderately develop nuclear power. All small and inefficient coal units will be closed by the end of 2005.

1.3.1. Structure of the Electricity Sector

By the end of 2002, China has set up 6 major trans-provincial and regional networks and 6 independent provincial networks in the mainland for distribution of the generated electricity by its power plants (which have a total capacity of about 357 GW). Among these, the largest one is the East-China Power network, which connects 62.5 GW of installed capacity. The next two largest networks are the Southern four Provinces (Guangdong, Guangxi, Guizhou and Yunnan) Interlined Power network and the Central China Power network with installed capacities of 57.3 GW and 50.5 GW, respectively. The installed capacities of the North-China Power network and the Northeast China Power network are 49.7 GW and 39.9 GW. The Northwest China Power network's installed capacity is 20.8 GW.

In addition, the Shandong Provincial Power network developed quite rapidly and reached an installed capacity of 24.3 GW at the end of 2002. The other independent provincial networks are Sichuan-Chongqing power network (19.8GW), Fujian power network (13.4 GW), Hanan power network (1.8 GW), Xingjiang power network (3 GW) and Xizang power network (0.2 GW).

All these power networks are state-owned. The State Grid Corporation of China (SGCC) is drawing up the nation-wide power net linking programme.

1.3.2. Decision Making Process

National Development and Reform Commission (NDRC) is responsible for planning, budgeting and final accounting of economic construction nation-wide. Construction projects exceeding a certain investing limit must seek pre-approval from NDRC. The various plans, such as the annual plan, the five years plan and the long-term development plan of China’s national economy, are all established under the leadership of NDRC. Large projects, like the Three Gorges Power Station, must be approved by the State Council. NDRC is also responsible for localization of nuclear power plants.

For new nuclear power projects, the China Atomic Energy Authority (CAEA) is jointly responsible for review and approval of the PFSR, the Project Proposal and the FSR submitted by the utility, the owner of the nuclear power plant. The utility has to submit the siting part of the FSR to the National Nuclear Safety Administration (NNSA) for review in order to get the Report for Siting of the Nuclear Power Plant from the NNSA. At the same time, the State Environment Protection Administration (SEPA) reviews the Environmental Impact Report of the nuclear power plant submitted by the utility. Favourable reviews by the two organizations are required before final project approval is granted by NDRC.

1.3.3. Main Indicators

In 2002, the total installed generation capacity was 356.6 GW, of which thermal power accounted for 74.5%, hydropower 24.1%, and nuclear power 1.3%. The total electricity production in 2002 amounted to 1,654 TW·h with a growth rate of 12% over the previous year. Most of the electricity was produced by thermal power (81.7%), whilst hydropower contributed 16.6% and nuclear electricity production only 1.6%. Nuclear power generation would play an important role as an alternative and supplementary energy resource, especially for the coastal areas where the economy is developing rapidly and there is a severe shortage of the primary energy resources. The electricity consumption per capita was 1,288 kW·h. Table 5 gives the historical electricity production and installed capacities and Table 6 the energy related ratios.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

	1970	1980	1990	1996	1997	1998	1999	2000	2001	2002	Average annual growth rate (%) 1980 to 2000
Electricity production (TW·h)											
-Total[1]	115.9	300.6	621.3	1079	1134	1158	1233	1368	1478	1654	7.9
- Thermal	95.40	242.3	495.8	878.4	924.7	938.8	1005	1108	1202	1352	7.9
- Hydro	20.50	58.3	125.5	186.7	195.1	203.8	212.9	243.1	257.5	274	7.4
- Nuclear				14.3	14.4	14.1	14.8	16.7	17.4	26	_
Capacity of electrical plants ($GW_{(e)}$)											
-Total	24.18	65.87	137.9	236.5	254.2	277.3	298.8	319.3	338.6	356.6	8.2
- Thermal	16.00	45.55	101.9	178.7	192.2	210	223.4	237.5	253.1	265.5	8.6
- Hydro	8.18	20.32	35.98	55.59	59.75	65.05	72.97	79.35	83	86.1	7.0
- Nuclear				2.27	2.27	2.27	2.27	2.27	2.27	4.5	_

[1] Electricity losses are not deducted.

Source: IAEA Energy and Economic Database and State Grid Corporation of China.

TABLE 6. ENERGY RELATED RATIOS

	1970	1980	1990	1996	1997	1998	1999	2000	2001	2002
Energy consumption per capita (G J/capita)	12	19	26	33	33	31	32	32	30	34
Electricity per capita (kW·h/capita)	140	282	506	875	917.63	929.13	960.40	1064.83	1158.31	1288.16
Electricity production/Energy production (%)	11	14	18	26	30	32	30	31	41	38
Nuclear/Total electricity (%)				1	1.3	1.2	1.2	1.2	1.2	1.6
Ratio of external dependency (%)[1]		-4	-4		1.7	1				3.47
Load factor of electricity plants										
- Total (%)	55	52	51	57	51	48	47	49	50	55
- Thermal	68	61	55	61	55	51	51	53	54	60
- Hydro	29	33	40	43	37	36	33	35	35	38
- Nuclear				72	60	70	75	84	88	77

(1) Net import / Total energy consumption

Source: IAEA Energy and Economic Database and Country Information.

2. NUCLEAR POWER SITUATION

2.1. Historical Development and current nuclear power organizational structure

2.1.1. Overview

In 1970, the former premier Zhou Enlai pointed out the necessity for the peaceful use of atomic energy and development of nuclear power. This triggered the first step of nuclear power development in China.

