India

Bakreswar Thermal Power Project (1) (2)

Bakreswar Thermal Power Station Unit No. 3 Construction Project (1) (2)

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Participating Organization	:	West Bengal Power Development Co. Ltd. (WBPDCL)
Field Survey	:	November, 2006

1． Project Outline and Japan's ODA Loan

Project Site Location Map

Bakreswar Thermal Power Station

1.1 Background

West Bengal State (area of 88,752 km^2 and a population of some 67.98 million in 1991) not only enjoys a high level of the agricultural production of rice, Indian jute and tea, etc. but also has a major commercial and industrial area centering on Calcutta. In 1992, the power demand of West Bengal (WB) of 12,833 GWh accounted for 4.2% of the entire power demand in India. In the first half of the 1990's, frequent power cuts caused by the considerable electricity supply shortage was a severe obstacle to economic activities and residents' lives in the state. At that time, the power demand in WB increased at an annual rate of approximately 7% and it was believed to be imperative to construct new power generating facilities to alleviate the power shortage.

The Bakreswar Thermal Power Station (BkTPS) was planned for the very purpose of alleviating WB's power shortage by the construction of a thermal power station using coal

[1] The project was jointly evaluated by JBIC and the WBPDCL with the participation of H. Sonoda (External Evaluator) and S. Mahapatra (Managing Director), D. Dey (Sr. Manager) and Tapas Roy (Sr. Manager) from the WEPDCL. In addition, K. Ramanathan, Shahid Hasan and Anirban Ganguly (The Energy Research Institute) also participated as experts to improve the evaluation capacity in India's electric power sector.

mined in the northwestern part of WB. Generating Units No.1 through No.3 were constructed with a Japanese yen loan in the period from January, 1994 to April, 2004.

1.2 Objective

The objective of the project was to meet the increasing demand for electric power and also to assure stable electricity supply in West Bengal State by means of constructing a TPS with a rated output of 630 MW (210 MW x 3; installation of six units planned under the master plan) using domestic coal produced at a nearby coal field and related transmission facilities at the village of Mutaberia in the Birbhum District located some 230 km northwest of Calcutta, thereby ensuring a stable supply of electricity to contribute to the promotion of industries and the improvement of residents' lives by electrification in WB.

1.3 Borrower/Executing Agency

President of India/WBPDCL[2]

1.4 Outline of Loan Agreement

	Bakreswar Thermal Power Project Phase 1
Loan Amount/Disbursed Amount	¥27,069 million/¥26,981 million
Date of Exchange of Notes Date of Loan Agreement	December, 1993 January, 1994
Terms and Conditions	Interest Rate: 2.6%/year Repayment Period: 30 years (Grade Period: 10 years)
Final Disbursement Date	March, 1999
	Bakreswar Thermal Power Project Phase 2
Loan Amount/Disbursed Amount	¥34,151 million/¥32,300 million
Date of Exchange of Notes Date of Loan Agreement	October, 1997 December, 1997
Terms and Conditions	Interest Rate: 2.3%/year Repayment Period: 30 years (Grace Period: 10 years)
Final Disbursement Date	February, 2003
	Unit No. 3 Extension Project Phase 1
Loan Amount/Disbursed Amount	¥8,659 million/¥8,336 million
Date of Exchange of Notes Date of Loan Agreement	December, 1994 February, 1995
Terms and Conditions	Interest Rate: 2.6%/year Repayment Period: 30 years (Grade Period: 10 years)

[2] West Bengal Power Development Corporation（WBPDCL）

Final Disbursement Date	March, 2002
	Unit No. 3 Extension Project Phase 2
Loan Amount/Disbursed Amount	¥11,537 million/¥9,695 million
Date of Exchange of Notes Date of Loan Agreement	March, 1999 March, 1999
Terms and Conditions	Interest Rate: 1.8%/year Repayment Period: 30 years (Grace Period: 10 years)
Final Disbursement Date	April, 2004
Contractors	Itochu Co. (Japan), MacNally Bharat Engineering Co. Ltd. (India), KEC International Ltd. (India), Subhash Project and Marketing Ltd. (India), Bharat Heavy Electricals Ltd. (India), Fuji Electric Group (Japan) (JV)
Consulting Services	Electric Power Development Co., Ltd.
Feasibility Study (F/S), etc.	WBPDCL (1984)

２．Evaluation Results

2.1 Relevance

2.1.1 Relevance at the Time of Appraisal

The electric power sector has been considered to be a principal means of economic development in a succession of India's five year plans and the priority of this sector has been consistently high. The Eighth Five Year Plan (1992 – 1997) emphasised public investment in this sector because of its extreme importance for the sound development of domestic industries and 18.3% of the total budget was allocated to dealing with the severe power shortage of 8% on a energy basis and 20% on a peak power basis.[3]

WB continually experienced a severe power shortage since the 1970's due to the insufficient generating capacity, low operating rate of thermal power plants and high transmission and distribution losses. In 1991, the power supply shortage was as high as 9%. Because WB relied on thermal power generation for 95% of the state's generating capacity, the power shortage during peak demand times was especially severe, reaching 26% in 1992. The resulting frequent long power cuts impeded economic activities and constituted a factor for the stagnation of industrial activities. As the power demand was expected to steadily increase at an annual rate of approximately 7%, the development of new generating capacity was a vital requirement for WB.

