People's Republic of China

Ex-Post Evaluation of Japanese ODA Loan

"Shandong Tai'an Pumped Storage Power Station Project"

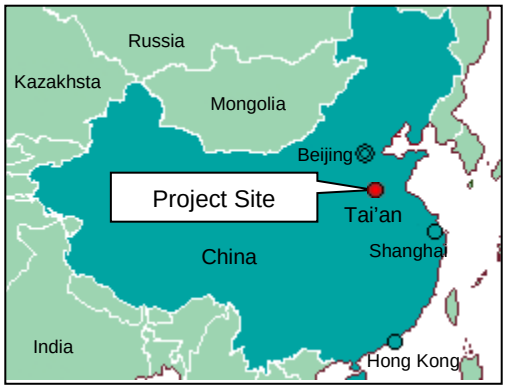
External Evaluator: Masahiro Oseko, OPMAC Corporation

0. Summary

This project was implemented with the purpose of constructing a pumped storage power station at a location in Shandong Province, where air pollution was worsening as a consequence of thermal power generation, in order to realize an environmentally-friendly, efficient power supply, thereby contributing to the economic development of the province. The project was consistent with China's development policy, needs and Japan's ODA policy, and therefore the relevance was high. Primary operation indicators such as maximum output of the power station have been achieved, and positive impacts have been observed in terms of the employment of local residents and regional development. However, as the project has only partially achieved air pollutant emission reduction targets (effect indicators), the effectiveness and impact of the project was fair. The project was implemented efficiently within the planned cost and project period. Therefore, the efficiency of the project is considered high. There have been no problems in terms of institutional, technical and financial aspects of the operation and maintenance of the project, accordingly sustainability of the project is judged to be high.

In light of above, the project is evaluated to be highly satisfactory.

1. Project Description



Project Location

Entrance of Underground Power Station

1.1 Background

China became the world's second largest power generation country in the late 1990s as a result of their emphasis on developing electric power as the driving force to support strong economic growth. China's power generation capacity has continued to grow in response to strong economic growth, at over 10% per year since the 2000s when they emerged from the

Asian economic crisis. Meanwhile, despite environmental issues having been exacerbated with thermal power plants making up over 70% of China's power supply, the development of coal-fired power plants has gone ahead against the backdrop of the increased power demand associated with economic development and China's abundant supply of coal resources. China has thus failed to effectively utilize its abundant hydropower resources.

Shandong, a coastal province of China, is blessed with an abundance of minerals, agriculture, fisheries and energy, and makes up part of the Bohai Bay Economic Rim which has become the driving force of the Chinese economy. Although the province has its own power system (Shandong power network), it has been almost completely reliant on thermal power generation. Furthermore, there is significant disparity between the maximum and minimum load, and output adjustment had been implemented through thermal power plant Daily Start and Stop (DSS) operations[1]. However, DSS operations have increased environmental impact, shortened the life of power generation equipment, decreased thermal efficiency, caused unplanned power outages, and increased operation and maintenance cost as a result. Notably, the air pollution in Shandong Province was primarily from coal combustion, with particulates and sulfur oxides emitted from the power plants comprising a substantial portion of the province's total emissions. Consequently, the environmental impact was becoming more pronounced every day.

1.2 Project Outline

The objective of this project was to realize an environmentally friendly, efficient power supply by constructing a 1,000MW pumped storage power station in Shandong Province where air pollution was worsening, thereby contributing to the economic development of the province.

Loan Approved Amount / Disbursed Amount	18,000 million yen / 9,182 million yen
Exchange of Notes Date / Loan Agreement Signing Date	March 2001 / March 2001
Terms and Conditions	Interest Rate: 0.75% Repayment Period: 40 years (Grace Period: 10 years) Conditions for Procurement: General untied (Consulting Services: Bilateral tied)
Borrower / Executing Agency	The government of People's Republic of China / State Grid Corporation of China
Final Disbursement Date	July 2011
Main Contractors (over 1 billion yen)	Marubeni Corporation (Japan)

[1] DSS refers to the repeated starting up and shutting down of the power plant within a single day in response to changes in power demand. Power plants often operate during the day when power demand is high, and shut down at night.

Main Consultant (over 100 million yen)	Electric Power Development Co.,Ltd. (Japan)
Feasibility Studies, etc.	F/S on power generation: SINOHYDRO Corporation Ltd., 1998 F/S on transmission/transformation: Shandong Electric Power Engineering Consulting Institute Cor. Ltd., 2000
Related Projects	World Bank (1992-1999) Loan for "Zouxian Thermal Power Project" ($ 800 million)

