China

Shisanling Pumped Storage Power Station Project

Report Date: March 2001
Field Survey: August 2000

1. Project Profile and Japan's ODA Loan

Site Map: Suburbs of Beijing

Shisanling Pumped Storage Power Station

(1) Background

When this project was planned, at the end of 1988, China's generating plant capacity had reached 115.5 GW. Particularly through the 1980s, the averaged 6GW power supply capacity completed each year, and China ranked fourth in the world, behind the USA, the Soviet Union and Japan in the scale of its generating capacity. Its generating plant was 70% thermal, mainly coal fired, with hydroelectric generation providing the remainder. The total power generated in 1988 was 554.1 billion kWh, but the rate of growth in power supplied was leveling off, from averaging nearly 10% per annum in the 1970s to approximately 6.4% from the start of the 1980s. Power supply growth was not keeping pace with the rapid increase in demand brought about by the economic growth which followed the adoption of openness policies.

The Jing-jin-tang area (Beijing, Tianjin, Tangshan), which was the target supply area for the Shisanling Pumped Storage Power Station, contains major metropolitan areas, such as Beijing, the capital, and Tianjin. It was one of the regions in China with the highest demand for electricity. Economic progress in these cities under the openness policies was reflected in increasing demand for electrical power for industrial and residential uses. Growth in daytime demand was particularly strong, with an extreme rise in peak demand and a growing demand gap between night and day. The gap was expected to grow to 5,229MW by 2000. From 1985, electrical supply was unable to cover the rapidly growing peak power demand (the daytime peak in the winter of 1989 was 6,360MW, against a possible supply output of around 6,450MW), and excess demand was suppressed by planned power cuts or unilateral load shedding (power cuts) on the supply side. The expansion of the load gap necessitated an adjustment power source to provide an efficient supply in line with demand. While the construction of a hydroelectric power station, which has superior load correspondence, was desirable, the area concerned lacked water catchments. Therefore pumped storage generation[1], which is easily scalable with superior load correspondence, was chosen as a peak-time power supply.

[1] Two adjustment reservoirs are built at different heights, with water being raised using excess power late at night and on holidays etc., and used to generate power at times of high daytime load.

(2) Objectives

The project was aimed at increasing power supply in the Jing-jin-tang area, which includes Beijing and Tianjin, and also delivering efficient power supply against the rapidly rising peak demand by constructing a pumped storage power station with a maximum output of 800,000kW, approximately 40km north of Beijing.

(3) Project Scope

The project is designed to construct a pumped storage power station comprising the Shisanling reservoir, which is the lower reservoir, situated approximately 40km north of Beijing, and the upper reservoir, which is constructed approximately 2km east, near a mountain peak. The maximum water intake volume is 3.8 million m^3, with a vertical distance of 430m, giving a maximum output of 800,000kW.

The Japan's ODA loan covered the entire foreign currency portion of procurement of equipment, materials and services necessary for the implementation of this project.

(4) Borrower/Executing Agency

Ministry of Foreign Trade and Economic Corporation, People's Republic of China[2] /Ministry of Energy, People's Republic of China[3]

(5) Outline of Loan Agreement

Loan Amount/Loan Disbursed Amount	¥13,000 million / ¥12,926 million
Exchange of Notes/Loan Agreement	March 1991 / March 1991
Terms and Conditions	Interest rate: 2.5%, Repayment period: 30 years (10 years for grace period), General Untied
Final Disbursement Date	April 1998

2. Results and Evaluation

(1) Relevance

As the power demand for the Jing-jin-tang area was growing, there was a growing need to meet peak demand, which was rising particularly rapidly. Therefore the project plan, to build a pumped storage power station able to meet peak demand efficiently, was relevant. At the time of evaluation, the load gap between night and day was still large (see Table 1) and the project plan retained its initial relevance.

(2) Efficiency

(i) Project scope

The project was implemented largely as planned, with no notable problems.

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2 Currently Ministry of External Trade and Economic Cooperatives. Since 1999, the agency receiving the Japan's ODA loans to China has shifted to the Government of the People's Republic of China (Ministry of Finance).

3 Currently Ministry of Electric Power

(ii) Project cost

The local currency portion of total project cost rose to three times the planned value, causing a 20% cost overrun overall.

(iii) Implementation schedule

The plan called for construction to begin in January 1989 for completion in 96 months, but the actual implementation schedule was 102 months. There were delays in the preparations for construction, such as soil surveys, but the efforts of the executing agency, the consultant and the equipment suppliers to reduce the implementation schedule succeeded in avoiding larger delays.

(iv) Implementation scheme

The Ministry of Energy (currently State Power Corporation) had previous experience of implementing large-scale hydroelectric power generation projects with Japan's ODA loans support, such as the "Tianshengqiao (Basuo) Hydroelectric Power Project" and the "Wuqiangxi Hydroelectric Power Project". It succeeded in completing the project without significant problems. The foreign consultant employed for this project was also highly experienced, and the suppliers worked around the clock on equipment installation. According to the executing agency, the performance of them was commendable.