The construction of the BkTPS was planned in the mid-1980's as a thermal power station

[3] These figures are for 1992.

located near a coal field to provide the base load. In addition, the Purulia Pumped Storage Power Station (900 MW) to meet the peak demand was planned in the western part of WB and it was planned to use the surplus electricity at off-peak time for the pumping up of water. In view of the overall situation of WB, the relevance of the project at the time of appraisal was judged to be extremely high.

2.1.2 Relevance at the Time of Ex-Post Evaluation

Under India's current 10th Five Year Plan (2002 – 2007), the electric power sector remains a vital sector with 16% of the budget being allocated to this sector. Although the overall power shortage at peak demand times has fallen compared to at the time of appraisal, the shortages still continue (2.4% on the generated electric energy basis and 2.2% on the peak demand power basis) during April 2006 to March 2007.[4]

Meanwhile, the power shortage in WB has substantially improved because of the addition of new generating facilities, including those under the project, improvement of Plant Load Factor (PLF) and reduction of the transmission and distribution losses. Even though a supply shortage of several percent still continues, there was room to sell surplus electricity during off-peak hours to other states in 2002.[5] Continual enhancement of the generating capacity, however, is required to maintain a stable power supply as the power demand and the peak demand are expected to increase at an annual rate of 7.1% and 5.2% respectively in the next 10 years.

At the BkTPS, Unit No. 4 and Unit No. 5 (210 MW each) are expected to be commissioned by 2007 following the commissioning of three units under the project. The installation of Unit No. 6 (600 MW) is also planned. The commissioning of the Purulia Pumped Storage Power Station is expected to take place by 2007 and it has been agreed that the BkTPS will provide surplus electricity at night for the pumping up of water at the latter.

It is believed that the project will continue to play a vital role in the coming years to maintain a stable power supply in WB where the power demand is continually rising and also to enable the sale of power to other states where the power shortage is much more severe than that in WB.

In view of the above situation, the project is judged to maintain a high level of relevance at the time of the ex-post evaluation.

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4 Power Supply Position, Central Electricity Authority, Government of India, 2007.

5 The large income (Rs 10 billion in 2005) from the sale of electricity has not only been reinvested in electric power sector infrastructure but has also contained the rise of the electricity charge. The power supply and demand situation in WB is described in more detail in 2.3.2.

2.2 Efficiency

2.2.1 Outputs

Under the project, a thermal power plant with a total output of 630 MW and new transmission lines for connection with the existing transmission grid were constructed as originally planned, even though the fly ash utilization plant was cancelled.

From left to right: stack for Units No.1 & 2, stack for Unit No.3 and stack for Units No.4 & 5 (under construction)

In 1997, bottom discharge wagons, a wagon tippler and a hydrogen generation plant were added (at the time of the Phase 2 appraisal of the project) to ensure the independent and uninterrupted operation of the power station without relying on external companies. A training facility equipped with a simulator for generator control room operation was also added, primarily for the technical training of the staff at this power station, and has subsequently proved to be a useful facility which is regularly used for staff training by other power utilities throughout India.[6]

Although the original plan included the construction of a plant to utilise the fly ash produced by the power station to make cement, bricks and aggregates,[7] the market for these products was found to be premature by the subsequent detailed study. As a result, this plan was cancelled. However, as products made of fly ash became popular in later years, fly ash from the BkTPS has been supplied to several external companies since 2003 at a low price as the raw material for such products. The utilization rate of fly ash exceeded 60% in 2005 and it is expected to reach 100% in several years' time. It can be said that the decision to cancel the construction of a fly ash utilisation plant has led to the realisation of fly ash utilization which is a less risky option for this power plant.

The raw water required for power generation primarily comes from the Tilpara Reservoir located 15 km away. The Bakreswar Reservoir (storage volume of 2.29 million m^3 and covering a maximum area of 10 km^2; outside the scope of the yen loan) has been constructed at a site some 3 km northwest of the power station as a back-up reservoir to supply raw water for a period of three months when water from the Tilpara Reservoir cannot be used.

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6 This training centre has accommodation facilities and provides more than 30 training courses, each lasting 2 – 20 weeks, a year. In 2005, it received more than 300 trainees from all over India.

7 Because of the policy adopted by the Indian Ministry of Environment and Forests, coal-fired thermal power stations are obliged to achieve the 100% re-use of dry fly ash within nine years of the time of commissioning.

