PEOPLE’S REPUBLIC OF CHINA

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1. GENERAL INFORMATION

1.1. General Overview

China, the world's largest country, has a population of about 1.3 billion people. The average annual growth rate of population was about 0.9% during the last decade (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 predominantly in the north and northwestern regions, while water resources are mainly in the southwestern 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 is rapidly becoming 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 are two nuclear power plants in operation, with a capacity of 2.27 GW(e): one plant consist of the 300 MW(e) PWR NPP at Qinshan, Zhejiang Province and the other one of two 984 MW(e) PWR units at Daya Bay, Guangdong Province.

The Qinshan Nuclear Power Plant is on the north side of Hangzhou Bay, which is eight kilometres from the city of Haiyan, 90 km from Shanghai, and 78 km from Hangzhou. The Qinshan nuclear power plant site enjoys a subtropical maritime climate. The mean annual temperature is 16.3°C°, with a maximum of 37.4°C and a minimum of -5.3°C. The relative humidity is higher than 80%. The plant site is located on a mountainous peninsula with a low population density (240 people per km^2). There are about 18,600 inhabitants within five kilometres of the plant.

The Daya Bay Nuclear Power Plant is located in Longgang Zone, Shenzhen City, Guangdong Province. The site faces Dapeng Bay, a small bay on the southwest of Daya Bay, and is close to low mountains (700 m high) on the Dapeng peninsula. Similar to Qinshan, the site has a subtropical maritime climate. The mean annual temperature is 21.8°C with a maximum of 36.7°C and a minimum of 0.2°C. The relative humidity follows the monsoon seasons with the highest humidity (80%) in spring and summer and the lowest (16%) in winter. The mountainous peninsula has a low population density (37 people per km^2). There are about 2,900 inhabitants within five kilometres radius from the plant.

TABLE 1. POPULATION INFORMATION

										Ann. av. growth rate (%)
	1960	1970	1980	1990	1996	1997	1998	1999	2000	1990 to 2000
Population (millions)	657.5	830.7	998.9	1,155	1,232	1,236	1,248	1,259	1,266	0.9
Population density (inhabitan/km^2)	68.8	86.9	104.5	120.8	128.9	129.3	130.5	131.7	132.4	0.9
Urban populations percent of total	-	-	19.4	26.4	29.3	29.9	30.4	30.9	36	3.1
Area (1000km^2) 9,561										

Source: IAEA Energy and Economic Database and Country Information

1.2. Economic Indicators

In 2000, China's Gross Domestic Product (GDP) was 8,940 billion RMB Yuan, a 8.0% increase from 1999. GDP was 1081 billion US$ (according to the exchange rate 8.27) with the per capita GDP

of 848 US$ in 2000 and annual growth rate of 8.3% during the 9th Five-Year Plan Period (1996-2000). Total industrial GDP increased to 4,430 billion RMB Yuan with a growth rate of 9.6% over the previous year. Agricultural sector grew to 1,480 billion RMB Yuan with a growth rate of 2.4 % over previous year. Service sector grew to 2,914 billion RMB Yuan with 7.8%. In 2000, the proportions of agriculture, industry and services were 17%, 50% and 33% 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	Ann. av. growth rate (%) 1996 to 2000
GDP[1]	123,424	392,056	505,750	815,412	896,933	943,383	990,459	1,081,064	8.3
GDP[2]	117,970	215,498	505,750	750,515	818,061				
GDP[3] per capita	151	400	446	662	732	772	780	848	6.4
GDP by sector (%):									
-Agriculture	35	30	27	20	19	18	18	17	3.3
-Industry	37	44	37	43	44	42	49	50	9.7
-Services	28	26	36	37	37	40	33	33	8.1

(1) Millions of current US$.
(2) Millions of constant 1990 US$.
(3) Current US$ per capita.
Source: IAEA Energy mid Economic Data Base and Country Information.

1.3. Energy Situation

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.

In 1999, the total output of primary energy was 1.1 billion tonnes of standard coal equivalent (11.3% higher than the previous year). The coal production accounted for 68.2% of total primary energy production while the production of petroleum, natural gas and hydropower accounted respectively for 20.9%, 3.1% and 7.8% of total energy production.

In 1999, primary energy consumption amounted to 1.22 billion tonnes of standard coal equivalent. The rates of coal, petroleum, natural gas and hydropower in energy consumption were 67.1%, 23.4%, 2.8% and 6.7%, respectively. Statistical energy data are given in Table 4. The per capita energy consumption in 1999 was 0.97 tonnes of standard coal.

