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Energy Construction Targets for 1993 Set

9360054B Beijing JINGJI RIBAO [ECONOMIC DAILY] in Chinese 1 Feb 93 p 5

[Article by reporter Xie Ranhao [6200 3544 3185]]

[Text] The Ministry of Energy Resources has announced that the targets for national energy production and construction for 1993 have been set. The 1993 goals are for a national output of 1.09 billion tons of standard coal, a 2 percent increase over 1992. Raw coal production will be 1.14 billion tons, 30 million tons more than last year, of which 506 million tons will come from aggregate coal mines, an increase of 16 million tons; crude oil output will be over 140 million tons, and natural gas, 16 billion cubic meters. Electric power production will be 800 billion kWh, 8.1 percent over last year, of which hydropower will be 127 billion kWh, nuclear will be 1.5 billion kWh, and thermal power will be 671.5 billion kWh.

State supplied investments for 1993 energy base construction targets will be 71.2 billion yuan, 44.4 percent over 1992 planned investments, or about 24.1 percent of the total capital construction investments for the whole country, and adding on local funds and other investments, the total investments in capital construction for energy could reach 80 billion yuan or more for the whole society.

From the standpoint of industries, investments in coal for the year could reach 16 billion yuan, 31.26 percent over the previous year, which for aggregate coal mines will be 14.56 billion yuan, Huaneng Coal Corporation investments will be 803 million yuan, and local coal mines will invest 640 million yuan. New coal mines just going into operation with production capability of 19.24 million tons, and adding on the Inner Mongolia Jungar open pit mine, the year's new mine output could be over 30 million tons. It is estimated that capacity of aggregate and local coal mines now opening up could be over 30 million tons.

The investment outlay for electric power for the year could reach 52.2 billion yuan, an increase of 50 percent over last year; 11.48 billion yuan for hydropower, 31.096 billion yuan for thermal power, and 7.376 billion yuan for power transmission facilities. 12,052MW of large- and medium-sized generating units will become operational during the year, including 3,147MW of hydropower, and 8,905MW of thermal power; 34 new power facilities will be under construction for a total installed capacity of up to 20,687MW, including six hydropower sites totalling 9,162MW, and 28 thermal sites totalling 11,425MW.

Petroleum and natural gas investments will be 40.93 billion yuan; 10.33 billion yuan for capital construction with the remainder going for geological prospecting expenses, production and maintenance expenses, and repayment on reserves and oil price fluctuations.

In addition, the initial intended scale of investments for electric power coal-saving technology will be 2.653 billion yuan, of which 1.38 billion will come from the various group and provincial electric power enterprises who can make conversions to 200MW units and put them into operation by year's end; 29 new construction tasks for 1,920MW, and 1,049MW of large coal-saving units to replace small high-consumption units.

Although in absolute numbers there is an increase in energy construction in 1993, compared to the proportion of total capital construction investment in 1992, it is down 2.2 percent. Concerned experts point out that, with the national economy reaching a new stage every few years, the energy industry must have rapid growth in order to meet its targets, and the whole society should be aware that the 2 percent slide in construction investments which has gone on for 2 years now, in 1991 and 1992, is being repeated in 1993. If sustained economic growth brings on a full-fledged supply and demand crunch, it will be too late to correct by increasing energy construction investments.

China Seeks To Oil Its Ties With U.S.

40100071 Beijing CHINA DAILY (Economics and Business) in English 26 Mar 93 p 2

[Article by staff reporter Chang Weimin]

[Text] Wang Tao, president of the China National Petroleum Corporation (CNPC), the country's largest State oil firm, is leaving for the United States next Monday to beef up ties with US oil firms.

Invited by the US oil industry, Wang will attend a Sino-American symposium in Houston on cooperation in petroleum exploration and development.

Wang is leading a delegation consisting of a dozen government officials, entrepreneurs and experts.

The group is to stay there for 10 days, during which time they will meet leading figures in US political circles, oil firms, industry, commerce and the media.

Agreements and contracts will be signed with US firms on cooperation and trade.

The agreements and contracts to be signed include:

—One between CNPC and US Halliburton company on setting up a petroleum engineering joint venture in North China.

The venture is to mainly provide services to Chinese oilfields. When conditions are mature, it will expand business to the outside world.

—Agreement between the two firms on jointly developing and manufacturing "bullets" for making holes under oil wells.

The "bullets" are mainly to be used by Chinese firms for exploring oil in new areas. The two firms also expect to compete internationally.

—Contracts on buying American-produced equipment and chemicals for oil exploration and development.

Trade volume is expected to reach $200 million.

A Chinese purchasing group—a vanguard of the delegation—is already in the United States.

At the symposium, which is organized jointly by oil industries of the two countries, Wang will talk about the geological situation in the south-eastern part of the basin of Tarim in Xinjiang Uygur Autonomous Region, which has been opened to foreign oil firms.

Wang will tell US oil firms the procedures and the current progress of an international bidding for risk oil exploration and development in the basin part, which covers some 73,000 square kilometers.

Wang will also elaborate Chinese policies on bidding and foreign firms' involvement in the risk exploration and development in the basin.

Chinese Premier Li Peng last month announced the opening of the basin.

So far at least 48 oil firms from 15 countries have entered the bidding. Of them, 15 are from the United States.

CNPC officials said their firm pins significance on cooperation with the American petroleum industry. US firms such as Exxon, Esso, Texaco, Mobil, Amoco, Arco, Chevron, and Occidental are among and first companies in cooperation with the Chinese.

Important discoveries have been made in the cooperation, and CNPC officials said more fruits are expected.

China expects big discoveries to be made in Tarim. Geological surveys and a 4-year-long exploration in the basin shows it will be the core of China's oil production in the future.

According to Wang Tao, a quality road running through the basin, which is surrounded by deserts, is under way. A length of 25 kilometers of the road has been paved and Wang said construction is now going toward the central part of the basin.

This year, another 130 kilometers will be paved. The road, to be over 400 kilometers long, is expected to be completed within 2 to 3 years.

China, Taiwan Meet on Peaceful Uses of Nuclear Energy

9360059A Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 5 Mar 93 p 5

[Article by reporter Wan Hongqiang [8001 4767 1730]]

[Text] Beijing, 4 March (XINHUA)—More than 80 scholars from both sides of the Taiwan Strait attended the 1993 bipartisan nuclear energy symposium convened in Beijing on 4 March.

During the 2-day conference, scholars from both sides will engage in academic exchange on 27 special subjects relating to four major topics: operations and management of nuclear power plants, nuclear safety controls, nuclear waste disposal, and environmental monitoring.

Mainland nuclear chemical industry expert and Vice President of the China National Nuclear Industry Corporation, Huang Qitao, said at the opening ceremony that Taiwan has had over 20 years of nuclear development, and has a wealth of experience in nuclear power plant construction, guaranteeing engineering quality and scheduling, nuclear power plant operation management, operational safety guarantees, and management improvement. This experience provides valuable objects of study for mainland colleagues.

Huang Qitao explained that nuclear development on the mainland got off to a late start, but the Qinshan and Daya Bay nuclear power plants are now underway. Debugging was finished last year at the 300MW Qinshan power plant, which is being built largely by mainland resources, and after realignments following a full-power run it is now being prepared for a re-start. The No 1 unit at Daya Bay will become operational in the second half of this year. He revealed that excavation for the 2 X 600MW Qinshan second-phase construction will begin in June of this year. Guangdong, Fujian, Jiangsu, and Liaoning provinces are now making preparations for new nuclear power plants.

Huang Qitao indicated that the mainland possesses a complete nuclear industry system, abundant nuclear technical talent, and there are numerous prospects for peaceful use of atomic nuclear S&T, but there is insufficient experience in construction and operational management of nuclear power plants, and for these reasons exchanges between the mainland and Taiwan colleagues can be mutually helpful.

Professor Su Qinglin, Head of the Taiwan Nuclear Energy Academic Team visiting the mainland, said in his speech that atomic energy development is unlimited, and the interchange between the nuclear energy people from both sides of the strait is essential. He expressed his hope that this symposium will be followed up by more meetings and exchanges between the two sides.

It is understood that nuclear energy experts of the two sides have met five times, but this is the first formal exchange.

China, Iraq Sign Contract for Construction of Two 300MW Nuclear Power Plants

9360060C Lanzhou GANSU RIBAO in Chinese 23 Feb 93 p 3

[Article by reporter Ge Xiangwen [5514 4161 2429]]

[Text] Teheran, 21 Feb (XINHUA)—In Teheran, on 21 February, Iran and China signed a contract to cooperate in the construction of a nuclear power plant. The contract was signed by Iranian Deputy President and Chairman of the Atomic Energy Organization, Reza Amrollahi, and China National Nuclear Industry Corporation President, Jiang Xinxiong. The Iranian Vice Minister of Foreign Affairs, Bulujiedi [1580 7626 0267 6611], and Chinese Ambassador, Hua Liming, attended the signing ceremony.

According to the contract, China will build two 300MW nuclear power plants in Khuzistan Province in southern Iran. This is the largest nuclear power plant construction to be undertaken by China outside of the country.

China and Iran have both signed the Nuclear Non-proliferation Treaty. Leaders of both countries emphasize the cooperative construction of the nuclear power plant is for the peaceful use of nuclear energy, and is solely for peaceful purposes. The nuclear power plant will be safeguarded and supervised by the International Atomic Energy Organization.

Stress Laid on Equal Development of Hydro, Thermal, and Nuclear Power

OW2503155193 Beijing XINHUA in English 1531 GMT 25 Mar 93

[Text] Beijing, March 25 (XINHUA)—A number of nuclear power projects planned or under construction in China give evidence that the country is trying to ease a worsening energy shortage by developing its nuclear industry.

The country has already made remarkable achievements in developing the nuclear industry while readjusting its energy development strategy.

The Qinshan nuclear power plant, the first to be designed and built solely by China, started operations in December 1991 with one 300,000-KW generator.

In November 1992, the state officially ratified a feasibility study on the second-phase project on the Qinshan nuclear power plant, which has two 600,000-KW generators. The initial design has been passed an expert appraisal, and civil engineering on the project will start in May this year.

Construction on the Daya Bay nuclear power plant in Guangdong, south China, has been running smoothly. At the end of last year, the No. 1 reactor succeeded in a cold-function experiment. Sources said the two 900,000-KW generating units are expected to go into operation between the end of this year and the middle of next year.

China has also approved the construction of the Guangdong nuclear power plant and the Liaoning nuclear power plant, on which feasibility studies and talks with foreign partners are underway. The two 1-million-KW units at the second Guangdong nuclear power plant after the Daya Bay have been listed in the state's Eighth 5-Year Plan, and efforts are being made to select suppliers of major equipment and site for the project.

The site of the Liaoning nuclear power plant has been determined, but officials have not disclosed it. In December 1992 the Chinese and Russian Governments signed an agreement on nuclear power cooperation in Liaoning.

In addition, China is now developing a small power reactor with a generating capacity of less than 50,000 KW. The reactor can be used for both military and civil purposes and can supply both heat and electricity, with the advantages of having high security, a short construction term and low cost. This new prototype reactor will be used in coastal areas, remote sections of the country and in economic development zones.

Energy, transportation and raw materials have long been deemed the three major bottlenecks restricting China's economic development. In recent years, with fast-paced and steady economic development, problems caused by these bottlenecks have become increasingly prominent.

In 1992, China turned out 742 billion kWh of electricity, up 64.5 billion kWh over the previous year. Yet many areas of the country, including some larger cities, still suffer from shortages of electricity.

A senior Chinese official in charge of the energy industry said that "to catch up with the electricity-consuming level of middle-level developed countries in the next 20 to 30 years, China has to have a generating capacity of 1.3 to 1.4 billion KW, of which hydropower can at most supply 300 million KW."

"It's impossible to supply the rest by relying solely on thermal power, which would burn two to three billion tons of coal annually," the official said.

"The only way out is to construct a large number of nuclear power plants and develop other new energy sources."

The most significant opportunity for the development of nuclear power in China is the common view formed in recent years on the importance of nuclear energy.

Zou Jiahua, vice-premier and director of the State Council's leading group on nuclear power, said recently that the economically-developed east and south coastal areas are short in coal and water resources, and that they should quicken the pace of development of nuclear energy.

As a result, the traditional policy of "paying major attention to the development of hydro and thermal power, with nuclear power as a supplement" should be readjusted to "paying equal attention to the development of hydro, thermal and nuclear power, while implementing measures suited to local conditions."

Chinese nuclear experts hold that, as a new energy source, nuclear power not only can help solve the shortage of energy in the east and south coastal areas, but also can help alleviate transportation problems and cut down air pollution.

Officials have revealed that Fujian, Jiangxi, Jiangsu, Shandong, Anhui, Hunan, and Shanghai, as well as other provinces and cities, have applied to the central government for permission to construct nuclear power plants.