Training using the simulator

Loading of fly ash to a transporter

2.2.2 Project Period

At the BkTPS, the installation of Unit No. 3 was completed in March, 2001 after a delay of six months compared to the original schedule at the time of appraisal and full-scale operation commenced. This delay was caused by extensive damage to the railway tracks and roads used for the transportation of the equipment and materials by major flooding of the area in 2000. For the record, Unit No. 1 was completed six months earlier than the original schedule at the time of appraisal which was a national record for the fastest installation of a generating unit compared to the original schedule. The procurement of the wagon tripper was delayed by 36 months compared to the original schedule at the time of appraisal. As this facility was planned as a reserve facility for bottom discharge wagons, the delay did not affect the commissioning of the generating unit. The overall completion of the project (i.e. commissioning of all three units) in March, 2001 meant a delay of six months compared to the original schedule at the time of appraisal and the total project implementation period of 74 months was 109% of the original project implementation period.

Table 1 Original Schedule and Actual Results for Commissioning of Generating Units

	At the Time of Appraisal	Actual Result
Unit No. 1	November, 1999	June, 1999
Unit No. 2	May, 2000	May, 2000
Unit No. 3	September, 2000	March, 2001

2.2.3 Project Cost

The total project cost was contained to ¥93.7 billion (82% of the original plan) as a result of the competitive bidding.

2.2.4 Overall Evaluation of Efficiency

In view of the above-mentioned commissioning results and cost performance, the efficiency of project implementation is judged to be extremely high.

2.3 Effectiveness

2.3.1 Power Generation Operation of Bakreswar Thermal Power Station

The overall plant availability factor at the BkTPS has been high even though the availability factor for Unit No. 2 temporarily dropped because of checking and rectification of the increased vibration of the turbines after its overhaul in 2004. Unit No. 3 recorded continual operation for 452 days, achieving the national record. The average availability factor for the five transmission lines is sufficiently high at 97.5% (2005).[8]

Since the commissioning of Unit No. 3 in March, 2001, the Bakreswar TPS has achieved a maximum output level (the maximum recorded so far was 670 MW in 2002) which exceeds the design generating capacity.

Both the plant load factor and annual power generation have continually exceeded the planned figures since 2001/02. In 2006/07, plant load factor reached very high level of 89.0% and annual power generation was higher than the target level by 30%.

The auxiliary power ratio was comparatively high until operation at the power plant became stable but subsequently improved to achieve the target in 2005/06. The ex-bus power generation (i.e. electric energy generated and actually sent to the transmission grid) exceeded the planned value in 2002/03 for the first time and achieved 4,454 GWh in 2005/06 which was 30% above the planned value.

[8] Power evacuation will not be disturbed even if some lines become non-operational, as the power evacuation capacity is planned to take of credible contingencies.

Table 2　Actual Operation Results for Bakreswar Thermal Power Station

(Source : WBPDCL)

	Plant Availability Factor	Maximum Output	Plant Load Factor	Annual Power Generation	Auxiliary Power Ratio	Ex-Bus Power Generation
Plan at Time of Appraisal	80.0 % (Note)	630 MW	68.5 %	3,780 GWh	9.5 %	3,421GWh
2000/01	50.2 %	-	63.9 %	1,274 GWh	12.4 %	1,117 GWh
2001/02	73.7 %	-	69.2 %	3,147 GWh	10.6 %	2,814 GWh
2002/03	83.0 %	670 MW	72.9 %	4,023 GWh	10.0 %	3,619 GWh
2003/04	91.8 %	647 MW	78.2 %	4,325 GWh	9.7 %	3,905 GWh
2004/05	83.0 %	645 MW	75.7 %	4,175 GWh	9.8 %	3,764 GWh
2005/06	87.6 %	636 MW	79.3 %	4,374 GWh	9.5 %	3,953 GWh
2006/07	93.2%	640 MW	89.0%	4,913GWh	9.3%	4,454 GWh

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

(The planned plant availability factor of 80% is the standard factor set forth by the Gov. of India.)

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

Auxiliary power ratio (%) = (annual auxiliary power consumption/annual power generation) x 100

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

All of the indicators for the generating efficiency, such as the station heat rate, specific coal consumption, specific oil consumption and DM water consumption are found to be better than that of their respective design values, indicating efficient power generation. The unit-wise cost of generation, excluding the depreciation cost and interest paid at Rs 1.27/KWh in 2005 was the lowest among the four thermal power plants owned by the WBPDCL.

Because of such excellent operation results, the BkTPS received a Meritorious Award for Low Oil Consumption and a Silver Shield for Overall Performance from the Government of India in 2003. The plant also received an Environmental Excellence Award from the Government of WB in 2002, 2003 and 2005.

Irrigated rice cultivation adjacent to the power plant

Night scene of the power plant reflected in the drainage basin

2.3.2 Contribution to Power Supply in West Bengal

According to the reference materials used for the appraisal in June, 1994, WB experienced a power shortage of 8.4% and a peak time supply shortage of 22.5% in 1991. In the early 1990's, Kolkata experienced several power cuts totalling some 10 hours a day.

