People's Republic of China

Ex-Post Evaluation of Japanese ODA Loan Project

"Shaanxi Hancheng NO.2 Thermal Power Plant Construction Project (1) (2)"

External Evaluator: Yasunori Nakamura, Global Link Management Inc.

0. Summary

The objective of this project is to meet the growing electricity demand in Shaanxi province by constructing total 1,200MW coal-fired thermal power plants (600MW x 2 units), thereby contributing to the regional economic development. The project has been highly relevant with the country's as well as Shaanxi province's 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 Shaanxi province and thereby fostering economic development of the province, 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 Location

Hancheng No.2 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 100,000MW of the installed power generation capacity between 1985 and 1994. By the end of 1994, the total installed power generation capacity in China reached 197,000MW. 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, the Chinese Government planned to increase the installed power generation capacity to 300,000MW by 2000. The investment for the development of the installed power generation capacity was therefore required from China as well as from abroad.

Shaanxi province had rich coal resources. Especially, Hancheng city area, which was the project location of this project, was called "Black Belt" and was one of main coal producing areas in the province. However, despite of such rich natural energy resources, Shaanxi province had not developed an adequate installed power generation capacity. It did not meet even the electricity demand in the province.

1.2 Project Outline

The objective of this project is to meet the growing electricity demand in Shaanxi province by constructing total 1,200MW coal-fired thermal power plants (600MW x 2 units), thereby contributing to the regional economic development.

	(1) CXIX-P95	(2) CXX-P95
Loan Approved Amount/ Disbursed Amount	35,000 million yen / 28,464 million yen	22,970 million yen/ 5,702 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 (For FGD) Interest Rate: 075 % Repayment Period: 40 years (Grace Period: 10 years) Conditions for Procurement: Untied
Borrower / Executing Agency	Government of People's Republic of China/ Datang Hancheng No.2 Power Generation Co. Ltd.	
Final Disbursement Date	April, 2006	June, 2009
Main Contractor (Over 1 billion yen)	Toshiba/Harbin Power Engineering (China)/Mitsui Co., Ltd., Harbin Boiler Co., Ltd./Harbin Power Engineering (China), Mitsubishi Heavy Industries, Ltd./Mitsubishi Corporation, Emerson Process Management Asia Pacific Private Limited (Singapore)	
Main Consultant (Over 100 million yen)	Tokyo Electric Power Services Co., Ltd.	
Feasibility Studies, etc.	"Feasibility Study for Shaaxi Hancheng No.2 Power Plant " Northwest Electric Power Design Institute of the Ministry of Electric Power , 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

2.3 Constraints during the Evaluation Study (if any)

None.

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, the medium-term plan of electricity sector of Shaanxi province emphasized that the province would meet its electricity demand by 2001 and would export the electricity to other province as mine mouth power producing area during the 10th Five-Year Plan (2001-2005).

The 12th Five-Year Plan (2011-2015) sets forth the development of diversified and clean energy sources, which includes the development of clean and efficient large scale power plants. Meanwhile, in its 12th Five-Year Plan (2011-2015), Shaanxi province set out to develop 35,000MW of the installed power generation capacity by 2015 to make the total installed power generation capacity in the province 60,000MW.

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

2 ③: High, ② Fair, ① Low

This project is therefore in consistent with the national development plan, the provincial development plan 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. For, 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

Average annual GDP growth in Shaanxi province between 1990 and 1995 was 9.4%. However, its installed power generation capacity has not been developed enough to meet the electricity demand. The electricity supply of Shaanxi province in 1995, which was 23.5 billion kWh, did not satisfy its electricity demand of 23.7 billion kWh.

The electricity demand in Shaanxi province increased annually by 14.5% on average between 2005 and 2010, while the installed power generation capacity of the province increased annually by 15.3% on average in the same period. The electricity supply and demand gap has narrowed little by little since 2007. However there is still the electricity supply and demand gap. Especially in the peak demand period, some areas in the province experience the electricity shortage.

