Ex-Post Project Evaluation 2011: Package I-3 (India)

July 2012

JAPAN INTERNATIONAL COOPERATION AGENCY

OPMAC Corporation

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Preface

Ex-post evaluation of ODA projects has been in place since 1975 and since then the coverage of evaluation has expanded. Japan's ODA charter revised in 2003 shows Japan's commitment to ODA evaluation, clearly stating under the section "Enhancement of Evaluation" that in order to measure, analyze and objectively evaluate the outcome of ODA, third-party evaluations conducted by experts will be enhanced.

This volume shows the results of the ex-post evaluation of ODA Loan projects that were mainly completed in fiscal year 2009, and Technical Cooperation projects and Grant Aid projects, most of which project cost exceeds 1 billion JPY, that were mainly completed in fiscal year 2008. The ex-post evaluation was entrusted to external evaluators to ensure objective analysis of the projects' effects and to draw lessons and recommendations to be utilized in similar projects.

The lessons and recommendations drawn from these evaluations will be shared with JICA's stakeholders in order to improve the quality of ODA projects.

Lastly, deep appreciation is given to those who have cooperated and supported the creation of this volume of evaluations.

July 2012
Masato Watanabe
Vice President
Japan International Cooperation Agency (JICA)

Disclaimer

This volume of evaluations, the English translation of the original Japanese version, shows the result of objective ex-post evaluations made by external evaluators. The views and recommendations herein do not necessarily reflect the official views and opinions of JICA. JICA is not responsible for the accuracy of English translation, and the Japanese version shall prevail in the event of any inconsistency with the English version.

Minor amendments may be made when the contents of this volume is posted on JICA's website.

JICA's comments may be added at the end of each report when the views held by the operations departments do not match those of the external evaluator.

India

Ex-Post Evaluation of Japanese ODA Loan
Dhauliganga Hydroelectric Power Plant Construction Project (I) (II) (III)

External Evaluator: Keishi Miyazaki and Junko Fujiwara, OPMAC Corporation

0. Summary

This project was implemented to cope with growing power and energy demand in the northern region of India by the construction of a hydroelectric power plant. Its objectives were highly relevant to India's development plan and development needs, as well as to Japan's ODA policy, therefore its relevance is high. Since the key operation and effect indicators such as maximum output, plant load factor, availability factor, and electric energy production met the targets, this project has largely achieved its objectives. Thus its effectiveness is high. However, there were constraints on the evaluation of the extent to which this project contributed to the improvement of the electricity supply in the northern grid due to the fact that the installed capacity of this project makes up less than 1% of the entire grid. Adverse impacts on natural and social environment remained at a minimum thanks to various actions implemented by the executing agency. T here were positive impacts such as improvements in the natural environment and in people's living conditions in the upstream area. Although there were some changes in design, such as dam type, the project outputs were realized mostly as planned. Although the project cost was within the plan, the project period slightly exceeded it and therefore the efficiency of the project is fair.

This project's organizational, technical and financial sustainability is high and the project is well operated and the facilities well maintained. In light of the above, this project is evaluated to be highly satisfactory.

1. Project Description

Project Location

Reservoir and Underground Power House

1.1 Background

Electricity demand in India showed rapid growth of as much as an annual average of 5.2% since 1996. The country, however, has suffered from severe electricity shortages due to deterioration of the financial condition of state electricity utilities and sluggish private sector involvement, which has meant that there has not been adequate investment in infrastructure. In response to this, the Indian Government began to concentrate on the effective utilization of the generation facilities owned by the central government in each state, the rehabilitation and modernization of existing power generation plants to secure energy production and to cope with peak demand, the development of new generation facilities with foreign assistance, and the improvement of transmission and distribution networks.

The northern electricity grid of India extends to Uttar Pradesh, Rajasthan, Punjab, Haryana, Himachal Pradesh, Jammu Kashmir and the National Capital Territory of Delhi[1], where electricity deficit has been as severe as anywhere in the entire country. Against 19,240 MW at peak demand, the electricity supply remained at 12,455 MW (64.8%) in 1993[2]. T he electricity supply in the same year was 90,106 GWh against the required amount of 102,416 GW (a shortage of 12%). Coping with the growing energy demand thus required immediate action from the Indian Government.

