India

EX-post Evaluation of Japanese ODA Loan Project
"Bakreswar Thermal Power Station Units Extension Project"

External Evaluator: Tomoko Tamura, Kaihatsu Management Consulting Inc.

0. Summary

The objective of the project was to meet the increasing demand for electricity and to assure a stable electricity supply in the state of West Bengal in India by constructing Units 4 and 5 of the Bakreswar Thermal Power Station. This would contribute to industrial development, increasing employment opportunities and improving living standard of people in the state. The relevance of the project is high, as the objective of the project is in line with the development plan and needs of India and with Japan's ODA policy.

Units 4 and 5 are operated effectively. The maximum outputs, unit load factors and unit availability factors have been consistently higher than the target figures. There was a remarkable improvement in the status of electricity supply after the completion of the project, with a reduction in power cuts and supply-demand gap at peak demand time. The number of consumers, electricity consumption and number of villages electrified[1] has been increasing. From the above-mentioned facts, this project, among others, has contributed to the stable electricity supply of the state. Therefore effectiveness of the project is high.

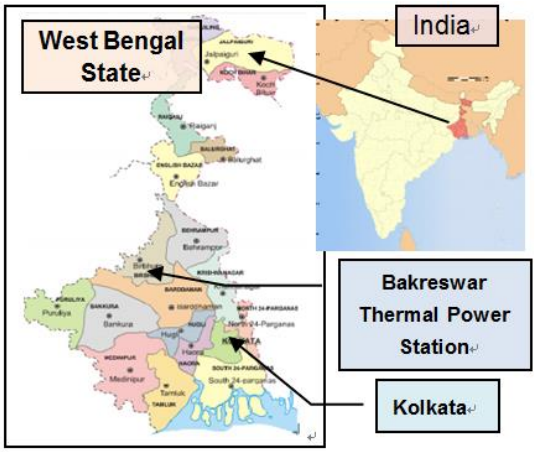
The planned outputs were created almost as planned and the project cost was within the plan; however, the project period was longer than the planned. Therefore, efficiency of the project is fair.

Sustainability of the project effect is high, as there is no problem about operation and maintenance of the units in terms of institutional, technical and financial aspects, and there is no serious problem about the current status of operation and maintenance of the same.

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

[1] According to the new definition of the Ministry of New and Renewable Energy of India introduced in September, 2006, a village is electrified when it meets the following three conditions; (1) the village has a basic infrastructure for electricity supply, (2) public buildings, such as schools and community halls in the village, are electrified and (3) more than 10 percent of the households of the village are electrified.

1. Project Description



Project Location

Bakreswar Thermal Power Station

1.1 Background

The state of West Bengal is located in the eastern part of India. It has an area of 88,752 km^2, and a population of 80 million in 2001. Agriculture is an important industry, with the production of rice, jute, tea and tobacco; mining and manufacturing industry have developed in and around Kolkata, the capital of the state. The state has faced a severe shortage of electricity since early 1990s, which caused frequent and lengthy power cuts. The shortage of electricity seriously disrupted the economic activity and daily life of the people in the state.

Bakreswar Thermal Power Station was constructed in the village of Mutaberia, Birbhum District, in the north-western part of West Bengal - around 230 km far from Kolkata- in order to meet the increasing electricity demand of the state. Units 1, 2 and 3 of the power station were constructed between 1994 and 2004 with official development assistance (ODA) loans from Japan. This project aimed to construct Units 4 and 5 of the power station with an ODA loan.

1.2 Project Outline

The objective of the project was to meet the increasing demand for electricity and to assure a stable electricity supply in West Bengal by means of constructing Units 4 and 5 of the Bakreswar Thermal Power Station, thereby contributing to developing industry, increasing employment opportunities and improving people's living standard in the state.

Loan Approved Amount/ Disbursed Amount	36,771 million yen / 36,641million yen
Exchange of Notes Date/ Loan Agreement Signing Date	March 2003 / March 2003

Terms and Conditions	Interest Rate: 1.8 % Repayment Period: 30 years (Grace Period: 10 years) Conditions for Procurement: General untied
Borrower / Executing Agency	Guarantor: President of India/ West Bengal Power Development Corporation Limited
Final Disbursement Date	August 2010
Main Contractor (Over 1 billion yen)	Itochu Co. (Japan)/ Bharat Heavy Electricals LTD.(India) / Larsen & Toubro LTD.(India)
Main Consultant (Over 100 million yen)	J-Power (Japan)
Feasibility Studies, etc.	None
Related Projects (if any)	ODA Loan Projects - Bakreswar Thermal Power Project (1) (L/A:1994) - Bakreswar Thermal Power Project (2) (L/A:1997) - Bakreswar Thermal Power Station Unit No.3 Construction Project (1) (L/A:1995) - Bakreswar Thermal Power Station Unit No.3 Construction Project (2) (L/A:1999)

2. Outline of the Evaluation Study

2.1 External Evaluator

Tomoko Tamura, Kaihatsu Management Consulting Inc.

