People's Republic of China

Ex-Post Evaluation of Japanese ODA Loan Project

"Shanxi Wangqu Thermal Power Plant Construction Project (1) (2)"

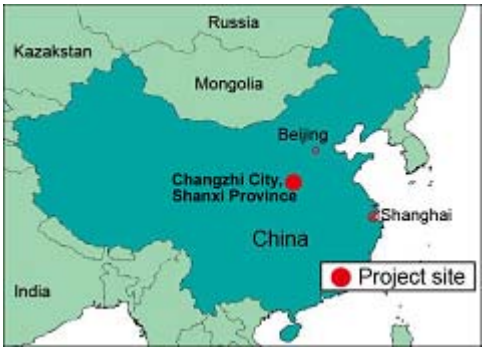
External Evaluator: Yasunori Nakamura, Global Link Management Inc.

0. Summary

The objective of this project is to contribute to accelerating the economic development in both Shandong and Shanxi provinces through meeting the increasing electricity demand in Shandong province and strengthening coal industries and power industries in Shanxi province by constructing total 1,200 coal-fired thermal power plants (600MW x 2 units) in Changzhi city, Shanxi province and transmitting the generated electricity to Shandong province. The project has been highly relevant with the country's as well as Shanxi and Shandong provinces' development plans, development needs, as well as Japan's ODA policy; therefore its relevance is high. The project has largely achieved its objectives of meeting the increasing electricity demand in Shandong province, strengthening coal and electricity industries in Shanxi province and thereby fostering economic development of two provinces, therefore its effectiveness is high. Although the project cost was within the plan, the project period was exceeded on a large scale; therefore efficiency of the project is fair. Some problems have been observed in terms of financial aspects of operation and maintenance, therefore sustainability of the project effect is fair.

In light of the above, this project is evaluated to be (B) satisfactory.

1. Project Description



Project Site

Wangqu Thermal Power Plant

1.1 Background

Between the mid-1980's and the mid-1990's, China recorded an average annual GDP growth rate of slightly less than 10 %. It recorded higher GDP growth rate of slightly less than 12 % in 1990's. As a driving force to sustain such high GDP growth, China developed more than 100,000 MW of the installed power generation capacity between 1985 and 1994. By the end of

1994, the total installed power generation capacity in China reached 197,000 MW. In the same period, the electricity supply in China increased by 2.3 times and reached 928.1 billion kWh in 1994. However, for the past 30 years, the electricity supply had never reached the electricity demand. There still existed more than 20 % of supply-demand gap in 1994. It was expected that the annual growth rate of the electricity demand would be 8% from 1995 to 2000. Accordingly, Chinese Government planned to increase the installed power generation capacity to 300,000 MW by 2000. The investment for the development of the installed power generation capacity was therefore required from China as well as from abroad.

Shanxi province, which had the largest coal reserves in China, fulfilled its electricity demand. It also transmitted its generated electricity to Beijing and Tianjin as mine mouth power producing area. Shanxi province gave high priority to construction of the power plant which transmits its generated electricity to other provinces in order to make electricity exports one of main industries of the province alongside coal exports. Meanwhile, the installed capacity of Shandong province was not able to provide enough electricity to fulfil its increasing electricity demand. It, therefore, required electricity import from mine mouth power plants.

1.2 Project Outline

The objective of this project is to meet the growing electricity demand in Shandong province and strengthen coal industries and power industries in Shanxi province by constructing total 1,200 MW coal-fired thermal power plants (600MW x 2 units) in Changzhi City, Shanxi province and transmitting the generated electricity to Shandong province, thereby contributing to the economic development in both Shandong and Shanxi provinces.

	(1) CXIX-P96	(2) CXX-P96
Loan Approved Amount/ Disbursed Amount	30,000 million yen / 26,512 million yen	27,000 million yen / 13,833 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	September, 1997 / September, 1997	December, 1998 / December, 1998
Terms and Conditions	Interest Rate: 2.3 % Repayment Period: 30 years (Grace Period: 10 years) Conditions for Procurement: Untied	Interest Rate: 1.8 % Repayment Period: 30 years (Grace Period: 10 years) Conditions for Procurement: Untied
Borrower / Executing Agency(ies)	Government of People's Republic of China/ Shanxi Lujin Wangqu Power Generation Co. Ltd.	
Final Disbursement Date	July, 2009	March, 2010
Main Contractor (Over 1 billion yen)	Doosan Babcock Energy Limited (UK), Hitachi / Itochu / Dongfang Electric Corporation of China (China), Honeywell International Inc. (US)	
Main Consultant (Over 100 million yen)	Tokyo Electric Power Services Co., Ltd.	
Feasibility Studies, etc.	"Feasibility Study for Shanxi Wangqu Power Plant Phase I" Shanxi Province Electric Power Survey and Design Institute, July, 1996	
Related Projects (if any)		

2. Outline of the Evaluation Study

2.1 External Evaluator

Yasunori Nakamura, Global Link Management

2.2 Duration of Evaluation Study

Duration of the Study: July, 2011 – September, 2012

Duration of the Field Study: October 16, 2011 – October 29, 2011, February 25, 2012 – March 6, 2012

