India

Ex-Post Evaluation of Japanese ODA Loan Project

"Eastern Gandak Canal Hydroelectric Project"

Third Party Evaluator: IC Net Limited

Kenji Momota

Field Survey: October 2009

1. Outline

Project site location

The power plant seen from downstream of the irrigation canal

1.1 Project Objective:

The objective of this project is to improve the electricity shortage of the state through low head hydropower generation[1] by constructing a bypass channel for power generation in the East Gandak irrigation canal in Bihar state, thereby contributing to regional economic development.

1.2 Project Outline (Outline of Loan Agreement):

Approved Amount/Disbursed Amount	1,630 million yen / 1,628 million yen
End Notes Exchange Date/Loan Agreement Signing Date	December 1984/July 1996
Ex-post evaluation	2003
Executing Agency	BHPC (Bihar State Electric Corporation)
Main Contractor	Sumitomo Corporation (Japan)

[1] Hydroelectric power generation performed with a dam of low height

(Over 1 billion yen)	
Main Consultant (Over 100 million yen)	None

1.3 Background/Reason for Post Monitoring

The total annual quantity of electricity generated in 2003(at the period of ex-post evaluation) remained less than thirty percent of that initially planned. The primary factor was due to design/structural problems of discharge canal of the plant. Outlet water level downstream of the power plant could not decrease sufficiently and the generating capacity did not reach the expected level. The ex-post evaluation report suggested that this problem could be resolved through establishment of an “escape channel” midway in the drainage channel, and recommended its rapid construction. Consequently, this project became subject to ex-post monitoring in order to reappraise the operating conditions of the power plant and the progress of outfitting the said escape channel since the ex-post evaluation. The ex-post monitoring was conducted in accordance with the distinct evaluation criteria based on the results of the recent field survey.

The field survey for this project was first scheduled for June. However, BHPC, the executing agency postponed the survey four times. It caused a significant delay in the schedule. In addition, parts of the data requested based on the questionnaire during the field survey were not provided. Thus a detailed analysis of these items was relinquished.

2. Monitoring Results

2.1 Effectiveness (Impact)

2.1.1 Quantitative Effects

2.1.1.1 Operation and Effect Indicators

(1) Operating Conditions of the Power Plant

With the total amount of electricity generated at around 20 - 30% of originally projected level and a capacity factor at 15 - 18%, no change in conditions is seen from the time of the ex-post evaluation. As per the following details, the primary factors are shortages in water quantity and insufficient outlet head etc.

Table 1 Results of Primary Operation and Effect Indicators for the Power Plant

Indicator/Year	2004	2005	2006	2007	2008
Operation Indicator					
1 Accidental outage (Hours/Year)	138.98	185.14	230.5	236.1	213.2

Mechanical error	28.9	70.05	90.5	87.5	78.1
Human Error			-	-	-
Others	110.08	115.09	140.0	148.6	135.1
2 Operating rate	18.5%	20.6%	18.8%	16.0%	15.6%
% of planned value(69% at time of planning)	26.8%	29.9%	27.3%	23.2%	22.7%
3 Planned outage (For Maintenance)	2,080	2,150	2,190	3,100	2,840
Effectiveness Indicators					
1 Total Power Generated (GWh/Year)	25.48	27.9	25.4	22.6	21.2
% of Planned value	28.3%	31.0%	28.2%	25.1%	23.5%
2 Net Power Generated (GWh/Year)	24.28	27.07	24.7	21.1	20.6
3 Maximum Output (MW)	7	7.4	7.3	7	7
% of Planned value(Max. 15MW)	46.7%	49.3%	44%	44%	44%

(Source: BHPC)

The reasons why there were not sufficient improvements in the operating conditions of the power plant have not been seen are as follows.

1) Insufficiency of water quantity

The rated output of the power plant is 15MW (5MWx3), with penstock water quantity of approx 297m^3/s necessary to operate all three power generators simultaneously. However, the water quantity diverted from the East Gandak irrigation canal is not maintained at this level. 198m^3/s is necessary to operate two generators simultaneously, but this level cannot be regularly secured. At the time of the field survey, just one generator operating at a water quantity of 99 m^3/s. BHPC engineers have recognized the cause as a decrease in water flow quantity due to silting in the irrigation canal, which is the source of the transmission water. The irrigation canals are under the jurisdiction of the Department of Water Resources and not the BHPC. BHPC has submitted application for silt removal operations. However, it has not been implemented for the past 15 years. BHPC staffs assume that the water level of the irrigation canals has decreased to 50% of planned level due to silting.

The BHPC engineers have also mentioned that this silting might cause the high water flow of the drainage channels as the irrigation canal is also the discharge point for the drainage channels. This is possibly the cause of the insufficient outlet head described in 2).