1.2 Project Outline

The objective of this project was to cope with growing power and energy demand in the northern region of India by the construction of a 280 MW (4 X 70 MW) hydroelectric power plant on the River of Dhauliganga, a t ributary of Sarda River in Darchula sub-division of Pithoragarh District, Uttarakhand State, thereby contributing to the improvement of people's living standards, to industrial development, employment creation and fuel diversification for power generation in the region.

Loan Approved Amount/ Disbursed Amount	1st Phase: 5,665 million yen / 4,976million yen 2nd phase: 16,316 million yen / 16,312 million yen 3rd phase: 13,890 million yen / 12,048 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	1st Phase: January 1996 / January 1996 2nd phase: October 1997 / December 1997 3rd phase: March 2004 / March 2004
Terms and Conditions Interest Rate, Repayment Period (Grace Period) and Conditions for Procurement	1st Phase: 2.3%, 30 years (10 years), general untied 2nd phase: 2.3%, 30 years (10 years), general untied 3rd phase: 1.3%, 30 years (10 years), general untied
Borrower / Executing Agency	NHPC Ltd. / NHPC Ltd.
Final Disbursement Date	1st Phase: May 2002 2nd phase: September 2004 3rd phase: July 2009
Main Contractor (Over 1 billion yen)	Hindustan Construction Company Ltd (India) / Samsung Corporation (Korea), Kajima Corporation (Japan) / Daewoo Corporation (Korea)
Main Consultant (Over 100 million yen)	Nippon Koei Co., Ltd. (Japan) / Electrowatt Engineering Services Ltd (Switzerland) / E lectrowatt Engineering Ltd (Switzerland)
Feasibility Studies, etc.	"Master Plan for the Dhauliganga River Hydro Development" NHPC Ltd., 1985 "Detailed Project Report for the Dhauliganga River Hydro Development" Swedpowser, July 1985
Related Projects	"Northern India Transmission System Project" ODA Assistance Loan

1 Part of Uttar Pradesh State became an independent state called 'Uttaranchal' in 2000, which was later renamed as Uttarakhand. As of 2011, Uttarakhand State and the Union Territory of Chandigarh are among those connected in the northern grid.

2 The Indian fiscal year starts in April and ends in March.

2. Outline of the Evaluation Study

2.1 External Evaluator

Keishi Miyazaki and Junko Fujiwara, OPMAC Corporation

2.2 Duration of Evaluation Study

Duration of the Study: August 2011 – June 2012
Duration of the Field Study: 20 November – 10 December 2011. 11 – 21 March 2012

2.3 Constraints during the Evaluation Study

Not applicable.

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

3.1 Relevance (Rating: ③[4])

3.1.1 Relevance with the Development Plan of India

The Eighth Five Year from 1992/1993 to 1996/1997 laid emphasis on: i) improvements in the operation of the existing generation units and other plants and equipment, ii) reduction of transmission and distribution losses, iii) improvement in the financial performance of central and state electricity bodies, iv) promotion of capacity additions to the existing installed generation capacity, and v) attraction of private investment for power development[5]. O ut of a total investment in the public sector of 4,341 billion Indian rupees, investment in the energy sector, 1,155.6 billion rupees, had the biggest ratio of 26.6%. The share of electricity in the energy sector was 795.9 billion rupees, which amounted to 18.3%[6].

The Government of India had the Eleventh Five Year Plan in place (2007/2008 to 2011/2012) at the time of this ex-post evaluation study. The Government projected that the gross electricity requirement by the end of the Eleventh Plan for power would be 1,097 GWh while the peak demand estimation was 158,000 MW. To fulfill the estimated electricity demand requirement, a capacity addition program was planned in order to increase the total by 78,577 MW during the period[7]. Out of 36,447.2 billion rupees of a total investment in the public sector, the Government allocated 8,541.2 billion rupees for the energy sector, which comprises 23.4% of the public sector investment of the Plan[8].

It is thus concluded that this project was highly relevant to India's development plan and its power sector development plan at the time of project appraisal as well as at the time of the ex-post evaluation study.

3.1.2 Relevance with the Development Needs of India

The Central Electricity Board projected that both electricity demand and peak demand would grow annually by as much as 6% on average from 1997/98 to 2012/13. Energy consumption in the northern region was immense with electricity demand and peak demand the biggest of all regions, as shown in Table 1 (129,587 GWh and 24,234 MW respectively). Second to the northern region was the western region.