(3) Effectiveness

1) Contribution to meeting power demand in the Jing-jin-tang area

Table 1 shows electrical power supply and demand situation in the Jing-jin-tang area, where the Shisanling Pumped Storage Power Station is located.

Table 1 The Power Supply and Demand Situation in the Jing-jin-tang Area

(Units: MW)

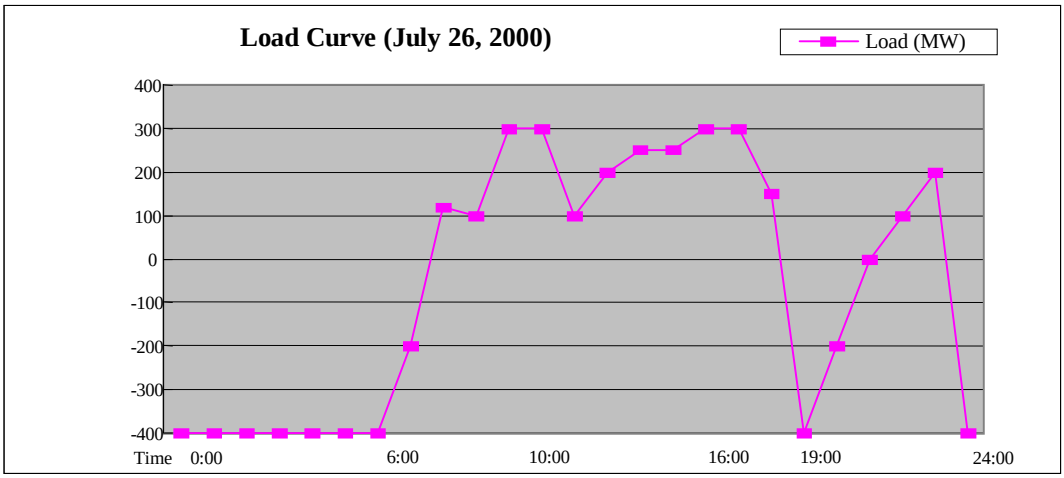
	Winter 1989	Winter 1997	Winter 1998	Winter 1999	Winter 2000
(State of demand in the Jing-jin-tang area)					
Daytime peak demand	6,360	11,561	12,194	13,876	14,000
Minimum nocturnal demand	4,330	5,679	6,558	7,817	8,800
Load gap between night and day	2,030	5,882	5,636	6,059	5,200
(Power source composition in the Jing-jin-tang area)					
Plant capacity	7,600	14,057	14,733	16,788	16,390
(Thermal generation portion)	7,450	12,629	13,245	15,275	14,985
(Hydroelectric generation power)	150	1,428	1,488	1,513	1,405
Potential supply capacity	Approx.6,450	N.A.	12,194	13,876	15,300
(Thermal generation portion)	Approx.6,300	N.A.	N.A.	N.A.	N.A.
(Hydroelectric generation power)	Approx.150	N.A.	N.A.	N.A.	N.A.

Source) Documents collected at the time of the appraisal in 1989. Figures from 1997 and beyond are from documents prepared by the North China Electric Power Administration.

At the time of the appraisal (1989), the Jing-jin-tang area had 7,600MW of generation capacity, most of which was thermal. By 1997, when this project was completed, the power source composition had shifted to include 10% hydroelectric power (1,428MW) within a total of 14,057MW. The Shisanling Pumped

Storage Power Station (plant capacity 800MW) provides a substantial 57% share of that hydroelectric capacity. Therefore this project appears to be making a significant contribution to achieving efficient power supply in the Jing-jin-tang area.

The diagram below illustrates the primary role of the Shisanling Pumped Storage Power Station, which is meeting peak demand. As the diagram shows, this power station pumps water up at night (the negative portion of the load in the diagram) and uses it for generation at the daytime demand peak (the positive load portion). Thus it supplies electrical power to meet peak demand.



The gap between daytime peak demand and nocturnal minimum demand in the Jing-jin-tang area in winter was 5,200MW in 2000. The Shisanling Pumped Storage Power Station has a capacity of 800MW, meaning that it is theoretically able to cover 15% of the demand gap.

According to the executing agency, the Shisanling Pumped Storage Power Station also plays important roles in failure response (standby generation) and in frequency regulation, besides meeting peak demand.

ii) Quantity of power generated

As described above, the main roles of the Shisanling Pumped Storage Power Station are meeting peak demand, failure response and frequency regulation. Although the power station is not required to operate constantly, its operating record is presented in Table 2 for reference. Power generation has been in the area of 700GWh since 1998, the year after the project was completed, which is less than 60% of the 1,183.25GWh set as the plan target at the time of the appraisal. As this project is used for peak generation, the operation record figures are only reference values for the power station's operational status, and it is not possible to assess the effects of the project from the quantity of generation alone.