Shanxi Leads Nation in Electric Power Construction

9360060A Taiyuan SHANXI RIBAO in Chinese 22 Feb 93 p 1

[Article by reporter Cui Jizhe [1508 3444 0772]]

[Text] Taiyuan, 21 Feb (XINHUA)—Shanxi is making full use of its superior coal resources by putting more effort into building large-scale mine-site power plants, as annual electric power construction reaches a new level. Last year, newly operating installed capacity was 1,450MW, setting a new record high. Shanxi now has four large-scale power plants with 1,000MW or more installed capacity, more than any other province in the country. As an energy base for the whole country, Shanxi has been emphasizing converting coal on location and developing a second energy resource. In 1978, the installed capacity of the whole province was only 1,950MW; last year, it reached 8,020MW, and electric power output rose from 10.3 billion kWh to 38.3 billion kWh. After the two-way 500 kV extra-high voltage transmission loop between Datong and Beijing went into use, Shanxi has routinely transmitted over 1,000MW per year to Beijing and the Beijing-Tianjin-Tangshan grid. Since 1988, Shanxi has been the largest exporter of electric power. Last year, Shanxi again set a new record by putting two 500MW units into operations in a single year, as the Shentou No 2 power plant, one year ahead of schedule, set a record for 1,000MW installed capacity in large-scale pit-mouth power plants. The Shanxi Province electric power industry is now in the large power plant, large unit, large grid, high-voltage, high-parameter, high-automation class.

Shanxi will make electric power construction the fountainhead for lifting the provincial economy to new levels, by converting to a second power resource, keying on new construction and expansion of pit-mouth power plants with large capacity units, and building good-quality full-scale power grids. This year, Shanxi will have new electric power engineering projects amounting to over 3,500MW of installed capacity.

Shaanxi Steps Up Pace of Power Construction

9360059B Xian SHAANXI RIBAO in Chinese 10 Feb 93 p 1

[Article by reporters Yuan Linsheng [5913 2651 3932] and He Tao [6320 7290]]

[Text] It was learned at the Shaanxi Province Electric Power Working Conference convened on 9 February that Shaanxi has stepped up the pace of electric power construction to stimulate development of the electric power industry throughout the province. Last year, the volume of power generated by the Shaanxi network reached 17.805 billion kWh, a 14 percent increase over the previous year, which made an outstanding contribution to Shaanxi's economic construction.

Last year, Shaanxi electric power construction grew rapidly; after the key national construction project—the Wei He power plant second-phase expansion with two 300MW units—went into operation, the final two 200MW units of the Ankang hydropower station, and a line of locally built small thermal-power units, all became operational in succession, lifting the total newly installed operating capacity for a single year over the 1,000MW mark, up to 1,080MW, which amounts to 30 percent of the total installed capacity constructed in the province since reconstruction, and equals the combined installed capacity total for the Seventh and Eighth 5-Year Plans.

At the conference, Vice Governor Liu Chunmao extolled the contribution made by the Northwest Electric Administrative Bureau and all of the workers of the province to the economic development of Shaanxi, exhorted them to continue the rapid pace of electric power construction, and urged the electric power enterprises to take part in the socialist market economy.

The Provincial Government made special invitations to the Chief Consultant, Zhang Bin, and authorities of pertinent departments to attend the conference.

Shanxi's New Policy: Laying Equal Stress on Exporting Coal and Electricity

9360054A Beijing RENMIN RIBAO in Chinese 14 Feb 93 p 1

[Article by reporter Wang Aisheng [3768 5337 3932]]

[Text] Taiyuan, 13 Feb—Hu Fuguo, who has just taken over as governor of Shanxi, has stated, "Shanxi must make a great effort to market electric power and expand the transmission of electricity outside of the province along with the export of coal, and turn Shanxi into an electric power commodity base for all of China."

Every year Shanxi produces over 290 million tons of coal, but because of limited transportation it can only ship out 194 million tons per year. The coal so urgently needed by the southern provinces (and cities) is managed by "letting transportation determine production" or "let sales determine production."

The Shanxi Provincial Committee and Provincial Government, after repeated investigations and scientific findings, has set a policy of laying equal stress on exporting coal and electricity. To make full use of Shanxi's excellent coal resources, the first-phase installed capacities at the two large-scale power plants in Yangcheng County in southwest Shanxi, a total of 4,000MW, will send electricity to Guangdong and Jiangsu; the Hequ power plant and second-phase of the Shentou No 2 power plant being built on the eastern shore of the Huang He and elsewhere for total capacity of 1,200MW, will send power to Beijing, Tianjin, and Tangshan; a 600MW unit being built at the Yangchuan No 2 power plant will export electricity to southern Hebei. When all of this construction is completed, Shanxi's total installed capacity will be over 10,000MW, and will be the major electric power province in China.

Shanxi's policy of laying equal stress on exporting coal and electricity has received the approval and support of central authorities and the welcome and cooperation of the receiving provinces. It has also been passed by the Shanxi Provincial 8th People's Congress Standing Committee, and this huge project is now well underway.

Regional Statistics Reported

Anhui Province

9360050A Hefei ANHUI RIBAO in Chinese 23 Dec 92 p 1

[Article by Zhang Dahe [1728 1129 0735]]

[Text] In recent years the Anhui electric power system has greatly advanced reforms and made further changes in the enterprise management system, lifting electric power production and capital construction to the highest level in history as the annual output of electricity broke the 23.6 billion kWh mark, completing and exceeding the national electric power production plan.

Faced with the accelerated development of Anhui's economy, the Anhui Electric Power Department applied economic leverage by setting up a reward system for high production, and induced power plants to produce more electricity. Moreover, monthly inspections and seasonal commitments motivated the various power plants to produce more electricity. The Huaibei power plant completed its mission to produce 4.6 billion kWh for the year one month ahead of schedule. The Pingyu power plant completed its annual mission 40 days ahead, and produced an extra 500 million kWh.

Under the daily increasing pressures of supply and demand for electricity, the electric power capital construction enterprises pushed forward various contract responsibility systems, focused in on safety and guaranteeing quality, and, driven to step up the pace of new unit construction, following the debut of the Maanshan power plant's 2nd 125MW unit, the Pingyu power plant's 2nd 600MW unit was put into operation on 24 December, which brought the installed capacity at Pingyu up to 1,200MW. In late December construction of the first 125MW unit for the Wuhu power plant expansion project, and the 200MW unit for the fourth-phase expansion of the Huaibei power plant were completed and, in succession, joined the grid.

Power transmission and transformer construction projects, concomitant with the power plant projects, were completed on schedule and went into operations precisely as planned. The Anhui segment of the 500kV Fanchang-to-Toushan, Jiangsu extra-high voltage transmission line was completed and the whole line was put into service. The 220kV Tongling-to-Guichi transmission and transformer project went into operation in November. The 220kV transformer station in the Huainan eastern suburbs came on line at year's end, and power from the newly installed units can now be transmitted safely and promptly out to points north and south of the Da Jiang.

Guangdong Province

9360050B Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 2 Feb 92 p 2

[Article by Wang Gaixian [3768 2395 3807]]

[Text] Most recently Guangdong Province set up a Guangdong electric power development program: By 2010 the installed capacity of the province will reach 80,000MW, about 8 times what it was at the end of last year; and annual production will be 460 billion kWh, or about 10 times that of last year.

In recent years electric power development has been quite rapid in Guangdong. The total installed capacity grew from 4,600MW in 1987 to 10,600MW by the end of 1992, moving from 7th place to 2nd place in the whole country. But the imbalance of supply and demand for electricity is still very serious in Guangdong, restricting the overall economic development of the province. In order to guarantee sustained and steady economic growth, Guangdong Province has decided to support concurrent growth in nuclear power, thermal power, and hydropower; and to raise funds and operate in accordance with the laws of market economy, there will be a greater latitude in raising social investments, and better use of stocks and bonds; the form of electric power management will be multi-channel and multi-level, not only through foreign commercial joint ventures, but also through joint ventures with fraternal provinces; and, in managing electric power, "He who invests and manages will reap the profits", will be the guiding principle.

Guangdong proposes to ease the tense power crunch situation after 3 years, and by 2000, energy development will be abreast of economic development needs; and by 2010 the installed power capacity will be 80,000MW.

Guangdong now has an array of key electric power projects on a scale of construction in excess of 7,000MW. Of these, the first 900MW unit at the Daya Bay nuclear power plant, which will have an installed capacity of 1,800MW, will join the grid within the year. The Guangdong pumped-storage power station, under construction for several years, is expected to have two 300MW units operating this year, and a strong effort is being made to put the 3rd unit into operation as well. One or two 300MW units of the Zhujiang power plant will also come on line, and the Maanshan and Shajiao-A power plants will each have one 300MW unit operating. If the other medium- and small-sized units are factored in, Guangdong will have a minimum of 3,000MW of medium-sized units and 2,000MW of small-sized units joining the grid this year.

Ningxia Autonomous Region

9360050C Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 3 Feb 92 p 1

[Article by special correspondent Yang Zhaohai [2799 0340 3189]]

[Text] Yinchuan, 2 Feb—Ningxia, one of the four major energy bases designated as key projects in the Eighth 5-Year Plan, has, in the past year, adopted the policy of concurrently raising national and local funds for production and construction to accelerate the pace of development of the electric power industry, and raise the output and supply of electricity, new construction projects, and agricultural electrification to a new level.

The volume of proven coal reserves in Ningxia is fifth in the nation, and the Huang He flows through the Yinchuan plain. Ningxia is thereupon richly endowed for major development in thermal- and hydroelectric power.

Last year, the Ningxia Regional Party Committee and Government seizing upon electric power as the driving force for economic development in the Region, raised 64.46 million yuan in national investments and 150 million yuan through many channels of local funding, a total of 217 million yuan, to be used for the development of the electric power industry, and they completed and put into operations the first-phase construction of the Daba power plant with 600MW of installed capacity, and the No 10 50MW unit at the Shizuishan power plant. The new units raise the total installed capacity of the Region to 1,602MW, and power output in 1992 broke the 7 billion kWh mark, reaching to over 7.5 billion kWh, an increase of 20.93 percent over 1991. The per capita consumption of electric power is 1,450 kWh, more than double the national average.

To guarantee electric power for industrial and agricultural production and the people's livelihood at the same time, Ningxia supplied 1 billion kWh of electric power to the northwest network, setting a new historic level.

Shandong Province

9360050D Shanghai JIEFANG RIBAO in Chinese 4 Feb 92 p 5

[Text] Jinan, 3 Feb (XINHUA)—Through one project after another, Shandong raised the funds, and got the facilities, coal, and water resources to accelerate electric power construction. Now, the 8,700MW of power construction called for in the Eighth 5-Year Plan is practically accomplished. In 1992, Shandong electric power output reached 56.5 billion kWh,, putting Shandong in first place in the country. It is planned that in the next 8 years Shandong will build 10,000MW of new installed capacity, more than the total installed capacity of the previous 43 years. In order to solve the problems of fuel, water resources and funds, the provincial authorities and the electric power departments studied and set measures to raise funds for electricity, encourage foreign investments, and allow electric power to move into the market.

Rural Hydropower Development Update

40100066 Beijing CHINA DAILY (National) in English 17 Mar 93 p 3

[Article by staff reporter Liang Chao]

[Text] China is pouring 11 billion yuan (about $1.93 billion) into an ambitious rural electrification project involving 200 counties.

It is part of the bid to lay a solid foundation for their economic development.

This will be achieved by developing more hydroelectric power projects in the selected counties—mostly in South China, with a few in the north—with rich hydropower resources. By 1995, "millions of farmers will have bade farewell to their oil lamps," officials with the Ministry of Water Resources said.

To meet demand the generators must have a capacity of 5.41 million kilowatts and be operational within 3 years, they added.

Under the power-supply program, electricity will be supplied to more than 90 percent of households in these counties. The annual electricity consumption of each household is expected to be more than 200 kwh—the national average in rural areas.

Industry and agriculture in these areas will be assured of electricity for at least 330 days a year.

But officials say more than 60 percent of the power supply will come from hydropower stations built with funding from local governments or raised directly by rural residents.

Just one billion yuan ($174 million) in loans has been granted by the central government—with low interest as a subsidy—for the rural electrical supply program.

Since 1991 the plan has run smoothly in the selected counties, which spread in 24 provinces throughout China. Of these, 151 counties, or 75 percent of the total, were on the government list of underdeveloped areas.

In 1992 alone a total of 337,700 kwh was generated by new hydropower stations, meaning the accumulative installed capacity reached 3.82 million kwh, or more than 70 percent of the program's planned total.

As a result, 1.9 million rural families in about 3,450 remote mountain villages have electricity while more than 3 million rural folk now can watch TV and more than 1.6 million rural families cook with electricity during the flood season.

This, experts say, saves an estimated 4 million cubic meters of firewood, helping to improve the local ecological environment, because forest reserves are being protected and water erosion-control kept under control.

Work Completed on First Phase of Tianhu Hydropower Station

936B0037B Beijing RENMIN RIBAO in Chinese 30 Nov 92 p 1

[Article by reporter Jiang Xia [3068 1115]: "First Phase of Tianhu Hydropower Station Project Completed and Generating Electricity, Head Is Greater Than 1,000 Meters, the Highest in Asia at the Present Time"]

[Text] A middle-sized hydropower station with the highest head in Asia at the present time, the first phase of the Guilin Tianhu Hydropower Station project, was formally placed into operation recently.

