India

FY2016 Ex-Post Evaluation of Japanese ODA Loan Project

"Purulia Pumped Storage Project (I) (II) (III)"

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0. Summary

In the 1990s, India achieved high economic growth and power demand was increasing along with it. As was the case across India, meeting the peak-time power shortage was an issue in the State of West Bengal. Given such situation, this project was expected to mitigate the shortage in peak-time electricity by constructing a pumped storage with an output of 900 MW and related transmission and substation facilities in Purulia District of West Bengal. From the time of the project appraisal to the ex-post evaluation, the power sector has always held an important position in the development policies of the Government of India and the Government of West Bengal. As in the case at the time of the appraisal, the peak-time power demand is ever increasing at the time of the ex-post evaluation. Therefore, it is necessary to strengthen the power supply capacity hereafter as well. The project objective is consistent with Japan's ODA policy and the relevance of the project is high. Outputs were implemented mostly as planned. With regard to the project cost, because of the fluctuation of the exchange rate during the implementation period, the project was implemented with about 60% of the planned cost. On the other hand, the project period exceeded the plan by 52 months because of the delay in obtaining forest clearance. As a result, the efficiency of the project is fair. Regarding the effectiveness of the project, the operation and effect indicators set at the time of the appraisal have been mostly achieved. A certain degree of impacts is also seen in reducing peak-time power shortage in West Bengal, improving the operational efficiency of coal fired thermal power plants, revitalizing industries through increased power supply, and improving the lives of people. No negative impact has been seen with regard to the natural environment, and the effectiveness and impact of the project are high. No particular problems have been seen in institutional, technical and financial aspects and the current status of the project's operation and maintenance; therefore, the sustainability of the project is high.

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

1. Project Description

Project Location

Purulia Lower Reservoir

1.1 Background

India achieved high economic growth at an annual average of 6–7% in the 1990s, and power demand, which supported the country's economic activities, was increasing along with it. However, shortage of peak-time power supply became a roadblock for industrial development and improving the standard of living. Thus, mitigating the power shortage was an urgent issue across India. Particularly in the State of West Bengal, reducing the gap between peak-time supply and demand was an issue. In the state, the estimated peak-time demand was 2,237 MW in fiscal year (FY) 1992 against the peak-time supply of 2,180 MW, causing power shortage. In the same fiscal year, the estimated electricity requirement was 6,525 GWh but the electricity sold by the West Bengal State Electricity Board was 6,189 GWh. Given such situation, scheduled power cuts were enforced mostly during peak time for two hours a day and affected the lives of the people in the state significantly. In addition, the state's energy mix was not balanced because 95% or more of the state's electricity was supplied by thermal power. This was due to slow development of hydropower while the north-western part of the state was rich in coal.

1.2 Project Outline

The objective of this project is to improve peak-time power supply gap and operational efficiency of coal fired thermal power plants by constructing a pumped storage with the capacity of 900 MW (225 MW x 4 units) with related transmission and substation facilities in Purulia District located about 300 km north-west of Kolkata, in the State of West Bengal, in eastern India, thereby contributing to the improvement of people's lives and economic development of the region.

Loan Approved Amount/ Disbursed Amount	I 20,520 million yen / 20,388 million yen II 23,578 million yen / 23,534 million yen III 17,963 million yen / 13,316 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	I December 1994 / February 1995 II March 2004 / March 2004 III March 2006 / March 2006
Terms and Conditions	Interest Rate 2.6% (I), 1.3% (II and III) Repayment Period 30 years (Grace Period 10 years) Conditions for Procurement General untied
Borrower / Executing Agency	The President of India / West Bengal State Electricity Distribution Company Limited[1]
Project Completion	February 2008
Main Contractor(s) (Over 1 billion yen)	Mitsui & Co., Ltd. (Japan), Mitsubishi Heavy Industries, Ltd. (Japan), Taisei Corporation (Japan), TM T&D Corporation (Japan) / Marubeni Corporation (Japan) (JV), KEC International Ltd. (India), Jyoti Structures Ltd. (India) / Kalpataru Power Transmission Ltd. (India) (JV)
Main Consultant(s) (Over 100 million yen)	Water and Power Consultancy Services (India) Limited (India) / Electric Power Development Co., Ltd (Japan)
Feasibility Studies, etc.	Overseas Economic Cooperation Fund (OECF) provided an Engineering Service (E/S) Loan in 1988.
Related Projects	Japanese ODA Loan ・ Purulia Pumped Storage Project (E/S) (February 1988) ・ Ghatghar Pumped Storage Project (December 1988) ・ Bakreswar Thermal Power Station Construction Project (I) (II) (January 1994, December 1997) ・ Bakreswar Thermal Power Station Unit 3 Extension Project (I) (II) (February 1995, March 1999) ・ Srisailam Left Bank Power Station Project (I) (II) (III) (February 1988, February 1995, December 1997) ・ Bakreswar Thermal Power Station Units Extension Project (March 2003) Asian Development Bank (ADB) ・ Power Sector Reform Project (2003) Department for International Development (DFID) ・ West Bengal Public Sector Enterprise Reform Programme (2004)

[1] The executing agency was originally the West Bengal State Electricity Board. Because of the unbundling in 2007, the project was handed over to West Bengal State Electricity Distribution Company Limited.

2. Outline of the Evaluation Study

2.1 External Evaluators

Yumiko Onishi and Ryujiro Sasao, IC Net Limited

2.2 Duration of Evaluation Study

This ex-post evaluation study was conducted with the following schedule.

Duration of the Study: September 2016 – October 2017

Duration of the Field Study: January 17–25, 2017 and April 10–14, 2017

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

3.1 Relevance (Rating: ③[3])

3.1.1 Consistency with the Development Plan of India

At the time of the Tranche I appraisal in 1995, the Eighth Five-Year Plan (April 1992–March 1997) of the Government of India allocated 18% of the Indian rupees (INR) 4,341 billion public work investment budget to the power sector (budget allocation to the energy sector as whole including the power sector was 26%). Similarly, in the Five-Year Plan of West Bengal, the power sector had a share of about 30% out of the INR 93.3 billion public work investment budget of the state government. At the time of the Tranche II and III appraisals, the priority for the power sector was high and the project was consistent with the development plans of the Government of India and the West Bengal State government.