Table 3 Power Demand – Supply Balance in WB

FY	Energy Surplus	Peak Energy Surplus
1998	2.8 %	-5.8 %
1999	1.9 %	-6.4 %
2000	0.9 %	-4.7 %
2001	-0.5 %	-5.5 %
2002	-1.5 %	-8.9 %
2003	-2.2 %	-4.8 %
2004	-1.6 %	-3.7 %
2005	-1.7 %	-3.0 %

Source: Central Electricity Authority

Since the end of the 1990's, the power shortage in WB has been considerably reduced compared to the early years of the decade (see Table 3). Load shedding is still necessary when the balance between the power supply and demand is tight. However, Kolkata today experiences a power cut once or twice a week lasting for a maximum of some 30 minutes a time at most.[9] Even though the power demand in WB has continued to rapidly increase, the peak time shortage is likely to be eliminated for a while once Unit No. 4 and Unit No. 5 (420 MW) at the BkTPS and the Purulia Pumped Storage Power Plant begin operation by the end of 2007.

Since its commercial operation, the Bakreswar TPS has been supplying up to some 18% of the power demand and peak time power demand in WB, playing an important role to ensure a stable power supply in WB in recent years (see Fig. 1 and Fig. 2).

2.3.3 Re-Calculation of Financial Internal Rate of Return (FIRR)

At the time of appraisal, the financial internal rate of return (FIRR) was calculated using the sales revenue of the generated electric energy as a result of the project as the benefit and the construction cost, maintenance cost and fuel cost under the project as the cost and the project life of 25 years. This calculation produced a FIRR of 0.6%. However, re-calculation using the same conditions for the present evaluation produced a FIRR of 8.3%. The reason for the improved FIRR are the lower construction cost, higher electric energy generated, higher unit sales price of electricity and lower fuel cost than the corresponding figures estimated at the time

9 According to the results of interviews with residents and companies in Kolkata, the power cut situation was drastically improved some five years ago when the operation of the Bakreswar TPS commenced.

of appraisal.

Fig. 1 Energy Requirement / Energy Availability in WB and Energy Supply by BkTPS
(Sources: CEA and WBPDCL)

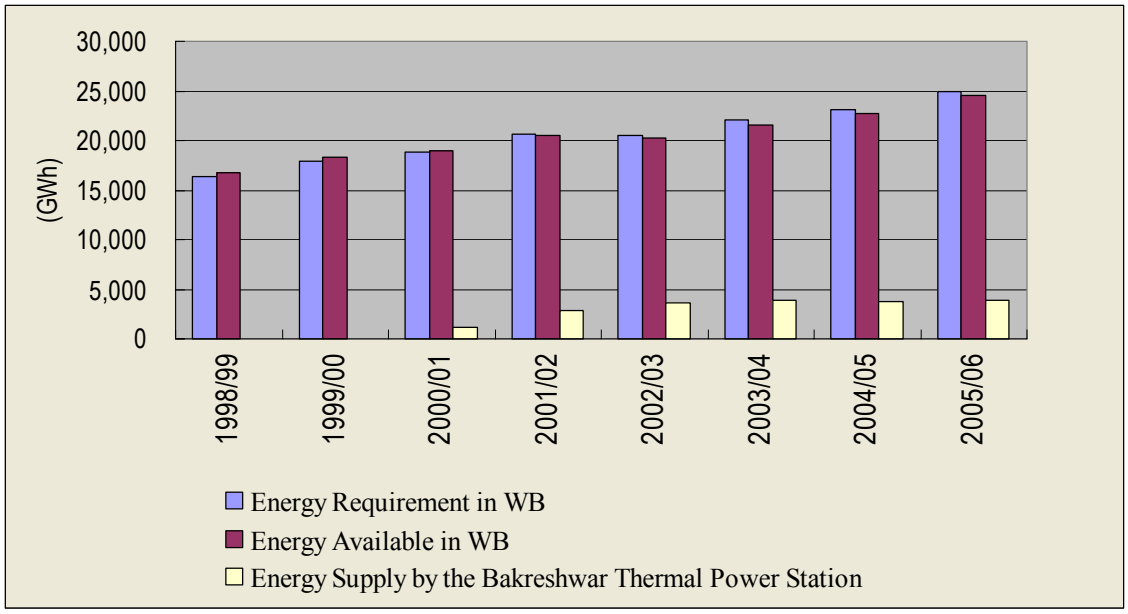
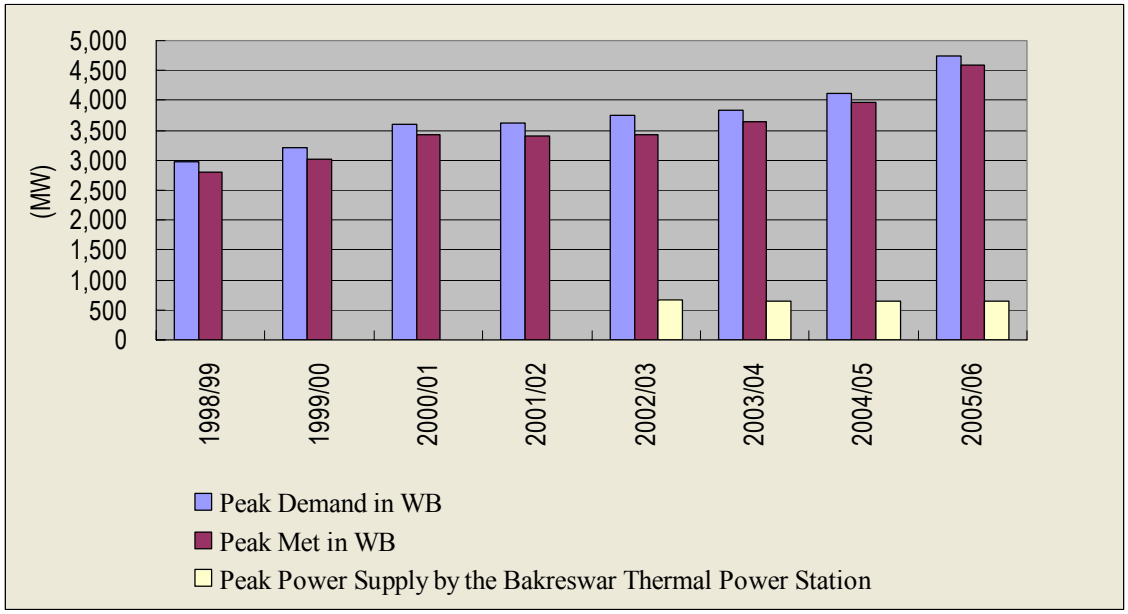