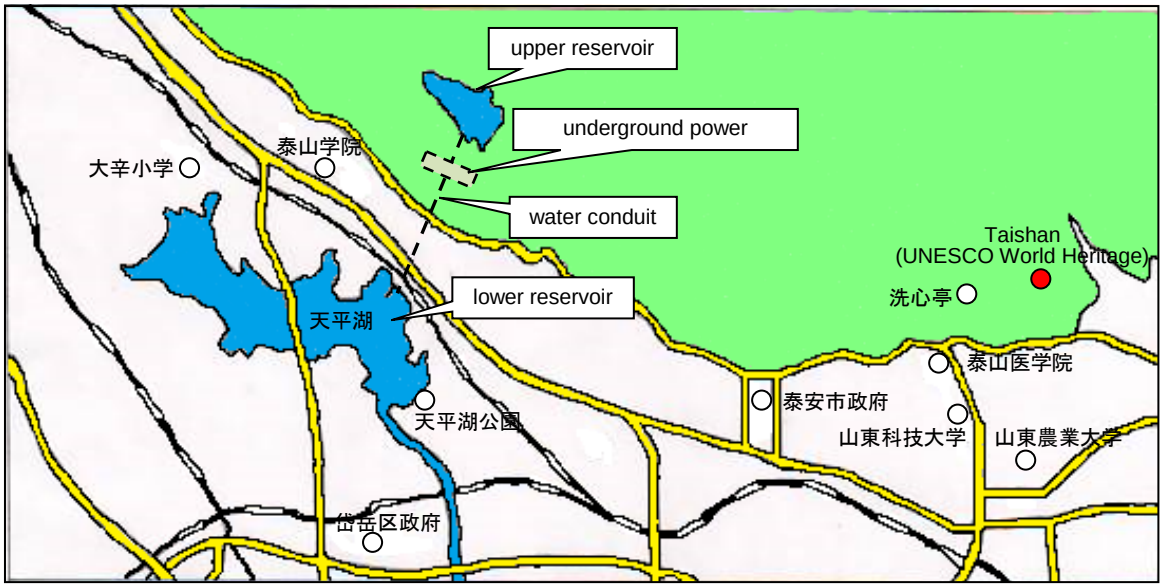


Figure 1: Location of the Project Site

2. Outline of the Evaluation Study

2.1 External Evaluator

Masahiro Oseko, OPMAC Corporation

2.2 Duration of Evaluation Study

Duration of the Study: August 2013 – November 2014

Duration of the Field Study: 30 November – 12 December 2013, 22 and 29 April 2014

2.3 Constraints during the Evaluation Study

In this ex-post evaluation it was attempted to acquire various data and confirm status through interviews and questionnaires on the executing agency (State Grid Corporation of China) and the operation and maintenance agencies (Taishan Pumped Storage Power Co., Ltd. for power generation facility and Shandong Electric Power Group Corp for transmission/transformation facility). However, it was unable to obtain necessary information such as the effect indicators of the frequency of DSS operations of thermal power plants and the amount of coal and oil consumption in Shandong Province during the evaluation period but only

managed to collect partial answers to questionnaires and interviews on financial officers. A pumped storage power plant performs pumping during off-peak periods of low power demand and discharges water and generates power during peak periods of high power demand. Therefore, whether or not an efficient power supply is being implemented effectively is determined by analyzing not only the typical operational status of the power plant, but also whether the plant is operating to match the regional power supply and demand in line with the local government's policies in relation to pumped storage power plant operations. However, since it was unable to confirm the policies and process relating to the operation of pumped storage power plants by the information from the project executing agency and the operation and maintenance agency, there was no choice but to conduct analysis based on the partial data that was available. The results of this ex-post evaluation shown below were derived under those constraints.

3. Results of the Evaluation (Overall Rating: A[2])

3.1 Relevance (Rating: ③[3])

3.1.1 Relevance to the Development Plan of China

The "9th Five-Year Plan (1996-2000)" at the time of the project appraisal listed specific measures for emerging away from the conventional policy of increasing power generation capacity to a policy of adjusting power structure, strengthening the transmission and distribution network, and promoting electricity price reform. With regards to environmental considerations, the 9th Five-Year Plan also called for the expansion of clean energy (pumped storage power and small hydroelectric stations in poor and rural areas, etc.) and closure and prohibition on the new construction of small thermal power plants. Environmental considerations continued to be emphasized in subsequent five-year plans, and the "12th Five-Year Plan (2011-2015)" in effect at the time of this ex-post evaluation listed "conversion to a resource-saving and environmentally-effective use society" as one of the “ten big tasks” to improve the quality of economy (to correct imbalances and improve sustainability). This five-year plan also set the following emission reduction goals by 2015 with respect to main contaminants: 8% for chemical oxygen demand (COD), 8% for sulfur dioxide (SO_2) and 10% for nitrogen oxide (NOx). In addition, the “12th Five-Year Plan for Energy Development (2011-2015)” also set the "binding targets" to suppress the primary energy consumption at the level of 4.1 billion tce (tons of coal equivalent), and to increase the proportion of non-fossil energy to 11.4% of the primary energy consumption, of which hydroelectric power should account for two-thirds.

In response to these national government policies, the Shandong Province government planned the Tai’an Pumped Storage Power Station project in their “Shandong Province 9th Five-Year Plan (1996-2000),” and set the goal of reducing coal consumption in the province by

[2] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

[3] ③: High, ②: Fair, ①: Low

approx. 150,000 tons per year by constructing this pumped storage power station. The “Shandong Province 12th Five-Year Plan (2011-2015)” in effect at the time of this ex-post evaluation adopted six guiding principles. One of these guiding principles, "maintain green development," specified energy saving, emission reduction and expansion of environmental conservation as codes of conduct. In addition, the first of four emphasized points in this plan's energy policy is "review coal-fired power generation," and the plan set the goal of reducing the proportion of coal-fired power plants throughout the province from 92% in 2011 to 71% by 2015. The second emphasized point is "massive development of new energy," which encourages pumped-storage power generation along with nuclear power, wind power and solar power.