In November 1981, the first nuclear project proposal, Qinshan 310 MW PWR, was reviewed and approved. In June 1983, site construction began. In December 1991, the Qinshan nuclear power plant was connected into the grid for the first time. Thus, nuclear power generation began on the Mainland of China.

Meanwhile, another proposal for building a nuclear power plant with two 984 MW PWRs on Daya Bay site was put forward and adopted by Chinese Government in 1982. In February 1985, Guangdong Electricity Power Company and China Light and Power Company Limited (Hong Kong) established a joint venture, Guangdong Nuclear Power Joint Venture Company, to construct the Daya Bay nuclear power project. The first pouring of concrete took place in August 1987. The two units began commercial operation in February and May 1994, respectively.

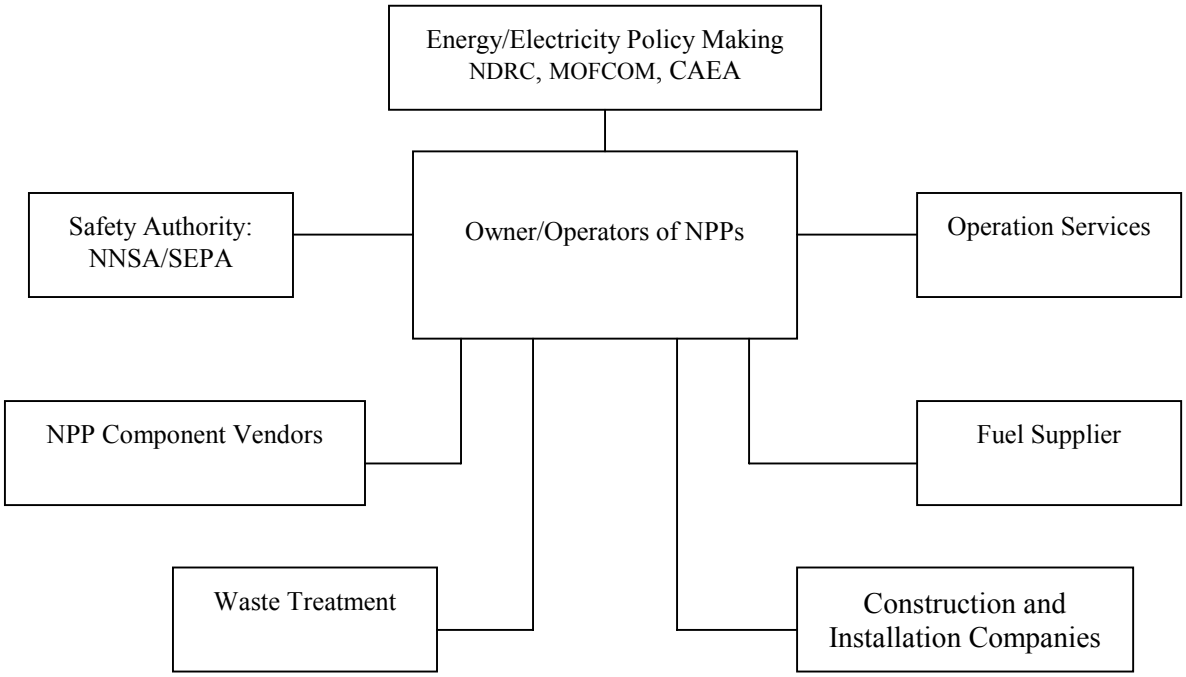
On China's mainland there are 6 nuclear power plants with 11 units in operation or still under construction by the end of 2002.

In China, pressurized water reactors have been selected as the mainstream of nuclear power development, whilst other types of reactors are considered where suitable.

Research and development on advanced PWRs started in 1986.
Research and development on LMFRs started in 1964. A 25 MW(e) Chinese Experimental Fast Reactor (CEFR) is under construction. First criticality is scheduled for the end of 2005. Also R&D on HTGRs is carried out. In December 2000, the 10MW(th) pebble bed high temperature reactor (HTR-10) at Tsinghua University achieved criticality, and connected to the grid at the end of 2002, its experimental operation with full-power will be taken further in 2003.

2.1.2. Current Organizational Chart(s)

The organizations involved with nuclear power are given in Figure 1. The China Atomic Energy Authority (CAEA) is a competent authority of the nuclear industry in China.



Legend:

CAEA: China Atomic Energy Authority

NNSA: National Nuclear Safety Administration

NDRC: National Development and Reform Commission

SEPA: State Environment Protection Administration

MOFCOM: Ministry of Commerce of the PRC

FIG. 1. Organizational Chart

As mentioned earlier, the CAEA is responsible for the short and long-term planning of nuclear power development according to the needs of national electricity and nuclear industry development. For new nuclear projects, the functions of CAEA are to review the Preliminary Feasibility Study Report (PFSP), the Project Proposal and the Feasibility Study Report (FSP) submitted by the project owner, then give its comments and decision to National Development and Reform Commission (NDRC) for final approval.

The roles and responsibilities of CAEA are as follows:

- Deliberating and drawing up policies and regulations on peaceful use of nuclear energy;
- Deliberating and drawing up the development program, plan and industrial standards for peaceful use of nuclear energy;
- Organizing argumentation and giving approval to China's major nuclear R&D projects; supervising and co-ordinating the implementation of the major nuclear R&D projects;
- Carrying out nuclear material control, nuclear export supervision and management;
- Dealing with the exchange and co-operation in governments and international organizations, and taking part in IAEA and its activities in the name of the Chinese government;
- Taking the lead to organize the State Committee of Nuclear Accident Coordination, deliberating, drawing up and implementing national plan for nuclear accident emergency.