3. Results of the Evaluation (Overall Rating: B[1])

3.1 Relevance (Rating: ③[2])

3.1.1 Relevance with the Development Plan of China

The 9th Five-Year Plan (1996-2000) prioritized the development of electricity sector because the electricity demand was expected to increase. The construction of high efficiency large scale thermal power plants was set out at the centre of its development. In its 9th Five-Year Plan, the Ministry of Electric Power set forth the following policies as priorities; i) Construction of mine mouth power plants in North and Central China, which are coal producing areas, and construction of large scale transmission line to transmit the generated electricity at mine mouth power plants to East and South China, which are large electricity consuming areas, ii) Moderate development of coal-fired power plants in power generation, and iii) Acceleration of high efficiency power plants with the installed power generation capacity of more than 300 MW in order for an increase of power generation efficiency. Meanwhile, in its 9th Five-Year Plan, Shanxi province set forth a shift in its energy development policy, i.e. from 'Coal Transport by Train' to 'Electricity Transport to coastal area in East China'.

The 12th Five-Year Plan (2011-2012) sets forth the development of diversified and clean energy sources, which includes the development of clean and efficient large scale power plants. It also sets forth the acceleration of building power grid system including west-to-east power transmission (Transmitting the electricity generated at inland area of North and Central China which are rich in natural resources to coastal area in South-West China which consume large electricity). Shanxi province, in its 11th Five-Year Plan (2006-2010), plans to continue the development of coal-based electricity-centred energy industries, which fulfil the electricity demand in the province and expand the electricity supply to other provinces. Meanwhile, Shandong province, in its 12th Five-Year Plan

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

[2] ①: High, ② Fair, ③ Low

(2011-2015), plans to accelerate the electricity import from other provinces.

This project is therefore in consistent with national development plan, provincial development plans at the time of appraisal as well as at the time of the ex-post evaluation. However, in the last 2 years of the 9th Five-Year Plan, the State Development Planning Commission announced the policy to stop the approval to start the construction of new thermal power plants for 3 years from January, 1999. In this period, the electricity was oversupplied due to the structural reform in Chinese industrial sector starting in the late period of the 8th Five-Year Plan (1991-1995), Asian Currency Crisis starting in 1997 and the flood of Yangtze River in 1998. Therefore, in this certain period of the project period, this project was not consistent with a national development policy of China. However, three-year-suspension of construction of the new power plants caused the electricity supply shortage after 2002.

3.1.2 Relevance with the Development Needs of China

The electricity demand in Shandong province was 79.7 billion kWh (1996) at the time of appraisal. It was expected to increase approximately by 9.2 % per year between 1996 and 2000 and approximately by 7.2 % per year between 2001 and 2010. The required installed power generation capacity was expected to be approximately 21,630 MW in 2000 and approximately 45,090 MW in 2010. Whereas, the electricity development plan of Shandong province set out 20,930 MW in 2000 and 43,520 MW in 2010 as target installed power generation capacity. It is, therefore, expected that the electricity supply shortage would still exist in the future. Meanwhile, at the time of appraisal, out of the installed power generation capacity of 9,560 MW (1996) of Shanxi province, 1,760 MW was the electricity exported to other provinces. It planned to increase the installed power generation capacity for the electricity export to other provinces to 11,000 MW by 2010. Shanxi province had a limited coal transporting capacity. That is, in 1995, it transported 210 million tons of coal while the total transporting capacity of train in the province was 260 million tons. The demand for coal exports was expected to be 300 million tons in 2000. Therefore, it was required to export coal through electricity generation alongside increasing a transporting capacity of train.

The electricity demand in Shandong province grew approximately by 11.5 % per year between 2005 and 2010. Whereas, the electricity supply increased approximately by 8.7 % per year. Therefore, although from 2005 to 2007, the electricity supply was slightly higher than the electricity demand, the electricity supply has not met the electricity demand since 2008. Especially during the peak demand period in summer and winter, the electricity is required to be imported from the other provinces. Shanxi province, meanwhile, exports approximately 30 % of the generated electricity to other provinces between 2005 and 2009

in accordance with the provincial 11th Five-Year Plan. In addition, there is still a problem in the coal transporting capacity in Shanxi province. In 2010, 340 million tons of coal were transported while 610 million tons of coal were produced.

Table 1 Electricity Supply and Demand in Shandong Province (2005-2010)

Unit: 100,000,000kWh

Year	2005	2006	2007	2008	2009	2010
Electricity Supply	2,002	2,314	2,691	2,697	2,871	3,043
Electricity Demand	1,912	2,272	2,596	2,727	2,941	3,298

Source: Executing Agency's Reply to Questionnaire

Table 2 Electricity Supply in Shanxi Province and Electricity Supply to Other Provinces (2005-2010)

Unit: 100,000,000kWh

Year	2005	2006	2007	2008	2009	2010
Electricity Supply	1,312	1526	1,761	1,786	1,873	2,121
Electricity Supply to Other Provinces	369	432	463	486	641	-

Source: Executing Agency's Reply to Questionnaire

Note1: It was impossible to obtain the data for electricity supply to other provinces in 2010

This project is therefore in consistent with the development needs of Shandong and Shanxi provinces at the time of appraisal and at the time of the ex-post evaluation.