2.2 Duration of Evaluation Study

Duration of the Study: September 2012 – July 2013

Duration of the Field Study: November 10 – 21, 2012; March 28 – April 3, 2013

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

3.1 Relevance (Rating: ③[3])

3.1.1 Relevance with the Development Plan of India

According to recent Five Year Plans of India,[4] the Central Government allocated 18 per cent of their total budget for public investment to the electric power sector at the time of planning and

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

[3] ③: High, ② Fair, ① Low

[4] Sources: "Ninth Five Year Plan (1997-2001), "Tenth Five Year Plan (2002-2006)" and "Eleventh Five Year Plan (2007-2011)", Twelfth Five Year Plan (2012-2016) of India.

implementation of the project, and 16 per cent at the time of the ex-post evaluation. Investment in the electricity sector was higher than any other sector. It is clear that the government places a top priority to this sector. The share of public investment to the electric power sector had been slightly reduced at the time of the ex-post evaluation, due to increase in the private sector investment.

At the time of planning the project, the Central Electricity Authority estimated that, up to 2012, the annual growth rate in both the demand for electricity, and peak demand, would be 6 per cent on average. Therefore the development of new sources of electricity generation was regarded as one of the most vital tasks for the electricity sector. In the 11th Five Year Plan, one of the most important tasks for the electricity sector was electrification of all villages in the country, with free connection for households below the poverty line.[5] The draft 12th Five Year Plan, published in December 2012 during the ex-post evaluation of the project, stated that it was a critical requirement to ensure access to energy for rural areas and the urban poor, as well as to make a certain minimum level of energy consumption available to everyone. In order to do that, the development of new sources of electricity generation is a priority.

In this way, the electricity sector, and the development of new sources of electricity generation, has been a priority in public investment in India continuously during the planning, implementation and ex-post evaluation of the project. The project aims to meet increasing demand for electricity and to ensure stable supply; therefore the project has high relevance with the development plan of the country.

3.1.2 Relevance with the Development Needs of India

The annual growth rate of electricity demand in the West Bengal was 2.96 percent at the time of planning the project. There was a severe shortage of electricity supply at that time, because the expansion of capacity to supply electricity was not enough to meet increasing demand. The percentage of supply-demand gap and that of at peak demand time were -20.6 per cent and -4.9 per cent respectively in the financial year 2001/02. It was projected that the deficit rate of electricity demand and supply would be continuously minus double digits some time. There was concern that there would be a serious shortage of electricity in the future as well. Therefore, expansion of capacity of electricity supply was an urgent task for the state. The urgency and importance of the expansion was further confirmed by the fact that the state government planned to increase the electrification rate of the state from 89.6 percent in 2003 to 100 percent in 2006. There was a possibility that the per capita electricity consumption of the state would increase in future to at least the national average; the figure of the state was as low as 235 kWh, while the national average was 355 kWh in 2001.

[5] The Tenth Five Year Plan defines “Below poverty line” for rural areas based on the degree of deprivation in respect of 13 parameters, such as type of housing, clothing, food security, sanitation, and means of livelihood, scoring each from zero to four. The families having less than 15 marks out of a maximum of 52 have been classified as below the poverty line.

As Table 1 shows, electricity demand of the state is still growing at 6.0–8.1 percent annually. There has been almost no power supply-demand gap at peak demand time in recent years; however, surplus deficit has been in the range of -10.4 percent to -14.7 percent, which shows continuous shortage of supply. The demand for electricity in the state has been increasing and there has been surplus deficit in recent years; therefore, development of generation sources is still an important issue for the state at the time of the ex-post evaluation.

Table 1 Status of Electricity Supply and Demand – West Bengal

Item/Financial Year		2009/10	2010/11	2011/12
1	Peak Demand (MW)	5,850	6,162	6,592
2	Annual Growth rate of peak demand (%)	13.0	5.3	7.0
3	Total peak availability (MW)	5,840	6,112	6,532
4	Supply-demand gap at peak demand time (MW)	-10	-50	-60
5	Supply-demand gap at peak demand time (%)	-0.2	-0.8	-0.9
6	Electricity requirement (GWh) (Gross)	33,750	36,481	38,679
7	Annual Growth rate of electricity requirement (%)	7.7	8.1	6.0
8	Electricity requirement / availability gap (GWh)	-4,335	-3,429	-4,683
9	Electricity requirement / availability gap (%)	-14.7	-10.4	-13.8

Source: The Central Electricity Authority, India
Note：Minus "-" shows that the electricity demand is more than the supply.

Table 2 shows that the West Bengal Power Development Corporation Limited (WBPDCL), the implementing agency for the project, currently has installed capacity of generation of 3,940 MW. Units 4 and 5 of the Bakreswar Thermal Power Station, which were constructed by the project, are important generation sources for WBPDCL. The installed capacity of the new units is 420 MW in total, 11 percent of WBPDCL's total installed capacity.

