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Energy Supply and Demand Situation in 1991 Reviewed

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[Article by Ji Tong [1323 1749] of the Ministry of Energy Resources Comprehensive Planning Department: "Characteristics of the Electric Power Supply and 1991 and My Humble Opinions on the Power Shortage"]

[Text] In 1991, as China went through improvement, rectification, and intensive reform, our national economy grew in a stable way, industrial production quickly rose again, agricultural production received a relatively good crop, and there was an obvious improvement in our overall economic circumstances. In a situation of slow growth in primary energy resources, although there was a rather substantial increase in electric power production, the electricity shortage intensified and the contradiction between supply and demand became increasingly acute.

I. Characteristics and Trends

China's total electricity output in 1991 was 675 billion kWh, up 8.9 percent from 1990. This included a slight reduction in hydropower and an 11.4 percent increase in thermal power, continuing the double-digit growth following 1987 and 1988. This resulted in a substantial improvement in the shortage of electric power supplies.

China added 90 new large and medium-sized generating units in 1991 with 10,495.7MW including 22 hydropower generators with 1,224MW and 68 thermal power generators with 9,071.7MW. Added to 500 kW and larger small generators, the total going into operation was 11,840MW. This was the most large and medium-sized generators going into operation in one year since our nation was founded and the fourth consecutive year since 1988 in which 10,000MW of generators were placed into operation. It took just 4 years after our installed generating capacity surpassed 100,000MW in 1987 for the electric power industry to leap up to a new stage, with China's installed generating capacity reaching 150,000MW in 1991.

However, the development of electric power still cannot keep pace with the growth in electricity use. The elasticity coefficient of electric power calculated on the basis of our gross value of industrial and agricultural output in 1991 was 0.75, one-fourth less than the value of 1 it should have attained. There was also an expansion of the ratio to China's electricity- using equipment. The new additions of power generation equipment during 1991 not only failed to make up for our long-term shortage of electricity but were even unable to satisfy the requirements of increased electricity use during the same period, which intensified the contradiction between electricity supply and demand. The situation for electricity use in all industries and by urban and rural residents during 1991 was:

1. Increased power use grew moving from west to east China. The amount of electricity used by society as a whole during 1991 increased by 9.3 percent, which included a surge in eastern China at a more than two-digit increase. The increase was particularly large in the developed cities along our coast, growing by 40.9 percent on Hainan, 19.1 percent in Guangdong, 15.4 percent in Fujian, and 14.2 percent in Zhejiang, all of which were greater than the rate of growth in power output. There were also rather surging increases in central China while western China grew more slowly.

2. Growth electricity use in township and town enterprises has not declined. Since reform and opening up, township and town enterprises have taken advantage of the East Wind of reform and used large and medium-sized enterprises as a basis for expanding markets in our vast rural areas. Their production has surged upward and their electricity use has skyrocketed. On the basis of a rather high rate of growth during the past several years, it grew by an additional 26.2 percent from 1990 to 1991, 18 percentage points higher than increases in electricity use in industry as a whole. It grew by more than 20 percent in provinces and municipalities along the east China coast as well as in Hunan, Sichuan, Gansu, and other provinces, including more than doubling in Fujian and increases of 88 percent in Sichuan and 44 percent in Guangdong.

3. Electricity use by urban and rural residents remains high. Since reform and opening up, household electrical appliances have been popularized at an unprecedented pace throughout China's cities and towns and then gradually shifted toward rural areas. Growing from televisions, refrigerators, washing machines, radios, and video recorders to heaters, humidifiers, household crushers, electric water heaters, and on to household air conditioners, household electricity use by urban and rural residents has increased abruptly and grown at a momentum of two digits for more than 10 years, and it grew another 15 percent from 1990 to 1991. During 1990 and 1991, after gradual popularization of household appliances in cities, the market for household appliances has gradually shifted toward rural areas and a momentum of comprehensive growth in durable consumer goods in rural areas has appeared. The growth in household electricity use by residents of rural areas has exceeded that of household electricity use of urban residents. Household electricity use by residents of rural areas grew 17.3 percent in 1991, 4 percentage points higher than urban residents.

4. Surging growth of electricity use in tertiary industries. There was another increase of 14.1 percent from 1990 to 1991. The growth was fastest in the commercial and service industries, reaching 16.3 percent. Electricity use by party and government organizations at all levels, social groups, S&T education, and so on increased by 15.3 percent. The increase was 10.5 percent in the communication and transportation and the posts and telecommunications industries, but electricity use increased by 24.6 percent for posts and telecommunications and 22.5 percent for electrified railways.

5. Substantial increases in electricity use in agriculture. The abnormal weather across China during 1991 with flood and waterlogging disasters and long periods of drought with no rain in most regions led to an increase in agricultural electricity use for drainage and irrigation. It increased by 20.1 percent from 1990 to 1991 in agriculture, forestry, animal husbandry, fishery, and water conservancy, including an increase in irrigation as a proportion of electricity use for agriculture, forest, animal husbandry, fishery, and water conservancy from 44.3 percent in 1990 to 48.6 percent in 1991, a rise of 4.3 percentage points.

With the intensification of reform and opening up and rapid development of the socialist forces of production, demand for electric power will continue to grow. As living standards of urban and rural residents continue to rise and the rural market of 800 million peasants continues to expand, there will be a substantial increase in peasant demand for the "three big items" [household appliances]. Forecasts by the State Statistics Bureau indicate that it will increase by more than 50 percent from 1991 to 1992. Moreover, demand for color televisions, washing machines, refrigerators, video recorders, and electric fans in the open provinces and municipalities of our eastern coast, which led the way in solving our food and clothing problems, will be higher than in the central and western China region, which will make the electric power shortage even more acute. For this reason, limited growth in electricity supplies associated with ever-growing demand and coexisting development and shortages will continue to be the main contradiction facing the electric power industry now and for some time into the future. The elasticity of electricity supplies and the rigidity of demand will pose a series of problems for management of the electric power industry.

II. Problems and Countermeasures

Given the characteristics and growth trends outlined above regarding demand for electricity by all industries and urban and rural residents, we must consider and resolve these problems:

1. Solving the shortage relationship between electricity supply and demand is a long-term task and the ideology of the energy resource industry centered on electric power cannot waver.

In 1988, China began improvement and rectification and readjusted our industrial structure and product mix to restrain part of the overheated production demand and reduce the growing demand for electricity, which brought temporary and partial relief for electric power supplies. Some people felt that the contradiction between electricity supply and demand had already been resolved and that the electricity shortage situation had ended. Actually, 3 years of improvement and rectification did bring a temporary improvement in the electricity supply situation but the original electric power shortage was not resolved and electricity use in all industries continued to grow, so improvement and rectification only brought a temporary delay in the contradiction of electricity shortages restricting development of our national economy. The electricity shortage did not happen in one day so overcoming this contradiction likewise cannot be done in one day.

However, there have been people during the past several years who have constantly suggested that the electricity shortage problem had been basically resolved and that the main contradiction now is the coal and transportation problem, so the guiding principle of "electric power as the center" could be announced to have ended. Energy resources, especially electricity, could be moved back from their primary status in national economic construction to a secondary position and we should "decide upon coal according to transportation" and "decide upon electricity according to coal". It should be acknowledged that there are certainly transportation and coal shortages, both of which restrict development of our national economy, and we should and must accelerate construction, but the guiding ideology of slowing development of the electric power industry to accelerate the development of other industries can only restrict development of the electric power industry and other industries. The reason is that development of the electric power industry is closely related to our national economy and people's lives and they have an interrelationship coefficient of almost 1. A slight relaxation would lead to development of the electric power industry restricting development of the national economy and cause some of society's production capacity to stand idle because of a shortage of electricity, and we would be punished by economic laws. A benevolent cycle can only appear by using electricity to promote coal and using coal to promote transportation and developing many energy resources simultaneously to convert them into electricity. As to whether the supply and demand relationship for electricity is tight or relaxed, the realities of economic life and electricity supplies during 1991 have provided the answer. There were serious power outages throughout China during 1991. In the Beijing-Tianjin-Tangshan region, for example, there was a 1,000MW difference between actual demand for electricity and power supply indices and the power outages averaged 700MW. There were 94,176 power outages in Hubei Province during 1991, an average of 258 each day, and there was an increase of 29,663 instances over 1990, which resulted in losses to the national economy and living problems. Moreover, the phenomenon of low cycles in excess of stipulations, which had not occurred for years, appeared in many power grids, threatening the safety of the electric power industry. It is apparent that the ideology of "electric power as the center" for the energy resource industry must not be relaxed in any way and the ideology of giving the energy resource industry a primary status in national economic construction can in no way be allowed to waver.

For the past several years, the highest proportion of total social investments in fixed assets that were invested in fixed assets for electric power in China was 7.5 percent, in 1978. The lowest was in 1982, at 4.6 percent. The yearly average from 1980 to 1990 was 5.3 percent. It is hard for this investment proportion to satisfy our ever-growing demand for electricity. Investments in technical upgrading for electric power accounted for less than 4 percent of all investments in technical upgrading in China, far lower than in other industries. In capital construction, according to the GUOJIA TONGJI GONGBAO [State Statistical Communique], investments in energy resources as a proportion of investments by units under the ownership of the whole people were 32.8 percent in 1990 and dropped to 30.4 percent in 1991. According to plan arrangements for 1992, however, the proportion of investments in the energy resource industry by the central government as a part of capital construction investments was 30.2 percent in 1991 but dropped to 28.3 percent in 1992. To change China's energy shortage and electricity shortage situations and achieve sustained, stable, coordinated, and effective development of our national economic construction, we must increase investments in the energy resource industry and electric power industry and implement a slanted investment policy.

2. We must continue to adhere to the principle of reform and opening up and continually perfect and intensify reform to be able to develop the electric power industry more quickly. We have carried out reform of the management system and investment system for the electric power industry over the past 10- plus years and conscientiously implemented the "20 character" principle for reform of the electric power system, which has greatly motivated the initiative of the central government and local areas for developing electric power. Reform of the investment system for raising capital to develop power and using multiple channels to develop power in conjunction with implementing the collection of electric power construction funds and other policies have provided a relatively good solution to problems in raising capital. In a situation of substantial reductions in investments by the state, we have still been able to guarantee a substantial scale of electric power construction and place over 10,000MW into operation each year. All of these things can be attributed to reform in the electric power industry. Moreover, active utilization of foreign investments and importing high efficiency equipment and advanced technology and management from foreign countries have also effectively promoted development of the electric power industry. Of course, several problems appeared in the area of electric power management after reform and they require further improvement through reform. We cannot refrain from doing something necessary for fear of a slight risk and turn back. We must boldly carry out reform and boldly import foreign investments, advanced equipment, and advanced management and technology to be able to develop the electric power industry more quickly.

To accelerate development, we must actively develop pit-mouth power plants and reduce the pressure on transportation. Reform is also needed here. We must change our ideology and concepts and, based on the requirement for socialized large-scale production and a division of labor and based on the principle of rational deployment of the forces of production and optimized configuration of resources, we should invest in establishing pit-mouth power plants in provinces with abundant resources and move out of our narrow regional cage. We should have the bravery and boldness of vision of Guangdong Province's socialized large-scale production in boldly investing to develop hydropower and thermal power in Guangxi, Guizhou, Yunnan, and other provinces to solve its own power shortage problems.

To reform the electricity price system, one urgent task at present is to implement electricity prices as quickly as possible to repay the principal and pay the interest on loans. If we fail to take this route, the inevitable result will be a capital shrinkage and there will be less and less. The pace of reform of electricity prices should be somewhat greater and actions should be taken somewhat faster. We should take advantage of a favorable opportunity at present to accelerate reform of electricity prices.

3. All of society must strengthen its consciousness of energy and electricity conservation and all industries should implement planned electricity use and conserve electricity in a major effort to undertake electricity conservation and consumption reduction activities. Enterprises in the electric power industry should look inward, exploit potential, and actively increase effective supplies. They should reinforce their own electricity conservation, loss reduction, and consumption reduction work and make major efforts to increase productivity and improve economic results. For this reason, equipment in newly-built power plants should have high efficiency and low consumption, good peak regulation performance, and reliable operation, and new methods for new plants should be implemented in management. Old power plants should gradually upgrade their small generators. Urban power grids and rural power grids should gradually carry out upgrading to reduce losses and increase supplies.

Based on the electric power industry's plans for the Eighth 5-Year Plan and 10-year program, China's installed generating capacity should reach 182,000MW in 1995 and 250,000MW in 2000 and power output should reach 870 billion kWh and 1.2 trillion kWh, respectively. Based on this program, China will still face a situation of the coexistence of development and shortages during the Eighth 5-Year Plan and the next 10 years. For this reason, we must first guarantee the achievement of this plan and then try to increase the scale of our installed generating capacity based on the development situation of our national economy. One thing that should receive attention at present is continued adherence to the principle of reform and opening up, protection and development of local government initiative at all levels for developing power and their enthusiasm for raising capital to develop power to ensure stable sources of construction capital. A second thing is to request support from machine-building and electronics departments to ensure equipment supplies and enable guaranteed quality, guaranteed quantity, and guaranteed product variety. When there is actually not enough available, we should permit importing and boldly use foreign investments to import equipment. Third, there should be a high degree of attention to the question of transportation capacity. We should also make major efforts to develop hydropower and other renewable energy resources, actively develop nuclear power, make major efforts to conserve electricity, oil, and coal, extend heat and power cogeneration, develop surplus heat utilization, continue to implement the policy of substituting coal for oil, and reduce environmental pollution. If every level in China resolutely adheres to the principle of reform and opening up and resolutely adheres to the development principles of the energy resource industry set forth in the Eighth 5-Year Plan and the 10-year program outline, the goal of resolving our power shortage is certainly attainable.

Accelerating Hydropower Construction, Reducing Lop-Sided Dependence on Coal

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[Article by Yang Zhirong [2799 1807 2837] of the State Planning Commission and Sun Guangxuan [1327 1639 1357] of the Chinese Academy of Sciences Energy Resource Institute: "Accelerate Hydropower Construction, Promote a Balance of Fuel and Motive Power"]

[Text] Acute problems that will exist for a rather long period of time in China now and into the future are: relatively insufficient energy resource supplies, a low quality energy resource structure, coal transportation shortages, low terminal utilization rates, and serious pollution from energy resources. For this reason, we must quickly transform China's strategic deployment of energy resources based on coal by combining major efforts to explore and develop petroleum and natural gas with efforts to take advantage of China's hydropower resources and accelerate hydropower construction.

I. Exploit Hydropower's Potential, Alleviate the Contradiction Between Energy Resource Supply and Demand

According to the goals of China's economic development program for the year 2000, expected demand for energy resources will be 1.5 to 1.6 billion tons of standard coal and expected supplies of energy resources will reach about 1.4 billion tons (Table 1), so there will be an energy resource supply shortage of about 150 million tons of standard coal. If we maintain present energy resource export levels at that time, the actual shortage of energy resources will exceed 200 million tons of standard coal, which is a major threat to the achievement of our last strategic objective for development of Chinese society.

