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CHINA: Energy

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China: Energy

JPRS-CEN-89-009 CONTENTS 26 September 1989

NATIONAL DEVELOPMENTS

POWER NETWORK

HYDROPOWER

THERMAL POWER

COAL

Energy Economics in Reform Stage Analyzed

40130114 Taiyuan JISHU JINGJI YU GUANLI YANJIU [TECHNOECONOMICS AND MANAGEMENT RESEARCH] in Chinese No 2, Apr 89, No 3, Jun 89

[Article by Wang Xin [3769 2500] and Bo Shengrong [5631 3932 2837]: "Energy Industry Policy During the Reform Stage"]

[No 2, Apr 89 pp 8-11]

[Text] Since the strategic objective of quadrupling the output of China's economy was laid down in the early 1980's, the problem of severe energy shortages has become the main factor limiting economic prosperity. In the late years of the Sixth 5-Year Plan, the accelerated coal development policy and the rise of regional small coal mines led to a major increase in raw coal output, resulting in local, temporary alleviation of the coal supply problem. But the regional and local coal mines received little or virtually no investment and had difficulty in obtaining manpower, and in many areas the coal was extracted in destructive ways; these factors created a latent danger of inadequate staying power in coal production and an increasing long-term energy supply shortage. In the last half of 1988, as national economic development became overheated and inflation occurred, the development of China's energy industry was rather sluggish and the energy supply became tighter. National shortages of electricity, coal and oil were occurring constantly. The East China, Central South, North China and Northeastern power grids and enterprises experienced coal shortages and had to shut down 4 out of 7 operations, and even the Shanxi coal and energy base had such an acute shortage of coal stocks, that none was available to ship, so that enterprises had their electricity cut off or limited. The energy shortage no longer consists primarily of electricity shortages; coal shortages are now the main factor and the electric power industry is being constrained not only by construction investments, but even more directly by shortages of coal, which has further exacerbated the power shortage. That so severe an energy shortage can occur indicates the precariousness of China's energy situation: energy, the physical impetus for almost all productive activity and the great majority of social activity, is the key to China's economic development in the reform stage. The prolonged character and profundity of the energy shortage will continually influence every step in our strategic thinking. The present paper analyzes energy industry policy in China's reform stage, and in particular the economic policy with regard to coal, and attempts to identify policy approaches that will fundamentally alleviate energy supply problems.

1. The Continuing Energy Shortage Is the Result of Misapplied Strategy and Policy

The energy industry has long been the weak link in China's economy; coal industry output has fluctuated on several occasions, and electric power continues to be in short supply. Owing to insufficient energy, every year an average of about one-third of industrial production capacity cannot be utilized normally; the resulting economic loss is hard to overestimate. In the last few years, there has been an increase in awareness of the main factors responsible for the situation, but there still has not been a thorough and systematic examination of the contradictions. The energy industry is a large system. The development of energy resources includes extraction, processing, conversion, integrated utilization, transport, sale and consumption and consequently involves many complex economic-technical and industrial policy problems. In the reform stage, with the conversion being made from old to new systems, China's energy problems are becoming increasingly complex and are directly related to strategy, the system, and mechanisms. As a result, exclusive reliance on increased investment or even on price reform cannot fundamentally resolve the energy problem. The crux of the energy shortage must be conscientiously analyzed in terms of strategy, the system, mechanisms, and policy.

a. The Place of Department Strategy and Local Strategy in China's Overall National Strategy

There is no question that the energy industry occupies a decisive strategic position in China's economic development. In 1982, when the 12th plenary session of the party comprehensively mobilized and deployed for socialist modernization, it designated the energy industry as a strategic focus for a rather long time to come. Because coal accounts for more than 70 percent of China's total energy output and consumption, a major effort in the development and utilization of coal involved the key to China's energy industry. As a result, when implementing an integrated national economic development strategy and highlighting such strategic focuses as energy, we must select regions with abundant coal resources and with conditions favorable to their development, institute investment preference and policy preference, and concentrate our efforts on establishing a fully developed, powerful energy base in the shortest time possible. Within this national overall strategy the departmental strategy and regional strategy will obviously be identical. But departmental strategy and regional strategy have missed the mark. In the initial stage, a simple departmental preferential strategy was used in energy base construction; there was a constant failure, in every stage, i.e., layout and construction of the bases and production, transportation and sales, to break away from the approach in which the center sets the program for the departments and the specialized management departments make decisions on the overall situation; in terms of energy base construction goals, imposing demands became the primary focus, and coal became the standard of judgment; there was a neglect of coordinated economic and social development within the base areas, which inhibited the regional economy's intrinsic capacity for autonomous development. In the subsequent stage, in the course of readjusting the strategic measures and relationships between the east and west of the country, the interior and the coast, and resource-driven and processing-driven economic zones, the priority position of strategic energy industries and energy base construction in the overall strategy was neglected, with the result that economic benefits and policy preferences followed the coastal-zone development strategy and the theory of the driving effect of regional centers, and the light processing-driven southeastern coastal zone was taken as a guide, which produced a powerful "model effect" on a national scale. Pursuing high rates of development and extensive expansion, all localities nationwide staked everything on developing high-profit processing industries, so that the price changes and loss of earnings of the energy bases increasingly made themselves felt, aggravating the conflict between burgeoning demands and an inadequate effective energy supply.

b. Conflict in the Energy Policy System Between the Investment Preference Policy and Holding Down the Prices of Energy Products

Since the institution of economic reform and comprehensive modernization, in order to promote the development of such strategic sectors as energy, transport, and raw and other materials, the state has implemented a preferential policy, setting up a considerable number of key engineering projects and increasing the share of these bottleneck industries in total capital investment on fixed assets under the whole-people ownership system in a vigorous effort to make the investment structure more rational. In the Sixth 5-Year Plan alone, nationwide investment in the energy industry reached 67.8 billion yuan, about 20 percent of total national investments. But in the overall industry policy system, price policy was ultimately at odds with investment policy, and the price management authorities instituted an unfair policy of controls on such upstream product as energy and raw and other materials, combined with a lack of restraints on the light processing industry, consumer goods, and other downstream products, which resulted in consistent underpricing of coal, crude oil and electric power; these prices were highly irrational whether compared with energy prices on international markets or with domestic products of other industries. Energy prices were set without reference either to social average profit rates or to the objective fact of increasing production costs; not only did this practice make it impossible to guarantee normal after-investment earnings to the energy industry, and in particular to the coal industry, but some mines actually were unable to recoup their direct consumption in the production process. Owing to large increases in production costs and various management expenditures in the last few years, all of the nation's coal enterprises were in a difficult position, and even so advanced an enterprise as the Kailuan coal mine operated at a loss for 2 years. In 1987, the profit tax per hundred yuan of fixed assets paid by the country's coal extraction and classification industry fell by 1.40 yuan, the profit tax per hundred yuan of funds by 1.91 yuan, and the profit tax per hundred yuan of total output value by 4.61 yuan. Because the price of electric power was too low and production costs were rising, the power industry's earnings-to-funds ratio dropped steadily, from 11.2 percent in 1980 to 4.8 percent in 1987. Electrical output in 1987 was 35 percent higher than in 1984, and coal consumption in the industry was slightly down, but the electric power industry's profitability rate fell by 30 percent and the profit per kilowatt sold fell from 44.32 yuan to 9.48 yuan. It has declined from a major profit-making industry to an industry with negligible profits, and it lacks the ability to repay capital with interest. As a result of this situation, the departments and localities became unwilling to invest more in energy enterprises, and the energy enterprises themselves lacked the ability to save and to expand with their own resources. In particular, owing to the current diversification of investment sources and to constraints on extrabudgetary construction funding, the share of energy-industry investment in the entire society's fixed-capital investment has fallen for several years. Between 1953 and 1986, investment in coal industry enterprises averaged 6.3 percent of all capital construction investment, but by 1984 the figure had fallen to 4.9 percent. The situation was similar in electric power industry investment. Inadequate investment deprived energy production of normal continuity and development, so that it failed to have the staying power that it should have had.

c. Limitations on Power and Transport Capacities and Chaos in Circulation Have Led to a Prolonged Coexistence of a Buyer's Market and a Seller's Market for Energy Producers and Consumers, With Profits Flowing to the Middleman

The increased overheating of the processing industries in recent years has exacerbated energy supply shortages, transport construction has not been able to keep pace and transport capacities have not expanded evenly, with the result that energy supply is not smooth, and in addition two-track pricing and corruption have led to downstream illegal activities such as bureaucratic and private profiteering, offering middlemen at all stages of transport and sales an opportunity to overcharge, creating imbalances unfavorable to the producer and purchaser throughout the country's energy market. On the one hand, it is a buyer's market, in which the coal enterprises' coal stocks are not decreasing and they have to cut prices to compete for sales, while paying high prices for railcars to transport their coal; on the other hand, it is also a seller's market in which there is no lack of demand in the coastal region and prices are as high as 300-400 yuan per ton, resulting in a concave profit structure that brings hardship to the coal miners, makes the coal speculators rich, and cheats the coal buyers. This situation not only damages the interests of the energy producers and consumers, but has also thrown the energy market into chaos and made the energy situation increasingly grave. Consider, for example, the outshipment of coal from Shanxi. In the past, the coal from the province's regional and local coal mines was grade 2 coal. Most of them lacked their own funds for coal transport, so that they used trucks to haul it to coal shipment stations where it was shipped out to be sold. In the last few years, not only have the transport and management costs for transporting the coal from the mines to the railroad stations risen sharply, but there has been a proliferation of fees for rail transport, sea transport and the like, all of which have been rising steadily. According to an official survey for 1987, the cost of hauling a ton of coal from Beiying Station in Taiyuan through Xinxiang, Heze, Jining and Yanzhou to Shijiousuo was as high as 36.28 yuan and the cost of water transport was 16.38 yuan, so that the total haulage cost of a ton of coal was 52.60 yuan; in addition, as a result of middleman's charges by the coal station and the transport company, specialized coal shipment fees, charges by the fuel company and the like, the cost of shipping coal to Shanghai and selling it there exceeded 110 yuan, of which more than half was irrational costs. The cost of producing Datong coal is not very high, but its transport costs are excessive, with the result that it lacks the proper competitiveness on the international market. In addition, there are a certain number of coal speculators who engage in speculation under the name of coal delivery contracts. According to newspaper reports, for a ton of Datong coal with a minehead cost of 54.36 yuan they add a contract fee of 145.64 yuan, so that the cost of a ton of coal arriving at Shanghai exceeds 200 yuan; thus, subtracting transit expenses, there is a net profit of about 90 yuan. This sort of huge profit results in failure to meet plan indicators for coal, while extra-plan transport is overfulfilled; last year the electric power system alone suffered from a shortfall of 8 million tons from the planned coal delivery figure, which exacerbated the shortage of electric power.

2. Another Basic Cause of the Continuing Energy Shortage Is Hitches in the System and Structural Dislocations

The energy shortage in China is a long-term problem. In addition to the direct results of lack of coordination in the strategy and policy research and drafting stage, the deeper-lying factors involve the inflexibility of the energy industry management system and structural contradictions in the industry's development.

a. In the Course of Reform, the Energy Industry Management System Not Only Was Not Streamlined, But Departmental Control of Enterprises Was Actually Intensified, and Economic Relationships Between Local Enterprises Were Curtailed, Which Fettered Enterprise Vitality

There has been a great deal of research on energy prices and investment problems in the last few years, but while there appears to be dissatisfaction with the changes in the energy industry management system in the course of reform, not a word has been said on the subject. But if we investigate the development of the energy industry, it is very hard to avoid this problem. Before the reform, while an attitude of benign neglect was adopted toward small energy enterprises and local coal mines, and the centralized control of large mainstay enterprises by the central energy management organizations was intensified, the contradictions between this type of centralized, uniform energy industry management system and the laggard productive forces of the energy industry was a major factor hindering the industry's normal development. In the case of the coal industry, for example, since comprehensive investment and output contracting was instituted, the conflict between direct ties between the government and the enterprises and the absence of a laterally and vertically interconnected system has increasingly made itself felt, and even though the centrally controlled coal mines receive preferential treatment in terms of prices, transport plans, technology and equipment, and material supply, they have higher investments, higher costs, and greater losses than the regional and local coal mines, as illustrated in the table below. The figures indicate that since contracting was instituted in the centrally controlled coal mines, the operating-loss contract stipulations have never been met. The operating loss was 560 million yuan in 1985, and thereafter the excess operating loss increased steadily. In 1986, 93 mining offices using the contract system spent a total of more than 1 billion yuan to compensate part of the losses. A third of the contracting mining offices used earnings from increased production or overproduction and from negotiated-price coal deliveries, and part of contract wages per ton of coal to compensate losses, thus using up most of the flexibility that the reform gave to the enterprises. In addition, a third of the mines actually used maintenance and simple reproduction funds to compensate losses, so that they were actually consuming their old capital and depriving the mines of their maintenance and simple reproduction resources. Naturally, excessive low coal prices and increased outlays are a major factor in the losses, but the management system in which the departments are the main contracting bodies and the government replaces the enterprises, thus limiting flexibility of the enterprise and the locality, is an even more direct contributing factor. Conversely, the regional and local mines, whose production facilities and management and operating facilities are inferior to those of the centrally controlled mines, have smaller losses, and the great majority of them actually show a profit. Since 1981, two-thirds of the annual increase in coal output has been contributed by the regional coal mines; from 1982 to 1985 national coal output had a net increase of 250 million tons, with the centrally controlled coal mines posting an annual increase of 4.9 percent, while the regional coal mines had an average annual increase of 12.9 percent. The gap in production cost between the centrally controlled coal mines and regional state-operated coal mines has been increasing year after year. Let us compare, for example, six of Shanxi Province's centrally controlled coal mines with all regional coal mines at the county level and above, together with the local coal mines: in 1981, the average production cost per ton of coal was 16.01 yuan for the centrally controlled mines and 14.5 yuan for the regional mines. The difference subsequently increased, so that the 1986 figures were respectively 28.14 and 19.34 yuan: thus the production cost for the nationally controlled coal mines was 35.2 percent above that for the regional coal mines and was nearly twice that of the local coal mines.

Comparison of 1986 Production Costs in State-Run Regional Mines, Local Mines, and Centrally Controlled Coal Mines of Shanxi Province

	Total production cost	Materials	Wages	Benefits	Electric power	Depreciation	Overhaul	Other
Six centrally controlled mines	28.14	7.01	7.08	0.48	1.29	7.74	2.15	2.39
Lu'an Mining Office	24.85	6.91	7.47	0.30	0.98	5.07	1.71	2.41
Regional state-run mines	19.34	4.94	4.94	0.40	1.07	3.96	0.57	3.55
Xiangyuan Coal Mine (regional)	17.96	4.69	3.07		0.86	4.00		5.38
Xiadian Coal Mine (local)	13.07	5.03	2.75		0.38	4.00		0.91

Similarly, the electrical industry's management system is also incapable of effectively adapting to the requirements of reform and development. Since the state was founded, the electrical industry has developed rapidly. Electric power grids for 1 million kW of power and more than 10 million kW of transprovince power grids had already been built, and the expansion of the number of generating units and the introduction of centralized uniform dispatching, has brought the advantages of power grid switching into play, promoting the power industry's development; but this management system is not adapted to the country's regional system structure in the current stage, to the level of productive capabilities, or to the "separate funding" finance system. Experience shows that provinces with separate power grids, e.g., Shandong, Guangdong and the like, take greater initiative in economic development. The transprovince power grids have been incapable of effectively mediating between the interests of the localities and the power grid as a whole in such cases as allocation of electric power, dispatcher powers, and differences in profits from generating and supplying electricity. Since the local power plants were incorporated into the power grids, not only have prices been higher, but it has not been possible to guarantee the local supply of power and the localities have had to provide for power plant electricity use and for inspection and maintenance. The investment ratio between the power plants and the grid is 85:15, but the profit distribution ratio is 40:60, so that the localities gain no benefit, which weakens the incentive of the local governments to engage in power production. These examples show quite clearly that this highly planned and centralized department overall contracting system involving a uniform ownership system has many deficiencies and is not conducive to a rapid increase in the effective energy supply.

b. Disproportionalities Within the Energy Industry Have Exacerbated Energy Shortages

In the past, China's energy industry had multiple management, the departments were separate domains, and the energy industry lacked a comprehensive, stable, coordinated development plan, with the result that energy policy wavered back and forth. For example, at a certain time, without consideration of the downstream water crisis, there was an extensive emphasis on building dams on the upper Huanghe River. In addition, there were several reversals on the question of whether it was more efficient to transport coal or transmit electricity, and no consistent policy was established. As a result, the structural proportionalities in the energy industry were not rationally adjusted. At present the hidden contradiction underlying the energy shortage is the serious shortage of coal for electric power plants, and lack of coordination between coal-industry and electric-power development, so that the power industry is being starved; not only has the supply of coal become a critical limiting factor for newly constructed coastal power plants, but even older plants whose output has been essentially normal for years are suffering from coal shortages. On one occasion in 1988, the coal stocks of all of the major power grids in the country fell to record lows. Several large power plants were compelled to shut down as a result of coal shortages, and statistics indicate that in the East China power grid alone, coal shortages in July and August resulted in the loss of 400 million kilowatt-hours of power production. Especially shocking is the fact that since the beginning of the Seventh 5-Year Plan, construction on medium and large-size mainstay coal mines has decreased, while the regional and local coal mines have inadequate reserve capabilities and are incapable of meeting the requirements of the generating capacity added during the Seventh and Eighth 5-Year Plans. As a result, the development of the entire country's energy industry is dependent on an appropriate reorganization of its internal structure, with strong points compensating weaknesses and with coordinated development. In addition, the entire country's energy consumption must be based on the specific characteristics of the energy industry, and appropriate energy consumption guidelines must be drafted for domestic appliances, which have increased tremendously in number in recent years, for high-grade hotels, and for the development of certain high energy consumption industries, in order to ease the energy shortage.

[No 3, Jun 89 pp 7-12]

[Text]

3. Suitably Adjusting Certain Strategic Ideas Regarding China's Energy Development Is a Precondition for Accelerating Energy Production and Adapting to Economic Development Needs

The strategic position of the energy industry in China's economic development has already been unambiguously affirmed. But the implementation of this strategy, some approaches and techniques are at odds with its true intent and are injurious to the fundamental position, priority and central focus of the energy industry. For example, is the strategic idea of using doubled energy output to support quadrupled output of the economy suited to the expansion of production in the current stage? Might the policy of quickly developing all coal resources adversely affect the benefits and staying power of energy production? Should the general energy-base development policy be changed from a primary emphasis on energy shipment to an equal focus on energy shipment and energy conversion? And what should be the role of energy conservation in China's energy consumption structure? Clarifying these strategic approaches will help assure the healthy development of the energy industry.

a. It Is Worth Rethinking the Energy Development Strategy of Having a Doubling of Energy Output Support a Quadrupling of Economic Output

Since 1980, experts have put a great deal of effort into forecasting future energy production and consumption trends; they have universally concluded that by the end of the century China's energy output will be able only to double; this doubled output is to be used to realize the objective of quadrupling agricultural and industrial output value. All 5-year plans since the sixth, as well as the long-term program through the year 2000, have been based on this assumption, and all simply assume an energy consumption elasticity of 0.5 when planning production and capital construction in the energy industry. In the late sixth and early seventh 5-year plans, China's energy consumption elasticity dropped sharply from the average of 1.34 over the previous 30 years to about 0.4. This is highly abnormal and promoted a mood of uncritical optimism regarding future energy demand. As a macroscopic index of the interrelationship of economic growth and energy resources and of development trends, the elasticity is subject to specific laws. The energy elasticity is highly dependent on a country's stage of development: it is greater than 1 for developing countries and less than 1 for developed countries, and the greater the per-capita output, the lower the elasticity. Statistics on 20 countries of various kinds indicate that the elasticity is greatest for developing countries, and especially poor countries, reaching 1.62, or even as high as 1.8 in the case of India. In countries with moderate income it is 1.24. In the initial stage of industrialization, because most countries adopt a strategy of favoring heavy industry, energy demand is very strong. In the United States between 1880 and 1920, owing to railroad development, energy consumption rose sharply, and in the mid-1940's the energy consumption elasticity reached 1.6. In Japan it was 1.2 in the period of heavy-industry development in the 1960's. Following the oil crisis, the energy elasticity dropped for several years in the industrially developed countries, but in recent years it has begun to rise again. China is in the initial stage of development of a socialist commodity economy and the reform is beginning to enter its middle stage, and we should therefore make increasingly scientific analyses and predictions of the current energy situation and resource requirements for the next few years. There are several reasons that energy elasticity has recently been falling in China. The first is that during the Sixth 5-Year Plan, large amounts of energy-intensive materials were imported, which caused a relative decline in energy consumption by China's iron and steel industry and chemical industry. During the Sixth 5-Year Plan, the country's imports of steel stock, aluminum, copper, fertilizer, soda ash and the like accounted for more than a third of total output, and this factor alone decreased national energy consumption by about 8-10 percent. Second, when the past policy of priority development of heavy industry was adjusted, a national tendency to lay increasing stress on light industry developed, which also caused some decline in energy consumption. Third, since the Sixth 5-Year Plan, in the course of reform there has been a decrease in industrial enterprises' energy consumption and benefits have risen somewhat. Fourth, in recent years industrial growth has continued to focus primarily on quantity and output value, while the development of new products has decreased the comparability of output value figures; the increases in output value and volume have greatly exceeded the increase in real output, and in addition price comparison factors have been distorted and economic coefficients have become inaccurate, with the result that energy elasticity figures have tended to decrease. It is estimated that the total current national energy consumption shortfall is about 15 percent (not including agricultural energy consumption).

China's industrialization is far from complete, and modernization of agriculture and improvement of the people's standard of living require major increases in the energy supply. The approaches of solving the energy problem include increasing supply and decreasing consumption. In the current stage, as rural industrialization has progressed, the development of nonagricultural production has increased the difficulty of conserving energy. From 1990 on, it is predicted that energy-intensive heavy industry and chemical industry will develop rather rapidly. The World Bank states in its paper on "the Chinese economy approaching the year 2000" that energy elasticity will rise to 0.6-0.7. Some domestic experts also predict that it will be rather difficult to support a quadrupling of agricultural and industrial output value with just a doubling of national energy output. Since 1980, national energy production elasticity has experienced rather large fluctuations, with a clear declining trend, while energy consumption elasticity has been increasing rather steadily; this is another expression of the fact that the country's energy supply is not in step with consumption requirements.