The CAEA has five departments:

- **The Administration Department**
  The department is in charge of the administration, logistics and safeguards of the CAEA, and the management on physical protection for nuclear material and fire protection for NPP. There are three offices in the department: the Office for Nuclear Material Control (ONMC), the Office for Isotope Management (OIM) and the National Nuclear Emergency Response Office

(NNERO).

- **The System Engineering Department**
  The department is in charge of organizing argumentation on major nuclear R&D projects, making a development plan for nuclear power plants and nuclear fuel; and is responsible for the construction, management and supervision on major projects, and routine work of nuclear accident emergency. The Nuclear Power Office (NPO) is under this department.

- **The Department of International Co-operation**
  This department is in charge of organizing and co-ordinating the exchange and co-operation in governments and international organizations in the field of nuclear energy; licensing for nuclear export and import and issuing governmental assurance.

- **The General Planning Department**
  The department is in charge of approving the study plan for nuclear energy, and drawing up the annual plan for nuclear energy development.

- **The Science, Technology and Quality Control Department**
  The department is in charge of organizing pre-studies on nuclear energy and mapping out nuclear technical criteria.

China has set up the personnel education and training system with universities, colleges and nuclear training organizations for systematic training young people in the field of nuclear technology and nuclear safety. At the same time, more attention has been given to the on-the-job training, all nuclear power plants and nuclear facilities dispatch a numbers of staff to universities or other training departments, a lot of person would be well trained. The training center and training department within the nuclear power plants or installations also take a variety of measures to achieve and maintain a high level of capability on nuclear technology and safety culture. Some encouragement measures are also considered to being taken to attract and promote more young people devoting to nuclear technology work.

2.2. Nuclear Power Plants: Status and Operations

Table 7 shows the status of nuclear power plants by the end of 2002. there are 5 operating NPPs with 7 units on the mainland of China and 3 NPPs with 4 units are under construction. Nuclear electricity production in 2002 was 26 TW·h accounting for 1.6% of total electricity production. Nuclear installed capacity was only 4.5 GW, accounting for 1.3 % of the total installed generation capacity. Obviously, nuclear power possesses a minor part in power generation.

TABLE 7. DESCRIPTION OF NUCLEAR POWER PROJECTS

Station	Type	Capacity (MW)	Status	Operator	Reactor Supplier
GUANGDONG-1	PWR	984	Operating	GNPJVC	FRAM
GUANGDONG-2	PWR	984	Operating	GNPJVC	FRAM
QINSHAN- 1	PWR	310	Operating	QNPC	CNNC
QINSHAN-2A	PWR	650	Operating	QNPC	CNNC
QINSHAN-2B	PWR	650	Under construction	QNPC	CNNC
LINGAO-A	PWR	990	Operating	GNPJVC	FRAM
LINGAO-B	PWR	990	Operating	GNPJVC	FRAM
QINSHAN-3A	PHWR	728	Operating	TQNPC	AECL
QINSHAN-3B	PHWR	728	Under construction [a]	TQNPC	AECL
TIANWAN-1	WWER	1060	Under construction	JNPC	AEE&ZAES
TIANWAN-2	WWER	1060	Under construction	JNPC	AEE&ZAES

[a] Operating in June 2003

Station	Construction Date	Criticality Date	Grid Date	Commercial Date	Shutdown Date
GUANGDONG-1	07-Aug-87	28-Jut-93	31-Aug-93	01-Feb-94	
GUANGDONG-2	07-Apr-88	21-Jan-94	07-Feb-94	07-May-94	
QINSHAN-1	20-Mar-85	31-Oct-91	15-Dec-91	01-Apr-94	
QINSHAN-2A	02-Jun-96	15-Nov-01	06-Feb-02	15-Apr -02	
QINSHAN-2B	02-Jun-96	15-Sep-02[a]	Dec-03[a]	Dec-03[a]	
LINGAO-A	15-May-97	28-Feb-02	15-Apr-02	28-May-02	
LINGAO-B	28-Nov-97	31-Oct-02	14-Sep-02	08-Jan-03	
QINSHAN-3A	08-Jun-98	13-Oct-02	19-Nov-02	31-Dec-02	
QINSHAN-3B	25-Sep-98	18-May-03[a]	12-Jun-03 [a]	24-Jul-03 [a]	
TIANWAN-1	20-Oct-99	2004[a]	May-04[a]	2004[a]	
TIANWAN-2	20-Oct-00	2004[a]	May-05[a]	2005[a]	

[a] Target dates（QINSHAN-3B started its operated in June 2003）.

GNPJVC Guangdong Nuclear Power Joint Venture Company;

QNPC Qinshan Nuclear Power Company;

TQNPC Third Qinshan Nuclear Power Company;

JNPC Jiangsu Nuclear Power Company;

Source: IAEA Power Reactor Information System and CAEA.

Qinshan NPP, a 310 MW PWR, is the first NPP with self-reliant design, construction and operation. Its commercial operation started in April 1994. Its total generation in 2002 was 1.78 TW·h with a load factor of 68 %(an overhaul act in 2002).

Daya Bay NPP has two 984 MW PWR units imported from France. Since commercial operation in February 1994 for the first unit and May 1994 for the other unit, the units have maintained good operation records. In 2002, the two units generated electricity of 14.7 TW·h and the load factor reached 90.5%.