3.1.2 Relevance to the Development Needs of China

The maximum load and minimum load in Shandong Province were estimated to be 13,300MW and 8,300MW respectively in 2000. These figures however have continued to grow along with the subsequent expansion of economic activity, and the disparity between the max. and min. load continues to expand each year (Table 1). In addition, Shandong Province is almost completely reliant on thermal power generation, and the output adjustment is done through DSS operations of thermal power plants responding to the significant disparity between the max. and min. load. But DSS operations have shortened the life of power generation equipment, decreased thermal efficiency as a result of repeated start and stop and intermediate output, caused unplanned power outages, and increased operation and maintenance cost. Although the proportion of thermal power generation is slightly declining, there is still a heavy reliance on it (Table 2), and thus a need for alternative power generation is still high.

Table 1: Maximum load and minimum load

Unit: MW

Year	2008	2010	2012
Maximum load	33,349	44,872	50,697
Minimum load	14,258	17,044	20,895
Max. and min. load disparity	19,091	27,828	29,802

Source: Tai’an Pumped Storage Power Station

Table 2: Proportion of thermal power generation

Unit: %

Year	2008	2010	2012
Proportion of thermal power generation	99.72	99.12	98.03

Source: Tai’an Pumped Storage Power Station

3.1.3 Relevance to Japan’s ODA Policy

The “(Former) Official Development Assistance Charter (Former ODA Charter) (1992)” at the time of appraisal of the project emphasized the East Asia region as well as environmental issues and population problems. The “Economic Cooperation Program for China (2001)”

formulated under the Former ODA Charter raised “cooperation to deal with global issues such as environment” as its first priority, and referred to energy consumption as one of the major causes of environmental issues. JICA’s “Medium-Term Strategy for Overseas Economic Cooperation Operations (1999)” placed emphasis on the “environment,” “food and poverty” and “focus on inland areas to correct regional disparities.” And the energy sector assistance policy described in JICA’s “Country Assistance Strategy for the People’s Republic of China” more specifically prioritized support such as the (1) promotion of hydropower development, (2) enhanced transmission and distribution network development and (3) use of low-sulfur coal, and introduction of desulfurization equipment and coal washing technology in thermal power generation while taking into account the overall situation of power supply and demand, environmental considerations, coal transport capacity, private sector investment, etc. The project, implemented with the purpose of constructing a pumped storage power plant in order to realize an environmentally-friendly efficient power supply, was deemed highly consistent with Japan's ODA policy at the time of the appraisal.

This project has been highly relevant to the Chinese development plan, development needs, as well as Japan’s ODA policy. Therefore its relevance is high.

3.2 Effectiveness[4] (Rating: ②)

3.2.1 Quantitative Effects (Operation and Effect Indicators)

In JICA’s appraisal documents, effect indicators, namely, the reduction of coal and oil consumption as well as NOx, SO_2 and CO_2, were established for the goal of “suppression of fuel consumption (air pollution prevention) along with improvement of thermal power plant operations by decreasing DSS operations” as an effect of this project. However, operation indicators for the Tai’an Pumped Storage Power Station were not defined in these appraisal documents. Therefore, it was decided in consultation with Taishan Pumped Storage Power Co., Ltd. to carry out this ex-post evaluation using the operation indicators shown in Table 3. The target values shown in Table 3 were not established at the time of appraisal, but they were established by the company at the time the power station commenced its operations. Regarding these operation indicators, the good operational conditions of the station was confirmed with maximum output and unplanned power outages in line with the target values, and the overall circulation efficiency and pump efficiency target values were achieved.

[4] Sub-rating for Effectiveness is to be put with consideration of Impact.

Table 3: Operation Indicators

	Target	Actual		
		2008 (1 year after completion)	2010 (3 years after completion)	2012 (5 years after completion)
Maximum output (MW)	1,000	1,000	1,000	1,000
Overall circulation efficiency (%)	75	81	81	79
Pump efficiency (%)	93.62	93.69	93.69	93.69
Unplanned power outages (hours/year)	0	0	0	0

Source: Tai'an Pumped Storage Power Station
Overall circulation efficiency = (sending-end output) / (power for pumping) x 100 (%)
Pump efficiency = (pump output) / (shaft power) x 100 (%)

Table 4 shows the effect indicators for the project agreed upon at the time of appraisal, which are air pollutant emission reduction effects associated with the improvement of thermal power plants' operations caused by the construction of the Tai'an Pumped Storage Power Station[5]. Since the target year by which the target values were to be achieved was not set at the time of appraisal, the ex-post evaluation was conducted by focusing on the changes in target values in five years after project completion. Looking at the changes from 2008 to 2012, the reduction in NOx emission has been fluctuating but its target was almost achieved. However, the reductions in SO_2 and CO_2 did not reach the target values. It should be noted that although a trend of reduced sending-end output (net power) can be seen in Table 4 from 2010 onwards, the staffs interviewed at the Tai'an Pumped Storage Power Station viewed this trend as a part of fluctuation within the range of ordinary variation but not as a true trend of decrease.