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

4 ③: High, ② Fair, ① Low

5 Planning Commission, Government of India. "Eighth Five Year Plan" (1992).

6 Oil (240 billion rupees: 5.5%), coal (105.1 rupees: 2.4%) and renewable energy (14.7 rupees: 0.3%) were also parts of the energy sector.

7 Planning Commission, Government of India. "Eleventh Five Year Plan (2007-2012), Volume I Inclusive Growth" (2008).

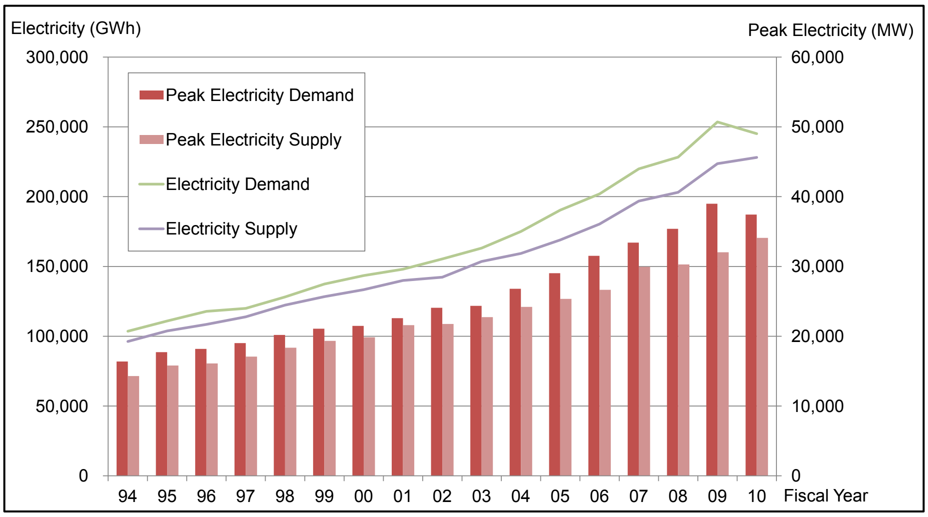
8 The social sector accounts for the biggest amount: 11,234 billion rupees (30.2%) in the Plan.

Table 1: Forecast of Electricity Demand and Peak Demand by Region (1996/97)

Regions	Electricity (GWh)	Peak Electricity (MW)
Northern	129,587	24,234
Western	121,159	19,587
Southern	103,191	18,150
Eastern	56,011	10,254
North-Eastern	6,169	1,388
Islands	157	43
Country	416,274	73,656

Source: Central Electricity Authority. 14th Electric Power Survey (1991)

According to the data provided by NHPC, electricity demand and peak demand in the northern region continued to increase (Figure 1). Power demand reached 245,137 GWh in 2010/11 while peak demand reached 37,431 MW. The power supply on the other hand saw a deficit of as much as 16,958.8 GWh (6.93%) and peak power lacked 3,360 MW (8.92%). Out of power demand, 31% was for domestic consumers, 29% for industrial consumers, 22% for agricultural consumers, 10% for manufacturing consumers, and 8% for others.



Source: NHPC.

Figure 1 : Growth of Electricity and Peak Electricity and their Gaps

The total installed capacity of the northern region as of the end of March 2012 (Table 2) was 53,925 MW, which was second in size only to the western region. Although dependency on thermal generation is obvious (approximately 66%)[9] for the country as a whole, the hydro ratio in the northern region was approximately 30%, second to the north-eastern region[10]. T he Eleventh Five Year Plan suggested the development of additional hydro power generation facilities with 16,533 MW in total[11], and potential hydro power remains one of the most important and abundant sources for power generation, especially to meet peak demand.

[9] Adding thermal power generation to the existing installed capacity was suggested at 58,644 MW in the Eleventh Five Year Plan.

[10] Uttarakhand, Jammu Kashmir and Himachal Pradesh are states where hydro power has a large share among all generation sources.

[11] Eleventh Five Year Plan (2007-2012), Volume III.