1.4. Energy Policy

The current power developing policy of the Chinese government is to fully utilize he existing capacity in generating electricity, to actively construct hydroelectric power and fossil power of large capacity units nearby pits, to reduce the number of fossil power units with small capacities and to moderately develop nuclear power. 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;
- Optimizing structure of fossil power:
- Developing hydraulic power extensively;
- Developing nuclear power appropriately;
- Promoting development of new energy resources in accordance with local condition.

TABLE 4. ENERGY STATISTICS

Exajoule

									Average annual growth rate (%)	
	1960	1970	1980	1990	1997	1998	1999	2000	1960 to 1980	1980 to 2000
Energy consumption										
-Total [1]	8.70	10.22	19.02	28.90	40.48	38.74	40.89	41.09	3.99	3.93
- Solids [2]	8.27	8.62	14.18	22.26	28.95	26.96	29.06	28.49	2.73	3.55
- Liquids	0.32	1.29	3.73	4.80	8.26	8.33	8.70	9.33	13.11	4.70
- Gases	0.04	0.11	0.56	0.60	0.69	0.85	0.91	0.95	13.99	2.71
-Primary electricity [3]	0.07	0.20	0.56	1.24	2.57	2.60	2.22	2.32	10.89	7.34
Energy production										
- Total	8.64	10.26	19.81	32.05	38.80	36.41	40.21	40.00	4.24	3.58
- Solids	8.31	8.67	14.26	24.44	28.75	26.18	29.97	29.40	2.74	3.68
- Liquids	0.22	1.28	4.44	5.79	6.71	6.73	6.91	7.07	16.27	2.36
- Gases	0.04	0.11	0.56	0.60	0.81	0.91	1.08	1.18	13.99	3.83
-Primary electricity [3]	0.07	0.20	0.56	1.22	2.58	2.60	2.25	2.35	10.86	7.42
Net import (import - export)										
- Total	0.06	-0.05	-0.79	-1.29	0.67	0.39	-2.19	-62.51	-14.22	24.41
- Solids	-0.04	-0.06	-0.08	-0.34			-1.08	-1.16	3.16	14.21
- Liquids	0.10	0.01	-0.71	-0.95			1.78	2.31	-10.34	-6.07
- Gases							-2.89	-63.65		

[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.

Source: IAEA Energy and Economic Database and Country Information.

2. ELECTRICITY SECTOR

2.1. Structure of the Electricity Sector

At present, China has set up 6 major trans-provincial and regional networks and 5 independent provincial networks in the mainland for distribution of the generated electricity by its power plants (which have a total capacity of about 320 GW). Among these, the largest one is the East-China Power network, which connects 56.7 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 51.4 GW and 45.6 GW, respectively. The installed capacities of the North-China Power network and the Northeast China Power network are 42.8 GW and 37.9 GW. The Northwest China Power network's installed capacity is 19.2 GW. In addition, the Shandong Provincial Power network developed quite rapidly and reached an installed capacity of 19.6 GW at the end of 2000. The other independent provincial networks are Sichuan-Chongqing power network (19.0 GW), Fujian power network (10.4 GW), Hanan power network (1.8 GW) and Xingjiang power network (2.7 GW). All these power networks are state-owned. The State Power Corporation of China (SPCC) is drawing up the nation-wide power net linking programme.

2.2. Decision Making Process

The State Development and Planning Commission (SDPC) 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 SDPC. 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 SDPC. The State Council must approve large projects, like the Three Gorges Power Station. SDPC is also responsible for localization of nuclear power plants.

The State Economic and Trade Commission (SETC) is responsible for short and long term planning of conventional electricity development according to the needs of the national economy. SETC is authorized to initiate a new power project. The owner of the power project prepares and submits the Preliminary Feasibility Study Report (PFSR), the Project Proposal and the Feasibility Study Report (FSR) to SETC (to for review. SETC reports its comments and decision to SDPC for final approval.

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 SDPC.