Table 1. Projected Energy Resource Supplies in the Year 2000

Item	Amount of supplies (billion tons of standard coal)	Coal (billion tons)	Petroleum (billion tons)	Natural gas (billion cubic meters)	Nuclear power (billion kWh)	Hydropower (billion kWh)
Projected supplies	1.346-1.486	1.4-1.5	0.17-0.18	20- 30	16.5	200-300
Percent	100.0	73.4-72.1	18.1-17.3	2.0-2.7	0.4	5.2-7.5

Over the next 10 years, compensating for expected energy resource shortages and restraining expansion of energy resource shortages will depend mainly on coal, petroleum, or hydropower. Beginning with the need to adapt to development of modern society, there undoubtedly is a hope of using petroleum and hydropower as the main force to compensate for energy resource shortages.

China has relatively abundant total petroleum resources but newly increased proven geological reserves are limited. Only a little more than one-half of the plan for increasing proven geological reserves during the Seventh 5-Year Plan was completed and our ratio between reserves and extraction at the end of 1990 had dropped by almost 3 percentage points from 1985.

Based on the tasks stipulated in the "National Economic and Social Development 10-Year Program and Eighth 5-Year Plan Outline", petroleum output must be increased to 145 million tons in 1995, for an average yearly increase of 1.4 million tons from 1990 to 1995. If yearly petroleum output in the year 2000 is to be 180 million tons, it must increase by an average of 7 million tons a year from 1995 to 2000, which will require a substantial dynamic increase in output. During the 10-year period from 1980 to 1990, the average yearly increase was only 3.2 million tons. Without major breakthroughs in proven geological reserves during the next several years, petroleum will be unable to play a role in compensating for our energy resource shortage through over-quota output.

Coal is the main force in China's energy resource supplies. The production task of about 1.4 billion tons in the year 2000 was stipulated in the "Outline". To ensure that the shortage of energy resources does not expand, we must increase output by 100 million tons over the quota, which will be rather hard to do.

For one thing, geological prospecting for coal cannot keep pace and there are too few precisely surveyed reserves available for building mines, so the dynamic increase in output cannot be very great.

Our proven available coal reserves at the end of 1990 were 954.4 billion tons, including 164.4 billion tons of reserves that are being utilized in producing mines and mines now under construction. The carefully surveyed reserves not yet being utilized are 94.7 billion tons. Excluding those that would be hard to utilize for the time being, this leaves just 37 billion tons, which cannot satisfy our requirements for increased coal output.

To increase the production scale for coal from 1.08 billion tons in 1990 to 1.4 billion tons in 2000, we will have to provide 64 billion tons of carefully surveyed reserves to build mines, which is at least 6.4 billion tons a year, so our existing carefully surveyed reserves of coal would only last for 5 years-plus. Detailed survey reports have not been submitted yet for 18.3 percent of the scale of construction starts for mines planned for the Eighth 5-Year Plan and there are no detailed survey reports for 50 percent of the mines planned for a start of construction during the Ninth 5-Year Plan. For coal production to reach 1.5 billion tons, the prospecting tasks are extremely numerous.

Given that geological prospecting work for coal lags behind the needs of production and mine construction, there is an obvious lack of reserve strengths, it will be rather difficult to maintain output increases as large as those during the previous 10 years, and over-quota increases in output in excess of plans are extremely limited.

Second, the structure of coal production departments is relatively weak and reliance on macro regulation and control provides no reliable guarantees for promoting an increase in coal output of 100 million tons over plans.

The proportion of output from unified distribution coal mines has fallen while the proportion of output from collective and individual coal mines has increased (Table 2), and the difficulty of macro regulation and control inevitably increases along with this. During the 10-year period from 1980 to 1990, output from unified distribution coal mines as a proportion of total coal output in China declined from 55.5 percent to 44.5 percent while local coal mines increased from 44.5 percent to 55.5 percent. Within the coal output from local mines, the proportion of coal output from state-run coal mines has fallen while the proportion of output from collective and individual coal mines has risen from 38 percent in 1980 to 65.8 percent in 1990. Local coal mines, especially collective and individual coal mines, have limited resources, poor management, unstable production, and a tendency toward declining rates of growth in output, so they are stressing the prevention of production landslides, not reinforcing output growth.

Table 2. Structure of Coal Production Departments

Item	1980	1985	1986	1987	1988	1989	1990
Total coal output in China (million tons)	620	872	894	928	980	1,054	1,079
Output from state-run unified distribution coal mines (million tons)	344	406	414	420	434	462	480
As a proportion of total coal output in China (percent)	55.5	46.6	46.3	45.3	44.3	43.8	44.5
Output from local coal mines (million tons)	276	466	480	508	546	592	599
As a proportion of total coal output in China (percent)	44.5	53.4	53.7	54.7	55.7	56.2	55.5
Output from collective and individual coal mines (million tons)	105	238	243	261	295	386	394
As a proportion of output from local coal mines (percent)	38.0	51.1	50.6	51.4	54.0	65.2	65.8

Given the current situation in the structure of coal production departments, it will be hard to achieve an excessively large scale of extraction in coal plans. During the Seventh 5-Year Plan, state-run unified distribution coal mines only completed one-half of the scale planned for a start of construction, only placed two-thirds into operation, and carried over three-fourths of the scale in the plan to the Eighth 5-Year Plan, while local state-run coal mines only completed a little more than two-fifths of the planned scale for starting construction.

This shows that the pressure for increased output that can be borne by coal is very limited and that we cannot depend excessively on substantial increases in coal output over quotas to compensate for the shortage of energy resource supplies.

The degree of development of China's hydropower resources is low and we still have hydropower reserves equivalent to 1 billion tons of coal that are a powerful latent force in resolving the contradiction between energy resource supply and demand and could play an even greater role in the area of compensating for future energy resource shortages.

The "Outline" stipulates that electricity output should reach 1.1 trillion kWh in the year 2000. In view of the trend toward growing demand for electricity in China, we should strive for a power output goal of 1.2 trillion kWh. For this reason, based on these two objectives, and using three programs for electricity output from hydropower of 200, 250, and 320 billion kWh, we have estimated the fuel and motive power balance for the year 2000. The bases for the estimates are:

1. An upper limit of 80,000MW for the installed hydropower generating capacity;

2. Coal output of 1.4 to 1.5 billion tons;

3. Petroleum output of 170 to 180 million tons;

4. Natural gas output of 20 to 30 billion cubic meters;

5. Nuclear power output of 16.5 billion kWh;

6. Average utilization hours for power generation equipment of 4,000 for hydropower, 5,500 for thermal power, and 5,000 for nuclear power;

7. Average coal consumption for power generation using thermal power of 350 kg/kW [as published]. The results of the computations are given in Tables 3 to 5.

Table 3. Estimated Hydropower, Thermal Power, and Nuclear Power Electricity Supply Programs for the Year 2000

Total electricity output (billion kWh)	Electricity output (billion kWh)				Installed generating capacity (MW)				
	Hydropower	Nuclear power	Thermal power	Hydropower proportion (percent)	Hydropower	Nuclear power	Thermal power	Total	Hydropower proportion (percent)
	200		883.5	18.2	50,000		160,460	213,940	23.4
1,100	250	16.5	833.5	22.7	62,500	3,300	151,550	217 ,350	28.8
	320		763.5	29.1	80,000		138,820	222,120	36.0
	200		983.5	16.7	50,000		178,820	232,120	21.5
1,200	250	16.5	933.5	20.8	62,500	3,300	169,730	235 ,530	26.5
	320		863.5	26.7	80,000		157,000	240,300	33.3

Table 4. Estimated Fuel and Motive Power Supply Programs for the Year 2000

Year	Item	Energy resource supplies (billion tons of standard coal)	Coal (billion tons)	Petroleum (billion tons)	Natural gas (billion cubic meters)	Nuclear power (billion kWh)	Hydropower (billion kWh)
1990	Amount	1.04	1.079	0.138	15.3	0	126.4
	Percent	100.0	74.3	19.0	2.0	0	4.7
2000	Amount	1.346-1.486	1.4-1.6	0.17-0.18	20- 30	16.5	200-300
	Percent	100.0	74.3-72.1	18.1-17.3	2.0-2.7	0.4	5.2-7.5

Table 5. Coal Used To Generate Electricity as a Proportion of Coal Output, 2000

Year	W (billion kWh)	Wsh (billion kWh)	Wh (billion kWh)	M (billion tons)	Md (million tons)	m (percent)	ΔM (million tons)	ΔMd (million tons)	Δm (percent)
1989	584.7	118.5	466.2	1.054	251	23.8	25	14	56.0
1990	621.3	126.3	495.0	1.079	265	24.6			
		200.0	883.5		435	31.1-29.0		170	53.0-40.4
	1,100.0	250.0	833.5		411	29.4-27.4		146	45.5- 34.7
2000		320.0	763.5	1.4-1.5	376	26.7-25.1	321- 421	111	34.6-26.4
		200.0	983.5		484	34.6-32.3		219	68.2-52.0
	1,200.0	250.0	933.5		460	32.9-30.7		195	60.8- 46.3
		320.0	863.5		425	30.4-28.3		160	49.8-38.0

Note: W - Total electricity output in China

Wsh - Electricity output from hydropower

Wh - Electricity output from thermal power

M - Total coal output in China

Md - Coal used for generating electricity with thermal power

m - Md/M

ΔM - New increases in coal output

ΔMd - Amount of new coal used for power generation

μ - ΔMd/ΔM

The following conclusions can be derived from the above estimates:

1. To attain a power output of 1.1 to 1.2 trillion kWh by the year 2000, we must try to reach an installed hydropower generating capacity of 80,000MW, at which time China's total installed generating capacity would reach 220,000 to 240,000MW, in order to satisfy increased demand for electric power.

2. The proportion of power generated by hydropower should be increased from 20 percent in 1990 to about 28 percent by 2000 and hydropower as a proportion of our installed generating capacity should be increased from 26 percent to about 34.5 percent to begin taking the route of preferential development of hydropower.

3. The extent of power utilization of hydropower resources should be increased from 6.6 percent in 1990 to 17 percent in 2000 and the extent of capacity utilization should be increased from 9.5 percent to 21 percent to begin closing ranks with average world levels at present, and there would still substantial hydropower potential.

4. Coal use for power generation (not including coal used to supply heat by power plants) will be 380 to 430 million tons in 2000, equal to 25 to 30 percent of coal output in that year, which is slightly higher than the 1990 figure of 24.6 percent. New increases in the amount of coal used to generate power as a proportion of new growth in coal output will drop from 56 percent in 1990 to 26 to 50 percent in 2000. In a country like China that mainly consumes coal, major efforts to develop hydropower and reduce the pressure on demand for coal by thermal power will help improve the balance of supply and demand for coal in departments and environmental quality.

5. Hydropower as a proportion of primary energy resource production will increase from 4.7 percent in 1990 to 7.5 percent in 2000, which is equivalent to developing 157 million tons of coal. By substituting hydropower for thermal power, each kW of hydropower will replace 2.5 tons of coal a year, so at that time hydropower will replace 200 million tons of coal. Comparing the amount of coal that would have to be developed to its hydropower equivalent in the energy resource balance table, there would also be latent actual coal conservation benefits equivalent to 43 million tons of coal, which could also play a role in increasing energy resource supplies, compensating for energy resource shortages, and promoting a balance of fuel and motive power.

II. Exploit Hydropower's Potential, Reduce the Burden on Railroad Coal Haulage

China is a country that mainly consumes coal. Our coal resources that can be utilized are mostly distributed in Shanxi and Inner Mongolia (mainly western Inner Mongolia) in northern China and in Shaanxi in northwest China, but our key energy resource consuming regions are in east, northeast, and south- central China. To achieve a regional balance of fuel and motive power, we must form a strategic deployment of "transporting coal from west to east China" and "transporting coal from north to south China". China has extreme shortages of railroad freight capacity and passenger capacity and the passenger transportation environment is still at levels of the 1950's. It reached 950 million passengers in 1990 and we have consistently been transporting excess numbers of passengers for decades, which is far below the requirements of modern society. The burden of freight transportation, especially coal haulage, continues to grow. The railroad freight volume in 1990 was 1.46 billion tons, with coal accounting for 630 million tons, equal to 43 percent of our railroad freight volume. For this reason, reducing the burden on railroads of hauling coal would play a positive role in improving the railroad transportation environment and promoting a regional balance of fuel and motive power.

1. There will be an abrupt increase in the amount of coal being transported in the year 2000 and a greater trend toward a configuration of "transporting coal from west to east China" and "transporting coal from north to south China".

The estimated surplus between coal consumption and production in Shanxi Province, Inner Mongolia Autonomous Region, and Shaanxi Province in 2000 will be 486 million tons, but these three provinces and autonomous regions only shipped out 155 million tons of coal in 1990, so there will be a 2.2-fold increase. An estimated 70 million-plus tons of coal will be shipped into northeast China in 2000, which is 2.8 times the amount actually shipped in during 1990. An estimated 170 million-plus tons of coal will be shipped into east China in 2000, which is 2.6 times the amount actually shipped in during 1990. An estimated 120 million-plus tons of coal will be shipped into south- central China in 2000, which is 6 times the amount actually shipped in during 1990. An estimated 10 million-plus tons of coal will be shipped into southwest China in 2000, which is 2.9 times the amount actually shipped in during 1990. Thus, the direction of flow for coal in 2000 will be centered on Shanxi, Inner Mongolia, and Shaanxi and extended toward northeast China, the southeast coast, south-central China, and southwest China, and the universal increase in the amount of the flow will undoubtedly increase pressures on railway transportation.

2. Actively develop hydropower, try to achieve "transmission of power from west to east China" as quickly as possible to reduce the railway coal haulage shortage and reduce the pressure on coal extraction.

The transportation capacity for shipping coal out of Shanxi, Inner Mongolia, and Shaanxi is now about 270 million tons, so there is now a need of rapidly supplementing 216 million tons of transportation capacity shortage if they are to ship out 486 million tons in 2000. The east China and south-central China regions mainly ship in coal from the "three wests" [Shanxi, western

Inner Mongolia, and Shaanxi], so there will be a 60 million ton transportation capacity shortage. The southwest China region is unable to achieve an intraregional balance for coal. With the exception of Guizhou, which transfers out coal, over one-half of the coal consumed will be hauled into Sichuan from Shaanxi and Shanxi, so there will be an expected transportation capacity shortage of more than 7 million tons. If we are unable to make rapid improvements in transportation conditions on railroads, maritime transportation, and river transportation, it will be a big restricting factor on achieving a regional balance of fuel and motive power in the year 2000.