Table 2 Installed Capacity of WBPDCL

Name of the power stations	Installed Capacity（MW）
Kolaghat Thermal Power Station	1,260
Bakreswar Thermal Power Station Units 1, 2 and 3	630
Bakreswar Thermal Power Station Units 4 and 5	**420**
Bandel Thermal Power Station	530
Santaldih Thermal Power Station	500
Sagardighi Thermal Power Station	600
Total of WBPDCL	3,940

Source: Annual report of WBPDCL, 2011

Both the central government and private sector are engaged in power generation in the state in addition to the WBPDCL, which is owned by the state government.[6] Table 3 shows that the state-owned thermal power stations by coal, including those of WBPDCL, are the primary source of electricity generation in the state. The installed capacity of Units 4 and 5, constructed by the project, constitute 5 percent of the total installed capacity of the state.

Table 3 Installed Capacity of the State of West Bengal (as of 30 June 2012)

Unit：MW

Ownership	Thermal			Total thermal	Hydro/ renewable	Renewable Energy	Grand total*
	Coal	Gas	Diesel				
State	4,970.00	100.00	12.06	5,082.06	977.00	143.40	6,202.46 (73%)
Private	1,341.38	0.00	0.14	1,341.52	0.00	18.05	1,359.57 (16%)
Central	805.96	0.00	0.00	805.96	139.30	0.00	945.26 (11%)
Total	7,117.34	100.00	12.20	7,229.54	1,116.30	161.45	8,507.29 (100%)

*Note: Figures in brackets show the percentage of installed capacity of each ownership out of the total installed capacity of the state

Source：Central Electricity Authority, India

In summary, the relevance of the project to development needs was very high both at the time of planning and ex-post evaluation, as development of generation sources has been prioritized need in West Bengal. The facility constructed by the project plays an important role in electricity generation of the state.

3.1.3 Relevance with Japan's ODA Policy

The Country Cooperation Policy of Japan International Cooperation Agency (JICA) of 2003

[6] The public sector has dominated the power sector for a long time in India. The New Economic Reform, which was introduced in 1991, paved the way for liberalization. New investment and expansion in generation and distribution by the private sector was allowed in 1991 and 1998 respectively. Currently, both the central and the state governments have authority in the power sector, and Independent Power Producers (IPPs) are invited to join the sector.

stated that "expansion of capacity of electricity supply and development of urban transport system" and "development of economic infrastructure mainly in electricity sector" were some of the important areas of cooperation at the time of planning the project. ODA loans to the electricity and gas sector were 47 percent of the total amount committed to India at that time. In this way, the project has high relevance with Japan's ODA policy, as there had been a continuous and significant amount of cooperation rendered to the electricity sector of the country.

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

3.2 Effectiveness[7] (Rating: ③)

3.2.1 Quantitative Effects (Operation and Effect Indicators)

The operation and effect indicators of Units 4 and 5 - maximum output, unit load factors and plant availability factors - are shown in Table 4. Every item in the table consistently shows better performance than planned, which confirms that the units are operated effectively.

Table 4 Operation and Effect Indicators of the Project

Financial Year	Year	2009/10	2010/11	2011/12	2012/13
Years after the completion of the project	-	-	1	2	3
Unit 4					
Maximum Output (MW)	Target	210	210	210	210
	Actual	226	224	226	226
Unit load factor (%)	Target	-	80.56	80.56	80.56
	Actual	79.68	89.23	84.77	89.84
Unit availability factor (%)	Target	-	89	89	89
	Actual	89	95	92	97
Unit 5					
Maximum Output (MW)	Target	-	210	210	210
	Actual	221	225	227	226
Unit load factor (%)	Target	-	80.56	80.56	80.56
	Actual	71.71	86.69	83.74	92.9
Unit availability factor (%)	Target	-	89	89	89
	Actual	82.82	92.19	89.61	99.76

Source：JICA documents and WBPDCL

Notes：

(1) The project was completed in December 2009. Commercial operation of Units 4 and 5 started in March 2009 and June 2009 respectively.

(2) Data of 2012/13 is actual from 1 April 2012 to 30 September 2012 (financial year of WBPDCL is from 1 April to 31 March)

(3) Unit load factor (%) = annual power generation/(rated output x annual hours) x 100

(4) Unit availability factor (%) = (annual operating hours/ annual hours) x 100

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

As Table 5 shows, there was no outage due to human error for Unit 4 and was very little for Unit 5. There were few chances of human error because most of the facility constructed by the project is operated automatically. The numbers of outages due to machine error have been reducing recently for both Units 4 and 5, and the number of outage has stably remained at single digit figure since 2001/12.

Table 5 Hours and Numbers of Outages

Financial year			2009/10	2010/11	2011/12	2012/13*
Years after commercial operation				1	2	3
Unit 4	Human error	Hours	0	0	0	0
		Nos.	0	0	0	0
	Machine error	Hours	141.42	212.55	82.35	188.19
		Nos.	19	8	5	9
	Scheduled stop	Hours	794.77	190.57	643.47	3.28
		Nos.	9	2	1	1
Unit 5	Human error	Hours	4.48	4.45	0	3.28
		Nos.	2	2	0	1
	Machine error	Hours	463.42	408.22	406.63	10.73
		Nos.	25	13	6	2
	Scheduled stop	Hours	1037.20	271.65	506.69	0
		Nos.	11	02	02	0

Source：WBPDCL

*Note：Actual from 1 April 2012 to 30 September 2013.