Table 4: Air pollutant emission reduction effects (Effect Indicators)

	Target	Actual (Years after completion in parentheses)				
		2008 (1 year)	2009 (2 years)	2010 (3 years)	2011 (4 years)	2012 (5 years)
Sending-end output (GWh/year)	—	251	145	309	264	163
Reduction in NOx emission (ton/year)	1,800	1,732 (96%)	1,001 (56%)	2,132 (118%)	1,822 (101%)	1,125 (63%)
Reduction in SO_2 emission (ton/year)	2,900	2,016 (70%)	1,164 (40%)	2,481 (86%)	2,120 (73%)	1,309 (45%)
Reduction in CO_2 emission (ton/year)	348,400	264,127 (76%)	152,584 (44%)	325,161 (93%)	277,807 (80%)	171,525 (49%)

Source: Tai'an Pumped Storage Power Station
Figures in parentheses indicate the ratio of values to the targets.

[5] The amount of air pollutants discharged from thermal power plants are calculated according to the coefficients specified by the Shandong Province Energy Saving Office. Coefficients are 6.90g/kWh for NOx, 8.03g/kWh for SO2 and 1.0523kg/kWh for CO_2. It must be noted that the suppression effect of air pollutants is better to be evaluated by the frequency of DSS operations of thermal power plants and the amount of coal and oil consumption in the province. However, as stated above in "2.3 Constraints during the Evaluation Study," the sufficient information was not available. Therefore, discussing with the staff of Tai'an Pumped Storage Power Station, it was decided to apply these coefficients as alternative way while it is not necessarily the best way to evaluate the suppression effect of air pollutants by the project.

3.2.2 Qualitative Effects

The qualitative effect anticipated at the time of appraisal of the project was "improved stability and economic efficiency of power system as a result of decreased DSS operations." Almost all of the 14 people such as relocated and neighboring residents who were interviewed face-to-face in the field survey as a part of this ex-post evaluation felt that voltage had been stabilized and power outage hours had been reduced. They were thus satisfied with the power supply. However, as the power supplied from the Tai'an Pumped Storage Power Station is connected to the regional power network and the supply areas cannot be identified, these effects cannot be deemed entirely attributable to this project alone. Information about improvement in the economic efficiency of power system was not available.

3.3 Impact

3.3.1 Intended Impacts

(1) Impact on economic development

In recent years, both Shandong Province and Tai'an City have maintained GDP growth rate of 10% to 20% (Table 5, Fig. 2) and steady GDP per capita growth (Table 6, Fig. 3). However, as the power supplied through this project is connected to the regional power network together with power supplied by other power generation facilities, it is difficult to identify the level of contribution of the project to this economic growth.

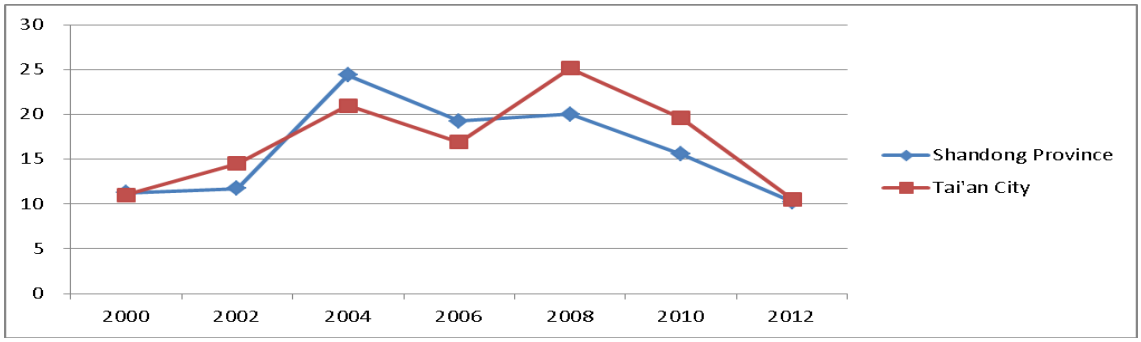
Table 5: Nominal GDP growth rate

Unit: %

Year	2000	2002	2004	2006	2008	2010	2012
Shandong Province	11	12	24	19	20	16	10
Tai'an City	11	14	21	17	25	20	11

Source: Shandong Province Statistical Yearbook 2013, Tai'an City Statistical Yearbook 2013

Unit: %



Source: Shandong Province Statistical Yearbook 2013, Tai'an City Statistical Yearbook 2013