As explained in the later section "3.1.2 Consistency with the Development Needs of India," at the time of the ex-post evaluation, the gap between peak-time demand and supply has been reduced in West Bengal. However, the Twelfth Five-Year Plan (April 2012–March 2017) still regards the development of new power sources including those for peak load as an important matter. According to West Bengal State Electricity Distribution Co. Ltd (WBSEDCL), the executing agency, the target for the power sector in West Bengal is as follows.

- Twenty-four-hour Power supplies
- Provide access to stable power to all households within 2017
- Developing agricultural feeder to promote agriculture
- Developing adequate power generation to cater for future industrial load growth.

In addition, because this project as a pumped storage contributed to reducing the gap between peak-time demand and supply as originally expected, the State of West Bengal plans to build a new pumped storage with the capacity of 1,000 MW to meet the future peak-time demand. As

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

[3] ③: High, ②: Fair, ①: Low

can be seen, the project is consistent with the development plans of the Government of India and the West Bengal State government at the time of the ex-post evaluation.

3.1.2 Consistency with the Development Needs of India

In West Bengal, both power supply capacity and electricity at peak hours were inadequate because of shortage of power generation facilities, low operational efficiency of thermal power plants, low capacity of coal fired thermal power plants for peak time, and high transmission and distribution losses, all of which were prevalent before the Tranche I appraisal. To solve these issues, it was necessary to secure a balanced energy mix through developing hydropower while reducing the peak-time power supply gap by constructing pumped storage, which corresponds to the peak-time power supply.

Table 1: Power Supply and Demand in West Bengal State

	2009	2010	2011	2012	2013	2014	2015
Peak demand (MW)	5,850	6,162	6,592	6,832	7,180	7,600	7,876
Annual growth rate of peak demand	13.0%	5.3%	7.0%	3.4%	5.1%	5.9%	3.6%
Peak availability (MW)	5,840	6,112	6,532	6,734	7,120	7,540	7,713
Gap between peak-time demand and availability (MW)	▲10	▲50	▲60	▲98	▲60	▲60	▲163
Percentage of gap between peak-time demand and availability	▲0.2%	▲0.8%	▲0.9%	▲1.4%	▲0.8%	▲0.8%	▲2.1%
Electricity requirement (GWh)	33,750	36,481	38,679	44,151	44,935	48,429	49,238
Electricity availability (GWh)	29,415	33,052	33,996	43,762	44,718	48,192	49,055
Annual growth rate of electricity requirement	7.7%	8.1%	6.0%	6.8%	1.8%	7.8%	1.7%
Gap between electricity requirement	▲4,335	▲3,429	▲4,683	▲390	▲217	▲237	▲183

and availability (GWh)							
Percentage of gap between electricity requirement and availability	▲14.7%	▲10.4%	▲13.8%	▲0.9%	▲0.5%	▲0.5%	▲0.4%

Source: Data from FY 2009 to 2011 are from the WBSEDCL Annual Statistics Report and those for FY 2012 onwards are from the Central Electricity Authority.

Table 1 shows the data related to electricity supply and demand for West Bengal from 2009. While peak-time supply capacity has been strengthened, the demand has kept increasing in recent years. Similarly, electricity requirement is also increasing. While power was being purchased from the central government and other state governments to respond to the situation, the average gap between peak-time supply and demand in term of installed capacity from 2009 to 2015 was minus 1%, and the power shortage has been almost resolved. The gap between electricity requirement and availability was minus 14.7% in 2009, but it decreased to minus 0.4% in 2015. Thus, the gap is decreasing. According to WBSEDCL's estimate, the future peak-time demand will continue to grow and it will reach 9,690 MW by 2026. The project meets the peak-time electricity requirement and has been consistent with the development needs of West Bengal from the time of the appraisal to the ex-post evaluation (See "3.4 Impacts" for details).

3.1.3 Consistency with Japan's ODA Policy

At the time of the Tranche I appraisal, development of economic infrastructure was one of the important areas for Japan's ODA policy for India. Particularly, it focused on supporting infrastructure development, mostly power and transport, which was a priority for the Five-Year Plan of India[4]. Thereafter, during the appraisals of the Tranche II and III in 2004 and 2006, development of economic infrastructure was an important area for JICA's Medium-Term Strategy for Overseas Economic Cooperation Operations at the time for India, and the project was consistent with Japan's ODA policy.

As described above, the project has been highly relevant to the development plan and needs of both India and West Bengal, as well as Japan's ODA policy. Therefore, its relevance is high.

[4] From the website of the Ministry of Foreign Affairs of Japan, "Country-wise Development Assistance (1991–1998)."

3.2 Efficiency (Rating:②)

3.2.1 Project Outputs

Table 2 shows the planned and actual outputs of the project.

Table 2: Planned and Actual Outputs

Plan	Actual
① Upper dam and reservoir: rockfill dam, dam height 71 m, dike length 1,505 m, total storage capacity 16.5 million m^3	As planned
② Lower dam and reservoir: rockfill dam, dam height 95 m, dike length 310 m, storage capacity 16 million m^3	As planned
③Penstock: 2 lanes, length 256.57 m, inner diameter 7.7 m	As planned
④ Power station: underground width 22.5 x length 157.0 x height 47.7 m, output 900 MW (225 MWx4 units)	As planned
⑤Switchyard (no details)	Switchyard: above ground, GIS floor area 45 x 152 m
⑥ Transmission: 2 routes Power station – Durgapur Substation: 400 kV, double circuit lines, length 160 km Power station – Arambagh Substation: 400 kV, double circuit lines, length 150 km	Power station – Durgapur Substation: 400 kV, double circuit lines, length 185 km Power station – Arambagh Substation: 400 kV, double circuit lines, length 209 km
⑦ Substations: 2 locations Durgapur Substation: 400 kV, Shunt reactor 4 x 50 MVAR Arambagh Substation: 400 kV, Shunt reactor 4 x 50 MVAR	As planned
⑧ Consulting services: 78 M/M (detailed design)	851 M/M (detailed design, bidding assistance, construction management)

Source: Documents provided by JICA and WBSEDCL

The infrastructure component of the project has been implemented almost as planned. The change from the plan is the length of transmission lines. This change is a result of adjustment at the time of the detailed design based on the situation on the ground.