Thus, in order to guarantee that the needs of the four modernizations will be met, in the current reform stage the energy production and consumption elasticity figures should both be made to increase. Experts estimate that the energy consumption elasticity should be at least 0.7 and that the electric power industry's lead factor should be at least 1.

b. Adjust the Policy of Rapid Development of All Coal Resources, Identify and Utilize Diversified Energy Resources, and Gradually Improve China's Energy Consumption Structure

China's coal-based energy consumption structure will persist for a long time to come. In the early part of the Sixth 5-Year Plan, some experts advocated the policy of rapid development of all coal resources, intensification of coal development, and vigorous development of fossil-fired power production. The implementation of this idea temporarily eased the energy supply shortage, but it also had the undesirable consequences of wasteful development of coal resources and an intensification of destructive extraction. During this period, the coal recovery rate in centrally run coal mines was generally about 45 percent, while that in regional and local mines was only about 20 percent (compared with a 1985 national coal mining region recovery rate of 77.8 percent). The resulting loss of resources was rather serious. China's proved reserves of coal are 859.4 billion tons, of which only a third are thoroughly explored reserves; and only 70 percent of the latter are being or will be worked by existing in-production mines and mines that are under construction. In addition, about 40 percent of the other usable reserves are beneath cities, railroads or water areas and are not currently usable. As a result, while China is a major energy-producing country, is rather energy poor on a per-capita basis; we must therefore inculcate the idea of protection and comprehensive utilization of resources and should develop and utilize energy sources other than coal in order to gradually improve China's energy consumption structure. For example, China's rich hydropower resources are very incompletely used, particularly in the energy-intensive East China and Northeastern regions, and to an even greater degree in the Southwest. Currently, China's theoretical hydropower resources total 370 million kW, sufficient to replace a billion tons per year of coal or 500 million tons of crude oil, both of which are nonrenewable resources. But hydropower has been developed only to a very small degree: only 8 percent of resources had been developed as of the beginning of 1988, and hydropower generating capacity accounted for only about 20 percent of total power industry capacity. With China's problem long-distance coal haulage from west to east and from north to south, its limited transported capacities and its shortage of energy, this situation should not exist. In certain countries, the construction cost per kilowatt of hydropower has been twice (or more) that of fossil-fired power, but its costs after construction are rather low, its benefits are excellent, and thorough use is made of recoverable hydropower resources. The large hydropower plants that China built in the 1950's and 1960's mostly required investments of under 1,000 yuan per kilowatt, less than twice the figure for fossil-fired power plants. In recent years, owing to inadequate preliminary engineering preparations, lax management, failure to carry out responsibilities, lump-sum funding, and policy vacillations, the cost of hydropower projects has risen sharply. These problems can be resolved in the course of reform, and as a consequence, hydropower development should be considered in strategic terms.

In addition, China should encourage thorough utilization of poor-quality coal and the waste products and tailings from coal washing such as gangue, middlings and the like. In 1986, the total amount of gangue produced in China was 130 million tons, of which the energy base areas produced 40 million tons. Multiyear experiments with middlings and coal gangue indicate that about a third of the total output is material with a calorific content of 1,500 kcal/kg, which could be used in fluidized-bed furnaces and is a fully usable energy source. The use of coal middlings for electric power generation has not yet been made practicable. Nationwide problems of low-caloric-content coal and brown coal utilization urgently require investigation. As a result, we should attach appropriate importance to the design, manufacture and extensive adoption of electric power plant equipment using low-caloric-content coal and thus to identifying and utilizing the potential of energy resources and wastes, thereby achieving the double objective of converting waste to valuable material and improving the environment.

c. Improving the External Environment of Energy-Base Construction and Development, Accelerating the Development of Energy-Intensive Industries in the Energy Base Areas, and Gradually Increasing the Output of Energy Carriers Represent a Superior Policy for Increasing the Strength of the Energy Base Areas and Alleviating the Energy Shortage

At present, the most realistic and direct basic means of alleviating the energy shortage is to rely on and invigorate the energy base areas. Since the Sixth 5-Year Plan, the Shanxi energy base area's energy output has indeed increased considerably. Its raw coal output now is a quarter of the national total, and the amount being shipped out of the area is nearly 80 percent of all interprovince allocations nationwide. Electric power transmission has increased in Shanxi by a factor of 18 since 1980, making it the country's only reliable, stable energy-exporting province. But there are still many serious difficulties in the construction of the Shanxi energy base area. First, there is inadequate reserve potential for energy industry development. Low energy prices fail to provide sufficient compensation for energy products, so that economic benefits are declining. The enterprises lack the capabilities for modernization and development with their own resources. Second, the exclusive focus on energy deliveries is deleterious to the coordinated development of Shanxi's economy and society. The effective supply of foodstuffs, consumer goods and other manufactured goods is inadequate, so that the inhabitants cannot obtain the necessary material compensation. Third, the energy transport and other departments are putting government in the place of enterprises, there are no lateral ties, there is much duplication, marketing channels are in disorder, and friction between interests is becoming increasingly serious, so that the energy base lacks a good system environment and the ability, motivation, and flexibility to develop through its own resources. Fourth, the outshipment of low-priced energy and materials and the flooding in of high-priced manufactured consumer goods has led to a double erosion of value and has created a situation in which the standard of living in Shanxi is rather poor. In 1987, the per-capita living income of town dwellers fell to last in the country. The contribution that Shanxi's local coal mines have made to alleviating the national energy crisis is universally known, and the local coal mines are the Shanxi peasants' principal means of gaining wealth, but their net per-capita income fell to 23d in the country in 1987. If the people cannot get the material benefits they should have, then energy base construction will lack internal motivation. As a result, making thorough use of Shanxi's advantages and improving the internal conditions and external environment of Shanxi's energy production are problems that now urgently require solution. First, we should improve the energy industry's management system, break through the barriers between centrally-controlled, regional and local mines, promote rational flow and circulation of funds, commodities and technology, and enable the large and small energy enterprises to help each other out in terms of production and operations and compete on an equal basis. Second, we must immediately bring order to coal transport and marketing channels, implement joint operations by coal enterprise groups and transport departments, and move toward direct supply of major users, while at the same time strengthening the planning and management of coal transport and suitably distribute energy transport between highways and rails in terms of direction and distance so as to make thorough use of transport potential. In addition, we must accelerate the development of energy-intensive industries in the coal base areas and implement coal conversion. Such basic industries as refining, chemical engineering and building materials are China's major energy consumers. As a result of the past influence of the coastal industrial base areas, many energy-intensive industries concentrated in the energy-poor eastern zone, which not only increased the amount of energy transport, but also prevented a rational adjustment of the nationwide distribution of industry on the basis of geographic division of labor and the principle of comparative advantage, and thus resulted in nationwide channeling of industrial development. In order to rectify this structural imbalance and alleviate the energy, transport, and materials shortages, we must accelerate the westward movement of energy-intensive industries. The central and western zones and particularly the five energy-base provinces centered on Shanxi and the Gansu-Qinghai and Hunan-Guizhou regions have abundant energy and other resources and are ideal regions for developing energy-intensive industries. For example, the energy base area centered on Shanxi has rich coal resources and also considerable reserves of aluminum ore, iron ore, chemical-engineering minerals and other nonmetallic ores, as well as excellent conditions for extraction; in addition, it has a rather high-quality heavy industry base, with the result that it is an ideal region for developing such energy-intensive industries as electric power, coke production, copper, iron and aluminum production, calcium carbide and caustic soda. Exporting energy in the form of energy carriers can alleviate the pressure on the transport system and replace electric power transmission, in addition to decreasing investments on power lines and cutting power transmission losses, thus alleviating the national energy, materials supply and transport capacity shortages. Even more important, it will become possible to increase the economic strength of the energy base area and to promote the coordinated development of their economies. As a result, this major strategic change should be implemented as rapidly as possible.

d. Energy Conservation Should Be a Focus of Future Energy Consumption

In 1988, China produced 970 million tons of raw coal, placing it first in the world, and generated 543.0 billion kWh of electricity, fourth in the world. The growth of China's energy output since 1980 has been far from slow, but the energy shortage, far from being alleviated, has actually been aggravated. The main reasons are that energy consumption by China's industry is too high and that the appropriate emphasis is not placed on energy conservation, which has greatly decreased the economic benefits realized from it. A joint report by the World Resources Research, International Environment, and Development Research Institutes states that China's energy consumption per dollar of national output value is 43,394 kJ, 4.97 times the figure for France, 3.82 times that for Brazil, and 1.65 that for India, indicating that China has great potential for energy conservation. Eight recent major state economic statistics documents indicate that the energy consumption (in tons of standard coal) per 10,000 yuan of output value is 5 tons, and that if this figure could be brought down to the level of the best figures nationwide, i.e., 2.2-3 tons in Jiangsu, Zhejiang and Shanghai, then China's energy consumption level would equal that of India (the ratio of China's energy consumption to India's is 497:302); China's output value then really would make a great leap. Furthermore, we should be aware that with the current contraction of financing and credit and the rise in prices, energy consumption is an intensive development effort that all enterprise management should consistently undertake and that energy consumption not only can promote decreased enterprise energy consumption, decreased costs, decreased use of funds, and increased benefit from funds, but also can alleviate the energy shortage and improve the external environment for enterprise production operations. As a result, energy conservation should as rapidly as possible be designated an energy consumption strategy. First, the idea that China has a per-capita scarcity of energy and that waste is shameful should be inculcated nationwide; second, conserving energy and increasing consumption should be made a major near-term project of China's enterprise technical modernization; and third, economic measures should be taken to promote energy conservation, with heavy rewards and penalties and with the best winning out and the worst being eliminated.

4. The Principal Objective in the Energy Industry Policy System Is To Effectively Implement Investment Policy and Price Policy

a. Energy Industry Investment Should Be Relatively Stable and Should Provide for Several Important Accessory Projects

Since the state was founded, investments in the energy industry have been huge. In the period from 1953 to 1985, the total capital construction investment in the country's energy industry was 199.237 billion yuan, or 18.6 percent of total capital construction investment in all sectors of the national economy. These large investments laid a rather solid energy-industry foundation for the country, so that China largely achieved energy self-sufficiency. But in every historical period, as a result of variations in understanding of the basic importance of the energy industry, energy investments have failed to be stable and sustained, with proportional growth, but have varied, the investment structure within the energy industry has sometimes not been entirely rational, and certain projects, once started, could not be canceled, and development proceeded by fits and starts, resulting in great waste of limited funds. Certain needed accessory projects were simply left out of consideration, thus increasing the financial burden that local governments had to bear in order to promote coordinated development and eliminate ancillary problems. As a consequence, overall investment results were not fully adequate and the energy industry's reserve potential for development was adversely affected. Thus rational establishment of the energy industry's investment proportionalities and of suitable rates of increase in investments is a basic factor in assuring the industry's long-term stable growth. In general, the absolute size of energy investment should be a specific proportion of national income distribution. Because the energy industry requires large investments in order to develop resources and carry out energy conversion, and particularly because of the law of increasing costs in resource development, energy investments must maintain a suitable rate of increase. In 1985, the World Bank estimated that in the next 10 years the developing countries' energy investments would reach about 4 percent of their output value. During China's Sixth 5-Year Plan, the total 5-year energy industry investment was 67.8 billion yuan, which was 2.4 percent of domestic output value. In 1987, national energy investments increased at a rather considerable rate, but still represented only 2.9 percent of domestic output value. China is a developing country; its total energy consumption is large, and it cannot import large amounts of energy, but must prepare for the long run and rely on self-sufficiency. As a result, energy investment should be at least 4 percent of domestic output value. This is the only way to assure that the development needs of the entire economy will be met. In addition, while assuring a steady increase in energy investments, the state must give due consideration to stable coordination of the economic and social structure of the mining districts and energy base areas and must invest in and undertake several accessory projects in order to support the diversification of the areas' economic development and to eliminate the ancillary difficulties of the local governments and energy industries; if instead they rely only on advances by the energy industry alone it will be difficult to guarantee long-term stable, sufficient supply.

b. Coal Industry Investments That Favor Regional and Local Mines, and Accelerated Improvement of Their Technical Level and Size Structure Are the Quickest Means of Alleviating the Coal Shortage

For more than 10 years the state has focused on providing for the construction of many large mines and opencuts, while making little or no investment in most of the local and regional state-run coal mines, allowing them to maintain ultrasmall-scale operations and use out-of-date production methods. This model should be reconsidered in terms of benefits from investment and rate of growth. From 1949 to 1984, an investment of 34.56 billion yuan, 67.23 percent of the national total, was made in the country's centrally run coal mines resulting in productive capacity of 390 million tons. Meanwhile, local mines spent 3.025 billion yuan, equivalent to 5.89 percent of total nationwide investment, and developed productive capacities of 217 million tons (see Table 2).

Table 2. Coal Mine Investment and Productive Capacity by Type

	Investment and productive capacity, 1949-1984			
	Centrally controlled mines	Regional state-run mines	Local mines	Other mines
Total investment (100 million yuan)	345.6	122.9	30.25	15.3
Productive capacity (100 million yuan)	3.9	1.85	2.17	0.327
Percentage of total	67.23	29.91	5.89	2.97

Source: China Development Bank Coal Survey

With the current funds shortage, the question of how best to allocate the funds, i.e., whether to focus on large size and slow recovery of investment or on small size and fast recovery, is truly a major problem of coal industry development. During the entire Sixth 5-Year Plan period, China's coal output increased by 250 million tons; of this amount, the increase in output in mines under collective ownership was 150 million tons, or more than half. If this coal had been produced by large coal mines, it would have required an investment of about 30 billion yuan and would not have produced the improvement in the coal situation that was actually realized in the short space of 5 years. The collective-ownership coal industry has the advantages of small scale and rapid return on investment; in addition it uses rolling development from small size to large, and differs greatly in production technology and management mechanism from the state-run coal mines; in terms of investments it is capable of simultaneous construction and production, and of putting production before living conditions, while in terms of its distribution of management personnel and workers, it has few idle personnel; in addition, it has few worker placement problems or social problems and lacks the defect of the "large rice pot" [lump-sum funding]. If relatively small investments were made in these small coal mines and if their combination into joint operations were supported and encouraged, they could achieve a considerable technical level, attain the appropriate economic scale and overcome the current deficiencies of poor safety, low technical level and low investment recovery rates in local coal mines. Surveys indicate that a collective-ownership coal mine with an annual output of about 150,000-200,000 tons with a service life of 15 years or more would require an investment of only about 60 yuan per ton of coal to be able to achieve an investment recovery rate of 30 percent. The United States coal industry is highly advanced and consists primarily of large coal mines and large-scale equipment, but at the same time, it is one of the world leaders in terms of the number of small coal mines, which play a decisive role in its coal industry. The Appalachian region has 5,600 coal mines, of which the 1,900 (34 percent of the total in the region) that have an output of less than 90,000 tons account for 20 percent of the region's coal production. These small mines are scattered among the large and medium-size coal mines, and their management standards, degree of mechanization, production benefits and safety are all good. As a result, an investment strategy that focuses on small size and rapid return should be the principal model in China's current development of the coal industry; this is also an important way of resolving the problem of inadequate investment and increasing the motivation of the localities and the peasants.

We emphasize that the approach in which "the state repairs the roads and the peasants dig the coal" should be continued further: we should rectify the past policy of letting the local mines grow by their own resources and without supervision, allowing their technology to become outdated and their benefits of scale to decline while discriminating against them in terms of investments, credit, transport, materials supply and prices; we should genuinely treat them as an enterprise. We believe that the state should make considerable investments in support of the local and regional small coal mines' modernization and amalgamation, so that they make new advances.

c. Coal Prices Must Be Rectified

There has already been much discussion and investigation of the question of coal prices, and the country's coal enterprises fervently wish for reform. The main way of alleviating structural conflicts in China's industrial development does not involve the specific size of the funding, but instead involves preference in terms of the benefits from production. We must therefore rectify the basic understanding of the problem of low energy and materials prices, high end-product prices, and controls on upstream products with no controls on downstream products: if we act without consideration for the law of gradual increase in coal production costs and fail to implement the principle of social-average profitability, if we fail to limit the profiteering of transport and marketing middlemen, and if we fail to emphasize the inherent potential for energy conservation and decreased consumption in industrial enterprises, but instead worry only about a succession of price rises and chaos in price management resulting from coal price adjustments, the price system will not be able to function smoothly and in orderly fashion and it will be very difficult to alleviate structural contradictions in industry.

To summarize, in its reform stage, China is facing a long-term energy problem. Exclusive reliance on stepped-up directive plans and on allocations and low-price subsidies to alleviate the energy crisis has already failed to help. The way to resolve the energy problem is further reform and opening up. On the one hand, we should reform the energy management system, improve management, identify unused potential, make every effort to use the existing base, develop and utilize conventional and unconventional energy resources, decrease energy supply costs, and increase effective supply; on the other hand, we should make a vigorous effort in energy utilization, conserve energy and decrease consumption, open up energy prices as rapidly as possible, accelerate the rate of commodity conversion of energy output. This is the only way for energy to become the true driving force of economic development and to prevent it from ever again becoming a constraining factor.

Material Technology Progress in Power Equipment Industry

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[Article by Sun Huilian, chairman of Materials Committee, Society of Power Engineering]

[Excerpts] Abstract: This paper reports on 10 outstanding achievements of material technology in the power equipment manufacturing industry attained in China during the year 1988, including HP and IP turbine rotors, welded rotors, blades, long blade precision forgings, bolts, boiler drums, protection of blade against erosion, austenitic boiler tubes, generator rotors and their retaining rings, as well as some analyses of material failures in large power plants. Technical objectives to be studied in the future are also highlighted.

I. High and Intermediate Pressure Turbine Rotor and 30Cr1Mo1V Steel[1]

For over 20 years China has been manufacturing high and intermediate pressure rotors with Russian 30Cr2MoV steel. This steel has good high-temperature creep and strength properties but difficult to heat treat. It has a high chromium content and its melt viscosity is high; as a result, impurities cannot rise easily and the steel is often rejected due to metallic inclusions. The 30Cr2MoV steel has severe cracking problem when forged and its large cross-section area hardenability property is also poor. Its center tends to form temper bainite and ferrite biphase structures, which lowers the impact toughness and causes inhomogeneities in property and structure. The acceptance rate is generally only 50 percent or so. In foreign countries most high and intermediate pressure rotor materials for large steam turbines are 1%Cr-1%Mo-1/4V steel. This class of steel has a low chromium content, but higher contents of Mo, C and Mn. [passage omitted]

In the past, China produced high and intermediate pressure rotors with acidic and basic open hearth furnaces and vacuum processing. In foreign countries the current technology uses basic electric furnace, steel refinery furnace and slag remelting furnace. In the early 1980's China imported the Japan Shi-Lan technology and refinery furnaces were built and put into production at the three major machine works. This has greatly improved the quality of the forgings. In January 1988 an evaluation was conducted in Shanghai for the intermediate pressure rotor of the 300 MW steam turbine produced with a steel refinery furnace. Four intermediate pressure rotors produced by the No 1 Heavy Machinery Plant (30Cr1Mo1V), the No 2 Heavy Machinery Plant (30Cr2MoV), and the Shanghai Heavy Machinery Plant (30Cr1Mo1V and 30Cr2MoV) were evaluated:

(1) The chemical composition and mechanical properties of the two 30Cr2MoV rotors met technical specification JB1265-85. With the exception of a separate agreement on the silicon content, the chemical composition and mechanical properties of the two 30Cr1Mo1V rotors also met the technical specifications of the Westinghouse Corporation.

The aluminum content and the contents of hazardous elements Sb, As, S, and Sn and gaseous elements H, O, and N were evaluated. With the exception of a slightly higher Sb content (exceeding 0.0005 percent) in the 30Cr2MoV rotor made at the No 2 Heavy Machinery Plant, and a slightly higher oxygen content (exceeding 0.0004 percent) in the 30Cr1Mo1V rotor made at the No 1 Heavy Machinery Plant, all the other hazardous elements, aluminum, and gases were within the technical specification of the Westinghouse Corporation. (JB1265-85 does not evaluate hazardous and gaseous element content except P and S.)

(2) Grain size evaluation revealed that the rotor made by the No 2 Heavy Machinery Plant had 5-6 class grains, with local regions of class 2 grains. (The JB1265-85 standard requires that grain sizes be no greater than class 4, and the Westinghouse standard requires that grain sizes be no greater than class 2.) The 30Cr1Mo1V rotor produced by the Shanghai Heavy Machinery Plant has class 4 grain size, with small amount of class 1-2 grains near the center.

(3) Hardness homogeneity test, acid etching, sulphur mark test, ultrasonic test, and boroscope inspection showed that the rotors have all met and far exceeded the requirements of specification JB1265-85. Based on the U.S. standard, ultrasonic flaw inspection used an initial sensitivity of 1.6 mm equivalent diameter (JB1265-85 called for 2 mm) and no flaws were found, meeting the Westinghouse requirement.

Based on available test results and technical data, the evaluation group believed that the mechanical properties and technical performance of 30Cr1Mo1V steel were better than those of 30Cr1MoV steel. Considering the foreign trend in rotor technology, it is reasonable to use 30Cr1Mo1V steel in place of 30Cr2MoV steel in the manufacturing of high and intermediate pressure rotors.

To the knowledge of the author, with the exception of the 30Cr2MoV rotors in stock, all new rotors ordered by turbine plants will now be made of 30Cr1Mo1V steel. This is indeed a large improvement in technology.

II. 25Cr2NiMoV Steel for Welded Turbine Rotors[2]

In 1964 China welded its first turbine compressor rotor (920 mm diameter by 5,000 mm) at the Shanghai Turbine Plant, followed by the welded 125 MW low pressure turbine rotor for thermoelectric power generation in 1969 and the 300 MW low pressure turbine rotor in 1972. By 1988, China has produced almost 70 125 MW low pressure welded turbine rotors and 20 300 MW low pressure welded rotors, all operating safely in power plants. The steel used in these rotors was 17CrMo1V (Swiss designation St560TS).

In order to meet the development need of larger coal powered and nuclear powered electrical plants, Shanghai Turbine Works and other units developed 25Cr2NiMoV steel for large forgings in the period from 1974 to 1980; this steel was certified in 1981. The certification group believed that, compared to the 17CrMo1V steel currently under production in China for welded rotor material, the 25Cr2NiMoV steel represented a breakthrough in strength, toughness, and brittle transition temperature and was the state-of-the-art in large welded rotors. It may be used as welded rotor material with 650 MPa strength for 600 MW turbine and as welded rotor material with 550 MPa strength in 300-1200 MW turbines. [passage omitted]

The Shanghai Steam Turbine Works, after depleting its stock of 17CrMo1V steel forgings, has begun to use 25Cr2NiMoV steel in 1988 in its 19th 300 MW turbine low-pressure welded rotor. The same was also done for the 125 MW machines and the change was listed in the revised plant standards of February 1988.

At the same time, the Harbin Steam Turbine Works, Shanghai Institute of Materials, and the No 1 Heavy Machinery Plant have also investigated the 25Cr2NiMoV steel as a material for the low-pressure welded rotor of 600 MW turbines. They obtained the same chemical composition and mechanical properties and arrived at similar conclusions.[4]

III. Blade Materials: AISI403 Steel, C-422 Steel and 17-4PH Steel[5]

In China, the thermoelectric power generator blade material has been primarily the Soviet series of 1Cr13, 2Cr13, and 15Cr11MoV. These steels are quite different from the ASTM series steel imported from the Westinghouse Corporation in the United States and cannot satisfy the requirements of imported 300 MW and 600 MW generators. Today the United States and Europe generally use C422 steel and 403 steel in high and intermediate pressure blades. These steels have better room temperature and high-temperature performances and the metallography of these materials are also controlled more closely. For blades in the low-pressure last stage and next to the last stage, Westinghouse uses its own special steel: precipitation hardened martensitic 17-4PH steel. Its corrosion resistance and damping properties are good, its strength classification can be easily adjusted, its corrosion fatigue behavior is superior and it is easy to weld. China had no experience with this particular steel and the current metallurgical technology in China cannot produce materials to meet ASME and Westinghouse standards. Westinghouse controls the structure and composition of 403 steel so that its limiting yield strength $\sigma_{0.2}$ greater than 548.8 MPa; in China the same steel without structural and composition control has only $\sigma_{0.2}$ greater than 441 MPa.

After spending major efforts, the various special topics units have solved the following problems:

(1) The metallurgical quality of the three steels made in China has met the technical requirements of Westinghouse. The steel property is sensitive to heat treatment; if the grain size of the carbide in C422 steel is nonuniform or large carbide grains exist at the grain boundary, a higher quenching temperature should be used. The heat treatments of 403 steel and 17-4PH steel may be properly adjusted according to their chemical composition. Coarse grains in blade steel may be eliminated with special annealing procedures.

(2) By controlling the percent content of σ-Fe, the $\sigma_{0.2}$ value of 403 steel may be increased to 550 MPa; by adding 0.2-0.6 percent of Mo, the residual toughness of the steel can be made large. Corrosion fatigue behavior of 403 steel and 17-4PH steel was investigated; their fatigue limit showed pronounced drop in corrosive environment. The fatigue property of 17-4PH steel has a greater resistance against corrosion.