Figure 2: Nominal GDP growth rate

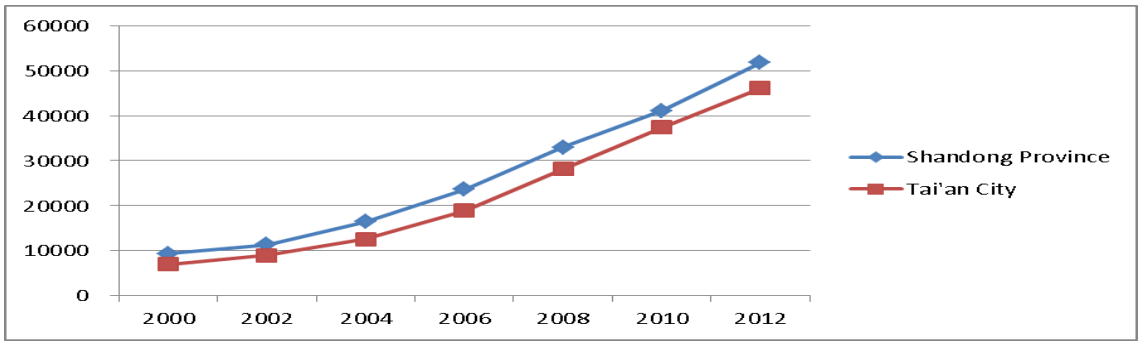
Table 6: Nominal GDP per capita

Unit: Yuan

Year	2000	2002	2004	2006	2008	2010	2012
Shandong Province	9,326	11,340	16,413	23,603	32,936	41,106	51,768
Tai'an City	7,031	9,002	12,608	18,863	28,179	37,376	46,130

Source: Shandong Province Statistical Yearbook 2013, Tai'an City Statistical Yearbook 2013

Unit: Yuan



Source: Shandong Province Statistical Yearbook 2013, Tai'an City Statistical Yearbook 2013

Figure 3: Nominal GDP per capita

(2) Employment opportunities for local residents

The project employed approx. 500 local people per year during the execution period, and continues to employ about 270 people per year after completion of the project (Table 7). The project thus had and continues to have a positive effect on the local economy by providing employment opportunities.

Table 7: Employment opportunities for local residents

Unit: person

Year	During the Construction				After the Project Completion		
	2000	2002	2004	2006	2008	2010	2012
Civil Work	150	450	780	260	—	—	—
Operation & Maintenance	35	70	120	160	270	274	280

Source: Tai'an Pumped Storage Power Station

3.3.2 Other Impacts

(1) Impacts on the Natural Environment

At the time of the appraisal, the project was classified as a Category A project under the "JBIC Environmental Guidelines for ODA Loans (1999)," and the impact on the natural environment was monitored accordingly. Water quality (10 items including water temperature, pH, suspended solids, DO, BOD), air quality (SO_2, NO_2, TSP) and noise level (Ld, Ln)[6] were

[6] DO: Dissolved Oxygen, BOD: Biochemical Oxygen Demand, SO2: Sulfur Dioxide, NO2: Nitrogen Dioxide, TSP: Total Suspended Particular, Ld: Day Sound Level, Ln: Night Sound Level

monitored by Shandong Agricultural University every three months during the construction period. While it was planned to promptly find causes and take necessary actions when reference values were exceeded, no major negative effects were reported during the construction period.

Upper Reservoir

Since the commencement of operation of the power station, Tai'an Shandong Water Environment Monitoring Center has monitored 28 items of water quality such as water temperature, smell, turbidity, color, pH, and free CO_2 once a year. All measurement results had been within the reference values up to the present time of this ex-post evaluation. The project has also incorporated vegetation conservation, tree planting, installation of sewage treatment facilities, waste management and workers' education as measures of environmental protection, and no major complaints have been received from local residents both during and after the construction of the project.

Although the upper reservoir constructed as a part of the project is located in the Taishan National Scenic Area grade 2 protected area, it does not encroach on the UNESCO World Heritage Site (Taishan National Scenic Area grade 1 protected area) nor affect that site whatsoever.

(2) Land Acquisition and Resettlement

The actual cost for the land acquisition and resettlement of residents were below the planned cost (Table 11). This was the result of the water level of the lower reservoir finally being 165.0m above sea level lower than the planned level of 165.5m, eliminating the need to acquire land and relocate residents between 165.0m and 165.5m above sea level.

Table 8: Land Acquisition and Resettlement

	Plan	**Actual**
Resettlement	Approx. 50 people from 20 households	37 people from 14 households
Land Acquisition	Approx. 140 ha	117 ha

Source: Tai'an Pumped Storage Power Station

The project provided compensation, alternate land and housing to relocated residents. The ex-post evaluation field survey team visited seven relocated households and conducted in-depth interviews with them. All the residents reported significant improvements in their living environment and high levels of satisfaction. As community infrastructures and living environment of these families improved along with their resettlement, the breadwinners can

leave their families free from anxiety and work away from home, and their salary has increased by three- to five-fold as a result. One of the relocated households interviewed opened its own grocery shop with the compensation, and its household income is now about 10 times more than before. It should be noted that the rural household registration of the 29 out of 37 relocated residents aged 60 years and younger were changed to urban household registration[7] along with their resettlement to urban areas. As a result of this, these residents are now secured with the accessibility to employment, schooling, medical care and a variety of social services in urban areas. Guaranteeing relocated residents these social rights, it was extremely significant from the perspective of compensation of resettlement and elimination of social disparity.