Qinshan Nuclear Power Phase 2 is located at the Yangliushan, 3 km south of Qinshan Phase 1 site. The 2 x 650 MW PWR units are mainly based on self-reliant design and construction, some heavy equipment were imported from foreign countries. The first unit started commercial operation in April 2002, and the second unit will be put into operation at the end of 2003.

Guangdong Lingao NPP, 1 km northeast of Daya Bay NPP, consists of 2 French-designed PWR units with 990 MW each. The first concrete was poured on 15 May 1997. The installation of the nuclear island was started in January 1999, ahead of schedule. The containment of unit 1 has been domed on 9 April 1999. At present, the project is proceeding satisfactorily, unit 1 and unit 2 started commercial operation in May 2002 and January 2003, respectively. Its total generation in 2002 was 6.2 TW·h with a load factor of 82.7 %.

Qinshan Phase 3 at Tanglangshan, 800m east of the Qinshan Phase 1 site, includes 2 x 728 MW CANDU-6 (PHWR) units. AECL is contracting the project through a turnkey mode with Canadian export credit and commercial financing. The first concrete was poured in June 1998. Unit 1 and unit 2 started commercial operation in December 2002 and July 2003, respectively.

Tianwan NPP in Lianyungang City, Jiangsu Province, 300 km north to Shanghai, includes 2 Russian advanced VVER-1000 91-Type PWR units with 1060 MW of installed capacity each. Russia will supply the design of the project and the main equipment for both nuclear and conventional islands. Some of equipment are procured from third parties. The Chinese party is responsible for civil engineering, erection and project management. The first concrete was poured in October 1999. Unit 1 and unit 2 are scheduled to complete for commercial operation by the end of 2004 and 2005, respectively.

Coastal and inland provinces, like Zhejiang, Shandong, Jiangsu, Fujian, Hunan, Jiangxi and Jilin, are considering the development of nuclear power. Some preliminary work has been done and a few sites have already been selected and approved by the relevant authorities.

Anyway, China will continue to develop nuclear power during its 10th Five-Year Plan period (2001-2005). China has the basic capability to design nuclear unit of one GWe class and manufacture its main equipment.

2.3. Supply of Nuclear Power Plants

It is important to achieve domestic manufacturing of nuclear power equipment and self-reliance of design and project management of nuclear power plants.

Architecture Engineering services are provided by:

- Shanghai Nuclear Energy Research and Design institute (SNERDI);
- Beijing Institute of Nuclear Engineering (BINE);
- Nuclear Power Institute of China (NPIC);
- East-China Power Design Institute;
- South-China Power Design Institute.

Construction and installation companies belonging to CNEC are:

- Huaxia Installation Co.;
- Huatai Construction Co.;
- Huachang Construction Co.;
- Huaxing Construction Co.;
- Huakang Construction Co.;
- Huayang Construction Co.

The following companies also have experiences in the construction and installation of nuclear power project:

- Zhejiang Electricity Power Construction Company;
- Shandong Electricity Power Construction Company;
- Jilin Electricity Power Construction Company.

The main component suppliers and their subsidiary companies are shown in Table 8.

TABLE 8. MAIN COMPONENT SUPPLIERS AND THEIR SUBSIDIARY COMPANIES

Equipment	**Manufacturing Works**
Steam generator	Shanghai Boiler Works
Turbine and generator	Shanghai Turbine Works
	Harbin Turbine Works
	Dongfang Turbine and Generator Works
Reactor pressure vessel	Fularji Heavy Component Works
	Shanghai Boiler Works
	Deyang Heavy Component Works
I&C, safety class valves	China Baoyuan Industry and Trade Corporation
	Shanghai Instrument Manufacturing Group Corporation

2.4. Operation of Nuclear Power Plants

CNNC, NPQJVC, TQNPC, GNPJVC and LNPC supply operation and maintenance services for Qinshan NPP, Qinshan Phase 2 NPP, Qinshan Phase 3 NPP, Daya Bay NPP and Lingao NPP, respectively (see Table 9).

TABLE 9. OWNERS AND OPERATORS OF NPPs

Project	Owner	Operator
Qinshan NPP	CNNC	QNPC
Daya Bay NPP	CGNPC	GNPJVC
LingAo NPP	CGNPC	LNPC
Qinshan Phase 2 NPP	NPQJVC	NPQJVC
Qinshan Phase 3 NPP	TQNPC	TQNPC
Tianwan NPP	JNPC	JNPC

CNNC China National Nuclear Corporation;
CGNPC China Guangdong Nuclear Power Holding Co., Ltd;
NPQJVC Nuclear Power Qinshan Joint Venture Company;
TQNPC Third Qinshan Nuclear Power Company;
JNPC Jiangsu Nuclear Power Company;
QNPC Qinshan Nuclear Power Company;
GNPJVC Guangdong Nuclear Power Joint Venture Company;
LNPC Lingao Nuclear Power Company.

2.5. Fuel Cycle

China has a comprehensive range of fuel cycle facilities capable of supporting the domestic nuclear power programme: for example, nuclear fuel assemblies for the nuclear power plants are fabricated and supplied by local Chinese fuel manufacturers.

The main entities related to the nuclear fuel cycle are:

- Hengyang Uranium Plant, Hengyang, Hunan Province;
- Fuzhou Uranium Centre, Fuzhou, Jiangxi Province;
- Yiling Uranium Mine, Yiling, Xingjiang Autonomous Region;
- Lantian Uranium Mine, Lantian, Sanxi Province;
- Qinglong Uranium Mine, Qinglong, Ganshu Province;
- Yibin Nuclear Fuel Element Plant;
- Qingyuan Corporation, Beijing (overall responsible for matters of waste management, facility design, etc.).