Tianhu Hydropower Station is located at the boundary of Quanzhou and Ziyuan Counties in the northern part of Guilin in Guangxi Zhuang Autonomous Region. The power station has a concentrated head of 1,074 meters, a total installed generating capacity of 60MW, and will generate 185 million kWh of electricity a year, 75 percent of which is dry season power. Each cubic meter of water can generate 2.37 kWh and its hydraulic energy utilization rate is the highest in China at the present time. Moreover, it can make good use of the water that is impounded in a cluster of reservoirs at the tops of the high mountains to regulate the conflict between wet and dry seasons, and will greatly improve the quality of power supplies in the Guibei [northern Guilin] Grid.

Tianhu Hydropower Station is China's first hydropower station with a head greater than 1,000 meters. The relevant areas overcame a series of technical difficulties in the program design, equipment manufacturing, and construction areas and built and manufactured extra-high head, super-standard, and extra- strong unlined vertical shafts, inclined shafts, and steel piping for the first time. It uses integral water turbine generators and monitoring and control systems that were for the first time designed, manufactured, and installed by China itself and that have a unit capacity of 15MW and a head of 1,220 meters. The completion and power generation at Tianhu Hydropower Station is an indication that the construction of high head hydropower stations in China has entered a new development stage.

Pubugou Update

9360058C Chengdu SICHUAN RIBAO in Chinese 25 Feb 93 p 1

[Article by Liang Jian [2733 1696] and Wang Yucai [3769 3768 1407]]

[Text] Minister Huang Yicheng of the Ministry of Energy Resources, accompanied by Vice Governor Ma Linfu, went to the Dadu He on 17 February to investigate the dam site of the Pubugou hydropower station and hear the station survey and design report. Minister Huang said that only the early stage work is yet to be done, before getting on with the project.

The Pubugou hydropower station, designed for an installed capacity of up to 3,300MW, is located on the mainstream of the Dadu He within the boundaries of Hanyuan and Ganluo counties. Once built, it will provide a regulating reservoir on the middle reaches of the Dadu He, with a regulating capacity of 3.88 billion cubic meters, capable of controlling 78 percent of the runoff and 88 percent of the stream load. Its construction will also improve the operating situation of the Gongzui and Tongjiezi hydropower stations downstream, and can reduce silt buildup and extend station operating life. The Chengdu Survey and Design Academy completed the feasibility study report on the station in 1987, and it has passed state inspection. This year, the preliminary design report will be completed, and preparations are being made for the early stage work to begin in the Eighth 5-Year Plan.

At the dam site, Huang Yicheng said that hydropower construction is mainly a question of investment, and giving investors confidence that building the hydropower station will be profitable will encourage domestic and international funds. He hopes that a shortened construction period will be the stimulus for bringing in investments.

Work To Begin on Daba Second Phase in 1993

936B0037E Yinchuan NINGXIA RIBAO in Chinese 24 Nov 92 p 1

[Article by Xiao Tan [5135 6151]: "State Planning Commission Issues Official Reply, Agrees to Start of Construction of Second Phase Project at Daba Power Plant in 1993"]

[Text] Based on the increased loads in China's electric power system and the need to develop Lingwu coal field, the State Planning Commission issued an official reply to the feasibility research report for the second-phase expansion project at Daba Power Plant and agreed to the second-phase expansion of Daba Power Plant. The construction scale will be 600MW and will involve installation of two 300MW steam turbine generators.

The expansion project also includes the 260 kilometer-long 330 kV line from Daba Power Plant to Guyuan for a 330 kV voltage connection into the Northwest China Primary Power Grid and the Guyuan transformer station where two 150,000 kVA transformers will be installed.

The second-phase expansion project at Daba Power Plant will involve a total investment of about 1.17 billion yuan, with the State Energy Resource Investment Company and Ningxia Hui Autonomous Region each being responsible for 50 percent. Work on the expansion project will begin in 1993 and the plan is for the two generators to go into operation in 1995 and 1996, respectively. After the expansion project is placed into operation it will require about 1.8 million tons of coal each year that will be supplied by the Lingwu Mining Region.

State Approves 4th Stage of Yaomeng Power Plant

9360060B Zhengzhou HENAN RIBAO in Chinese 24 Feb 93 p 1

[Article by Liu Lin [0491 3829]]

[Text]The State Planning Commission has just approved the 4th-stage construction of two 300MW coal-fired units for the Yaomeng power plant.

The investment for this joint-venture will be 1.39 billion yuan, 50 percent of which will be provided by the National Energy Investment Corporation, and 50 percent by Henan Province.

The Yaomeng power plant, the largest thermal power plant in central China, has an installed capacity of 1,200MW, and when this stage of construction is finished it will be up to 1,800MW, which will be an important asset for Henan's economic development.

Shanghai Waigaoqiao Update

936B0037A Shanghai JIEFANG RIBAO in Chinese 26 Nov 92 p 1

[Article: "Foundation Laid for Construction of Shanghai's Waigaoqiao Power Plant, One of 10 Basic Projects To Develop Pudong, Investment of 3 Billion Yuan in First Phase Project, No 1 Generator To Be Connected to Grid and Generate Power in 1994"]

[Text] The foundation was laid on 25 November 1992 for Shanghai Waigaoqiao Power Plant, a key state project for the Eighth 5-Year Plan and the thermal power plant with the largest planned installed generating capacity in China at the present time. Shanghai Waigaoqiao Power Plant is one of 10 basic projects for the development of Pudong. Construction has been progressing smoothly since the pilings were driven for the main plant building project at the power plant on 27 December 1991. The pile driving tasks for the 2,200 steel pipe pilings and 3,200 concrete pilings for the main plant building were completed in June 1992 and the outer tube of the smokestack to be jointly used by the four generators has been poured up to 210 meters (the smokestack will be 240 meters tall) and the driving of the pilings for the 10,000-ton grade pier approach bridge has basically been completed, which has provided the conditions for a formal start of construction.

The Waigaoqiao Power Plant now under construction has a planned installed generating capacity of 3,600MW. The first phase of the project will involve installation of four 300MW Chinese-made imported type coal-fired generators. The construction schedule for the No 1 generator is 27 months and it will be connected to the grid and generate electricity by the end of 1994. All four of the 300MW generators will be completed and placed into operation by the end of 1996. The investment in the first phase of the power plant project is about 3 billion yuan and it is the largest construction project in terms of investment in Pudong New Zone at the present time. This project is being built via a joint investment by the State Energy Resource Investment Company, the Shanghai Municipality Shenneng Electric Power Development Company, and the Shanghai Municipality Electric Power Industry Bureau. The Huadong [East China] Electric Power Design Academy was responsible for the overall design and the Shanghai Electric Power Construction Bureau is responsible for construction of the main parts of the project.

Ministry of Energy Resources vice minister Shi Dazhen [0670 1129 2923], Shanghai Municipality vice mayor Gu Chuanxun [7357 0278 6064], and others attended the foundation laying ceremony and broke ground for the bedrock fill.

Jingyuan Second Stage Construction To Begin: Two 300MW Units To Be Added

9360059C Lanzhou GANSU RIBAO in Chinese 7 Feb 93 p 1

[Article by Zhou Haiwen [0719 3189 2429]]

[Text] For yet another key energy construction project which will be closely watched by the people of Gansu, the State Planning Commission has just agreed by formal document to expand the Jingyuan power plant by adding on to the first-stage 800MW installed capacity, two additional 300MW units of Chinese manufacture in a second-stage project, which when completed can raise the installed generating capacity of this large-scale project to 1,400MW.

Over 1.2 billion yuan will be invested in the Jingyuan second-stage construction, which will be a national-local joint venture project. The Provincial Electric Power Bureau called on the construction and installation units to set a target of "Fight for two, and assure one" (Strive to get two done, and guarantee that one will be generating power) in 1995.

It is planned that 200 million yuan will be invested in 1993 to set up for construction and installation. The Jingyuan power plant second-stage construction site is now going well all around, facilities and goods have been ordered, the engineering and installation designs are ready, and the goal is to break ground and start work in the 2nd quarter.

Nation's Largest Coal Collective Organized

936B0037C Beijing RENMIN RIBAO in Chinese 11 Dec 92 p 1

[Article by reporter Li Anda [2621 1344 6671]: "China's Largest Coal Group Established"]

[Text] A meeting to commemorate the establishment of the Northeast China Inner Mongolia Coal Group and the 10th anniversary of the founding of the Northeast China Inner Mongolia Coal Company was held in Changchun on 10 December 1992. Premier Li Peng inscribed the name for the group. The Northeast China Coal Group is the largest coal enterprise group established in China to date, and its establishment is an indication that northeast China's coal industry has entered a new development stage.

The Northeast China Coal Group was developed out of the Northeast China Coal Company. After 10 years of arduous effort, the Northeast China Coal Company has formed a large-scale integrated enterprise group that is focused on coal production, management, and construction and includes geological exploration, coal machinery manufacturing, scientific research, design, education, economic diversification, tertiary industry, and other aspects. The Northeast China Coal Group now has 85 member units. Besides the core enterprises, it has 39 tightly stratified enterprises, 1.6 million employees under the publicly-owned and collective ownership systems, and a gross value of 26.5 billion yuan in fixed assets. Its coal output increased from 86.13 million tons in 1982 to 138.11 million tons in 1991, equal to one-fourth of total output from China's unified distribution coal mines and an average yearly growth rate of 5.78 million tons. They have submitted a total of 136 geological reports of all types, found 19.32 billion tons of new proven reserves, placed 80 mines into operation, added 54 million tons in new capacity, and increased the number of mining bureaus with a yearly capacity greater than 10 million tons from four to seven.

Feasibility Study Approved for Two Big Yunnan Mines

936B0037D Kunming YUNNAN RIBAO in Chinese 20 Nov 92 p 2

[Article by Yu Tian [7183 3944] and Wei Yanchang [7614 1693 2490]: "Feasibility Reports for Two Big Coal Mine Construction Projects in Yunnan Pass Examination"]

[Text] The Chongqing Coal Design and Research Academy and Yunnan Province Coal Mine Design and Research Academy have now produced a research report on feasibility research for preparatory work for construction of Xianfeng Open-Cut Coal Mine and Bailongshan Mine in the Laochang Mining Region of Yunnan Province. This report recently passed examination by the Ministry of Energy Resources.

Xianfeng Open-Cut Coal Mine is located in Xundian County and has 222 million tons of superior-quality brown coal. Its construction scale is a yearly output of 3 million tons and it will be coordinated with the expansion project at Yangzonghai Thermal Power Plant. Laochang Mining Region is located in Fuyuan County just 4.5 kilometers from the Nan-Kun [Lunan?-Kunming] Railroad. Laochang Mining Region is one of the few huge anthracite coal mining regions in south China and now has 3.88 billion tons in proven reserves with as much as 5.45 billion tons in long-term prospective reserves.

The experts at the meeting gave a high assessment to the development of these two coal mines and unanimously passed the inspection of these two, and they proposed that the state immediately establish these two projects for construction.

Breakthrough in Xinjiang Crude Production

9360058B Urumqi XINJIANG RIBAO in Chinese 28 Jan 93 p 1

[Article by correspondent Zhang Tianmei [1728 3944 2734]]

[Text] The Xinjiang Petroleum Bureau has completed this year's crude oil production mission 5 days ahead of schedule, and has made a new breakthrough in prospecting.

In early 1992, the China Petroleum and Natural Gas Corporation gave the Xinjiang Petroleum Bureau a contract production goal of 7.22 million tons of crude oil. The Bureau let contracts with 46 of its 2nd-class units, specifying 19 articles of details and regulations and 30 articles of economic policy. The units took on contracts for target volumes and cost accounting with a variety of contracting particulars including wage structures, production overage incentives, and cost-saving awards, and shortfall penalties. In the first quarter the administrative bureau continued to stress getting new well into production at Hongshanzui and Xiazijie, putting crude oil output out front with production results not seen in over 10 years, as the volume of water-oil at the oil fields, which in late 1991 was 60 percent, held steady at 59.9 percent, and dropped in proportion to the total volume of oil from 5.22 percent to 4.9 percent.

Besides keeping the crude oil production figures pointing upward, the Bureau also exceeded quotas in completing their oil and gas prospecting plan, promptly validating Cainan oil field, and new major finds in the central and northwest rim, making this the most successful prospecting year in recent time.