(3) The structure of C422 steel is stable at 540°C, but after a certain amount of time at 570°C the Laves phase begins to appear. This phase has a small strengthening effect and little effect on toughness. The 403 steel structure is stable at or below 510°C. [passage omitted]

The research project on blade material passed certification in August 1988. Efforts should be spent in the future so that Chinese-made material may replace imported material.

IV. Precision-Forged Large Turbine Blades

China has always relied on imports for precision forged large turbine blades (665 mm or greater). Data shows that from 1979 to 1986 a total of 39,200 blades was imported from Austria, Japan, and the United States at a cost of US$9.32 million. In 1988-1990, an additional 33,000 blades will be needed; the cost will be US$24 million if all of them were imported.

In 1987 the East Turbine Plant and the Beijing Institute of Electromechanics collaborated in producing 600 precision rolled 700 mm 2Cr13 blades using a 630 mm rolling machine and a 10,000 KN friction press. These blades have passed certification. In the meantime, the Wuxi Blade Plant has also batch produced precision rolled 665 mm blades.

In December 1987, the State Machine Council organized a large blade quality evaluation group to visit the Hongyuan Forging Plant in Sanyuan, Shaanxi, and the Wuxi Blade Plant. They evaluated the quality of the blanks of 710 mm precision-forged blades and concluded that the quality of the products at the two plants has reached the technical requirements of 1983 imports from Austria.

In April 1988, the Electrical Component Bureau of the State Machine Council organized a task force to solve the 869 mm (17-4PH) blade problem. Development work is currently under way.

On 2 May 1988, the first batch of Chinese-made 710 mm precision forge blade blanks were evaluated in a meeting to promote domestic manufacture of blades. The 252 positive and negative blanks made by the Wuxi Blade Plant met the requirements of the Harbin Turbine Plant and were certified as acceptable. In March 121 positive blanks of good quality were delivered by the Hongyuan Forging Plant, in November another 600 blades were delivered.

Precision forging of 665 mm, 700 mm and 710 mm large blades is a major step forward in the manufacturing of turbines.

V. Fastener Material of Steam Turbines

1. GH145 Alloy[7,8]

The original design of the imported 300 MW turbine called for Refractory-26 (abbreviated as R-26) as the material for high and intermediate pressure inner chamber bolts and gas seal springs. However, R-26 contains 20 percent of cobalt, a rare and expensive metal; an alternative was sought.

When trace amounts of Mg, Zr, and B were added to GH145 alloy while improving the traditional heat treat process, the intermediate temperature endurance plasticity was greatly increased and the notch sensitivity of the alloy was also eliminated. The technical problem of replacing R-26 alloy with GH145 alloy was therefore solved.

The Shanghai Municipal Metallurgical Bureau organized a special topic evaluation meeting in March 1988 and concluded that the mechanical properties of the improved GH145 alloy have met the standards of the Westinghouse R-26 alloy and the stress corrosion resistance under slow strain rate and in a harsh environment was slightly better than that of R-26 alloy. The GH145 alloy can therefore be used in place of the R-26 alloy to further improve the reliability of turbine fasteners at high temperature. [passage omitted]

2. C422 Bolt Steel[9]

Imported 300 MW and 600 MW turbines use a great amount of C422 steel fasteners. After tests were performed by research units, technical assessments were made on Chinese-produced C422 steel and found that it completely met the standards of Westinghouse. [passage omitted]

VI. Research on Water Corrosion Prevention of Last Stage Turbine Blades[10,11]

In China, water corrosion prevention of last stage turbine blades has been based on the facilities available at the various plants, the original design blueprints, and customary practices. Methods used included welding of si-tai-li alloy, welding of hard chromium, and electric discharge enhancement. Since no systematic scientific studies have been made, there were conflicting arguments about which method was the best. The above three methods have been used in foreign machines, but most recent models of foreign units are now using welded rolled si-tai-li alloy sheets. The Shanghai Turbine Plant has always used a hard chromium plating method in the past; beginning in 1981, they have performed last stage turbine blade water corrosion resistance experiments using high frequency induction surface quench hardening, hard chromium electroplating, and welding of si-tai-li alloy sheet. They have conducted more than 17,000 hours of power plant operation testing and fatigue tests and obtained scientific and reliable data. In December 1988 an evaluation conference was held and the following conclusions were arrived at:

(1) The resistance to water corrosion of last stage blades with plated hard chromium was poor; once the chromium layer was damaged, water corrosion progressed toward deeper into the metal. Vibration fatigue tests also showed that the fatigue strength of chromium plated blades was relatively low. The method of hard chromium plating should therefore be discontinued.

(2) Blades with high frequency induction quench hardening and welded si-tai-li alloy had obvious resistance against water corrosion. The water corroded area using the former method was slightly greater than using the latter method, but the overall resistance against water corrosion of the two methods can be regarded as of the same order.

(3) The procedures for surface quench hardening of turbine blades are relatively simple and inexpensive to implement and the process can provide a certain degree of water corrosion resistance. It should be applied in the batch production of 125 MW and 300 MW turbines at the Shanghai Turbine Plant.

In the last few years the Dongfeng Turbine Plant carried out water corrosion prevention experiments using TIG overlay welding of si-tai-li alloy. The method passed certification in June 1988. Tests on the two peak scheduling generators in the last 7 years have demonstrated the method to be simple and reliable, conducive to power plant maintenance and the cost was much less than that of inlay welding of si-tai-li alloy.

VII. Study of Austenitic TP304H and TP347H Boiler Steel Pipes[12]

The superheater and reheater steel pipes of Chinese-made power plant boilers (from intermediate pressure boilers to subcritical pressure boilers, including 1,000 t/h boilers for 300 MW) are all made of carbon steel and low alloy steel, and, in some instances, 12Cr steel. This practice has simplified the production, avoided the welding of dissimilar steels and lowered the cost. However, it has also suffered from limitations in pressure and temperature and affected the optimum design. The superheater and the high temperature section of the reheater of the boiler made by the American Combustion Engineering Company used austenitic steel and thereby increased the safety margin and layout of the boiler. In the mid-1980's, the first 300 MW boiler designed and produced by the Dongfeng Boiler Plant and the 300 MW and 600 MW boilers made by the Shanghai Boiler Plant and Harbin Boiler Plant using the technology of the CE Company all used TP304H and TP347H austenitic steel. But all these steel pipes were imported.

From 1982 to 1987, China test produced and re-evaluated the two above steels and conducted a technical evaluation in December 1987. Tests showed that as-received steel pipes made in China without solid solution treatment had relatively poor quality and could not be used in production directly. However, steel pipes which went through a solid solution treatment in the laboratory have met the technical requirements of ASME codes and their strengths were comparable to imported Japanese steel pipes. In order to further improve the long-term plasticity properties of Chinese-made steel pipes, the steel plants should take appropriate measures. [passage omitted]

VIII. SA299 and BHW35 Steel for Steam Domes of Boilers[13]

The steam domes of large power plant boilers in China are made of West German BHW35 steel plates. The cylinder wall thickness of superhigh pressure steam domes is 85 to 95 mm and the wall thickness of subcritical pressure 300 MW boiler steam dome is 145 mm. In 1981, China imported the technology from Combustion Engineering of the United States to produce SA299 (carbon manganese) steel plates for the steam domes of subcritical pressure 300 MW and 600 MW boilers. After this, there were different opinions in the industry regarding BHW35 steel versus SA299 steel. [passage omitted]

In order to make a rational choice of the material, a special topics project "Comparison and analysis of the properties of super-thick steel plates of BHW35 and SA299 steels" was established to assess the advantages and disadvantages of the two steels. After 3 years' work, the project has now been completed and passed technical evaluation in July 1988. The major conclusions of the project were:

(1) The room temperature and 365°C tensile property and impact toughness of automatic weld joints of BHW35 steel and SA299 steel have all met the required standards. However, in both steels the mechanical strength of the weld joint and the weld seam were poorer than the host material. These lower mechanical strengths should be considered in the product property evaluation and design calculation of strength.

(2) The mechanical properties of BHW35 and SA299 each have their strong points. BHW35 has a higher strength so the wall thickness of steam domes may be less. SA299 steel has a lower plasticity-free transition temperature so that water pressure tests may be performed at lower temperatures. BHW35 steel suffers less low cycle fatigue damage, but SA299 steel has better fracture toughness so the danger for brittle fracture of flawed steam dome is less. The two steels have comparable impact toughness, ductile-brittle transition temperature, and crack propagation rate, but BHW35 has a better resistance against crack propagation.

(3) The low cycle fatigue damage of boiler steam dome for 300 MW generators made by automatic welding of 145 mm thick BHW35 steel plates was considerably less than that in a steam dome made of 170 mm-202 mm SA299 carbon manganese steel plates. Because the BHW35 steel steam dome has a thinner wall, the thermal stress is less, so that even though the membrane stress is greater, the alternating stress amplitude at the base of the descending pipe is still smaller. Furthermore, since the low cycle stress fatigue properties of BHW35 steel are better, the life time degradation due to alternating loads is less. This is very important to large power plant boilers used for peak shifting.

(4) China now has the technology for producing steam domes using BHW35 steel. Metallurgical departments have also tried producing similar extra-thick steel plates made of 13MnNiMoNb alloy. Considering the need to produce BHW35 steel and steam domes in China, it is advisable to opt for the thinner BHW35 steel plates in the manufacture of super-high pressure and subcritical pressure boiler steam domes. Domestic production of steam domes, with assurance of safety and reliability, carries considerable economic benefits.

IX. 600 MW Generator Rotor and Mn18Cr18 Guard Ring

Domestically produced and foreign produced large generator rotors are all made of medium carbon steel containing chromium, nickel, molybdenum and vanadium. Rotors for generators with a capacity of 300 MW or less are now produced domestically and the acceptance rate is slightly higher than that of turbine rotors. In 1988, the No 2 Heavy Machinery Plant produced a set of large forgings for a 600 MW unit, including generator rotor, high pressure, intermediate pressure and low pressure turbine rotors and guard rings. If these forgings can pass the evaluation to be held in the first quarter of 1989, they would represent a major breakthrough in the history of large forging production.

Large electric generator guard rings[14] are made with 50Mn18Cr4WN in China. Industrially advanced nations are now using Mn18Cr18 steel which has a better resistance against stress corrosion. Companies in West Germany have been using the 18-18 steel for large generator guard rings since 1985 and this practice was listed in their industrial standards.

The three large heavy machinery plants in China have all begun research and industrial testing of Mn18Cr18 steel guard rings. [passage omitted]

Since the second half of 1987, the Shanghai Heavy Machinery Plant has cooperated with the Shanghai Institute of Materials in optimizing the chemical composition of the Mn18Cr18 steel. They have now advanced to industrial tests. According to the schedule of the Ministry of Machine-Building and Electronics Industry, the No 1 Heavy Machinery Plant is to produce a pair of 300 MW guard rings in the first quarter of 1989, the Shanghai Heavy Machinery Plant is to produce a pair of 300 MW guard rings in the second quarter of 1989, and the No 2 Heavy Machinery Plant is to produce a pair of 200 MW guard rings in the fourth quarter of 1989. In addition, it was recommended that the entire manufacture process be monitored so that the key technology for producing guard rings may be established as soon as possible. Evaluation meeting will be held for delivered Mn18Cr18 guard rings to consolidate and exchange the experience in order to move into batch production as early as possible.

X. Failure Analysis of Large Power Plant Materials

(1) Failure Analysis of No 5 200 MW Generator[15]

In February 1988, the 200 MW No 5 generator of a power plant had a major accident. Failure analysis of the turbine shaft, generator rotor and other four components led to the following conclusions:

1. No signs of old cracks were observed on the fractured surfaces. The failed turbine shaft and generator rotor had rather different yield limits.

2. The fracture of the emergency interrupter was due to overloading.

3. The fracture of the slip ring was due to the impact by a tile cushion.

4. The fracture of turbine blades was due to overload.

5. The thread stripping of the fan blades was a result of axile bending vibration and mechanical impact.

6. Low pressure rotor fractured because of the compound alternating load consisted mainly of bending.

7. The fracture of the generator shaft was an abrupt fracture due to large compound alternating stress.

(2) Failure Analysis of the Bend in the Descending Water Supply Pipe in the Aft Cooling Wall of the No 5 Boiler (670 t/h) of a Power Plant[16]

The descending pipe bend (φ159x14.2, St45.8/III) of the No 5 boiler of a power plant exploded in October 1988. Broken pipe and debris were thrown out for 5-10 meters and the boiler underwent an emergency shutdown.

Analysis revealed the following causes for the accident:

1. The fracture of the pipe bend was a typical brittle fracture.

2. The source of the fracture was mechanical damage on the curvature of the pipe bend.

3. The intrinsic cause of the fracture was the aging brittle of the material. The minimum impact toughness of the bend was 10J and the minimum impact toughness of the straight pipe was 5J, far less than the required minimum of 27J.

Quality analysis of the descending pipe revealed the following:

1. Re-check of 42 specimens when the pipes were received at the plant showed an impact toughness of 100-174J, far greater than the required minimum.

2. The aluminum content of the steel was too low and the nitrogen content was too high. The latter tends to cause aging brittle. The inclusion content of the steel was too high and the skin of the pipes was thick. The remnant pipes failed to pass the crush test and the surface hardness was too high.

The current codes do not specify the content of trace elements such as aluminum and nitrogen, nor do they mention the requirements on nonmetallic inclusions. Revised codes should clearly specify these quantities.

In addition, the Qingdao Steel Plant test produced spiral pipes for the boiler cooling wall, the Jiuliting Scissor Plant batch produced a special flat steel coil for welding finned pipes, and other units have investigated the cold-bending of automated buried arc welding plates for boiler steam domes and the residual life of II11 steel pipes.

The lead time for power plant material test is usually 3 or more years. It was coincidental that many of the materials and technologies described here were certified or promoted in 1988 and similar situations have rarely happened since 1949. But it was no accident that so much was achieved in view of the attention and support by the Office of Major Facilities in the State Council, the Ministry of Machine-Building and Electronics Industry, and leaders in the Ministry of Energy.

Although a great deal has been achieved in recent years in the area of power station materials and technology, there are still many projects to be continued or initiated. Examples are the research of serialization of steels, building up the steel property data bank, development of supercritical materials, development of titanium alloy blades, development of large forged rotors without central holes, and the prediction of residual life of components. It is the author's belief that before long the level of power plant materials in China will reach the world standard.

References

1. Number 1 Heavy Machinery Plant, "Production Technology of Intermediate Pressure Rotor for 300 MW Turbine Using Steel Refining Furnace," September 1987.

2. Shanghai Turbine Plant, et al., "Welding of Turbine Rotors for Large Thermal Power Plants and Nuclear Power Plants—A Research Report," 1981.

3. Shanghai Turbine Plant, "Metal Material Standards," February 1988.

4. Harbin Turbine Plant, "Test Production of Welded Low-Pressure Turbine Rotor Disk Forging for 600 MW Turbine," March 1978.

5. Shanghai Institute for Power Generation, Harbin Turbine Plant, and Shanghai Turbine Plant, "A Study of Blade Materials," June 1988.

6. Sun Huilian, "Power Generation Facilities," No 9, 1988.

7. Shanghai Bureau of Metallurgy, Shanghai United Electric Appliances, "Certification of GH145 Alloy Technology," March 1988.

8. Shanghai Institute for Power Generation, Shanghai Turbine Plant, and Harbin Turbine Plant, "A Study of Alternates for R-26 Alloy," June 1988.

9. Shanghai Institute for Power Generation, Harbin Turbine Plant, and Shanghai Turbine Plant, "Performance of C422 Screw Steel," June 1988.

10. Shanghai Turbine Plant, "Test Report on Water Corrosion Resistance of Last Stage Blades," December 1986.

11. Dongfeng Turbine Plant, "TIG Overlaying Welding of si-tai-li Alloy for Water Corrosion Resistance of 680 mm Blades," November 1987.

12. Shanghai Institute for Power Generation, Harbin Boiler Works, Dongfeng Boiler Works, Shanghai Boiler Works, "Application and Properties of Austenitic Boiler Pipes," December 1987.

13. Shanghai Institute for Power Generation, Dongfeng Boiler Plant, Harbin Boiler Works, Shanghai Boiler Works, "Comparison Analysis of BHW35 and SA299 Steels for Steam Domes," May 1988.

14. N. L. Kilpatrick, "Application of 18Mn18Cr Steel for Generator Rotor Retaining Rings," Third Joint Technical Seminar, June 1987.

15. National Investigative Group for No 5 Generator Accident, "Accident Investigation and Analysis Report," September 1988.

16. Harbin Boiler Plant, "Analysis of Pipe Bend Explosion in Water Cooling Wall of No 5 Boiler," November 1988.

On Building Huge Energy Materials Base in Hunan

40130123c Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 2 Aug 89 p 3

[Article by Cong Shuying [0654 2885 5391], commissioner in the Hunan Province Loudi Prefecture Administrative Office: "Build an Energy Resource Raw Materials Base Area, Strive To Develop Horizontal Integration, Actively Import Capital and Technologies"]

[Text] Loudi Prefecture is a treasurehouse in central Hunan Province. Its 8,067 km^2 area contains rich reserves with 45 types of extractable mineral deposits. This includes large and widely distributed coal reserves with a full complement of varieties and rather good coal quality, so it has been called "central Hunan's sea of coal." Prospecting indicates industrial reserves of 1 billion tons and long-term reserves of 3 billion tons. The region holds first place in the world in antimony output and Lengshuijiang City's Xikuang Shan is famous as the "world antimony capital." It has substantial gold ore reserves. Large deposits of many metallic ores, mainly gold, have been proven in the Gutai Shan area of southwestern Xinhua County in the past few years. Prospects for exploitation are extremely gratifying. It also is rather rich in ferrous metals like manganese and iron, and it is a materials mixture base area for Shanghai's Baoshan and Hunan Province's main iron producing region. It also has substantial reserves of gypsum, graphite, marble, limestone, barite, and other nonmetallic mineral reserves.

Abundant mineral resources have created enormous conditions for developing Loudi Prefecture's energy resources and raw materials industry. Over the past few years, all areas resolutely began with the actual situation and worked hard to develop energy resources. In the past 40 years it established over 23,000 large and small plant and mine enterprises like the Lianshao Mining Bureau, Jinzhu Shan Power Plant, Xikuang Shan Mining Bureau, Lianyuan Iron and Steel Mill, Lengshuijiang Steel and Coking Complex, and others. In 1988, the prefecture produced over 11 million tons of coal, 30 percent of total raw coal output in Hunan Province. Yearly electricity output has reached 3.1 billion kWh, including 2.94 billion kWh from thermal power, equal to 37.1 percent of total thermal power output in Hunan, and it transmitted out about 2 billion kWh of electric power. It produced over 18,000 tons of antimony products, about one-half of the total for China and one-third of the world total. It produced 416,000 tons of steel, 45 percent of the total for Hunan. Pig iron output was 648,000 tons, equal to 54 percent of the total for Hunan, and it produced 30,000 tons of soda ash, equal to 70 percent of the provincial total. The prefecture now holds first place in Hunan in output of six products: raw coal, coking coal, pig iron, antimony products, soda ash, and thermal power. It holds second place in Hunan in output of steel, steel materials, cement, and calcium carbide. Moreover, it holds an important status in Hunan in plate glass, fire-resistant materials, structural ceramics, marble slabs, and other products. The prefecture now sells several 10 types of key products in international markets including antimony products, threaded steel rods, coking coal, high quality cement, calcium carbide, electric power tools, household ceramics and artistic ceramics, and others. At the end of 1988, the prefecture's value of output from heavy industries, mainly the energy resource and raw materials industries, was 1.654 billion yuan renminbi, equal to 74.4 percent of the gross value of industrial output. It has become a primary heavy structural industry region at a preliminary scale and is an important production base area in Hunan for energy resources and raw materials.

During the process of developing energy resources and raw materials, we consistently adhered to the principle of opening up to promote development, strove to develop horizontal integration, and actively imported capital, technologies, and skilled personnel. The prefecture has now formally signed 720 economic and technical cooperation projects within China and with foreign countries and brought in over 137 million yuan renminbi, including nearly 80 million yuan renminbi in imported foreign investments. To further attract and encourage foreign businessmen and compatriots in Hong Kong, Macao, Taiwan, and foreign countries, the Loudi Prefecture administration formulated several preferential policies in accordance with relevant stipulations by the State Council and Hunan Provincial Government. All foreign businessmen who come to Loudi Prefecture for joint development of energy resources, raw materials and for prototype and blueprint processing or compensated trade projects receive preferences in areas like land use, site leasing, manpower, construction materials, communications and transport, and other areas. All foreign businessmen who come to Loudi Prefecture to develop resources, develop new products, and key construction projects receive profit dividends from Loudi Prefecture according to investment proportions. All foreign businessmen who import personnel, capital, technologies, and information to Loudi Prefecture and who make important contributions in foreign economic contracts can receive remuneration. In summary, we are following the principle of equality and mutual benefit, transferring authority to clients, wholehearted cooperation, and joint development. We encourage compatriots from Hong Kong, Macao, and Taiwan, compatriots in foreign countries, and foreign friends to come to Loudi Prefecture to invest in building plants. We believe that the vast central Hunan region with its rich natural resources, enormous material foundation, excellent investment environment, and preferential policies of opening up to the outside world will attract people from all realms to give full play to their abilities!

Sichuan Developing Large, Medium, and Small Projects Simultaneously

40130123b Chengdu SICHUAN RIBAO in Chinese 27 Jul 89 p 1

[Article by SICHUAN RIBAO reporter Xia Guangping [1115 0342 1627]: "Good Momentum in Sichuan Province's Energy Resource Production and Construction, Integrate Development and Management, Develop Large, Medium, and Small Projects Simultaneously"]

[Text] For the past few years, energy resource production and construction in Sichuan Province have adhered to the principles and policies of "integrated development and management, combined development and conservation" and "simultaneous development of large, medium, and small scale, everyone involved in developing energy resources." We have made obvious achievements, and our accomplishments in the first half of 1989 are particularly noteworthy.

The scale of electric power industry projects now under construction in Sichuan exceeds 7 million kW, and the installed generating capacity placed into operation in the first 3 years of the Seventh 5-Year Plan exceeds 1.4 million kW, equivalent to four times the total installed generating capacity placed into operation in the Sixth 5-Year Plan. The average annual growth rate over this 3-year period was 9.3 percent. The scale under construction is more than 7 million tons for coal and 2 billion m^3 for natural gas. The Ertan Power Station, Junlian Coal Mine, and several other big key energy projects have been included among state reserve projects and engineering preparations have begun for the Ertan Power Station. Sichuan's total primary energy resource output in 1988 was 61 million tons of standard coal, up by more than 10 million tons of standard coal over 1985. New advances have been made in conservation work and energy resource consumption has declined every year. Average annual conservation exceeds 2 million tons of standard coal.

Total primary energy resource output in Sichuan for the first half of 1989 was 30,994,200 tons of standard coal, up by 7.89 percent over the same period in 1988. This includes 34,621,300 tons of raw coal, up 7.37 percent, 3.173 billion m^3 of natural gas, up 2.03 percent, and power output of 15.436 billion kWh, up 11.81 percent, which is one of the better periods for energy resource development over the past several years.

However, Sichuan has substantial bills due for energy resources and considerable shortages which continue to be major factors which restrict economic development. First, there was a reduction in state investments in energy resource construction and development in Sichuan and sluggish energy resource construction. Second, there was overheated economic growth over the past few years. This is particularly true of the excessively rapid growth of processing industries which was not coordinated with energy resource construction. Third, energy conservation work awaits further reinforcement. High energy consumption and substantial waste are still quite common.