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

Unit:100,000,000kWh

Year	2005	2006	2007	2008	2009	2010
Electricity Supply	443.4	491.6	546.8	609.5	641.9	775.1
Electricity Demand	436.7	574.0	660.0	705.0	733.7	859.2

Source: Executing Agency's Reply to Questionnaire

This project is therefore in consistent with the development needs of Shaanxi 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 and the project related to environment in addition to the economic infrastructure. This project, which was to contribute to the improvement of economic infrastructure by using rich coal resources in China's inland regions and which was the first Yen Loan project providing fuel gas desulfurization (FGD) to Chinese thermal power plant, 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 province's 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 2 Operation and Effect Indicators

Indicator	Unit	Plan/ Actual	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	100,000,000kWh	Plan	61..0	61.0	61.0	61.0	61.0
	100,000,000kWh	Actual	49.7	66.6	59.1	57.0	56.4
Plant Load Factor	%	Plan	62.79	62.79	62.79	62.79	62.79
	%	Actual	50.26	66.91	59.78	57.69	57.32
Availability Factor	%	Plan	68.49	68.49	68.49	68.49	68.49
	%	Actual	84.22	93.03	88.63	89.56	90.82
Auxiliary Power Ratio	%	Plan	7.5	7.5	7.5	7.5	7.5
	%	Actual	5.97	5.37	5.92	6.06	6.31
Gross Thermal Efficiency	%	Plan	60	60	60	60	60
	%	Actual	39.18	39.73	40.52	40.85	40.94
Outage Hours for Every Cause (Hours/Year)	Human Error		0	0	0	0	0
	Machine Trouble		39	1	91	0	0
	Planning Outage		1343	610	905	914	803

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

Indicator	Unit	Plan/ Actual	2006	2007	2008	2009	2010
Outage Hours for Every Cause (Times/Year)	Human Error		0	0	0	0	0
	Machine Trouble		3	1	2	0	0
	Planning Outage		9	4	7	5	4

Source: JICA Appraisal Documents, Execution 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) calculation at the time of appraisal, and then compared with the actual data. In comparison with the planned indicators for reference, all indicators except gross thermal efficiency mostly met the target[4]. With regard to gross thermal efficiency, although the actual value of 41% is lower than the planned indicator for reference, it is similar to those of the developed countries[5]. Therefore, it can be said that this project has produced certain effect in gross thermal efficiency. There were outage hours caused by machine troubles in 2006, 2007 and 2008. The reasons for the machine troubles were detected to be transformer trips[6] and flashover[7] of contaminated lightning arrestor. These machine troubles were properly repaired. At the time of the ex-post evaluation, the power plant was operated without machine troubles.

Meanwhile, the electricity generated at the power plant is transmitted to power grid in Shaanxi province through Xizhuang substation, Gaoming substation and Xinyi substation.

[4] It assumes that among the data applied in FIRR calculation, the cost of coal was calculated by using the coal consumption of 1.96 million tons rather than 3.5 million tons which were planned by the power plant. As a result, the planned gross thermal efficiency has come to have an unrealistic figure.

[5] According Tokyo Electrici Power Company's document, examples of gross thermal efficiency of developed countries are as follows; USA 38.8%, Germany 39.5%, France 41.6%, Nordic 41.8%, Japan 43.2%, UK/Ireland 44.0% (Actual in 2007).

[6] To cut off the current in the case of over current

[7] To discharge electricity after not being able to keep insulation due to the dust adhering to the insulation.