TRPO Extraction Process for Recovery of Actinides From Highly Radioactive Waste

936B0049A Beijing QINGHUA DAXUE XUEBAO [JOURNAL OF TSINGHUA UNIVERSITY] in Chinese Vol 32, No 6, Dec 92 pp 1-12

[Article by Zhu Yongrui [2612 3057 6296/4213] of the Nuclear Energy Technology Design and Research Academy: "An Effective Method for Using Trialkylphosphine Oxide To Extract Actinides from Highly Radioactive Liquid Waste"; manuscript received 7 May 1992]

[Excerpts] Abstract: This article introduces the composition, properties, and radiation stability of China's unique trialkylphosphine oxide (TRPO) extractant and the process chemistry for extracting actinides from highly-radioactive liquid waste. It describes the results of TRPO flow process parameter design and verification, which indicate that the TRPO flow process has excellent functions. [passage omitted]

0. Preface

In addition to the fission materials that are produced in the uranium fission process inside a reactor, several transuranic elements up to element number 96, curium, are also produced from multiple neutron captures. Depleted uranium fuel reprocessing plants recover and reuse over 99 percent of the uranium and plutonium. The remaining uranium and plutonium, a large portion of the neptunium, and nearly all of the americium, curium, and fission products enter the highly-radioactive liquid waste. The main transuranic elements in the high-level liquid waste are neptunium, plutonium, and americium, and they determine its long-term radioactive toxicity. The potential hazard from solidified blocks of this high-level liquid waste persists for more than 10^7 years[1]. To improve the safety of the fuel cycle, the concept of Partitioning and Transmutation (P-T) was proposed in the late 1960's. It involves partitioning out the neptunium, plutonium, and americium in the high-level liquid waste and transporting it to a transmutation device (nuclear reactor, accelerator, etc.) where it is converted into short-lived fission products. This would permit the high-level liquid waste to attain the original toxicity levels of natural uranium ore after storage for 700 to 800 years (consideration must also be given to partitioning and transmutation of long-lived fission products such as ^{99}Tc, ^{129}I, etc.). In a suitable device, transmutation of transuranic elements could also provide additional energy. Moreover, non-α conversion of current stocks of high-level liquid waste has been placed on the agenda of all countries. As a result, scientists in all countries have been very concerned about research on removing transuranic elements from high-level liquid waste for the past several years. [passage omitted]

Researchers in the Nuclear Energy Technology Design and Research Academy started with China's realities in developing the trialkylphosphine oxide flow process for extracting transuranic elements from high-level liquid waste[3]. The TRPO extractant used in this process is a compound of different trialkylphosphine oxides that are produced in batch quantities in China and are inexpensive in price. It is intersoluble with paraffin and when using it kerosene can be used as a diluent, and it has excellent properties when used as an industrial extractant. It has a relatively high extraction capability for americium and can effectively extract americium from about 1 mol/L of nitric acid solution. Its extraction capabilities for valence 6 and valence 4 transuranic elements are even higher. It has a high extraction capacity. The TRPO process can be used to remove transuranic elements from high-level liquid waste from nuclear power reactor depleted element reprocessing plants in the future and can also be used in the short term for non-α conversion chemical pretreatment of other high-level liquid wastes (such as processing high-level liquid waste from production reactor elements). [passage omitted]

II. TRPO Extraction Process Chemistry

A. Extraction reaction, distribution ratio, equilibrium constants

TRPO is an alkylphosphine oxide compound. It has been confirmed[4,5] that it extracts different state actinide ions (M^{3+}, M^{4+}, MO_2^+, and MO_2^{2+}) from nitric acid solution in the following reaction.

$$M^{3+}_{(a)} + 3NO^-_{3(a)} + 3TRPO_{(o)} \rightleftharpoons M(NO_3)_3 \cdot 3TRPO_{(o)}$$

$$M^{4+}_{(a)} + 4NO^-_{3(a)} + 2TRPO_{(o)} \rightleftharpoons M(NO_3)_4 \cdot 2TRPO_{(o)}$$

$$MO^+_{2(a)} + NO^-_{3(a)} + TRPO_{(o)} \rightleftharpoons MO_2NO_3 \cdot TRPO_{(o)}$$

$$MO^{2+}_{2(a)} + 2NO^-_{3(a)} + 2TRPO_{(o)} \rightleftharpoons MO_2(NO_3)_2 \cdot 2TRPO_{(o)}$$

For extraction from nitric acid, when the nitric acid concentration is relatively low, it is:

$$H^+_{(a)} + NO^-_{3(a)} + TRPO_{(o)} \rightleftharpoons HNO_3 \cdot TRPO_{(o)}$$

When the nitric acid concentration is relatively high, it is generated by $2HNO_2$.TRPO.

The apparent equilibrium constant K for each extraction reaction is:

$$K = \frac{[C^{n+}(NO_3^-)_n \cdot qTRPO]_{(o)}}{[C^{n+}]_{(a)} \cdot [NO_3^-]^n_{(a)}[TRPO]^q_{(o)}} = \frac{D_c}{[NO_3^-]^n_{(a)}[TRPO]^q_{(o)}}$$

In the formulas, [ ] is the organic phase (o) and aqueous phase (a) of the extracted components, C is the cations, n is the cation charge number, q is the solvation number, and D_c is the distribution ratio (the ratio between the organic phase concentration and aqueous phase concentration). Table 2 lists the apparent equilibrium constants for some of the extraction reactions[4,5,7].

Table 2. Apparent Equilibrium Constants of TRPO Extracted from Nitric Acid Solution

Cation	C_{H+}/molL^{-1} concentration	Solvation number q	K
H^+	0.50	1	9.02
Pm^{3+}	0.28	3	2.3×10^3
Eu^{8+}	0.20 (+6 mol/L $NaNO_3$)	3	1.5×10^5
Am^{3+}	0.30	3	1.1×10^3
Cm^{3+}	0.30	3	6.6×10^4
UO_2^{2+}	0.16	2	2.1×10^6
Np^{4+}	0.90	2	1×10^5
NpO_2^{+}	0.40	1	14
NpO_2^{2+}	0.70	2	5.3×10^4
Pu^{4+}	0.21	2	1.4×10^5
PuO_2^{2+}	0.50	2	5.2×10^5

*TRPO concentration 0.01-0.1 mol/L, diluent No. 240 kerosene, temperature 25 +/- 1°C

TRPO has a very powerful extraction capability for valence 4 and valence 6 actinide ions and a very high distribution ratio for all types of nitric acid concentrations. Its extraction capability for valence 3 actinides and rare earth elements is also extremely high, but because of competition by the nitric acid, a peak in the valence three ion distribution along the curve of changes in the aqueous phase nitric acid concentration occurs at about 0.3 mol/L HNO_3 and the distribution ratio reaches several 10 (there is no large salt component in the aqueous phase, there are trace amounts of actinide and rare earth elements, and the organic phase is 30 percent TRPO-kerosene). Its extraction capability for valence 5 actinide ions is very low. The zirconium and technetium in the fission products also have a high distribution ratio. [passage omitted]

TRPO extraction removes over 99.9 percent of the uranium, plutonium, americium, and neptunium in the high-level liquid waste. In stripping, there is very little intersection of the americium, neptunium+plutonium, and uranium in the components. The behavior of the technetium is more complex and further research is needed. See references [15] and [16] for concentration distribution charts of the various actinides and technetium in each stage in the cascade experiments. The experimental values and computed values for the concentration distributions conform very well.

The behavior of the other components in the high-level liquid waste in the TRPO extraction process were analyzed. The strontium, cesium, barium, cadmium, rhodium, and so on were apparently not extracted. Nearly all of the rare earths, palladium, zirconium, and molybdenum were extracted, with the rare earths, a large part of the palladium, and about 40 percent of the molybdenum and americium being stripped together. Nearly all of the zirconium, about 55 percent of the molybdenum, and 3 percent of the palladium were stripped together with the neptunium and plutonium. About 6 percent of the molybdenum was stripped by 5 percent Na_2CO_3. Part of the iron, nickel, ruthenium, silver, and technetium are extracted by the TRPO, and post-extraction washing can reduce their extraction.

See Figure 5 for the principles flow process for recovering actinides from high- level liquid waste using TRPO extraction.

IV. TRPO Process for Use in Production Reactor Element Reprocessing With Chemical Pre-Treatment Prior to Solidification of High-Level Liquid Waste

Production reactors are nuclear reactors used to produce plutonium for military purposes. The transuranic elements in this category of reactors have shallow burnup and a much smaller transuranic element content compared to power reactors. However, analytical measurements show that high-level liquid waste from production reactors still contains substantially more of the transuranic elements plutonium, americium, and neptunium. The amount of α nuclides contained in the glass blocks after solidification will be about 100 times higher than the standard for non-α radioactive wastes (3.7 Bq/g), so as α wastes they must be stored for long periods in deep strata. This poses enormous technical difficulties and economic expenditures. The United States has now begun experimenting with using the TRUEX method for chemical pretreatment of its high-level liquid waste for non-α alpha conversion. China has also decided to focus during the Eighth 5-Year Plan on research of using the TRPO process in chemical pretreatment of high-level liquid waste and has proposed non-α conversion of over 99 percent of actinides and working toward the industrial experiment and application stage during the Ninth 5-Year Plan. Using non-α pretreatment could divide high-level liquid wastes from production reactors into a large non-α portion and a small α portion (a few percentage points), which is expected to conserve substantial expenditures. The experience gained in the treatment could be used for ultimate disposal and the P-T process for future high-level liquid waste from power reactors.

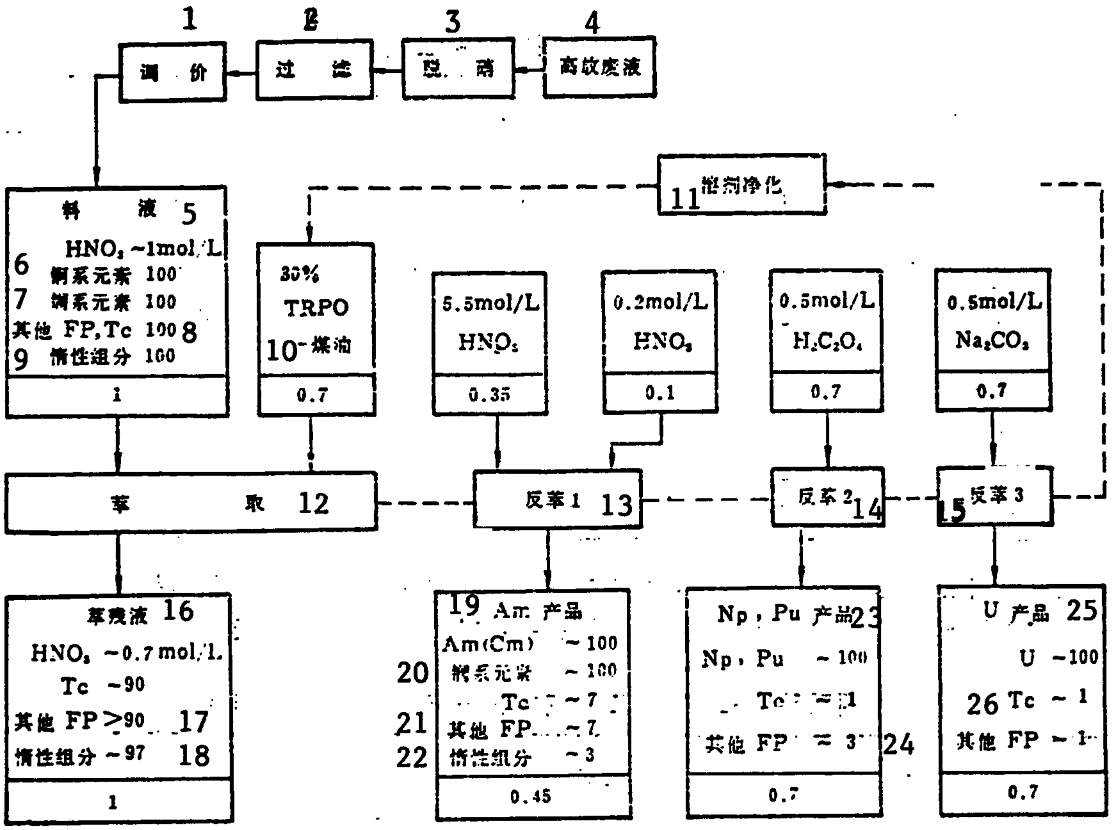

Figure 5. TRPO Extraction Principles Flow Chart

Key: 1. Valence adjustment; 2. Filtering; 3. Denitrification; 4. High-radioactive liquid waste; 5. Feed liquid; 6. Actinides 100; 7. Lanthanides 100; 8. Other FP, Tc 100; 9. Inert components 100; 10. 30% TRPO-kerosene; 11. Solvent purification; 12. Extraction; 13. Stripping 1; 14. Stripping 2; 15. Stripping 3; 16. Extracted raffinate; 17. Other FP >90; 18. Inert components 97; 19. Am products; 20. Lanthanides 100; 21. Other FP 7; 22. Inert components 3; 23. Np, Pu products; 24. Other FP 3; 25. U products; 26. Other FP 1

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Domestic HTGR Technical Features, Development Schedule

936B0049B Beijing QINGHUA DAXUE XUEBAO [JOURNAL OF TSINGHUA UNIVERSITY] in Chinese Vol 32, No 6, Dec 92 pp 18-28

[Article by Xu Yuanhui [1776 0337 6540] and Zhong Daxin [6988 1129 6580] of the Nuclear Energy Technology Design and Research Academy: "Technical Features and Development Trends of High-Temperature Gas-Cooled Reactors"; manuscript received 7 May 1992]

[Excerpt] Abstract: This article describes the development history, technical features, and present development trends of high-temperature gas-cooled reactors [HTGR] and proposes development paths and applications prospects for HTGR in China based on China's strategic economic development objectives, and concludes with a comprehensive introduction to the performance features of the 10MW high-temperature gas-cooled experimental reactor China has design and manufactured. [passage omitted]

IV. Applications Prospects and Development Paths for HTGR in China

Based the strategic economic objectives China has formulated, we will achieve a quadrupling of our GNP by the end of this century compared to 1980 and our per capita GNP will attain the levels of the moderately developed countries by the mid-21st Century. Computed in 1980 U.S. dollars, China's per capita GNP will reach $1,000 by the year 2000 and $4,000 or even more by 2050. According to projections, demand for energy resources will be 41 to 44 EJ in 2000 and 117 to 133 EJ in 2050. However, total supplies of conventional energy resources can only meet 80 percent of demand, so there will be a shortage of 20 percent. Secondly, it has been estimated that petroleum production in China will attain its peak between 2020 and 2030 at 200 to 300 million tons in the year of highest output and then will decline each year after that to about 100 million tons by 2050, whereas demand at that time will be at least 400 to 500 million tons, so shortages of liquid fuels will be one of the main problems at that time. To compensate for shortages of conventional energy resources, it is essential that China develop nuclear energy. In terms of the levels and degrees of HTGR development at the present time, the main roles of HTGR in China's nuclear energy development are:

1. Modular HTGR can be used as important compensators for power output from pressurized-water reactors [PWR]. China does have a vast territory but its population is relatively concentrated in residential terms. This is particularly true of the industrial centers which require electric power. Their population density is far greater than average world levels. Thus, the development of nuclear power will inevitably be subject to extreme restrictions by plant site selection. The characteristics of PWR place extremely strict requirements on plant sites. In contrast, because of the unique advantages of HTGR due to their inherent safety and the greater degree of freedom in selecting plant sites, they can be built in industrial regions or near densely-populated cities. Moreover, modular HTGR have a relatively small capacity per reactor and low initial investments, which is particularly well-suited to medium-sized and small power grids. Thus, there is an extremely great possibility that HTGR may become a part of PWR power generation.