In summary, considering the national and regional balance of fuel and motive power and transportation capacity conditions in the year 2000 and into the future, there is an objective need to accelerate hydropower construction in China to achieve as quickly as possible the "transmission of power from west to east China", focused improvement of energy resource supply conditions in the east and south-central China regions, partial compensation for transportation capacity shortages via railroads and maritime and river shipping, and reduced pressures on coal extraction. These are problems we should start resolving now.

The Fluidized-Bed Boiler: Breakthrough in China's Coal Combustion Technology

926B0116C Beijing ZHONGGUO NENGYUAN [ENERGY OF CHINA] in Chinese No 6, 25 Jun 92 pp 38-39

[Article by Yuan Chunsheng [5913 2504 3932] of the State Council Production Office: "China Makes Another Important Breakthrough in Coal Burning and Energy Conservation Technology with Successful Trial Operation of the First Chinese-Made 75 Tons/Hour Circulating Fluidized-Bed Boiler"]

[Text] In March 1992, an energy conservation demonstration project jointly organized by the Ministry of Materials, State Planning Commission, and State Council Production Office, the 75 tons/hour circulating fluidized-bed boiler at Shengxian County Power Plant in Zhejiang Province, underwent successful trial operation carrying 6MW of heat supply generators. The operationalization of China's largest capacity circulating fluidized-bed boiler at the present time is an indication that coal burning technology in China has achieved major breakthroughs in the areas of high efficiency and low pollution that are very important for promoting upgrading of boiler technology, promoting conservation of energy resources, and improving economic results in China.

Circulating fluidized-bed boiler combustion of coal is a new type of coal burning technology that has been developed during the past decade and is a major innovation compared to traditional grate furnaces and pulverized coal furnaces. It has been called the third generation of new coal burning technology. Its characteristics are: high combustion efficiency, as much as 98 to 99 percent; good desulfurization results, and limestone can be added for relatively simple desulfurization within the furnace, opening up a route to economical burning of high-sulfur coal; good adaptability to burning all types of coal, with a relatively low temperature inside the fluidized combustion furnace chamber, generally 850 to 900°C, and relatively low discharges of nitrous oxides (NO_x). Another prominent characteristic of this furnace is flexible regulation with changes in load at a speed of 5 percent per minute within a range of 25 to 100 percent. This characteristic is adapted to China's power plants for heat and power cogeneration that have unstable loads, and it can develop in the direction of larger models.

Circulating fluidized-bed boiler technology was a state project to attack key problems in China during the Sixth 5-Year Plan and Seventh 5-Year Plan. After operationalization of a 10 tons/hour circulating fluidized-bed boiler in 1988, 20 tons/hour and 35 tons/hour boilers were placed into operation in succession. Besides the Shengxian County 75 tons/hour project (100 vane window graded circulation) that has already gone into operation, there are 55 tons/hour, 65 tons/hour, and 75 tons/hour boilers now under construction. Qinghua University and Jiangxi Boiler Mill also successfully upgraded a 20 tons/hour chain furnace at Jiujiang Chemical Fertilizer Plant into a 35 tons/hour circulating fluidized-bed boiler.

The 75 tons/hour graded and separated circulating fluidized-bed boiler at Shengxian County Power Plant (Model NG-75/3.82-M 1) was developed cooperatively by the Chinese Academy of Sciences Engineering Thermophysics Institute and Hangzhou Boiler Mill. Experts consider the development of this boiler to be basically successful.

This boiler is a framework-type all-steel structure single furnace tube with natural circulation and centralized descending tubes that overall has a "Π" type semi-open dual-layer configuration structure.

The front part of the boiler is the furnace chamber (composed of two parts, an upper membrane-type water-cooled wall furnace chamber and lower combustion chamber). The first stage of the furnace chamber outlet is a high-temperature inertial separator fabricated from a special type of material. The second stage is a low-temperature cyclone separator. Separation of the two stages guarantees a high efficiency of separation.

The performance requirements of this boiler are:

1. Guaranteed efficiency $\geq$ 87 percent (with design fuel);

2. Desulfurization efficiency (at a sulfur content $>$ 3 percent and Ca/s $<$ 2 hours) $\geq$ 80 percent;

3. Original soot discharge concentration $<$ 20 g/m^3 (standard);

4. Guaranteed design parameters for the boiler at 75 to 100 percent of the rated load, guaranteed safety of the boiler circulation water at 50 percent of the rated load;

5. Mixed fuel: A^V = 20 to 50 percent; W^V = 8 to 20 percent; $Q^V ow$ = 25,120 to 10,467 kJ/kg (6,000 to 2,500 kcal/kg).

The design of this boiler absorbed design, fabrication, and operation experience and lessons from similar products made in China and foreign countries, took into consideration the characteristics of circulating fluidized-bed boiler positive pressure operation on sealing and prevention of wear to heated surfaces inside the boiler, adopted a fully-sealed furnace chamber, and employs corresponding wear prevention measures on non-heated surfaces and all easily worn components.

Only 70-odd days have passed since operation at load on 9 February 1992 at the 75 tons/hour circulating fluidized-bed boiler at Shengxian Power Plant and its advantages are manifested in:

1. Energy conservation: Over 98 percent of the carbon is completely burned up and an extremely small amount of slag is discharged, 2 percent combustible material, so the projected thermal efficiency is greater than 85 percent. There was a more than 15 percent reduction in coal consumption to generate power. It can conserve 14,000 tons of coal each year at a value of more than 1 million yuan. The investment can be recovered in 2 years from the coal savings alone. Construction of a heating network for this project is now being speeded up and coal consumption may drop to less than 400 g/kWh after heat is supplied and may be even lower than a 200MW condensed steam generator.

2. Peak regulation: Because circulating fluidized-bed boilers have excellent load adaptability characteristics, they can operate stably under a variety of loads and require no sprayed oil to assist combustion. Moreover, load variation regulation is quick and the furnace can be shut down to suppress the fire. The entire units can be started up from a cold state in less than 5 hours and started up from a hot state in about 1 hour. This is especially appropriate for regions in China that have major day and night heat load variations. Shengxian County is also a county with the largest installed hydropower generating capacity in Zhejiang Province, and small-scale thermal power must conform to the characteristics of small-scale hydropower peak regulation. Circulating fluidized-bed boilers have flexible regulation properties and can reduce consumption of oil, coal, electricity, and so on related to generator shutdown and startup, which also produces a corresponding improvement in enterprise economic results.

3. Fuel adaptability: Circulating fluidized-bed boilers can burn "three high and one low" coal (high ash content, high water content, high sulfur content, low heat value) and they can burn coal slag from other grate furnaces.

4. Operating manipulability: This was the first time Shengxian Power Plant had used a circulating fluidized-bed boiler and it had no experience. Actual debugging and trial production, however, provided a widespread indication that it was more stable and operated better than chain furnaces and it was welcomed by the employees.

5. Easy comprehensive utilization of ash and slag: The ash discharged by the circulating fluidized bed at Shengxian County can be used to make bricks and tile, and it has substantial heat value for use as internal heat to reduce energy consumption in brick and tile production. Because the furnace slag is burned at low temperatures, its activation is rather good and it can be used as a superior quality mixing material for cement.

The expected total investment for this project is about 16 million yuan (including the heating network project), which is a construction cost of 2,666 yuan per kW, an investment savings of at least 1,000 yuan per unit kW compared to similar regional heat and power cogeneration plants. The project took only 1 year and 3 months from excavation of the foundation at the end of 1990 to its completion of 72 hours of trial operation on 17 March 1992, about one-half year faster than heat and power cogeneration plants of similar scale. The low construction cost and short construction schedule further improve enterprise economic results.

Practice has proven that adopting circulating fluidized beds to achieve heat and power cogeneration is an important route for technical progress in small thermal power plants. As a new combustion technology, it requires continual practice before it can gradually become mature.

Circulating fluidized-bed boilers have broad applications prospects and potential in China. The relevant departments have already made increasing the scale of circulating fluidized beds a key project to attack S&T problems during the Eighth 5-Year Plan and, while actively borrowing on advanced technology and experience in foreign countries, the state and relevant units should also provide appropriate policy and capital support for several construction projects and development units to apply and develop circulating fluidized-bed technology more quickly in several realms in China.

Area in Northern Shaanxi Found To Be Rich in Coal, Oil, Natural Gas

926B0097A Shanghai WEN HUI BAO in Chinese 3 Jun 92 p 1

[Article by special correspondent Li Qigui [2621 0366 6311]]

[Text] Exclusive for WEN HUI BAO from Xi'an: The Yulin area in northern Shaanxi has become one of the few energy and heavy industry and chemical industry development bases in China. According to the Shaanxi geological authorities, about 40 different minerals in eight categories have been discovered in this area. The specific quantities of about 20 minerals have been verified and designated as controlled reserves. They are: coal, natural gas, oil, kaolin, bauxite, salt, mirabilite, limestone, quartz sand, etc. It is very rare in China that valuable minerals such as coal, natural gas, oil, and kaolin, are found in concentrations in one area. This area is an ideal base for energy and heavy industry and chemical industry development.

The Dongsheng Coal Field in Shenfu was formed in the Jurassic period over 140 million years ago. Up to now, verified reserves are about 223.6 billion tons; and overall prospective reserves are 860 billion tons, or over 30 percent of China's proved reserves. The reserve in the Yulin area is 70 times that of the Datung reserve, and 160 times that of the Fushun reserve. This makes the Dongsheng coal field one of the few exceptionally large, high-quality coal fields in the world. The Dongsheng coal field, one of the seven largest coal fields in the world, produces superior quality coal (very low ash, sulfur and phosphorus contents; but high in heating value, as high as 6,900-7,200 kilo-calories per kilogram of coal), and the field is easier to mine because of its thick coal seams and shallow buried layers. The entire coal field straddles the territory of Shaanxi and Inner Mongolia. The coal reserves in the seven counties of the Yulin area amount to over 70 percent of the total reserves in the territory.

The discovery of the natural gas field in northern Shaanxi positioned China as a significant member in the world's energy community. There are three verified, highly concentrated natural gas reserves in Yulin: in the Zhenchuan region of Yulin City, a reserve of 3.52 billion cubic meters is under control; in the Jingbian-Hengshan region, the center of abundant concentration, a reserve of 80.4 billion cubic meters in a deep drilling area of 1,200 square kilometers is under control; and in the Zizhou County region, a reserve of 5 billion cubic meters is under control. Beginning last winter till this spring, over 10,000 people were mobilized to aggressively prospect the natural gas resources in Northern Shaanxi. A great underground prospecting breakthrough took place in the 3,200 square kilometers of Jingbian and Hengshan Counties. The controlled reserves of the area surpass far beyond 100 billion cubic meters, and this area joins the rank of world-class natural gas fields. Currently natural gas is pumped up in Zhidan and Anzhai counties in Yan'an region, moving the range of the natural gas field much farther south.

There are also tremendous amounts of reserves of oil and kaolin in Yulin. Particularly, the kaolin reserves amount to over 800 million tons, or two-thirds of the total proved reserves in China. Kaolin is a widely used material in the electronics industry, the rubber, paper, and other chemical industries as well as in highly sophisticated areas of science and technology.

Shanghai-Made 125MW Generators Said Comparable to World's Best

926B0101A Shanghai JIEFANG RIBAO in Chinese 14 Jun 92 p 1

[Article by reporter Zhang Zhiyuan [1728 5268 6678]: "Shanghai's Power Plant Manufacturing Industry Much Stronger, Its Products Can Be Found Everywhere in China, Performance Catches Up With and Surpasses International Levels"]

[Text] Shanghai's large-scale power plant manufacturing industry has decided to supply its 100th 125MW generator to Jingdezhen Power Plant in Jiangxi. This sales contract was signed between Shanghai Integrated Electric Company and Jingdezhen Power Plant on 13 June 1992.

China now has over 80 125MW generators in operation with a total installed generating capacity of more than 10,000MW, equal to about one-tenth of China's total thermal power installed generating capacity, and the products are now spread throughout 20 provinces and municipalities including Tianjin, Shandong, Jiangsu, Zhejiang, Shanghai, Guangdong, and others. All of these 80-plus generators were jointly manufactured by more than 30 key large and medium- sized enterprises in Shanghai and their primary and auxiliary equipment matchup capacity has now reached about 85 percent. In particular, the four plants with primary manufacturing responsibility, Shanghai Steam Turbine Plant, Shanghai Electrical Machinery Plant, Shanghai Boiler Mill, and Shanghai Power Plant Auxiliary Equipment Plant, have been constantly making improvements and making the performance of their generators increasingly perfect and mature. Compared to representative similar generators imported from foreign countries, the primary indices for the operational reliability and economy of the 125MW generators in operation at Tianshenggang in Jiangsu and Huangpu in Guangdong are both as high as or higher than levels for products in any industrially developed country.

Through the unremitting efforts of several generations of S&T personnel, heat consumption in China's 125MW generators has been reduced to 2,040 kilocalories/kWh, a reduction of more than 50 kilocalories compared to products in earlier times, and each generator can conserve about 6,250 tons of standard coal a year, which is equivalent to 1.5 million yuan renminbi.

Newly Installed Capacity Exceeds 5 Million kW in First Half of Year

92P60369 Beijing RENMIN RIBAO in Chinese 3 Jul 92 p 1

[Text] Electric power capital construction has surpassed the target for the first half of the year. Up to 30 June, 29 large and medium-sized generating units with a total capacity of 5.25 million kW have gone into operation, accomplishing 63 percent of the yearly state plan.

Scientific Research Work for Three Gorges Project Reviewed

926B0117 Beijing SHUILI FADIAN [WATER POWER] in Chinese No 6, 12 Jun 92 pp 38-43, 65

[Article by Chu Chuanying [0328 0278 5391] of the China Three Gorges Project Development Corporation (Preparatory): "Review and Prospects of Scientific Research Work on the Three Gorges Project"]

[Text] The Three Gorges project is a huge project that has attracted world attention, and its construction will have a profound impact on China's socialist construction. For a long time, under the personal concern of the CPC Central Committee and State Council, a great deal of work has been done throughout China. Re-appraisal work related to the Three Gorges project has now been completed and leading comrades of the State Council heard a comprehensive report on the appraisal work in July 1990. In July 1991, the State Council Three Gorges Project Examination Committee examined the "Chang Jiang Three Gorges Key Water Conservancy Facility Feasibility Research Report" compiled by the Chang Jiang Water Conservancy Commission. The 5th Session of the 7th National People's Congress held not long ago passed a decision concerning construction of the Chang Jiang Three Gorges project. This was an enormous encouragement to all the people of China. To match up with the appraisal work, several thousand scientific research personnel throughout China (including researchers, engineers, experiment personnel, and professors) and several tens of renowned scientific research units and institutions of higher education proposed over 1,000 scientific research achievements concerning the Three Gorges project, and many of the scientific research achievements attained international levels and vanguard levels in China at the present time. These achievements have provided a reliable foundation for appraising the Three Gorges project and compiling the Three Gorges project feasibility research report.