3.1.3 Relevance with Japan's ODA Policy

Country Assistance Policy to China in Japan's ODA Annual Report (1997) indicated that 'Japan is providing assistance, primarily through ODA loans, to support improvement of economic infrastructure. In addition, in order to promote balanced development, Japan devotes more effort to China's inland regions, which have a relatively large potential for development, and provides assistance for agriculture and development of rural areas, as well as assistance to develop China's plentiful natural resources.' Meanwhile, in its 4th Yen Loan to China, which was disbursed between 1996 and 2000, Overseas Economic Cooperation Fund (OECF) emphasized the projects related to the development of the inland regions in addition to the economic infrastructure. This project, which was to contribute the improvement of economic infrastructure by using rich coal resources in China's inland regions, was in consistent with Japanese ODA policy at the time of appraisal.

This project has been highly relevant with the country's as well as provinces' development plan, development needs, as well as Japan's ODA policy; therefore its relevance is high.

3.2 Effectiveness[3] (Rating: ③)

3.2.1 Quantitative Effects (Operation and Effect Indicators)

Operation and Effect Indicators from the project completion in 2006 to 2010 are shown below.

Table 3 Operation and Effect Indicators

			2006	2007	2008	2009	2010
Maximum Output	MW	Plan	1,200	1,200	1,200	1,200	1,200
	MW	Actual	1,200	1,200	1,200	1,200	1,200
Net Electricity Energy Production	1,000,000,000 kWh	Plan	18.9	66.3	66.3	66.3	66.3
	1,000,000,000 kWh	Actual	24.8	70.1	63.1	62.6	66.5
Plant Load Factor	%	Plan	63.26	63.26	63.26	63.26	63.26
	%	Actual	71.64	66.36	66.38	66.33	66.43
Availability Factor	%	Plan	68.49	68.49	68.49	68.49	68.49
	%	Actual	91.96	92.48	91.24	88.5	92.81
Auxiliary Power Ratio	%	Plan	4.8	4.8	4.8	4.8	4.8
	%	Actual	5.03	4.95	4.98	4.91	5.06
Gross Thermal Efficiency	%	Plan	32	32	32	32	32
	%	Actual	41.9	41.97	41.48	41.32	41.5
Outage Hours for Every Cause (Hours/Year)	Human Error		0	0	0	0	0
	Machine Trouble		65	46	13	0	0
	Planning Outage		456	1727	1526	2014	1259
Outage Hours for Every Cause (Times/Year)	Human Error		0	0	0	0	0
	Machine Trouble		8	5	4	0	0
	Planning Outage		2	2	4	4	4

Source: JICA Appraisal Documents, Executing Agency's Reply to Questionnaire

Note: Each Operation and Effect Indicator is calculated by using the following formula:

Net Electricity Energy Production	=	annual electricity production – annual electricity consumption within a plant
Plant Load Factor	=	annual electricity production/(rated output x number of hours a year) x 100
Availability Factor	=	(hours of operation a year/ number of hours a year) x100
Auxiliary Power Ration	=	(annual electricity consumption within a plat/annual electricity production) x 100
Gross Thermal Efficiency	=	(annual electricity production x 860) / (annual fuel consumption volume x fuel calorific value) x 100

At the time of appraisal, operation and effect indicators were not planned. Therefore, at the time of the ex-post evaluation, planned operation and effect indicators for reference were calculated by referring the data applied in Financial Internal Rate of Return (FIRR)

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

calculation at the time of appraisal, and then compared with the actual data. As a result of such comparison, all indicators mostly met the planned indicators for reference. There were outage hours caused by machine troubles in 2006, 2007 and 2008. The reasons for the machine troubles were as follows; steam leaked out of a boiler during commissioning, bottom ash[4] turned into a solid mass at bottom of a boiler due to a change of coal and an unstable ignition in a boiler made protection system activated. These machine troubles were properly repaired. At the time of the ex-post evaluation, the power plant was operated without machine troubles.

The electricity generated at the power plant is transmitted to the power grid in Shandong province through Lucheng Switching Station, Handan East Xin'an Substation in Hebei province with 500 kV double-circuit line. At the time of appraisal, the transmission lines between Wangqu Power Plant and Laiyang Substation in Shandong province were planned to be constructed with Yen loan project and Chinese local currency. However, Yen loan was cancelled due to Chinese Government's request and the procurement for transmission lines from Wangqu Power Plant to Shandong province was done only with Chinese local currency.

Transmission line from Wangue Power Plant to Shandong Province

3.2.2 Qualitative Effects

(1) Efficient use of coal resources

Wangqu Power Plant contributes to efficient use of coal resources of Shanxi province, which has a limited coal transportation capacity, by consuming approximately 2.5 million tons of coal per year at the power plant which transmits its generated electricity to other provinces. The interview with a coal company in Shanxi province also reveals that Wangqu Power Plant contributes to an increase of coal production in Shanxi province by consuming coal (Refer to Box 1).

(2) Improvement of living standards by stable electricity supply

Wangqu Power Plant has transmitted stable electricity of over 6 billion kWh, which is equivalent to approximately 2-3 % of the electricity demand in Shandong province, to Shandong province since 2007. Growth Domestic Production (GDP) per capita in

[4] Coal ash dropped on the bottom of a boiler after coal combustion.