Fig. 2 Peak Demand / Peak Met in WB and Peak Power Supply by BkTPS
(Sources: CEA and WBPDCL)



2.3.4 Conclusions

Both the plant availability factor and plant load factor of the project have been quite high and

the power generation and ex-bus power generation for the four year period from 2002/03 to 2006/07 exceeded the planned figures by approximately 15%. During this period, the BkTPS supplied nearly 20% of the power demand as well as the peak time power demand in WB, playing a crucial role in the stabilisation of the state's power supply. Accordingly, the objective of the project has been sufficiently achieved and the effectiveness of the project is judged to be very high.

2.4 Impacts

2.4.1 Impacts on the Promotion of Industries

In the 1960's, WB was ranked second among the states in India in terms of industrial output. However, since the introduction of a policy emphasising agricultural development by the state government in the 1980's, investment in the industrial sector in WB became sluggish because of excessive manpower, frequent labour disputes and the lack of the development of such infrastructure as roads and electricity supply. Consequently, many companies moved to other states. Even though the industrial sector showed an annual growth rate of 7% nationwide, the industrial sector in WB became stagnant with its share in the national industrial production falling by 50% in the 15 year period up to 1995. In subsequent years, however, the industrial sector regained an annual growth rate of nearly 6%, primarily because of the high growth of informal manufacturing industries in urban as well as rural areas.[10]

The present administration which came to office in 2001 has adopted a policy of giving industrial development priority through the active promotion of investment while showing strong political commitment to the promotion of industries by means of improving the system to deal with labour disputes and consciously developing the industrial infrastructure. In response, large companies at home and abroad have shown interest in setting up their businesses in the state including special economic zones. In Kolkata, the IT-related industry has achieved rapid growth. As a result, employment in the formal private sector is being restored.[11]

The industrial sector consumes 42% of the total power supply in WB (2004) and the consumption grows at an annual rate of as high as 8.4%. Accordingly, a stable supply of electricity is an important condition for the growth of the industrial sector.

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10 The agricultural sector in WB has recorded high growth since the 1980's due to agrarian reform and highly productive rice cultivation using groundwater irrigation. In the 1990's, the economic growth rate of the state was the second highest among all Indian states as it was supported by the sharp growth of the service sector. In the period from 2001 to 2004, the annual economic growth rate was 7.6% which was much higher than the national growth rate of 5.6%.

11 The number of employees in the formal private sector fell from 10.84 million to 6.92 million in 2002, reflecting the decline of the industrial sector. However, it subsequently recovered to 7.52 million in 2004 as a result of the policy of the present administration of promoting industries.

Table 4 Growth Rate and SDP Share by Sector in WB

	Net SDP Growth Rate (1993 – 2003)	Share of SDP (2003)
Agriculture	3.5 %	27 %
Industry	5.8 %	20 %
Service	9.9 %	53 %
Total	7.1 %	100%

Source: State Government of West Bengal

In fact, power cuts caused by a power shortage have become a rare phenomenon. In addition, voltage fluctuations have been substantially reduced since around 2003 as a successful result of the installation of new transmission facilities and the inter-state operation of the power grid.[12] In 2002, the electricity infrastructure in WB was praised as the best in the country and electricity no longer poses a major problem for the promotion of industries and investment in WB.[13]

As the project has played an important role in stabilising the power supply in WB as described earlier, it has constituted a factor enabling rapid industrial growth in the state in recent years.