With regard to consulting services, at the time of the Tranche I appraisal, 78 man/month (M/M) was planned only for detailed design. However, at the time of the Tranche II appraisal, the number of personnel was being reduced as part of the unbundling of the executing agency (see "3.5 Sustainability" for details). Thus, construction management was included in the consulting services although the executing agency had planned to be responsible for it. Therefore, the consulting services amounted to 851 M/M.

At the time of the Tranche III appraisal, as part of assistance for institutional strengthening, the following items were added to the project's scope: a) strengthening of Availability Based Tariff (ABT) system on power trading business among states, b) promotion of Total Quality

Management (TQM), and c) development of a transmission system database. Nevertheless, citing the unbundling of the executing agency was nearing, the additional items were not implemented using the funds from the Japanese ODA Loan. Eventually, a section was set up within WBSEDCL after unbundling and the necessary mechanism for promoting ABT was established. TQM was implemented as part of the routine work of the consulting services mentioned above. The executing agency also took up TQM activities on its own (see "3.5 Sustainability" for details). A database for the transmission system has not been developed by the time of the ex-post evaluation; however, according to WBSEDCL, it is being prepared. The addition of the items above to the scope for institutional strengthening should have been considered carefully in the Tranche III appraisal. However, it was reasonable to exclude them from the project considering the changes surrounding the project.

3.2.2 Project Inputs

3.2.2.1 Project Cost

Table 3 compares the planned project cost from the Tranche I appraisal with the actual one. As shown in the table, the project cost was within the planned amount. Sixty-five percent of the Japanese ODA Loan was used for a dam and other main civil works and procurement of equipment including hydropower related facilities. The funds from the executing agency were spent for tax, land acquisition, and administrative cost.

Table 3: Planned and Actual Project Cost

	Plan	Actual	Actual against Plan
Total project cost	JPY 107,150 million	JPY 60,256 million	56%
Japanese ODA Loan	JPY 88,027 million	JPY 57,238 million	65%

Source: Documents provided by JICA and WBSEDCL

The major reason that the actual project cost was far below the planned one was the substantial fluctuation in the exchange rate during the project period. Between 1995 and 1998, INR 1 was equivalent to around JPY 3, but it became less than JPY 2.5 around 2003 when the project implementation was in full swing. Further, it became less than JPY 2 from 2009. It is difficult to foresee at the time of project planning any fluctuation of the exchange rate; thus, it is fair to say that the project cost was estimated properly. Other reasons that the project cost was reduced include the following: the project was recognized as a Mega Project of the Government of India and received some tax exemptions; and some of the contractors' bidding prices were below the estimated prices.

3.2.2.2 Project Period

According to the Tranche I and II appraisals, the completion of this project was defined as beginning of commercial operation of all four units. As the institutional strengthening component was added in the Tranche III appraisal, project completion was then defined as the completion of the activities related to the component. However, as described earlier, institutional strengthening was not implemented in the project. Therefore, as defined originally, start of commercial operation means project completion. At the time of the Tranche I appraisal, the planned project period was 105 months between the Loan Agreement (L/A) scheduled in July 1994 and March 2003.

The actual L/A was in February 1995, and Unit 1 to 4 became commercially operational in January 2008, February 2008, November 2007 and October 2007 respectively. The project completion was February 2008, making the project period 157 months (i.e., 150% of the plan). It means that there was a delay of 52 months from the original plan. The biggest reason is that it took time for processing of acquiring forest land (forest clearance) needed for construction of various project facilities. Out of total 373 ha of the forest land required for the project, 233 ha was provided based on the clearance from the Ministry of Environment and Forest. However, no clearance was given for the remaining 140 ha until 2002. Forest clearance is administered by the Ministry of Environment and Forest and it would have been difficult for the executing agency to avoid delays arising out of this process. While awaiting forest clearance, the project tried to reduce the delay by proceeding with the bidding process and part of the preparatory civil works. The main civil work was scheduled to take 75 months, but it actually took 60 months. The project also tried to reduce the project period even after obtaining the clearance.

3.2.3 Results of Calculations for Internal Rates of Return (Reference only)

Table 4 shows the internal rate of return (IRR) of the project calculated at the times of the appraisal and the ex-post evaluation along with assumptions. The IRR calculated at the time of the appraisal is from Tranche III. The IRR at the time of the ex-post evaluation was recalculated using the same assumptions as the ones used for the appraisal.

Table 4: IRR and Assumptions

	Financial IRR	Economic IRR
IRR	Appraisal: 5.3% Ex-post evaluation: 11.1%	Appraisal: 10.4% Ex-post evaluation: 9.1%
Cost	Project cost, operation and maintenance cost, cost of pumped-storage power generation	Project cost (excluding taxes), operation and maintenance cost, cost of pumped-storage power generation
Benefit	Revenue from sale of energy	Savings on purchasing alternative energy
Project life	25 years	

Financial Internal Rate of Return (FIRR)

The main reason that the FIRR became higher at the time of the ex-post evaluation was as follows: the cost applied for calculating FIRR was only about 40% of the amount estimated at the time of the appraisal both because the project cost was reduced by the exchange fluctuation, and because the amount of energy used for pumping water during off-peak hours was less than what was estimated. In addition, with regard to benefit, the sales tariff for electricity was INR 4.20/KWh at the time of the appraisal; however, it was INR 5.41/KWh (average of 2008–2016) at the time of the ex-post evaluation, contributing to the higher FIRR.