Shandong province increased annually by 15% on average from 2006, when Wangqu Power Plant was constructed, to 2010. In contrast, Consumer Price Index (CPI) increased annually by 3.6% in the same period, therefore it can be said that living standards in Shandong province improved from economic view point. However, Wangqu Power Plant supplies only approximately 2-3% of the electricity demand in Shandong province. In addition, the electricity supply in Shandong province increased approximately by 35 billion kWh per year between 2005 and 2007. Therefore it is difficult to identify direct impact of this project on growth of GDP per capita in Shandong province. Whereas, the interview with a company in Shandong province reveals that (although it is difficult to identify the direct impact of this project) since 2007 there have been the decrease in frequency of electricity restrictions and the improvement in electricity stability, which enabled full operation of its factory and increased its producing capacity . Considering such fact, it can be considered that Wangqu Power Plant, which has transmitted the stable electricity to Shandong province since 2007, has contributed to revitalization of economic activities in Shandong province through playing a part in stabilization of the electricity in Shandong province.

Box 1 Notes: Interview with Electricity bulk users

CET Shandong Power Equipment Co. Ltd. (Jinan, Shandong province)

Transformers manufacturing company established in 1958 and having 1,300 employees. 'Since 2007, both the electricity supply and electricity stability have been improved. Business profit was increased by 22 times between 2006 and 2009. An increase in the demand of transformers is the biggest factor for such increase. However an increase of producing capacity is also an important factor. That is, since 2007, there have been less electricity restrictions, and it has got possible to run the factory at full capacity and a producing capacity has been also increased. Whereas, it is impossible to see a direct impact of Wangqu Power Plant in it because the electricity is procured from power grid of Shandong province.'

Luan Mining Group (Changzhi, Shanxi province)

3rd largest mining company in Changzhi established in 1987 and having 980 employees. 'Since 2005, coal production has been increased by 10 million tons annually. 0.6 to 0.7 million tons of coal are yearly supplied to Wangqu Power Plant. Business profit has increased by 5 times between 2005 and 2010. In addition to an increase in coal production, an increase in coal price has contributed to an increase in business profit. In Shanxi province, which has limited coal transportation capacity, it is beneficial for coal industries that power plants like Wangqu consumes coal in the province and exports the electricity to other provinces.'

Shanxi Coal Transportation and Sales Group Co. Ltd. (Changzhi, Shanxi province)

Coal trading company in Changzhi established in 2006 and having 60 employees. 'Coal provided to Wangqu Power Plant by trucks are supplied by our company. Coal is procured from regional small coal mining companies in Changzhi. One third of coal treated by our company, which amounts to approximately 1.6-1.8 million tons per year, is sold to Wangqu Power Plant.'

3.3 Impact

3.3.1 Intended Impacts

(1) Economic development in Shandong province by meeting the electricity demand

The below table shows GDP and industrial sector[5]'s share in GDP of Shandong province in the last 5 years.

Table 4 GDP and Industrial Sector's share in GDP of Shandong Province (2006-2010)

Unit: million yuan

Year	2006	2007	2008	2009	2010
GDP (Actual)	2,430,501	2,775,632	3,108,708	3,487,970	3,916,992
Industrial Sector's Share	52.8%	52.0%	52.1%	49.8%	47.9%

Source: National Bureau of Statistics of China

Table 5 Industrial sector's share in electricity consumption in Shaanxi Province (2006-2010)

Year	2006	2007	2008	2009	2010
Industrial Sector's Share	79.9%	79.9%	78.9%	78.3%	77.5%

Source: National Bureau of Statistics of China

Average annual GDP growth rate from 2006 to 2010 was 12.7%. However, with regard to a contribution of this project to such GDP growth, it is difficult to identify how much Wangqu Power Plant has directly contributed to economic development of Shandong province. For, as mentioned in 3.2.2, the electricity supply in Shandong province increased approximately 31.2 billion kWh between 2005 and 2006 while it has also increased annually by 8.73 % on average between 2006 and 2010. Whereas, the industrial sector had approximately 50% share in GDP of Shandong province between 2006 and 2010 and was the biggest component of GDP in Shandong province while as shown in Table 5, the industrial sector had approximately 80% share in the electricity consumption of Shandong province. Considering these facts, it can be considered that this project has partly contributed to the economic development of Shandong province through the stable electricity supply[6].

(2) Economic Development of Shanxi province through the development of coal industries and power industries

The below table shows nominal GDP and energy sector's GDP of Changzhi city, prefecture-level city of Shanxi province, and Lucheng city, country-level city of Changzhi city, where Wangqu Power Plant is located[7].

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[5] Industrial sector includes mining, manufacturing, electric/gas/water industries.

[6] This evaluation presupposes that the electricity supplied to the power grid of Shandong province is distributed equally to each sector.

[7] Nominal GDP was used for Changzhi and Lucheng city because actual GDP data were not able to be obtained. .