At a provincial energy resource work conference which began on 25 July 1989, relevant provincial level departments, specialists, mayors, prefecture leaders, and planning commissions from all prefectures, cities, and autonomous prefectures which manage energy resources, and responsible persons from some enterprises reviewed Sichuan's accomplishments in energy resource construction and problems which exist in accordance with Deng Xiaoping's recent instructions regarding reinforcement of energy resources and discussed major plans to accelerate development of Sichuan's energy resources.

Energy Output Up in First Half of 1989

40130111b Beijing RENMIN RIBAO in Chinese 4 Jul 89 p 1

[Text] A concerned responsible cadre of the Ministry of Energy Resources today divulged to this reporter that there is much hope that China's raw coal production will reach the 1 billion-ton target this year. As of the end of June, nationwide raw coal output totaled 479 million tons, accounting for 48.6 percent of that planned for the year and a net increase of over 38 million tons compared with the same period last year.

According to the briefing, in the first half of this year China's energy output was up overall. Raw coal output has shown a progressively increasing trend. As of June, daily production levels had reached 2.9 million tons to set the highest record in history. For the first half of the year, the average daily production level reached 2.65 million tons. Ministry of Energy Resource personnel consider that if this level is maintained, then the state's plan for 985 million tons for the entire year can be fulfilled.

Electric power production in the first half of the year supplied 276.8 billion kilowatt-hours, fulfilling 48.57 percent of that planned for the whole year, and an increase of 13.8 billion kilowatt-hours over the same period last year. Of this amount, hydropower generation reached 53.43 billion kilowatt-hours, already fulfilling 51.87 percent of the year's plan. During the latter half of last year, coal stored by power plants and water stored in reservoirs were both seriously inadequate, therefore, at the beginning of this year, electric power production encountered difficulties. Power generation in the spring only equaled that of the same period last year. Through the many instances when relevant departments of the State Council worked to coordinate and increase the supply of coal for electric power, after entering summer an increasing trend appeared in power production.

Crude oil output for the first half of the year was 67.583 million tons, fulfilling 48.59 percent of that planned for the entire year and an increase of 420,000 tons compared with last year. However, it was still far from the originally determined target increase of 3 million tons. In particular, the Shengli oil field, which this year had the best hope of increasing production, had more shortfalls in output in the first half year due to encountering natural disasters such as floods and hail.

Natural gas production during the first half of the year achieved 7.04 billion cubic meters, just reaching one-half of that planned for the entire year.

A few days ago, the Ministry of Energy Resources convened the National Energy Production Conference and assigned production tasks for the latter half of the year. It was required that the energy industry must fulfill this year's state planning across the board. Raw coal output must reach or exceed 1 billion tons, power generation must reach 570 billion kilowatt-hours and every possible method must be used to achieve 139 million tons of crude oil output.

Assuring Resumption of Normal Operations in East China Grid

40130111a Shanghai JIEFANG RIBAO in Chinese 31 May 89 p 1

[Excerpts] In order to reverse the low cycle operational state of the East China power grid which includes three provinces and one municipality, the State Planning Commission and the Ministry of Energy Resources have decided to adopt appropriate measures. Beginning 1 June, the East China power grid will resume and sustain normal cycle operation. In this connection, the State Planning Commission and the Ministry of Energy Resources set up the East China Power Grid Power Supervisory Group which will travel to East China in June.

This year, supplies of fuel at power plants in Jiangsu, Zhejiang, Anhui and Shanghai have been seriously inadequate. From January until April of this year, the East China power grid contract called for the supply of 12.336 million tons of coal, but only 10.915 million tons actually arrived at the power plants, or 88.48 percent. With the addition of other factors, for the period from January to April taken as a whole, the power generated in the East China grid fell 2.35 percent as compared with the same period last year. Moreover, power consumption did not drop correspondingly according to plan, forcing the East China grid into regular low cycle operation threatening the safety and stability of the grid.

Because of this, the State Planning Commission and the Ministry of Energy Resources decided to continue to adhere to and execute the policy of giving priority to the transport of coal for electric power in East China, and the Ministry of Railways has taken emergency measures to rush coal to areas other than Anhui Province. The Ministry of Communications has increased transport capacity in a maximum effort to satisfy the requirements of the power plants in each of East China's ports. Each provincial and municipal department of electric power must continue to expedite generation and transport, and increase stockpiled coal. Each province and municipality must plan to purchase negotiated price oil for processing and generation of power, and more power should be generated for use by the provinces and municipalities which supply oil. [passage omitted]

The State Planning Commission and the Ministry of Energy Resources further require that Anhui fulfill plans for contributing electric power. The primary responsibilities of the Xinanjiang and Fuchunjiang hydropower plants are peak regulation and incidental contingency use, not the support of excessive power consumption.

Power Supply To Remain Tight in Jilin Through Rest of Year

40130119a Changchun JILIN RIBAO in Chinese 6 Jul 89 p 1

[Excerpt] On 3 July, the provincial government convened the Second Provincial Conference on the Coordination of the Supply and Transport of Fuel for Power Generation to find ways to continue to solve Jilin's tight power supply problem.

Each of the province's concerned departments and responsible comrades from coal mines attended the conference. The conference also invited responsible comrades from the Dongmei Company and the Shenyang Railway Bureau to attend.

The conference pointed out that since last winter, the northeast power grid has been short of water and low on coal, generating unit operation has been unstable and generation levels have continued to fall by large amounts. Under these circumstances, despite the very great support given to Jilin by the Northeast Power Administration, in the first half of this year the average daily supply quota of electric power provided to Jilin was only 24.637 million kilowatt-hours. This constituted a reduction of 10.138 million kilowatt-hours compared with the daily electric power supply for the same period last year and has seriously affected the economic development of Jilin and the lives of the people. In order not to cause a major backslide in Jilin's industrial production and major problems in the lives of the people, the provincial government last December convened the First Provincial Conference on the Coordination of the Supply and Transport of Fuel for Power Generation. Because each concerned department put into practice the spirit of the conference, the difficulties of inadequate resources and strained transportation were overcome, and the original plans for fuel transport and power generation were fulfilled relatively well. Of the actual amount of electricity used during the first half of the year, Jilin's fuel transport and independent power generation accounted for 27.37 percent. The early attention paid to the work of stressing coal and ensuring electric power by the provincial government, the major support efforts and close coordination of the Dongmei Company, the Shenyang Railway Bureau, the Provincial Bureau of Electric Power, and other departments has resulted in effective fuel transport and independent power generation work and has stabilized Jilin's economy. In the latter half of the year, Jilin's industrial production task will be extremely difficult. The planned 8 percent increase for the entire year must be fulfilled. In the forefront is the electric power issue. Preliminary forecasts indicate that in the northeast power grid, electricity supply levels for the second half of the year will be roughly the same as during the first half of the year. The shortfall will remain at around 40 percent. Because coal requirements are greater in the latter half of the year than those of the first half, the fuel transport and power generation task will be exceedingly difficult. The conference required that each department must fully exploit all potential to ensure that the plan is fulfilled.

During the conference, responsible comrades from the coal, electric power, and transportation sectors reported on the implementation of fuel transport and power generation work for the first half of the year and indicated that the utmost effort would be made to fulfill these tasks for the second half of the year. [passage omitted]

Major Role for Hydropower in Nation's Energy Strategy

40130106a Beijing SHUILI FADIAN [WATER POWER] in Chinese No 5, 12 May 89 pp 2-4

[Article by a SHUILI FADIAN reporter: "Energy Strategy Calls for Hydropower—Sidelights on a Hydropower Situation Discussion Conference"]

[Text] The China Hydroelectric Engineering Society recently held a conference to discuss the present hydropower situation. Those invited to attend the conference included the society's president and vice president, standing director, and advisers, and officials from the Ministry of Water Resources and Ministry of Energy Resources and from the relevant departments (bureaus) and design and scientific research units, as well as some experts and professors. The discussion conference was conducted in the spirit of "Relying on Reform and Policies To Promote Major Development of Hydropower—Minister Huang Yicheng [7806 3015 6134] of the Ministry of Energy Resources Answers SHUILI FADIAN Reporter's Questions" in issue No 1 for 1989 and the National Energy Resource Work Conference in January 1989. With support by Comrades Li Eding [2621 7725 7844] and Zhang Tiezheng [1728 6993 6927], an enthusiastic conference was held. Yang Zhenhuai [2799 2182 2037], Lu Youmei [7120 0147 2812], Li Rui [2621 6904], Pan Jiazheng [3382 1367 6927], You Jishou [3266 0679 1108], Zhu Erming [2612 1422 2494], Zhang Jinsheng [1728 3160 3932], Shen Xinxiang [3088 0207 4382], and other comrades gave speeches. This discussion conference was held in today's situation in which the energy resource and electric power shortages have become hot points and are drawing special attention.

I. Opportunities and Hopes

Comrades at the conference, particularly several older leaders and experts, felt that the strategic ideas, strategic goals, and strategic measures outlined by Minister Huang Yicheng for hydropower development were very good. However, serious challenges and difficulties may be encountered in realizing them. Faced with the current situation of a grim energy resource shortage, accelerated development of China's abundant hydropower resource advantages obviously is one way to eliminate our energy problems. This point is being acknowledged by increasing numbers of people and they are raising a growing cry. There is opportunity and hope for major hydropower development and we should seize this opportunity and strive in every possible way to realize our hopes. We can no longer delay this opportunity. Otherwise, there will be losses in China's energy resources which cannot be compensated for.

II. We Must Think Things Over and Struggle for Progress

"The river waters roll eastward, but the flow is all coal and oil." This is a cherished appeal and we have been talking about accelerating development of China's hydropower resources for many years now. Senior engineer Pan Jiazheng has figured the accounts: China has developable and usable hydropower resources of 1.9 trillion kWh yearly, and a 1 year delay in developing them is equivalent to losing 1 billion tons of raw coal or 500 million tons of crude oil. Of course, we cannot develop all our hydropower resources in one fell swoop, but this fact should make us understand the great importance of accelerating hydropower resource development in China. Premier Zhao Ziyang pointed out in October 1980 that "hydropower is different from coal and petroleum in that it is a renewable resource, not a primary consumption resource, nor does it pollute, so it should be handled as a strategic measure." "This requires a strategic vision. We cannot yield to present difficulties year after year and delay the time, because we will look back in the future and see that we made a big mistake." It has been 10 years since Premier Zhao Ziyang made this statement, but don't we still lack a strategic vision? Have we delayed the time? Why? Comrades at the conference felt that now is the time to think things over and summarize experiences and lessons.

Some comrades pointed out that we had already clarified this point in the mid-1950's. China has special hydropower resource advantages, possibly the greatest reserves in the world. The development conditions are far better than in the Soviet Union and the West and the cost of construction is not that much more than thermal power. Our development experiences in northeast China show that cheap hydropower has promoted industrial development in that region. We have definite technical forces and can design and build our own large hydropower stations. Economic construction and comprehensive river basin utilization in China urgently require major development of hydropower, and so on. More than 30 years have passed, and practice has proven fully that these understandings are correct and that they are even more rich and profound. However, for various reasons, a major effort to accelerate hydropower development still has not become a reality, and we have instead been "fighting in a crevice." In the early 1980's, coal department leaders said many times that the pressure on the coal industry is too great and they hope for development of more hydropower. Another 10 years has passed and the proportion of thermal power has risen while that of hydropower has declined. Some new thermal power generators cannot operate because they lack coal. This is like certain old thermal power plants having coal supplies in the morning but no guarantees for the evening. If we look at the world, some Western nations have already developed their hydropower to its limits. The Soviet Union is making a total effort to develop hydropower resources in Siberia and the Far East to transmit power more than 2,000 km to its western parts. India has developed over 19 percent of its hydropower resources but China has reached less than 6 percent and still have problems developing hydropower. Shouldn't we rely on profound thinking and fighting to advance?

III. Implementation Is the Key

We have been discussing the status and role of hydropower in the national economy and energy resource structure for many years. This is particularly true of debate and discussion in all areas over the past 10 years. It is being understood by increasing numbers of people and has gained their support. Minister Huang Yicheng recently wrote an article answering SHUILI FADIAN magazine reporters' questions. The Ministry of Energy Resources formulated the "Outline Plan for Medium-Term (1989 to 2000) Development of Electric Power Construction in China" and submitted it to the State Council. The China Energy Resource Investment Company spoke "Concerning the Need for a Gradual Shift in the Focus of Electric Power Construction to Hydropower" at the National Energy Resource Work Conference, and so on. All of them stressed the necessity of major efforts to develop hydropower and proposed several reform measures. Older leaders and experts and the relevant officials at the conference resolutely supported it but fear it will be hard to achieve. Thus, I urgently hope that relevant leaders and administrative departments will truly focus on implementing the following areas.

First, we should implement it in ideology and understanding and correctly evaluate the economy of hydropower. Implementation in understanding means confirming the concept of hydropower as simultaneous development of primary and secondary energy resources. This should be the foundation for evaluating comprehensive economic benefits and social benefits from the perspective of developing the national economy. There was a major effort to develop oil-fired power over 10 years ago but afterwards there was not very much petroleum and the generators were forced to transform to "substitute coal for oil." There was a major effort to develop coal-fired power over the past few years but the result is that one-quarter of our national raw coal output goes to generate power, which has sharpened the contradiction between coal supplies and demand and led to greater railway transport shortages. Analyzing this situation in terms of guiding ideology shows that it can only be due to short-term behavior for immediate benefit. Viewed in terms of the medium-term planning goals for electric power and coal, we must add 100 million kW in coal-fired generators and 440 million tons in raw coal output over the next 12 years. Adding 100 million kW of coal-fired power requires 250 million tons of raw coal, equal to 57 percent of additional raw coal output. Can we handle such a large proportion? For this reason, we should have a better understanding of hydropower and questions of its economy. Hydropower has developed slowly over the past 30-plus years and now should be the time to readjust the structure of electric power.

Second, we should begin with implementing preparatory work and strive to increase design reserves. Hydropower at present has a small scale, few design reserves, and inadequate reserve strengths. Survey and design work should lead the way if we wish to complete generator installation and startup tasks for 50 million kW over the next 12 years. Planning and design departments plan to conduct preparatory work for 55 engineering projects over the next 7 years, including feasibility research reports for 60 million kW and preliminary designs for 89.5 million kW. They should complete all the feasibility research reports and 60 million kW in preliminary designs in the first 7 years. This is an extremely difficult task. The biggest problem now is inadequate funds for preparatory work. Natural conditions for future survey and design projects are becoming increasingly poor and the geological conditions increasingly complex. Moreover, we now face technical problems with more high dams, large reservoirs, high side slopes, long and big tunnels, large capacity generators, long distance power transmission, and so on. However, the preparatory work funds now provided are far from adequate for the demands of this situation. In the current situation of state financial difficulties, the Ministry of Energy Resources' proposal to requisition a hydropower survey fund of 0.002 yuan per kWh from power output is extremely feasible. Prior to the provision of these funds, planning and financial departments should devise ways to raise funds to meet urgent needs. Otherwise, we will lose the opportunity.

Third, it should be implemented in policies to solve problems with sources of construction funds as quickly as possible. We must raise 150 billion yuan in hydropower construction investments over the next 12 years, which is an enormous sum. The plan of the Ministry of Energy Resources calls for the state to allocate more investments to hydropower, an average of 4 billion yuan annually. The 0.02 yuan per kWh requisitioned from hydropower output income should be used to develop hydropower. The requisitioned electric power construction fund would average 2 billion yuan annually. There should be an average of 3 billion yuan annually from local capital raising, sales of power rights, utilization of foreign investments, and so on. Hydropower should implement independent accounting and profits from transmitting power to power grids should go for hydropower construction. The key to achieving this plan is electricity prices, and the way out is reform. Reforms in distorted electricity prices are now essential. Without changes in electricity prices, no one will be willing to invest in hydropower and major efforts to develop hydropower will be meaningless. However, changing electricity prices, making policies, and promoting reform concerns many state departments and there are many problems. Comrades at the conference firmly hope that administrative departments will take the route of relying on reform and policies and push forward unrelentingly!

Some comrades also suggested that one issue which deserves attention is reorganization of economic procedures, reducing investments in fixed assets, and preventing adoption of simple old indiscriminate methods in projects under construction. The reason is that controlling the scale of capital construction and reducing capital construction investments now concerns hydropower. Investments in hydropower in 1989 decreased slightly, not increased, compared to 1988. The pace of some projects has been slowed. There are no new additional projects. There formerly was a major shortfall in funds for preparatory work and financial departments have requested that hydropower survey and design units substantially reduce administrative expenses, so it will even be hard to sustain normal work. In this situation, how can we say that hydropower construction should be accelerated? Another argument made recently is that electric power should be used to regulate and control the national economy. If this view is accepted by China's macro control departments, then energy resources as the foundation and hydropower leading the way will be merely empty talk and development of the national economy as a whole will be affected even more.

In the grim energy resource situation, the hope of a major effort to develop hydropower is emerging. The outline has already been drawn and merely requires fulfillment and implementation. A rather long time period is involved in hydropower from preparatory work to power generation and startup, so the task of adding 50 million kW in installed generating capacity in 12 years is too arduous. I hope that reforms will be more intensive and that policies will appear to move hydropower onto the track of benign development as soon as possible.

Hydropower Stressed at National Energy Working Conference

40130106b Beijing SHUILI FADIAN [WATER POWER] in Chinese No 5, 12 May 89 pp 6-8, 5

[Article by Mao Yajie [3029 0068 2638] of the Ministry of Energy Resources Hydropower Development Company: "Challenges and Tasks Facing Hydropower Construction—A Summary of Questions Concerning Hydropower Development at the National Energy Resource Work Conference"]

[Text] The National Energy Resource Work Conference convened by the State Planning Commission and the Ministry of Energy Resources was held in Beijing in January 1989. Relevant departments from the central authorities and local areas as well as large energy resource enterprises attended the conference. The conference discussed the national energy resource situation, short-term countermeasures, and the "Outline Plan for Medium-Term (1989-2000) Development of China's Energy Resource Industry (Revised Draft)" (abbreviated below as the Outline).

The present energy resource situation can be said to be both gratifying and troubling. On the one hand, the efforts of a vast number of employees have led to substantial development of the energy resource industry, and we have attained first place in the world in raw coal output, fourth place in electric power output, and fifth place in crude oil output. On the other hand, the rate of industrial growth over the same period has greatly exceeded that in the energy resource industry, and the rate of growth in thermal power generation has greatly exceeded that in the coal industry (the ratio between the growth rates for these three areas in 1988 was 17:9.3:3.5). The long-term loss of proportional development has created comprehensive shortages of primary and secondary energy resources in China and resulted in power shortages for industry and agriculture and coal shortages for thermal power plants. It also has affected industrial and agricultural production and the people's lives, and thus endangers social stability.

To deal with the shortage of energy supplies, the Outline proposed the overall energy resource development principle of "electric power as the center, active development of petroleum and natural gas, major efforts to develop hydropower and nuclear power, and speedier construction of rural energy resources and electrification." For hydropower, the Outline proposes that we try to add 50 million kW in new installed generating capacity before 2000, composed of 32 million kW in large scale, 10 million kW in medium scale, and 8 million kW in small scale, and it gave special emphasis to the need to build several medium-sized hydropower projects within the short term. Both in and outside of the meetings, comrades at the conference discussed the Outline's correctness regarding hydropower development methods, our ability to accomplish medium-term development goals for hydropower and how to accomplish them, how to develop medium-scale hydropower, and so on. They exchanged all kinds of views and offered many ideas and opinions, which are summarized below:

I. Quickly Implement the Principle of "Gradually Shifting the Focus of Electric Power Construction to Hydropower"

The principle of "major efforts to develop hydropower" was suggested many years ago but our implementation of it has been extremely lax. There has been a trend of decline in installed hydropower generating capacity as a proportion of the total electric power installed generating capacity. Our installed hydropower generating capacity at the end of 1988 was 32.29 million kW, equal to 28.6 percent of China's total installed electric power generating capacity of 113.09 million kW. The Outline calls for new installed hydropower generating capacity to account for 31 percent of the total new installed generating capacity of 160 million kW up to the year 2000. For this reason, State Council member Zou Jiahua [6760 1367 5478] feels that given the 30 percent coal shortage in the Outline's installed thermal power generating capacity indices, it will be rather hard to develop electric power by merely relying on coal production due to problems with coal mine construction, coal transport, and environmental protection. Thus, we must consider both the issue of thermal power construction and the issue of hydropower construction at the same time. China has very rich hydropower resources, but only about 8 percent have been exploited so far, so we should accelerate development. He pointed out that we must acknowledge hydropower advantages and focus on developing hydropower resources. When compared directly to thermal power plants, investments for hydropower stations are indeed higher, but if we include the cost of investments to build coal mines and transportation capacity, there is not much difference in the cost of the two. Hydropower does, of course, have problems with wet and dry seasons, but this problem is not unsolvable if we strive to select locations with rather stable flow first when choosing sites for hydropower projects or use reservoirs for regulation. Hydropower construction should adopt the principle of integrating large, medium, and small scales. The State Energy Resource Investment Company has clearly pointed out that in a situation of insufficient coal and petroleum and a nuclear power industry that is just getting off the ground, the electric power industry must gradually shift its focus to hydropower and make a major effort to develop hydropower resources. Sichuan has limited coal resources and there will be extreme problems if we rely mainly on shipments from outside the province to provide coal to develop thermal power. After thinking it over, they affirmed the principle of preference for developing hydropower and appropriate development of hydropower.

China has implemented the principle of major efforts to develop thermal power for a long time. This is particularly true in the past few years due to the sustained power shortage, which has led to rapid growth in thermal power. One primary reason is that hydropower construction requires small investments, involves short schedules, and produces results quickly. After the Ministry of Energy Resources was established, electric power was placed in the energy resource system for comprehensive balance and consideration was given to communications and transport factors, to clarify further that hydropower has the unique advantage of simultaneous development of primary and secondary energy resources. Analysis of data shows that at 1988 price levels, the unit investment to build a thermal power plant was 3,072 yuan/kW, which includes 1,500 yuan invested in the thermal power plant, 739 yuan invested in coal mine construction, and 833 yuan invested in transport. This does not include investments for power transmission and transformation for thermal power plants. In comparison, the unit investment for a hydropower station is 2,244 yuan/kW, which includes 1,600 yuan invested in hydropower plant construction and 644 yuan invested in power transmission and transformation. In analyzing unit investments for electric power, if we assume that a thermal power plant has a yearly utilization time of 6,000 hours, and the investment to build a thermal power plant is 0.51 yuan/kWh, which includes 0.25 yuan invested in the thermal power plant, 0.12 yuan invested in coal mine construction, and 0.14 yuan invested in transport. Similarly, the investment for power transmission and transformation at thermal power plants is not considered here. In contrast, if we assume a yearly utilization time of 4,300 hours for a hydropower station, the unit investment for electric power would be 0.52 yuan/kWh, which includes 0.37 yuan/kWh for hydropower station construction and 0.15 yuan/kWh for power transmission and transformation. If we build a thermal power plant at the pit mouth of a coal mine, the unit investment would be 2,239 yuan/kW, which includes 1,500 yuan invested in the thermal power plant and 739 yuan invested in coal mine construction. For hydropower, however, the unit investment is just 1,600 yuan/kW. The unit investment for electric power is 0.37 yuan/kWh for both a hydropower station and a pit mouth thermal power plant.