Economic Internal Rate of Return (EIRR)

For calculating EIRR, although taxes are excluded from the project cost, the calculation of cost is basically the same as in the case of FIRR. Thus, when recalculated at the time of the ex-post evaluation, the cost has become about 40% of the amount calculated at the time of the appraisal. Benefit is the saving from alternative energy purchase replaced by power generated by the Purulia Pumped Storage Power Station. For calculating the cost of alternative energy purchased, the actual power generated from the Purulia Pumped Storage Power Station was used until 2016. Thereafter, it was calculated using 1,515 GWh/year, which is the expected power generation from the project. EIRR has become slightly less than the estimate at the time of the appraisal because of less power generation than the plan and the tariff for power purchase has become INR 3.53/KWh (average of 2008–2016) instead of INR 4.20/KWh at the time of the appraisal.

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

3.3 Effectiveness[5] (Rating: ③)

3.3.1 Quantitative Effects (Operation and Effect Indicators)

Effectiveness has been evaluated with an emphasis on the operation and effect indicators that were established at the time of the Tranche II appraisal[6]. Table 5 shows the target and actual operation and effect indicators for the project. For the project, the target year is fixed as two years after the project completion; therefore, figures from 2010, which is two years after the project completion, were used for evaluating the level of achievement.

Table 5: Target and Actual Figures for Operation and Effect Indicators

	Target	Actual		
	2010	2008	2009	2010
	2 Years after Completion	Completion Year	1 Year after Completion	2 Years after Completion
Unplanned outage hours (hours/year)	258	5	73	892
Planned outage hours for inspection and repair (hours/year)	42	2	0	41
Comprehensive circulating efficiency (%)	75.5	77.9	78.0	77.7
Net electric energy production (GWh/year)	700	668	863	872
Maximum output (MW)	900	900	900	900

Source: Documents provided by JICA and questionnaire survey to the executing agency

The target for unplanned outage hours, one of the operation indicators, was fixed at a total of 258 hours including 168 hours of mechanical failure, 0 hours of human error, and 90 hours caused by other factors. The actual figure in 2010 is 892 hours, which is 3.5 times the target. The ones in 2011 and 2012 are also 355 hours and 672 hours respectively, significantly exceeding the target. This was caused by unexpected breakdown of generators and turbines and the significant amount of time that it took to repair them. According to WBSEDCL, all the unplanned outage hours were caused by mechanical failures. Planned outage hours for inspection and repair in 2010 were within the target. However, after 2010, because of overhaul, it has significantly exceeded the target at 198 hours in 2011 and 795 hours in 2013 (see Table 6). Comprehensive circulating efficiency, which is an indicator to determine the performance of the power plant, has been in line with the target.

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

[6] Operation and effect indicators were set at the time of the Tranche II appraisal since they were not set at the time of the Tranche I appraisal.

Table 6: Actual Outage Hours of Purulia Pumped Storage Power Plant

Unite: hours/year

	2011	2012	2013	2014	2015
Unplanned outage hours	355	627	5	108	405
Planned outage hours for inspection and repair	198	40	795	602	109

Source: WBSEDCL

At the time of the Tranche II appraisal in 2004, the Purulia Pumped Storage Power Plant was to be connected to the regional grid once its operation started. Therefore, the target for net electric energy production was fixed at 1,721.4 GWh/year. However, the national grid was introduced gradually in India, and the power plant was connected to the national grid by the time of the project completion. In India, the Central Electricity Authority (CEA) determines annually the amount of power to be generated by each power plant. Based on this generation plan and instructions from the Regional Load Despatch Center, the power plants generate power. The Purulia Pumped Storage Power Plant must also comply with the CEA's plan instead of generating power according to its own decision. Thus, it seemed appropriate to use the net electric energy production determined by the CEA for the Purulia Pumped Storage Power Plant, and compare actual figures with the target set by the CEA. As a result, the target was achieved in 2010. As shown in Table 7, the project met the target of net electric energy production since 2010 with the exception of 2015.

Table 7: Net Electric Energy Production of Purulia Pumped Storage Power Plant

Unit: GWh/year

	2010	2011	2012	2013	2014	2015
Target	700	700	700	700	1,200	1,200
Actual	872	759	791	778	1,408	1,048

Source: WBSEDCL

In addition, data on the capacity and availability factors of the Purulia Pumped Storage Power Plant were collected as reference indicators. Table 8 shows annual data for these indicators. The capacity factor has no baseline figure for comparison. Regarding the availability factor, the national average of hydropower plants published by the CEA in 2015 was 87.9%, and the Purulia Pumped Storage Power Plant has been maintaining it above the average in the past.

Table 8: Capacity Factor and Availability Factor[7]

Unit: %

	2008	2009	2010	2011	2012	2013	2014	2015
Capacity factor	39	50	51	44	46	45	82	61
Availability factor	97	100	99	93	93	91	92	77

Source: WBSEDCL

The project has achieved four out of the five operation and effect indicators. Particularly, the net electric energy production meets the instruction given by the CEA. Thus, it is fair to say the project is generating the expected effects.

3.3.2 Qualitative Effects (Other Effects)

It is fair to say that, based on their content, qualitative effects expected at the time of the appraisal are impacts. Therefore, they are evaluated as impacts in the following section.