(3) Local Development

The urbanization of rural area was also a significant impact caused by the road construction in the project. For instance, a large-scale complex development of approx. 30 apartment buildings, hospitals, schools, kindergartens and mosques were expected to be completed in 2014[8] in Chang Jia Cun, a community of Hui Muslims located near the lower reservoir. Furthermore, according to the interviews of the chairman of residents' committee and residents of the Chang Jia Cun area, the construction of the road network connecting city centers with the upper reservoir located in the Taishan National Scenic Area has activated the local economy and increased employment opportunities for local residents with restaurants, grocery shops and souvenir shops opened along the roadside as the number of tourists and passersby increases.

Development of Chang Jia Cun area

As stated above in "2.3 Constraints during the Evaluation Study," a pumped storage power plant project should be evaluated by the degree of achievement of operation and effect indicators while looking at the regional power supply status such as the balance between power supply and demand. However, since it was not possible to obtain sufficient data and information about overall power supply status including generation policies of pumped power plants, there was no choice but to conduct analysis based on the partial data that was available.

In terms of effectiveness, while the target values for the operation indicators and NOx reduction were achieved, the target of effect indicators such as SO2 and CO2 reduction amount

[7] In China, farmers are registered as rural households and non-farmers as urban households in accordance with the "Family Register Registration Ordinance" promulgated in 1958. Economic disparity and inequality in terms of access to public services between urban and rural residents have been pointed out as negative effects of this system.

[8] Investors included Tai'an City, Taishan Pumped Storage Power Station Co., Ltd., companies and local residents.

were not achieved. Regarding impact, a contribution to the local economy in the form of regional development and employment could be seen while a negative impact on the natural environment has not been observed.

Taking account of a comprehensive set of factors stated above, it can be deemed that this project has somewhat achieved its objectives. Therefore its effectiveness and impact are fair.

3.4 Efficiency (Rating: ③)

3.4.1 Project Outputs

The output of the project, namely, the construction of the upper reservoir, improvement of the lower reservoir, construction of water tunnels and a power station with four generators and transmission-transformation facilities, was executed as planned (Table 9).

Table 9: Output (planned and actual)

Output	Planned	Actual
Upper reservoir	Approx. 10 million m^3	11.08 million m^3
Lower reservoir (improvement)	Approx. 22 million m^3	22.35 million m^3
Water tunnels	Upper reservoir – Power station, Power station – Lower reservoir	As planned
Power Station	Underground power station Generators 250MW×4	As planned
Transmission/transformation facilities	Switch yard, 220kV transmission lines, transformation station (substation)	As planned
Consulting Services	· Assistance in bidding activities, review of detail designs, assistance in construction supervision, environmental measures · Man month: 63 M/M	· As planned · Man month: 68 MM

Source: Tai'an Pumped Storage Power Station

The man-months of consulting services exceeded the initial plan because the time required for report writing following the completion of consulting services took longer. The consultants effectively managed the assistance in tendering activities, detailed design review, construction supervision support and environmental consideration leaving the related Chinese organizations highly satisfied.

3.4.2 Project Inputs

3.4.2.1 Project Cost

The originally estimated total project cost at the appraisal was 59,756 million yen, and the actual project cost at completion was 51,095 million yen, which is equivalent to 86% of the planned cost (Table 10). This was a result of international competitive bidding for the import of electrical and mechanical equipment which reduced procurement costs, and the reduction of consulting services paid for in local currency as much as possible. The use of foreign currency (Japanese ODA Loan disbursement) was only about 50% of the plan. This was mainly because

that, along with the cost suppression effect through international competitive bidding, the import value-added tax (about 17%) which was subject to the tax exemption for ODA loans was included in the cost estimation at the time of the appraisal.

Table 10: Project Cost (planned and actual)

Unit: million yen

	Planned (Note 1)			Actual (Note 2)		
	Foreign Currency	Local Currency	Total	Foreign Currency	Local Currency	Total
Civil work	743	20,384	21,127	233	22,684	22,917
Machine and equipment	15,593	13,273	28,866	8,754	17,385	26,139
Consulting services	220	2,587	2,807	195	695	890
Land acquisition and resettlement	0	1,248	1,248	0	1,149	1,149
Price escalation	598	2,301	2,899	0	0	0
Contingency	846	1,963	2,809	0	0	0
Total	18,000	41,756	59,756	9,182	41,913	51,095

Source: Tai'an Pumped Storage Power Station
Note 1: Exchange rate: 1 yuan = 13 yen (Source: JICA appraisal documents)
Note 2: Exchange rate: 1 yuan = 13.39 yen (average between 1999-2011)
(Source: International Financial Statistics; Yearbook)

3.4.2.2 Project Period

The planned project period was 82 months from March 2001 (signing of the Loan Agreement) to December 2007 (completion of the official trial run of No.4 generator). The project was completed ahead of time with a total period of 76 months, or equivalent to 93% of the plan, from March 2001 (signing of the Loan Agreement) to June 2007 (completion of the official trial run of No.4 generator) (Table 11).