This shows that electric power indices for hydropower and thermal power are about the same, while the unit investment per kW for thermal power is about 1.5 times that for hydropower. In the area of construction schedules, it takes about the same amount of time to build a hydropower station as it does to build a coal mine of equivalent scale. Thus, in terms of investment benefits, building hydropower stations is better than building thermal power stations. Hydropower has obvious advantages compared to thermal power if we look at operating expenses after going into operation, their useful life (60 years for a large coal mine), reductions in environmental pollution, resource consumption, transport capacity, and other production benefits and social benefits. For many years, because hydropower was treated as a secondary energy resource during plan formulation and investment and financial systems in the electric power industry had two separate lines for power generation income and capital construction outlays, an artificial difference was created in calculation of these benefits and they have been unable to be mutually complementary, which has caused people to have unneeded mistaken ideas about hydropower.

The central part of work in the Ministry of Energy Resources has shifted from the single focus by the former Ministry of Water Resources on power and the single focus by the Ministry of Coal Industry on coal to simultaneous consideration of coal and power for comprehensive equilibrium. By starting with this focus, the Ministry of Energy Resources has gradually shifted the development focus in the electric power industry to hydropower.

II. The Possibility of Adding 50 Million kW in Installed Hydropower Generating Capacity Within 12 Years

The 50 million kW increase in installed hydropower generating capacity by 2000 in medium-term energy resource development plans is a minimum standard, and the corresponding construction scale and construction funding requirements were proposed on this basis. For the construction scale, adding 50 million kW in installed hydropower generating capacity within 12 years means we must put about 4.2 million kW into operation on average each year. The construction scale for large and medium-sized hydropower in 1989 state plans is 14.07 million kW. With reasonable construction schedule arrangements, 11.95 million kW of this figure will go into operation before 1995, so the yearly average amount placed into operation during these 7 years will be just 1.7

million kW. With an additional 500,000 to 600,000 kW of small hydropower going into operation on the average yearly, just 2.20 million kW will go into operation before 1995, which is 2 million kW less than needed to achieve the Outline. Thus, construction starts for large and medium-scale hydropower project capacity should be no less than 4 million kW, including 3 million kW in large scale and 1 million kW in medium scale. Only in this way will the yearly average placed into operation reach 3 million kW before 1995 and then gradually grow to 5 million kW to enable realization of the goals set forth in the Outline.

Analysis of the scale of investment shows that budgetary estimate statistics for 19 large and medium-scale projects now under construction involve an average investment of 1,422 yuan/kW, equivalent to 1,600 yuan in 1988 prices. It will cost 80 billion yuan to put 50 million kW into operation, an average of 6.7 billion annually (not including investments for power transmission lines). Using this as a base figure and considering a 5 percent price index, it ultimately will require 106.2 billion yuan. Thus, the annual scale of investments in hydropower should increase in the near term to 6.7 billion yuan and afterwards grow at 5 percent yearly if we are to satisfy the need to invest to complete 50 million kW. Nevertheless, the sum of actual yearly investments falls substantially below this amount. Hydropower investments completed in 1988 totaled 3.5 billion yuan and estimates are that investments arranged for 1989 will be about the same as the 1988 figure. Inadequate investments have forced some projects to slow the pace of construction, such as at the Lijia Gorge Hydropower Station. Some projects have all the necessary conditions for exploitation but construction cannot begin, such as at the Ertan Hydropower Station.

This situation shows that the demands proposed in the Outline cannot be met, whether in terms of the scale of investment, the scale of construction starts, or the scale of operationalization. Thus, we must adopt extremely effective measures if we wish to achieve the arduous task of adding 50 million kW in installed hydropower generating capacity within the next 12 years.

III. The Core Issue Is Raising Construction Capital

Such difficult tasks for hydropower construction before 2000 and the resulting limited amount of time available mean that the core issue is raising construction capital. For this reason, Minister Huang Yicheng proposed that the following measures be adopted: 1) Implement independent accounting for hydropower stations now under construction and sell power directly to power grids to give them a reasonable repayment capacity. 2) The state should increase its investments in hydropower and expand the proportion invested in hydropower. 3) Requisition 0.02 yuan/kWh from power produced via hydropower and use it to develop hydropower. 4) All areas, the China Energy Resource Company, and other companies should invest in hydropower. The way to achieve the proposals made by Minister Huang Yicheng is resolute reform, intensive reform, and faster progress in reform.

A. Implement policies to "substitute hydropower for coal." Hydropower involves simultaneous development of primary and secondary resources. Putting 2 million kW of hydropower into operation can generate 8 billion kWh each year, equivalent to producing 4.48 million tons of raw coal. If we calculate at a total cost of 220 yuan/ton for coal, this is equivalent to replacing 1 billion yuan in coal costs. Thus, we should arrange investment channels which "substitute hydropower for coal" in plans and calculate an investment sum to "substitute hydropower for coal" according to the hydropower capacity which begins operation in that year in order to take advantage of hydropower as a primary energy resource.

B. Requisition a construction fund for matching coal mines. Thermal power is a secondary energy resource and the state invests in construction for coal and sustains losses. Assuming an increase in electric power, thermal power construction does not include coal mine and transport construction so it saves investments and has short construction schedules. Many localities and enterprises have invested their money in thermal power, which has caused leading growth in secondary energy resources. This is the main cause for the rather rapid growth in thermal power over the past few years, and it is a primary factor behind the coal and transport shortages. To reverse this situation, a matching coal mine construction fund should be requisitioned from localities, departments, and enterprises which build thermal power plants. We should requisition a 1.5 billion yuan coal mine investment, for example, to build and operationalize a 2 million kW thermal power plant which consumes 6.72 million tons of raw coal annually. Only in this way is balanced development of primary and secondary energy resources possible to correctly reflect the investment "value" of hydropower and thermal power and reverse the situation of declining hydropower investments and insufficient coal investments.

C. Encourage east and west China to make joint investments to exploit west China's hydropower resources. China's hydropower resources are concentrated mainly in west China, whereas its industrially developed and capital rich regions are in east China. If we wish to exploit west China's hydropower, west China must attract east China's capital. The 0.02 yuan/kWh electric power construction fund is requisitioned from the terminal power users, so it is local capital that should be returned to hydropower. A "hydropower compensated trade" arrangement can be adopted to deal with this issue. Western regions can use electric power or power consuming products to compensate hydropower investments by east China. The development of hydropower from Guangdong to Guizhou is an example of this model. Regions with the proper conditions also can utilize foreign capital according to this model.

D. Organize hydropower development companies on the basis of provinces or river basins. To accelerate development of hydropower resources, we should reform the existing hydropower management system and organize hydropower development companies on the basis of provinces or river basins in provinces (autonomous regions) with abundant hydropower resources. This would strengthen leadership over hydropower development in the system. Rational economic policies should be adopted for the development companies to make them a mechanism for rolling self-development and gradually form a model of self-development capabilities and sustained cascade development. Adoption of this method would allow hydropower to retain the profits from hydropower and enterprises could earn their own funds to develop hydropower. Self-funding for electric power enterprises accounts for a substantial part of electric power construction in all nations. China implemented a policy of unified income and unified outlays with a 55 percent tax on profits and 28 percent regulation tax. Enterprises had no development funds and basically could not try development.

E. We must reform electricity prices. Distorted electricity prices at the present time have reached the time where they must be changed. The Yunfeng and Shuifeng Power Plants under the Yatu Power Generation Company established in 1987 received a price of just 0.01 yuan/kWh for power sold to the grid and are now experiencing serious losses. From the perspective of developing the Tumen Jiang and Yalu Jiang, the establishment of this company was a failure. Thus, electricity prices and profit retention are the keys to development company existence. If development companies are shifted from central financial plans to local financial channels and the income from adjusted electricity prices is still retained by localities, local areas will be willing to assume the burden of price adjustments. Viewed this way, the electricity price problem is not hard to solve. For power grids, the power from a development company is power purchased from outside and can be priced as high as necessary. Power generating stations placed under jurisdiction of the development companies can employ contractual responsibility to remit a fixed amount of profits and taxes to higher authorities to assure the state's existing financial income. The portion remaining after contractual responsibility is exempt from income taxes and the energy resource communications fund to give development companies their own capital.

I hope that these measures to implement the spirit of a "major effort to develop hydropower" from the National Energy Resource Work Conference will receive support from the relevant State Council departments to accelerate growth in hydropower construction and make the needed contribution to reducing the electric power shortage.

IV. On the Question of Reservoir Inundation and Population Resettlement

Hydropower construction in China has been vexed by the issues of reservoir inundation and population resettlement for quite some time. Statistics for projects under construction show that reservoirs account for about 10 percent of the investment. After project construction begins, resettlement costs continue to grow and there is a substantial rise in reservoir costs. Building of some large hydropower stations has been stopped for this reason. The view that "the hydropower resettlement problem is hard to solve" has had a profound effect on state policymaking departments, and we must adopt effective measures to deal with it. A more feasible method is for the state to select reservoir sites after a construction project is established, with the area where it is located using its own capital to take responsibility for the shares of shareholders. If the cost of the reservoir rises after contractual responsibility is established, the party having contractual responsibility assumes the burden and the sum of the shares does not change. This unites responsibility, rights, and interests, aids in controlling unreasonable increases in reservoir costs, and it aids in implementation of development-oriented resettlement policies. In another area, maintenance funds for existing reservoir regions are too low and should be increased as appropriate. Moreover, we must assure that all these funds are used for reservoir region construction at the location of the power station to provide the resettled population with a long-term and stable capital source for continued economic development in the reservoir region.

V. On the Relationship of Medium and Small Hydropower Stations With Power Grids

For many years, there has been a significant contradiction between medium-sized and small hydropower stations and power grids regarding the issue of electricity prices and dispatching. Large grids have central financial channels and remit profits to central authorities, so local areas do not want large grids to regulate prices. However, medium-sized and small hydropower stations built by localities also want higher electricity prices to repay their loans and grids have a hard time bearing the burden when the price of electricity sold to the grid is raised. Grid power output is greatest during peak water periods and power output by medium-sized and small hydropower stations also is greatest, but grids do not want medium-sized and small hydropower stations to connect to the grid at this time. Irrational electricity prices have made medium-sized and small hydropower stations unwilling to participate in peak regulation. The contradiction between electricity prices and dispatching has led to the appearance of two parallel grids in some regions, which undoubtedly is a retreat technically. The conference called on the state to solve these problems as quickly as possible. They also should separate ownership rights and production management rights of medium-sized and small hydropower stations connected to grids to ensure unified dispatching and safe operation in grids and to give medium-sized and small hydropower a self-development capacity and promote comprehensive development of large, medium-sized, and small hydropower.

Sanxia Project Said Unable To Meet Three Basic Requirements

40130109 Beijing KEJI RIBAO in Chinese 8 Jun 89 p 3

[Article by Li Dazhi [2621 1129 1807]: "Three Decisive Factors Not To Proceed With the Sanxia Project"]

[Text] Many people are concerned about the Sanxia project. Some want to proceed with it promptly, some want to wait and see, and some want to scrap it altogether. I believe that we should not proceed with it. The bottom line is that the Chang Jiang, the enormous and complex ecological and social system, does not permit us to build huge dams in Sanxia.

I. The amount of water and sand flowing into the upper reaches of the Chang Jiang is enormous. Compared to this huge flow, the flood prevention benefit of the Sanxia project is limited. The threat of major flooding to the Jianghan Plain essentially remains unsolved because of its failure to contain floodwaters carried down the Chang Jiang. On the contrary, it will further worsen the flooding in Sichuan. Although it may alleviate the flooding in the middle and lower reaches of the Chang Jiang from time to time, it will greatly increase the frequency and magnitude of flooding in Sichuan. In addition, it will gradually alter the ecological system along the Chang Jiang. It will negatively impact the entire region. There are far more harms than benefits.

Those comrades who are anxious to proceed with Sanxia project drastically overestimated the flood control capability of the Sanxia dam. They are overly optimistic about the silt buildup problem upstream from the dam. They claim that "The benefits of the Sanxia project can be preserved over a long period of time by building a number of reservoirs upstream." To control the upper reaches is an important premise. Are the problems associated with the Chang Jiang solved after the Sanxia project is completed if we do certain things in the upper reaches? I am afraid it is not that simple.

Floods can be categorized into super, large, medium, and small in magnitude, rainfall may vary from heavy rain to showers and the river flow gentle or rapid. If a rainstorm is concentrated at a certain point, any preventive measure is useless. There are numerous precedents. If the storms are scattered, any danger can be avoided by taking preventive measures. This has been true for the Chang Jiang and Huang He for thousands of years. The Sanxia dam cannot prevent a super flood and it is difficult to prevent sudden flooding. It can only prevent ordinary flooding. Therefore, the Sanxia project has limited flood prevention function.

The sand carried down the river by the Chang Jiang has advantages and disadvantages. Professor Huang Wanli [7806 8001 6849] of Qihua University scientifically analyzed the ecology of the Chang Jiang from a geological perspective. He pointed out that the flow of water and sand is a strong natural phenomenon which helps the human race. Historically, the Chang Jiang was geologically responsible for building up the alluvial plains along the two great lakes and three major rivers in its middle and lower reaches as it flows through the gorges into the ocean. It is still building beaches in Qidong and Rudong in northern Jiangsu. The construction of a tall dam in Sanxia will cut off the flow of sand and mud for a couple of hundred years and will permanently block off the flow of pebbles. The channel downstream will have enhanced sand removal capability which is good for flood prevention. However, it will slow down or stop any land-making activity. Beaches will retreat as a result of erosion. Furthermore, it will reduce the transport of fertile organic soil which will negatively affect agriculture and fishing. The existing favorable ecological balance will be altered. Upstream from the project, all branches of the rivers in Sichuan will silt up to gradually raise the flood level along the shores. Flooding will become more frequent. These harmful consequences will eventually force us to dismantle the Sanxia dam.

The Sanxia dam offers very limited benefit in flood control. It cannot provide "macroscopic control" in key moments and can only be used to provide fine tuning in normal situations. As concluded by Comrade Zhang Guangqin [1728 1639 2953], vice chairman of the investigative group and the Sichuan committee of the Chinese National Political Association and ex-director of the Sichuan Water Conservation Office, the Sanxia dam cannot possibly have a decisive effect on flood control along the middle and lower reaches of the Chang Jiang. The bases are summarized as follows:

(1) Based on the data gathered by the Chengdu Institute of Survey and Design of the Ministry of Water Resources and Electric Power, the amount of water involved in the so-called flood of the century in 1954 reached 102.3 billion cubic meters. The 150-meter dam plan only has a flood control capacity of 7.3 billion cubic meters. The 180-meter dam plan has a flood control capacity of 18 billion cubic meters. The design flood discharge rate is 110,000 cubic meters per second. Even if the canyons can be filled to the top to hold dozens of billions of cubic meters of water, it will be impossible to stop all the floodwater flowing down the river. It will also force us to open the flood gates of the Jing Jiang dam. The Chang Jiang Office also adopted the same design. Even after the Sanxia dam is constructed, we cannot be assured not to have the need to open the gates to release floodwater. We can only reduce the number of times we need to do so. However, the key issue in flood control down the river is whether floodwater is discharged or not. If this objective cannot be met, the project is no longer worthwhile.

(2) Flooding in the Jianghan Plain is not merely dependent upon the rivers in Sichuan. Three water systems merge at the Jianghan Plain. There is the Shuan Jiang in

the north, rivers in Sichuan in the west and the Xiang, Zi Yuan and Feng rivers in the south. These three systems have their own torrential rain areas. A disaster occurs only when two rivers crest at the same time. This is the cause for a disastrous flood. The super "81.7" flood in Sichuan did not result in disaster downstream. In 1954, flooding in Sichuan was not very serious. However, due to torrential rain in the Xiang, Zi Yuan and Feng river basins, it resulted in a huge disaster downstream. In 1984 a super flood hit the Han Jiang. Ankang was flooded and the Jianghan Plain was victimized. Thus, as long as the crests of floodwaters meet, the number of times we need to open the flood gates increases.

(3) The ecological environment of the lakes in the middle reaches, which play an important role in flood control downstream, has fundamentally been changed. They seem to have lost the ability to regulate the water from the three systems, particularly from the Chang Jiang. The most conspicuous example is the huge Dongting Hu. Due to the fact that the lake is silting up and people are filling the lake to make new farmland, the lake bed is rapidly rising. The area covered by the lake has decreased from 6,000 to 2,740 square kilometers. "Seas change into mulberry fields." However, its flood regulating capacity is diminished. No wonder the middle and lower reaches suffer from frequent floods.

"Running water is heartless." It will not end upon completion of the Sanxia project. In addition, a new natural phenomenon will take place. Once the Sanxia dam is constructed, the reservoir area will be submerged and Sichuan will be susceptible to more frequent and serious flooding. Based on calculations, according to the 180-meter plan, the water level at the dam is 190 meters once the flood-of-the-century hits. The water level will be 210 meters in Chongqing and over 220 meters at Jiangjin and Hechuan. Backwater will rise to the hilly area of the Sichuan basin. It will back further upstream along tributaries of the Jialing Jiang. The water level will be even higher in the open area between Hechuan and Tongliang. This is a key area in Sichuan and southwest China which is densely populated with numerous industries and is an economic and culture center. What is the magnitude of this flood loss? Even a major flood only occurs once every 50 or 100 years, the bed load is blocked in the rivers in Sichuan. There is no doubt that the trend in flooding will be more frequent and serious in central, southern, and northern Sichuan. Many scholars and experts have questioned the flood control function of the Sanxia project and concluded that it would not provide flood control along the Chang Jiang. This point should not be considered as an argument without any basis.

II. The Sanxia project will have a major impact on a very large social environment. This system includes: 1) Sichuan, the largest economic center in the southwest and the tri-city of Wuhan and its surrounding Jianghan plain. Their economic losses must not be underestimated. 2) The number of people living in the reservoir area and flood zones exceeds 10,000,000. (The existing count is not accurate. Based on the Chang Jiang Office count, 216,700 people will have to be relocated in the first wave according to the 150-meter plan. However, Wanxian alone has 396,000 people.) The number of people to be relocated for secondary reasons and to be temporarily evacuated due to flooding has not been estimated. 3) Valuable farmland in the reservoir area in central, southern, and western Sichuan will be permanently submerged. Based on an estimate made by Chang Jiang Office, the two schemes involve 146,000 and 400,000 mu, respectively. 4) There are giant slopes in the reservoir area and the threat of landslides and earthquakes always exists. It is inappropriate to build a giant dam to block the entire river in such a social and ecological environment. Next, there is a basic conflict between man and the environment. China has too many people and too little land. The amount of land resources is shrinking. In particular, there is a shortage of rich flat valley and platform land. We should not permit anyone to submerge it. Land shortage is a major problem, especially in China. Energy resources are easy to obtain, but land is hard to find. The priority is to fight for every inch of land and other things have to be secondary.

III. Estimation of losses associated with the Sanxia project.

How much domestic currency and foreign exchange will have to be invested in the Sanxia project? What is the magnitude of the overall benefit? Who knows the real answer? Proponents say that it is cost effective and the benefits are immediate. Opponents claim that it won't pay back the principal plus interest in 300 years. Since the disagreement is so great, it seems wise to establish a special agency to review it in order to pin down a number to avoid costly mistakes.

According to the budget prepared by the Chang Jiang Office in May 1985, there are two or three major items. One is associated with relocation of people which is 3.547 billion yuan. The other is construction cost of 12.4 billion yuan. The two will add up to 15.947 billion yuan. The third item is the construction of an electric power grid which requires 20 billion yuan in total, including over $1 billion of foreign exchange. Some people believe that it will cost two to three times more even without taking the cost-of-living index into account.

In addition to one time and initial investment items, there will be follow-on investments and other investments such as dam protection projects, annual upstream flood control projects and construction of flood control bases. Some of the spending can be projected and defined and some cannot be. Nevertheless, the need for such investments is always there. As a matter of fact, these are investments associated with risk. For instance, if the project lasts 20 years, we may encounter a major flood or landslide. These costs cannot be avoided and must be included in the balance sheet. It is questionable whether the income derived from selling electric power will be sufficient to support the reservoir.

In its "Preliminary Investigation Report," the Sanxia Project Ecological and Environmental Study Group of the Chinese Academy of Sciences pointed out that all Class one terrace land and flood land and most Class two terrace land along the river in the reservoir area will be submerged. The reservoir area now produces a large portion of the crops in the counties involved. Based on the 180-meter plan, it is estimated that several hundred million pounds of crops will be lost and nearly 50,000 mu of land will disappear. High-quality sweet orange bases such as Fengjie, Badong, and Xingshan will be under water. The loss will be 4 million dan. Although this does not represent a comprehensive accounting, the losses should be figured out in detail. Let us consider the losses suffered by the citrus industry alone.

The citrus industry has been included in the strategic plan of the Seventh 5-Year Plan in Sichuan and for China. Sichuan will become a national and world class orange producing base. The Wanxian and Sanxia areas alone are projected to produce 3 million tons of oranges by the end of this century. Based on 0.8 yuan per kilogram, the growers will have a combined income of 2.4 billion yuan. If 90 percent of the oranges is turned into juice, the value of the product is 8.6 billion yuan based on the per bottle price received by the factory. The combined value is 11.04 billion yuan. This does not include the value of other by-products. The submerged area is most suited for planting oranges. Most of this fortune will be buried under the reservoir. The losses per year are 10 billion yuan. Over 100 years, we will lose 10 trillion yuan. Compared to the losses due to the flood-of-the-century where floodwater is diverted to the Jin Jiang, and compared to the income from selling electricity, the difference is quite obvious.

In conclusion, the Sanxia project will cost us a valuable piece of land which should not be sacrificed to be submerged. We should not sacrifice so much in return for very limited amount of electric power and a few other benefits.

Guangdong, Guangxi To Develop Changzhou Hydropower Scheme

40130123a Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 24 Jul 89 p 1

[Article by reporter Fang Xin [2455 2450]: "Guangdong and Guangxi Join Together To Build Changzhou Key Hydropower Project"]

[Text] Guangdong and Guangxi formally signed a cooperation agreement for joint development of the Changzhou Key Hydropower Project on 23 July 1989 in Guangzhou City. This agreement will be submitted to the Guangdong and Guangxi People's Congresses Standing Committees for approval and submission to the State Planning Commission for project establishment.

The Changzhou Key Hydropower Project, which involves total investments of more than 2 billion yuan renminbi, is located in Guangxi's Wuzhou Prefecture on the Nanning to Guangzhou Xi Jiang water-borne transport trunkline. It has a planned installed generating capacity of 620,000 kW and yearly power output of 2.7 billion kWh. The funds needed to build the project were raised by Guangdong and Guangxi and they plan to apply for some foreign loans. Guangxi is providing 10 percent of the funds and Guangdong is providing the remainder. The time limit for cooperation is 45 years.

Projections are that project construction may begin in 1991 and the first group of generators may go into operation and generate electricity in the latter part of the Eighth 5-Year Plan. The entire project will be completed within 10 years.

Heilongjiang Puts More Power Plants on Stream

40100068 Beijing XINHUA in English 1207 GMT 30 Aug 89

[Text] Beijing, August 30 (XINHUA)—Since last year, eight large thermal power plants with a combined generating capacity of 1,075,000 kW have been put into operation in northeast China's Heilongjiang Province, according to today's PEOPLE'S DAILY.

After 40 years of construction, Heilongjiang has been turned into an important energy production base. Apart from its large supply of petroleum and petrochemical products, the province can provide the state with more than 70 million tons of coal and more than 24 billion kWh of electricity a year.

Before 1949, Heilongjiang could only produce 4.6 million tons of coal a year. Its power generating capacity was just 171,000 kW, and there was no petroleum production.

After liberation, the central authorities gave priority to developing its coal and power resources. In the late 1950s, development of the Daqing oil field began.

Construction of four coal production bases—Jixi, Hegang, Shuangyashan and Qitaihe—has added production capacity of 45.2 million tons. Meanwhile, coal mines run by localities rather than the state can turn out 20 million tons a year.