3.4 Impacts

3.4.1 Intended Impacts

The intended impacts of the project were as follows: a) reducing peak-time power shortage in West Bengal; b) improving the operational efficiency of nearby coal-fired thermal power plants; c) revitalizing industries by increased power supply; and d) improving the lives of people[8].

a) Reducing peak-time power shortage in West Bengal

Power generated from the project is limited when it is seen against the total electricity availability in West Bengal State. However, as shown in Table 1 regarding the peak-time power demand supply situation of the state, there was 163 MW of peak-time power shortage in 2015. The project has the maximum output of 900 MW and holds about 12% of peak-time output for West Bengal in recent years. Accordingly, it can be said that the project's supply capacity holds an important position.

b) Improving the operational efficiency of nearby coal-fired thermal power plants

Regarding improvement of the operation efficiency for coal-fired thermal power plants, it was assumed to use the power generated from Units 4 and 5 of the Bakreswar Thermal Power Station, which was under construction at the time of the appraisal, for pumping water for the Purulia Pumped Storage Power Plant. However, in reality, the power from the Bakreswar Thermal Power Station is not directly supplied to the Purulia Pumped Storage Power Plant for

[7] WBSEDCL calculates the factors as follows: capacity factor (%) = annual net electric energy production / maximum electric energy production x 100; and availability factor (%) = number of days operated / 365 days x 100.

[8] At the time of the appraisal, it was "improving the lives of people through revitalization of industries." Because it is difficult to identify the direct contribution of the project to industrial revitalization, it has been changed to improving the lives of people through electrification.

pumping. The power is supplied through the grid; thus, it is not appropriate to take a specific thermal power plant's capacity factor and other data to explain the improvement in the operational efficiency resulted from the project. For reference, the recent average capacity factor of five thermal power plants belonging to the same regional grid with the project is compared to multiple thermal power plants that the executing agency was operating in 1992. The average of these multiple thermal power plants was 28.7% and there was a significant improvement as shown in Table 9.

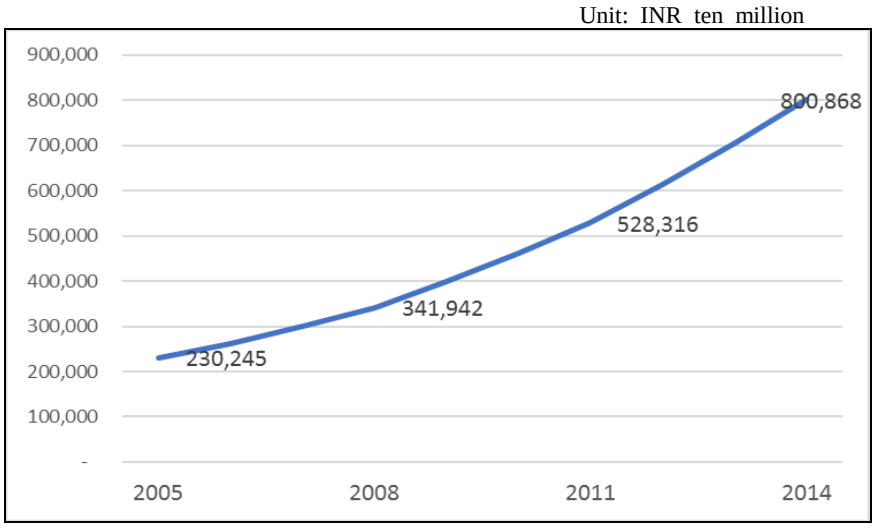
Table 9: Capacity Factor of Thermal Power Plants Belonging to the Same Grid as the Project

Thermal Power Plant	Average Capacity Factor (2007–2015)
Bakreswar	83%
Kolaghat	64%
Bandel	45%
Santaldih	58%
Sagardighi	67%

Source: WBSEDCL

c) Revitalizing industries through increased power supply

Figure 1 shows changes in GDP of West Bengal State between 2005 and 2014. Although it is difficult to specify the direct contribution from the project, it gives an indication that the state's economy has been growing in a stable manner.



Source: West Bengal State Government

Figure 1: Changes in GDP of West Bengal State

In addition, at the time of the ex-post evaluation, interviews with 10 business units[9] were conducted in the town of Baghmundi in Purulia District, the project site. All the business units interviewed felt that the power supply became stable from around 2004. Although it is not the direct impact from the project, because of electrification in the area and stable power supply, they also felt that becoming able to operate after the sunset was a major improvement. Moreover, there seemed to be a temporary boost in the local economy because many project-related people came from outside and spent money and the local residents were employed by the project during the implementation.

d) Improving the lives of people

It is difficult to specify the geographical areas benefited by the project because the power generated from the project is supplied to the national grid. In addition, it is difficult to determine the project's direct contribution to industrial revitalization. Therefore, in the ex-post evaluation, the changes in living standards of the local residents that arose from power generation (i.e., electrification) was surveyed. The Baghmundi area was electrified prior to the project and the project did not establish any distribution network in this area. By contrast, the rate of electrification in Purulia district increased from 64.2% in 2001 to 99.9% since 2012. To confirm the changes in living standards of the electrified households in the area, a rapid beneficiary survey was conducted covering the households electrified since 2007 in the project site[10]. In the area, there is a large Scheduled Tribe population and eight out of the ten households surveyed were below the poverty line. Therefore, although they are electrified, these households had only bulbs for lighting and none of them owned electric appliances such as TV and refrigerator. Under such circumstances, they felt the biggest impact of electrification has been the fact that children can study after the sunset. Some of the women felt that their income increased a little because they became able to do handiwork even after the sunset.

Figure 2: Settlement in the Project Site

Figure 3: Compensatory Afforestation Site

[9] Besides companies, it includes unregistered businesses and shops run by individuals.
[10] Households for the survey were selected from electrified houses with someone at home starting from the house located at the center of villages close to Baghmundi by moving away from the main road. Two households were selected in each of the five target villages.

3.4.2 Other Positive and Negative Impacts

a) Impacts on the Natural Environment

The project site is situated at the edge of Ayodha Hills, which is a habitat for some of the protected species in India including Indian Elephants. According to the survey conducted by the Indian Zoological Survey at the time of the project planning, the area was reportedly not an important habitat for the protected species.

The project was implemented after obtaining the environmental and forest clearances of the Government of India. To monitor the impact on the natural environment during the project implementation, the Environmental Monitoring Committee was established in 1996. Among the committee members were the state's Forest Department, Environment Department, Schedule Tribe Development Department, and Power Department. Until 2007, the year of the construction completion, the executing agency reported to the committee every six months the situation on noise, vibration, soil quality, air quality, water quality and flora and fauna of the target area. No particular problem was reported during the monitoring by the committee. According to WBSEDCL, until 2016, the committee conducted site surveys including during the operational phase when needed.