2. The outlet temperature of the primary loop of HTGR is 700°C, so they can be used to supply industrial steam for hot extraction of dense oil and in the petrochemical and other industrial departments. The petrochemical industry is one of China's biggest energy consuming departments, with electricity accounting for about one-fourth and heat for about one-third of its consumption of energy resources. At present, it mainly uses petroleum and natural gas as well as a small amount of coal, which causes serious environmental pollution and the greenhouse effect as well as waste of our precious fossil raw materials and liquid fuels. The safety features of HTGR make them extremely suitable for establishment near petrochemical industry enterprises for integrated supply of heat and electricity to petrochemical and chemical industry enterprises. In another example, China began developing steam injection hot extraction technology for dense oil in the early 1980's and it has gradually developed in China. Dense oil output in the year 2010 will be an estimated about 20 million tons, which is another important realm for utilizing HTGR.

3. As mentioned previously, demand for liquid fuels in the year 2050 will be about 400 to 500 million tons, which will

depend primarily on the conversion of coal. Coal gasification and liquefaction requires high-temperature process heat at 750 to 950°C, and HTGR with an outlet temperature of 950°C are the only type of nuclear reactor that can satisfy this requirement. Using nuclear energy and coal conversion technology to produce synthetic liquid fuels would play a significant role in reducing China's liquid fuel shortages and effectively utilizing nuclear energy to conserve coal resources.

China's strategic deployments for developing HTGR can be divided into three phases:

1. 1990 to 2000

This mainly involves gaining an understanding of HTGR technology and making good technical preparations for construction of a demonstration reactor and high- temperature process heat applications and building an experimental HTGR with a thermal power of 10MW by the year 2000.

2. 2000 to 2030

Carry out commercial extension of modular HTGR. Use the high degree of inherent safety, flexibility in plant site selection, and good adaptability to loads of modular HTGR, open up the market for nuclear energy technical heat supplies, supply heat to the petrochemical industry, heavy oil extraction, and other industrial users and provide integrated heat and electricity supplies to frontier regions and densely-populated regions with site selection difficulties.

Also conduct intermediate testing and R&D work on high-temperature (950°C) process heat supplies during this phase, complete vanguard reactors for high- temperature process heat supplies by 2030, and complete technical preparations for using nuclear energy for high-temperature process heat supplies.

3. 2030 to 2050

High-temperature process heat supplies will begin to move into commercial applications for use in coal gasification and liquefaction. Foster the advantages of nuclear energy for the strategic objectives of solving China's liquid and gaseous fuel supply problems, reducing environmental pollution, and conserving coal resources.

V. Construction of a 10MW High-Temperature Gas-Cooled Experimental Reactor

To achieve the extension and application of HTGR in China during the early part of the next century, as one step in a truly feasible development strategy Qinghua University's Nuclear Energy Technology Design and Research Academy will complete an HTGR with a thermal power of 10MW prior to the year 2000.

The objectives in building the experimental reactor are: 1) Power generation and regional heat supplies; 2) Conducting fuel element and materials irradiation tests; 3) Gaining an understanding of design and manufacturing technology; 4) Confirming the inherent safety of modular HTGR; 5) Undertaking research on high-temperature process heat supply applications.

The primary parameters of the 10MW high-temperature gas-cooled experimental reactor are:

Thermal power, P_t/MW	10
Primary helium gas pressure, P_{He}MPa	3.0
Secondary system pressure, p/MPa	3.5
Electrical power, P_e/MW	2.5
Cold helium gas temperature, T_{He}/°C	250
Steam temperature, T/°C	435
Hot helium gas mean temperature, T_{He}/°C	700-950
Core volume, V/m^3	5
Primary core indicators:	
Average power density, d_p/MW	2
Core diameter, d/cm	180
Number of fuel elements	27
Average burnup B/MWd.t^{-1}	80,000
Number of fuel elements required each day	25
Height/diameter, h/d	1.09
Average core height, h/cm	196.5
Heavy metals content in elements, m/g	5
Time fuel elements are in core, t/d	1,078
Loading and unloading arrangement	Multiple passes

VI. Technical Lines and Characteristics

The HTGR that China will develop will adopt general international technical lines. Their technical features are a modular inherently safe design that uses U-Pu and tracks Th-U fuel cycle trends.

The mature configurations for 10MW HTGR stand shoulder-to-shoulder internationally. Spherical fuel element modular high-temperature reactors are the original version and basically reflect their modular characteristics, but further simplification based on experimental reactors is still necessary (Figures 3-5) [Figure 3 not reproduced].

The main characteristics:

- Use of spherical fuel elements;
- The core and steam generators are installed inside separate steel pressure vessels and a cascaded "shoulder to shoulder" configuration is used;
- The pressure vessel is placed inside an air-sealed concrete vessel;
- Decay heat is carried out by surface coolers outside the reactor vessel;
- The spherical fuel elements are loaded into the core from the top of the reactor and are unloaded from the unloading tubes at the bottom of the reactor, passing through the core several times;

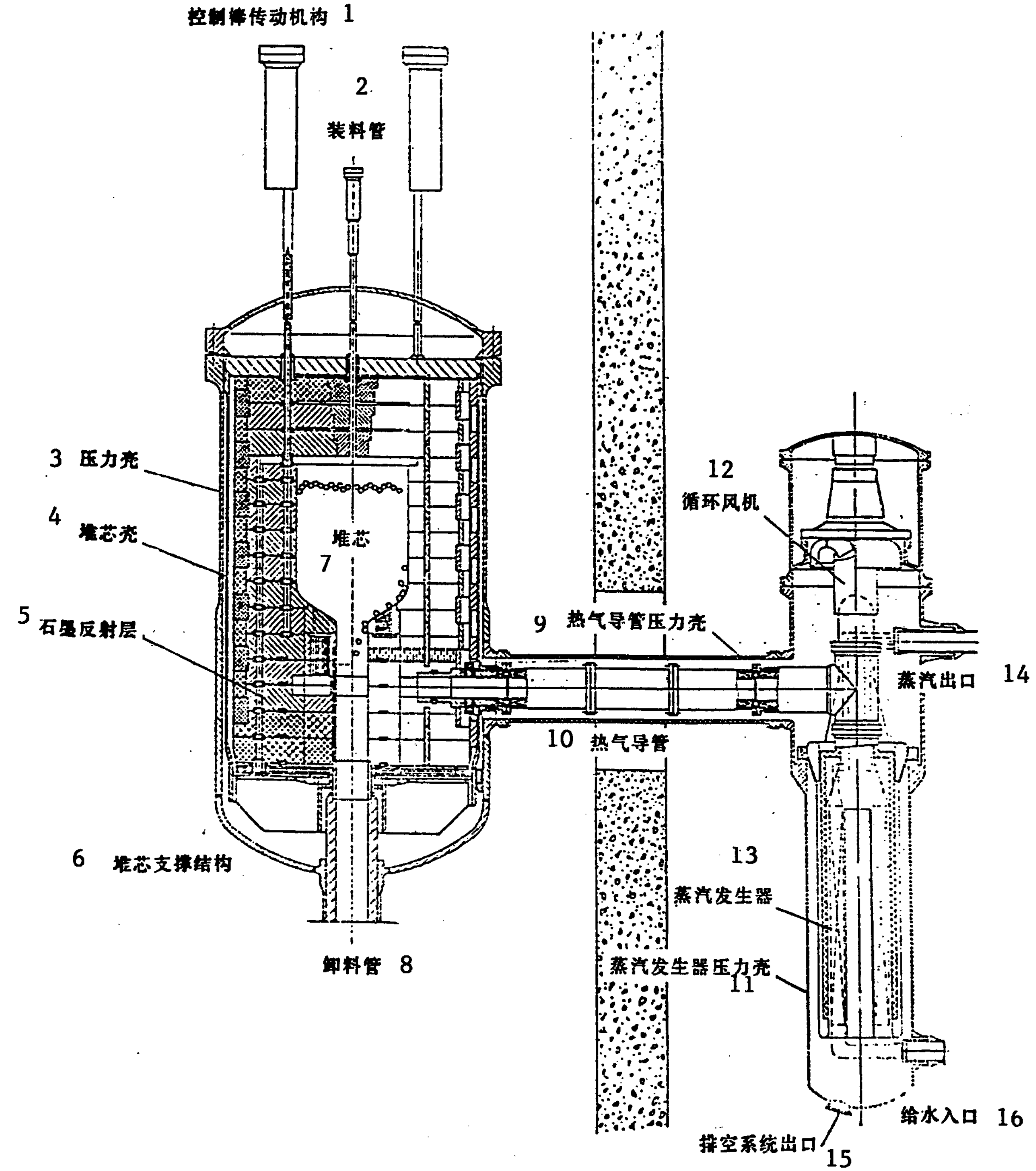

Figure 4. 10MW High-Temperature Gas-Cooled Experimental Reactor Primary Loop System Diagram

Key: 1. Control rod drive mechanism; 2. Loading tube; 3. Pressure vessel; 4. Core vessel; 5. Graphite relecting layer; 6. Core support structure; 7. Core; 8. Unloading tube; 9. Hot air duct pressure casing; 10. Hot air duct; 11. Steam generator pressure vessel; 12. Circulating blower; 13. Steam generator; 14. Steam outlet; 15. Evacuation system outlet; 16. Feedwater inlet

- The reactor control rods are located in graphite reflecting layer ducts;
- Graphite material is used for all of the structures around the reactor core, and there are no metal components;
- Chinese-made standardized steam turbine generators are used for the power generator equipment.

Work has already begun on the initial design for the 10MW HTGR and the construction of this reactor is expected to be completed in 1997.