Reviewing the past, scientific research work for the Three Gorges project had already gotten underway in the 1950's. The State Science and Technology Commission included the Three Gorges project among key state scientific research projects in 1958 and made several 10,000 scientific research achievements. All of these achievements reflected rather high levels within China at the time. After the 1960's, research work on the Three Gorges project took a tortuous route and work in this area did not return to the right track until the beginning of the 1980's. To promote intensive appraisal work for the Three Gorges, the State Science and Technology Commission arranged for research projects in 10 areas including silt, water-borne shipping, geology, hydraulic engineering, ecology, the environment, and so on and scientific research on these 10 areas was included in projects to attack key problems during the Seventh 5-Year Plan in 1986. At the same time, the Three Gorges Project Development Corporation (Preparatory) arranged for several tens of topics for preparatory scientific research. From 1985 to 1991, overall scientific research work for the Three Gorges project composed of these two groups of research projects was divided into 10 parts and a total of more than 1,150 scientific research achievement reports were submitted. I will briefly describe these 10 parts based on my understanding of the situation.

I. Research on the Silt and Water-Borne Shipping Questions for the Three Gorges Project

Since 1985, a great deal of experimental research work has been done on the questions of silt and shipping, with the studies focusing on these issues:

1. Analytical research on the conditions of the water and silt that would enter the Three Gorges reservoir. Analysis was done of the trends of silt arriving from the region above the Three Gorges covering a period of several years. On the basis of analyzing measured silt information and applying fuzzy mathematics and gray control system theory, analysis was done of the measured data to explore the laws of silt arriving from upstream and to do macro research on the role of upstream reservoirs in impounding silt (including small reservoirs on tributaries) and its impact on the Three Gorges project.

2. Silt flushing and accumulation in the Three Gorges backwater variation region and riverbed evolution and their impact on flood control and water- borne shipping. This research project combined actual models and mathematical models to conduct the research and established a total of nine actual models with boundary conditions supplied by the results of one-dimensional mathematical model computations. The mathematical model computations for silt in the entire reservoir region were done in parallel by two units. The research focused on solving these questions: 1) Whether or not the water impounded in the reservoir could be utilized over the long term. The research indicates that adoption of an operational arrangement to "impound clear water, discharge turbid water" would permit the retention of a large part of the effective reservoir capacity, that about 85 percent of the flood prevention reservoir capacity could be retained, and that more than 91 percent of the regulation reservoir capacity could be retained. 2) The impact on shipping of the movement of water and silt in the backwater region and evolution of the riverbed. The results of experimental research indicate that dangerous shoals in the backwater region would be submerged during normal years and that there would be a significant improvement in the shipping channel. During the period lasting about 5 to 6 months before and after the rainy season each year, 10,000-ton vessels could directly reach the Jiulong Harbor region at Chongqing. There would be improvements to different degrees of the dangerous shoals in the variable backwater region, but accumulative sedimentation would occur at some ports and docks like the slope at Jiulong slope and both sides of Chaotianmen. After the reservoir has been in operation for about 20 years, it could affect the passage of ships and dock operations, so

comprehensive measures like improvement, optimized reservoir dispatching, and so on would have to be adopted to deal with this. 3) The impact of reservoir silt accumulation on flood prevention at Chongqing City. The research indicates that after the reservoir has been in operation for 100 years, silt accumulation would raise the level of floodwaters during 100-year floods at Chongqing by 4.79 to 6.35 meters and the water level at Chaotianmen in Chongqing would be about 199 meters. There is hope of lowering water levels during floods if attention is given over the next 100 years to good soil conservation work and building upstream reservoirs.

3. The questions of river conditions, silt accumulation, and ship passage in the dam area. The overall research was done by arranging to conduct three models in parallel. The research results indicate that before a silt accumulation equilibrium is attained in the reservoir, it would tend to increase as the time of operation is extended. There would not be substantial silt accumulation in the temporary locks and pilot channels for ship passage during construction and it could be dealt with via mechanical dredging. During the later period of reservoir operation, silt accumulating in the upper and lower pilot channels that would obstruct shipping would reach 1 million m^3 and 1.3 million m^3, respectively, which would affect the passage of ships, and it would have to be dealt with by installing silt flushing gates, further optimizing river situation programs, or other measures.

4. The impact of scouring downstream from the Three Gorges reservoir on the lower reaches and mouth of the river. The research indicates that long- distance scouring would occur in the river channel downstream from the dam during 40 to 50 years of operation of the reservoir and that water levels would drop. The water level at Yichang would drop 1.7 to 2.1 meters below the design line of Gezhouba (at a flow rate of 5,000 m^3/s) and floodwater levels on the Jing Jiang would drop about 3 meters. Research on the impact on the mouth of the river indicates that saltwater intrusion during moderately wet and wet years would not affect the water quality, but the chlorine concentration would increase slightly during dry years. Regarding the shipping channel that enters the sea, the longitudinal length of the bars at the river mouth may shrink, so overall it can be stated that there would be not an appreciable impact on the mouth of the Chang Jiang.

5. The question of the passage of 10,000 ton-grade flotillas after the Three Gorges project is completed. Simulation experiments of actual passage of 10,000 ton-grade flotillas at Xitan, Shuitianjiao, Huangcao Gorge, and other primary dangerous shoal control segments on rivers was used to explore dimensional standards for the shipping channel and the impact on shipping of daily regulation at power plants between the two dams (the Gezhouba project to the Three Gorges project). Two hydraulic model experiments indicated that daily regulation by the power plants basically would have no effect on shipping.

Research over 7 years produced several rather high-level scientific research achievements that provided a reliable foundation for appraising the Three Gorges project and compiling the feasibility research report. Mathematical models and actual models were used in the research, with more actual models being employed and there are few instances internationally of work done with comparable intensity.

II. Hydraulic Research on the Three Gorges Project Key Facility and Shipping

Hydraulic research on the Three Gorges project key facility and shipping was divided into three areas.

1. The issue of the effect of the configuration of the Three Gorges project key facility on the overall situation of the Three Gorges project. The Chang Jiang Academy of Sciences and Water Conservancy and Hydropower Academy of Sciences did experimental research on, respectively, two overall hydraulics models for Wuhan and Beijing and prepared a total of six types of flood relief structure and power plant configuration programs. These six programs were divided into open diversion channel ship passage programs and open diversion channel no-passage programs. The hydraulics questions regarding the sluice structures mainly involved research on the hydraulic characteristics of surface outlets including sluicing capacities and pressure distributions, cavitation characteristics of spillway surfaces, and facilities to reduce corrosion by the mixed-in air. Research was also done on adoption of a program for partial overflow over the top of the plant buildings to reduce the leading edge of the overflow.

2. The difficulties of the hydraulics issues for the Three Gorges project are the high head, large body of water to be transferred, and large amplitude of upstream and downstream water level changes regardless of whether a multi- stage continuous lock or decentralized multi-stage lock program is adopted. Some of the hydraulics indices exceed world levels at the present time. Model research was done on four places, Wuhan, Yichang, Nanjing, and Tianjin by, respectively, the Chang Jiang Academy of Sciences, Nanjing Water Conservancy Academy of Sciences, and Tianjin Water-Borne Shipping Scientific Research Institute. Research was done first on model selection, with experimental research being done on models for a decentralized 3-level program, continuous 4-level program, and continuous 5-level program. Next, experiments were conducted on the hydraulic characteristics of water transfer in the lock chambers and ship berthing conditions. The experiments showed that when using fast-opening valves (t_v = 1 s), the water transfer time would be less than 12 minutes while using slow-opening ones would take more than 12 minutes. However, when a multi-stage ship lock chamber is flushed, the force of the tie-up cables would perform a controlling function, so measures would have to be adopted to reduce the energy of the water flowing into the lock chamber. Experimental research was carried out on top

expansion form and an abrupt expansion form for cavitation of the restraining valves. The research showed that an abrupt expansion form is significantly superior when there are rapid-opening valves. Research was done in the area of valve hydraulics focused on opening speed, valve type, and ventilation measures behind the valves.

3. Model experiments were conducted on the diversion schedule and diversion hydraulics by the Chang Jiang Academy of Sciences and Water Conservancy and Hydropower Academy of Sciences at, respectively, Yichang and Beijing, and comparative research was carried out on two types of temporary ship passage programs.

III. Structural Research on Hydraulics and Ship Passage Structures for the Three Gorges Project

The Three Gorges key water conservancy facility is composed of three main structures—a large dam, ship passage structures, and power station—and the structure is relatively complex. The most complex structure in the large dam as a whole is the multilevel large-opening spillway dam section. The overall research work was divided into three areas: 1) Analysis of the structure of the overflow dam section; 2) Analysis of the underwater structure of the steel intake piping and powerhouse; 3) Analysis of the structure of the ship locks.

The overflow dam section has a multilevel large opening structure. A representative program selected in the feasibility report has three sluice openings: surface openings, deep openings, and diversion bottom openings. Because of the large openings and multiple levels, the rationality of the distribution of stress on the body of the dam is related to the acceptability of the multilevel opening program configuration. A three-dimensional photoelastic experimental method was used during the research, as were three- dimensional finite element computations. The computations simultaneously used SAP84, ADINA (edition 5.0), and FIESTA to make the calculations. In addition, the NOLM-85 finite program was used to compute 18 programs for the temperature stress on this section of the dam (including two programs: rapid pouring and pouring by seams and blocks). The results of the research indicated that the multilevel large openings seriously weakened the dam form. Dynamic finite element analysis and dynamic modeling experiments were also conducted for the body of the dam and the dynamic safety of this section of the dam was also analyzed. Degree of reliability theory and methods were used in the research to assess the safety of the body of the dam and all positions.

The intake penstock for the behind-the-dam plant building at the Three Gorges project is 12.3 meters in diameter. The non-calculated water hammer value PD is 145.14 kN/cm, making it a huge penstock. Research on the penstock focused on three questions: 1) A configuration in which the steel piping is fully buried within the dam and structural analysis; 2) A configuration for shallow burial of the steel piping in the body of the dam and stress analysis; 3) A configuration with a steel-encased steel-reinforced concrete piping structure and analysis. Analysis of underwater structures at the power plant focused on research on two questions: 1) Overall calculation of the modal characteristics of the underwater structures, analysis of structural vibration source mechanisms, and resonance checks, as well as analysis of their overall dynamic reactions under the effects of earthquake and generator dynamic loads. 2) Plant building underwater structure integral finite element analysis and three-dimensional photoelastic experiments.

Structural research on the Three Gorges ship locks included these three areas:

1. Selection of the structure of the ship locks, including selection of the lock head structure and selection of the lock chamber structure. Research on the lock head structure focused on a separated structure and integral structure, and exploration of the effects of different baseplate thicknesses. During selection of the lock chamber structure, comparisons were made of a gravity type, lined type, and mixed type, and detailed research was conducted on anchoring arrangements for a thin lining.

2. During analysis of ship lock anchor rod stress and anchoring plate stress, research was done on interactions among the chamber baseplate, anchor rods, and bedrock and on the stress from slow temperature changes on the concrete baseplate.

3. Overall stability and local stability in the ship lock region. Because the tall slopes in the ship lock region are as much as 130 meters high, maintaining the stability of the tall slopes is extremely important, so research was done focused on the tall slope question. Research was also done on the local stability of the special zones where faults and fractures have developed (such as F215). Geomechanics models and three-dimensional finite element computations were employed during the stability research.

IV. Research on Geological, Rock Dynamics, and Earthquake Questions for the Three Gorges Project Reservoir and Dam Region

This research got underway during the mid-1950's and as far back as the 1950's to mid-1960's a great deal of basic geological research and dam region, dam section, and dam site comparison and selection had been done. During the Seventh 5-Year Plan, further intensive experimental research was also carried out in the five areas listed below in conjunction with the appraisal work.

1. The question of crustal stability at the dam site and surrounding region. Intensive exploration was carried out in the research on deep geological structural characteristics, primary fault and fracture activity, earthquake risk in the dam region, and other areas. For the "Sandouping Region NNE Strike Linear Image" derived from interpretation of synthetic aperture radar images, it was confirmed through trenching, caving, exploratory drilling, surface surveys, and shallow strata seismic sounding that this linear image was not a fault-fracture structure and that there were no concealed faults or fractures associated with it. The "Shizikou NNW Strike Linear Image" derived from interpretation of

color infrared images is mainly a comprehensive reflection of steeply-dipping rock beds and small faults with an almost north-south strike as well as steep cliffs and gullies within a zone 10-odd kilometers from the south bank of the Chang Jiang, and there are no large faults or fractures with a NNW strike. The research showed that the crustal stability in the Three Gorges region is relatively good and that the stability and safety of the Huangling crystalline rock block where the project is located is even better.

2. Research on reservoir induced earthquakes began by exploring the formational mechanisms and occurrence processes of reservoir induced earthquakes and made comparative studies with existing reservoir induced earthquake precedents in conjunction with regional stress field testing, and observed the intensity of seismic activity in key areas. The research considered three reservoir sections. The Yumiao He reservoir section at the dam site does not have the conditions for the occurrence of relatively strong reservoir induced earthquakes but the possibility of the reservoir inducing roughly magnitude 3 shallow source small earthquakes after impounding water could not be eliminated. In the Miao He to Baidicheng reservoir section, two earthquake zones cut through the reservoir section and the occurrence of relatively powerful reservoir induced earthquakes is possible (the maximum estimated earthquake magnitude was about magnitude 5.5). The results of preliminary analysis of the greatest risk of earthquakes induced by the reservoir indicated that, assuming that an induced earthquake with a strength of magnitude 6 occurred in the Jiuwanxi fault nearest the dam site, the earthquake intensity affecting the Sandouping dam site similarly would not exceed magnitude 6. Seismic activity is very weak in the reservoir section above Baidicheng and in general it does not have the conditions to cause reservoir induced earthquakes.

3. The reservoir bank stability question. The reservoir banks would extend for a total length of about 1,300 kilometers and have rather good overall stability conditions. Based on the river valley's structure and lithology and the combination of the two, the current situation in bank slope stability, and other conditions, over 80 percent of it would have relatively good stability condition, but there are 14 sites with poor stability conditions. Deformation is already occurring at eight sites including Lianziya, Xiangxi, Huanglashi, and so on. Monitoring is now being done at Lianziya, Huanglashi, and other key reservoir sections and prevention and control programs are in effect.

4. Research has been done in many areas on the stability of the high slopes in the dam region. They include engineering geology characteristics and stability analysis of the high slopes, geological stress field testing and analysis, anisotropic vadose field research for non-homogeneous rock bodies on the high slopes, and monitoring technology for the high slopes. Engineering questions regarding rock bodies in the dam region involve preliminary research focused on rock body structures, rock body stability, geological stress fields in the dam region, fractured rock body hydraulics and rock mechanics and experiments in the dam region, and so on.