2.6. Research and Development

Main entities engaged in R&D of nuclear power include:

- China Institute of Atomic Energy (CIAE);
- Nuclear Power Institute of China (NPIC);
- Beijing Institute of Nuclear Engineering (BINE);
- Shanghai Nuclear Energy Research and Design Institute (SNERDI);
- Research Institute of Nuclear Power Operations (RINPO);
- China Institute for Radiation Protection (CIRP);
- Institute of Nuclear Energy Technology, Tsinghua University (INET).

China is actively involved in the development of advanced designs of water-cooled reactors, gas-cooled reactors and liquid metal cooled reactors.

In the water-cooled reactor area, the China National Nuclear Corporation (CNNC) is developing the CNP-1000 plant. China is pursuing self-reliance both in designing the plant to meet Chinese safety requirements and in fostering local equipment manufacture with the objective of reducing construction and operation costs. Lessons learned from the design, construction and operation of the Qinshan Phase 2, Daya Bay and Lingao NPPs are being incorporated. At a smaller scale, the Institute for Nuclear Energy Technology near Beijing has developed an integral PWR of 200 MWth, called the NHR-200, for desalination and district heat.

The High Temperature Reactor (HTR-10) at Tsinghua University has been used to gain experience with pebble bed reactor operations and to conduct experimental and safety demonstration testing. Initial operation will be with a steam turbine, with prospects for later conversion to a gas turbine configuration. Benchmark experiments in reactor physics are being conducted in conjunction with the IAEA Coordinated Research Project (CRP) on Evaluation of HTGR Performance.

The 25 MW(e) Chinese Experimental Fast Reactor (CEFR) which is under construction will be used to gain experience with fast reactor operations and to conduct experimental and safety demonstration testing.

Otherwise some organizations have decided to make the feasibility study on using nuclear energy for heat supply and desalinization.

2.7. International Co-operation and Initiatives

International co-operation on the nuclear power development is encouraged.

- Co-operation with Framatome and GEC/Alsthom to build Daya Bay NPP and Lingao NPP.
- Co-operation with AECL to build two CANDU 6 units at Qinshan site.
- Co-operation with Russia to build two advanced VVER-1000 91-Type PWR units in Lianyungang City.
- Research reactor project in Algeria and nuclear power plant construction in Pakistan undertaken by the China Zhongyuan Engineering Corporation (CZRC).
- Qinshan nuclear power plant and Nuclear Power Qingshan Joint Venture Company participated in World Association of Nuclear Operators WANO-TC as ordinary members.
- Daya Bay nuclear power plant participated in WANO-PC as an ordinary member.

3. NATIONAL LAWS AND REGULATIONS

3.1. Safety Authority and the Licensing Process

3.1.1. Safety Authority

The National Nuclear Safety Administration (NNSA), the State Environment Protection Administration (SEPA) and the Ministry of Health are responsible for surveillance on the safety of NPPs, environmental protection, the individual dose to the site personnel and the general public, hygienic and health conditions respectively.

The NNSA, which is endowed with the responsibilities of independent surveillance and management of the safety of Chinese civilian nuclear installations, was established in 1984 by the State Council. The responsibilities of the NNSA are:

- To organize the drafting and formulating of regulations relating to the safety, of NPPs and to review technical standards of nuclear safety;
- To organize review and assessment of both the safety, performances of NPPs and the capability, of the operating organizations to ensure safety; to issue or revoke nuclear safety, licenses;
- To be responsible for exercising nuclear safety, surveillance;
- To be responsible for investigating and dealing with accidents of nuclear safety;
- To provide guide and surveillance in drawing up and implementing emergency preparedness plan in co-operation with departments concerned;
- To organize departments concerned to develop scientific research relating to safety and management of NPPs, disseminate information to the public as well as relevant international professional links;
- To be responsible for surveillance of safety of civilian nuclear materials;
- To be responsible for regulation of nuclear pressure retaining components;
- To conduct mediation and adjudication of disputes relating to nuclear safety, in co-operation with departments concerned.

The responsibilities of the SEPA are:

- To be responsible for formulating, supervision and enforcement of the regulations and standards relating environmental management of NPP;
- To be responsible for reviewing instrument of ratification of the environmental impact assessment reports of NPP;
- To be responsible for the monitoring of radiological environment of NPP;
- To be responsible for the management of radioactive waste;
- To participate emergency response activities.

The responsibilities of the Ministry of Health are:

- To be responsible for formulating hygienic rules and standards related to nuclear facilities;
- To be responsible for monitoring exposure dose of occupational personal and the public;
- To be responsible for the evaluation of the health effects on human body due to nuclear contamination;
- To be responsible for the prevention and cure of radiation injury.

3.1.2. Licensing Process

China has adopted a licensing system for nuclear safety. The nuclear safety license is a legal document that is approved by the regulatory body and authorizes applicant to deal with nuclear safety

related specific activities (such as siting, constructing, commissioning, operation, decommissioning of NPPs; ownership, use, production, storage, transportation and disposal of nuclear materials, etc.). Figure 2 shows the procedure of application and issuing of licenses in China.

The following types of licenses for NPPs exist:

- Site permit;
- Construction permit;
- Commissioning permit;
- Operating permit;
- Decommissioning permit.