3.2.2 Qualitative Effects

(1) Improvement of living standards by stable electricity supply

Hancheng No.2 Power Plant has transmitted stable electricity of 5.6 to 6.6 billion kWh, which is equivalent to 6 to 10% of the electricity demand in Shaanxi province, to Shaanxi province since 2007. Gross Domestic Product (GDP) per capita in Hancheng city, where the power plant is located, increased annually by 18.9 % on average from 2006, when Hancheng No.2 Power Plant was constructed, to 2010. In contrast, Consumer Price Index (CPI) increased annually by 4.4 % on average in the same period, therefore it would be able to say that living standards in Shandong province improved from economic viewpoint. The interview with Weinan Hancheng Electricity Supply Bureau, where Hancheng No.2 Power Plant is located, reveals that before the construction of Hancheng No.2 power plant, the electricity restriction was imposed during the outage of Hancheng power plant which was constructed in 1970, while the interview with a bulk electricity user reveals that because the electricity restriction has not been imposed after the construction of Hancheng No.2 Power Plant, it has become easier to plan the company's investment and given positive impact on the management of the company. Considering such fact, it can be said that this project has contributed to revitalization of economic activities in Hancheng city through the stable electricity supply and the improvement of the management of the company in Hancheng city.

Box 1. Notes: Interview with Electricity bulk users

Shaanxi Shaan-Han Co. Ltd. (A company under Hancheng Coal Bureau, Shaanxi province)

Mining company established in 1998 and having 15,000 employees. 'In the 1990s, due to the electricity supply and demand gap, even in mining sector which could preferentially secure the electricity by the Government policy, there was still electricity outage except for main machines. However, since 2000, the company has not experienced electricity outage. Therefore, a direct impact of the construction of Hancheng No.2 Power Plant is not seen. Whereas, there are the positive impact of the contribution to the regional economy through the stable electricity supply and the negative impact of the increase of traffic.

Shaanxi Longmen Iron and Steel Co., Ltd. (Hancheng, Shaanxi Province)

Steel company established in 1995 and having 1,280 employees. Its annual sales in 2009 were 16.4 billion yuan. It accounts for 1/3 of electricity consumption in Weinan city. 'Before the construction of Hancheng No.2 Power Plant, the company consumed approximately 1.3 billion kWh while after the construction, it consumes approximately 1.7 billion kWh. There were 1-2 electricity outages per month before the construction, however there have been no electricity outage after the construction. Thanks to this, it has become easier to plan the company's investment, which contributes to the increase in the business profit. Therefore, the construction of Hancheng No.2 power plant is highly satisfactory.'

3.3 Impact

3.3.1 Intended Impacts

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

The below table shows GDP and the industrial sector[8]'s share in GDP of Shaanxi province in the last 5 years.

Table 3 GDP and Industrial sector's share in GDP of Shaanxi Province (2006-2010)

Unit: million yuan

Year	2006	2007	2008	2009	2010
GDP(Actual)	576,910	668,061	777,623	883,380	1,012,348
Industrial Sector's Share	46.3%	46.6%	48.0%	42.9%	45.0%

Source: National Bureau of Statistics of China

Table 4 Industrial sector's share in electricity consumption in Shaanxi Province (2006-2010)

Year	2006	2007	2008	2009	2010
Industrial Sector's Share	65.6%	66.8%	66.1%	63.2%	64.2%

Source: National Bureau of Statistics of China

Average annual GDP growth rate between 2006 and 2010 in Shaanxi province is 15.1 %. However, it is difficult to identify how much Hancheng No.2 Power Plant contributes to economic development of Shaanxi province. For, the electricity supply in Shaanxi province increased annually by 11.82 % on average between 2006 and 2010. However, the industrial sector continuously had approximately 45% share in GDP of Shaanxi province between 2006 and 2010 and was a driving force behind GDP growth while as shown in Table 4, the industrial sector has approximately 65% share in the electricity consumption of Shaanxi province. Considering these facts, it can be considered that this project partly contributes to the economic development of Shaanxi province through the stable electricity supply.[9]

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

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

3.3.2 Other Impacts

(1) Impacts on the natural environment

① Fuel Gas

Fuel Gas Monitoring System

With regard to the measure against Sulfer Oxides (SOx), the power plant installed 2 units of FGD with SOx removal efficiency of 93%. At the time of appraisal, 1 unit of FGD with SOx removal efficiency of 65% (30% for the power plant) was planned to be installed. However, in accordance with the reinforcement of Emission Standard for Air Pollutants for Thermal Power Plants in China (hereafter 'Emission Standard'), the SOx removal efficiency was changed to 93% and the power plant also procured 1 more unit of FGD at its own cost after the completion of the project.[10]