Although this problem was not raised at the time of the ex-post evaluation, the executing agency did not mention the conditions at that time. However, considering the fact that removal of silt for the irrigation canals have not been implemented for the past 15 years, a certain risk may have existed even though this problem had not surfaced at the time of

planning and starting operation of the power plant.

2) Insufficient water level of Outlet Head

This problem has already been identified at the time of the ex-post evaluation, and still no great changes were observed. Details are as follows.

1. The East Gandak hydroelectric plant generates power by using the outlet head. The rated head at time of design was set at 5.3m. However, the head, when two units operate simultaneously, is 4.3m, which is too small to operate the generators under optimum conditions. The cause of this is the water level of the drainage channel reaching the upper limit of design of 104.9m, as pointed out at the time of the ex-post evaluation. Sufficient water quantity could not let two generators operate simultaneously at maximum output because it would cause overflow from the canal.

2. The operating test carried out in 2003 by the supplier described that elevation of water level is an obstacle to the full operation of the generators. It recommended expansion of width and depth of drainage channel.

3. At the time of the field survey, the engineer stated that the cause of the current problems is the above 1-2 and that there is no problem with the condition of the power facilities themselves. Also the opinion of the Central Water Commission which designed the escape channel as detailed below supports the view of the supplier. Thus, the resolution of this outlet head problem is deemed the most effective measure to improve the operating conditions of the power plant.

Fig. 1 Present Condition of the Outlet (One Generator Operating)

Fig. 2 Present Condition of the Outlet (Opposite Side)

3) Present Condition of the escape channel

The present conditions of the escape channel, which was proposed by the ex-post evaluation, are as follows. Although a contract of its civil work was signed in 2007, actual construction has not yet begun and the start of construction has not yet been clearly scheduled.

1. The location for the channel has already been confirmed[2] and a contract of civil work was already signed in October 2007 (project cost: 230 million rupees). Also, the land acquisition has already reached agreement with respective landowners. (The compensation itself has not yet been paid.)
2. At present, the drainage channel has not been constructed and even the foundation work has not yet begun. According to the contractor, commencement of the civil work was planned for November 2009 after the end of the rainy season[3].
3. BHPC plans 50% of the budget from their own capital and thre rest to borrow from the National Bank for Agriculture and Rural Development (NABARD).
4. BHPC did not clearly answered to enquiries why construction was not commenced at the time of the ex-post monitoring, when two years or more had passed since the contract.

Fig. 3 Scheduled Location for Construction of the escape channel

Fig. 4 Primary Canal

(2) Position of the Project in the Total Power Distribution Network of the State

This power plant serves as a base load plant and is connected to the state grid except for the power supplied to the project area (approx.1MW). The share of the power generated by the plant is as follows, which only occupies less than 1% of the total power distribution

[2] The design of the drainage channel was created by the Central Water Commission (a research and study organization under the jurisdiction of the ministry of water resources)
[3] The work did not yet started as of November 2009

network of the State.

Table 2 Position of the Power Plant in the Total Power Distribution Network of the State

Item	Power generated (GWh) 2006-7	2007-8	2008-9
Whole state	9,629	11,134	12,874
BHPC Plant Total	111.45	90.85	95.95
East Gandak Power Station	25.33	20.67	19.14
% of Whole state	0.26%	0.19%	0.15%
% of BHPC Plant Total	23%	23%	20%

(Source: BHPC)

(3) Accidental outage

The rate of outage stays approx. 2.4 to 2.7% over the past few years, which remains under the standard rate[4] and seems to pose no particular problem.

Table 3 Transition of Unscheduled Shutdown Time for the Power Plant

Index	2004	2005	2006	2007	2008
Unscheduled Shutdown (Hours/Year)	138.98	185.14	231	236	213
Shutdown Rate	1.59%	2.11%	2.63%	2.70%	2.43%

(Source: BHPC)

(4) Recalculation of the Financial Internal Rate of Return (FIRR)

Recalculation of the FIRR was scheduled in this survey in accordance with the calculation method at the time of the ex-post evaluation. However, FIRR was not calculated this time since the requested data such as records of operation and maintenance costs was not provided from BHPC.

2.1.2 Qualitative Results

This item is explained in the subsequent paragraph 2.1.3 as it overlaps the evaluation of impact.

[4] According to the Manual on Planning Criteria confirmed at the ex-post evaluation report, 4.5% is the upper limit of the outage rate.

2.1.3 Impact

Although the originally planned quantity of power generation is not achieved, 1MW of the generated output is being supplied to the project area (Valmiki Nagar). In order to assess the impact of the supply of power to the project area, a beneficiary survey was conducted.