2.4.2 Contribution to Improvement of People's Lives Through Electrification

The village electrification rate in WB increased from 79% in 2000 to 91% in 2006 and 100% village electrification in the state is scheduled to be completed in 2008. The household electrification rate of 37.5% at the end of 2003, however, was ranked 13th among India's 18 states, indicating that two-thirds of the state population did not receive power supply.[14] The annual per capita power consumption in 2004 was 414 KWh and it was two thirds of the national average.

The impact of the project on improving the lives of people in WB is indirect through stabilisation of the electricity service. The benefits of this service were enjoyed by some 52 million people (two-thirds) out of the total state population of some 83 million as of the end of

[12] According to a printing ink manufacturing plant (monthly production volume of 1,200 tons) in Kolkata which was visited during the field survey for the present evaluation, it was forced to operate its own independent generator for some 2,000 hours a year in the early 1990's but the annual hours of generator operation have now dropped to approximately 50 hours. This company has a plant in Mumbai (Maharashtra State), Ahmadabad (Gujarat State) and Noida (Uttar Pradesh State) in addition to a plant at the main office in Kolkata. 10 years ago, the power supply situation was the best in Mumbai but the situation in Kolkata is now considered to be the best. The voltage fluctuation (450 V) at the Kolkata plant is the lowest at less than 2 – 3% and the quality of the power is satisfactory.

[13] Gartner of the US and India's NASSCOM (National Association of Software Service Companies) ranked the electricity infrastructure in WB as the highest among Indian states.

[14] In accordance with the universal household electrification policy of the Government of India, the WB state government has adopted a policy of achieving a 100% household electrification rate in 2011. The household electrification rate in WB should have reached 72% in urban areas and 29% in rural areas or some 40% throughout the state in 2006.

2003. There is still much room for the improvement of people's lives through electrification as both the per capita power consumption and household electrification rate in WB are far below the respective national averages.

Table 5 Annual per Capita Power Consumption

	West Bengal	India
2003/04	410.2 KWh	592.0 KWh
2004/05	413.5 KWh	612.5 KWh

Source: All India Electricity Statistics, General Review 2005 and 2006
Central Electricity Authority, Ministry of Power

2.4.3 Impacts on the Project Area

Some 4,500 people were employed short-term as a result of the implementation of the project (approximately 900,000 man-days) and half of these were local residents. Some 1,350 people are employed for the operation of the power stations, one-third of which are local residents. In addition, 80 – 100 local residents are employed from time to time to conduct short-term work, including cleaning of the power station, etc.

A company colony to accommodate 750 households has been constructed adjacent to the power station and this estate has a primary school, a secondary school, a high school, market and a clinic. Nearby villages have experienced an increase of shops, service providers and small manufacturers along with the opening of two new bank branches, illustrating the conspicuous growth of economic activities in the area. It is planned to construct a cement plant to use fly ash from the power station and a further increase of local employment opportunities is hoped for.

Local residents who lost their land because of the construction of the power station and reservoir were compensated in the form of relocation to new settlements and the provision of alternative land, money and/or employment. Three new settlements were established and 107 families moved to these settlements. No major problem was encountered in regard to relocation or compensation.

Moreover, the WBPDCL has been actively assisting socio-economic development and welfare improvement in the area through the various activities listed below around the power station.

- Provision of a free health service at a clinic located at the company colony (drugs are not free)
- Events aimed at raising awareness of the importance of health care and education among local residents and regular eye checks for the elderly in the area
- Acceptance of local children in primary, secondary and high schools located on the company colony and provision of a free school bus service
- Acceptance of local children in addition to those of relocated residents at the primary school built at each newly created settlement

- Improvement of the power wiring and the provision of educational equipment (PCs, etc.) at schools on four sites
- Financial assistance for education for poor households
- Vocational training using the staff training facilities at the company colony (training of electricians and self-help groups and guidance on application for and use of the electricity service etc.)
- Construction of drinking water supply facilities in nearby villages
- Construction of a railway station adjacent to the power station
- Construction of recreational facilities using the park and reservoir and sponsoring of sports meetings

Relocation Settlement

As described above, the WBPDCL has greatly contributed to the development of local communities and has successfully built an extremely good relationship with local residents. This has in turn assisted the smooth construction and operation of the power station.

According to the household survey conducted near the power station,[15] a slight decrease of the agricultural income due to the decrease of the farming land caused by the construction of the power station has been more than compensated by the increase of non-agricultural income.