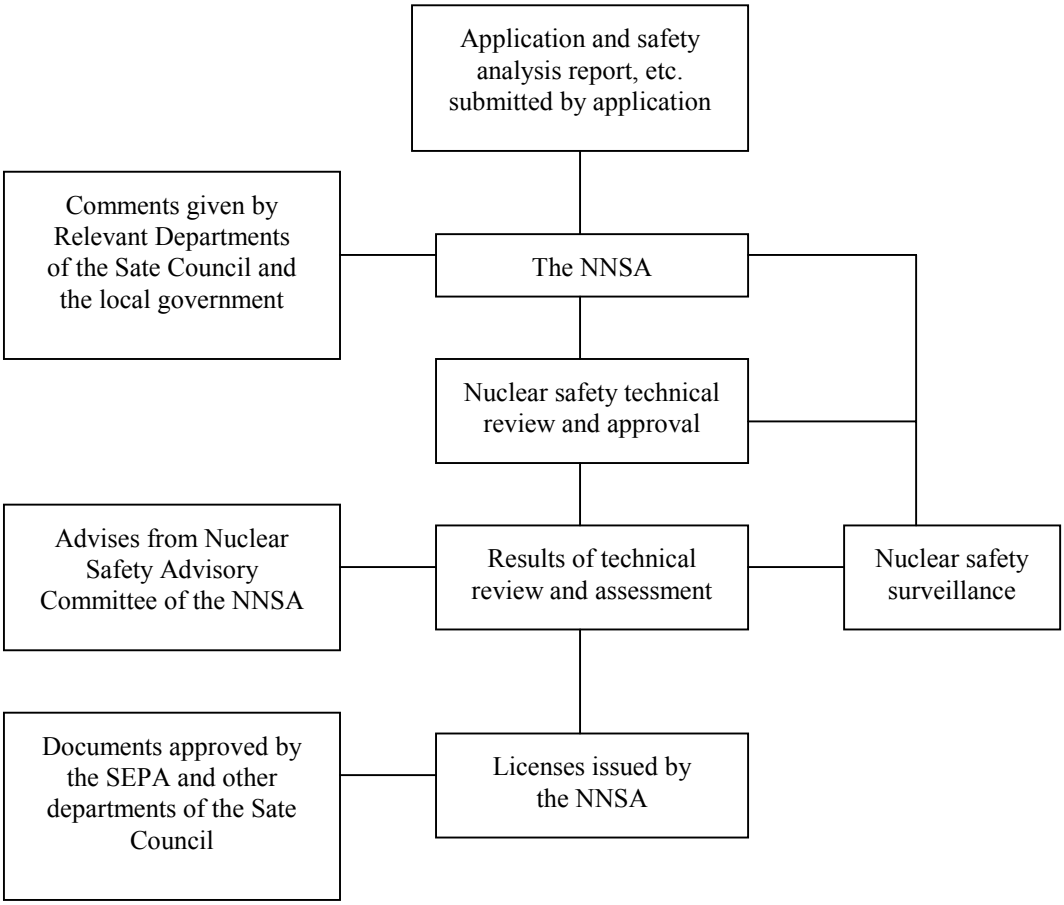


FIG 2. The procedure of application and issuing of licenses

Site Permit

In accordance with the Chinese nuclear safety code "Application and Issuance of Safety License for Nuclear Power Plant", the applicant should follow national basic construction procedure: submitting the Nuclear Power Plant Feasibility Study Report to the NNSA and the Environmental Impact Report of Nuclear Power Plant to the SEPA prior to NPP site is selected. These reports should adequately explain that the site complies with the requirements of building NPP and national environmental protection standards. The reports are examined and evaluated by the NNSA and the SEPA respectively to determine whether the NPP to be built will be safely operated on the selected site. After that the Reviewing Comments on Nuclear Power Plant Siting and the Instrument of Ratification of the Environmental Impact Report for Nuclear Power Plant are granted.

Construction Permit

After the NPP's site is finally selected, the applicant should submit to the NNSA the

Application for Construction of the Nuclear Power Plant, attached with the Preliminary Safety Analysis Report and other relative documents twelve months before starting the construction.

Commissioning Permit

The applicant should submit to the NNSA the application for the First Fuel Loading Authorization, attached with the Final Safety Analysis Report (FSAP) and other relative documents twelve months before the fuel is initially loaded into the reactor core. The authorization must be obtained also for the criticality, power raising and the first year trial operation.

Operating License

The applicant should submit to the NNSA the application for Operation License of the Nuclear Power Plant with a revised FSAR after twelve months trial operation from the date of initially reaching full power. An operation license allows operation under specified conditions for the whole design life of the installation.

Decommissioning Permit

The applicant should submit to The NNSA the Application for Decommissioning of Nuclear Power Plant with the Report for Decommissioning of Nuclear Power Plant two years before the beginning of decommissioning of the plant.

The applicant should submit the application, safety analysis report and other related documents to the NNSA for appraisal and approval and only after that, applicant can carry out relevant nuclear activities. During the process of appraisal, the NNSA should ask for opinions of the departments concerned of the State Council as well as the local government of province, autonomous region or municipality directly under the central government where NPP is located. After getting the results of technical appraisal, asking for comments of the departments concerned of the State Council and local government, and also seeking advice from the Nuclear Safety Advisory Committee, the NNSA decides independently whether the licenses are to be issued or not, meanwhile the NNSA enacts the essential requirements for licenses.

The operating organizations of NPPs are directly responsible for the safety of NPPs they operate. The main responsibilities are as follows:

- To comply with the relevant laws, administrative regulations and technical standards of the country to ensure the safety of NPPs;
- To be subjected to the surveillance on safety by the NNSA, the SEPA and the Ministry of Health, etc.; to report in time the safety situation strictly according to the facts and to provide relevant information; and
- To be wholly responsible for the safety of NPPs under operation, the safety of nuclear materials and the safety of the site personnel, the public and the environment.