Outage due to scheduled stop includes: overhaul of turbines, which should be conducted once in four years and requires around 40 days (960 hours); and overhaul of boilers, which should be conducted once in two years and requires around 20 days (480 hours). The hours and numbers of the outage due to scheduled stop were small in financial year 2010/11 as there was no overhaul conducted during the year. They were also small in financial year 2012/13, as of September 2012, for the same reason.

Units 4 and 5, constructed by this project, share several facilities of the power station with other units. Therefore, it is not possible to calculate Auxiliary Power Ratio, Ex-bus Power Generation and Gross Thermal Efficiency for Units 4 and 5 separately. For reference, Table 6 shows information on the power station as a whole, including Units 1 to 5, on the above-mentioned items.

Table 6　Auxiliary Power Ratio, Ex-bus Generation and Gross Thermal Efficiency

（Bakreswar Thermal Power Station Units 1 - 5）

Item	Year	2009/10	2010/11	2011/12
Auxiliary Power Ratio (%)	Target	-	9.50	9.50
	Actual	10.80	10.54	9.48
Ex-bus Power Generation (GWh)	Target	-	7,358.4	7,358.4
	Actual	6,077.5	7,726.8	7,725.4
Gross Thermal Efficiency (%)	Target	-	38	38
	Actual	33	34	34

Source: JICA documents and Annual reports and other documents of WBPDCL

Note：Auxiliary power ratio (%) = (Annual Auxiliary Power Consumption)/(Annual Power Generation) x 100

Ex-bus power generation (GWh) = annual power generation – annual auxiliary power consumption

Gross thermal efficiency (%) = (Ex-bus power generation) x 860 / (Annual fuel consumption x Fuel calorific value) x 100

3.2.2 Qualitative Effects

Gross Domestic Product (GDP) of West Bengal was USD 8,400 million in the financial year of 2009/10. The service sector, agriculture sector, and industrial and manufacturing sector contributed 57.8 percent, 24.0 percent and 18.2 percent respectively.[8]

Table 7 shows the number of consumers and total electricity consumption of the West Bengal State Electricity Distribution Company, which supplies 80 percent of the peak electricity demand of the state. The table shows that all these figures have been increasing year by year. The number of villages electrified has also been increasing. The village electrification rate of the state was 99.7 per cent in May 2012.[9]

Table 7　Information on Electricity Distribution in West Bengal

Financial year	2004/05	2005/06	2006/07	2007/08	2008/09
Number of consumers	5,101,805	5,695,861	6,345,472	6,835,269	7,293,994
Total electricity consumption（GWh)	13,549	14,727	14,937	15,887	17,577
No. of villages electrified	32,171	32,809	34,385	36,204	37,308

Source: Annual Report 2008/09, West Bengal State Electricity Distribution Company[10]

Shortage of electricity supply created serious problems for both management of and investment in industry in the state during the 1990s and early 2000s. There has been a remarkable improvement in the status of electricity supply in the state in recent years and the problem of shortage of electricity to the industry has almost been solved. A senior staff member at the head office of the Chamber of Commerce of India in Kolkata explained that there have

[8] Source: “West Bengal, Culturally Artistic”, India Brand Equity Foundation, November 2011.

[9] Source: Central Electricity Authority, India.

[10] The latest published annual report of the West Bengal State Electricity Distribution Company is 2008/09.

been almost no power cuts, especially in the urban areas of the state, for the last few years, and that improved electricity supply has contributed to smooth operation of businesses in the industry and manufacturing sectors.

West Bengal is achieving remarkable economic development. The net state GDP growth rate has been high in recent years, and has been especially high since financial year 2009/10 onwards as shown in Table 8. These figures show that the industry of the state has been developing. Information on the number of people in employment in recent years was not available at the time of the ex-post evaluation, so it is not possible to give data on employment creation, which was planned to be one of the indicators for qualitative effects of the project.

Table 8 Net GDP Growth Rate of West Bengal

Financial year	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Net State GDP Growth Rate (%)	10.35	13.65	14.45	14.18	18.60	16.85	16.03

Source Ministry of Statistics and Programme Implementation, India

As Table 9 shows, percentages of power supply-demand gap at peak demand time has been in single digit figures during the period of project planning and implementation. However, it has improved remarkably, and been less than -1 percent since project completion.

Table 9 Peak Demand and Electricity Demand of the West Bengal

Year / Item	During project planing			During project implementation		After project completion		
	1999/00	2000/01	2001/02	2007/08	2008/09	2009/10	2010/11	2011/12
Surplus deficit in peak demand	4.04%	0.33%	-4.94%	-9.80%	-3.60%	-0.20%	-0.80%	-0.90%
Surplus deficit	-21.20%	-20.91%	-20.69%	-12.39%	-13.48%	-14.74%	-10.37%	-13.77%

Source: JICA documents and the Central Electricity Authority of India

This shows that there was a notable improvement in the status of electricity supply after the completion of the project, with a reduction in both power cuts and the supply-demand gap at peak demand time while the number of consumers, electricity consumption and number of villages electrified has increased. This project, among others, has contributed to the stable electricity supply and industrial development of the state.