2.3. Main Indicators

In 2000, the total installed generation capacity was 319.3 GW, of which fossil power accounted for 74.4%, hydropower 24.8%, and nuclear power 0.7%. The total electricity production in 2000 amounted to 1,368 TW·h with a growth rate of 11% over the previous year. Most of the electricity was produced by fossil fuels (81%), whilst hydropower contributed 18% and nuclear electricity production only 1.2%. 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 1,064 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

										Average annual growth rate (%)	
	1960	1970	1980	1990	1996	1997	1998	1999	2000	1960 to 1980	1980 to 2000
Electricity production (TW·h)											
-Total[(1)]	59.40	115.9	300.6	621.3	1079	1134	1158	1233	1368	8.5	7.9
- Thermal	52.00	95.40	242.3	495.8	878.4	924.7	938.8	1005	1108	8.0	7.9
- Hydro	7.40	20.50	58.3	125.5	186.7	195.1	203.8	212.9	243.1	10.9	7.4
- Nuclear					14.3	14.4	14.1	14.8	16.7	_	_
Capacity of electrical plants ($GW_{(e)}$)											
-Total		24.18	65.87	137.9	236.5	254.2	277.3	298.8	319.3	_	8.2
- Thermal		16.00	45.55	101.9	178.7	192.2	210	223.4	237.5	_	8.6
- Hydro		8.18	20.32	35.98	55.59	59.75	65.05	72.97	79.35	_	7.0
- Nuclear					2.27	2.27	2.27	2.27	2.27	_	_

[(1)] Electricity losses are not deducted.[(2)] Solid fuels include coal, lignite and commercial wood.

Source: IAEA Energy and Economic Database and Country Information.

TABLE 6. ENERGY RELATED RATIOS

	1960	1970	1980	1990	1996	1997	1998	1999	2000
Energy consumption per capita (G J/capita)	13	12	19	26	33	33	31	32	32
Electricity per capita (kW·h/capita)	90	140	282	506	875	917.63	929.13	960.40	1064.83
Electricity production/Energy production (%)	7	11	14	18	26	30	32	30	31
Nuclear/Total electricity (%)					1	1.3	1.2	1.2	1.2
Ratio of external dependency (%)(1)	1		-4	-4		1.7	1		
Load factor of electricity plants									
- Total (%)		55	52	51	57	51	48	47	49
- Thermal		68	61	55	61	55	51	51	53
- Hydro		29	33	40	43	37	36	33	35
- Nuclear					72	60	70	75	84

(1) Net import / Total energy consumption

Source: IAEA Energy and Economic Database and Country Information.

2.4. Impact of the Open Electricity Market in the Nuclear Sector

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. 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 compete against other power plants in the electricity market.

3. NUCLEAR POWER SITUATION

3.1. Historical Development

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 300 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.

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.

However, pressurized water reactors have been selected as the mainstream of nuclear power development in China, whilst other types of reactors are considered where suitable. Research and development on advanced PWRs started in 1986.

3.2. Status and Trends of Nuclear Power

Table 7 shows the current status of nuclear power plants. There are two operating NPPs on the mainland of China and 4 NPPs with 8 units are under construction. Nuclear electricity production in 2000 was 16.7 TW·h accounting for 1.2% of total electricity production. Nuclear installed capacity was only 2.27 GW, accounting for 0.71 % 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	GNP JVC	FRAM
GUANGDONG-2	PWR	984	Operating	GNPJVC	FRAM
QINSHAN- 1	PWR	300	Operating	QNPC	CNNC
QINSHAN-2A	PWR	600	Under construction	QNPC	CNNC
QINSHAN-2B	PWR	600	Under construction	QNPC	CNNC
LINGAO-A	PWR	986	Under construction	GNP JVC	FRAM
LINGAO-B	PWR	986	Under construction	GNP JVC	FRAM
QINSHAN-3A	PHWR	728	Under construction	TQNPC	AECL
QINSHAN-3B	PHWR	728	Under construction	TQNPC	AECL
TIANWAN-1	WWER	1000	Under construction	JNPC	AEE&ZAES
TIANWAN-2	WWER	1000	Under construction	JNPC	AEE&ZAES

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[a]	01-Feb-02[a]	01-Jun-02[a]	
QINSHAN-2B	02-Jun-96	15-Sep-02[a]	01-Dec-02[a]	01-Apr-03[a]	
LINGAO-A	15-May-97	28-Feb-02[a]	15-Apr-02[a]	15-Jul-02[a]	
LINGAO-B	28-Nov-97	31-Oct-02[a]	15-Dec-02[a]	15-Mar-03[a]	
QINSHAN-3A	08-Jun-98	13-Oct-02[a]	10-Nov-02[a]	12-Feb-03[a]	
QINSHAN-3B	25-Sep-98	18-May-03[a]	15-Jun-03[a]	12-Nov-03[a]	
TIANWAN-1	20-Oct-99	01-3an-03[a]	01-Jan-03[a]	01-Jan-04[a]	
TIANWAN-2	20-Oct-00	01-Jan-04[a]	0l-Jan-04[a]	01-Jan-05[a]	

[a] Target dates.