Table 2 Operational Record of the Shisanling Pumped Storage Power Station

Item	Target value	Completion point (1997)	1998	1999	2000	2001 (estimated)
Net electric energy production (GWh)*	1,183.25	584.06	687.73	685.54	746.24	730.00

(Source) Prepared from executing agency's materials
Note) * Net electric energy production = Gross electric energy production – Station use electricity

iii) Financial internal rate of return (FIRR)

The financial internal rate of return (FIRR) was calculated at 10.3% at the time of the appraisal, taking the benefits as revenue from the sale of electricity, and the costs as construction cost and operation and maintenance costs, assuming a unit sales price of 0.25 Yuan/kWh and a project life of 30 years. In this evaluation, the current unit sale price of 0.7179 Yuan/kWh was used, with the assumption that current levels of cost and benefit will be maintained beyond 2002, yielding a result of 4.3%. The FIRR fell below the initial forecast because the actual quantity of generation did not match the planned value (it fell below 60%). For pumped storage generation, economical system operation that minimizes the cost of water pumping is generally used, and the plant is used to secure necessary supply and handle excess supply, in line with the changing supply and demand situation. Therefore it is difficult to evaluate project effects from FIRR alone.

(4) Impact

The Hydropower Environmental Impact Research Center of the China Hydropower and Water Use Science Research Institute is commissioned to monitor water quality (concentrations of harmful substances) twice a year to gauge the environmental impact of this project. The results satisfy national environmental standards and do not indicate any problem.

The project required the relocation of 38 people, who were resettled within Beijing by September 1990. Housing was constructed for them, and there was no problem with the relocation. The area of land that had to be acquired for tipping excavated soil was larger than anticipated, because geological conditions necessitated expansion of the area of the upper reservoir. The necessary additional land area was acquired.

(5) Sustainability

At the time of the appraisal, the North China Electric Power Administration[4] was to operate and maintain the facilities, but after the completion of construction the Beijing Shisanling Pumped Storage Power Station was established for the purpose, as a subsidiary organization under the Administration. It is a 100% state-owned enterprise, with 70 of its own staff and 81 staff from related agencies, for a total staff of 151 (as of 7th February 2001). Of the staff, approximately 70% are educated to at least technical school graduation level. By age, over 60% are aged 35 or younger, and the average age is 39.8, making it a relatively young organization. In 2000, 121 staff received a total of 5,992 hours of training in various specialist fields, or to gain qualifications.

The annual maintenance cost is 200 million Yuan, and the necessary budget is provided. Regular

[4] At present, the North China Electric Power Administration is also named the North China Power Corporation, but the latter name is scheduled to become the sole name in future.

inspections are carried out over 14 day periods annually (the regulations call for twice a year for 7 days each time).

Thus there are no notable problems at present with the maintenance scheme for this project, or with its technical and budgetary aspects. It appears that the project will carry on its role of meeting peak power demand, and retain its sustainability.

Table 3 Movements in Electricity Sale Revenues and Maintenance Costs

(Units: millions of Yuan)

Category	1997	1998	1999	2000	2001 (estimated)
Revenue from sale of electricity	419.33	493.75	492.18	535.90	524.10
Maintenance cost	206.91	216.04	217.68	230.50	201.46

(Source) Prepared from executing agency's materials

Comparison of Original and Actual Scope

Item	Plan	Actual
①Project Scope		No basic changes
・Upper reservoir	Rock-filled dam with impermeable asphalt surface wall (wall height 120.0m, wall top length 463.9m). Total water storage capacity: 4 million m^3	4.45 million m^3
・Lower reservoir	Rock filled dam with internal steel reinforced concrete impermeable layer (wall height 29m, wall top length 627m). Total water storage capacity: 81 million m^3	79.77 million m^3
・Power station	Underground type, Installed capacity: 800MW (200MW x 4 units)	Same as left
・Waterway etc.	Headrace channel, surge tank, hydrostatic pipeline, tailrace	Same as left
・Power-transmission line	Two 220KV lines, 6km (from the Power Station to a Transformation Station)	Same as left
②Implementation Schedule	Jan. 1989 ~ Dec. 1996 (96 months)	Jan. 1989 ~ Jun. 1997 (102 months)
③Project Cost		
Foreign currency	¥13,000 million	¥12,926 million
Local currency	951.57 million yuan	2,885.02 million yuan
Total	¥45,734 million	¥56,197 million
ODA loan portion	¥13,000 million	¥12,926 million
Exchange rate	1 yuan ＝ ¥34.4	1 yuan ＝ ¥15.2098