In villages located within a radius of 2 – 3 km of the power station, more than 30% of the households include someone employed by the power station and the real income of these households has increased by 40 – 50% in the last 10 years. The real income in one village has increased by as much as 80% in 10 years due to the substantial growth of the agricultural income, the main factor for which is irrigation using water from the reservoir and power station. In one village located some 6 km from the power station, there has been a clear increase of the income from waged labour as 10% of the households in the village include someone employed by the power station. In the case of 33 households which moved to a new settlement near the power station as their homes were submerged due to the construction of the reservoir, while their agricultural income has become almost non-existent, more than half include someone employed by the power station. Consequently, the average real income of these households has increased by more than 30% in 10 years.

The household electrification rate in the area is 65% which is much higher than the state average (29%). For most households, the diet has greatly improved compared to 10 years ago. For one-third of households, the expenditure for education and health care has increased by more

[15] Interviews using a questionnaire were conducted at 316 households which were randomly selected from six villages near the power station.

than 50%. As the school enrolment rate for local children has substantially increased, the number of pupils at the nearest schools (secondary and high schools) to the power station has trebled. Almost all of the people interviewed believe that the BkTPS has had a favourable impact on the education of local children while three-quarters believe that there has been a favourable impact on health care.

View of the power station from the reservoir catchment area

Tree planting in the reservoir catchment area

Emissions from the power station are well managed and all of the relevant emission standards are met. As a result, no negative impact on the environment has been found.[16] The catchment area (approximately 100 km^2) of the newly constructed reservoir used to be mostly waste land but the natural environment in this area has been improved due to planting over some 1,350 ha and the construction of irrigation ponds to the extent that water fowl are now seen in the area.[17]

2.5 Sustainability

2.5.1 Sustainability of the Project Operated by the WBPDCL

2.5.1.1 Technical Aspect

Both the plant availability factor and the plant load factor of the WBPDCL have been improving since 2001. Even though the average plant load factor of the four thermal power plants operated by the WBPDCL is not especially high at 59.5% (2005), this is because of the operation of two old power stations which have exceeded their design life. The plant load factor of the two newer power stations, including the BkTPS, is sufficiently high.[18] Given the excellent operating performance of the BkTPS, the technical performance of the WBPDCL is deemed to

16 The power station has received the Environmental Excellence Award from the state government three times since 2002.

17 The planting of trees was conducted by the WBPDCL as part of the power station construction work with the technical assistance of the Forestry Department of the state government. As in the case of the reservoir, the planting work was not included in the scope of the yen loan.

18 The plant load factor by power station in 2005 was 79.0% for the Bakreswar TPS (six years old), 67.0% for the Kologhat TPS (16 years old), 30.0% for the Santaldih TPS (32 years old) and 38.7% for the Bandel TPS (41 years old).

be at a satisfactory level.

Table 6 Plant Availability Factor and Plant Load Factor of the WBPDCL

	Plant Availability Factor	Plant Load Factor
2001	72.6%	50.5%
2002	75.6%	54.8%
2003	75.4%	55.6%
2004	78.7%	59.2%
2005	81.2%	59.5%

2.5.1.2 Institutional Aspect

The WBPDCL is wholly owned by the WB state government and was established in 1985 when it was separated from the WB State Electricity Board (WBSEB). The WBPDCL is responsible for the construction and operation of some thermal power plants in WB and employs 4,028 people (2005).

Among a number of states in India, WB has played a pioneering role in various reforms of the power sector. In 1985, the WB state government privatised the distribution business in Kolkata and conducted the partial restructuring of the WBSEB. In 1998, the state government formulated a power sector reform plan, proposing structural reform which included the unification of thermal power plants and the separation of the power transmission / distribution business. In 2001, the state government signed a memorandum with the central government and has since been proceeding with wide-ranging reforms, including further restructuring of the SEB, rationalisation of the electricity tariff, assured transparency of the tariff system and reduction of the transmission and distribution losses, under the action plan while receiving the financial assistance of the central government.

The performance of the electric power sector in WB is ranked fifth among Indian states[19] and the WBPDCL is believed to have a system to sufficiently ensure the sustainability of the project.

2.5.1.3 Financial Status

Since the completion of the project, the revenue and profit after tax of the WBPDCL have

[19] According to the State Power Sector Performance Ratings (June, 2006) of the Ministry of Power, the financial performance of the WBSEC has been much improved by power sales to other states through the improvement of the transmission and distribution losses and improvement of the electricity charge collection rate, indicating the great achievements of the reform of the distribution sector. Since 2001, the subsidy by the state government has been no longer required. Meanwhile, the structural reform of the finance of the SEB and improvement of the household electrification rate are judged to have been slow. Thereafter, the SEB have been separated into WBSETCL (West Bengal State Electricity Transmission Co. Ltd.) and WBSEDCL (West Bengal State Electricity Distribution Co. Ltd.). The household electrification rate is increasing significantly.

steadily increased (see Table 7). The revenue sharply increased in 2001 because of the transfer of the Bandel TPS and Santaldih TPS (1,010 MW in total) from the SEB. In the three year period from 2003, the profit after tax sharply increased, primarily because delayed payment by the SEB, which is the main customer, has been mostly eliminated.