1) Target beneficiaries

- 99 electrified households, residing within a 10 km from the power plant (of which 18 are businesses) and 12 non-electrified households.
- 79% of household are below the poverty line (BPL[5]).
  (60% are of annual income 20,000 rupees or less, 40% are of annual income 100,000 rupees or less)
- A breakdown of the businesses includes tea processing, catering, electromechanical and rice production businesses, among others.

2) Survey Results

1. The principal purpose of electrification was to increase the time of education for children and the productivity of night-time household chores. Approximately 86% responded that they were “very satisfied” or “satisfied” with the level of achievement of the expected effects and goals due to electrification.

2. Approximately 83% of businesses replied that they were “very satisfied” or “satisfied” with the level of achievement of goals due to electrification. Also, 94% of these businesses replied that the economic level had improved by electrification. This probably reflects an improvement in productivity due to electrification. Additionally one electromechanical business replied that the number of customers had increased thanks to the increase in houses using electrical appliances due to electrification. It is thus fair to say that electrification has an impact in changing the business environment.

3. Meanwhile, 75% of households expressed discontent because of unstable electrical supply such as the occurrence of power outages on an almost daily basis. In addition, the occurrence of these power outages at the peak time of 6 - 10 PM aggravates the dissatisfaction.

[5] Below Poverty Line

Fig. 5 Level of Satisfaction with Electrification (71 Standard Households)

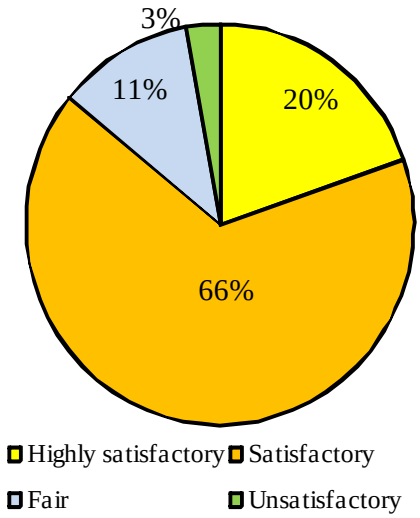
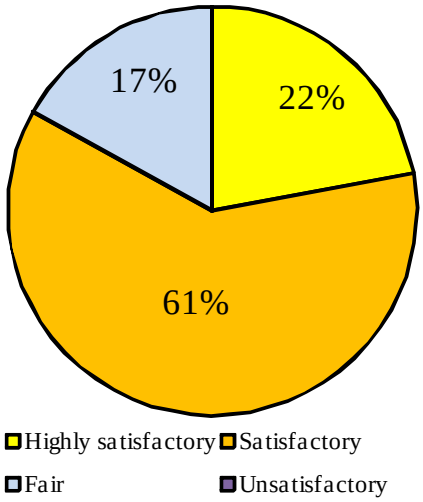


Fig. 6 Level of Satisfaction with Electrification (18 Businesses)



(Source: created based on the beneficiary survey)

From the above, it is observed that a certain number of local people enjoy the benefits of electrification by the project and improve their daily life and economic environment. Meanwhile, constant shortage of power supply and frequent occurrence of interruption (almost daily) are confirmed. Urgent countermeasures should be taken since improvements in the operating condition of the power plant would probably make a difference on this problem,.

Fig. 7 Appearance of the Beneficiary Survey (1)

Fig. 8 Appearance of the Beneficiary Survey (2)

[Summary of Effectiveness and Impact]

Majority of the power generated by the plant has been sent to the Bihar State Grid, and

part of the generation is supplied to the project area. Although this power distribution contribute to the improvement of electric power supply of the whole state to a certain extent, the project has not achieved satisfactory outcome, considering the fact that the power generated only reaches approx. 30% of the original plan.

As mentioned earlier, the deficiency in water quantity and outlet head have been hindering the optimal operation of the power plant, and the situation is deteriorating. Although the construction of escape channel may improve the insufficiency in outlet head, optimum performance is still unlikely to be achieved due to insufficient water quality. Concerning the deficiency in water quantity, it is necessary to improve the quantity of water in the irrigation canal, which is the source of the water transmission.

2.2 Sustainability

2.2.1 Operation and Maintenance Agency

2.2.1.1 Operation and Maintenance Management System

The personnel of the power plant number 15 with a breakdown as below. No great change is seen concerning the total number of personnel or their classification. In the on-site interview survey, power plant personnel responded that the current number of personnel is appropriate for the operation of the plant.