Regarding the forest land acquired from the state government for the construction of project facilities, it was obligatory to afforest an alternative area of the same size. By the site survey conducted at the time of the ex-post evaluation and through documents, it was confirmed that the Forest Department did compensatory afforestation in the same size of acquired land for 373 ha. Moreover, as part of environmental consideration, the Forest Department was to construct water holes for the wild animals, establish a corridor for migration between the upper and lower dams, develop fodder, and implement watershed management. According to the interview with the Forest Department, because the corridor between the upper and lower dams existed prior to the project, new one was not established; the Forest Department undertook other measures mentioned above. Fodder development and watershed management was implemented originally around 2001 by the Forest Department. Measures, such as soil conservation, that require maintenance were later taken up by other government schemes. Monitoring of siltation is conducted at intake point from the Kistbazaar River. Transmission lines established by the project are not passing through the protected area or the habitats of rare species; thus, no unintended negative impact on the environment was confirmed.

In a rapid beneficiary survey conducted at the time of the ex-post evaluation, the situation on air quality, water quality, waste, noise, vibration and odour during and after the project was investigated. The figure below shows the results on beneficiaries' views regarding the situation during the construction phase.

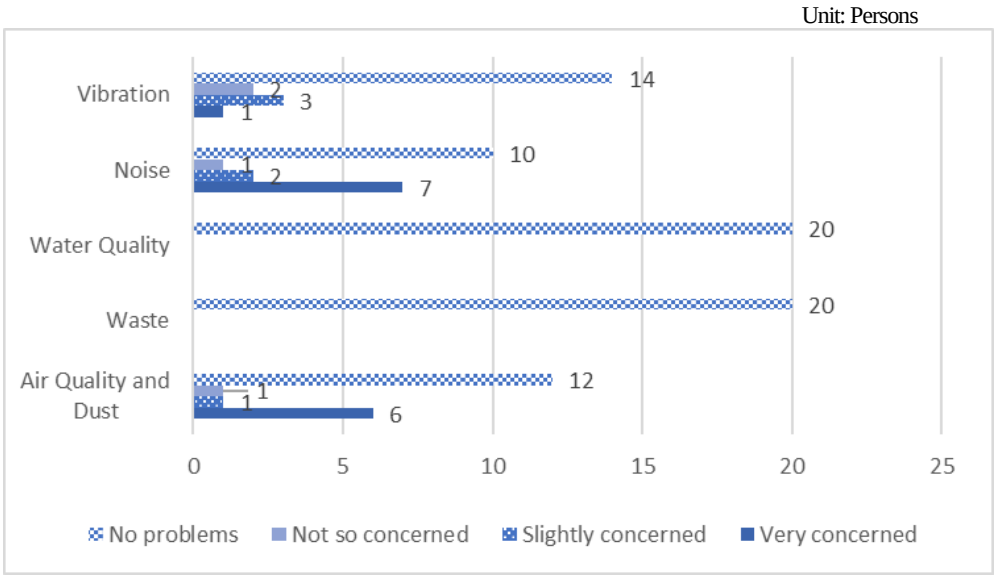


Figure 4: Beneficiaries' Views on Environment during the Construction Phase

There was a little variation in responses on the situation on vibration, noise and air quality and dust. Mainly the households close to the upper dam were concerned about noise and dust around the construction site and vibration caused by dynamite. No health-related issues arising out of noise and dust were reported. As all the respondents said 'there are no issues' for all these parameters after the project completion, it is fair to say there is no specific problem now. For filing complaints against the project, no specific system was established in the project. At the same time, in interviews with local residents, they stated that, if there were problems, they would be able to bring their concerns to the executing agency either directly or through local politicians and administrations.

b) Land Acquisition and Resettlement

For the project, in addition to the 373 ha of forest land, 24 ha of private land and 28 ha of government land were acquired, making the total of 425 ha. No resettlement occurred. The private land acquired from local residents had been used mainly as agriculture land. For acquisition of private land, compensation was paid to the affected households through district administration office by adding30% to the market price at that time in accordance with the Land Acquisition Act of India. In 2004, the executing agency conducted a survey on the affected households to check the situation on their livelihood. However, since 2004, no similar survey to monitor the situation was done. According to interviews with three of the affected households at the time of the ex-post evaluation, they opined that parting with the agriculture land posed a burden on the household income. However, they also seemed satisfied with the compensation given for the land.

c) Unintended Positive/Negative Impact

The upper and lower dams constructed by the project are discharging water to the existing Loharia dam downstream. According to WBSEDCL and the Irrigation Department, the completion of the Purulia upper and lower dams resulted in stable supply of irrigation water. Particularly, cropping areas during the dry season seem to have increased slightly. However, the changes in the volume of irrigation water and agricultural outputs before and after the project in the irrigated villages could not be confirmed quantitatively.

In addition, as the project was situated at the edge of Ayodha Hills, after the construction of the dams, local tourists using the project area as a gateway for Ayodha Hill tourism increased. Because of the increase in the number of visitors, stalls selling souvenirs and snacks were set up around the upper dam. However, according to residents in the area nearby, the people who run the stalls came from other areas. The dumping of garbage by visitors appeared to be damaging the landscape as well.

The project has largely achieved its objectives. Therefore, the effectiveness and impact of the project are high.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

At the time of the Tranche I appraisal, the executing agency for the project was the West Bengal State Electricity Board (WBSEB), which was established in 1955 in accordance with the Electricity Supply Act of 1948. It was responsible for generation, transmission and distribution of power in the State under the West Bengal Power Department. Thermal power plants were already transferred to the West Bengal Power Development Corporation established in 1985. As part of the power sector reform implemented by the state government, West Bengal Rural Energy Development Corporation was established in 1998, and electrification and power distribution in the rural areas were being transferred to the corporation. In 2007, because of the unbundling, WBSEB was divided into West Bengal State Electricity Distribution Company Limited (WBSEDCL) and West Bengal Sate Electricity Transmission Corporation Ltd. The project was transferred to WBSEDCL.