Table 6 Nominal GDP and Energy Sector's GDP of Changzhi City and Lucheng City (2005-2010)

Unit: million yuan

	2006	2007	2008	2009	2010
Changzhi City's GDP (Energy Sector)	46,040 (24,520)	55,060 (30,270)	68,210 (40,140)	77,530 (45,280)	92,020 (57,290)
Lucheng City's GDP (Energy Sector)	4,810 (3,030)	5,650 (4,420)	6,210 (4,860)	6,750 (5,100)	7,210 (5,370)

Source: Lucheng City Economic and Information Technology Commission

Annual GDP growth rate in Changzhi city from 2006 to 2010 is 18.9% on average while annual GDP growth of energy sector is 23.6% on average during the same period. Meanwhile, annual GDP growth rate in Luchange city is 10.65 % on average while annual GDP growth rate of industrial sector is 15.38 % on average during the same period. It is, therefore, able to see that energy sector is a driving force for GPD growth in both cities. With regard to the contribution of this project, according to Lucheng city, Wangqu Power Plant consisted of 10-20 % of its tax revenue in the same period. This shows that Wangqu Power Plant has large economic impact in Lucheng city. Therefore, it can be said that Wangqu Powe Plant's contribution to the development of electricity industries and economic development in Lucheng city is large. Meanwhile, Wangqu Power Plant purchased approximately 2.5 million tons of coal, which is equivalent to approximately 2.5% of coal production in Changzhi city in 2011[8], from mining companies and coal trading companies in Changzhi city. Therefore, it can be considered that the Power Plant plays a role in the development of coal industries in Changzhi city.

3.3.2 Other Impacts

(1) Impacts on the natural environment

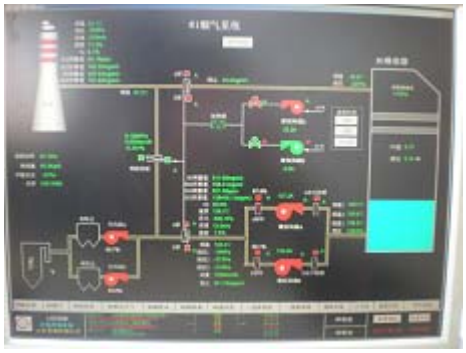
① Fuel Gas

Following measures against fuel gas emission were taken as planned at the time of appraisal; i) low-sulfer coal of 0.35 % sulphur was used for a measure against Sulfer Oxides (SOx), ii) low-Nox burners and two stage combustion were installed for a measure against Nitrogen Oxides (Nox), and iii) high-performance electrostatic precipitators with more than 99 % dust collection for measure against dust emission. In addition, in accordance with the revision of Emission Standard for Air Pollutants for Thermal Power Plants of China (hereafter referred to as 'Emission Standard') in 2003, which requested to be followed by 2004, the project procured 2 units of fuel gas desulfurization (FGD) at its own cost in 2005 and 2006[9]. As a result, all actual fuel gas

[8] Source: Popular Government of Changzhi City

[9] At the time of appraisal, planned SOx concentration was 590.5mg/Nm3. Whereas, SOx concentration set forth in

emission met Emission Standard. Meanwhile, the power plant installed an online monitoring system in 2009. Shanxi province environmental protection agency monitors all fuel gas emission from Wangqu Power Plant through this monitoring system. Emission Standard was also revised in 2012 and existing power plants are requested to take necessary countermeasures to meet new standards by 2014. Because Wangqu Power Plant does not meet the new standard for NOx, it is required to take necessary countermeasure to meet the new standard. With regard to new Emission Standard, mercury emission standard of 0.03 mg/Nm^3 is added and is requested to be met by 2015. However, detailed information on mercury concentration standard has not yet come from the provincial environmental protection agency.



Fuel Gas Monitoring System

Network Equipment for Online monitoring system

Table 7 Emission Standard for Air Pollutants for Thermal Power Plants

Standard / Item	-	New Standard (2012) (GB13223-2011)	At completion of the project (GB13223-2003)	At the time of appraisal (GB13223-91)
	Actual (2011)	Standard	Standard	Standard
SOx	104.74mg/Nm^3	200mg/Nm^3	400mg/Nm^3	-[10]
NOx	254.21mg/Nm^3	100mg/Nm^3	650mg/Nm^3	-
Dust	25mg/Nm^3	30mg/Nm^3	50mg/Nm^3	469mg/Nm^3

Source: Executing Agency's Reply to Questionnaire
Note: New Standard (GB13223-2011) will be applied from 2014 for existing power plants

② Noise

As a measure against noise, sound wall was installed. As a result, actual noise meets the standard.

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the Emission Standard was 400mg/Nm^3.

[10] While SOx concentration was not set forth, the amount of SOx emission was set forth as 20,440 kg/h (without FGD).

Table 8 Emission Standard for noise

Standard / Item	-	Latest (GB12384-2008)	At the time of appraisal/ At the project completion (GB12384-90)
	Actual	Standard	Standard
Noise level	45.9-49.1dB (Night) / 47.9-52dB (Day)	50dB (Night) 60dB (Day)	50dB (Night) /60dB (Day)

Source: Executing Agency's Reply to Questionnaire

③ Others (Effluent, Ash Treatment, Coal Yard[11])

With regard to effluent, it was planned to discharge the wastewater into the river after water treatment within the standard. However, according to the executing agency, the wastewater are treated with wastewater treatment system and fully recycled in the power plant. Site inspection during the ex-post evaluation found that fly ash is disposed in a landfill at the disposal site located about 2 Km north-west of the power plant as planned at the time of appraisal. As a measure against powder dust from fly ash, followings measures were planned and actually implemented; fly ash is transported with trucks with water spray system and belt conveyer with dust cover, fly ash is consolidated periodically with water spray, and trees and grass are planted around the disposal site. Meanwhile, yellow soil lining[12] is also used in order to avoid polluting groundwater. A measure against powder dust at coal yard is also taken as planned at the time of appraisal. That is, sprinkler and fence are installed, trees are planted and special road for the trucks transporting coal is prepared.