3.1.3. Licensing Operating Personnel

There are two categories of operator licenses: Senior Operator License and Operator License. There shall be at least three licensed persons in each shift at NPP. Among them there shall be at least one person who holds the Senior Operator License of the NPP. The operator licenses are valid for two years. The NNSA also reviews the granting of operator and senior operator licenses held by the licensees and can veto them.

The SEPA is responsible for approving instrument of ratification of environmental impact assessment of different phases of NPPs. Instrument of ratification of environmental impact assessment report is one of the necessary prerequisites before issuing a license.

3.2. Main National Laws and Regulations in Nuclear Power

In 1989, the Environmental Protection Act of the People's Republic of China was authorized by the Standing Committee of the National People's Congress.

Regulations on the Safety Regulation for Civilian Nuclear installations of the People's Republic of China and Regulations on Nuclear Materials Control of the People's Republic of China were promulgated by the State Council in 1986 and 1987 respectively, which systematically stipulated the purpose and the scope of surveillance of civilian nuclear installations and nuclear materials, established nuclear safety licensing system, defined the duty of regulatory bodies and the legal responsibility of operation organizations. In 1993, Emergency Management Regulations for Nuclear Accidents at Nuclear Power Plants was promulgated by the State Council, which stipulated principles, countermeasures and measures adopted for nuclear accident emergency preparedness.

Codes on the safety of siting, design, operation and quality assurance of the NPP were issued by the NNSA in 1986. In 1990 the State Environmental Protection Administration (SEPA) issued the Management of Radioactive Environment. Codes on radiation protection were enacted by the NNSA, the Ministry of Health, etc. In 1991 the NNSA promulgated codes on the Safety of the Management of Radioactive Waste from Nuclear Power Plants. All these rules and regulations form the basic requirements on the safety of the NPP.

In addition, the NNSA, the SEPA and the Ministry of Health consecutively formulated relevant codes of practice and safety guides, thereby formed a relatively systematic hierarchy of rules and regulations on nuclear safety. At present, the scope of regulations on nuclear safety in China includes:

- NPPs (electricity generating NPPs, nuclear co-generation plants, nuclear heat and steam supply plants, etc.),
- Other reactors (research reactors, experimental reactors and critical assemblies, etc.),
- Installations for nuclear fuel production, processing, storage and reprocessing,
- Management of radiological environment,
- Monitor of the individual dose, hygienic and health conditions,
- Facilities for radioactive waste treatment and disposal,
- Emergency preparedness of nuclear accidents,
- Ownership, use, production, storage, transportation and disposal of nuclear materials,
- Nuclear pressure retaining components (design manufacture, installation and usage).

Since 1982, China has collected extensively and studied carefully the laws/regulations on nuclear safety applied in advanced nuclear power countries, consulted the nuclear safety codes and guides of IAEA and established the nuclear safety regulations hierarchy of China. It consists of state laws, administrative regulations of the State Council, department rules, nuclear safety guides, standards and specifications.

The **Atomic Energy Act** (waiting for approval) is the legal document to adjust and accelerate the development of atomic energy enterprises and has the highest legal status in the area of atomic energy. It enacts not only the principles of the development of atomic energy enterprises, but also the requirements of nuclear safety surveillance and management.

The **Environment Protection Act** of People's Republic of China issued by the Standing Committee of the National People's Congress is a state law which protects and improves the living environment, prevents and cures the pollution and the contamination, ensures public health and promotes social development.

The **Act of Prevention and Remedy of Radioactivity Contamination** is a legal document. It gives directives to prevent environmental contamination due to the release of waste gas, discharge of

liquid waste, disposing of solid waste and penetrated radiation during the process of nuclear energy development, nuclear technology application and the exploitation of associated mineral resources resulted in the protection of the environment and public health.

Nuclear Safety Control Regulations are rules to stipulate the scope of management, regulatory body and its rights, principle and procedures of surveillance and other important issues. They were promulgated by the State Council and have legal binding effect.

Detailed rules and regulations of implementation are **department rules**, which stipulated exact measures to be put into effect. They have been promulgated by departments concerned of the Chinese Government according to Nuclear Safety Control Regulations and have legal binding effect.

Nuclear Safety Codes are department rules enacting nuclear safety objectives and basic safety requirements. They have been promulgated by the relevant departments of the Chinese Government approved by the State Council and have legal binding effect. Standards and specifications related to nuclear safety are enacted by the SEPA and the Ministry of Health, etc. Nuclear Safety Guides are guiding documents that supplement or illustrate nuclear safety codes and recommend relevant methods or procedures.

4. CURRENT ISSUES AND DEVELOPMENTS ON NUCLEAR POWER

4.1. Energy Policy

Currently, the following issues relative to the future nuclear development program in China are discussed between the governmental authorities and industry:

(1) How many nuclear power capacities should be installed up to 2020?
(2) What type of NPP design will be chosen for massive construction in next step?
(3) How can the self-reliance goal be achieved in the development of large-scale nuclear unit?

It is sure that the final decisions will be made in near future on those issues.

4.2. Privatisation and deregulation

At present, the electricity market has started to be decontrolled by the government, and a new price system will be set up with the reform of the electricity market.