According to the plan of the Tranche III appraisal prior to the unbundling, the Purulia Pumped Storage Power Plant was to be manned by 164 personnel for its operation and maintenance. Table 10 indicates the planned staffing, sanctioned posts and actual deployment at the time of the ex-post evaluation.

Table 10: Operation and Maintenance Staffing for the Project

	Plan (2006)	Sanctioned	Deployed
		(As of December 2016)	
Engineer	82	29	49
Technical staff	50	70	43
Professional staff (excluding engineers)	12	17	10
Non-technical staff	20	19	21
Total	164	135	123

Source: WBSEDCL

The number of operation and maintenance personnel planned at the time of the Tranche III appraisal was 164, which took the unbundling into consideration. This has included the personnel for maintenance as well. However, maintenance is actually outsourced, and the total number of personnel deployed indicated in Table 10 does not include the maintenance personnel. The number of outsourced personnel is approximately 34; if this is added to the deployed personnel, the actual staffing is almost in line with the plan. According to WBSEDCL, there was temporary shortage of staff immediately after the unbundling; however, currently, the institution as a whole faces no issues caused by the unbundling.

For operation and maintenance of the Purulia Pumped Storage, the necessary number of personnel is secured, and there is no problem on institutional aspects of operation and maintenance.

3.5.2 Technical Aspects of Operation and Maintenance

Table 11 shows the level of education required for personnel engaged in operation and maintenance of the project and the actual education level of deployed personnel. The personnel engaged in the operation and maintenance of the project have the required educational background.

Table 11: Educational Level of Operation and Maintenance Staff

	Required Education	Education of Deployed Staff
Engineer	Graduate Engineer	M-tech, Graduate Engineer
Other technical staff	Diploma, ITI	Graduate Engineer, Diploma, ITI
Professional staff (excluding engineers)	Chattered and Cost Accountancy, Personal & Business Management	Chattered and Cost Accountancy, Personal & Business Management
Non-technical staff	Graduate	Graduate, Inter Pass

Source: WBSEDCL
Note: Educational level indicated in each cell is listed in order of higher degree from left to right.

In the project, training for operation and maintenance of a power plant and related equipment was conducted during the implementation phase on the site and in Japan. Generally, in

WBSEDCL, regular training is conducted within the institution to maintain and improve the technical standards of the personnel for refresher training and introduction of new technologies. However, training on pumped-storage power generation is not conducted in WBSEDCL; thus, technical skills required for operation and maintenance of the project is acquired through on-the-job training and external training arranged as required. According to WBSEDCL, personnel engaged in the operation and maintenance of the Purulia Pumped Storage possess necessary technical skills and there are no issues with technical aspects.

Manuals on operation and maintenance are prepared for each machinery and equipment. Most of the manuals were prepared by the manufacturers at the time when the power station started operating. Because no need to revise the manuals has been seen, the same manuals have been in use so far. Inspections for generators, turbine and other main equipment are conducted following the schedule prescribed by the manufacturers and the inspection record is also maintained.

For TQM, which was part of the institutional strengthening mentioned in "3.2 Efficiency," the activities are carried out in WBSEDCL separately from the project. To improve the quality of electricity supplied to the consumers, Quality Customer Care Centers (QCCC) were established and 120 QCCC have so far been established across the state. In addition, a helpdesk has been set up in 500 customer care centers and award for good performing QCCC is initiated by holding regular competition among QCCC.

Personnel have necessary education and technical skills. Efforts are made to maintain and improve their technical standards, and there is no problem in technical aspects of operation and maintenance.

3.5.3 Financial Aspects of Operation and Maintenance

Table 12 shows the budget and expenditure (excluding expenses on personnel and administration) for the operation and maintenance of the Purulia Pumped Storage from 2013 to 2015. For the budget of the power plant, the required amount is first requested to the WBSEDCL headquarters and the budget for each fiscal year is distributed after the assessment by the headquarters. According to the power station personnel, sufficient budget has been provided so far and there has been no incident of budget shortage for operation and maintenance.

Table 12: Operation and Maintenance Budget and Expenditure of Purulia Pumped Storage

Unit: INR million

	2013	2014	2015
Budget	352	273	588
Expenditure	192	233	436

Source: WBSEDCL

Table 13 shows the financial statement of WBSEDCL from 2012 to 2015. It has been reporting profit in the last four years. In regards to the current ratio, it seems there is no issue in short-term repayment. Although the debt equity ratio officially reported by WBSEDCL is high, it is because long-term borrowing is also included in the debt when calculating the debt equity ratio. WBSEDCL is still taking up projects to improve the electrification rate for households and deliver stable power supply, and it seems the borrowings on these projects are high.

Table 13: Financial Statement of WBSEDCL

Units: INR million (current ratio and debt equity ratio are in real numbers)

	2012	2013	2014	2015
Total Assets	279,397	322,153	361,066	406,177
Share Capital	57,080	59,257	22,567	22,567
Fixed Assets	129,867	146,301	161,973	173,662
Non-Current Liabilities	130,656	151,304	161,648	174,255
Current Assets	90,583	133,077	133,519	179,862
Current Liabilities	91,660	111,592	127,158	145,719
Current Ratio	0.99	1.19	1.05	1.23
Debt Equity Ratio	6.23	7.10	7.53	8.18
Total Revenue	174,999	178,799	195,833	186,113
Expenses	173,915	178,503	195,533	185,761
Net Profit	817	191	198	216

Source: WBSEDCL Annual Report

There is a rating for domestic power corporations (performance rating) commissioned by the Indian Ministry of Power and conducted by a rating agency since 2013. WBSEDCL ranked high at fifth out of 39 corporations in the first overall rating in 2013. In the fourth overall rating of 2015, WBSEDCL ranked 15th out of 40 corporations. Although the ranking came down compared to 2013, the fact WBSEDCL's dependency on subsidy is very limited has been highly regarded in 2015. Detailed information on the amount of subsidy WBSEDCL receives could not have been collected. However, according to the Annual Report, it is clear that no subsidy was provided to supplement WBSEDCL revenue in FY 2014.