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 of 31 December 2000.

Qinshan NPP, a 300 MW PWR, is the first NPP with self-reliant design, construction and operation. Its commercial operation started in April 1994 and four times of refuelling and overhaul were conducted up to 2000. The plant was out of operation during August 1998 to the middle of September 1999 due to the fourth reloading and repairing the damaged component of barrel container of the reactor. Encouragingly, since then the plant operated continuously and safely till the end of 2000. Its total generation in 2000 was 2.035 TW·h with a load factor of 77.2 %.

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 2000, the two units generated electricity of 14.0 TW·h and the load factor reached 85%.

As decided by the Chinese government, commencement of work for 4 additional nuclear power projects, namely Qinshan Phase 2, Guangdong Lingao, Qinshan Phase 3 and Tianwan NPP, including

8 units with a total installed capacity 6,628MW, was scheduled for the 9th Five Year Plan period (1996-2000).

Qinshan Nuclear Power Phase 2 is at the Yangliushan, 3 km south of Qinshan Phase 1 site. The 600 MW PWR units are mainly based on self-reliant design and construction, some heavy equipment will be imported from foreign countries. The first concrete was poured in June 1996. The first unit has been completed and trial operation has started in October 2001. Unit 1 is expected to be connected to the grid and commence generating electricity in 2002.

Guangdong Lingao NPP, 1km northeast of Daya Bay NPP, consists of 2 French-designed PWR units of 986 MW capacity. 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 and unit 1 is expected to be completed and put into operation in 2002.

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, and both containments have been domed, ahead of schedule. At present, the project is proceeding smoothly. Unit 1 is expected to be completed and put into operation in 2003.

Tianwan NPP in Lianyungang City, 300km north to Shanghai, includes 2 Russian advanced VVER-1000 91-Type PWR units with 1000MW of installed capacity each. Russia will supply the design of the project and the main equipment for both nuclear and conventional islands. Some equipment will be 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 is scheduled to be completed for commercial operation in 2004.

Coastal and inland provinces like Zhejiang, Shandong, Jiangsu, Fujian, Hunan, JiangxJ, 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.

3.3. Current Policy Issues

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, and then to give its comments and decision to the State Development and Planning Commission (SDPC) for final approval.

The roles and responsibilities of CAEA are as follows:

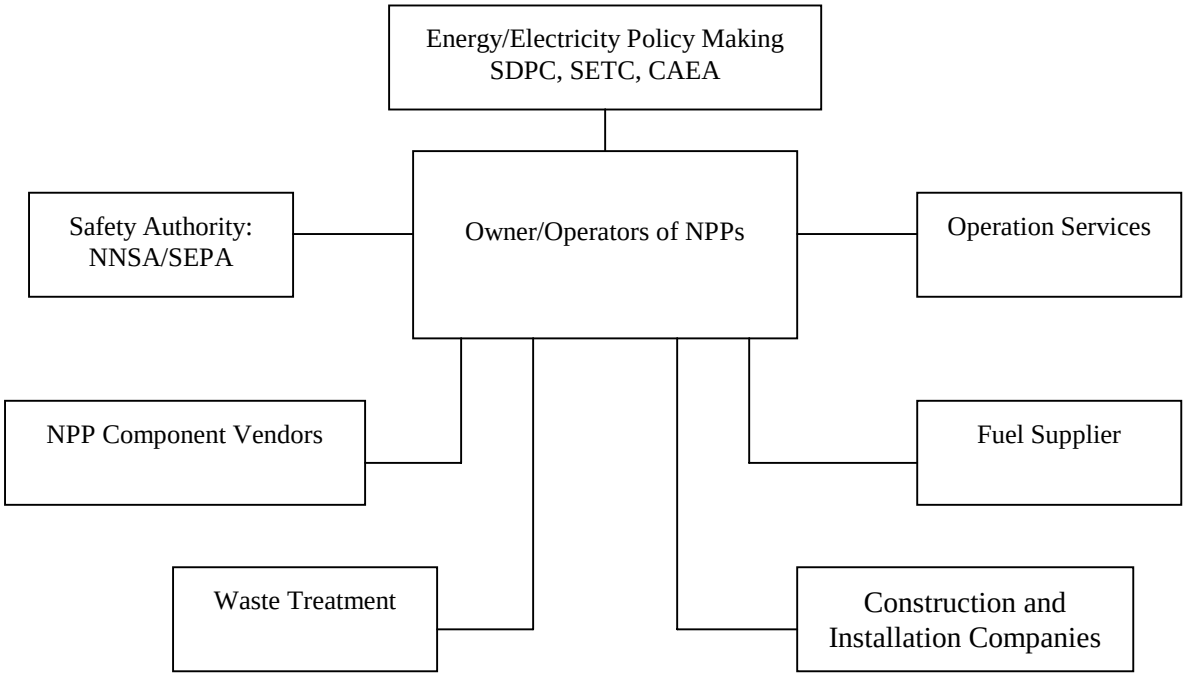
- Deliberating and drawing up policies and regulations on peaceful use of nuclear energy;
- Deliberating and drawing up the development programming, planning and industrial standards for peaceful use of nuclear energy;
- Organizing argumentation and giving approval to China's major nuclear R&D projects; 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.