(2) Land Acquisition and Resettlement

A discussion on land acquisition was completed at the time of appraisal while there was not resettlement required. The acquired land was approximately 1.59 km^2[13].

(3) Other positive/negative impact

With regard to other positive impact, there is an employment creation at local area. Among major staffs at Wangqu Power Plant, 40 % were hired at local area while 270 staffs are employed for cargo carriers, cleaners and guards.

This project has largely achieved its objectives, therefore its effectiveness is high.

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11 There are no standards for ash treatment and coal yard. The site inspection at the time of the ex-post evaluation found that there was no powder dust from the ash disposal site and coal yard

12 To cover yellow soil, which has high water holding capacity, in order to avoid water from seeping into the underground.

13 The land is for phase I which was financed by this project and for phase II which is now under preparation.

3.4 Efficiency (Rating: ②)

3.4.1 Project Outputs

The below table shows the output (plan/actual) of this project.

Table 9 Output (Plan/Actual)

	Numbers, Specification	
	Plan	Actual
Boiler	2 units, Supercritical pressure coal fired	Same as planned
Turbine Generator	2 unites, Output 600MW,Reheat condensing tandem compound, 50Hz, 3,000pm, Water-Hydrogen Cooling System	Same as planned
Main Transformer	2 x 3 x 240 MVA + 1 x 240 MVA	Same as planned
Instruments & Control	Dispersed Control System (DCS)	Same as planned
Coal Pulverizer	High level of pulverization, Middle Speed	Same as planned
Combustion System	-	Same as planned
Water Treatment System	400m^3/h	Same as planned
Electrostatic Precipitator	2 units, dust collection efficiency more than 99 %	Same as planned
Stack	Double-shaft 220m x 1 units	Same as planned
Coal Handling System	Truck-hopper 2 units, Bottom-hopper, Coal Storage 200,000 tons, Coal Bin 6 units, Unloader 700,000 tons/year	Same as planned
Ash Handling System	Dry type	Same as planned
Cooling Tower	Natural Draft 2 units, Spray area 7,500 m^2, Height 135 m	Same as planned
Switch Yard	500kV and 220kV	Same as planned
Hydrogen producing device	-	Same as planned
Consulting Services	Total107M/M Project Manager 23M/M, Mechanical Engineer (2) 28M/M, Electrical Engineer (2) 28M/M, I&C Engineer (2) 28M/M provide following services; ① Assistance in finalizing bidding documents ② Assistance in bid evaluation ③ Assistance in technical contract negotiation ④ Assistance in designs ⑤ Supervision for progress of project ⑥ Assistance in commissioning	Total121M/M Preparation for Bidding documents for Boiler and Turbine Generator (27.9M/M) Preparation/Contract Conclusion for Transformer, Combustion system (15.1M/M) Management for designs (61M/M) Commissioning (10M/M) Performance test (7.0M/M)
FGD	-	Added. 2 units, SOx removal efficiency of more than 97 %

Source: JICA appraisal documents, Executing Agency's Reply to Questionnaire

Project outputs were mostly realized as planned at the time of appraisal. However, additional 14 M/M were used for consulting services due to the late in the bidding process affected by the late in the construction approval in China. Meanwhile, the project procured 2 units of FGD in order to meet the standard for SOx, whose emission concentration standard was additionally set out when Emission Standard was revised.

3.4.2 Project Inputs

3.4.2.1 Project Cost

The planned project cost was 138,492 million yen (Foreign currency 57,082 million yen/Local currency 81,410 million yen) while the actual project cost was 69,960 million yen (Foreign currency 40,345 yen/Local currency 29,615 yen). The actual project cost was 51% of the planned project cost and lower than planned. The cost for consulting services, for which more M/M was used, was also under the planned cost.

Table 10 Project Cost (Plan/Actual)

	Plan					Actual			
	FC		LC	TOTAL		FC	LC	TOTAL	
	million yen	Loan in 1997	million yuan	million yuan	million yen	million yen	million yuan	million yuan	million yen
Boiler	21,391	13,440	554	2,127	28,925	18,946	-	1,324	18,946
Turbine	24,886	11,577	469	2,299	31,264	19,761	-	1,381	19,761
I&C	2,512	855	110	295	4,008	1,086	-	75	1,086
Sub-station (Swithgear)	1,651	674	263	384	5,228	-	218	218	3,117
Construction Machinery	329	329	-	24	329	-	83	83	1,187
Laboratory Equipment	249	249	45	63	86	-	10	10	143
Transportation Equipment	-	-	74	74	1,006	-	10	10	143
Auxiliary Equipment	-	-	189	189	2,570	-	1	1	14
Welfare Equipment	-	-	44	44	598	-	1	1	14
Railroad outside the plant	-	-	165	165	2,244	-	104	104	1,487
Microwave Equipment	-	-	5	5	68	-	-	-	-
Custom and import tax	-	-	1,216	1,216	16,538	-	0	0.0	5
Others	-	-	703	703	9,561	192	-	14	192
FGD	-	-	-	-	-	-	117	117	1,673
Construction Engineering	-	-	-	-	-	-	1,037	1,037	14,829