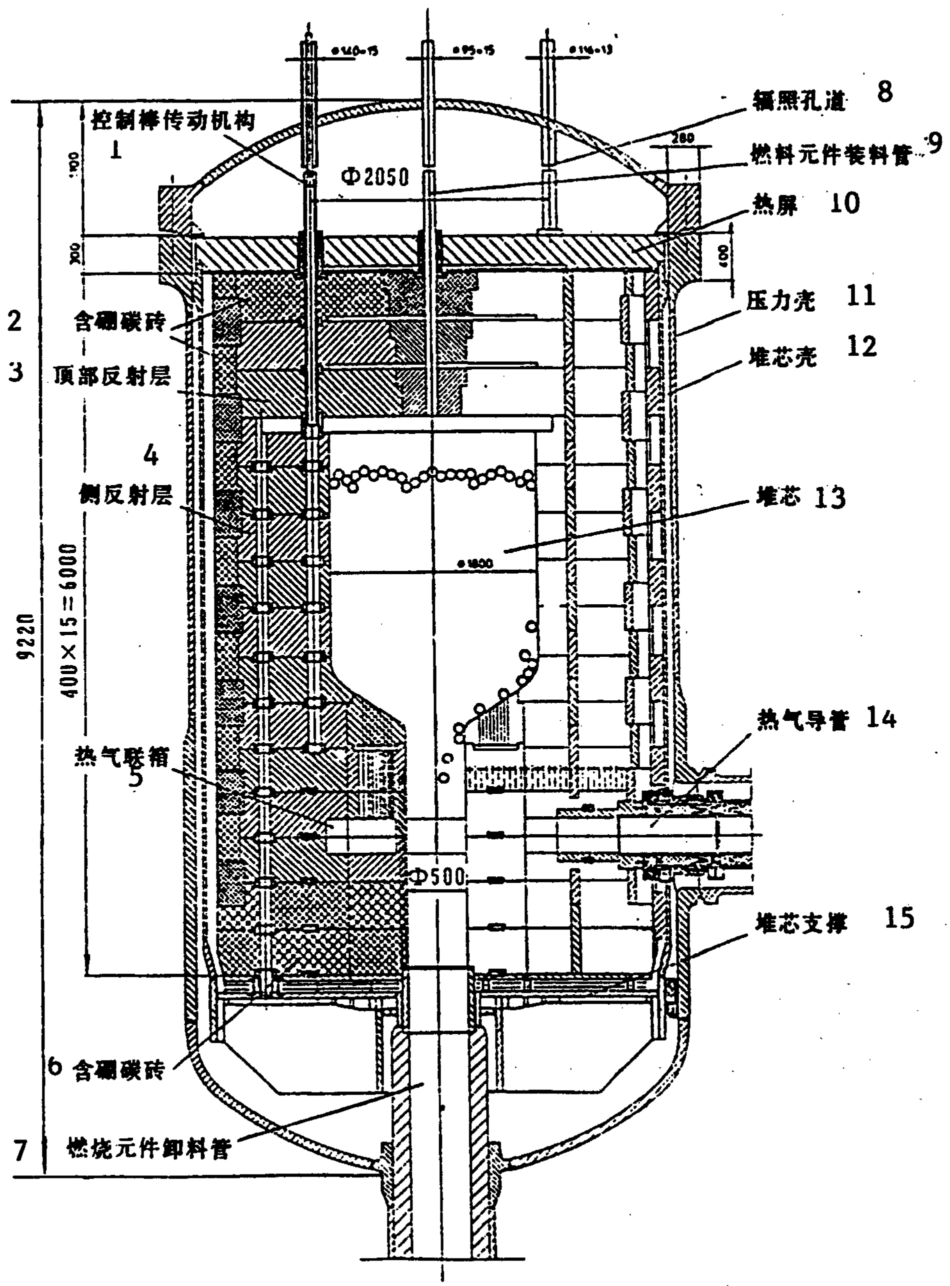

Figure 5. Cross-Section of Reactor Body of 10MW High-Temperature Gas-Cooled Experimental Reactor

Key: 1. Control rod drive mechanism; 2. Boronided carbon bricks; 3. Top reflecting layer; 4. Side reflecting layer; 5. Hot air connecting tank; 6. Boronided carbon bricks; 7. Fuel element unloading tube; 8. Irradiation duct; 9. Fuel element loading tube; 10. Heat shield; 11. Pressure vessel; 12. Core vessel; 13. Core; 14. Hot air duct; 15. Core support

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Systematic Analysis, Comparative Evaluation for Nuclear, Coal Energy System

936B0049C Beijing QINGHUA DAXUE XUEBAO [JOURNAL OF TSINGHUA UNIVERSITY] in Chinese Vol 32, No 6, Dec 92 pp 29-35

[Article by He Jiankun [0149 1696 0981] and Lu Yingyun [0712 2019 6663] of the Nuclear Energy Technology Design and Research Academy: "Systematic Analysis and Comparative Evaluation of Nuclear and Coal Power Generation and Heating"; manuscript received 7 May 1992]

[Text] Abstract: Starting with China's future energy resource supply and demand situation, we discuss the expectations for nuclear energy in our domestic energy resource system and compare the economy of nuclear energy to coal in the two areas of power generation and heating. We also begin from the perspective of the overall energy resource industry system from resource extraction, processing, transportation, and conversion and on to ultimate utilization in making a systematic assessment of the nuclear energy system and coal system in areas like system investments, energy input/output, energy resource utilization rates, environmental protection, and so on and analyzing the impact and role that nuclear energy may have on China's future energy resource system. [passage omitted]

I. The Role of Nuclear Energy in China's Future Energy Resource System

Total consumption of primary energy resources in China in 1990 was 28.7 EJ. Coal accounted for 75.6 percent of this amount while petroleum accounted for 17.0 percent, natural gas for 2.1 percent, and hydropower for 5.3 percent. China is one of the few countries in the world in which coal is the dominant factor in its primary energy resource structure.

Changing trends in future energy resource demand will be affected mainly by population growth, economic development objectives, changes in our national economy and industrial structure, S&T progress, improvement in peoples living standards and consumption levels, and other factors.

According to forecasts by several research organizations in China, China's population will reach about 1.5 billion by the middle of the next century and we will achieve our strategic goal of attaining a per capita GNP that is at the level of a moderately developed nation. Based on the change trends in the industrial structures of most countries in the world during their development histories and taking into full account technical progress and energy conservation benefits in China in the area of energy resource utilization and energy resource conversion, total demand for primary energy resources in China in the year 2050 has been projected at 117 EJ. Demand for electricity will reach 4.7 trillion kWh, our installed generating capacity will be about 900,000MW, and the proportion of primary energy resources used to generate electricity will approach 40 percent. Energy conservation will still be maintained at about 1 percent a year during the next century and the energy resource consumption elasticity coefficient will be about 0.6 to 0.7.

An assessment of China's energy resources and forecasts of their development prospects indicate that by the middle of the next century annual petroleum output will have passed its peak and yearly output can only be sustained at about 100 million tons at that time. There is hope for greater growth in natural gas development and yearly output at that time could be 160 to 200 billion m^3 and initial energy resources from petroleum and natural gas supplies may total an equivalent of 13 EJ. With the exception of Tibet, all of our useable hydropower resources will basically be developed in their entirety and our hydropower installed generating capacity may reach 280,000 to 300,000MW, which is equivalent to about 11 EJ of primary energy resource supplies. There is hope of greater development and utilization of wind power, solar power, and other new energy resources, but this will still lag far behind the formation of a independent industrial system and large-scale commercial extension and they will not constitute a very large proportion of our energy resource system by 2050 with total supplies of less than 3 EJ. China has abundant coal resources with substantial development potential, but large-scale development is severely restricted by the environment and transportation. The 18 provinces and municipalities of east China are a region of concentrated energy resource consumption but severe energy resource shortages. Their coal supplies in the next century will depend mainly on in-shipments from Shanxi, Shaanxi, and Inner Mongolia but because of restriction by the capacity of transportation routes to outside areas, it will be difficult for out-shipments of coal from Shanxi, Shaanxi, and Inner Mongolia during the middle part of the next century to exceed 1 billion tons of raw coal. Added to the amount mined in the region itself, coal supplies in the 18 provinces and municipalities of east China could reach 2.2 billion tons at the most, which still cannot satisfy demand for energy resources in this region. Added to consumption in the Shanxi, Shaanxi, and Inner Mongolia and the output of the southwest and northwest China regions that is mined and used by these regions themselves, total supplies of coal in China in the year 2050 will at a maximum reach 3.5 billion tons of raw coal, which is equivalent to 73 EJ. There will be a shortage of nearly 18 EJ of primary energy resources that must be met by nuclear energy.

There is now a high tide of environmental consciousness on a global scale. Development and utilization of fossil energy resources is one of the main sources of discharges of greenhouse gases and environmental pollution. Consumption of primary energy resources in China will reach 117 EJ during the middle part of the next century and if we still have an energy resource system that is dominated by coal at that time an amount of coal now being consumed in the world each year will be burned in a concentrated way on China's 9.6 million square kilometers of land. At present technical levels of energy resource consumption, the environmental pollution will reach an unbearable level. Thus, the development of China's energy resource system should establish the objective of "an environmentally appropriate clean energy resource system". Given China's technical and economic development levels and natural resource conditions, preferential development of hydropower, nuclear power, and other non-fossil energy resources during the next century is a practical way to solve our energy resource supply problems and associated environmental problems. Nuclear energy will play an important role in the process of China's energy resource system in making a transition to a clean energy resource system.

II. An Economic Comparison of Nuclear and Coal Power Generation and Heating

Besides safety issues in the future development of nuclear power, its economic competitiveness is an important aspect. Table 1 gives comparative data on the economy of a nuclear power plant and coal-fired power plant standardized for a commercial power output of 2 X 600MW. In the table, a baseline equivalent rate of 5 percent is assumed for constant prices with the price of coal at 122 yuan/ton and the price of nuclear fuel at 7.5 million yuan/ton.

Table 1. Economic Comparison of Nuclear Power Plants and Coal-Fired Power Plants

Item	Nuclear Power	Coal-Fired Power
Electrical power (MW)	2 X 600	2 X 600
Comparative investment at basic prices (yuan/kW)	3,500	2,013
Efficiency (percent)	33	33
Load factor (percent)	70	70
Economic lifespan (years)	30	30
Investment recovered costs (yuan/kWh)	0.062	0.030
Fuel costs (yuan/kWh)	0.038	0.061
Transportation costs (yuan/kWh)	0.011	0.007
Power generation costs (yuan/kWh)	0.111	0.098

Table 1 shows that the comparative investment for nuclear power is 1.74 times that for coal, but because the transportation costs for the fuel are lower than for coal, the average power generation costs is basically equivalent to coal-fired power and it would be substantially competitive with coal-fired power in economic terms.

In feasibility research on a 200MW industrial demonstration low-temperature nuclear heat supply reactor, the total investment at basic prices for the project would be 247 million yuan (including two-thirds of the initial fuel loading cost) and the cost would also drop after commercial extension. Because low-temperature heat supply reactor technology is simpler than nuclear power plants and there are no steam turbine generator plant buildings, analysis by the Siemens Corporation in Germany indicates that the comparative investment for a commercial low-temperature nuclear heat supply reactor would only be equivalent to 80 percent of the comparative investment for a nuclear power plant with an equivalent electrical power of 1,300MW. Using 2 X 200MW as a typical nuclear heat supply plant, its comparative investment would also be lower than a single-reactor heat supply plant. This article computes the comparative investment for a 2 X 200MW commercial nuclear heating plant as 90 percent of the comparative investment for a 2 X 600MW nuclear power plant and reduces its comparative investment in basic prices 15 percent over a demonstration reactor. The total investment at basic prices for a 2 X 200MW nuclear heating plant (including two-thirds of the initial fuel loading cost) is 420 million yuan. The reactor maintenance, operation, and management expenditures and other parameters are all referenced to the feasibility research data for a 200MW reactor from the Qinghua Nuclear Energy Technology Design and Research Academy. The economic parameters for a coal-fired central heating boiler plant at present can be referenced to data for the Zuojiazhuang and Fangzhuang central heating plants. The Zuojiazhuang central heating plant was completed in 1986 and has a heat supply capacity of 837 GJ/h. The investment for the heating plant (not including the piping network) was 73 million yuan and the average purchase price for coal in 1990 was 122 yuan/ton. The Fangzhuang coal-fired central heating plant was completed in April 1990 and has a heat supply capacity of 1.05 TJ/h. The investment in the heating plant was 203 million yuan. Deducting unreasonable appropriations, the equivalent basic price was about 190 million yuan. In comparing nuclear heating to coal-fired central heating, basic prices for 1991 were adopted, the comparative investment for a coal-fired heating plant was computed according to the Fangzhuang Heating Plant that was completed in 1990, the operating costs and other parameters were computed in reference to actual operating costs at Zuojiazhuang in 1990, and the annual number of operating hours were readjusted to make them consistent with the low-temperature reactor. The relevant data are given in Table 2.

Table 2. Economic Comparison of Nuclear Heat Supply and Coal-Fired Central Heat Supply

Item	Nuclear Heat Supply	Coal-Fired Central Heat Supply
Heating capacity (TJ/h)	1.44 (2 X 200MW)	1.05
Annual number of operating hours (h)	3,548	3,548
Amount of heat supplied annually (PJ/a)	5.11	3.73
Heating efficiency (percent)	98	75
Economic lifespan (a)	30	30
Comparative investment for heating station (yuan/kJ/h^{-1}	0.292	0.182
Yearly capital recovered costs (yuan/GJ)	5.354	2.957
Operating maintenance and management costs (yuan/GJ)	3.120	3.074
Fuel costs (yuan/GJ)	2.919	7.864
Retirement and spent fuel processing costs (yuan/GJ)	0.981	—
Average heating costs (yuan/GJ)	12.37	13.89

Table 2 shows that although the comparative investment per unit of heat supply capacity from nuclear heating is higher than coal-fired central heat supply, the fact that its fuel consumption costs are lower during operation means that at a coal price of 122 yuan/ton, the average heating cost is still about 10 percent lower than coal-fired central heating, so it is economically competitive.

In the two areas of power generation and heating, there are examples in which the comparative investment in nuclear compared to coal is higher and the two overall are equivalent. However, because efficiency in using nuclear energy for heating is much higher than the efficiency of using coal to supply heat while the efficiency of using nuclear and coal to generate electricity are basically identical, using nuclear energy to supply heat could replace much more coal compared to using nuclear energy to generate power. Thus, a comparison of costs per unit of output shows that the cost of using nuclear energy to supply heat is lower than coal while the cost of nuclear power is slightly higher than coal-fired electric power. Thus, nuclear energy has substantial advantages in replacing coal in the heat supply realm (see Table 3).