5. Environmental geology evaluations and forecasts for the Three Gorges project.

V. Research on Construction Technology and on Construction Machinery and Materials for the Three Gorges Project

The Three Gorges project will involve a large amount of engineering and complex construction. Research over the past 7 years has been focused on questions in these areas:

1. The form, structure, and construction technology for the second phase deep water earth and rock weir. Several programs were compared for the form of the weir and several experimental studies were conducted on the physical, chemical, and mechanical properties of the construction fill material—weathered sand—and on the depth, natural slope, and so on after the fill is dumped. Research was also done on weir stress and strain, cross section optimization, boring technology for the weir's leakage prevention wall, monitoring technology for the weir, and so on.

2. The rolled concrete weir for the third phase. A proposal was made to utilize rolled concrete with a high mixture of powdered coal ash for the weir material and to conduct intermediate testing on the weir at Yantan Hydropower Station to explore the possibility of pouring 1.3 million m^3 during the dry season and raising it to 90 meters.

3. Research on rapid construction technology for the concrete at the large dam. Detailed analysis was done of all links including construction loading bridges, cranes, horizontal transportation, trimming and vibrating, the mixing building, and so on. Research was also done on rapid pouring and temperature control and the possibility of pouring 4.6 million m^3 in 1 year was appraised.

4. Comprehensive research was done on construction on the high slopes. In the area of construction machinery, research was done on design programs for an automated mixing building and a 4 X 3 m^3 mixing building was used at the Wuqiangxi construction site. Feasibility research was done on the long arm overhead tower crane, and a CF_{1B} reverse cycle excavator was developed to excavate the deep trench for the core wall of the weir for the second phase. Concrete tank cars, spreaders, and other equipment were also developed.

In the area of construction materials, research was done on selection of product quality of the cement and powdered coal ash used in the concrete, and we developed external additives, did comparative experiments on artificial sand, did concrete grade mixing experiments and tensile experiments on large samples (non-wet screens), did experiments on the thermal performance and slow changes of the concrete, and conducted research on special types of shock-resistant and wear-resistant concrete.

VI. Research on Key Technologies for the Ship Lift and Large Metallic Structures at the Three Gorges Project

Research on the ship lift for the Three Gorges project began in 1958. After a great deal of program comparison and scientific research work over a long period, a one-stage vertical ship lift program was selected. A steel cable hoist weight-balancing arrangement was adopted for the main part. It includes a ship carrying compartment, cable hoist lifting equipment, weight balancer, weight-bearing tower column, and so on. Studies on the speed and hydrodynamic characteristics of ships entering and leaving the ship compartment suspended from the steel cables did experiments on the overall dynamic model at the Nanjing Academy of Sciences and Chang Jiang Academy of Sciences. Research has been done on the uneven force on the 48 lifting cables in the ship compartment during the lifting process, on the problem of local stress created by the abrupt braking action at the suspension points at the four corners of the ship compartment, on hydraulic balancing equipment, and so on. Preliminary achievements were made in synchronized lifting for the lifting mechanism of the ship lift, development of a large-dimension rotating tube, and so on. The key to guaranteeing safety during operation is preventing water leaks in the ship compartment, breakage of the steel cables, and other accidents, and specialized research was done on these questions.

Several programs were studied for the weight-bearing tower column of the ship lift. The temperature field and temperature stress on the tower column when illuminated by the sun concerned the selection of the tower column, and specialized research was done on this. Research was done on two programs for the upper lock head of the ship lift, a separated type and an integral type, as was temperature field and temperature stress analysis for the upper lock head, to provide a basis for model selection in the preliminary design.

Research was also done on the large penstock for the Three Gorges project, and survey research was done on Chinese-made high-strength steel plate for materials selection. The research results indicated that the two programs for the penstock and steel-encased steel-reinforced concrete piping each had its advantages and disadvantages, and that the steel to be used could be produced within China. The inverted V-shaped ship locks at the Three Gorges project are 37 meters high and have an operating water depth of 35 meters. Experiments were done on models for their operating resistance, startup arrangements, and so on.

VII. Research on the Large Generators and Comprehensive Automation Technology for the Three Gorges Project

The big generators at the Three Gorges project will have a single unit capacity of 680MW. Two programs were studied for selection of the single unit capacity, one program for 680MW and the other for 800MW. The 680MW generators can be manufactured in China but the equipment in the plants for the 800MW generators would have to undergo technical upgrading and they would be more difficult to manufacture, but there would be benefits for the configuration of the key facility and economic results. Water turbine model selection and optimum selection of water turbine characteristics and water turbine parameters is now under way. Mathematical modeling calculations and physical modeling calculations were also done for the through-flow portions of the water turbines for the Three Gorges, and a preliminary model water turbine rotor has been developed for the Three Gorges power station, which is a step toward further development of higher efficiency rotors. In the research, we also conducted comparative experiments with a model rotor supplied by Canada and made rather good achievements. Regarding the generators, optimum selection of generator parameters has been done, as has research on model changes for the generator thrust bearings. We have also focused on developing a new type of fluorine plastic thrust bearing material and structure, and made initial achievements. In the area of connection of the power station to the electric power system, we have studied a mixed AC/DC connection arrangement and done research on the reliability of the electrical connecting lines. Preliminary research has also been done on a comprehensive automation system program for the Three Gorges project, including a regimen measurement and reporting system and reservoir dispatching system. The power station's monitoring and control system, Three Gorges-Gezhouba integrated ship passage dispatching system, safety monitoring and control system, and communications system form the comprehensive automated system for the Three Gorges project.

VIII. Research on the Electric Power System for the Three Gorges Project

After the Three Gorges project is completed, it will inevitably form an ultrahigh voltage, multiple large region integrated electric power system centered on the Central China Power Grid in the region where the Three Gorges power station will be located. This electric power system will cover a broad region and concern many factors, and it involves substantial technical difficulty and a long construction schedule, so research is necessary from the perspective of macro strategies. This research focused on studying the following areas: 1) Research on power source programs and balanced development of energy resources to study the economic rationality of the Three Gorges power station from the perspective of large systems. The research work started with the load requirements of the region to be supplied with electricity by the Three Gorges to optimize the power source structure of the power supply region system and started with total demand for coal and electricity in China to optimize the structure and deployment of China's regional coal transportation and electric power transmission systems. It developed eight pieces of mathematical modeling software for load forecasting, power source optimization, and coal transportation and electricity transmission system optimization, and appraised the economic rationality of the Three Gorges hydropower station; 2) The network structure of the Three Gorges electric power system. Research done on the three levels of energy resource programs, power source programs, and power transmission network structure programs proposed principles, theoretical methods, mathematical models, and computer software for power transmission network structure programs and used this software to propose an optimal program for the Three Gorges power transmission network structure; 3) Analysis of the integration and operational performance of several large regional electric power systems studied analysis of stability levels of integrated systems, and analyzed the power-frequency dynamic process and the setting of low frequency load reduction equipment, decentralized load and frequency control, linked circuit power oscillation and its control, and AC/DC parallel operation DC power control; 4) Simulation of the Three Gorges project AC/DC mixed power transmission system. This mainly used non-real time digital simulation with appropriate augmentation by existing physical simulation to develop 20 applications programs; 5) The electric power system requirements for the operating parameters of the Three Gorges power station electric power equipment and network reliability; 6) Comprehensive technical measures for improving safe and stable operation of the Three Gorges electric power system; 7) Optimized development of hydropower in the upper and middle reaches of the Chang Jiang and nearby regions and its effect on the Three Gorges power station; 8) Optimized compensation and regulation for hydropower station clusters and optimized dispatching for comprehensive utilization of the Three Gorges reservoir (flood prevention, power generation, shipping, etc.); 9) Near-term optimized operation of the cascade hydropower station at the Three Gorges, with research on four areas: near-term optimized operation of the Three Gorges multi-generator large capacity cascade hydropower station in an integrated electric power system, ultra-short term optimized operation of the Three Gorges cascade power station, comprehensive short-term optimization of power generation and shipping at the Three Gorges cascade power station, and computer monitoring and control system programs for the Three Gorges project; 10) Research on major kinetic energy and economic questions for the Three Gorges project, including the macroeconomic benefits of investments in the Three Gorges project from the perspective of the Three Gorges project and development of our national economy, assessment of the financial feasibility of the Three Gorges project, the importance of implementing phased electricity prices for the Three Gorges power station, investment allocation and capital raising arrangements for the Three Gorges project, rational utilization of seasonal electric power from the Three Gorges power station, and so on.

IX. Research on the Program (Including Flood Control and Hydrology) and Comprehensive Benefits for the Three Gorges Project

This part mainly studied aspects like the Chang Jiang flood control system centered on the Three Gorges project, comprehensive benefits of the Three Gorges project, Three Gorges regional development programs, and so on. Research on the Chang Jiang flood control system included research on the hydrology and regimen of the Chang Jiang, which included basic data on flood prevention, stochastic modeling of flooding, thunderstorm and flood prediction, and so on. Based on hydrological and regimen data for the Chang Jiang and the concepts and methods of systems engineering, the cluster of reservoirs on tributaries above Yichang, the Three Gorges reservoir, and the dike projects and floodwater diversion and impoundment regions below Yichang were organized into an integral flood control system for the research, which was conducted by establishing a simulation model of the Chang Jiang flood control system, a computer model of flood control benefits, an optimized analytical model for the water resource system, and an analytical model of flood prevention benefits and risk. The research results indicate that the Three Gorges project can effectively control flooding above Yichang and is an irreplaceable and important part of the Chang Jiang flood control system.

Research on the comprehensive benefits of the Three Gorges project included these aspects: 1) Research on the investment for the Three Gorges project; 2) Analysis of the flood prevention benefits of the Three Gorges project; 3) Analysis of the benefits to water-borne shipping from the Three Gorges project; 4) Evaluation research on the financing of the Three Gorges project; 5) Evaluation research on the Three Gorges project and our national economy; 6) Analysis of the national economy's ability to bear the burden of the Three Gorges project; 7) Analysis of the national, regional, and departmental impact of the Three Gorges project; 8) Research on the economic risks involved in the Three Gorges project; 9) Research on the investment decision-making support system for the Three Gorges project; 10) Evaluation of a system of multiple objectives for the Three Gorges project; 11) The relationship of the Three Gorges project to the transfer of water from southern China to northern China via the middle line; 12) Research on economic evaluation information and data for large-scale water conservancy and hydropower projects; 13) Research on multiple objective decision-making theory and methods for huge projects.

Research on development programs for the Three Gorges region included these aspects: 1) Economic and social development strategies for the Three Gorges region, including economic development goals, social development goals, S&T development goals, living development goals, and ecological and environmental goals. 2) Key aspects of agricultural development programs for the Three Gorges region, including grain production, cash crops, fruits, local and special product resources, forestry, animal husbandry, mountain and slope grasses, fishery, rural energy resources, and other key aspects of development programs; 3) Key aspects of industrial and communication development programs for the Three Gorges region, including communication and transportation, readjustment of the industrial structure, and other key program aspects; 4) Key aspects of social development programs, including key aspects of population control programs, key aspects of educational development, key aspects of cultural and health activities development programs, keys aspects of S&T development programs, and so on; 5) Key aspects of service system development programs; 6) Other related issues and policy measures including: the relationship between population resettlement and regional development for the Three Gorges project, analysis of the cost of resettlement from the reservoir region, management methods for the capital utilized, appropriate preferential policies and intensification of reform and opening up policies for development in the Three Gorges region, establishing experimental economic development zones, and so on.

X. Research on Ecological and Environmental Issues and the Question of Resettlement from the Reservoir Region for the Three Gorges Project

The Chang Jiang basin is a large integral ecological system. The question of what the actual impact of building the Three Gorges project will be on this large ecological system is something that concerns the people of China. When it compiled the key points of the Chang Jiang basin program and the key points of the preliminary design for the Three Gorges key water conservancy facility in the 1950's, the Chang Jiang Commission conducted surveys and studies on the ecological and environmental impact of water quality, aquatic organisms, land organisms, natural resources, backwater, reservoir inundation, bank slope stability, reservoir region resettlement, and human activity. Studying a large system, however, was something that started after the appraisal work begins. The content of the research included: 1) The impact of the Three Gorges project on the ecology of water areas in the Chang Jiang and countermeasures; 2) The impact of the Three Gorges project on the land ecology in the area along the banks of the Chang Jiang and countermeasures; 3) The impact of the Three Gorges project on aquatic organisms and valuable species in the Chang Jiang and countermeasures; 4) The environmental impact of the Three Gorges project on the section of the river below the dam and on lakes and ponds and low-lying areas in the middle and lower reaches of the Chang Jiang, and countermeasures; 5) The impact of the Three Gorges project on the ecology and environment of the river mouth region and countermeasures; 6) The impact of the Three Gorges project on the environmental geology of the reservoir region and countermeasures; 7) The impact of the Three Gorges project on the climate and hydrology of the region around the reservoir and countermeasures; 8) The impact of the Three Gorges project on environmental pollution and human health in the reservoir region and countermeasures; 9) The ecological and environmental impact of the current soil erosion situation in the Three Gorges reservoir region and countermeasures; 10) Comprehensive assessment of the ecological and environmental impact of the Three Gorges project. In addition, remote sensing data was used to compile an environmental atlas of the reservoir region.

Population resettlement in the Three Gorges reservoir region is an extremely complex issue. Wide-ranging survey research has been conducted in the reservoir region since 1985 and the breadth and depth of the work has been unprecedented. On the basis of the survey research, analytical research was done focused on these areas: 1) Analysis of the environmental capacity for resettlement, including analysis of the load-bearing capacity of the land and the environmental capacity for secondary and tertiary industry and cities and towns; 2) The direction of arrangements for the rural population resettled from the reservoir region; 3) Proposals for moving and rebuilding cities and towns, industrial and mining enterprises, communication, electric power, communications, and cultural relics in the reservoir region; 4) Estimated investments to deal with inundation in the reservoir region; 5) Research on resettlement policies and measures for the Three Gorges reservoir region. Because the issue of population resettlement for the Three Gorges reservoir involves complex systems engineering that touches upon many social, technical, and economic disciplines as well as an important part of the Three Gorges project, and more intensive research is needed about how to implement the principle of development-type resettlement in the areas of development content, capital utilization and benefits, implementation methods, management systems, and so on.

An overall look at the scientific research work situation for the Three Gorges project during the past 7 years shows that abundant scientific research achievements have been made concerning the Three Gorges and that affirmative conclusions have been drawn in regard to several important S&T questions that have attracted world attention, such as silt accumulation and ship passage, multilevel ship locks, reservoir bank slope stability, induced earthquakes, the ecology and environment, ship lift development, the ecology and environment [as published], and so on that have provided a reliable foundation for appraising the feasibility of the Three Gorges project and compiling the Three Gorges project feasibility report. The main reasons that these high-level scientific research achievements have been made are clear scientific research objectives and the concentration of several thousand top-notch schedule personnel and the forces of several tens of renowned scientific research units and institutions of higher education from throughout China to undertake broad-ranging cooperation and foster the spirit of reliance on one's own efforts and arduous struggle during the scientific research process, and in a situation of insufficient scientific research funds and incomplete scientific research facilities, fully fostering the intelligence and spirit of tribute of China's S&T personnel and spurring scientific research in this field to attain in a relatively short period of time world levels of the present day.