Meanwhile, low NOx burners and two-stage combustion were installed for the measure against Nitrogen Oxides (NOx) while high-performance electrostatic precipitators with more than 99.5% of dust collection were installed for the measure against dust emission. As a result, all actual fuel gas emission met Emission Standard. Meanwhile, the power plant installed online monitoring system in 2009. Shaanxi Province Environmental Protection Agency monitors all fuel gas emission from Hancheng No.2 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 Hancheng No.2 Power Plant does not meet the new standards for SOx, NOx and Dust, it is required to take necessary countermeasures to meet the new standards. With regard to new Emission Standard, mercury emission standard of 0.03 mg/Nm^3 is also 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.

[10] Emission Standard for Air Pollutants for Thermal Power Plants (GB13223-1996/Applied from 1997) set forth SOx concentration of 1,200mg/Nm^3. Using the FGD with the SOx removal efficiency of 65% as planned at the time of appraisal, SOx concentration was to be 1,500mg/Nm^3. Therefore, higher SOx removal efficiency was applied.

Table 5 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 (January-September,2011)	Standard	Standard	Standard
SOx	300-400mg/Nm^3	200mg/Nm^3	400mg/Nm^3	-[11]
NOx	500-600mg/Nm^3	100mg/Nm^3	650mg/Nm^3	-
Dust	40-50mg/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 Effluent

The wastewater is discharged into the river after wastewater treatment within Class III of Integrated Wastewater Discharge Standard as planned at the time of appraisal. As a result, all actual figures which ought to be reported to Shaanxi Province Environmental Protection Agency, namely Power of Hydrogen (PH), Chemical Oxygen Demand (COD) and Suspended Solid (SS) .

Table 6 Integrated Wastewater Discharge Standard

Standard / Item	-	Latest/ At the project completion (GB8978-1996)	At the time of appraisal (GB8978-88)
	Actual (January-September, 2011)	Standard	Standard
PH	7-8	6-9	6-9
COD	20-40	150	500
SS	30-50	150	400

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

③ Noise

As the measure against noise, 20-meter sound wall was installed. As a result, actual noise meets the standard.

Table 7 Emission Standard for industrial enterprises noise at boundary

Standard / Item	-	Latest (GB12384-2008)	At the time of appraisal/ At the project completion (GB12384-90)
	Actual	Standard	Standard
Noise level	45dB (Night) /55dB (Day)	50dB (Night) 60dB (Day)	50dB (Night) /60dB (Day)

Source: Executing Agency's Reply to Questionnaire

[11] While SOx concentration was not set forth, the amount of SOx emission was set forth as 20,941kg/h (with FGD with SOx removal efficiency of 30%).

④ Others (Ash Treatment)

With regard to ash treatment, site inspection at the time of the ex-post evaluation found that fly ash is disposed in a landfill at the disposal site located at the old river bed of Yellow River, which is about 1.5 km east of the power plant, as planned at the time of appraisal[12]. With regard to a measure against powder dust from fly ash, compressed air transfer pipeline is installed while yellow soil lining[13] is used for a measure against groundwater pollution as planned at the time of appraisal.

(2) Land Acquisition and Resettlement

Land acquisition of 135 hectors and resettlement of 83 households/435 people have been done as planned at the time of appraisal. Meanwhile, compensation of 17.86 billion yuan per household was paid while 200 ㎡ of land as well as brick and concrete structured house were allocated for each household at the resettlement site. Site inspection at the time of the ex-post evaluation found that the resettlement site is located approximately 5 minutes drive from Hancheng No.2 Power Plant and that it has become a village called Da Qian Xin Cun with village hall and gymnasium after the resettlement.