Table 3. Economic Comparison of Nuclear and Coal Power Generation and Heating

Item	Nuclear power	Coal-fired power	Nuclear heat supply	Coal- fired central heat supply
Production capacity	600MW	600MW	720 GJ/h	837 GJ/h
Investment (million yuan)	2,100	1,208	210	162.4
Efficiency (percent)	33	33	98	75
Comparative investment	3,500 yuan/kW	2,013 yuan/kW	0.292 yuan/kJ/h^{-1}	0.182 yuan/kJ/h^{-1}
Product cost	0.11 yuan/kWh	0.098 yuan/kWh	12.37 yuan/GJ	13.89 yuan/GJ
Ratio of comparative investment, nuclear/coal	174	100	161	100
Ratio of production cost, nuclear/coal	113	100	0.89 [as published]	100

III. Analysis of Energy From Nuclear and Coal Heat Supply

Table 4 shows the electricity consumption situation for the nuclear fuel and coal production and supply processes. The amount of electric power that is consumed using the diffusion uranium enrichment process throughout the links of extracting the uranium ore, converting and enriching it, fabricating the elements, and transport and storage to produce 1 ton of 3 percent enriched uranium nuclear fuel elements that supply 1 kJ of useable energy in a heat-supply reactor is 5.412×10^{-6} kWh, which is an amount of primary energy resources that is only equivalent to 5.7 percent of the useable energy output. The amount of electric power that is consumed during the coal supply process to produce 1 kJ of useable heat energy from a central heat supply boiler is 4.055×10^{-6} kWh. Comparing these two items, the amount of electricity consumed during the nuclear fuel element fabrication process is only 1.33 times the amount of electricity consumed during the process of producing and transporting coal, so when computed according to the amount of energy output, electricity consumption in the nuclear fuel element production process compared to coal is certainly not an acute problem.

Table 4. Electricity Consumption in the Nuclear Fuel Element Fabrication and Coal Supply Processes

Item	Nuclear heat supply	Coal-fired centralized heat supply
Electricity consumption (kWh)	To produce 1 ton of 3 percent enriched uranium elements:	To produce 1 ton of coal:
	Mining: 69.9×10^3	Mining: 42.73
	Ore dressing: 98.69×10^3	
	Conversion: 58.29×10^3	Dressing: 10.0
	Enrichment: $12{,}841.9 \times 10^3$	
	Element fabrication: 99.19×10^3	Railway transportation: 10.94
	Storage and transportation: 10.66×10^3	
	Total: $13{,}178.41 \times 10^3$	Total: 63.67
Heat energy that can be generated at present technical levels (kJ)	$2{,}485 \times 10^{12}$	21×10^6
Heating station efficiency (percent)	98	75
Electricity consumed to produce fuel per unit of useable heat energy output (kwh/kJ)	5.412×10^{-6}	4.055×10^{-6}
Ratio of nuclear relative to coal	133	100

IV. Comparison of Nuclear and Coal-Fired Power Generation and Heat Supply Systems

We will now analyze the question of using nuclear energy as a replacement for coal in the fields of power generation and heat supply from the perspective of the energy resource system as a whole and use this to do a systematic evaluation of using nuclear energy for power generation or heat supply.

A. Economic Performance Analysis

In doing the analysis from the perspective of system investments, replacing coal with nuclear requires consideration of the production links in power generation or heat supply as well as consideration of investments to expand production capacity for extraction of the initial energy resource, processing, transportation, distribution, and other links that must be added to meet power generation and heating requirements. Among these items, the comparative investment associated with the nuclear fuel cycle system per kW of capacity at a nuclear power plant is 1,500 yuan, while the comparative investment in coal mine extraction per ton of coal production capacity is 181 yuan, the comparative investment in new railway construction per ton of coal hauled is 86 yuan, and the comparative investment in a coal washing plant per ton of dressed coal production capacity is 50 yuan. The comparative investment values converted into unit heat energy output capacity (kJ/h) for a power (heating) plant are given in Table 5.

Table 5. Systematic Comparison of Replacing Coal With Nuclear (yuan/kJ/h^{-1})

Item	Nuclear power	Coal-fired power	Nuclear heat supply	Coal- fired central heat supply
Comparative investment in power (heating) station	0.325	0.19	0.291	0.182
Comparative investment in transmitting and distributing power	0.045	0.045	—	—
Comparative investment in associated nuclear fuel cycle	0.14	—	0.69	—
Comparative investment in associated coal mine extraction	—	0.055	—	0.041
Comparative investment in associated coal dressing plant	—	0.014	—	0.011

Table 5. Systematic Comparison of Replacing Coal With Nuclear (yuan/kJ/h^{-1}) (Continued)

Item	Nuclear power	Coal-fired power	Nuclear heat supply	Coal-fired central heat supply
Comparative investment in associated railway transportation	—	0.026	—	0.020
Comparative investment in main heat supply trunklines	—	—	0.098	0.084
Total comparative system investment	0.506	0.325	0.459	0.337
Ratio of comparative investments, nuclear/coal	156	100	136	100

The figures in Table 5 show that when using nuclear energy to replace coal for generating electricity or supplying heat, the ratio between the comparative investment in the nuclear energy system and the comparative investment in the coal system is somewhat lower than the ratio between independent nuclear and coal-fired power generation (heating) stations. In the area of power generation, the comparative investment in a nuclear power plant is 74 percent higher than a coal-fired power plant while the comparative investment in the associated nuclear system is just 56 percent higher than the coal system, a reduction of 18 percentage points. In the area of heat supply, the comparative investment for nuclear heating is 61 percent that for coal-fired centralized heat supply but the associated nuclear energy system is only 36 percent higher than the coal system, which is a reduction of 25 percentage points. Comparison from the system perspective indicates that the ratio between the comparative investment for nuclear heat supply and the comparative investment for coal-fired heat supply is reduced even more (mainly due to relative efficiency advantage factors). In summary, in comparing the economic performance of nuclear energy and coal in power generation and heat supply, analysis from the system perspective is more favorable to nuclear energy than analysis in terms of a single power (heating) station.

Low-temperature nuclear heating reactors are already tending toward greater technical maturity than PWR nuclear power plants. The pressure and temperature parameters of low-temperature nuclear heating reactors are both lower than PWR nuclear power plants, the technology is easier to realize, and all of the key equipment can be produced domestically so there is no need to import the technology and equipment from foreign countries. We are still considerably far from a complete shift to domestic production of nuclear power plants. Key equipment constituting an estimated 30 percent or so of the total investment for the 2 X 600MW PWR power plant now being drawn up for the second phase at Qinshan must still be imported. Moreover, low-temperature nuclear heating reactors are inherently safe, they are capable of guaranteeing automatic shutdown under any type of accident conditions, no core melting accidents can occur, and they can be built at the edges of cities. Thus, in terms of the technical conditions, extending low-temperature nuclear heat supplies in large and medium-sized cities more quickly is realistic and feasible.

B. Analysis of environmental factors

Global environmental problems are now a hot point of concern in international society and China's coal-dominated energy resource structure has already caused serious environmental pollution problems. According to a 1985 survey of cities throughout China, with the exception of nitrous oxides in the atmosphere which have not yet exceeded the standards, particulates exceeded standards in 52 of the 56 cities surveyed, equal to 93 percent. Precipitates exceeded standards in 41 of the 46 cities for which statistics are available, equal to 89 percent. SO_2 exceeded standards in 14 of the 64 cities for which statistics are available, equal to 22 percent. In more than 10 cities including Benxi, Shijiazhuang, Jinan, Taiyuan, and others all three categories of pollutants exceeded standards. In the area of their seasonal distribution, SO_2, nitrous oxides, and particulates cause the most serious pollution during the winter season and while there are quite a few reasons for this they are obviously extremely closely related to the burning of coal for heating in cities during the winter.

The benefits for environmental improvement are even more significant from using nuclear energy to replace coal for heating in cities than in replacing coal for power generation. Coal-fired power plants can be placed distant from urban regions and the electricity transmitted to the cities at high voltages, which reduces urban environmental problems. However, coal-fired centralized heating stations cannot be too far from urban residential areas. Although environmental pollution from central heating boiler plants is less than from scattered boilers and the small coal stoves of users, their discharges of ash, SO_2 and other pollutants are still the primary source of environmental pollution in urban areas. Because of their inherent safety, low-temperature heat supply reactors can be built in areas near the edges of cities. One 2 X 200MW low-temperature nuclear heating station can replace 450,000 to 550,000 tons of coal a year and reduce ash discharges in cities by 30,000 tons and SO_2 discharges by 4,000 tons, thereby playing a major role in improving the urban environment.

C. Analysis of the extent of replacement of coal by nuclear energy

While there are advantages to developing nuclear heat supplies and developing nuclear power plants in terms of the areas described above, as far as the status of nuclear energy in China's future energy resource system is concerned nuclear power will still be the main battlefield in China's development of nuclear energy. By the middle part of the next century we hope that nuclear energy will account for an equivalent of 18 EJ of primary energy resources in our energy resource system. At that time, demand for energy for heating in urban areas will be about 4.4 EJ and if 30 percent of this came from nuclear energy it would be equivalent to building over 300 of the 200MW low-temperature nuclear heat supply reactors, which would equal about 1.9 EJ in primary energy resources, so nuclear heating would play a major role in urban heating systems. In another area, nuclear energy equal to about 15 EJ in primary energy resources will still have to be provided in the form of nuclear power, so the energy resources provided by nuclear power will account for more than 85 percent of the total nuclear energy for power generation, which is equivalent to building 225GW in installed nuclear power generating capacity, and nuclear energy will account for about one-third of our total power generation. In summary, heat supplies from nuclear energy and power generation from nuclear energy will both play important roles in our future energy resource system. There is no way that one of them can replace the other, and they should be developed in a coordinated manner.

The long-term development of nuclear energy in China may be restricted by nuclear fuel resources. During the period of its service life, a GW grade thermal neutron nuclear power plant will consume 40,000 tons of natural uranium. Will China have enough uranium resources by the middle of the next century to support the development of our nuclear industry? Because the degree of exploration of China's nuclear resources is still very low at the present time, accurate projections are hard to make. This requires us to start soon in reinforcing exploration work to increase our developable reserve resources. In addition, we should actively undertake research on advanced reactor types and increase the degree of utilization of nuclear fuels to ensure the development pace of our nuclear industry and complete our historical mission for nuclear energy in our progress in China's socioeconomic development.

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LTHR Computerization Strategy, Progress

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[Article by Zhang Liangju [1728 5328 7467] and Xie Zhengguo [6043 1767 0948] of the Nuclear Energy Technology Design and Research Academy: "Tactics and Progress in Computerization of Low-Temperature Reactor Instrument and Control Systems"; manuscript received 7 May 1992]

[Excerpts] Abstract: During the process of developing low-temperature nuclear heating technology, Qinghua University's Nuclear Energy Technology Design and Research Academy has consistently been involved in implementing an instrument and control (I&C) system computerization plan. This article discusses the necessity and possibility of total I&C computerization for low-temperature reactors, analyzes the tactics and implementation steps that must be taken to achieve total I&C computerization for low-temperature reactors, introduces the functions, key technologies, and applications benefits of the 5MW low-temperature reactor computer system, and concludes with the objectives and R&D work now in progress for 200MW nuclear heating station I&C computerization. [passage omitted]

[Introduction]

Monitoring and display of parameters in the realization process of using computers in the 5MW low-temperature nuclear heat supply experimental reactor has effectively improved the man-machine interface and has now supported continuous operation of the low-temperature reactor for three heating seasons, with very good results. The 200MW low-temperature nuclear heating demonstration plant will further expand and intensify the degree of computer applications. Important advances have now been made in the related design work and in research and experiments on the key technologies and we are now progressing toward the goal of total computerization. [passage omitted]

II. Low-Temperature Reactor I&C Computerization Tactics

During the process of developing low-temperature nuclear heat supply technology, Qinghua University's Nuclear Energy Technology Design and Research Academy has consistently implemented an I&C computerization research plan. By gradually moving computer technology into the control room and instrument and control systems of the low-temperature reactor, we will eventually achieve total computerization of I&C for the low-temperature reactor. The basic objectives are to improve the man-machine interface, simplify operation of the low-temperature reactor, and improve the operating safety of the low-temperature reactor. In functional terms, total computerization of I&C for the low-temperature reactor will include the following areas:

—Total adoption of color CRT displays, improved information description modes, and more centralized monitoring capabilities;

—High-level information processing functions such as alarm analysis and screening, safety state analysis, component breakdown diagnosis, etc.;

—Intelligent operational support functions, provision of control and operation guidance, accident handling guidance, etc.

—High-level automation under operating personnel guidance. Complete automation of reactor startup, normal reactor shutdown, normal operation, and other procedural work. For important decisions, automatic execution after the system provides suggestions for adjudication by operating personnel.

The role of operating personnel will be shifted from monitoring the parameters of every procedure and operating every piece of equipment to supervising the overall safety state and overall performance of the reactor and adjudicating important operational steps. This can reduce mistakes in man-made diagnoses and operations and thereby improve the operating safety of the low-temperature reactor.

However, work on total computerization of I&C for the low-temperature reactor involves complex systems engineering. Besides making a full estimate of the technical difficulty and development work, several other factors must also be taken into consideration:

1. The overall design and economic objectives of low-temperature reactors must be satisfied to facilitate extension and application of low-temperature reactors and reduce the investment in I&C as much as possible. Thus, we cannot rely on importing complete sets of equipment or support by designs from foreign countries. We can only import the basic computer equipment and rely on our own strengths for development.