3.3 Impact

3.3.1 Impacts on the Natural Environment

Prior to implementing the construction of a large-scale thermal power station in India, it is necessary to obtain environmental clearance from the Ministry of Environment and Forest of the

central government, and to obtain approval from the state pollution control board. For this project, an Environment Impact Assessment Study was conducted in 1987, and Environmental Clearance was received from the Ministry of Environment and Forest of the central government. Approval was given from the West Bengal Pollution Control Board prior to implementation of the project. WBPDCL has been conducting environmental monitoring on emission gas, ambient air and effluent water since the commissioning of the power station. Results of the monitoring have been submitted to the West Bengal Pollution Control Board every month and to the Ministry of Environment and Forest of the central government once in six months.

Table 10 shows the results of the environmental monitoring, which were submitted to the external evaluator from WBPDCL at the time of the ex-post evaluation. All the figures on emission gas, ambient air and effluent water were within the limits of the Indian standard. Regarding quality of underground water, results of the monitoring of underground water conducted by WBPDCL once in three months showed that no heavy metal except iron was detected. There is no concern about pollution of the underground water at the moment, although there is no particular standard for the quality of underground water in India.

Table 10 Result of Environmental Monitoring

Emission gas (max. figure in 24 hours of measurement on 2012.11.30) (unit: mg/Nm^3)	Item	Result of Measurement		Indian standard
		Unit 4	Unit 5	
	SO2	588.00	561.86	2000
	Nox	563.60	547.05	750
	TPS	88.24	54.32	150
Ambient air (max. figure in 24 hours of measurement on 2012.11.30) (unit: μg/m^3)	Item	Beside pump house	Neighboring village named de Chandra	Indian standard (Industrial area)
	SO2	7.96	7.39	120
	Nox	30.03	26.5	120
	TPS	48.30	41.84	500
*Effluent water (sampling on 2012.10.18) (unit: mg/liter)	Item	at guard pond	at ash pond	Indian standard (surface water)
	pH at 25C	7.10	7.16	5.5-8.5
	TSS	54.60	80.00	100
	BOD	7.00	10.00	30
	Oil and grease	2.80	4.50	10
	Total Iron	0.45	0.73	3
	Cadmium	<0.149	<0.149	2
	Lead	<0.088	<0.088	0.1
	Total Chromium	<0.506	<0.07	2

Source: WBPDCL document, "Ground Water Quality in Shallow Aquifers of India", Central Ground Water Board, Ministry of Water Resources, Government of India, "National Ambient Air Quality Standards", Central Pollution Control Board, Notification on 18 November 2009

＊It is only from the guard pond that effluent water is discharged to the outside of the power station.

Box 1 Environmental Protection by Utilization of Coal Ash

India has been promoting utilization of coal ash. The newly-constructed thermal power stations should attain 100 percent recycling of the coal ash within 9 years from the date of commissioning of the stations, according to the gazette notification issued in 1999.

To attain this target, WBPDCL is actively engaged in coal ash recycling. Currently the Bakreswar Thermal Power Station has attained 100 percent recycling of the coal ash generated from Units One to Five. The Power Station provides local authorities and private companies in the area with the coal ash for cement manufacturing, earth filling for road construction and other purposes. The utilization of coal ash accelerated in recent years as a result of the Power Station actively promoting it through advertisements in newspapers and other media. There are several companies that purchase the coal ash and export it to Bangladesh, which is low in elevation and has a high demand for material for earth filling. This use was promoted further after financial year 2011/12, in addition to the utilization of the coal ash stored in the silos, the Power Station started excavating a part of the dried ash, which had been deposited in the ash pond for a couple of years, for earth filling, etc.

3.3.2 Providing Educational Opportunity to the Local Community

Staff quarters, a primary school, a junior and senior high school, a clinic, recreation facilities, shops and other facilities were constructed at the time of construction of Unit 1 of the Power Station. Under this project, the emergency treatment facility of the clinic was expanded, and electrification of the primary school, the junior and senior high school was carried out. Originally most of the students of the schools were children of the staff of the Power Station. However, as a result of the continuous support of WBPDCL to the schools, including school bus services that started recently, the schools became popular among neighboring villages. Currently, around 75 per cent of the students of the schools are from the local community. It is appreciated that the WBPDCL is contributing to the local community by providing educational opportunity.

The junior and senior high school constructed in the premises of the Power Station

3.3.3 Land Acquisition and Resettlement

There was no involuntary resettlement and land acquisition conducted by the project, as they had been carried out in the preceding projects.