With rich coal resources, thermal power generation has made great progress. Since liberation, 15 large and medium-sized thermal power plants have been built, adding generating capacity of more than 4 million kW.

Last year, the province produced 24.68 billion kWh of electricity, 117 times more than before liberation.

The paper said Heilongjiang plans to invest 880 million yuan in construction of nine power generation facilities this year.

Shajiao-A Adds 200MW Unit

40130128b Guangzhou Guangdong Provincial Service in Mandarin 0400 GMT 1 Sep 89

[Text] The 200,000-kW No 3 generating unit of the Shajiao-A power plant was officially put into operation last night after operating on a trial basis for some time earlier. This power generating unit, purchased with funds raised through various channels, is the last of the three units to be installed under phase one of the Shajiao-A Power Plant Project. The two other units had gone on line in 1987 and 1988. It is reported that this power generating unit started operating 2 months ahead of schedule as fixed by the provincial construction commission.

Coal Supply Said Sufficient for Five Major Grids

40130118a Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 30 Jun 89 p 3

[Article: "Railway Departments Reinforce Dispatching, Five Major Grids in China Have Sufficient Coal Sources"]

[Text] Reporters learned from the Ministry of Railways that railway departments have now obtained firm coal guarantees for power generation in five of China's major grids, the Northeast, East, Central, Beijing-Tianjin-Tangshan, and Shandong grids, and that coal stores have increased, meeting the needs of normal power generation in the grids.

Statistics through the middle part of June 1989 show that these five big national grids have more than 5.05 million tons of coal stocks, up more than 1 million tons from late May 1989. The daily number of loaded coal cars transported by rail exceeded plan requirements in the four big Northeast, Central, Beijing-Tianjin-Tangshan, and Shandong grids from 1 to 20 June 1989. Although railway coal transport in the East China Grid failed to reach plan requirements, sufficient coal stores at Qinhuangdao Harbor and continued arrival of coal shipped by sea prevented shortages. Information indicates that from 11 to 20 June 1989, the daily average number of loaded coal cars shipped by rail to the East China Grid exceeded plan requirements and they are now gradually compensating for shortages over the past 10 days.

Interruptions for the previous period of time on the railways led to problems in coal transport. Railway employees took the overall situation into consideration, stood firm at their positions, used favorable opportunities, and loaded coal needed to generate power first. The Ministry of Railways has reinforced dispatching and adopted methods like detouring around areas with severe obstructions and so on to provide reliable transport guarantees for coal used to generate power in each major grid.

Improvement in Coal Quality Seen Urgent

40130118c Beijing RENMIN RIBAO in Chinese 20 Jul 89 p 5

[Article by RENMIN RIBAO reporter Liu Xieyang [0491 3610 7122]: "Improvements in Coal Quality Demand Immediate Attention"]

[Text] The northeast is China's heavy industry base area and uses more than 90 billion kWh of electricity each year. Power grid officials said that serious consequences arose from poor coal quality in the first half of 1989. One is unstable boiler combustion and frequent extinguishing. A total of 21 extinguishings occurred between January and May. Eight extinguishings occurred over a 6-day period from 14 to 19 May 1989 at Jinzhou Power Plant. The second is severe wear on equipment and frequent leaks in the four pipes (water pipes, gas pipes, oil pipes, and coal pipes) of boilers. Over 90 percent of accidents with power plant equipment between January and June 1989 occurred in boilers, and 80 percent of these were leaks in the "four pipes" of boilers. The third is that poor coal quality has caused generator output to lag. On 9 June 1989, the Jinzhou, Qinghe, Liaoning, and Chaoyang power plants could have dispatched 2.81 million kW of power but actually dispatched just 1.97 million kW, a generation loss of 840,000 kW. East China is an important window for China's opening up to the outside world and an important light industry base area in China. It uses 80 billion kWh of power each year. Power grid officials said that there has been a substantial decline in heat output from raw coal in 1989. Average heat output from raw coal for the entire East China Grid from January to April 1989 was 4,801 kilocalories/kg, a 6 percent drop compared to 1988, and raw coal consumption rose by 26 g/kWh. Similar situations can be found in the Northwest and Central China Grids.

One reason for poor coal quality is an incorrect management ideology in several coal supplying units. They use poor quality to supplement good quality and are concerned only with making money without considering the interests of the state and users.

A second reason is that most local coal mines lack inspection measures and processing facilities. Most unified distribution coal mines rely on manual sampling, which causes major errors and many omissions, and it is very easy to be deceived by a small number of people.

A third reason is that some coal mines focus on output while neglecting quality. They do not consider the economic benefits to society and do not wash and process coal which should be washed and processed, causing a rapid decline in coal quality.

This situation has attracted the attention of relevant departments. Jiangsu and Anhui Provinces have joined together to control the economic environment and straighten out economic procedures, and they are now comprehensively reorganizing coal markets. Xuzhou City has established a coal management office and formulated administrative methods and clear stipulations. All units and individuals which administer coal should reapply to industry and commerce bureaus for examination and certification as evidence of administration. To strengthen coal quality management, all coal production and administration units should submit a coal quality chemical inspection statement to users and conscientiously handle the mixing of contaminants for deception and other illegal activity and to deal with them strictly.

The China Unified Distribution Coal Mine Corporation has made better coal quality an important topic. It called for leaders at all levels to adopt firm measures to solve the problem of declining coal quality and for locations with imperfect inspection measures to reorganize earnestly. We must reinforce washing and processing and assure the quality and quantity of coal provided to users.

We should take action to mobilize people to go to user units and solicit opinions on coal quality and improve our work.

The Ministry of Energy Resources reaffirmed that coal is China's main energy resource and that coal quality has an enormous effect on the national economy. If we can restore our coal quality to the 1966 level, we can produce an additional 2,000 tons of steel, conserve over 1.5 million tons of fuel, and save over 1.6 million tons of limestone. Savings of fuel, solvents, and transport costs can be over 170 million yuan. Improving coal quality means improving economic results, so all enterprises should correct their management ideologies! They should be concerned with both enterprise economic results and social results in pushing improvements in coal quality.

Increasing Benefits From Fully Mechanized Coal Mining

40130101 Beijing MEITAN KEXUE JISHU [COAL SCIENCE AND TECHNOLOGY] in Chinese No 1, Jan 89 pp 3-10

[Article by Jia Yueqian [6328 1878 6197] of the Coal Industry Technical Advisory Commission: "Effective Ways To Increase Benefits From Fully Mechanized Coal Mining in China"; first paragraph is MEITAN KEXUE JISHU introduction]

[Text] China began using fully mechanized mining 15 years ago in 1974. We have made notable achievements in developing fully mechanized mining over the past 15 years. Several high output fully mechanized mining teams with good economic results have appeared and moved several bureaus (mines) into the ranks of modernized mining bureaus (mines). There are, however, many problems in fully mechanized mining like output problems, performance problems, effective man-hour utilization problems, selection of fully mechanized mining equipment models and work sites, personnel training problems, and so on. To promote solution of these problems, take full advantage of fully mechanized coal mining, and improve economic results, the editorial department of MEITAN KEXUE JISHU asked Coal Industry Technical Advisory Commission member and senior engineer (professorial level) Jia Yueqian to write this article. This article summarizes the fully mechanized mining development process and utilization situation in China and suggests truly feasible measures to increase fully mechanized mining output and benefits in China.

China began using fully mechanized coal mining 15 years ago in 1974. We now have 408 sets of fully mechanized mining equipment at 51 mining bureaus and 135 mines. The 265 sets of fully mechanized mining equipment now in use at working faces are used on gently inclined, inclined, and steeply inclined coal seams. The best applications have been in mining gently inclined medium thick coal seams and slice mining of thick coal seams. Total output from fully mechanized mining in 1987 was 99.06 million tons. The degree of fully mechanized mining is 29.06 percent, average monthly output from fully mechanized mining is 39,419 tons, and average working face efficiency is 16 tons/worker. Nineteen fully mechanized mining teams produce over 1 million tons yearly. This is particularly true of the No 1 fully mechanized mining team at Lu'an Wangzhuang Mine which produces 1.7 million tons annually, a national record. Wangzhuang Mine produced 3.1 million tons of coal in 1987 with just two fully mechanized mining teams and two fully mechanized tunneling teams. The full staff efficiency was 4.2 tons/workers, a leap into the advanced ranks of the world's modernized mines. This was due to the major role played by fully mechanized coal mining. Practice over the past 10-plus years shows that fully mechanized mining has advantages like high output, high efficiency, good safety, good economic results, low labor intensity, and so on, and that it is the main way to modernize coal mines and is very important for increasing economic results of coal mines.

China adopted fully mechanized mining rather late, development is uneven, and management levels have not kept pace, so we lag far behind the world's main coal producing nations. This is manifested mainly in low unit output per working face, low effective man-hour and equipment utilization, slow and repeated moves to other faces, low working face efficiency, and poor economic results. At some mines, fully mechanized teams produce less than 150,000 tons per year and some even less than 100,000 tons. This is due mainly to poor management, poor equipment maintenance and upkeep, slow solution of production technology problems, and so on.

Chinese-made or imported fully mechanized mining equipment now used in China costs 10 to 20 million yuan per set, a rather expensive investment. When yearly output from fully mechanized mining falls below 300,000 to 500,000 tons, this is very uneconomical. Large inputs with little output is one reason for mine losses. When foreign countries adopt expensive fully mechanized mining equipment, they first do feasibility research to see if it would be economical. The main criterion is a critical lower limit of output. The United States uses an economical critical output lower limit of 1,500 tons per shift, England uses yearly output of 500,000 tons, and Australia uses an output of 2,000 tons per shift. Otherwise, fully mechanized mining is not used. It is extremely urgent given the necessity and importance that China use fully mechanized mining equipment to increase economic results. Improving economic results in fully mechanized mining should begun with higher unit output and efficiency. The main ways to achieve this are:

I. Rational Selection of Fully Mechanized Mining Sites Is the Key To Increasing Unit Output and Efficiency

A. Essential Conditions for Taking Advantage of Fully Mechanized Mining Equipment

1. The mine size should exceed 900,000 tons. To take full advantage of fully mechanized mining equipment, the

size of the mine should be greater than 900,000 tons. If a mine with a yearly output of 450,000 to 600,000 tons is chosen, it will be impossible for a set of fully mechanized mining equipment to produce 1 million tons annually. Practice has confirmed that when a fully mechanized mining working face is set up in the area of a 900,000 ton mine with good geological conditions, while conventional extraction or blast extraction working faces are used in areas with poor conditions, taking advantage of fully mechanized mining is limited in extent. China has 142 unified distribution coal mines with mine output over 900,000 tons. Fully mechanized mining equipment is now being used at 95 mines with output over 900,000 tons. Practice has confirmed that these mines are more effective in taking advantage of fully mechanized mining equipment. Nearly all high output teams with yearly output in excess of 600,000 to 1 million tons in 1987 can be found in these mines. These fully mechanized mining sites were chosen correctly and economic results were higher. There are 48 mines under 900,000 tons which use fully mechanized mining equipment, but the equipment is somewhat restricted by the mines being too small, so it is not completely effective. Buxin Ping'an No 5 Mine, for example, has a production capacity of 210,000 tons. A set of fully mechanized mining equipment deployed there produced 240,000 tons in 1986. An additional increase in output would not satisfy the mine's production capacity. Jixi Donghai Mine with a production capacity of 450,000 tons is another example. Because of the relationship between limits to increased capacity and mining, fully mechanized mining produced an average of 17,144 tons/month and it was quickly shut down. There are many similar situations and we should decide to readjust them. It is apparent that application of fully mechanized mining equipment should be chosen in mines with a mine production capacity of more than 900,000 tons.

2. Mine transport, ventilation, lifting, and other main production links should be matched with fully mechanized mining capacity. A lack of matchup between the capacity of production links in some mines now restricts fully mechanized mining capacity and is manifested at mines mainly as inadequate lifting capacity, inadequate ability to move upward in mining regions, inadequate coal storage capacity in mining regions, a lack of matchup between working faces and trenches, and so on. Thus, we should make technical transformations in weak production system links at fully mechanized mines to meet the need for high output and high efficiency in fully mechanized mining.

B. Determining Endowment Conditions of Coal Seams Is a Reliable Guarantee for the Effectiveness of Fully Mechanized Mining

The quality of mine geology conditions is an important aspect which affects output from fully mechanized mining. Unclear endowment conditions of coal seams can severely affect fully mechanized mining output. This is a common problem now. The main aspects are:

1. Coal seam thickness and variations, including thin coal zones. There are limits to the maximum and minimum elevations for supports in fully mechanized mining. Fully mechanized mining is effective only when support elevations are adapted to variations in coal seam thickness. Otherwise, roof and floor coal can be lost when coal seams are thicker than the upper elevation limit of supports. Supports cannot be moved along when coal seams are thinner than the minimum elevation of supports. Forcing them into place can cause major losses in the useful life of rock cutter teeth, machinery cannot operate normally, output will decline, and economic results will be affected. At the No 8405 working face on the No 3 seam at Datong's Yungang Mine, for example, the coal seam thickness changes from 2.3 m to 1.4 m. They use a model 4/500 imported support with an elevation of 1.65 to 2.65 m. When fully mechanized mining equipment reaches a thin coal region, the coal seam is thinner than the lower elevation limit of the supports and they cannot be moved along. After blasting or cutting the floor of the shaft, there was severe wear on the load gears, output declined, costs rose substantially, and they eventually had to cease production and move, which affected production.

Thus, coal seam thicknesses should be plotted on the basis of borehole data and coal seam thickness revealed during tunneling for analytical research to explore the laws of thickness variations, clarify coal seam endowment conditions, and suggest mining regions and mining faces adapted to the elevation of different types of supports to assure normal production at fully mechanized mining faces. Practice and experience at many mines have shown that the minimum coal seam thickness should be 0.2 m more than the lower elevation limit of fully mechanized mining supports, the maximum value should be approximately the same as the upper elevation limit of the supports, and so on.

2. Small geological structures—the effects of folded faults. Looking at all of China's coal mines, folded faults are one of the main factors which affect fully mechanized mining performance. When folded faults and small faults with a 2 to 3 m displacement not discovered during preparations are abruptly encountered during mining, they pose problems for fully mechanized mining. Practice has proven that the key effects of fault displacement on fully mechanized mining lie in the thickness of the coal seam where the coal seam is not mined at the upper and lower walls of a fault. When this thickness exceeds or equals the lower elevation limit of the supports, they can be moved along. Otherwise, the effects will be great. The coal at the No 8301 fully mechanized mining face at Datong Tongjialiang Mine is 3.5 m thick and they use an imported model 4/500 hydraulic support. A fault with a displacement of 1.2 m was encountered between mining faces. It ran obliquely to the working face. Because the coal seam was too thick and the displacement rather small, output was minimally affected when fully mechanized mining equipment moved through the fault and normal production was restored quickly. The No 8306

working face at Yungang Mine has a coal seam 2.7 to 2.8 m thick, a working face fault displacement of 1.1 m, and they used a model 4/450 support. A 1.7 m thick coal seam at the upper and lower walls of the fault displacement was not mined. The supports were moved into place easily. Later, another fault with a 2.4 m displacement was encountered and the support could not be moved, forcing them to move to the opposite face. Thus, fault displacements should be clearly understood.

3. The effects of collapsed pillars and washout zones. China's Xishan, Yangquan, Qincheng, Luo'an, Datong, Xuzhou, and other mining bureaus have quite a few collapsed pillars and washout zones which seriously affect fully mechanized mining production. Some collapsed pillars at 10 to 20 m in diameter, and some are as big as 30 m, which makes fully mechanized mining impossible. Thus, we first of all should clarify the location and direction of collapsed pillars. Many countries including the Federal Republic of Germany, England, the United States, the Soviet Union, Poland, Canada, and others now use slot wave seismic technologies (slot wave transmission method) to pre-select and prove collapsed pillars or fault zones. The pit transmission device imported from Canada and developed by the Xishan Bureau and Hebei Coal Institute is now undergoing prospecting experiments for collapsed pillars or faults, and an MYZ hydraulic drill is being used to drill boreholes 100 to 150 m long to determine collapsed pillars or faults.

C. Supports Chosen for Fully Mechanized Mining Should Be Adapted to the Quality of the Surrounding Rock

The choice of fully mechanized mining supports should be based on full consideration of the characteristics of fully mechanized mining supports, characteristics of the surrounding rock, and roof and floor preservation conditions, and it should be based on the lithic properties and dynamic strength of the rock of the roof and floor of the coal seam and its stability to select the type of fully mechanized mining support. Stability of the direct roof of the Permian limestone rock strata in existing producing mine regions in China is mainly poor and the roof is fractured. Mine pressures are not great, however, generally from 25 to 30 t/m^2. It is best to use a covered support for this type of roof. Another type is where the direct top stability is good, the rock hard, and mine pressures great. The Datong mining region, for example, has a hard roof. It is best to use a high tonnage stacked-type support (braced type). In summary, different types of supports should be adopted for roofs with different rock properties.

II. Using Advanced Mining Technologies Is an Effective Way To Increase the Level of Fully Mechanized Mining Production

A. Use Reciprocating Extraction Technologies

Reciprocating extraction technologies refer to retreating-type recovery after cutting a hole on the first working face at the edge of one side of a mining region to install fully mechanized mining equipment and then moving the equipment to the opposite side after moving up to the stop extraction line of a coal pillar to cut a hole in an adjacent working face and then mining forward toward the edges of the mining region. After mining up to the stop mining line at the edge, there is once again retreating recovery after moving the equipment down to the lower adjacent working face. Thus, it involves retreat—advanced—retreat to form reciprocating-type extraction. This technology has been used in mines in the Federal Republic of Germany, England, the Soviet Union, Poland, France, and other nations. It also has been used at China's Kailuan Linxi Mine, Fangezhuang Mine, and Xuzhou Quantai Mine. This has been very important in reducing the moving distance, reducing the moving time, lowering the passageway tunneling rate, increasing unit output and efficiency, and increasing economic results.

Implementation of reciprocating mining first requires technologies to support tunnel sides along the empty space. Kailuan Tangshan Mine successfully experimented with trying tunnel side wind force filling support techniques. The filler material is a mixture composed of coal gangue and concrete additives. Fully mechanized coal mining at Tiefa Xiaonan Mine used plastic sandbags and bags of power plant ash in tunnels left behind to support the tunnel sides. Experiments have shown that they can be reused a second time for tunnel maintenance to achieve Y-type ventilated coal extraction and solve problems of exceeding limits on gas at the angles of mining faces. The Xizhang No 8 shaft at Yangquan No 2 Mine uses Y-type ventilation at the fully mechanized mining working face to extract coal and leave passageways. They use an imported high water velocity condensing pump filling system and the tunnel walls are supported by a fill zone 1 to 1.2 m thick. The filler material is high aluminum concrete, bentonite (15 percent) and water (85 percent). Since experiments in 1986, they have been affected by second extraction activities at the recovery working face with excellent results. Domestic production of the equipment and filler material is now being developed, and this will be a tunnel side support technology with development prospects after costs are reduced.

B. Adopt Rotary Extraction Technologies

When the mining face reaches the stop mining line, on the basis of slope adjustment of the working face, the working face is rotated for 90° to 180° for continued extraction. It is characterized by a mining face conveyor head which is the center of a circle and a conveyor running the length of the diameter, with fanned rotation of the supports and conveyor for the entire working face. This rotary arrangement demands a rather high technical operating level. The Federal Republic of Germany and England have been rather successful in using this mining technology. Trials of rotary extraction also have been successful at China's Yangquan No 2 Mine and Jixi Xiaoheng Shan Mine. Mines with suitable conditions should actively try it out.

C. Fully Mechanized Mining Roof Blasting Mining Technologies

At present, there are problems with low output, low efficiency, high labor intensity, poor safety, and so on in extraction of especially thick coal seams. Although slice mining techniques for thick coal seams are rather mature, the many work procedures affect efficiency. Since France successfully began developing sectional roof blasting supports to mine especially thick coal seams in the 1960's, France, England, the Federal Republic of Germany, Hungary, and other nations began to develop inserted plate type, open roof light type, and open back door type roof blasting coal hydraulic supports. The overall development characteristics of roof blasting coal hydraulic supports was from sectional type to braced type and screened type. The roof blasting coal pattern moved from inserted board type to open roof light type and open back door type coal blasting. The extraction face developed from dual conveyor coal transport to single conveyor coal transport.

France uses four pillar braced and screened type roof blasting coal supports with average daily output of 2,000 t and worker efficiency of 40 t. Yugoslavia's (Welinye) Mine uses (Hemeixiate) roof blasting coal supports from the Federal Republic of Germany with an average daily output of 1,000 to 1,200 t and worker efficiency of 27 to 40 t. China began studying roof blasting coal mining techniques in the 1980's and we have now solved problems with roof blasting coal hydraulic supports. Experiments have been conducted at Pu He Mine in the Shenyang Bureau, Mei He Mine in the Liaoyuan Bureau, Yaojie Bureau's No 2 mine, Liudaowan Mine in the Urumqi Bureau, the Pingding Shan Bureau's No 1 mine, and others, and definite achievements have been made. Horizontal slice roof blasting coal mining has been tried in 20 m thick coal seams steeply inclined at an angle of 55° in the No 4 shaft at the Yaojie No 2 mine (slice elevation 10 m, extraction elevation 2.5 m, coal blasting elevation 7.5 m), with average unit output of 19,036 t, average daily output of 697 t, maximum daily output of 970 t, and average per-worker efficiency of 10.11 t. A lack of matchup between the coal extractor and transport system has prevented full realization of its effectiveness. Pingding Shan No 1 Mine has coal 6 to 8 m thick and a working face 140 m long. They use Hungarian open roof light hydraulic supports for an extraction elevation of 2.5 m and a coal blasting elevation of 3.5 to 5.5 m, with rather good economic results.

Experimental conditions at several bureaus show that in a situation of immature fully mechanized mining roof blasting coal technologies and a lack of equipment matchup, definite achievements have been made and the experiments were successful. This is a feasible extraction technology and should be extended in bureaus and mines with the proper conditions. However, we should work on problems with developing equipment matchup for steeply inclined short wall mining in roof blasting coal. We also should expand trial utilization of fully mechanized mining spread net roof blasting coal mining to increase recovery rates.

III. Use Design and Management for Shorter and Faster Moves

All the world's main coal mining countries have studied fully mechanized mining equipment moving and adopted corresponding measures for shorter and faster moves of fully mechanized mining faces to assure stable output from fully mechanized mining and increase working times.

Fully mechanized mining requires a great deal of heavy tonnage equipment. With heavy supports (greater than 10 t), for example, each set of equipment weighs 1,800 to 2,100 t and fills over 400 cars during transport. Given the lack of extension of auxiliary transport mechanization in China at present, a transport distance of 2 to 3 km, and an average moving time of 25 to 40 days per move, it takes 4,500 to 8,700 work hours and sometimes as much as 15,000, at a cost of 80,000 to 280,000 yuan. Table 1 shows the number of days, number of workers, and cost of each move in fully mechanized mining in several of China's main mining regions.

Table 1. Statistics for Fully Mechanized Mining Moving Data for Several Primary Bureaus, January to August 1986

Name of mining bureau		Number of moves	Number of days required	Number of workers required	Cost (10,000 yuan)
Kailuan	Overall design	13	680	93,850	216
	Average for one time	1	52	7,219	16.6
Pingding Shan	Overall design	13	286	112,532	375
	Average for one time	1	22	8,656	28.8
Datong	Overall design	29	629	248,003	477
	Average for one time	1	21	8,551	16.4

Table 1. Statistics for Fully Mechanized Mining Moving Data for Several Primary Bureaus, January to August 1986

Name of mining bureau		Number of moves	Number of days required	Number of workers required	Cost (10,000 yuan)
Yangquan	Overall design	12	351	70,337	155
	Average for one time	1	29	5,861	12.9
Xishan	Overall design	14	620	63,000	350
	Average for one time	1	44	4,500	25
Lu'an	Overall design	7	430	61,578	77
	Average for one time	1	61	8,796	11
Qincheng	Overall design	3	120	18,000	24.9
	Average for one time	1	40	6,000	8.3
Xingtai	One time	1	40	7,000	12.1

In China, each fully mechanized mining team moves an average of 1.2 to 1.5 times a year, which means that one set of fully mechanized mining equipment can operate for just 9 to 10 months each year. There is a serious drop in output during the moves which has significant effects on balanced mine production. Thus, there should be fewer and faster moves of fully mechanized mining equipment by creating excellent extraction conditions and scientifically organizing moves.