During the 10th Five-Year Plan Period (2001-2005), an appropriate number of new nuclear units will be considered to build in some coastal provinces, but the final decision has not been made

by the central government up to now.

3.4. Organizational Chart

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



Legend:
CAEA: China Atomic Energy Authority
NNSA: National Nuclear Safety Administration
SDPC: State Development and Planning Commission
SEPA: State Environment Protection Administration
SETC: State Economic and Trade Commission

FIG. 1. Organizational Chart

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 System and Engineering 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 and nuclear facilities dispatch a numbers of staff to universities or other training method, a lot of person would be well trained. The training center and training department within the nuclear power 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.

4. NUCLEAR POWER INDUSTRY

4.1. 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.

Architect 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.

4.2. Operation of Nuclear Power Plants

CNNC and GNPJVC supply operation and maintenance services for Qinshan NPP and Daya Bay NPP, respectively (see Table 9).

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

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.

4.3. Fuel Cycle and Waste Management Service Supply

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.).

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4.4. Research and Development Activities

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 2 and Daya Bay 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 will be 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.

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

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.
- 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.

5. REGULATORY FRAMEWORK

COMPETENT DEPARTMENT OF NUCLEAR INDUSTRY

5.1. Safety Authority and Licensing Process

5.1.1. 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.

5.1.2. 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.