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

3.4 Efficiency (Rating: ②)

3.4.1 Project Outputs

The following table shows the planned and actual outputs of the project. All the planned outputs were attained as planned apart from the construction of a new ash pond, which was cancelled. A plan to construct a new ash pond had been included in the project at the time of appraisal. However, it was also agreed that the ash generated from Units 4 and 5 should be discharged to the existing ash pond, constructed for Units 1, 2 and 3, provided there was sufficient capacity. Currently, the ash pond for the Units 1, 2 and 3 has adequate capacity to store the ash discharged from Units 4 and 5 as well, and is estimated to be adequate another 15 years. The excavation and utilization of the dried ash in the pond, mentioned in Box 1, is contributing to increase the lifetime of the ash pond. Therefore, construction of a new ash pond was not urgent, and the decision to cancel was appropriate. WBPDCL is planning to construct an additional ash pond for future needs, and is in the process of land acquisition at the moment.[11]

Table 11 Planned and Actual Outputs of the Project

	Plan	Actual
1	Installation of two units each of 210 MW turbine generator sets together with boiler of matching capacity and associated auxiliaries and civil works.	As planned except the cancellation of construction of a new ash pond
2	Procurement of spare parts	As planned.
3	Operation and maintenance training	As planned.
4	Staff quarters and other welfare facilities	As planned.
5	Consulting Services	Period of assignment of international consultant was extended due to the extension of the project period. Period of assignment of the local consultant was as planned.

Source: JICA document and document submitted by WBPDCL

3.4.2 Project Inputs

3.4.2.1 Project Cost

The planned total cost of the project was JPY 43,443 million, which included JPY 15,903 million in foreign currency and JPY 27,540 million in local currency. The actual project cost was

[11] The Power Station achieved 100 per cent of utilization of the coal ash recently as explained in Box 1. The coal ash discharged from the generation facility is stored in the silos, transported by trucks and utilized. In addition to that, the Power Plant excavates and utilizes the coal ash that was deposited in the ash pond and become dried after several years. They are planning to construct an additional ash pond as they need to ensure additional space, which will become necessary to discharge and deposit the coal ash until they are utilized.

JPY 41,202 million in total, which included JPY 13,542 million in foreign currency and JPY 27,660 million in local currency. Therefore, the project cost was within the plan (95 percent of the planned amount). The amount of ODA loan was planned as JPY 36,771 million and was actually JPY 36,604 million. The actual project cost was slightly lower than the planned cost as a result of effective competitive bidding.

Table 12 Plan and Actual Project Cost

Unit: Million yen

Item	Foreign currency (JPY)		Local currency (JPY)			Total (JPY)	
	Total foreign	ODA loan	Total local	ODA loan	Government of India	Total cost	ODA loan
Plan	15,903	15,903	27,540	20,868	6,672	43,443	36,771
Actual	13,542	13,542	27,660	23,062	4,598	41,202	36,604
Difference	-2,361	-2,361	120	2,194	-2,074	-2,241	-167
Difference (%)	-15%	-15%	0%	11%	-31%	-5%	-1%

Source: JICA document and data submitted by WBPDCL

3.4.2.2 Project Period

The project period was planned as 60 months and was actually 82 months, which was longer than planned, with 137 percent extension of the plan. Units 4 and 5 were planned to be commissioned in July and October 2007 respectively. They were actually commissioned in March and June 2009, which meant they were delayed by 21 months. Unit 4 had a 5-month, 4-month and one-year delay for the lighting of the boiler, the synchronization and commissioning respectively. Unit 5 had a one-year, 6-month and 3-month delay for the lighting of the boiler, the synchronization and commissioning respectively. This was mainly because the state owned heavy electric enterprise, which was the supplier of the boilers and undertook civil works and installation, was over-burdened as they had undertaken many projects at the same time. The delay of the project was mainly because the enterprise could not supply the necessary materials and manpower in time at each stage of the work.

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

The Financial Internal Rate of Return (FIRR) was 10.4 percent at the time of planning the project, with the benefit of the project defined as electricity sales, the cost of the project as costs of construction, maintenance of the facility and fuel, and project life as 25 years. It was 9.3 percent when it was updated at the time of the ex-post evaluation with the same definitions and actual values. The reduction of the FIRR was mainly because the actual fuel prices was higher than what was assumed at the time of project planning and the prices were increased year by year.

The Economic Internal Rate of Return (EIRR) was 28.8 percent at the time of planning the

project. In addition to the benefit calculated in FIRR, there were two additional benefits taken into consideration in EIRR. One was the consumer surplus, which would be created by more stable power supply and was calculated by considering willingness to pay. The other was substitution effects, which is the benefit that consumers who were dependent on high-cost self-generation at the time of power shortages would enjoy from inexpensive power from the grid as a result of the project. The cost of the project would be the costs of construction, maintenance and fuel, and the project life was defined as 25 years. The EIRR was 23.7 percent at the time of the ex-post evaluation with the same definitions. The reason for the reduction in the EIRR was because the fuel was more expensive than the assumption and was increasing year by year, similar to the reason of reduction of the FIRR.