Table 11: Project Period (planned and actual)

	Planned	Actual
Land acquisition and resettlement (upper reservoir)	Jan. 2000 – Dec. 2000	Apr. 2000 – Nov. 2000
Signing of L/A	Mar. 2001	Mar. 2001
Civil work of upper reservoir	Nov. 2000 – Oct. 2005	Jan. 2002 – Aug. 2005
Installation of generating facilities	Oct. 2000 – May 2003	Jan. 2002 – Feb. 2007
Construction of underground facilities	Feb. 2001 – Dec. 2007	Jan. 2002 – Feb. 2007
Land acquisition and resettlement (lower reservoir)	Oct. 2000 – Feb. 2001	Apr. 2000 – Nov. 2000
Civil work of lower reservoir	Apr. 2001 – Jul. 2004	Jan. 2002 – Jul. 2004
Installation of transmission/ transformation facilities	Jan. 2002 – Mar. 2005	Jan. 2002 – Dec. 2005
Trail run of No.1 generator	Dec. 2007	Jul. 2006
Trail run of No.2 generator	Dec. 2007	Oct. 2006
Trail run of No.3 generator	Dec. 2007	Jun. 2007
Trail run of No.4 generator	Dec. 2007	Jun. 2007

Source: Tai'an Pumped Storage Power Station

Delay in water tunnels construction works was apprehended due to a large volume of seepage water caused by the high groundwater level at the bottom portion of the upper reservoir. But it was prevented from realization by taking countermeasures in advance such as a meticulous repetitive implementation of flooding and draining tests on the water drawing system. According to the interview with the Tai'an Pumped Storage Power Station, Shandong Electric Science Research Institute, a research institute of the State Grid Corporation of China, was involved in the testing and trial running of generator No.3 and 4 for research purposes, reducing the time for testing and trial running and thereby shortened the entire construction period.

3.4.3 Results of Calculations of Internal Rates of Return (Reference only)

3.4.3.1 Financial Internal Rate of Return (FIRR)

At the time of the appraisal of the project, the FIRR in the 30 years of the project life was calculated to be 6.8% accounting construction cost, power purchase cost for water pumping, operation and maintenance cost and tax as costs while income from electricity sales as revenue. At the time of this ex-post evaluation, the power station is under a fixed amount long-term contract with a power supply destination or Shandong Electric Power Group Corp. regardless of the amount of power generation (refer to 3.5.3). Thus, there are no power purchase cost for water pumping and no income from electricity sales. Recalculation of FIRR therefore is not very much applicable. Only as a reference, with the data available from the Tai'an Pumped Storage Power Station, the construction cost, operation and maintenance cost and tax as expenses and the fixed contract amount as revenue in the 30 years of the project life, the FIRR at the time of this ex-post evaluation is recalculated to be 6.84%.

3.4.3.2 Economic Internal Rate of Return (EIRR)

Given that EIRR was not calculated at the time of the appraisal, and the necessary information and data such as the economic benefits, construction and maintenance cost for alternative thermal power plants and the willingness to pay (WTP) for air pollution reduction were not available, the ex-post evaluation did not undertake a recalculation of EIRR.

Both project cost and project period were within the plan. Therefore efficiency of the project is high.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

The organization undertaken the construction of this project, “Shandong Taishan Pumped Storage Power Station Co., Ltd.,” continues to manage operation and maintenance of the power station. The company is under the umbrella of the State Grid Xinyuan Company LTD., the

power transmission and distribution network company of the State Grid Corporation of China[9] (the executing agency for this project), and is financed by State Grid Xinyuan Company LTD. (50%), Shandong Electric Power Group Corp (44%) and Tai'an Taishan Investment Co., Ltd. (6%).

Shandong Taishan Pumped Storage Power Station Co., Ltd. is comprised of 2 directors, 3 deputy directors, 15 engineers, 40 technicians and 24 clerical staff as of the end of November 2013. According to the interviews conducted at the company, this number of staff is currently sufficient for their operations. The average ages of the directors is 52, deputy directors is 49, engineers is 37, technicians is 32 and clerical staffs is 36, which are relatively young. Directors and deputy directors are supposed to be transferred every five years, and there have been no personnel changes among engineers, technicians and clerical staff since the commencement of operations in 2006. From these, no major institutional problem are expected regarding operation and maintenance of the power station.

3.5.2 Technical Aspects of Operation and Maintenance

The power station has obtained ISO9001 (Quality Management Systems) and ISO14001 (Environmental Management Systems) and takes thorough care in quality management and environment management.

All of the power station personnel including clerical staffs are bachelor or master degree holders in the field of technology or business administration. And all engineers under the directors have obtained government qualifications such as Senior Engineer or Engineer and have high technical competencies[10]. The supervising organizations, State Grid Xinyuan Company LTD. and Shandong Electric Power Group Corp, provide regular training to the power station staff concerning operations, reliability improvement, control systems, machine inspection, irrigation facilities monitoring, etc. once a year. These agencies provide training to all staff members of power plants and stations under their umbrella, and therefore have substantial teaching materials, training content and experienced lecturers.

Operation and maintenance manuals and system brochures are prepared for operation, inspection, maintenance and repair of facilities and equipment prescribing rules, regulations and specific work procedures. Daily operations are performed in accordance with these manuals and brochures, and supervisors check the compliance with manuals in workplaces on a daily basis.