The Three Gorges project will now enter the stage of actual battle. From the tactical perspective, to coordinate with design and construction, scientific research work for the Three Gorges should be further intensified and, based on summarizing experience in previous stages, we must first reinforce overall scientific research work organization and leadership. For this reason, I propose that after the Three Gorges Construction Commission is established, it should exercise unified leadership over scientific research work for the Three Gorges to closely coordinate scientific research work and construction of the Three Gorges. Second, we must guarantee scheduled funds for the Eighth 5-Year Plan and take into consideration price indices. Scientific research funds for the Three Gorges project during the Eighth 5-Year Plan should be more than during the Seventh 5-Year Plan. Third, reinforce management and avoid repetition. Only by conscientiously following the guiding ideology as instructed by comrade Deng Xiaoping that S&T are the first force of production in guiding construction of the Three Gorges project can we build the Three Gorges project well and make the world-renowned Chang Jiang Three Gorges project bring prosperity to our people and invigorate China.

Baishan Reported Finished; Last 300MW Unit Now Operational

926B0101B Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 24 Jun 92 p 1

[Article by reporter Du Xiaoming [2629 2556 2494]: "China's Second Largest Hydropower Station, Baishan Hydropower Station, Is Fully Completed at a Total Investment of 1.4 Billion Yuan"]

[Text] The final 300MW generator for the second phase project at Baishan Hydropower Station was formally placed into operation on 23 June 1992. This marks the full completion of China's second largest hydropower station, second only to Gezhouba Power Station.

This generator underwent 72 hours of trial operation before being connected to the grid. The State Inspection and Acceptance Committee considers the equipment operation conditions to be excellent and all data met the design requirements.

Located on the upper reaches of the Songhua Jiang at the boundary between Huadian City and Jingyu County in Jilin Province, Baishan Hydropower Station was designed, built, and managed by China itself and we manufactured all of the generating equipment ourselves. The top of the large dam at the power station is 676.5 meters long and the maximum height of the dam is 149.5 meters. The geometric dimensions of the body of the dam attained advanced levels in China and foreign countries and it is now China's tallest gravity dam. The total investment was 1.4 billion yuan. So far, it has generated 17 billion kWh, recovered the entire investment, and produced enormous economic benefits.

Ge'ermu Hydropower Projects Taking Shape

926B0099A Xining QINGHAI RIBAO in Chinese 7 May 92 p 1

[Article by Xie Ru [6200 5423], Gu Yue [0657 1471], and Wei Ping [5898 1627]]

[Excerpts] The Ge'ermu hydropower projects, a state and local jointly funded project, is taking shape. Naijili and Xiaogangou power stations, already built and operating, have fundamentally solved the power shortage problem in this area, and have promoted the stable development of industrial and agricultural production of the entire area and created a favorable environment for future large-scale resource development.

Located on the southern rim of Qaidam Basin, Ge'ermu is blessed with rich mineral resources and water resources of the Ge'ermu River, which has a water head of some 1,100 meters on its main stream. [passage omitted] Under the policy of "relying on water resources and bringing change with electricity" in the 1970's, the state and the province invested a total of 23 million yuan and built the 9,000 kW Naijili power station. In the 1980's, state high-priority projects—the Ge'ermu refinery and Qinghai Potassium Fertilizer Plant—were built. In order to meet the needs of resource development, the state and Qinghai Province jointly invested 110 million yuan in 1986 to build the 32,000 kW Xiaogangou power station with an annual output of 190 million kilowatt-hours. The station has played an important role ever since it was completed in 1991. [passage omitted]

The success at Xiaogangou attracted more attention from the state and the Ministry of Water Conservancy made Ge'ermu the model city for developing hydroelectric power in desert areas. In addition to a 25-million-yuan line-item allocation, the state has also invested 2 million yuan to improve the old grid that can no longer meet the needs of industrial development. In the meantime, 30 million yuan were invested in the construction of the Wenquan Reservoir. The reservoir has a capacity of 255 million cubic meters and will provide water storage and flood prevention functions. The reservoir is now under construction. In the Eighth 5-Year Plan period, the 20,000 kW Dagangou power station and the 11,000 kW Jinliu First Stage hydroelectric power station will also be built. It is estimated that more than 100 million yuan will be invested on the development of hydroelectric power in Ge'ermu.

State Approves Longtan Project

926B0100A Lanzhou GUANGXI RIBAO in Chinese 12 May 92 p 1

[Article by Yan Jingxin [0917 4842 2450]: "State Council Approves Construction of Longtan Hydropower Station, Will Make the People Prosperous and Accelerate Economic Development in Guangdong, Guangxi, and Guizhou, Total Investment About 9 Billion Yuan, Scale of Current Phase of Construction To Be an Installed Generating Capacity of 4,200MW, Long Term To Be 5,400MW"]

[Text] After submitting it to the State Council for approval, the State Planning Commission issued its "Official Response Concerning the Hongshui He Longtan Hydropower Station Project Construction Proposal" on 11 May 1992 which agreed to construction of Longtan Hydropower Station.

Longtan Hydropower Station is the largest scale power station among the 10 cascade power stations planned for construction on the Hongshui He. Accelerated construction of it will reduce the electric power shortage in Guangdong Province, Guangxi Zhuang Autonomous Region, and Guizhou Province around the year 2000. The power station is designed for a normal water impoundment level of 400 meters and the present phase will be built on the basis of 375 meters. The construction scale is 4,200MW, involving installation of seven water turbine generators with a single unit capacity of 600MW. When the long-term plan to raise the height of the large dam and have a normal water impoundment level of 400 meters is achieved, two more generators will be added for a total installed generating capacity of 5,400MW. The estimated total static investment for the power station portion is about 9 billion yuan (at 1991 end-of-year price levels). It will be built via a joint investment by the State Energy Resource Investment Company, Guangxi Zhuang Autonomous Region, and Guizhou and Guangdong Provinces, which will provide 40 percent, 25 percent, 20 percent, and 15 percent, respectively, of the joint investment. The rather substantial amount of capital required to build Longtan Hydropower Station will make use of some foreign investments that will be used for part of the civil engineering, generators, construction equipment, electrical equipment, and so on.

To speed up construction of Longtan Hydropower Station, the Guangxi Electric Power Industry Bureau has established the Guangxi Longtan Hydropower Station Project Construction Company Preparations Office and all items of construction preparation work are now being actively carried out.

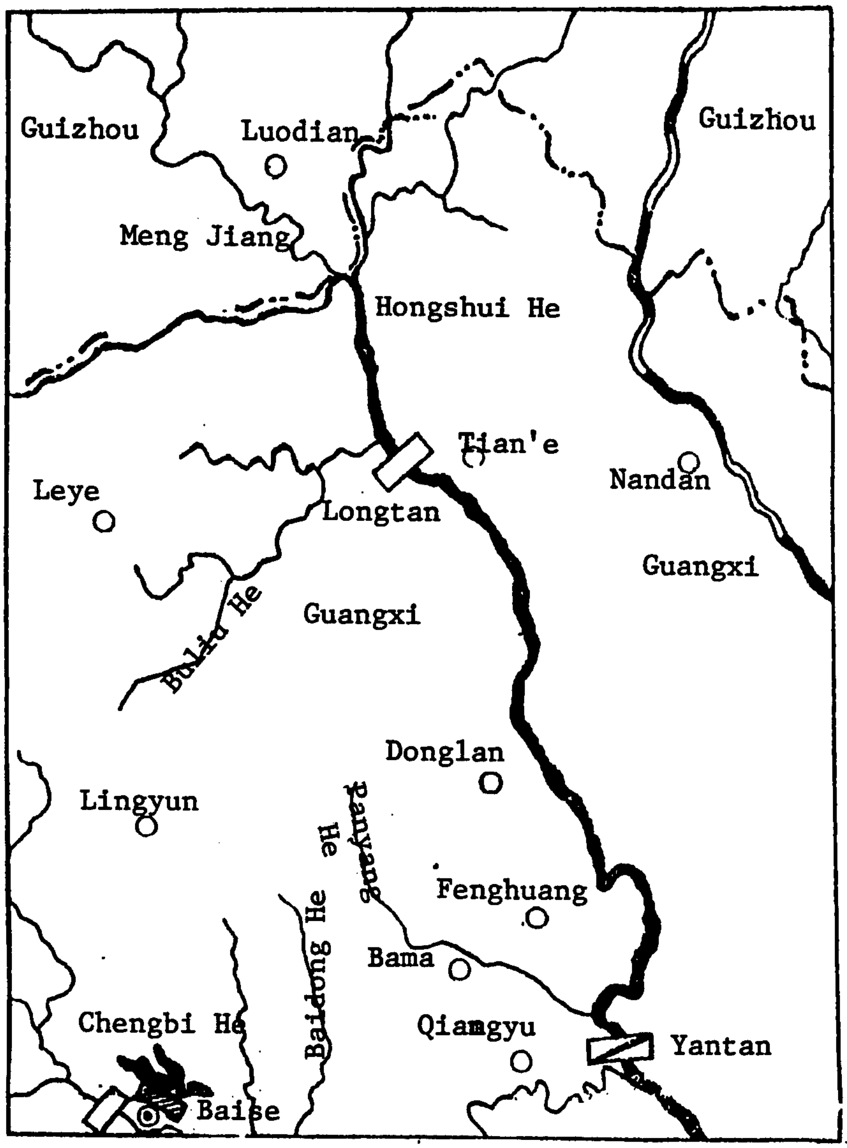

Figure 1. Geographic Location of Longtan Hydropower Station

Work Begins on Tongtou; Station Is Part of Baoxing He Cascade Development

926B0115A Chengdu SICHUAN RIBAO in Chinese 10 Jul 92 p 1

[Article by SICHUAN RIBAO reporter Zheng Rucheng [6774 3067 2052]: "Construction Begins on Main Project at Tongtou Hydropower Station, Opening the First Battle in Cascade Development of the Trunk of Baoxing He"]

[Text] With the support of relevant units in the province, prefecture, and county, work lasting over 7 months to put in roads, power, and water and to grade the site has been completed at Tongtou Hydropower Station at Lushan, a key construction project in Sichuan Province.

Tongtou Hydropower Station is the first medium-sized power station to get started for cascade development of the trunk of Baoxing He. It is located at the Tongtou site in Lushan County. To develop Baoxing He, the China Huaneng Group Company and the Sichuan Province Investment Company, Sichuan Province Hydropower Department, and Ya'an Regional Electric Power Company jointly established the Baoxing He Development Company and plan to invest 2.1 billion yuan in six cascades for rolling development of six medium-sized power stations with a total capacity of 700MW. Tongtou Power Station is the first phase project at a total investment of 200 million yuan. It will have a total reservoir capacity of 22.5 million m^3, a total installed generating capacity of 80MW, and will generate 473 million kWh of electricity a year. Construction is expected to be completed and it will go into operation in October 1995. This power station is 45 kilometers from Ya'an City and 192 kilometers from Chengdu and can be connected to the nearby Sichuan Power Grid and local power grids to regulate surpluses and shortages with local grids, which is very important for alleviating electric power shortages and invigorating the local economy.

Solicitation of bids for contractual responsibility was the arrangement employed for construction of the Tongtou Power Station project. Based on the requirement of reforming capital construction, an objective management responsibility system and project quality supervision and management system were implemented from the project's headquarters to the units having responsibility for construction. Since the project got underway, Sichuan Provincial CPC Committee deputy secretary Li Baiyong [2621 0184 0516], Sichuan Province vice governor Ma Lin [7456 7792], and others have visited the construction site and resolved problems in project construction to guarantee smooth progress at the project. By early June 1992, they had completed an investment of 25.72 million yuan, completed the requisition of 625 mu of land, improved, built, and rebuilt 20 kilometers of construction roads, built two construction bridges, installed 7 kilometers of high-voltage power lines, completed a matching transformer station, and completed all of the electrical and communications systems. After inspection, qualitative and quantitative guarantees were made for the preparatory work.

First Supercritical Unit Goes Into Operation at Shidongkou

926B0099D Shanghai WEN HUI BAO in Chinese 11 Jun 92 p 1

[Article by Yang Ying [2799 5391]]

[Excerpts] The first 600,000 kW supercritical generator of the Huaneng Shidongkou No. 2 power plant in Shanghai has completed 4 months of test runs and successfully accomplished its 72-hour full-load operation; it was officially transferred for operation today. This is China's first imported large-scale supercritical power station of 1980's [technology].

This national priority project, with a total investment of 3 billion yuan, was built jointly by Huaneng International Electric Power Development Company and the Shanghai Municipal People's Government using foreign capital and joint investment. [passage omitted] Eighteen units, including Shanghai Municipal Electric Power Bureau and the East China Institute of Electric Power Design, participated in the design, construction and testing [of the plant]. Twelve units, including the Shanghai Boiler Works and the Shanghai Electric Machinery Plant served as domestic contractors for manufacturing. Foreign experts from the United States, Germany, Switzerland, and France provided technical guidance. Both the main frame and the auxiliary unit operated smoothly throughout the test run. Under supercritical parameters at 250 bar and 540°C, a total of 43.18 million kWh was generated, the average load was 599,700 kW. All the specifications were met in the test run and the operation was superior.

The completion of the Shidongkou power plant marks another significant step forward in China's construction of large power plants and fills the void of supercritical power plants in China. The coal consumption per kWh is only 281.2 grams, at least 10 percent lower than other plants; this amounts to a saving of 300,000 tons of coal per year. The plant is highly automated. The central control room controls four distributed microcomputers for the main machinery, water treatment, coal transport, and ash removal. It requires only 20 workers to operate two generators. The total number of workers in this plant is only one-fourth of that in other plants. Since the first 600,000 kW supercritical generator was put into operation, 922.18 hours of operating time and 282 million kWh of electric energy have been accumulated.

The phase I project of the Shidongkou No. 2 plant calls for the installment of two 600,000 kW supercritical generators and there is room for an additional two units. Today, the No. 2 unit is already in the adjustment stage and the plan is to have it in operation at the end of this year. At that time, two units will be providing electric power for Shanghai and eastern China. The output will further alleviate power shortages and promote development in Shanghai.

Gangue Power Plant Goes Into Operation at Dangyang

92P60381 Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 28 Jul 92 p 1

[Text] The Dangyang city (Hubei) gangue power plant, one of four gangue power plants in China, recently went into operation. This power plant, using the locally rich resources of gangue as fuel, has a total installed capacity of 12,000 kW. It can save 75,000 tons of standard coal a year, increasing the industrial output value by about 0.4 billion yuan.