First, at extraction regions which use fully mechanized mining, extractable reserves which in design terms are adapted to fully mechanized mining equipment generally should be no less than 3 million tons. For extraction conditions, make a reasonable increase in the strike length, increase the amount of coal extracted, and reduce the number of moves. For trans-rock arch extraction at Kailuan Fangezhuang Mine, for example, the strike length was increased from 600 m to 1,200 m. For trans-rock arch extraction at Qincheng Fenghuang Shan Mine, the strike length was increased from 1,200 m to 2,100 m. In a situation of a coal seam inclination angle of less than 12°, a rather short strike length, and a rather large inclination length at the Yangquan Zhangbali shaft, there have been obvious results from extending the inclined long wall coal mining method.

Second, the moving distance when using reciprocating extraction is a new mining face length of 150 to 200 m. This provides favorable conditions for moving to the opposite face. At the No 26 shaft at the Audobon Mine in Illinois in the United States which has a long wall working face of 152 m and heavy supports, for example, when the work surface is being moved, bolts are used to anchor the roof at stop mining locations. This improved moving efficiency and allowed completion of moving tasks equivalent to 8 days in 24 hours. In the Ruhr mining region in the Federal Republic of Germany, moving to the opposite face of a working face which used heavy supports took just 7 days and 50 workers. At a 140 m long working face at the Besemer Mine in England, quick-setting resin anchors were used for direct support of the roof at the stop mining position for fully mechanized mining equipment and hydraulic supports are used around them. Automated mine car transport and other new methods also were used, and the moving tasks were completed in 7 days with 550 workers.

Third, strive throughout for scientific management and organization measures. China's current experiments in organizing rapid moves are mature. After spending 7 days to complete moving light supports at Pingding Shan No 10 Mine, the Datong Mining Bureau and Pingding Shan Mining Bureau set a record in taking 21 to 22 days to move light supports. By implementing reciprocating extraction, cutting alignment holes at stop mining lines, and adopting effective organizational and technical measures, moving tasks certainly can be completed in 10 days. The measures are: When stabilizing top plates, bolts should be used to anchor the direct roof. When the roof is fragmented or during slice mining, lay roof nets 10 m ahead of the terminal and make good preparations to recover the supports. Dig trenches along the working face and lay tracks. Add rotating plates on the transport carts and solve problems with support installation, removal, and tone problems. Try rubber tired automated mine cars and other auxiliary transport equipment on nearly horizontal coal seams, and so on. Implement a scientific division of labor in organization and parallel support removal shifts and support installation shifts, make good arrangements for each worker and each position, and increase the man-hour utilization rate.

IV. Reduce the Effects of Accidents, Increase the Effective Work Utilization Time of Fully Mechanized Mining

Within a specified production period at a fully mechanized mining working face, the ratio of the net coal extraction time of coal extraction machinery to the stipulated time is the effective man-hour utilization rate.

It is a reflection of fully mechanized mining face management levels and the equipment utilization situation. Foreign countries have been very concerned with increasing the effective man-hour utilization of fully mechanized mining equipment. Those with higher effective man-hour utilization rates are:

Country	Effective man-hour utilization rate (percent)	Year
Federal Republic of Germany	51	1984
England	33	1984
Japan	38	1984
Soviet Union	23	1982
China	16.2-18.1	1986

China's average effective man-hour utilization rate for fully mechanized mining faces in 1986 was from 16.2 to 18.1, as shown below:

Coal output situation	Effective man-hour utilization rate (percent)
Yearly output over 1 million tons	27.5-34.2
Yearly output over 500,000 tons	19.3-23.8
Yearly output over 300,000 tons	14.0-16.5
Average	16.2-18.1

The situation outlined above shows that the effective man-hour utilization rate for China's fully mechanized mining equipment is rather low and should receive our attention. In the present work system of three 8-hour shifts, the net coal production time for each 7.5 hour production shift is just 1.2 to 1.4 hours or 2.4 to 2.8 hours for two shifts. The relationship between the net coal extraction time and output is:

$$Q = q \times t \times T$$

In the formula, Q is the monthly output, t; q is the coal mining machinery quota time output at a coal cutting speed of 4 to 5 m/minute, and is 500 t; t is the net coal extraction time per day, and is assumed to be 2.8 h; T is the number of production days monthly, and is assumed to be 30 days.

When the assumed values for the parameters in the formula are substituted into the equation, the calculated monthly fully mechanized mining output is 40,500 tons. For one set of fully mechanized mining equipment which produces for 10 months each year, coal output is 400,000-plus tons, approximately the same as the data announced in the national fully mechanized mining table. This shows that China's present effective man-hour utilization rate for fully mechanized mining equipment is rather low. Gushuyuan No 1 Extraction Team in the Qincheng Mining Bureau produced 1.24 million tons of coal in 1987, an average monthly output of 103,300 tons. This team measured its effective man-hours. Its net coal extraction time was about 7 hours, so the effective man-hour utilization rate is 7 hours divided by 24 hours = 29 percent. It is apparent from this that given the hourly production capacity conditions determined by China's present fully mechanized mining equipment, the main way to increase output is to increase the net coal extraction time.

At present, the main factors affecting effective man-hour utilization are electromechanical accidents at the working face, inadequate supplies of full coal cars at the coal storage site, or a failure of terminal supports to keep up. Statistics for 1986 show that electromechanical equipment accidents account for 38.8 to 41.8 percent (with coal extraction machinery accidents accounting for 12.4 to 13.3 percent, conveyor accidents for 20 to 21.6 percent, and electrical accidents for 6.4 to 6.9 percent). Inadequate supplies of full coal cars at the coal storage site account for 39.3 to 40.3 percent, and the failure of terminal supports to keep up with canopy handling of roofs for 17.9 to 21.9 percent. The time of accident effects for 249 fully mechanized mining teams throughout China in 1986 was 12,948 hours, equivalent to 35 years of work by one fully mechanized mining team. Thus, we must track shifts in measuring man-hours, determine factors having effects and adopt measures to deal with them, do good fully mechanized mining equipment inspection and maintenance work, perfect inspection measures, assure the quality of equipment inspection, and increase the equipment completeness rate. We should organize development of terminal supports for all types of situations and reduce terminal roof leakage accidents. We should enlarge mining regions and coal storage at working faces (400, 500, and 800 tons) and do good coal car dispatching work.

V. Organize High Output Fully Mechanized Mining Teams, Increase Unit Output Levels

Besides high efficiency and good safety, a very important goal of the world's main coal producing nations in striving to develop fully mechanized coal mining is the criteria of modernized mines, meaning high output and extremely good economic results. China has used organized competition between fully mechanized mining teams of equal grades and fully mechanized mining activities to produce 1 million tons. China had 50 fully mechanized mining teams which produced 500,000 to 1 million tons in 1987 and 19 fully mechanized mining teams which set output records of more than 1 million tons annually. The highest was 1.7 million tons (see Table 2). Table 2 shows that working face lengths for high output teams with yearly output of 1 million tons ranged from 123 to 171 m, and the average extraction height was 2.5 to 3.3 m. All of the extraction heights of less than 4 m were on gently inclined coal seams, yearly progress was more than 1,000 m, and the maximum was 2,247 m.

Table 2. Basic Conditions for 1 Million Ton Fully Mechanized Mining Teams, 1978

Unit (bureau, mine, team)	Coal mining working face conditions							Output			Working face efficiency (tons/worker)
	Working face annual progress (meters)	Working face length (meters)	Coal seam thickness (meters)	Extraction height (meters)	Coal seam angle (degrees)	Roof rock properties	Floor rock properties	Yearly output (10,000 tons)	Average monthly output (10,000 tons)	Highest monthly output (10,000 tons)	
Lu'an, Wangzhuang, No 1 fully mechanized mining team	2248	162	6.4	3.01	3-5	Sandy shale and mudstone	Sandy shale	170.1	14.1	15.9	55.6
Qincheng, Gushuyuan, No 1 fully mechanized mining team	1120	150	6.0	2.98	1-5	Metal net	Sandstone	123.9	10.3	14.1	48.0
Yanzhou, Xinglongzhuang, No 3 fully mechanized mining team	1280	171	8.65	2.5	5	Metal net	Clay rock	119.8	9.9	14.5	45.4
Lu'an, Shigejie No 2 fully mechanized mining team	1520	161	6.4	3.3	3-5	Shale	Coarse sandstone	110.1	9.1	11.6	37.9
Pingding Shan, No 1 mine, No 5 fully mechanized mining team	1650	150	5.6-6.4	3.0	6-9	Dark gray shale	Gray mudstone	108.9	9.0	12.1	24.0

Table 2. Basic Conditions for 1 Million Ton Fully Mechanized Mining Teams, 1978

Unit (bureau, mine, team)	Coal mining working face conditions							Output			Working face efficiency (tons/worker)
	Working face annual progress (meters)	Working face length (meters)	Coal seam thickness (meters)	Extraction height (meters)	Coal seam angle (degrees)	Roof rock properties	Floor rock properties	Yearly output (10,000 tons)	Average monthly output (10,000 tons)	Highest monthly output (10,000 tons)	
Pingding Shan, No 4 mine, No 2 fully mechanized mining team	1653	140	3.7	3.2	3-10	Mudstone	Mudstone	107.0	8.9	11.0	35.7
Qincheng, Fenghuang Shan, No 1 fully mechanized mining team	1100	163	6	2.94	3-5	Sandy shale	Soft coal	105.9	9.0	12.5	57.3
Qincheng, Fenghuang Shan, No 2 fully mechanized mining team	2142	134	6	2.97	3-5	Metal net	Sandy mudstone	105.6	8.8	11.0	61.5
Yanzhou, Nantun, No 2 fully mechanized mining team	1487	143	6	2.97	2-4	Fine sandstone	Fine sandstone	104.0	8.6	14.0	58.2
Lu'an, Zhangcun, No 1 fully mechanized mining team	1770	158	6.4	3.2	3-6	Metal net	Sandstone	102.0	8.5	10.2	44.8

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Unit (bureau, mine, team)	Coal mining working face conditions							Output			Working face efficiency (tons/worker)
	Working face annual progress (meters)	Working face length (meters)	Coal seam thickness (meters)	Extraction height (meters)	Coal seam angle (degrees)	Roof rock properties	Floor rock properties	Yearly output (10,000 tons)	Average monthly output (10,000 tons)	Highest monthly output (10,000 tons)	
Yima, Changcun, fully mechanized mining team	1308	183	8	3.0	8	Shaly mudstone	Mudstone	101.1	9.0	11.5	39.3
Lu'an, Wangzhuang, No 2 fully mechanized mining team	1285	170	6.4	2.90	3-5	Sandy shale and mudstone	Sandstone	101.1	8.4	9.8	57.4
Lu'an, Zhangcun, No 2 fully mechanized mining team	1492	169	6.4	3.2	3-5	Sandy shale	Sandstone	100.8	8.4	12.0	43.4
Yanzhou, Nantun, No 1 fully mechanized mining team	1671	143	6	2.24	6-10	Metal net	Clay rock	100.8	8.4	10.2	46.7
Yima, Gengcun, No 2 fully mechanized mining team	1608	128	5	2.58	10	Mudstone	Mudstone	100.5	8.5	11.5	31.1
Qincheng, Wangtaipu, No 1 fully mechanized mining team	1040	157	6	2.86	1-5	Sandy shale	Soft coal	100.4	8.3	14.8	31.0

Table 2. Basic Conditions for 1 Million Ton Fully Mechanized Mining Teams, 1978

Unit (bureau, mine, team)	Coal mining working face conditions							Output			Working face efficiency (tons/worker)
	Working face annual progress (meters)	Working face length (meters)	Coal seam thickness (meters)	Extraction height (meters)	Coal seam angle (degrees)	Roof rock properties	Floor rock properties	Yearly output (10,000 tons)	Average monthly output (10,000 tons)	Highest monthly output (10,000 tons)	
Datong, Tongjialiang, No 1 fully mechanized mining team	1427	137	3.3-3.7	3.18	2-5	Medium coarse sand	Fine sand	100.3	8.3	13.3	34.2
Lu'an, Wuyang, No 2 fully mechanized mining team	1542	139	6.4	2.84	6-8	Sandstone	Sandstone	100.2	8.3	10.0	24.0
Qincheng, Gushuyuan, No 2 fully mechanized mining team	1050	123	6	2.65	1-5	Metal net	Sandy mudstone	100.0	8.4	11.9	45.0

Yearly output of 1 million tons by a single extraction team is equivalent to the output of a large mine during the 1950's and the 1960's. The world's main coal producing nations place even higher demands on unit output from fully mechanized mining, at 2 million tons yearly output per set of fully mechanized mining equipment (without reserve equipment). This production level has already been attained. Australia is now experimenting with fully mechanized mining working faces with daily outputs of 10,000 tons for longwall working faces. China's Yanzhou Mining Bureau's Nantun Mine produced 1.88 million tons of coal in 1980 with four fully mechanized mining teams and 6,500 employees. They increased unit output and produced 2.23 million tons of coal in 1987 using only two fully mechanized mining teams and two fully mechanized tunneling teams. The full staff efficiency surpassed 2 tons with 3,500 employees. They have achieved mine modernization.

VI. Implementing a Leasehold System for Fully Mechanized Mining Equipment Is a Good Way To Increase Equipment Utilization Rates

In a fully mechanized mining equipment leasehold system, units which need equipment lease it from units which own it and pay a specified rent. This arrangement is a product of the development of the commodity economy and an objective demand for development of the social forces of production, so it has been widely applied in the main coal producing nations. China began implementing it in several mining regions in the 1980's. The results have been best at Datun, Yanzhou, and Kailuan. Yanzhou Mining Bureau, for example, established a bureau leasing station for fully mechanized mining equipment in 1984 to unify management of fully mechanized mining and tunneling equipment. This increased equipment utilization rates, completion rates, and the self-capacity for updating and transformation.

Fee standards for the leased equipment were based on a 15 percent deduction from fixed assets for installation at new faces, major equipment overhauls, and new equipment purchases.

VII. Strengthen Training, Improve Employee Quality

Improvements in mine management and technical levels are closely related to improvements in the technical qualities of cadres and workers. Practice in China also has proven the importance of training work. In the No 1 mining team at Qincheng Mining Bureau's Gushuyuan Mine, for example, upper middle school graduates who have worked at least 3 years in a coal mining team were chosen prior to beginning fully mechanized mining to organize fully mechanized mining teams. They were given intensive theoretical training for 6 months and studied operations in the mine for 2 months. This team has 175 employees (35 coal miners, and all of the rest were electromechanical workers). All of them have a firm grasp of equipment performance and understand operating regulations and accident handling methods. This team went into production successfully on the first try in the last quarter of 1984 and their output surpassed 1 million tons for 3 successive years in 1985, 1986, and 1987. On a national scale, it would appear that the technical quality of fully mechanized mining staffs at present is low and newly arrived personnel in fully mechanized mining teams have not undergone strict training. This is particularly true of the yearly increase in negotiated workers in fully mechanized mining teams, which has caused a significant decline in the technical quality of fully mechanized mining teams and technical operations levels. Thus, we should adopt urgent measures to raise cadre management levels and worker technical operating levels and gradually raise educational levels of fully mechanized mining team employees up to the polytechnic school level. Moreover, the number of workers at the working face should be limited to 80 to 100 and each person should hold operating certifications for at least two types of jobs.

Based on current coal mine economic policies, we should focus on managing existing fully mechanized mining equipment well. Thus, we must use the effective ways described above to increase production levels and economic results for each set of fully mechanized mining equipment and catch up with advanced world levels.

New Method To Extract Liquid Fuel From Coal

40130118b Taiyuan SHANXI RIBAO in Chinese 4 Jul 89 p 4

[Article by assistant researcher Wu Lianzeng [2976 4887 1073]: "Supercritical Gas Extraction—A Method for Extracting Liquid Fuel From Coal"]

[Text] Coal is a combustible mineral which is composed of carbon, hydrogen, oxygen, nitrogen, sulfur, and other elements as well as a small amount of water and inorganic matter. Its hydrogen/carbon ratio is too low when burned as a conventional fuel, so it wastes raw materials and can cause environmental pollution. If coal undergoes chemical processing to convert it to a liquid state, the goals of eliminating impurities, increasing the hydrogen/carbon ratio, and conversion to a high quality liquid fuel are attained. Supercritical gas extraction from coal is a new method for direct extraction of liquid fuel from coal. It mainly employs the high dissolution capacity and strong permeability of the supercritical gas of certain solvents for direct extraction of liquefied product oil from coal.

Supercritical gas extraction is a new technology that has been widely developed and applied in many industrial departments. To obtain liquid fuel from coal, England's National Coal Bureau first applied supercritical extraction technologies to research on coal processing in the 1970's. Afterwards, many countries continued to do a great deal of research and development work. The Chinese Academy of Sciences Shanxi Coal Chemistry Institute began R&D work on technologies for supercritical extraction of raw material oil from lignite in 1980. This topic has now been included among Chinese Academy of Sciences projects for major attacks on key S&T topics in the Seventh 5-Year Plan, and a simulated experimental facility which produces 30 to 50 kg of fuel oil daily has been completed.

Development work on this topic shows that this technology has these obvious advantages: 1) No hydrogen gas is used in the extraction process. 2) The extraction solvent usually is industrial tolulene, xylene, etc., which is liquid at normal temperatures, so little energy is consumed in compressing and transmitting the liquid. 3) It has a rather strong separation capability and can cause self-separation of solid products, which avoids problems of filtering viscous liquids. The extracted oil and solvent also can automotize, so no distillation facilities are required. 4) The solvent employed can be recycled with loss of only a small amount of solvent, which can be compensated for by the light components produced during the extraction process.

This technology uses lignite as a raw material and all the products obtained are usable. The hydrogen/carbon atomic ratio of the extracted oil is rather high and it can be used directly as a boiler fuel or for processing together with crude oil. This makes addition of hydrogen to change its properties easy to make fuel for internal combustion engines and other chemical products. The gas produced during the extraction process can be used as high heat value coal gas after carbon dioxide removal. After molding and activation, the residual coal left after extraction can be used as an inexpensive absorbent as well as an excellent solid fuel or raw material for producing coal gas.

Estimates are that the extracted oil costs 217 yuan/ton, and this process basically creates none of the three wastes [waste water, waste gas, and industrial residues]. Experiments show that under rather optimum conditions, 3.5 tons of Shanxi lignite or 3 tons of Yunnan Xundian lignite can produce 1 ton of extracted oil and 2 tons of inexpensive activated carbon. This technology is particularly appropriate for processing inexpensive young coal varieties (lignite and peat) to extract oil, and it is a new method for direct liquefaction of coal with definite development prospects.

Characterization, Utilization of Chinese High-Sulphur Coal

40130107 Beijing MEITAN KEXUE JISHU [COAL SCIENCE AND TECHNOLOGY] in Chinese No 5, May 89 pp 30-35

[Article by Dai Hewu [2071 0735 2976] and Chen Wenmin [7115 2429 2404], Beijing Institute of Coal Chemistry, Institute of Coal Science and Technology]

[Text]

I. The Role of Coal in China's Energy Picture

From the 1970's to the 1980's, coal has been on the rise in China's energy consumption structure. In 1980 coal accounted for 71.8 percent of China's total energy consumption, in 1986 this percentage went up to 76 and the upward trend is still continuing.

In every year since the 1970's, more than 80 percent of China's coal has been burned directly as a primary energy source without going through the dressing process. It is estimated that China releases into the atmosphere 18 million tons of SO_2 each year, about 90 percent of which comes from coal. Acid rain is a common occurrence in Guilin, Guiyang, and Chongqing. In Chongqing more than 8 million tons of coal are burned each year; the average sulphur content of coal is as high as 3.24 percent. The pH value of the acid rain is sometimes as low as 3 and the impact on industrial and agricultural production and the environment is great.

II. Distribution of High-Sulphur Coal

The mechanism of coal formation is such that the upper layer of many coal fields is the continental sedimentary facies coal series with a low sulphur content, and the lower coal series of alternating continental and marine deposits or marine deposit alone have a higher content of sulphur. As time goes on and coal output increases, the output of lower carboniferous high-sulphur coal has been on the rise in north China. For example, Jiaozuo coal field in Henan Province used to produce only high-grade, low-sulphur coal, but now some pits are producing only carboniferous Taiyuan series high-sulphur (greater than 2 percent) coal. Preliminary estimates of the annual output of high-sulphur coal ($S_{t,d}$ greater than 2 percent) in China show a figure greater than 100 million tons. Out of the 400 million tons of raw coal output of uniform distribution coal mines in 1988, the average $S_{t,d}$ of the 380 million tons of commercial coal was 1.04 percent. In the future the output of high-sulphur coal will be on the rise as the mine shafts get deeper and the output of local coal mines increases. The research of de-sulphurization methods and wise use of high-sulphur coal to reduce environmental pollution are important topics to be addressed.

In the distribution of sulphur in Chinese coal, low sulphur coal is located in northeast China and in the northeastern part of the Nei Monggol Autonomous Region. In these areas the sulphur content $S_{t,d}$ is generally lower than 1 percent and the average sulphur content of coal in Heilongjiang is less than 0.4 percent. The sulphur content gradually increases in Jilin and Liaoning. Coal from the Nanhong coal mine in Liaonan often has more than 2 percent sulphur. In northern China the sulphur content of upper layer coal is often in the 0.5 to 1.5 percent range, but the lower layer coal has mostly 2 to 4 percent sulphur. Some coals, like those from Fenxi, also contain more organic sulphur, which lowers the rate of de-sulphurization in the dressing process. Most of the coal in northwest China has a low sulphur content, especially the coal from Qinghai and Xinjiang where the sulphur content is 0.27 and 0.61 percent respectively. However, for coal in the three provinces (regions) to the southeast—Gansu, Ningxia, and Shaanxi—the average sulphur content in the production coal is 1.11, 1.46, and 2.84 percent respectively.

Sulphur content in east China coal is generally higher, especially the coal from old mines in Zaozhuang and Zibo in Shandong Province. Since the shallow low-sulphur coal from the continental deposit is basically depleted, the output of deeper high-sulphur coal from the alternating continental and marine deposits increases year by year. Coal from Changguang coal mine in Zhejiang Province has particularly high contents of ash and sulphur. Exceptions are the two large coal mines in Huainan and Huaibei where the coal deposits with mostly 1 percent or less sulphur content are mostly Shihezi series and Shanxi series continental sediments from the Permian period of the late Paleozoic era. In the Wannan region, on the other hand, the deposits are alternating continental and marine sediments of the late Permian period and the sulphur content is 2 to 6 percent or more.

In central and southern China, Henan has a fair amount of low-sulphur coal but the sulphur content of the sparse coal deposits in Hunan, Hubei, Guangdong, and Guangxi is generally more than 2 to 5 percent. The sulphur content of the coal in Hubei Province is rarely less than 2 percent and most of that is organic sulphur with a fine dispersion of pyrite. The sulphur content of coal from a number of coal mines in this area decreases very slightly or may even increase after dressing. The bituminite and anthracite in the Guangxi Zhuang Autonomous Region generally have 4 to 8 percent of sulphur. The coal from Heshan has 5 to 10 percent of sulphur and even more after dressing.