Table 4 East Gandak Canal Hydroelectric Plant - Personnel Structure

Position	At Ex-Post Evaluation (2003)	Current (October 2009)
Assistant chief engineer	1	1
Superintending engineer	2	1
Executive engineer	4	2
Assistant engineer	8	2
Outsourced Contract Personnel	25	44
Total	40	50

(Source: BHPC)

The operation of the plant is outsourced to the Patna-based Associated Engineering Centre. BHPC staff are primarily responsible for supervising outsourcers. The manager of the power plant stated that there is no great problem concerning the personnel structure and sufficient number of personnel is secured in order to maintain the power plant.

2.2.1.2 Technical level for Operation and Maintenance

1) There are no special problems concerning routine operations of the power plant. BHPC has operated 11 hydroelectric plants in addition to this one. It is reasonable to assume that BHPC is maintaining the plant at appropriate technical level.
2) However, BHPC claimed that final commissioning test of the generators was not implemented by the supplier at the time of delivery and it causes issues in support in occurrence of trouble.[6]
3) In the on-site interview survey, it was confirmed that the required training for personnel and education through OJT are carried out. In addition, staff periodically participate training of various education and research institutions (National Power Training Institute etc.)
4) The outsourcers also have experience of operating other BHPC power plants, therefore they are assumed to maintain sufficient technical level for the appropriate operation of the power plant. BHPC also considers there is no problem with the quality of outsourcers.

2.2.1.3 Financial Status of Operation and Maintenance Management

In the on-site interview, staff of the power plant responded that appropriate funds are allocated for the necessary operational costs. However, a detailed analysis of the current condition was not possible as detailed information relating to the financial statement was not provided.

2.2.2 Operation and Maintenance Conditions

1) As detailed in the chapter of Effectiveness, the deficiency in water quantity due to silt in the irrigation canal, which is the transmission water source for the power generation channel, has become a large problem. The capacity of the irrigation canal, which is under the jurisdiction of the Department of Water Resources, is declining as silt removal operations have not been carried out over the past 15 years.

2) No major problems are seen concerning the principal functions of the power facilities. If water quantity and outlet head can be improved, appropriate operation will be possible. However, a fault with the flow meter to monitor the quantity of flow has been reported.

[6] According to the report from supplier, final test was conducted on unit 1 and 2. Final test on unit 3, which had been installed after termination of L/A due to the significant delay of civil work, was not conducted by supplier as installation work was done by BHPC themselves.

Table 5 Status of Principal Power Facilities

Fig. 9 Irrigation Canal

Fig. 10 Appearance of the Inside of the Power Plant

3. Conclusion and Lessons Learned/Recommendations

3.1 Conclusion

Power generation still remains at around 30% of the original plan and almost no improvement was observed since the ex-post evaluation. Several factors affected this problem such as a deficiency in water quantity and issues in design. With initiatives to improve each problem delayed, no clear prospect toward improvements hereafter is observed.

3.2 Lessons Learned

The deficiency in drainage channel capacity is the cause of the deficiency in outlet head. As identified at the time of the ex-post evaluation, it is conceivable that a more careful survey such as carrying out more thorough simulations should have been conducted at the design stage.

3.3 Recommendations for the Executing Agency

1) As construction of an escape channel, which has been delaying from original schedule, seems one of the effective options for the operation of two generators, urgent implementation is desirable.

2) It is necessary to coordinate with the Department of Water Resources concerning the silt in the irrigation channel. Formal communication channel should be used, such as the establishment of regulatory functions between the top of the organisations.

Comparison of Original and Actual Scope

Item	Planned	Actual
(1) Output		
1)Headrace		
Length	1,067m	1,432m
Designed water depth	4.88m	As planned
2)Power Plant		
Installed capacity	5MW×3 Units=15MW	As planned
Type of hydraulic turbine	Valve-regulated tubular	As planned
Head (rated)	5.3m	5.1m (when only one generator is operated)
3)Drainage canal		
Length	3,230m	4,282m
Depth	3.2m	3.2m
(1) Project period		
Preparatory work	Nov.1983-Oct.1984	Not known
Land acquisition	Nov.1983-May.1984	1985-1990
Headrace and tailrace	Oct.1984-1987	1986-1993
Power plant	Oct.1984-Nov.1986	1988-1992
Equipment procurement	Dec.1983-Oct.1986	1984-1994
Switch yard construction	Feb.1985-May.1987	Completed in 1994
Installation of the plant	Aug.1986-Oct.1987	Completed in 1997
(2) Project Cost		
Foreign currency	1,630 million yen	1,628 million yen
Local currency	3,630 million yen (165 million Rupees)	2,192 million yen (226 million Rupees)
Total	5,260 million yen	4,225 million yen
ODA loan portion	1,630 million yen	1,628 million yen
Exchange rate	1 Rupee= 22 yen	1 Rupee=9.85 yen