	Plan					Actual			
	FC		LC	TOTAL		FC	LC	TOTAL	
	million yen	Loan in 1997	million yuan	million yuan	million yen	million yen	million yuan	million yuan	million yen
Installation Engineering	-	-	-	-	-	-	489	489	6,993
SUB-TOTAL	51,018	27,124	3,837	7,588	103,201	39,985	2,071	4,894	69,600
Consultant	379	379	-	28	379	359	-	25	359
Price Escalation	2,985	1,087	1,864	2,083	28,335	-	-	-	-
Physical Contingency	2,700	1,410	285	484	6,576	-	-	-	-
TOTAL	57,082	30,000	5,986	10,183	138,492	40,345	2,071	4,920	69,960

Source: JICA Appraisal Documents, Executing Agency's Reply to Questionnaire

Note: Exchange rate at the time of appraisal 1 yuan = 13.6 yen, Exchange rate at the time of the ex-post evaluation 1 yuan = 14.3 yen (Average during loan period)

The followings are the main reasons for reduction of the project cost.

① Foreign procurement spent less cost as a result of international competitive bidding which was affected by huge decrease in material prices such as steal price

② The decrease of material prices in China

③ Customs and import tax were not applied because National Development and Reform Commission approved to apply tax exemption for equipment import for this project in 2004.

There was a restriction in the evaluation of the cost efficiency. That is, because the executing agency used cost items which were different from those at the time of appraisal, it was difficult to compare the project cost for each item. According to the executing agency, such difference was caused by change of the executing agencies during the project implementation period.

3.4.2.2 Project Period

The project period was significantly longer than planned. At the time of appraisal, the project period was planned to be 72 months from January, 1997 (Starting month of reviewing conceptual design) to December, 2002 (Commissioning of Unit 2). However, the actual project period was 116 months from January, 1997 to August, 2006, which are 161% of the planned project period.

The followings are the main reasons for such excess.

① As described in the relevance clause, the electricity reform by State Development Planning Commission restricted its approval to start construction of the new power

plant for 3 years from 1999. An approval of construction for this project was also postponed for 53 months from December, 1997 to April, 2002.

② An approval of the feasibility study by the State Council was delayed for 15 months from June, 1997 to August, 1998 due to a delay in the project procedure in China.

Meanwhile, with regard to the period from the approval of construction to commissioning of unit 2, it was planned to be 61 months from December, 1997 to December 2002. However, it was actually 52 months from April, 2002 to August, 2006, which are 85 % of the planned period.

3.4.3 Results of Calculations of Internal Rates of Return (IRR)

At the time of the ex-post evaluation, FIRR was recalculated to 6.06%, which is lower than the planned FIRR of 15.63%. Main reasons for such reduction are as follows; the coal price was much higher than planned, the electricity selling price was lower than planned and the local tax rate was higher than planned. However, according to the executing agency, because it is difficult to estimate the coal price and the electricity selling price in the future, the actual contract price in 2012 is applied for the coal price in the future while the electricity selling price after 2012 is calculated by using the increase rate of the electricity selling price between 2010 and 2011. Therefore, recalculated FIRR are not calculated based on the accurate estimation. Economic Internal Rate of Return (EIRR) was not calculated at the time of appraisal.

Although the project cost was within the plan, the project period was exceeded, therefore efficiency of the project is fair.

3.5 Sustainability (Rating: ②)

3.5.1 Structural Aspects of Operation and Maintenance

The power plant is owned by Shanxi Lujing Wangqu Power Generation Co., Ltd., a company invested by Shandong Luneng Group[14] (75%), Shandong International Trust Company Limited (20%), Emerging Energy Industry Group Ltd., Shanxi (5%) while it outsources operation and maintenance of the power plant to CPI North China Power Investment Power Engineering Co., Ltd(hereafter referred to as 'CPI') , a company invested by China Power Investment Corporation (51%) and Shanxi Zhangze Electric Power Co. Ltd. (49%). CPI allocates 132 staffs for integrated management, machine maintenance, electric maintenance, ash maintenance, fuel maintenance of Wangqu Power Plant.

[14] Shandong Luneng Group is owned by State Grid Corporation of China.

3.5.2 Technical Aspects of Operation and Maintenance

Among CPI staffs deployed for operation and maintenance of the power plant, 50 % are graduates from higher education. Over 65% has the working experience in power plants for more than 20 years.

With regard to the training courses for operation and maintenance, there are training courses for annual check and dehydration warehouse[15] renovation. As of today, 26 staffs and 42 staffs have taken the courses respectively. As the manuals for operation and maintenance, manuals are prepared for production supervision and management, safety rules, equipment maintenance and equipment management.

3.5.3 Financial Aspects of Operation and Maintenance

Business profit has been negative since 2008. Main reasons for such loss are the increase of main business cost due to the increase in coal price and the slow increase of main business income due to the control of the electricity selling price by the Government. Main business cost has increased by 30% since 2008 onward compared with 2007 due to the increase in the coal price. Whereas, main business income has increased by less than 10% during the same period because the electricity selling price has been controlled to stay low by the Chinese government. However, according to the executing agency, a discussion with the National Development and Reform Committee and the State Grid Corporation by Shandong Luneng Group, which is a top share holder of the company, has resulted in the increase of the electricity selling price by 19.8% since April, 2011. The executing agency forecast that the business profit in 2011 will be surplus. The financial sustainability in the future would not have a problem considering that the Chinese Government works on the stabilization of the coal price which causes the increase of the main business cost of the power plants. For example, the National Development Reform Commission notified the request to keep the coal price at the level of the previous year in April, 2011. Meanwhile, because the Power Plant has to take necessary measure in accordance with the new Emission Standard, the modification costs of the facilities will be required. According to the executing agency, such cost is included in its financial plan.