State Planning Commission Approves 400MW Expansion of Xinyu

926B0113C Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 23 Jul 92 p 4

[Article by Jian Lian'gen [4675 6647 2704]: "Jiangxi's Xinyu Power Plant Expansion Project Enters Design Stage"]

[Text] The State Planning Commission recently approved establishment of a key construction project in Jiangxi Province during the Eighth 5-Year Plan, the Xinyu Power Plant 2 X 200MW generator expansion project. With this, the Xinyu Power Plant expansion project at a total investment of 740 million yuan has entered the project design stage.

Xinyu is an iron and steel base area in Jiangxi that has a large iron and steel mill, medium-sized chemical fertilizer plant, and over 300 enterprises including machine building and electronics, chemical industry, construction materials, and so on.

After the Xinyu Power Plant 2 X 200MW expansion project is completed, it will play an extremely significant role in alleviating the electricity shortage for industrial and agricultural production uses in western Jiangxi and in promoting development of the local coal and construction materials industries. It is expected that the first generator in this project may be connected to the grid and generate power at the end of 1995 and that construction will be fully completed and go into operation in 1996.

Shanxi Accelerates Construction of Thermal Power Base

926B0097B Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 17 Jun 92 p 1

[Article by RENMIN RIBAO reporter Pan Yanxi [3382 5888 5045]]

[Text] The electric power system in Shanxi, taking full advantage of Shanxi's abundant coal resources richly endowed by nature, accelerates the construction of thermal power bases so that primary energy sources can be converted directly into secondary energy sources.

Each year the system has increased its electricity transmission to regions outside of Shanxi, effectively easing the tense situation of coal export from Shanxi.

It is understood that last year Shanxi transmitted 7.7 billion kWh of electric power outside of the province. The volume was 28 times over what it was before 1978, the year reform commenced. In the first 4 months of this year, Shanxi exported 2.7 billion kWh of electric power. Since 1980, Shanxi has successively exported a total of 42.1 billion kWh, taking the lead in power exports in China.

Since the reform, Shanxi has newly constructed or expanded 52 large, medium, and small thermal power plants. The total newly installed generating capacity of these facilities amounts to 4.56 million kW. By the end of last year, there were 152 power plants of different sizes in Shanxi with a total generating capacity of 6.57 million kW. As a national thermal power base, Shanxi has transmitted over 20 percent of its electricity to Beijing, Tianjin, Hebei, Shaanxi, and Inner Mongolia. One-fourth of the electricity used in Beijing comes from Shanxi.

Bian Xuehai, chief of the Shanxi Electric Power Bureau, believes that the vital strategy of building Shanxi as an energy and heavy industry and chemical base is to grasp the opportunity, to take advantage of Shanxi's natural superiority, and to develop electric power. He disclosed that in 1992 the Shanxi thermal power base is going to complete facilities with a total power generating capacity of 1.4 million kW, and that the generating capacity of the entire Province will exceed eight million kW. By the end of this century, Shanxi's power generating capacity will be doubled again.

Foreign Investment Reaps Big Dividends for South China Sea Oil and Gas Development

926B0103A Beijing LIAOWANG [OUTLOOK] in Chinese No 25, 22 Jun 92 p 16

[Article by Chen Binguang [7115 3521 0342]]

[Text] It is reported that the production of crude oil at the South China Sea reached 1.46 million tons last year, and this year it will reach 2.25 million tons. It is predicted that by 1995, oil production will be around 8 million tons; and the natural gas production, more than 3.2 billion cubic meters. At that time, the South China Sea will become the largest ocean oil and gas production base in China.

Underneath the South China Sea seabed, there lie abundant reserves of oil and natural gas. According to the estimation of Chinese and foreign experts, under some 220,000 square kilometers of the continental shelf in the northern part of the South China Sea alone there are already four sedimentary basins: the mouth of Zhu Jiang, Beibu Gulf, Yinggehai, and the basin southeast of Hainan. These basins have the favorable geological conditions for oil and gas reserves. The reserves could amount to over 10 billion tons of oil and 1 trillion cubic meters of gas.

However, the exploitation of oil under the seabed requires large investments and complicated technology, as well as high risks. Therefore, under these circumstances, by taking advantage of the favorable opportunity of the government's reform and open door policy, China's best option is to utilize foreign investments to jointly develop the South China Sea oil and gas resources.

In March 1979, the Delegation of Chinese Oil Industries visited the United States. They signed a memorandum with the ARCO Oil Company on the geophysical prospecting in the waters south of Hainan. Later, letters of intent and agreement for geophysical prospecting of the South China Sea were signed by China and well-known oil companies in the world. In May 1979, ARCO's geophysical exploration ships "Java Seal" and "Atlantic Seal" first started prospecting in the Yinggehai. Following that, 12 modern geophysical exploration ships from 12 countries (including the United States, the United Kingdom, France, Japan, and Italy) converged in the South China Sea and started large-scale geological prospecting. Within a year, seismic prospecting lines 87,000 kilometers long were completed and 420 oil-gas geological structures were discovered.

Subsequently, observing international bidding practices, the Chinese authorities invited three public biddings in 1983, 1986, and 1989 respectively. According to the agreements with successful bidders, the winning companies will take care of all the prospecting expenses. The recovering of oil would be co-invested by China and the winning companies. The foreign investments would be paid back with the oil produced.

The Chinese/foreign cooperative prospecting and development of oil is concentrated in the northern continental shelf of the South China Sea. This area includes the mouth of Zhu Jiang, the Beibu Gulf, Yinggehai, and the basin southeast of Hainan, a total area of 240,000 square kilometers. Altogether, 36 foreign companies have participated in the prospecting and exploration work. So far, China and the foreign companies have invested close to $2.6 billion, of which $2 billion, equivalent to 76 percent of the total, is from foreign companies. Overall, this is one of China's largest projects utilizing foreign investments.

Generally speaking, there are two types of cooperations in the South China Sea exploration: one is through joint investment by China and foreign companies (the latter assume the responsibility of prospecting and managing the oil fields); the other type is to form a joint management committee, and in the course of the cooperation, Chinese personnel will be trained and they will gradually replace foreign operators.

Up to now, a geological oil reserve of 450 million tons has been found in the waters east of the mouth of the Zhu Jiang. After an evaluation by both China and the foreign companies, it was agreed that nine oil fields, with a combined reserve close to 400 million tons, about 87 percent of the total reserve, have the value for commercial development. Two medium-sized oil fields, Huizhou-21-1 and Huizhou-26-1, located southeast of Hong Kong, have been put into production. They are cooperatively developed by China and the ACT Consolidated Task—an organization composed of AGIP (the Italian National Oil Company) Overseas Company, Ltd. of Italy, the Texaco Orient Oil Co., and the Chevron Overseas Co., both of the United States. The yearly oil production capacity of these two oil fields amounts to 2.5 million tons. The planned production of this year is 2.05 million tons. In the first 4 months of this year, the crude oil production has reached 1 million tons, about two-thirds of the total national seabed oil production.

In the western part of the South China Sea, 10 oil fields with a verified reserve of 110 million tons, and two natural gas fields with a verified reserve of 120 billion cubic meters, have been found. Among these, the Ya-13-1 gas field in the Yinggehai, a field exploited by China-foreign cooperation, has a reserve as much as 100 billion cubic meters. At present, it is the largest natural gas field in China. This field was cooperatively discovered by the China Ocean Oil Co., the ARCO Oil Company of the United States, and the Overseas Oil Exploration Co. of Kuwait in June 1983. Recently, the gas field and its customer—organized by the Hong Kong Zhunghua Electric Power Company and the Exxon Energy Company—signed an agreement on supplying gas to Hong Kong. According to this agreement, starting 1 January 1996 the Ya-13-1 gas field will supply natural gas to Hong Kong at the annual rate of 2.9 billion cubic meters for a new 3,000 MW power plant. At the same time the oil field will also supply natural gas to Hainan Province and the Zhu Jiang Delta.

This huge engineering project includes the building of gas extraction platforms, an 800-kilometer undersea pipeline to Hong Kong, and a 100-kilometer pipeline to Nanshan of Hainan Province. Additionally, a large-scale chemical fertilizer factory with annual production of 300,000 tons of synthetic ammonia and 520,000 tons of urea will be built in the Basuo Harbor of Hainan Province. The total investment in the project is estimated at billions of dollars. The projected production date of Ya-13-1 natural gas field is 1995, and the annual production rate is 3.25 billion cubic meters. It is ascertained that the extracting life of this area will be 20 years.

It is reported that in the next few years the exploitation of the South China Sea oil and gas fields will be further developed. China and the Amoco Oriental Oil Co. are now jointly prospecting the large Liuhua-11-1 oil field located southeast of Hong Kong. The reserve of this oil field exceeds 100 million tons. It is planned to put the oil field into production in 1995. There will be over 10 other oil fields put into production by then.

Another Success in Oil, Gas Exploration in East China Sea

926B0100B Shanghai JIEFANG RIBAO in Chinese 15 Jun 92 p 1

[Article by Han Naiming [7281 0035 2494]: "Another Report of Victory in East China Sea Oil and Gas Exploration, Project To Supply Shanghai With Gas Now Being Planned"]

[Text] China has reported another victory in petroleum and natural gas exploration in the East China Sea. The "Kongqueting-1 Well" located on the Kongqueting structure in the Pingbei region of the East China Sea produced a high-output oil and gas flow with a daily output of 370,000 cubic meters of natural gas and 282 cubic meters of crude oil. Eight strata with oil and gas indications were also found during drilling and extraction, and logging after completion of the well confirmed that two of the strata were high-output oil and gas strata.

The Exploration and Extraction No 3 Drilling Platform in the Ministry of Geology and Mineral Resources Shanghai Maritime Geology Survey Bureau which worked on the "Kongqueting-1 Well" began drilling in December 1991 and completed the drilling and began logging on 30 March 1992. This was another high-output oil and gas flow following the discovery of the industrial oil and gas flow from the Baojingting-2 Well in the East China Sea. The breakthrough at "Kongqueting-1 Well" expands the scope of the oil and gas-bearing area and confirms that the Pingbei region is a favorable oil and gas accumulation zone that has major significance for development and utilization of the East China Sea's oil and gas resources.

The East China Sea is a maritime region in which China is managing its own exploration and extraction of oil and gas. To date, the Ministry of Geology and Mineral Resources has discovered three oil and gas fields and four petroliferous structures in this area of the sea. They include the Pinghu Oil and Gas Field Project, which is a "gas-supply engineering project for Shanghai Municipality" that is now actively being planned.

Big Breakthrough Claimed in Seismic Exploration Methods

926B0115B Beijing ZHONGGUO KEXUE BAO in Chinese 21 Jul 92 p 2

[Article by reporter Deng Xianchun [6772 6343 2504] and geological information reporter Lin Shengbiao [2651 4141 5903]: "Major Breakthrough in China's Seismic Exploration Methods, Percentage of Hits in Locating Oil and Gas Deposits Greatly Increased"]

[Text] The scientific research project on "Complex Structure Seismic Frequency-Wave Number Domain and Wave Field Imaging Methods" completed after 8 years by the topical group led by professor He Zhenhua [6320 2182 5478] of the Chengdu College of Geology was a major breakthrough in theory and methods and in technology and has produced significant social and economic benefits in petroleum and natural gas exploration and other fields.

Seismic exploration done on strata slopes, fault development, and other complex geological structure regions to reflect the actual situation of complex underground geological structures for guiding exploratory drilling and oil and gas resource assessment and development are one of the main research topics today in international and Chinese petroleum and natural gas exploration. The topic group used a frequency compensation method to improve the fidelity of seismic waveforms in the computer data processing process; it used dynamic and rapid boundary energy absorption technology to deal with the end-point effects of complex structures; it created a method for replacing pre-superimposition time displacement with pre-superimposition depth displacement; it developed phase shift displacement software and formed production software for the first time. During the data processing process, they proposed a two-step method and blocked homogeneous vertical and horizontal velocity variation delay method; they rationally arranged data conversion methods among computer magnetic tape drives, disk drives, and mainframe internal memory, developed vector functions using groups of arrayed computers for computations, placed Fourier normal and reverse conversions that consume substantial computer time into the arrayed computers for computation and used parameter experiments, optimized processing, and modification processing to improve their quality; achieved standardization and modularization of computer program compilation that made the software easy to read and easy to install and transplant, which increased the degree of commercialization of the software and facilitated its extension and use in actual production. Practice on several occasions has confirmed that these series of programs are superior to similar programs in foreign countries and that they increase computing efficiency several fold to more than 10-fold.

Conversion of these research achievements into forces of production has significant benefits and applications benefits. Using these programs to process seismic data on the northern section of the Lanliao large fault-fracture zone in Henan's Dongpu depression, for example, correctly homed in on the cross section with a fault inclination of as much as 65 to 75 degrees, which after interpretation and comprehensive research increased the percentage of hits in exploratory drilling and added an additional 100 square kilometers of oil-bearing area in this region, with significant oil location benefits. Production departments have stated that this technology provided enlightened ideas in correctly processing petroleum prospecting data in this region and played a key role in producing the excellent results. Moreover, four key pieces of software in this entire series of programs have been transferred to six units and they have produced excellent geological benefits and economic benefits in the application process.

Great Potential in Development and Utilization of Natural Gas Reserves in Xinjiang

926B0109A Urumqi XINJIANG RIBAO in Chinese 19 Jun 92 p 2

[Article by Wu Xiang [0702 7534]: "Great Potential Claimed for Xinjiang's Natural Gas Resources"]

[Excerpts] The economic development and the social progress of Xinjiang are closely related to the speedy exploration and utilization of its oil reserves. It is commonly recognized that to create great wealth in Xinjiang is to have great oil production. However, how to stimulate Xinjiang's economic growth through oil development presents very difficult challenge. Meeting challenge requires not only guidance from the leadership, but also concrete, feasible proposals from experts. [passage omitted]

While many departments have conducted considerable investigative research on the exploration and utilization of natural gas, they have not stressed adequately the immediate development and application of natural gas. So far, no construction plan is on the agenda.

Bright Future for Natural Gas Resources in Xinjiang

Reports of successful prospecting of oil in Xinjiang have come in quick succession. In 1991, oil production exceeded 7 million tons. The proved oil and gas reserves in the Tarim oil field alone could guarantee that the crude oil production will reach 5 million tons and natural gas 600 million cubic meters. Although a late starter, the Tuha oil field has made rapid progress. Its controlled reserves guarantee a production of 4 million tons of oil and 600 million cubic meters of natural gas by 1995.

It has been proved that the Tuha and Talimu oil fields (including the Zepu oil field) are both oil- and gas-producing fields. In 1992, the crude oil production of these two oil fields could reach 1.2 to 1.5 million tons. The gas-to-oil ratio in these two fields ranges between 150 to 300 M^3/ton. At present, even after the regular gas consumption by these oil fields is deducted, there is still at least 1 million cubic meters of surplus gas to be burned into the atmosphere. In other words, about 300 million cubic meters of natural gas will be wasted annually. Moreover, the burning of the natural gas heavily pollutes the environment. Therefore, one of the most urgent tasks is to find ways to quickly and feasibly utilize these natural gas resources so that people of the different nationalities in Xinjiang will be benefited.