By the end of 2002, the Chinese electric power set up (reorganization) 11 companies, the act realized the plant and grid to separate, has introduced competition mechanism, is the Chinese electric power organizational reform important achievement. The electric power organizational reform involves aspects, must according to the system design, divide the step of implementation positively, is safe, necessary advancement request, step by step as stages to complete the reform task. After reform of the electricity market, electricity prices would decline in a long-term.

Now the former State Electric Power Corporation has been divided into the following companies: State Grid Corporation of China and China Southern Gird Limited Company, as well as five electricity generation company — China HuaNeng Group, China DaTang Group, China HuaDian Corporation, China GuoDian (group) Corporation and China Power Investment Corporation with four auxiliary industry companies — China Electric Power Engineering Consultant Corporation, China Hydro Power Engineering Consultant Corporation, China National Water Resources and Hydro Power Engineering Corporation and China Gezhouba Construction Group for Water Resources and Hydro Power.

In China, as a new source of electricity generation, nuclear power will get the support in different ways and its electricity price will keep a stable level in the near term. However, it is a basic goal to decrease the nuclear generation cost by great efforts, because NPPs will finally face to competition against other type of power plants in the electricity market.

REFERENCES

[1] IAEA Energy and Economic Data Base (EEDB).
[2] IAEA Power Reactor Information System (PRIS).
[3] Data & Statistics, The World Bank, www.worldbank.org/data.
[4] Country Information

Appendix 1

INTERNATIONAL, MULTILATERAL AND BILATERAL AGREEMENTS

AGREEMENTS WITH THE AGENCY

- Agreement on privileges and immunities

- Agreement between the People's Republic of China and the International Atomic Energy Agency for the Application of Safeguards in China

- Additional protocol to Agreement between the People's Republic of China and the International Atomic Energy Agency for the Application of Safeguards in China

- Improved procedures for designation of safeguards inspectors

- Supplementary agreement on provision of technical assistance by the IAEA

- RCA

MAIN INTERNATIONAL TREATIES

- NPT

- Convention on physical protection of nuclear material

- Convention on early notification of a nuclear accident

- Convention on assistance in the case of a nuclear accident or radiological emergency

- Convention on nuclear safety

BILATERAL AGREEMENTS

There are bilateral agreements for co-operation in the peaceful use of nuclear energy between the Chinese Government and 16 countries:
Germany, Brazil, Argentina, Belgium, USA, UK, Japan, Pakistan, Switzerland, Iran, Canada, Korea, Russia, France, Viet Nam, Egypt.

In addition, there are the following bilateral nuclear safety co-operation agreements between NNSA and:

- USNRC of USA;
- DSIN of France;
- BMU of Germany;
- CSN of Spain;
- ENEA/DISR of Italy;
- DNSRP of Pakistan;
- MITI, STA of Japan;
- MOSI of Korea;
- AECB of Canada;
- IPSN of France;
- KINS of Korea;
- Russia.

Appendix 2

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

NATIONAL ATOMIC ENERGY AUTHORITIES

China Atomic Energy Authority (CAEA)
A8, Fuchenglu, Haidian District
Beijing, 100037
Tel.: +86 10-88581381 or 88581286
Fax: +86 10-88581516
http://www.caea.gov.cn/english/

National Nuclear Safety Administration (NNSA)
Attached to National Environment Protection Agency
No. 115 Xizhimennei Nanxiaojie
Beijing, 100035
Tel.: +86 10-6611 1436 or 1446
Fax: +86 10-6612 6715

China National Nuclear Corporation
P.O. Box 2102
Beijing 100822, PRC
Tel: 86-10-6851-2211
Fax: 86-10-6853-3989
http://www.cnnc.com.cn/

China Engineering and Technology
Nuclear Information Network (CETIN):
http://www.nuclear.cetin.net.cn/

NUCLEAR ORGANIZATIONS

Nuclear Fuel Complex
P.O. Box 508
Lanzhou 732850, PRC

Nuclear Fuel Fabrication
P.O. Box 257
Chengdu, Yibin 610002
Tel: 86-0831-22-1811
Fax: 86-0831-22-3622

Nuclear Power Institute of China
P.O. Box 436
Chengdu 610041, PRC
Tel: 86-28-558-2199 Ext. 33171
Fax: 86-28-558-2223

Shanghai Nuclear Engineering and Design Institute
29 Hongcao Road Lu
Shanghai 200233, PRC
Tel: 86-021-6485-5415
Fax: 86-021-6439-0846

NUCLEAR RESEARCH INSTITUTES

Institute of Nuclear Energy Technology
Tsinghua University
P.O. Box 1021
Beijing 100084, PRC
Tel: 86-10-6259-4533
Fax: 86-10-6256-4177
http://www.inet.tsinghua.edu.cn/

Beijing Institute of Nuclear Engineering
P.O. Box 840
Beijing 100840, PRC
Tel: 86-10-8802-2213
Fax: 86-10-6841-5067
http://www.nuclear.cetin.net.cn/bine/index.htm

China Institute of Atomic Energy
P.O. Box 275 Tel: 86-10-6935-7676
Beijing 102413, PRC Fax: 86-10-6935-7008

China Nuclear Energy Industry Corporation
P.O. Box 822 Tel: 86-10-6802-2491
Beijing 100037, PRC Fax: 86-10-6801-0445

Institute of High Energy Physics
Academia Sinica (IHEP): http://www.friends-partners.org/~china/ins/IHEP/bsrf/bsrf1.html

National Synchrotron Radiation Laboratory
in Hefei (NSRL): http://www.ustc.edu.cn/english/srl.htm

University of Science and Technology of China
(USTC - Hefei, Anhui): http://www.ustc.edu.cn/chinese/content.htm