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

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

The General Manager of the Bakreswar Thermal Power Station is responsible for operation and maintenance of the Power Station, including Units 4 and 5, while the Head Office of WBPDC has overall responsibility for administration of the Power Station. The Power Station currently has 781 staff in total. Forty engineering staff are assigned to the operation room of Unit 4, and 40 to the operation room of Unit 5. Other staff members, who are in charge of operation and maintenance, including administration, coal delivery, and operation of electrical machineries, do not work only for Units 4 and 5 but for the whole plant. Some staff members are also assigned to the schools and the clinic of the Power Station. The Power Station currently has 18 contracts for outsourcing maintenance of the equipment. The manufacturers undertake overhaul and repair of turbines, boilers and some other equipment. WBPDCL has obtained approval from the State Electricity Regulatory Commission for a plan to enhance organizational capacity in financial year 2012/13, and is in the process of staff recruitment. There is also a plan to increase the number of staff at the Power Station to enhance its institutional capacity in, for example, information technology (IT) and operational efficiency.

The Operation Room of Unit 4

3.5.2 Technical Aspects of Operation and Maintenance

Most of the management-level staff members of the power station are senior engineers who have more than 20 years of experience in operation and maintenance of power stations, or have

worked from the beginning of the commissioning of Unit 1. WBPDCL transferred some of the engineers from other power stations to Bakreswar and recruited new staff for the operation and maintenance of Units 4 and 5.

The staff refers to the operation manuals provided by the original manufacturers and suppliers of the facilities whenever necessary. During the project, manufacturers and suppliers conducted several technical training courses for the staff of the power station on operation and maintenance, as well as safety management of the facilities. Technical transfer has been conducted for newly-recruited engineers and technicians by providing training at the training center, with a simulation facility established in the premises of the power station, as well as on-the-job training.

In summary, there is no problem on operation and maintenance of the power station, including Units 4 and 5, in terms of technical aspects, as necessary numbers of engineering and technical staff have been assigned and their technical level is satisfactory.

3.5.3 Financial Aspects of Operation and Maintenance

The financial status of WBPDCL is satisfactory, as the income statement of WBPDCL has remained in surplus and the amount of sales has been increasing in recent years, as shown in Table 13. The West Bengal State Electricity Regulatory Commission specifies the electricity tariff and cost of electricity generation periodically and thereafter adjusts them at the end of the financial year by issuing gazette notifications so that the tariff reflects the costs. The amount of annual net profit of WBPDCL varied, because the payment from the Commission to WBPDCL for the adjusted amount was sometimes made the following financial year.

Table 13 Financial Information on WBPDCL

Unit: INR 10 million

Item / Financial Year	2007/08	2008/09	2009/10	2010/11	2011/12
Gross revenue	2,837.34	3,548.32	5,242.63	5,889.44	7,240.22
Less: Expenditure	2,407.09	3,118.33	4,357.96	4,937.92	5,807.82
Gross profit before interest and depreciation	**430.25**	**429.99**	**884.67**	**951.52**	**1,432.40**
Less: Interest	84.47	161.98	468.38	473.00	560.05
Profit before depreciation	**345.78**	**268.01**	**416.29**	**478.52**	**872.35**
Less: Depreciation	139.06	135.78	388.15	381.15	396.93
Net profit for the year	**206.72**	**132.23**	**28.14**	**97.37**	**475.42**
Less: Provision for taxation	23.88	15.44	4.78	19.41	95.13
Profit after tax	**182.86**	**116.79**	**23.36**	**77.96**	**380.30**
Less: Reserve for unforseen exigencies	25.00	12.56	12.56	12.56	39.18
Proposed dividend on equity shares	5.00	0.00	0.00	0.00	0.00
Tax on proposed divided	0.85	0.00	0.00	0.00	0.00
Balance brought forward from last year	321.41	473.42	577.64	588.44	653.84
Reserve & surplus at the end of financial year	**473.42**	**577.64**	**588.44**	**653.84**	**994.96**

Source: Annual Reports of WBPDCL (Financial years of 2011/12, 2010/11, 2009/10 and 2008/09)

The approved actual cost of operation and maintenance of the power station was INR 710 million,[12] INR 973 million and INR 1,169 million respectively in financial years 2009/10, 2010/11 and 2011/12 respectively.[13] The amount increased year by year due to the escalating costs of employment and fuel. The approved amount for total operation cost of the power station for the financial year of 2012/13, which includes employment cost, payment of interest, depreciation, insurance and tax after deduction of the income, was INR 7,000 million.[14]

The West Bengal State Electricity Regulatory Commission approves annual operational costs giving consideration to costs of generation, employment, etc. WBPDCL claims the actual expenses and then the Commission reviews the claims, admits them and makes payment for the shortage of the allocated amount. The power station does not have a problem in purchasing fuel and spare parts at the moment.

In summary, the operation and maintenance of the power station in terms of financial aspects is satisfactory, as the financial status of WBPDCL has been profitable, the necessary budget allocation for operation and maintenance has been approved and provided, and the approved amount has been increased giving consideration to the escalating costs of employment and fuel.

3.5.4 Current Status of Operation and Maintenance

Units 4 and 5, which were constructed by the project, are operated efficiently and are in a good condition, as shown by the fact that the unit load factors and unit availability factors were satisfactory, and the maximum outputs exceeded the targets, as explained in the section on "Effectiveness" in this report.