It seems that the budget for operation and maintenance of the Purulia Pumped Storage is provided sufficiently, and the executing agency's financial status is relatively good.

3.5.4 Current Status of Operation and Maintenance

As explained earlier, the regular inspections (daily, weekly and monthly) are conducted in accordance with the prescribed schedule. Although there was breakdown of generators in 2010 and there have been several breakdowns and other issues thereafter, necessary repairs have been done. According to WBSEDCL, although it takes time to procure some of the spare parts as they

need to be brought from Japan, there is no issue with securing the spare parts. At the time of the ex-post evaluation, the power station was functioning properly.

According to the plan at the time of the appraisal, overhaul was to be conducted once every 10 years; however, overhaul is actually required every five to seven years. In the project, based on the equipment conditions at the time of the inspection and the history of breakdown, overhauling was done in January 2014 for Unit 1, March 2015 for Unit 2, October 2016 for Unit 3, and January 2017 for Unit 4.

As can be seen, there is no issue with the current status of operation and maintenance of the project.

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

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

In the 1990s, India achieved high economic growth and power demand was increasing along with it. As was the case across India, meeting the peak-time power shortage was an issue in the State of West Bengal. Given such situation, this project was expected to mitigate the shortage in peak-time electricity by constructing a pumped storage with an output of 900 MW and related transmission and substation facilities in Purulia District of West Bengal. From the time of the project appraisal to the ex-post evaluation, the power sector has always held an important position in the development policies of the Government of India and the Government of West Bengal. As in the case at the time of the appraisal, the peak-time power demand is ever increasing at the time of the ex-post evaluation. Therefore, it is necessary to strengthen the power supply capacity hereafter as well. The project objective is consistent with Japan's ODA policy and the relevance of the project is high. Outputs were implemented mostly as planned. With regard to the project cost, because of the fluctuation of the exchange rate during the implementation period, the project was implemented with about 60% of the planned cost. On the other hand, the project period exceeded the plan by 52 months because of the delay in obtaining forest clearance. As a result, the efficiency of the project is fair. Regarding the effectiveness of the project, the operation and effect indicators set at the time of the appraisal have been mostly achieved. A certain degree of impacts is also seen in reducing peak-time power shortage in West Bengal, improving the operational efficiency of coal fired thermal power plants, revitalizing industries through increased power supply, and improving the lives of people. No negative impact has been seen with regard to the natural environment, and the effectiveness and impact of the project are high. No particular problems have been seen in

institutional, technical and financial aspects and the current status of the project's operation and maintenance; therefore, the sustainability of the project is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

None.

4.2.2 Recommendations to JICA

None.

4.3 Lessons Learned

Revising Operation and Effect Indicators When the Environment Surrounding the Project Changes

In the project, operation and effect indicators and their targets, excluding the planned outage hours, were set at the time of the Tranche II appraisal. At the time of the Tranche III appraisal, although planned outage hours was added as an operation indicator, the target for net electric energy production remained the same as the Tranche II appraisal and was not revised. Moreover, until the time of the Tranche III appraisal, it was envisaged that the project was to be connected to the regional grid. However, the national grid was introduced and was in progress, and, at the time of the project completion, the net electric energy production fixed at the time of the appraisal was no longer appropriate as the target for the project. Operation and effect indicators are important information for confirming the level of achieving project objectives. Accordingly, for any project whose appraisal is conducted in several phases, it is advisable for JICA and the executing agency to check the operation and effect indicators and their details in every phase. This can help renew the understanding on any expected effect from the project among its stakeholders. In addition, when the environment surrounding the project changes, it is important to revise the operation and effect indicators and their targets when and if necessary, taking the changes into consideration.

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1. Project Outputs a. Upper dam and reservoir	Rockfill dam, dam height 71m, dike length 1,505 m, storage capacity 16.5 million m^3	As planned
b. Lower dam and reservoir	Rockfill dam, dam height 95m, dike length 310 m, storage capacity 16 million m^3	As planned
c. Penstock	2 lanes, length 256.57m, inner diameter 7.7 m	As planned
d. Power station	Underground width 22.5 x length 157.0 x height 47.7 m, output 900 MW (225 MWx4 units)	As planned
e. Switchyard	No details	Above ground, GIS floor area 45 x 152m
f. Transmission lines	2 routes Power station – Durgapur Substation: 400 kV, double circuit lines, length 160 km Power station – Arambagh Substation: 400kV, double circuit lines, length 150 km	2 routes Power station – Durgapur Substation: 400 kV, double circuit lines, length 185 km Power station – Arambagh Substation: 400 kV, double circuit lines, length 209 km
g. Substations	2 locations Durgapur substation: 400 kV, shunt reactor 4 x 50 MVAR Arambagh Substation: 400 kV, shunt reactor 4 x 50 MVAR	As planned
h. Consulting services	78 M/M (detailed design)	851 M/M (detailed design, bidding assistance, construction management)
2. Project Period	July 1994 – March 2003 (105 months)	February 1995 – February 2008 (157 months)
3. Project Cost Amount Paid in Foreign Currency Amount Paid in Local Currency Total ODA Loan Portion Exchange Rate	 69,815 million yen 37,335 million yen (11,112 million rupees) 107,150 million yen 88,027 million yen 1 rupee = 3.36 yen (As of April 1994)	 27,472 million yen 32,784 million yen (13,717 million rupees) 60,256 million yen 57,238 million yen 1 rupee = 2.39 yen (Average between January 1995 and December 2015)
4. Final Disbursement	January 2016	