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[9] The State Grid Corporation of China was founded in December 2002 as a result of the company split of State Electric Power Corporation, the executing agency at the time of the project appraisal. The corporation was divided into five power generation groups and two transmission and distribution networks following the electric power reform policy of "Plant-Grid Separation." The State Grid Corporation of China currently controls the transmission and distribution networks of 26 provinces, self-governing districts and government-ruled municipalities, and has jurisdiction in 88% of China area-wise excluding southern China, which is controlled by China Southern Power Grid Company.

[10] Job classes of administrative officers certified by provincial governments. A qualified Engineer is a job class of an engineer and the highest-class engineer is the Senior Engineer.

3.5.3 Financial Aspects of Operation and Maintenance

Tai'an Pumped Storage Power Station generates power under the direction of Shandong Electric Power Group Corp[11], the power system operator of Shandong power grid, and the total amount of power generated by the station is taken over by Shandong Electric Power Group Corp. The station is under a fixed-amount long-term (indefinite-term) contract, regardless of the amount of power generation, with Shandong Electric Power Group Corp. The fixed annual contract sum of 415 million yuan the plant receives under this agreement secures its managerial stability (Table 12). This fixed annual fee was set by the National Development and Reform Commission taking into account a 5% annual return on investment and other terms and conditions, and has not changed since 2009. According to the interviewees of the Finance Department of the State Grid Corporation of China and the Tai'an Pumped Storage Power Station, the contract fee can be subject to change in the future as a consequence of changes in economic conditions, but it has never been up for discussion so far.

Table 12: Revenue and expenditure

Unit: million yuan

Year	2007	2008	2009	2010	2011	2012
Revenue	345	402	415	415	415	415
Expenditure	295	346	357	403	395	283
Profit	50	56	58	12	20	132

Source: Tai'an Pumped Storage Power Station

3.5.4 Current Status of Operation and Maintenance

In the power station, generator local discharge, switch temperature, disconnector temperature, unit vibration and others are monitored online 24 hours a day by automatic devices, while generator stator insulation diagnosis is conducted regularly according to a manual. Regarding transmission-transformation facilities, leakage of electricity, insulation and breakdown voltage of circuit arresters, water vapor measurement of GIS (gas insulated switchgear), circuit protection inspection and others are conducted regularly according to a manual. These data have been recorded and stored and a proper operation and maintenance situation was confirmed in the field survey of this ex-post evaluation. Maintenance equipment is also well maintained according to the regulations concerning the inspection, repair and storage.

It was visually confirmed in the field survey that the inside and outside of buildings of the power station and transmission-transformation facilities were kept clean and well-organized. It was observed in the filed survey that a minor repair work in a building was conducted after setting up a tent over the site to prevent dust from affecting nearby equipment. Such close attention was paid to the maintenance of facilities and equipment of the station. In addition,

[11] This is a subsidiary wholly owned by the State Grid Corporation of China and in charge of the operation and maintenance of the power system in the whole area of Shandong Province.

small group quality control activities (QC circles) were encouraged and the achievements of employees who have made suggestions for improvements around the facilities were displayed with their photographs.

No major problems have been observed in the institutional, technical and financial aspects of the operation and maintenance system. Therefore sustainability of the project effect is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project was implemented with the purpose of constructing a pumped storage power station at a location in Shandong Province, where air pollution was worsening as a consequence of thermal power generation, in order to realize an environmentally-friendly, efficient power supply, thereby contributing to the economic development of the province. The project was consistent with China's development policy, needs and Japan's ODA policy, and therefore the relevance was high. Primary operation indicators such as maximum output of the power station have been achieved, and positive impacts have been observed in terms of the employment of local residents and regional development. However, as the project has only partially achieved air pollutant emission reduction targets (effect indicators), the effectiveness and impact of the project was fair. The project was implemented efficiently within the planned cost and project period. Therefore, the efficiency of the project is considered high. There have been no problems in terms of institutional, technical and financial aspects of the operation and maintenance of the project, accordingly sustainability of the project is judged to be high.

In light of above, the project is evaluated to be highly satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

None

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

None

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
1. Project Output	1) Upper reservoir (newly-established) 10 million m^3 2) Lower reservoir (repaired) 22 million m^3 3) Water tunnels Upper reservoir – Power station Power station – Lower reservoir 4) Power station Underground power station Generators 250MW×4 5) Transmission/transformation facilities switch yard 220kV transmission lines transformation station (substation) 6) Consulting Services 63 M/M	1) Upper reservoir (newly-established) 11.08 million m^3 2) Lower reservoir (repaired) 22.35 million m^3 3) As planned. 4) As planned. 5) As planned. 6) Consulting Services 68 M/M
2. Project Period	March 2001 – December 2007 (82 months)	March 2001 – June 2007 (76 months)
3. Project Cost Amount paid in Foreign currency	18,000 million yen	9,182 million yen
Amount paid in Local currency	41,756 million yen	41,913 million yen (2,525 million yuan)
Total	59,756 million yen	51,095 million yen
Japanese ODA loan portion	18,000 million yen	9,182 million yen
Exchange rate	1 yuan = 13 yen (as of March 2001)	1 yuan = 13.93 yen (average between 1999-2011)