Resettlement site

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

3.4 Efficiency (Rating: ②)

3.4.1 Project Outputs

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

[12] There are no standards for ash treatment. The site inspection at the time of the ex-post evaluation found that there was no powder dust from the ash disposal site.

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

Table 8 Output (Plan/Actual)

	Numbers, Specification	
	Plan	Actual
Boiler	2 units, Natural circulation or Forced circulation (Sub-critical pressure coal fired), Reheating type	Same as planned (Forced circulation was applied)
Turbine Generator	2 unites, Output 600MW, 50Hz, 3,000pm, Water-Hydrogen Cooling System	Same as planned
Main Transformer	3 x 240 MVA	Same as planned
Instruments & Control	Dispersed Control System (DCS)	Same as planned
FGD	1 unit, Limestone-gypsum process, SOx removal efficiency of 60% (30% for the power plant)	1 unit, SOx removal efficiency of 93%. One unit was added after the project completion. SOx removal efficiency of 93% for the power plant
Water Treatment System	2 x 50t/h	Change in the volume of water to be treated 2x 60t/h
Electrostatic Precipitator	4 units, dust collection efficiency more than 99.5 %	Same as planned (dust collection efficiency more than 99.79%)
Stack	240m x 1 unit, Diameter 10M	240m x 2 unit, Diameter 6.9M
Coal Handling System	Coal Yard: 53,000m^2, 250,000 ton	Same as planned
Coal Pulverizer	High level of pulverization, Middle Speed	Same as planned
Ash Handling System	Dry type, Pneumatic ash conveying system	Same as planned
Cooling Tower	Natural Draft	Same as planned
Consulting Services	Total 145M/M Project Manager 23M/M, Mechanical Engineer (2) 28M/M, Electrical Engineer (2) 28M/M, I&C Engineer (2) 28M/M, Desulfurlization Engineer 19M/M, Environment Engineer 19 M/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	Total 84.6M/M Bidding Process (62.3M/M) Designs (7.8M/M) Construction/Commissioning (14.5M/M)

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

Project outputs were mostly realized as planned at the time of appraisal except changes in the specifications. Such changes are as follows; SOx removal efficiency has become higher in accordance with the reinforcement of Emission Standard in China, which set forth SOx concentration, the capacity of water treatment has become bigger in accordance with the actual volume of effluent, and the specification of stacks has been changed as a result of domestic bidding, by which the stacks with different specification, but lower cost and the same performance were applied. Meanwhile, although the consulting services spent 84.6 M/M, which is 58 % of the planned, the service contents were the same as planned. According to the executing agency, the reason for such difference could be that the plan was overestimated, however, the detailed reasons could not be found from the executing agency.

Turbine Generator

FGD

3.4.2 Project Inputs

3.4.2.1 Project Cost

The planned project cost was 131,315 million yen (Foreign currency 57,970 million yen/Local currency 73,345 million yen) while the actual project cost was 74,060 million yen (Foreign currency 34,167 yen/Local currency 39,893 yen). The actual project cost was 56% of the planned project cost and lower than planned. However, due to the changes in the specifications in the outputs, the cost for FGD and water treatment system exceeded the planned cost. Meanwhile, as a result of international competitive bidding, the cost for construction machinery exceeded the planned cost.

Table 9 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	18,873	11,265	732	2,120	28,828	11,506	307	1,108	15,911
Turbine	22,008	13,019	824	2,442	33,214	13,906	330	1,299	18,641
I&C	2,914	2,046	202	416	5,661	1,200	110	193	2,778
FGD	3,370	1,987	99	347	4,716	3,803	68	333	4,778
Ash Handling System	980	726	189	261	3,550	711	60	109	1,572
Coal Handling System	2,157	1,298	193	352	4,782	984	141	209	3,007
Water Treatment Equipment	104	104	89	97	1,314	457	94	125	1,805
Sub-station Switchgear	1,105	825	584	665	9,047	627	194	237	3,410
Construction Machinery	228	228	11	28	378	618	-	43	618
Others	-	-	460	460	6,256	34	1,476	1,478	21,214
Consulting services	465	465		34	465	321	-	22	321
Price Escalation	3,027	1,392	1,752	1,975	26,849	-	-	-	-
Physical Contingency	2,739	1,645	258	459	6,248	-	-	-	-
TOTAL	57,970	35,000	5,393	9,656	131,315	34,167	2,780	5,161	74,060

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 = 14.35 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

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 the 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 111 months from January, 1997 to March, 2006[14], which are 154% 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 the 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 56 months from December, 1997 to July, 2002.