2. We must ensure progress in the overall project. The development of low- temperature reactors must go through several research and manufacturing phases from the 5MW experimental reactor, 200MW industry demonstration reactor, and commercialized heat supply reactor and the I&C development must also be coordinated with this and meet the progress requirements of each phase.

3. We must ensure the safety of the reactors. The I&C must go through full confirmation, debugging, testing, and inspection and acceptance before a low- temperature reactor can be placed into actual operational use. A full estimate must be made of the amount of development work and the inspection and approval process. Work on shifting to microcomputers and microprocessors must be done in sequence for safety protection, nuclear measurements, advance alarms, and much other non-standard equipment used in the reactors, and a huge amount of work must be done on I&C system software development. West Germany spent 150 man-years on developing I&C system software for the KWU KONVOI nuclear power plant[5]. The United States spent a total of 100 man-years on designing and installing its CPCS core protection computer system and the Nuclear Regulatory Commission (NRC) invested 15 many-years in conducting a safety inspection and acceptance of the CPCS[1].

4. Real-time on-line application of computers in reactors is still in the initial stages in China and there is a process of gradually understanding and adaptation in psychological and customary terms for operating personnel and nuclear safety supervision departments.

5. Fully computerized nuclear power plant I&C is a new thing internationally that only appeared in the late 1980's and the relevant nuclear power plant design standards and inspection and approval procedures in China and foreign countries have not yet embodied this new technical development situation[2]. There are no clear and unified standards at present that be used as a reference for fully computerized I&C design work.

If we conscientiously take into account all of these factors and seek truth from facts in estimating the required manpower and material inputs, it is not difficult to see that successfully achieving the objective of total computerization in one step in the near term will be technically difficult and that there are no reliable guarantees in the areas of reactor safety and temporal progress. The correct principle should be: on the one hand, having a full understanding that total computerization is the technical direction for I&C development and that deployments should truly be made to work actively toward this objective, and on the other hand that we should seek truth from facts, proceed from our strengths, and gradually advance.

Work for total computerization of low-temperature reactor I&C should be divided into three steps: 1) The 5MW experimental reactor stage, which will focus on realizing the use of computers for monitoring and display functions and auxiliary work on analog gauges, with computers not being involved in control and protection; 2) The 200MW industrial demonstration reactor stage to achieve total computer monitoring, total CRT display (with redundant display measures for a small number of important safety parameters), partial realization of distributed control by levels and the introduction of partial intelligence; 3) The commercial low-temperature reactor stage, with complete realization of CRT display and distributed control by levels, realization of operational automation under the guidance of operating personnel, and the gradual introduction of various types of intelligence and operational support measures.

III. 5MW Experimental Reactor—Computers as First-Line Monitoring Measures

We have successfully realized the use of computers for first-line monitoring measures for reactor operation in the 5MW heat supply reactor with very good benefits from their utilization.

The 5MW low-temperature reactor computer system has data collection and processing, color graphics display and data table display, report printing, trend curve plotting, alarm handling, historical review, and other functions that have effectively improved the man-machine interface and are significantly superior to analog gauges[6]: 1) It has greatly simplified the design of the control consoles and reduced the work area of operating personnel; 2) The CRT displays are centralized, directly visible, and provide images, which has improved centralized monitoring capabilities; 3) The variety of display and recording arrangements has increased the availability rate of the data and facilitated monitoring and analysis of operating conditions and change trends by operating personnel; 4) It has reduced the data recording and processing burden on operating personnel and enabled them to concentrate their energies on operation; 5) It has provided effective tools for recording all types of operating conditions and dynamic processes.

The success of the 5MW low-temperature reactor computer system lies in the design's adoption of several advanced technologies: 1) It uses distributed data collection technology. The intelligent data collection station based on microprocessors is installed at the measurement site and independently carries out measurement, conversion, and processing. All of the collection stations are linked in a distributed network and communicate with the main computer via a network bus that reduces the number of signal cable entering the control room and shortens the transmission distance for analog signals; 2) It achieves total isolation of data transmission. Isolation was realized between the measurement channels and the network bus and between the network bus and the main computer, thereby completely isolating the computer system from the site. This effectively increased the system's interference resistance capabilities and operational reliability. 3) The software design adopts parallel multitasking technology and task intercommunication technology, which simplifies the software structure and guarantees the reliability of the software. 4) It combines a variety of man-machine interfaces that make operation simple and flexible, give operation a powerful fault tolerance capability, and are easy for reactor operating personnel to accept and understand.

The 5MW low-temperature reactor process computation system is playing a significant role in reactor operation and has provided real confirmation that:

1. The adoption of computers has latent potential and significant benefits in improving the man-machine interface in the reactor control room;

2. The reliability of the computers is entirely capable of satisfying reactor operation requirements. The two MICRO PDP11/73 computers used in the 5MW low-temperature reactor have been in actual on-site operation for 3 years without experiencing any type of equipment malfunction;

3. The basic software structure and basic technology adopted in the design are rational and effective.

IV. The 200MW Nuclear Heat Supply Demonstration Station—Total Computer Monitoring

In functional terms, the extent of I&C computerization in the 200MW reactor is a major step forward technologically.

1. The computers will implement total monitoring of the reactor and its auxiliary systems including technical parameter monitoring, equipment (pumps, valves) open and closing state monitoring, important equipment (nuclear measurement, safety protection, power regulation, etc.) breakdown state monitoring, manual/automatic control operations monitoring, effective monitoring of operations, monitoring and recording of major accidents, and so on.

2. The control room will implement total CRT display and provide all types of information on the reactor and its auxiliary systems under normal working conditions and accident working conditions. For safety redundancy purposes, there will still a small number of analog indicators to enable the reactor to maintain a safe state or execute a safety shutdown if the computers are not operational. The display equipment will use graphic workstations or X-Windows terminals (diskless workstations), and computer-controlled analog disks or projection screens will be used at the front of the control room to display the overall reactor state.

3. Some intelligent and support measures will be introduced such as the reactor safety state analysis and display (SPDS), alarm screening and processing, routine operations procedures, accident handling procedure prompts, and so on.

4. The non-safety grade systems will make local use of industrial standard programmable controllers (PLC) and intelligent instruments and gauges based on microprocessors;

5. The reactor's special-purpose nuclear instruments (power regulation, agricultural protection, nuclear measurement, advance alarm) will actively undertake development of microprocessors (or microcomputers) that will be placed into use after strict testing to confirm that their performance and quality conform to the design standards and pass safety inspection and acceptance. Each will be put into use as it becomes mature.

6. A graded distributed architecture will be adopted for the overall I&C of the 200MW reactor.

—Two redundant computers and graphic workstations and printing and plotting equipment will be connected via an ethernet into a network computer system;

—The IMP isolated collected station that has been successfully applied in the 5MW reactor will also be adopted for data collection to form a distributed data collection network;

—The computer system will provide industrial standard busses (IEEE-488 GP-IB bus, BITBUS) to make good preparations for connecting the programmable controllers and intelligent instruments into the computer network and the degree of on-site control instrument computerization can be continually expanded as required.

The adoption of a network computer system, graded distributed architecture, and dual-computer redundant technology will eliminate single malfunctions to the maximum extent and prevent a partial lost of effectiveness from resulting in a loss of the overall functions in the system.

Research on the key technologies to achieve the objectives outlined above is now in progress.

V. Commercial Low-Temperature Heat Supply Reactor—Total Computerization

On the basis of I&C at the 200MW demonstration station, there will be additional expansions in the following areas to achieve total computerization.

1. Introduction of sufficient intelligence

Based on operation of the demonstration station and after accumulating sufficient operating experience and dynamic experimental data, we will then conduct intensive special topic research that will enable the introduction of fault diagnosis, disturbance analysis, decision-making support, and other functions;

2. Complete implementation of automatic control under the guidance of operating personnel

Programmable controllers and intelligent instrument and gauges will be adopted for all equipment control and microprocessors and microcomputers will be implemented for all of the special-purpose instruments (developed ourselves or purchased in China). Moreover, all of them will be connected into the computer network system to enable the operating personnel to use the computer network for management and dispatching of the equipment under their jurisdiction and achieve automatic control under management by the operating personnel;

3. With the exception of safe reactor shutdowns, operations of the on-site equipment will also be done via computer function keyboards or touch screens.

The achievement of all the functions described above will imply total computerization of I&C for the low-temperature reactor.

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Qinshan 2 X 600MW Expansion Project Could Be Finished by End of Century

9360058A Beijing ZHONGGUO KEXUE BAO [CHINESE SCIENCE NEWS] in Chinese 19 Feb 93 p 2

[Article by Zhai Peitian [5049 1014 1131]]

[Text] The preliminary design for the nuclear island and main cooling system for the Qinshan second-phase 2 X 600MW nuclear power plant undertaken by the China Nuclear Power Academy has been completed at Chengdu, and has passed state inspection.

The Qinshan second-phase 2 X 600MW nuclear power plant is a key national construction project of the Eighth 5-Year Plan. This is the first time that China has undertaken a design of this scale, especially the design of a nuclear island and cooling system, which are critical to the construction of a nuclear power plant.

Since winning the competition for the national public bid in 1988, The participating technicians took on the design of this formidable task of great technical difficulty, and, plagued with delays in funding outlays, they overcame numerous obstacles through their own efforts, completed their mission, and presented it for state inspection.

After listening carefully to the research and design report presented by the China Nuclear Power Academy, the leaders and specialists, over 200 in all, from 57 departments of the State Planning Commission, State Council Nuclear Power Office, Ministry of Energy Resources, and State S&T Commission proceeded with group discussions and passed the preliminary design.

State Council Vice Premier and Head of the Leading Group for Nuclear Power Plants, Zou Jiahua, congratulated the conference and spoke of the necessity, urgency, and favorable conditions for development of nuclear power in China, and he advised changing the former energy development policy of "equal emphasis on thermal and hydropower with nuclear power for supplemental energy" to "equal stress on thermal, nuclear, and hydropower." He exhorted the various units to cooperate closely and work to get the second-phase Qinshan project completed and into the network by the end of the century.

More Nuclear Plants in the Offing

40100068 Beijing CHINA DAILY (BUSINESS WEEKLY) in English 22 Mar 93 p 1

[Article by Ren Kan]

[Text] Plans are in the offing to build more nuclear power plants to ease China's electricity shortage.

China National Nuclear Corporation (CNNC) has been in touch with various local governments interested in the scheme.

Foreign investments and joint venture projects are being sought as part of the plan. Three coastal provinces, including Liaoning, Guangdong and Zhejiang, have conducted pre-feasibility studies about nuclear power plants and are waiting for final approval of the State Council

Fujian, Jiangsu, Jiangxi and Shandong provinces are also active in the site selection of nuclear power plants, said an official with the China National Nuclear Corporation.

The corporation and its local partners have already started to build the second phase of the Qinshan plant in Zhejiang Province (two power generating units of 600,000 kilowatts for each).

A third phase of the same size is also planned at the plant.

The official said high economic growth has exacerbated the electricity shortage, and convinced people of the paramount importance of nuclear power.

According to China's energy-development plan, thermal and hydro power have been decided on as two of the major electricity resources.

During the Eighth 5-Year Plan (1991-95), the country is planning to increase its electricity generating capacity by more than 10 million kilowatts annually (nuclear power will account for a small proportion of this).

But the status of nuclear power has been rising in the country's overall energy industry in the past year.

Vice-Premier Zou Jiahua said last year that Southeast China should develop thermal, hydro and nuclear power at the same time.

And some Chinese energy experts say China should build up three energy bases, including Shanxi-centered coal base, a hydropower base in Southwest China and a nuclear power base in southeast coastal provinces.

The official said China welcomes foreign investors to participate in the construction of nuclear power plants either through loans or joint ventures.

He said China and Russia have signed an agreement to join hands in the construction of a nuclear power plant in Liaoning Province.

The plant, still waiting for the State Council's approval, will use Russia governmental loans and import two units of power generators from Russia with a capacity of 1 million kilowatts for each.

Negotiations are under way between China and Russia about jointly conducting a feasibility study for the plant which is expected to be located in Wentuozi, he said.

And another two nuclear power plants in Southeast China, which are still waiting for the final approval, are also planning to use foreign loans and equipment.

These plants, in Guangdong and Zhejiang provinces, will have an annual power generating capacity of 2 million kilowatts each.

Some places have been chosen as the best sites for the two plants and have received good appraisal from experts.

The official said Southeast China, where the country's first two nuclear power plants are located, is the best part of the country to develop nuclear power plants since it has spearheaded the economic reforms.

The development of the nuclear industry in China started in the 1950s. The country started the construction of its first nuclear power plant, Qinshan Nuclear Power Plant, in 1982.

The Qinshan plant, with an electricity generation capcity of 300,000 kilowatts in its first phase, has turned out 520 million kilowatt hours since it was put onto the power grid in 1991.

And the Daya Bay Nuclear Power Plant is expected to put its first reactor into the power grid by the end of this year.

The official said China's nuclear power industry has promising prospects because China's scientists and technicians have the experience in developing nuclear power.

The country's rich uranium resources can ensure a long life span for nuclear plants.