Yunnan Province in southwest China has high sulphur coal ($S_{t,d}$ greater than 2 percent). Most of the coal in Guizhou Province is high sulphur coal from the Leping series of the late Permian period and the content of organic sulphur is often high. For example, dressing the organic-sulphur-rich coking coal from the Lindong coal mine in Guiyang either decreases the sulphur content very little or may even increase the sulphur content. In Sichuan Province, with the exception of some low-sulphur coal in the continental deposits of the Triassic period in the Mesozoic era, about ¾ of the Leping series high-sulphur coal from the late Permian period, such as those found in the Nantong, Tianfu, and Zhongliangshan coking mines, have 3 to 5 percent sulphur. The Tibet Autonomous Region, even the top of the Himalayas, was once at the bottom of the ocean, so the coal in this area is located in alternating deposits of continental and marine sediments and has high contents of ash and sulphur. The sulphur is usually greater than 2 to 4 percent and rarely less than 2 percent.

III. Sulphur Formation Mechanisms in Different Eras

Table 1 shows the average sulphur content of coal formed at different eras in China. The late Permianperiod Leping series coal in Nantong mines in Sichuan Province and the Taiyuan series bituminous coal formed in the Carboniferous period from the Tongchuan mines in Shaanxi Province are both in alternating continental and marine deposits and the average sulphur contents are respectively 4.42 percent and 3.30 percent. Furthermore, the sulphur content of these two coal series both contain considerable organic sulphur, which indicates that they were formed in a strongly reducing environment. A review of the distribution trend of the high-sulphur coal in China shows that the total sulphur content and the content of iron sulphate track each other, and the organic sulphur content is high when the sulphur content is high. In high sulphur coal with a high content of organic sulphur, the iron sulphate often exists as a dispersoid impregnated in the organic matter and cannot be easily removed by dressing. As a result, the total sulphur content after dressing is often not much lower or even somewhat higher than that in the raw coal. One of the topics for research and investigation is how to dress and utilize China's high-sulphur coal.

Table 1. Typical Sulphur Content of Chinese Coal Formed at Different Periods

Period	Mine	No. of samples Total sulphur, dry $S_{t,d}$ (%)	Ave.	Min.	Max.
Late Tertiary	Xiaolongtan	14	1.74	0.42	3.75
Early Tertiary	Fushun	17	0.46	0.29	0.65
Late Jurassic	Jixi	100	0.30	0.20	0.50
Early, mid Jurassic	Datong	300	1.00	0.33	3.42
Late Permian	Nantong	15	4.42	2.67	10.62
Early Permian	Yangchuan	13	0.49	0.37	0.91
Late Carboniferous	Tongchuan	35	3.30	1.31	7.33

It should be pointed out that late Carboniferous Taiyuan series coal and early Permian Shanxi series coal are distributed mainly in northern, eastern and northeastern China, and some also in southern Liaoning and in Henan. During these periods, the geology, weather, and plant life were particularly good for coal formation. Coal fields formed during these periods are large in area, rich in strata and hold a vast reserve of coal; they are the main source of China's coking coal. Coal in the Shanxi series of the early Permian period is low-sulphur coal in continental sediments; it consists mainly of bituminite but not of brown coal. The lower Taiyuan series coal from the Carboniferous period was formed by alternating sediments of continental and marine deposits and the total sulphur content was usually greater than 2 percent. However, the Taiyuan series near Datong not affected by ocean ingression has a sulphur content less than 1 percent. The overall trend is that the lower Taiyuan series coal has a higher content of volatiles and a greater adhesion than the higher Shanxi series low-sulphur coal. Microscopically, the Taiyuan series also has a higher content of xylovitrain. The high-sulphur Taiyuan series was obviously formed under a strongly reducing environment and its hydrogen content H_{daf} was also higher than the low-sulphur Shanxi series. Clearly the Xi-er-te principle does not apply to series formed at different periods. Since the high-sulphur coal reserves in China are deeply buried and vast in size, old mines of Carboniferous Permian coal mined for decades or even 100 years often produce high-sulphur coal. For example, the average sulphur content of the 11 trough coal at the bottom of the Kailuan coal mine is more than 3 percent. The output of high-sulphur coal in China in the future will increase as time goes on.

IV. Distribution of High-Sulphur Coal According to Species

Different species of coal are coalified to different degree. In China coals of different coalification show obviously different sulphur content. The sulphur contents of 2,093 samples of different era collected from several hundred coal mines in different regions were analyzed according to the coal species; the results are listed in Table 2. The overall trend is that the average sulphur content of less coalified coal is lower. For example, the average sulphur content of long flame coal is only 0.74 percent, the average sulphur content of 500 gas coal samples is 0.78 percent, for inviscid coal the sulphur content is 0.89 percent, and the average $S_{t,d}$ for brown coal is 1.11 percent. However, 249 samples of rich coal, the species of coal with the highest sulphur content in China, showed an average sulphur content of 2.33 percent. Other species of high degree of metamorphism such as coking coal, depleted coal, lean coal, and anthracite averaged a sulphur content of 1.4 percent. The average $S_{t,d}$ of lean coal was 1.94 percent. The reason that the sulphur content increases when the degree of coalification increases is that the Shanxi series coal from the Jurassic and Permian periods was formed by continental deposits, so the sulphur content was also low. The lower Taiyuan series Carboniferous period coal and the Leping series coal of the late Permian period formed by alternating continental and marine deposits are more coalified and therefore have higher sulphur contents.

Table 2. Average Sulphur Content of Major Coal Species in China

Species	No. of samples	Total sulphur content, dry $S_{t,d}$ (%)		
		Ave.	Min.	Max.
Brown coal	91	1.11	0.15	5.20
Long flame	44	0.74	0.13	2.33
Inviscid	17	0.89	0.12	2.51
Weakly viscid	139	1.20	0.08	5.81
Gas coal	534	0.78	0.10	10.24
Rich coal	249	2.33	0.11	8.56
Coking coal	295	1.41	0.09	6.38
Lean coal	172	1.82	0.15	7.22
Depleted coal	120	1.94	0.12	9.58
Anthracite	412	1.58	0.04	8.53
Total	2093	1.21	0.04	10.24

Based on the high sulphur content of Chinese coal, research must be strengthened to find coal dressing and de-sulphurization methods and to establish a proper mix of high and low-sulphur coal in coking.

Table 2 also shows that the average sulphur content of strata samples from major coal mines in China is 1.21 percent, consistent with the 1.04 percent sulphur content of 1985 national unified distribution commodity coal. The sulphur content of commodity coal after dressing is invariably lower than that of strata samples.

The $S_{t,d}$ value of high-sulphur bituminites in China, especially those in the Leping series in Sichuan and Guizhou, is usually greater than 2 to 5 percent. Methods are needed to de-sulphurize them so that they may be used in the civilian sector. Efforts should be made to fully utilize high-sulphur coal and also to minimize the environmental impact.

V. Chemical Composition of Sulphur in Chinese Coal

Study shows that the primary source of sulphur in low-sulphur coal (0.5 percent or less) is the protein in plants that formed the coal. Sulphur in this kind of coal is therefore mainly organic sulphur. It contains very little pyrite. This is why the sulphur content of this kind of coal can sometimes increase after dressing.

High-sulphur coal of the Taiyuan series in the Carboniferous period and Leping series of the late Permian period contains about ⅔ pyrites sulphur and ⅓ organic sulphur; sulphates are mostly less than 0.2 percent. The overall trend is that pyrite sulphur increases as the total sulphur increases (see Figure 1). However, in some high-sulphur coal containing mostly organic sulphur, the pyrite content is no more than 2 percent even when the total sulphur content is as high as 8 to 10 percent. Statistical data based on 500 high-sulphur coal samples showed that the pyrite sulphur content $S_{p,d}$ in most Chinese coal may be estimated with the following formula:

$$S_{p,d} = 0.857\ S_{t,d} - 0.657$$

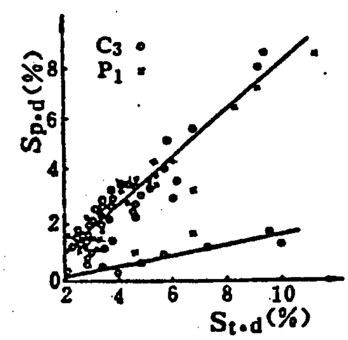

Figure 1. Relationship Between $S_{t,d}$ and $S_{p,d}$ in High-Sulphur Coal

For raw coal with a sulphur content as high as 2 to 10 percent, separate dressing with 1.4 density zinc chloride heavy liquid lowers the sulphur content in almost 90 percent of the samples to below 3 percent (see Figure 2). Gravity dressing can therefore remove a substantial amount of pyrite sulphur in most Chinese coal.

Microscope observations made on a large number of coal samples showed that pyrites in high sulphur coal existed mainly in three morphologies: discrete lumps, nodules, and strips, finely divided masses impregnated and dispersed in organic matters, and symbiotic growth with organic matter and filling cell cavities. Pyrites in Leping series coal of the late Permian period in Chongqing

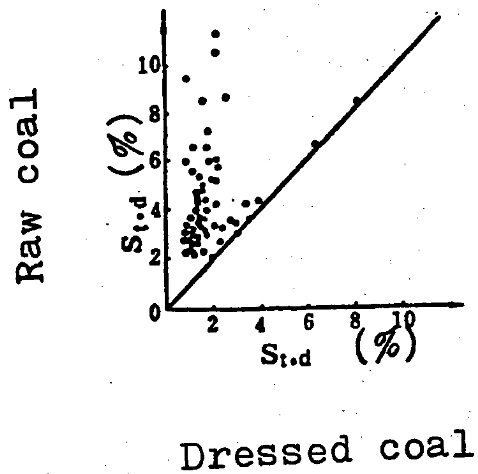

Figure 2. Relationship Between $S_{t,d}$ of Dressed Coal and Raw Coal

region can be divided into four types: lumps, veins, nodules, and dispersoids. Their morphological structures are as follows:

1. Lumps

The lumps are highly mineralized and the pyrites and the marcasites often form dense lumps. Some pyrites form ribbon-like structure and can separate easily from the vein. Gravity dressing recovers easily.

2. Veins

These pyrites may exist as phanerocrystalline or cryptocrystalline structures at the gap of veins or fissures. They can be separated after grinding and dissociation.

3. Nodules

Pyrites often appear as nodules. They are usually filled with organic wood cells and may retain the wood structure. After dissociation, nodules may be recovered by gravity liquid dressing.

4. Dispersoids

Scattered dispersoids of pyrites are usually cubic crystals of pyrites and marcasites less than 0.02 mm in size. They are often scattered in the vein and in the coal strata and are difficult to recover.

In coal strata with a high degree of metamorphism, the grain size and nodule size of the pyrites are usually large. The pyrites often exist in organic matters in the form of imbedded nodules, dense grains or impregnated dispersoids. In coal strata of a less degree of metamorphism, the content of organic matters is higher, the grain size of pyrites is smaller and most of the pyrites exist in an impregnated form. In short, the morphology of pyrite depends largely on the formation and sedimentation conditions of the high sulphur coal and follows a regular pattern.

VI. Rational Utilization of High-Sulphur Coal in China

1. Recovery of Pyrite From Tail and Sandwich Gangue

Since the pyrite in high-sulphur coal in China exists in a separated form, it is entirely possible that pyrites can be recovered from the tail (washed gangue) in the coal dressing plant. Also, pyrites and marcasites tend to accumulate in the sandwich gangue near the top and bottom plates of the coal mines and can be important sources for recovery. Based on incomplete statistics, more than 30 tons of sulphur and pyrites were recovered from coal systems in 1986. In future developments of high-sulphur coal mines, China may recover 1 million tons of pyrite per year.

2. Dressing and De-Sulphurization of High-Sulphur Coal

Since 1949, only about 16 percent of raw coal in China was dressed and most of it was coking coal. In 1987 only 7 million tons (less than 7 percent) of high sulphur content coking coal were dressed, and most of it was high inviscid rich coal and gas coal. The sulphur content of most dressed coal was reduced to less than 1.5 percent, a small portion was reduced to 1.5 to 2.0 percent, and in isolated cases the sulphur content was still as high as 2 to 2.5 percent.

Only a small amount of non-coking bituminous coal in China was dressed and high-sulphur coal was almost never dressed. Since coal dressing is still the simplest and most effective way for de-sulphurization, China should put a great emphasis on dressing high-sulphur coal, including power coal. At the coal dressing plant in Nantong, Sichuan, raw coal goes through a preliminary de-sulphurization process in a jumper screener, the screened coal is de-sulphurized again in a double decker shaker for better results. A power plant in Chongqing decided to build a large coal dressing plant to treat its high-sulphur anthracite because it costs less than installing gaseous de-sulphuring facilities at the plant and it helps to control the coal quality used in the power generation and is better for the normal operation of the boiler. It is certain that more extensive use of coal dressing for coking and power generation will have very good economic and environmental benefits, considering the low percentage of Chinese coal that is dressed. Today, some research units and universities are actively investigating microwave and chemicalde-sulphuring techniques for high-sulphur coal. In addition to the less-than-ideal de-sulphuring efficiency, the high costs also prevented the general use of the developed methods.

3. Utilization of High-Sulphur Coking Coal and Production of Bound-Sulphur Coke

Sulphur content data on metallurgical coke from 17 major steel industries showed that three steel works had $S_{t,d}$ less than 0.6 percent, eight steel plants had $S_{t,d}$ greater than 0.6 to 0.8 percent, five plants had $S_{t,d}$ between 0.8 and 1 percent and one had $S_{t,d}$ greater than

1 percent. On the whole the sulphur content in metallurgical coke in Chinese steel industry is still not too high. In the future, however, it would be difficult to maintain the sulphur content of metallurgical coke at the present level because of the following reasons: the growth of the steel industry, the increasing proportion of high-sulphur coal produced, and the concentration of high-sulphur coke (20.6 percent of coke reserve) on high-adhesion rich coal and coking coal. In addition, the scattered distribution of high-sulphur coal and the transportation problems also contributed to the difficulty. For long-term considerations, the production ratio of high-sulphur coking coal and low-sulphur coking coal should be adjusted to preserve and protect low-sulphur, high-adhesion coking coal. In the meantime, low-sulphur gas coal should be used as much as possible in the coking process and more should be done in ore preparation and metallurgical processing in order to use more high-sulphur coking coal.

Since most of China's high-sulphur coking coal are concentrated in the southwest and south central regions, local small and medium steel works cannot transport low-sulphur coal over long distances. This makes it very important to develop de-sulphurization techniques for high-sulphur coal in coking and in iron refinery. China has experimented with the production of "bound-sulphur coke" (lime coke) in smelters. Acceptable cast iron has been produced in small blast furnaces using bound-sulphur coke with a sulphur content as high as 3 percent (mainly organic sulphur in raw coal), and the technical and economical indicators were all better than using high-sulphur coke of the same kind of coal. However, the stability of calcium sulfide in bound-sulphur coke still needs further investigation.

4. Burning of High-Sulphur Coal and De-Sulphurization by Fluidized Burning

Mixing of power production coal is just emerging in China but the future prospects are very bright. For example, some high-sulphur coal of the Taiyuan series in the late Carboniferous period with $S_{t,d}$ in the 2 to 3 percent range can often be mixed with low-sulphur coal in the Shanxi series and Shihezi series of the Jurassic period and early Permian period ($S_{t,d}$ less than 1 percent) so that the sulphur content of the mixed coal is less than 1.5 percent and can serve as a better power coal. This practice not only reduces the sulphur content in the coal, but also adjusts the content of ash and volatiles and the melting point of ash to improve burning.

Formed coal is a widely used fuel in the civilian sector and its use is currently being promoted. In order to form the shape and to fix the sulphur, a certain amount of lime is added. By adding lime to high-sulphur coal, the sulphur fixing rate is substantially increased. For a sulphur content of 2 to 3 percent, the sulphur fixing rate can reach 60 percent or higher by controlling the Ca/S ratio at 2.5. The sulphur fixing rate of coal containing 4 to 5 percent sulphur can also reach 60 percent when Ca/S is 2.0.

Fluidized burning developed recently has a number of advantages, including enhanced combustion, better heat transfer, high compatibility, lower burning temperature, and low NO_x output. In the burning process, lime may also be added to remove sulphur dioxide. Since the technique provided an important outlet for high-sulphur coal, it has attracted the attention of responsible departments. The bench test currently under way (500 x 500 mm cross-section and 4200-5000 MJ/h heat capacity) and the experiment with small-scale fluidized boiler burning of high-sulphur coal have also produced some results. In the combustion of dressed gangue with a heat value of 4.2 to 6.3 MJ/kg and a sulphur content of 2.5 to 3.0 percent, the rate of de-sulphurization can be 85 percent when the molar ratio is controlled at 2.6 to 3.0 percent and the fluid bed temperature controlled at 850 to 900°C. Also under investigation are reburning of fly ash and circulating fluidized bed de-sulphurization.

5. Gasification and Sulphur Recovery of High-Sulphur Coal

In the gasification of high-sulphur coal, not only the operation of the gasification furnace must be modified to suit the characteristics of high-sulphur coal, but the de-sulphurization problem of the high concentration of hydrogen sulfide must also be solved. In China anthracites with 4 to 6 percent sulphur have been used for the generation of semi-water coal gas routinely in 1.98 m diameter coal gas generator furnaces of small synthetic ammonia plants with annual output of 5,000 tons. Such high-sulphur anthracites have poor thermal stability, low ash melting point, and tend to form slag. Controlling the grain size of the raw material will improve the operation of the gasification furnace, increase the percent of the blast steam, lower the temperature of the flame layer, prevent the formation of scabs, and ensure the normal operation of the furnace.

However, the semi-water coal gas generated from high-sulphur coal generally has an H_2S content of 5 to 15 g/Nm^3, with a maximum of 24 g/Nm^3. Since the improved ADA method (similar to the Streford process) was used, the ADA usage in the solution was 5 g/L. Under room temperature and pressure, the H_2S content in the coal gas may be decreased to less than 0.1 g/Nm^3. The operation of this de-sulphurization system is easy to control and the composition of the solution is stable and nontoxic. (The solution is mainly Na_2CO_3 and $NaHCO_3$, plus anthraquinone sulfonic acid 2,6 and 2,7 isomeric sodium salt.) In the meantime, 99.5 percent pure molten sulphur can be recovered in the process as a bonus.

In general, it is possible to remove the sulphur in the coal gas generated in a variety of furnaces burning high-sulphur coal. However, the economic feasibility requires a general evaluation.

6. Direct Liquification of High-Sulphur Coal

Due to the increasing demands on liquid fuel and the fact that coal resources are far more abundant than petroleum, China reinstated its research of direct coal liquification technology in 1980.

It should especially be pointed out that sulphur in coal is a hazardous material in almost every application except in the direct liquification of coal, where sulphur is not only harmless but is a helpful catalyst. In fact, if the sulphur content is low, extra sulphur containing materials such as pyrites. High-sulphur young coal is therefore the ideal raw material for liquification.

Three types of bituminites containing 2.5 to 4.8 percent sulphur have been tested for direct liquification in 0.1 t/d small continuous direct coal liquification setups. At a coal slurry concentration of 40 percent, a reactor temperature of 450°C, and a pressure of 25 MPa, the conversion rate reached 79 to 83 percent and the oil output was 44 to 49 percent. If the operation procedures were improved, the oil output is expected to reach 50 percent or above.

VII. Conclusions

The distribution of coal sulphur in China is characterized by an increasing trend running from north to south and from west to east. The highest average sulphur content in coal is found in coking coal from southwestern China.

The high-sulphur coal in China was formed mainly in two coal formation periods: Leping series in the late Permian period and Taiyuan series in the late Carboniferous period. Continental sedimentation coal usually has a sulphur content of 1.5 percent or less, but alternating continental and marine sedimentation coal and shallow sea coal deposits usually have 2 to 10 percent coal.

In China the sulphur content is the highest in strongly adhesive coal and the sulphur content is commonly lower in low coalified coal.

In China's high-sulphur coal, about two-thirds of the sulphur is from pyrite and one-third from organic sulphur. After dressing, most of the pyrite sulphur can be removed.

Dressing of high-sulphur coking coal and power coal should be made a common practice. In the meantime, recovery of pyrite should be improved to increase the economic benefits.

Before the technology for de-sulphurization is mature, high-sulphur coal and low-sulphur coal should be mined and used with a sensible mixture in order to improve and stabilize the coal quality and to make good use of coal resources.

Attention should be given to the research of desulphurization of high-sulphur coal and the application techniques. In areas producing high-sulphur coal, fluidized-bed boilers and formed coal with added lime for sulphur fixing should receive immediate attention.

Is Shanxi's Coal Industry Facing a Crisis?

40130119b Shanghai WEN HUI BAO in Chinese 14 May 89 p 4

[Excerpt] In the latter half of last year, the national coal situation suddenly lost equilibrium. East China was short of coal, Central China was short of coal and even in Shanxi Province, located in a sea of coal, some enterprises halted production while awaiting coal. In one period, a number of people in coal circles cried out in alarm that China's coal production had sunk into crisis. Railway transportation department then promulgated even more perplexing and disturbing news: There was no coal in Shanxi to move.

Has the "Coal Capital" Shanxi sunk into crisis? A journalist of OUTLOOK weekly magazine recently interviewed the governor of Shanxi Province, Wang Senhao. The special report published in this publication's 17th issue is summarized below.

Wang Senhao summarized the present coal production situation in Shanxi in two points: The situation remains good, but there are also many problems and difficulties.

How can it be said that the situation remains good? Wang Senhao said the most convincing point is that coal production continues to increase incessantly. In 1988, Shanxi's coal output reached 246 million tons, a 6.9 percent increase over the previous year and exceeding the year's production plan by 9 percent. In the same year, the amount of coal transported out of the province totaled 175 million tons which represents an increase of 8.7 percent compared with 1987. This year coal output has continued to improve. During January, output of the entire province rose 4.1 percent compared with the same period last year and for February, although it was affected by the new year and lunar new year holidays, output was still 1.7 percent higher than during the previous month. Daily reports indicate that during March the task was still being fulfilled and exceeded on a daily basis.

Then what are the difficulties in Shanxi's coal production? Wang Senhao said that today, the paramount issue is that coal prices are too low. There are too many inflationary factors so that there is no longer any profit to be sought in coal extraction. The vast majority of local or village coal mines lack dedicated rail lines and must transport over public roads to stations for loading onto trains. The cost for transporting on public roads has risen from an average of 6 yuan per ton in the past to over 10 yuan. The cost for loading onto trains by coal discharge stations has increased from 5 yuan to 9 yuan. Coal mines located close to rail lines can retain a small profit while, for the coal mines a little further away it is already difficult to survive. A great many coal mines can only compensate for losses by keeping the funds for maintenance of simple reproduction. Today, in Shuozhou City alone, there are already 18 coal mines showing losses.

Investment is decreasing, and Wang Senhao considers this to be a fundamental problem. He emphatically pointed out: "From a long-range perspective, if this issue does not attract attention the future will be dangerous." Between 1984 and 1987, very few new mines began operations in Shanxi, resulting in insufficient staying power in coal production. In Shanxi, establishing a mid- to large-size mine requires at least 3 to 5 years. Therefore, as time does not wait for us, we must begin now to increase investment in coal. [passage omitted]

Another Big Field Found in Heilongjiang

40130128a Harbin Heilongjiang Provincial Service in Mandarin 2100 GMT 30 Aug 89

[Text] A large coal field with proven reserves of 1.5 billion tons of coal has been discovered in Heilongjiang. This coal field occupies an area of 500 square km and is situated between Qixing He and Raoli He, east of the Shuangyashan power plant on the Sanjiang Plain.

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