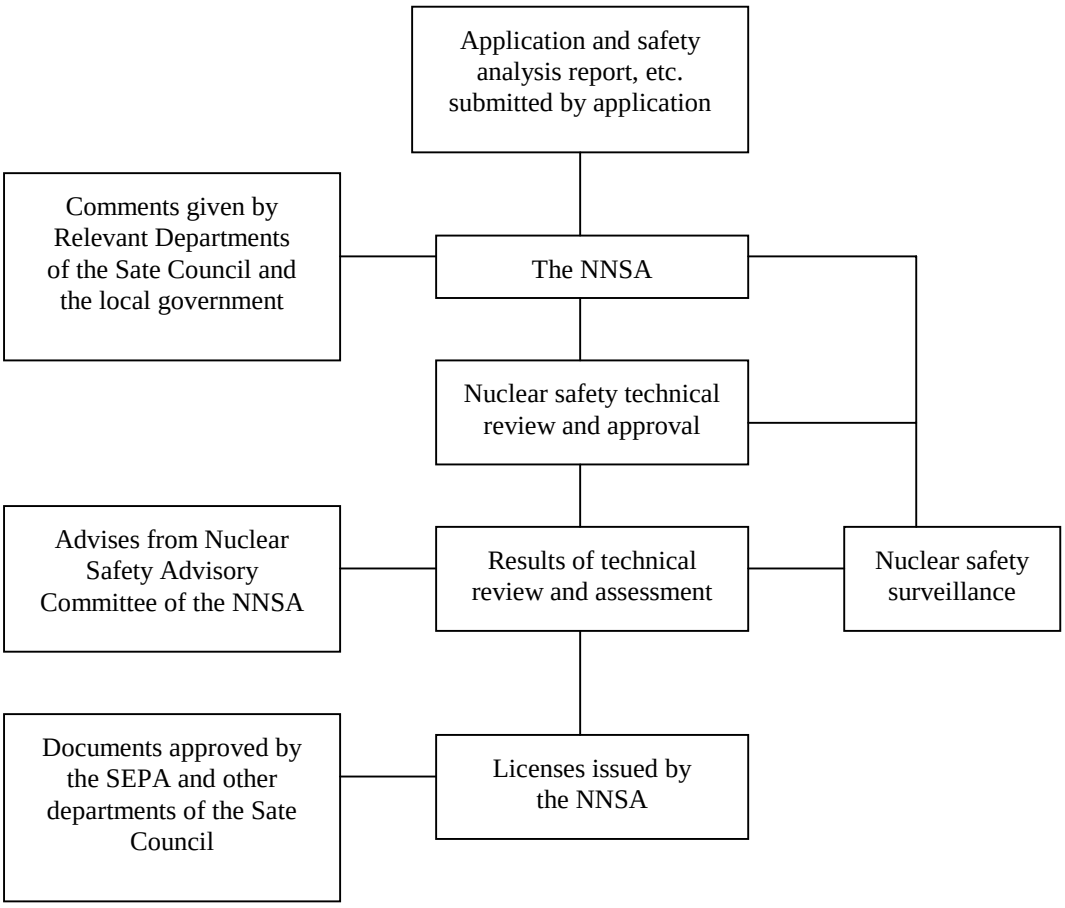

FIG 2. The procedure of application and issuing of licenses

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.

5.1.3. 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.

5.2. Main National Laws and Regulations

In 1989, the Environmental Protection Act of the People 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** (waiting for approval) 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 techniques' application and the exploitation of associated mineral resources resulted in the protection of the environment and taking care of 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.

5.3. International, Multilateral and Bilateral Agreements

AGREEMENTS WITH THE AGENCY

• Amendments of Article VI & XIV.A of the IAEA statute	Not Ratified	
• Agreement on privileges and immunities	Entry into force:	16 July 1984
• Safeguards agreement concluded on the basis of voluntary offer INFCIRC/369	Entry into force:	18 September 1989
• Additional protocol	Signature:	31 December 1998
• Improved procedures for designation of safeguards inspectors	Following EU policy.	
• Supplementary agreement on provision of technical assistance by the IAEA	Entry into force:	22 June 1990
• RCA	Entry into force:	12 June 1987

MAIN 1NTERNATIONAL TREATIES

• NPT	Entry into force:	9 March 1992
• Convention on physical protection of nuclear material	Entry into force:	9 February 1989
• Convention on early notification of a nuclear accident	Entry into force:	11 October 1987
• Convention on assistance in the case of a nuclear accident or radiological emergency	Entry into force:	11 October 1987
• Vienna convention on civil liability for nuclear damage	Non-Party	
• Paris convention on third party liability in the field of nuclear energy	N/A	
• Joint protocol relating to the application of Vienna and Paris conventions	Non-Party	
• Protocol to amend the Vienna convention on civil liability for nuclear damage	Not signed	
• Convention on supplementary compensation for nuclear damage	Not signed	
• Convention on nuclear safety	Entry into force:	24 October 1996
• Joint convention on the safety of spent fuel management and on the safety of radioactive waste management	Not signed	

OTHER RELEVANT 1NTERNATIONAL TREATIES

• Improved procedures for designation of safeguards inspectors	Prefers the present system until further experience is gained.
• Nuclear Export Guidelines	Not adopted. The Chinese Government has issued its own Regulations on Nuclear Export Control of the People's Republic of China. Three principles of nuclear export policy are quoted in PRC statement to 36th GC, pp.9 and 10.
• Acceptance of NUSS Codes	All codes (except the one on Governmental Organizations) have been formally introduced into the regulatory system. Regulations were amended in 1991, based on the Revised NUSS Codes.
• ZANGGER Committee	Non-Member
• Nuclear Suppliers Group	Non member

BILATERAL AGREEMENTS

There are bilateral agreements for co-operation in the peaceful use of nuclear energy between the Chinese Government and 14 countries. 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.

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.

Appendix

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

NATIONAL ATOMIC ENERGY AUTHORITIES

China Atomic Energy Authority (CAEA)
A2, Guangamnen Nanjie
Beijing, 100053
Tel.: +86 10-8398 3381
Fax: +86 10-8398 3516
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
Beijing 102413, PRC

Tel: 86-10-6935-7676
Fax: 86-10-6935-7008

China Nuclear Energy Industry Corporation
P.O. Box 822
Beijing 100037, PRC

Tel: 86-10-6851-2211
Fax: 86-10-6851-2393

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