An online inspection, operation and maintenance and inventory control information system has been adopted by the power station to optimize the performance of the maintenance work and the inventory management of spare parts. The system displays a list of information on items needed for inspection and maintenance, as well as details of necessary work, which are instructed to the relevant sections daily. The relevant sections input information on progress of the work to the system, which is utilized by the supervisors for the purpose of monitoring progress.

The staff members in the system control rooms monitor the indicators on operation of the facility shown in the display in real time for 24 hours a day. In addition, the major indicators are shown in displays set-upped at several places in the power station, so that senior management staff can always monitor these indicators and make necessary decisions.

The power station uses coal supplied mainly from the Bengal Emta open-cut mine. The supplier mixes the coal from the mine with imported coal and washed coal to keep the standard quality needed. So far, the quality of the coal has been satisfactory and did not have any problem

[12] The cost of 2009/10 includes only the cost of Units 1 to 4 until May 2009, as Units 4 and 5 were commissioned in March 2009 and June 2009 respectively.
[13] Source: Document submitted by WBPDCL.
[14] Annexure-3B, Order of the West Bengal Electricity Regulatory Commission, In Case No. APR-27/ 11-12, In re the application of the WBPDCL for annual performance review of the financial year 2010-2011.

to give negative effects on the performance of the power station. The raw water required for the power generation comes from the Tilpara Reservoir and Bakreswar Reservoir as planned, which are located 15 km and 3 km away from the power station respectively. There has been no issue with regard to water quantity and quality.

The major issues for operation and maintenance of Units 4 and 5 are a problem with vibration of the cooling tower fan gearbox, and leakage of the tubes in the high pressure heaters. The vibration of the gearbox started at the time of commissioning; however it is now stable and under control with consistent monitoring and timely maintenance.

The leakage of the tubes in the high pressure heater of Unit 4 and Unit 5 occurred occasionally from the time of the commissioning and from July 2012 respectively. The staff members of the power station attend to the leakages at the earliest opportunity through continuous monitoring of the drip level of the high pressure heaters[15] and the total flow of running from the boiler feed pumps.[16] They make sure that every leakage is attended to completely when a sign of a leakage is observed. Therefore, there is very little possibility that a leakage will create a dangerous situation. The WBPDCL plans to replace all the heater tubes if the number of plugged heater tubes reaches around 10 percent of the total, as the station heat rate would be affected. The manufacturer of the high pressure heaters is conducting an investigation into the cause of the leakages at present.

In summary, sustainability of the project effect is high, as no major problems have been observed in the operation and maintenance. There is no serious concern about the current status of operation and maintenance, as necessary action for early detection and appropriate measures are taken for the problems that occasionally occur in some parts of the facility.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The objective of the project was to meet the increasing demand for electricity and to assure a stable electricity supply in the state of West Bengal in India by constructing Units 4 and 5 of the Bakreswar Thermal Power Station. This would contribute to industrial development, increasing employment opportunity and improving living standard of people in the state. The relevance of the project is high, as the objective of the project is in line with the development plan and needs of India and with Japan's ODA policy.

Units 4 and 5 are operated effectively. The maximum outputs, unit load factors and unit availability factors have been consistently higher than the target figures. There was a remarkable improvement in the status of electricity supply after the completion of the project, with a reduction in power cuts and supply-demand gap at peak demand time. The number of consumers, electricity consumption and number of villages electrified has been increasing. From the

[15] Water level in the body of the high pressure heaters.
[16] Leakage of the tubes of the high pressure heater can be detected earlier by monitoring the total flow of ruing boiler feed pumps as flow increase when there is a leakage.

above-mentioned factors, this project, among others, has contributed to the stable electricity supply of the state. Therefore effectiveness of the project is high.

The planned outputs were created almost as planned and the project cost was within the plan; however, the project period was longer than the planned. Therefore, efficiency of the project is fair.

Sustainability of the project effect is high, as there is no problem about operation and maintenance of the units in terms of institutional, technical and financial aspects, and there is no serious problem about the current status of operation and maintenance of the same.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

It is recommended that WBPDCL share information on its remarkable performance with other power generation companies through its website on their activities such as achievement of 100 per cent of utilization of coal ash, the results of environmental monitoring, and provision of educational opportunity to the local community as part of corporate social responsibility (CSR).

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	(1) Installation of two units each of 210MW turbine generator sets together with boiler of matching capacity and associated auxiliaries and civil works. (2) Procurement of spare parts (3) O&M training (4) Staff quarters and other welfare facilities (5) Consulting Services	As planned except the cancellation of construction of a new ash pond and extension of the assignment of the international consultants.
2.Project Period	March 2003 – March 2008 (60 months)	March 2003 – December 2009 (82 months)
3.Project Cost		
Amount paid in Foreign currency	15,903 million yen	13,542 million yen
Amount paid in Local currency	27,540 million yen (11,241 million indian rupees)	27,660 million yen (11,348 million Indian rupees)
Total	43,443 million yen	41,202 million yen
Japanese ODA loan portion	36,771 million yen	36,604 million yen
Exchange rate	INR 1 = JPY 2.45 (As of September 2002)	INR 1 = JPY 2.43 (Average between March 2004 and March 2011)