Transmission Is Key to Utilization of Natural Gas

The key question to the utilization of the natural gas is how to transport the gas:

1. Pipelines: Two years ago, the leaders of the Central Committee and the State Council decided that except for a small amount saved for local processing, crude oil will be transported outside of Xinjiang to support the rest of China. All the natural gas will be consumed locally. The realistic situation of Xinjiang shows that there is no adequate condition for long pipelines. At present, China has difficulties in construction investment. A 2,000-kilometer-long pipeline needs an investment of hundreds of millions of yuan. The economic benefit is not favorable because the volume of gas transportation is inconsistent.

2. Liquefied Natural Gas: Natural gas is first compressed under a pressure of between 20-60 atmospheres, then fed into a refrigerator. As a result of the reaction of expansion and heat exchange process, the gas reaches the cryogenic temperature of -162°C by flowing through a restrictor and becomes liquefied natural gas (LNG). The volume of LNG is only 1/625 that of the gas in its natural state. Outside China, LNG is the major method to collect, transport, and store natural gas. The means to transport LNG by train and truck are being studied by many nations.

3. Compression Bottling: The low-pressure natural gas is compressed and bottled under a pressure of 20-25 MPa for transportation. For the natural gas in a few scattered remote fields with uncertain reserves and low production rate, the bottling method appears feasible, especially when plans to build pipelines are undecided. The advantages of bottling compressed gas are: comparatively low investment, immediate results, and flexibility. In view of conserving energy, minimizing waste, and improving the environment, the bottling method is clearly efficient and superior.

In other nations, compressed natural gas has been in use for over 30 years. The technology and experience of using natural gas as motor vehicle fuel are quite reliable. Today, worldwide there are about 1 million vehicles using compressed natural gas as fuel.

China has just begun to use compressed natural gas. In Xinjiang, it is also feasible to adopt the compressed natural gas method for transportation and other applications.

Unique Advantages of Utilizing Compressed Natural Gas

It is universally agreed that the utilization of compressed natural gas provides the following advantages:

1. Safer Than Gasoline

The specific gravity of natural gas is 0.5-0.6 (in which methane is 0.424). The low density and lightness makes it evaporate quickly if leaking occurs, so the chance of spontaneous explosion is low. Moreover, its ignition point is 650-700°C, 260°C higher than that of gasoline, so natural gas is safer than gasoline. Before leaving the factory, each steel gas bottle has to pass a 100 MPa compression test and a gunshot test from a distance of 30 meters. Therefore, the bottles are very safe as gas containers.

2. Lower Energy Cost

Figuring the retail cost of 1 standard cubic meter of natural gas at 0.3 yuan and that of 1 kilogram of gasoline at 1.32 yuan, the consumption of 1 standard cubic meter of gas can save 0.31 yuan over the cost of gasoline producing the same amount of energy. In other words, the fuel cost of natural gas is 40 percent that of gasoline. For a bus traveling 200 kilometers daily (assuming gasoline consumption is 37 liters per 100 kilometers, an equivalent of natural gas consumption of 33 standard cubic meters per 100 kilometers), the saving of fuel cost will be 21 yuan daily by using natural gas, that is, 6,930 yuan annually. The cost of converting a bus to a dual-fuel vehicle (using natural gas or gasoline) is 6,200 yuan. Hence, the cost of gasoline saved within a year is more than adequate for the bus modification. In other words, the economic advantage can be obtained in less than a year.

3. Better Combustion

The octane number of natural gas is as high as 120. Natural gas in the cylinder mixes easily with air and produces safer combustion and higher thermal efficiency. In the winter, a cold engine is easy to start on natural gas. This feature is especially convenient for the high altitude and cold weather of Xinjiang.

4. Longer Engine Life

Since natural gas burns cleaner than gasoline, the carbon deposition on the engine is reduced, and consequently the engine wear is reduced. Periodic inspection intervals can be more than doubled. The consumption of lubrication oil can be reduced by one-half to two-thirds.

In order to protect the environment and reduce pollution in the cities, Urumqi should accelerate its drive to modify vehicles to use natural gas.

Xinjiang has a continental climate with low rainfall, thin vegetative covering, and weak ecology. This makes it harder for the polluted environment to adjust and recover ecologically. It is a well-known fact that vehicle exhausts will pollute the atmosphere in the cities and damage the public health. Hence, to promote natural gas as a fuel is very beneficial to the environment. It is especially practical for the large- and medium-sized cities in Xinjiang to use gas-fueled vehicles. Natural gas would drastically reduce pollutants, keep the atmosphere clean, and help the ecological cycle.

Pinghu Oil and Gas To Be Explored

926B0113B Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 3 Aug 92 p 1

[Article: "State Formally Approves Start To Development of East China Sea Pinghu Oil and Gas, Total Investment To Be 2.2 Billion Yuan, Will Try To Go Into Operation in 3 Years"]

[Text] Officials from relevant departments in Shanghai Municipality announced on July 31 1992 that the state has formally approved the start of substantive development of the East China Sea Pinghu Oil and Gas Field.

Since entering the East China Sea in 1974, China's geology and mineral resource departments have carried out a large number of systematic geological and geophysical surveys and comprehensive analysis and research work. Since completing exploratory drilling of the Pinghu No 1 Well in 1983 and obtaining high-output oil and gas flows, they also obtained high-output oil and gas flows from the Pinghu No 2, No 3, and No 4 wells. Exploration has confirmed that Pinghu Oil and Gas Field is a moderate-sized oil and gas field that is dominated by natural gas, that the mineral reserves in the development region are 8.26 million tons of light crude oil and condensate and 14.65 billion cubic meters of natural gas. At the same time, they also discovered in succession the Xuecan Oil and Gas Field, Baoyunting Oil and Gas Field, and four oil and gas-bearing structures.

The total investment for the Pinghu Oil and Gas Field development project is 2.2 billion yuan renminbi and we will try to place it into operation within 3 years for a daily output of 8 to 12 million cubic meters of natural gas, at which it can sustain stable supplies for 15 years, and we will also extract 1.6 to 1.8 million tons of condensate and crude oil. After this project is completed, it will lead the way in achieving full gasification of civilian fuels in Pudong New Economic Zone and lay a solid foundation for achieving civilian coal gasification in Shanghai during the Eighth 5-Year Plan.

High-Output Oil and Gas Wells Found in Shengsi Island Area

926B0113A Hangzhou ZHEJIANG RIBAO in Chinese 8 Jul 92 p 1

[Article by Guo Zhenmin [6753 2182 3046]: "Surveys in Marine Area Around Shengsi Produce Several High-Output Oil and Gas Wells, Shengsi Islands Will Become an Advance Guard Base Area for China's Development of Marine Petroleum and the Oil and Gas Industry"]

[Text] The Ministry of Geology and Mineral Resources Shanghai Marine Geology Survey Bureau has surveyed several high-output oil and gas wells, including the Pinghu No 1 to No 4 Wells, in the seas around the Shengsi Islands.

So far, the Shanghai Marine Geology Survey Bureau has collected a large amount of geophysical data from the East China Sea and drilled nearly 20 oil and gas wells in the sea bottom. Through several years of efforts and comprehensive research of a large amount of data, they have given a "three large, three many, one good" assessment of oil and gas resources in the East China Sea centered on the Shengsi Islands. This refers to the East China Sea's large area of sedimentary basins, large scale of local structures, and large thickness of Cenozoic sediments; many local structures, many categories of oil and gas pools, and many oil and gas-bearing combinations; and the excellent development prospects for East China Sea oil and gas resources. This is especially true for the area of the sea nearly 100 nautical miles southeast of Shengshan Island in Shengsi County where surveys have produced several superior quality high-output oil and gas wells, including the Pinghu No 1, No 2, No 3, and No 4 wells. The Pinghu No 4 Well is the oil and gas well with the highest tested oil and gas output at present in China's marine area at present.

The Shengsi Islands, located nearest to the high-output oil and gas region in the East China Sea's oil and gas fields, are now a maritime navigation base area for oil and gas field exploration positioning in the East China Sea. As the East China Sea's oil and gas fields are developed, the Shengsi Islands will inevitably become an advance guard base area for China's development of marine petroleum and its oil and gas industry.

Research Reveals Greater Reserves in Western Basins

926B0118A Beijing ZHONGGUO KEXUE BAO in Chinese 10 Jul 92 p 1

[Article by reporter Wang Lichao [3768 4539 2600]]

[Text] The CAS Lanzhou Institute of Geology supervised a strategic long-range research and analysis project for the development of oil and gas reserves in the major western sedimentary basins, for which a comprehensive multi-discipline oil and gas assessment and long-range forecast was conducted, involving tectonics, stratigraphic paleontology, sedimentology, and geochemistry, which have yielded many important results, and provide a scientific basis for China's go-west petroleum strategy.

Multi-faceted analysis and research on oil and gas formation, and the evolutionary formation of the Junggar, Tarim, Qaidam, Turpan-Hami, and Jiuxi [6794 6007] basins has revealed for the first time that in the triassic system of the Tarim Basin under the profile of the Kuche River and on the upheaval of the ridge of the Huangshan range there exist the geochemical indicators of elements of marine characteristics, and the paleoclimate as reflected in the paleobiological assemblage of the oil and gas source-rock was hot and moist, or warm and humid, which is favorable to the formation of oil and gas. The theses that climates that tend toward warm and wet can form oil and gas, and semi-arid climates of the temperate zone can form natural gas have broadened the theories of continental oil generation. From examination of the Mazhuang gas field, it is evident that low-temperature decomposition and microorganisms working together produced warm gases from low-temperature bio-decomposition, and it was also found that the microorganisms in the sediment were distributed in zones, which was a revelation. A new appraisal system was established for oil and gas resources in the western regions, included the movement and evolution of the earth's crust, and classification and analysis of basins, and that lead to the idea of oil and gas formation on the rim of the oceanic trough system in the crust, and put an end to the tradition of looking for oil only, in such basins. Examination of Junggar and Tarim carboniferous and Permian continental sediment shows that the abyssal environment, and the bathyal to abyssal zone are the best environments for formation of oil and gas, and that entrapped tidal flats, coastal lagoons, and sediment traps are good oil producers.

This key CAS project of the Seventh 5-Year Plan was a joint 5-year effort by the Institute of Geochemistry, Nanjing Geology and Paleontology Institute, Institute of Geophysics, Beijing Institute of Geology, Nanjing Geography and Limnology Institute, and the Lanzhou Institute of Geology which supervised the project.

Large Oil and Gas Deposit Found Off Zhejiang

926B0100C Hangzhou ZHEJIANG RIBAO in Chinese 12 Jun 92 p 1

[Article by He Liangjing [0149 5328 0079]: "Large Area of Oil and Gas Resources Being Explored, Development of Cixi and Yuyao To Begin June 1992, Experts Say This Zone Has Strata With the Most Oil Sources Among China's Oil Fields"]

[Text] Starting in June 1992, the Zhejiang Petroleum Exploration Office will begin exploring for oil and gas resources over a large area of beaches in Cixi and Yuyao.

The Hangzhou Bay Basin is located in the northeast part of Zhejiang Province and covers a total area of more than 17,000 square kilometers, including over 2,000 square kilometers that are favorable to the generation of oil and gas. Experts state that the Cixi and Yuyao coastal zone located in the Changhe depression in the southern part of the basin have the only Lower Tertiary strata in Zhejiang, which are the strata where the most oil sources have been found among all of China's oil fields. China Petroleum and Natural Gas Corporation president Wang Tao [3769 3447] has indicated that Zhejiang should be treated as a key region in oil exploration in southern China. The corporation has now included oil and gas exploration in Zhejiang in its plans for the Eighth 5-Year Plan.

Exploration of the Cixi and Yuyao regions is expected to be completed during the first quarter of 1993.

Jidong Oil Field's Output Growing Continuously

926B0099C Shijiazhuang HEBEI RIBAO in Chinese 3 Jun 92 p 1

[Article by Zhao Renfu [6392 0088 4395], Zhang Lida [1728 4539 6671], and Jia Yujun [6328 3768 0689]]

[Excerpts] In the first 4 months in 1992, Jidong oil fields produced a total of 127,000 tons of crude oil and over-fulfilled the state's quota.

The Jidong oil field faces some severe difficulties in production in 1992. The natural rate of decrease of old wells has gone up and no new wells are coming on-line. The output of some wells went down because of high water content, shallow sand layer, high viscosity, and depletion; these wells could not meet the target. [passage omitted] Beikou well No. 1 was a high-pressure well with a fire hazard and had not been in operation for a long time. In order to make the well produce oil, the workers searched for new ideas, took safety precautions, worked day and night, and finally made the well produce more than 100 tons of crude oil and 80,000 cubic meters of natural gas per day. By improved de-waxing and "hot wash," they restored the productivity of some old wells. From February to April, the number of producing wells was kept at a constant 144, which was 20 more than in January.

Surveys showed that four wells in the Beibao area could not operate due to a lack of electric power. The workers of the capital construction engineering office decided to solve the energy problem by themselves. They laid a 7.5-kilometer-long pipeline and used natural gas as energy to restart these wells. The output per day was more than 100 tons.

Southern Sichuan Develops High-Output Natural Gas Field

926B0099B Chengdu SICHUAN RIBAO in Chinese 29 May 92 p 1

[Article by Gao Zhu [7559 2691]]

[Text] The difficult problem of searching for natural gas in Sichuan, which has cost the province a great deal of foreign exchange in hiring foreign experts, has now been solved by Professor Chen Liguan [7115 4539 1351] of the Chengdu Geology College.

In the natural gas field area in southern Sichuan, faults greater than 100 meters have been considered "geological forbidden zones" for gas exploration. From 1984 to 1986, responsible units and departments have spent $600,000 on hiring American and French experts to investigate the difficult problem of searching for natural gas in this area, but the foreign experts failed to produce results. In 1989, Professor Chen led a group in attacking the problem. With support from the Sichuan Petroleum Bureau and cooperation from the southern Sichuan Mining Zone, they conducted theoretical and practical investigations on the search of large reserve structures of natural gas.

Professor Chen's group investigated the relationship between faults and gas enrichment and studied the geological characteristics of large, medium, and small storage systems. They proposed a new theory that the combination of faults and favorable structures favor the enrichment of natural gas and a new concept that large storage systems may exist in large faults with good closure and their surrounding areas. These new theories formed the basis for exploring large faults.

Under the guidance of the new theory, four wells were drilled in southern Sichuan; two of the walls produced high output industrial gas flows with an unimpeded flow of 2.04 million cubic meters and 1.03 million cubic meters per day. The reserves in these two wells are at least 700 million cubic meters; 4 years before Chen's study, the average per well was 30 million cubic meters. With the higher output, the number of wells drilled can be reduced by at least 19, at a saving of 95 million yuan.