② An approval of the feasibility study by State Council was delayed for 10 months from June, 1997 to March, 1998 due to a delay in the project procedure in China.

Meanwhile, with regard to the period from the approval of construction or the first contract conclusion[15] to the project completion, it was planned to be 61 months from December, 1997 to December 2002. However, it was actually 58 months from June, 2001 to March, 2006, which are 95 % 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 6.52%, which is lower than the planned FIRR of 12.01%. 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. With regard to the coal price in the future, approximately 4% annual increase is estimated with reference to the Chinese Government policy of controlling the increase of the coal price. With regard to the electricity selling price in the future, the average annual increase rate between 2006 and 2011, which is 5%, is used for the calculation. 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.

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[14] Although commercial operation of the power plant started in August, 2005, it was March, 2006 when the FGD, which is one of the project outputs, commissioned. Therefore, March, 2006 is defined as the month of the project completion.

[15] In this project, the contracts for turbine generator and boiler were concluded in June, 2001 and August, 2001 respectively , which were before the approval of construction.

3.5 Sustainability (Rating: ②)

3.5.1 Structural Aspects of Operation and Maintenance[16]

Datang Hancheng No.2 Power Generation Co., Ltd., a company invested by Datang Shaanxi Power Generation Co., Ltd (60% share)[17] and Shaanxi Investment Group Company (40% share), is responsible for operation and maintenance of Hancheng No.2 Power Plant. 342 employees work in the following departments; human resource, finance, political work, planning, audit, supervision and production safety, fuel, power generation, electricity supply, environment protection. With regard to equipment check, Datang Hancheng No.2 Power Generation Co., Ltd. outsources to Hancheng Power Maintenance Carrier, which allocate 798 people for the power plant.

3.5.2 Technical Aspects of Operation and Maintenance

Among the employees of Datang Hancheng No.2 Power Generation Co., Ltd., 5 employees have master's degree or above, 186 have bachelor degree, 126 have degree from technical college. That is, over 90% of the employees are college graduates or above. In addition, among 191 staffs in power generation related departments, 1 has senior technician certificate, 7 have technician certificate, 75 have senior engineer certificate, 60 have intermediate engineer certificate.

With regard to the trainings for operation and maintenance, there were the trainings about I&C before the commissioning of the power plant. More than 150 employees participated in such trainings while those who participated in the trainings offer the trainings to other employees today. There are many manuals for operation and maintenance. For example, 16 manuals for check and management and 16 manuals for equipment management are prepared.

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 50-100 % since 2008 onward compared with 2007 due to the increase in coal price[18]. Whereas, main business income has increased by less than

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[16] Hancheng No.2 is responsible for operation and maintenance for 4 units of power plants, i.e. 2 units of Phase-1 which was constructed by this project and 2 units of Phase-2 which was constructed at its own cost. All information about Datang Hancheng No.2. in this report is for both Phases.

[17] A company fully owned by China Datang Corporation.

[18] With regard to the rate of increase of the main business income and the main business cost, it was impossible to see the rate only for Phase-1 because Phase-2 started its operation in 2008. Although the rate of increase changed significantly between 2007 and 2008 due to the start of Phase-2 operation, it is obvious that the main business

10-70 % 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 State Grid Corporation by five Power Generation Groups[19] including China Datang Corporation, which is a parent company of Datang Hancheng No.2 Power Generation Co., Ltd have resulted in the increase of the electricity selling price by 16% since April, 2011. The executing agency forecasts that the financial status in 2011 will be improved and business profit will not be deficit in 2012. Such forecast by the executing agency seems relevant 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.