[15] Device to dehydrate bottom ash.

Table 11 Financial Status (2007-2010)

Unit: 1000 yuan

	2007	2008	2009	2010
Main Business Income	1,836,431	1,737,538	1,856,771	1,989,409
Main Operation cost	1,349,430	1,726,832	1,708,570	1,800,194
Business tax & VAT	24,212	15,847	12,186	13,198
Profit from main business	462,789	-5,141	136,015	176,017
Income from other business	0	209	371	2,981
Cost from other business	0	18	588	528
Financing costs	161,560	212,086	146,514	411,774
Business profit	301,229	-217,036	-10,716	-233,304

Source: Profit and Loss Statement

3.5.4 Current Status of Operation and Maintenance

In addition to a daily check, the power plant has 5-year cycle annual check which consists of 4 times of C-check (25 days) and one A-check (60 days). Since the start of the operation, the power plant has conducted annual check as planned and realized stable electricity supply.

Some problems have been observed in terms of financial aspects of operation and maintenance, therefore sustainability of the project effect is fair.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The objective of this project is to meet the growing electricity demand in Shandong province and strengthen coal industries and power industries in Shanxi province by constructing total 1,200 MW (600MW x 2) coal-fired thermal power plant in Changzhi City, Shanxi province and transmitting the generated electricity to Shandong province, thereby contributing to the economic development in both Shandong and Shanxi provinces. The project has been highly relevant with the country's as well as Shanxi and Shandong provinces' development plans, development needs, as well as Japan's ODA policy; therefore its relevance is high. The project has largely achieved its objectives of meeting the increasing electricity demand in Shandong province, strengthening coal and electricity industries in Shanxi province and thereby fostering economic development of two provinces, therefore its effectiveness is high. Although the project cost was within the plan, the project period was exceeded on a large scale; therefore efficiency of the project is fair. Some problems have been observed in terms of financial aspects of operation and maintenance, therefore sustainability of the project effect is fair.

In light of the above, this project is evaluated to be (B) satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

(1) Countermeasure to reduce NOx concentration should be taken by 2014 to meet the new Emission Standard. With regard to mercury concentration standard, the sensor to measure mercury concentration should be installed and, if required, necessary measure to meet the standard should be taken by 2015.

(2) The executing agency should take measure to secure financial sustainability of the power plant, for example continuing the discussion with the National Development and Reform Commission, Shandong provincial government and State Grid Corporation together with Shandong Lunang Group in order to increase the electricity selling price or obtain the subsidies for power plant operation.

4.2.2 Recommendations to JICA

None.

4.3 Lessons Learned

None.

End

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
1. Project Outputs		
Boiler	2 units, Supercritical pressure coal fired	Same as planned
Turbine Generator	2 unites, Output 600MW, Reheat condensing tandem compound, 50Hz, 3,000pm, Water-Hydrogen Cooling System	Same as planned
Main Transformer	2 x 3 x 240 MVA + 1 x 240 MVA	Same as planned
Instruments & Control	Dispersed Control System (DCS)	Same as planned
Coal Pulverizer	High level of pulverization, Middle Speed	Same as planned
Combustion System	-	Same as planned
Water Treatment System	400m^3/h	Same as planned
Electrostatic Precipitator	2 units, dust collection efficiency more than 99 %	Same as planned
Stack	Double-shaft 220m x 1 units	Same as planned
Coal Handling System	Truck-hopper 2 units, Bottom-hopper, Coal Storage 200,000 tons, Coal Bin 6 units, Unloader 700,000 tons/year	Same as planned
Ash Handling System	Dry type	Same as planned
Cooling Tower	Natural Draft 2 units, Spray area 7,500 m^2, Height 135 m	Same as planned
Switch Yard	500kV and 220kV	Same as planned
Hydrogen producing device	-	Same as planned
Consulting Services	Total107M/M Project Manager 23M/M, Mechanical Engineer (2) 28M/M, Electrical Engineer (2) 28M/M, I&C Engineer (2) 28M/M provide following services; ① Assistance in finalizing bidding documents ② Assistance in bid evaluation ③ Assistance in technical contract negotiation ④ Assistance in designs ⑤ Supervision for progress of project ⑥ Assistance in commissioning	Total121M/M Preparation for Bidding documents for Boiler and Turbine Generator (27.9M/M) Preparation/Contract Conclusion for Transformer, Combustion system (15.1M/M) Management for designs (61M/M) Commissioning (10M/M) Performance test (7.0M/M)
FGD	-	Added. 2 units, SOx removal efficiency of more than 97 %
2. Project Period	January, 1997 – December, 2002 (72 months)	January, 1997 – August, 2006 (116 months)
3. Project Cost		
Amount paid in Foreign currency	57,082million yen	40,345million yen
Amount paid in Local currency	81,410million yen (5,986 million yuan)	29,325million yen (2,071 million yuan)
Total	138,492million yen	69,960million yen
Japanese ODA loan portion	57,082million yen	40,345million yen
Exchange rate	1 yuan = 14.6 yen (As of February, 1997)	1 yuan = 14.36 yen (Average between September 1997 and March, 2010)