At present, the WBPDCL is constructing Units No.4, 5 and planning to construct Unit No.6 at the Bakreswar TPS. The plant load factor is expected to increase in the coming years as a result of the opening of new sales outlets other than the SEB. As such, both the sales revenue and profit after tax are expected to maintain the trend of a steady increase, suggesting that a sufficient source of finance will continually be secured for the operation of the facilities constructed under the project.

Table 7 Financial Status of the WBPDCL (Unit: Rs million)

	Revenue from Power Sales	Profit After Tax
2000	9,107	32.7
2001	16,936	70.6
2002	20,097	13.3
2003	21,989	91.3
2004	24,316	104.9
2005	23,306	225.9

Source: WBPDCL

2.5.2 Operation and Maintenance

The vibration of Unit No. 2 which occurred in 2004 fell within the tolerance after six months as its operation was suspended to allow adjustment. The unit has since been operating without any problems. The overall operating performance of the BkTPS has been high as it has fully achieved the planned levels of the operating indicators, including the plant availability factor and plant load factor.

The maintenance of the equipment is conducted by outsiders through 15 maintenance contracts but the original manufacturers may be requested to conduct the overhaul and repair of some equipment. An on-line maintenance and inventory control information system featuring more than 1,000 pieces of equipment has been created in order to prevent the stoppage of operation due to mechanical breakdowns and data has been accumulated to optimise the performance of the maintenance work and the inventory management of spare parts.

The training facility equipped with a simulator has so far not encountered any maintenance problems, partly because of the on-site availability of spare parts. In 2005, this facility earned Rs 7.5 million in training fees and this was used for maintenance work. Meanwhile, the transmission facilities have been transferred to the WBSEB as planned and have been operated

and maintained in an appropriate manner.

With the imminent commissioning of Units No. 4 and No. 5 and the future installation of Unit No. 6 at this power station, the consumption volumes of coal and water are expected to substantially increase in the coming years. Coal is now supplied from the Bengal Emta mine (low quality, low cost) developed by a joint venture in addition to the originally planned Sonepor Bazari open cast mine (high quality, high cost). Since 1998, the coal from these two mines has been mixed for use, making it possible to secure an economical fuel for a long period. In the case of water supply, the recycling of water has fairly reduced the water consumption for power generation from the original plan, enabling the continual supply of the required water from the existing reservoir, etc.

The overall maintenance situation of the facilities constructed under the project has been favourable based on the above evaluation results and continual operation and maintenance in the coming years is judged to be highly feasible.

３．Feedback

3.1 Lessons Learned

- The social and economic welfare activities for local communities near the project site will bring about the understanding and support for the project among local residents, resulting in the smooth implementation and operation of the project.
- The implementation of a baseline survey on the socioeconomy and environment in the surrounding area at the initial stage of the project will enable an accurate assessment of the impacts on the surrounding area and concrete demonstration of such impacts.

3.2 Recommendations

- WBPDCL should compile reference materials on the best practice at the BkTPS, particularly on its excellent social and economic welfare activities to support local communities, so that this important information can be shared with other power utilities.
- WBPDCL should continually improve its plant load factor through the sale of power to the WBSEDCL and other trading avenues.
- WB state government should steadily implement the plan to electrify all households in the state with the target completion year of 2011 so that the benefits of an improving power sector in the state can be widely spread throughout the state.

Comparison of the Original Plan and Actual Performance

Item	Plan	Performance
①Outputs	a) Thermal Power Station (output: 210 MW x 3 units) ・ Main plant (with boiler, turbine, generator and auxiliary facilities) ・ Coal handling facility ・ Water supply and cooling water treatment facility ・ Fly ash utilisation plant ・ Bottom discharge wagons ・ Wagon tippler ・ Hydrogen generation plant ・ Training simulator b) Transmission and transformer facilities ・ Transmission lines 400 kV x Single Circuit : 2 lines 302 km 220 kV x Double Circuit : 3 lines 158 km ・ Expansion of sub- stations: 5 sites c) Consulting services	a) TPS Almost as planned except for the cancellation of the fly ash utilisation plant b) Transmission and transformer facilities Almost as planned c) Consultant service Almost as planned
②Project Period		
Main generator/turbine	July, 1996 – September, 2000	July, 1996 – March, 2001
Auxiliary facilities	August, 1996 – January, 2001	August, 1996 – January, 2003
Transmission and transformer facilities	July, 1996 – August, 1999	July, 1996 – March, 2001
Consultant service	February, 1994 – September, 2000	February, 1994 – June, 2001
③Project Cost		
Foreign currency	¥29,240 million	¥25,717 million
Local currency	¥85,338 million (Rs 25,264 million)	¥68,003 million (Rs 21,251 million)
Total	¥114,578 million	¥93,720 million
ODA loan portion	¥91,107 million	¥77,314 million
Exchange rate	Rs 1 = ¥3.26	Rs 1 = ¥3.20