Table 10 Financial Status (2007-2010)

Unit: 1000 yuan

	2007	2008	2009	2010
Main Business Income	1,590,678	1,718,160	2,580,849	2,729,869
Main Operation cost	1,255,043	2,061,454	2,651,278	2,941,601
Business tax & VAT	19,299	9,626	20,811	1,532
Profit from main business	316,336	-352,920	-91,240	-213,264
Income from other business	6,929	7,336	4,249	4,819
Cost from other business	2,993	2,967	3,289	3,326
Financing costs	-60,003	53,807	284,040	248,846
Business profit	380,275	-402,358	-374,330	-460,617

Source: Loss and Profit Statement

3.5.4 Current Status of Operation and Maintenance

In addition to a daily check, the power plant has 6-year cycle annual check which consists of 5 times of C-check (25 days) and one A-check (65 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.

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cost increased more than the main business income.

[19] China Huaneng Group, China Datang Corporation, China Huadian Corporation, China Guodian Corporation, China Power Investment Corporation

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The objective of this project is to meet the growing electricity demand in Shaanxi province by constructing total 1,200MW (600MW x 2) coal-fired thermal power plant, thereby contributing to the regional economic development. The project has been highly relevant with the country's as well as Shaanxi province's 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 Shaanxi province and thereby fostering economic development of the province, 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 SOx and NOx concentration as well as Dust emission 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 would be taken to meet the standard by 2015.

(2) The executing agency should take measure to secure financial stability of the power plant, for example continuing the discussion with the National Development and Reform Commission, Shaanxi provincial government and State Grid Corporation through China Datang 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.

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
1. Project Outputs		
Boiler	2 units, Natural circulation or Forced circulation (Sub-critical pressure coal fired), Reheating type	Same as planned (Forced circulation was applied)
Turbine Generator	2 unites, Output 600MW, 50Hz, 3,000pm, Water-Hydrogen Cooling System	Same as planned
Main Transformer	3 x 240 MVA	Same as planned
Instruments & Control	Dispersed Control System (DCS)	Same as planned
FGD	1 unit, Limestone-gypsum process, SOx removal efficiency of 65% (30% for the power plant)	1 unit, SOx removal efficiency of 93 %. One unit was added after the project completion. (SOx removal efficiency of 93.2% for the power plant)
Water Treatment System	2 x 50t/h	2x 60t/h
Electrostatic Precipitator	4 units, dust collection efficiency more than 99.5 %	Same as planned (dust collection efficiency more than 99.79%)
Stack	240m x 1 unit, Diameter 10M	240m x 2 unit, Diameter 6.9M
Coal Handling System	Coal Yard: 53,000m^2, 250,000 ton	Same as planned
Coal Pulverizer	High level of pulverization, Middle Speed	Same as planned
Ash Handling System	Dry type, Pneumatic ash conveying system	Same as planned
Cooling Tower	Natural Draft	Same as planned
Consulting Services	Total 145M/M Project Manager 23M/M, Mechanical Engineer (2) 28M/M, Electrical Engineer (2) 28M/M, I&C Engineer (2) 28M/M, Desulfurlization Enginner 19M/M, Environment Engineer 19 M/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	Total 84.6M/M Bidding Process (62.3M/M) Designs (7.8M/M) Construction/Commissioning (14.5M/M)
2. Project Period	January,1997 – December,2002 (72 months)	January, 1997 – March, 2006 (111 months)
3. Project Cost		
Amount paid in Foreign currency	37,970million yen	34,167million yen
Amount paid in Local currency	73,345million yen (5,393 million yuan)	39,893million yen (2,780 million yuan)
Total	131,315million yen	74.060million yen
Japanese ODA loan portion	57,970million yen	34,167million yen
Exchange rate	1 yuan = 13.6 yen (As of February, 1997)	1 yuan = 14.35 yen (Average between September, 1997 and June,2009)