Table 2: Sources of Power Generation by Region (as of March 2012)

Regions	Hydro		Thermal		Nuclear		Renewable		Total	
	MW	%	MW	%	MW	%	MW	%	MW	%
Northern	15,122.8	28.04	32,791.8	60.81	1,620.0	3.00	4,391.4	8.14	53,925.9	100.00
Western	7,447.5	11.57	47,196.8	73.29	1,840.0	2.86	7,910.0	12.28	64,394.2	100.00
Southern	11,338.0	21.50	28,512.6	54.06	1,320.0	2.50	11,569.3	21.94	52,739.9	100.00
Eastern	3,882.1	14.77	22,005.1	83.71	0.0	0.00	398.7	1.52	26,285.9	100.00
North-Eastern	1,200.0	48.88	1,026.9	41.83	0.0	0.00	228.0	9.29	2,454.9	100.00
Islands	0.0	0.00	70.0	91.99	0.0	0.00	6.1	8.01	76.1	100.00
Country	38,990.4	19.51	131,603.2	65.84	4,780.0	2.39	24,503.5	12.26	199,877.0	100.00

Source: Central Electricity Authority.

3.1.3 Relevance with Japan's ODA Policy

At the time of the first appraisal in 1996, the Japanese Country Assistance Program for India had not yet been established by the Ministry of Foreign Affairs in Japan. However, based upon preceding studies and research as well as on policy dialogue between the Japanese and Indian governments, economic infrastructure development, particularly for power and transport infrastructure, was among the priority areas of Japan's ODA strategy for India at that time[12].

The current Japan's Country Assistance Program for India, formulated in 2006, also emphasizes economic infrastructure development, in which the power sector takes most priority[13] as seen in the Eleventh Five Year Plan of India.

It is thus concluded that the selection of this project was highly appropriate and relevant to Japan's assistance strategy.

This project has been highly relevant to India's development plan and development needs, as well as to Japan's ODA policy; therefore its relevance is high.

3.2 Effectiveness (Rating: ③)

3.2.1 Quantitative Effects (Operation and Effect Indicators)

Table 3 shows the major operation and effect indicators at Dhauliganga Hydroelectric Power Station from 2005/06 to 2011/12[14].

Although the design energy was 1,134GWh per year[15], the estimated gross electric energy production of Dhauliganga Power Station exceeded that figure. A s for net electric energy production, NHPC and JICA agreed to set 1,110 GWh per year as a target. Gross energy

[12] The Ministry of Foreign Affairs. "Japan's ODA White Paper" (1998).
[13] The Ministry of Foreign Affairs. "Japan's Country Assistance Program for India" (2006).
[14] HPC and JICA agreed to apply net electric energy production, maximum output, plant load capacity factor, and forced power outage as the operation and effect indicators in the third appraisal in 2003. In this ex-post evaluation study, in addition to the above indicators, the evaluators also collected gross electric energy production, availability factor, planned outage hours, hydro utilization factor, annual total volume of inflow to the reservoir and volume of sedimentation in the reservoir for a more comprehensive analysis of the project effectiveness.
[15] In the Darchula area of Pithoragarh District where the Dhauliganga Power Station is located, there is a huge difference in rainfall between the monsoon season (June to September) and the dry season (December to March), which gives a seasonal gap in the volume of water inflow from the Dhauliganga River to the Dhauliganga dam. The Power Plant supplies base electricity in the monsoon period, and peak electricity during the dry season, when water inflow declines, according to order by the Northern Regional Load Dispatch Center. Moreover, the potential effect on electric energy production of silt sedimentation in the reservoir was also taken into account in the original design. Out of the designed production (1,134 GWh), 12% is given as free power to the homeland state (Uttarakhand).

production almost reached the estimated amount, except in 2006/07 and 2008/09. Net energy production exceeded the estimated amount except for the above two years. According to NHPC, the reason for lower achievement than the estimate in 2006/07 and 2008/09 was that there were forced outages due to problems with main inlet valve of turbines in 2006/07, while in 2008/09 there was less inflow in the river. In any case, planned production was almost achieved every year.

Table 3: Major Operation and Effect Indicators

Indicator		2005/06(1)	2006/07	2007/08	2008/09	2009/10	2010/1	2011/12(1)
Gross Electric energy Production (GWh per year)	Estimate (2)	279.00	1,191.75	1,197.10	1,191.75	1,155.00	1,144.56	1,151.68
	Actual	314.93	1,093.95	1,186.00	1,116.59	1,134.35	1,134.45	982.00
Net Electric energy Production (GWh per year)	Estimate	1,110.00	1,110.00	1,110.00	1,110.00	1,110.00	1,110.00	1,110.00
	Actual	313.99	1,089.14	1,173.52	1,103.70	1,124.04	1,117.43	967.44
Maximum Output	Estimate	280	280	280	280	280	280	280
	Actual	280	280	280	280	280	280	280
Plant Load Capacity Factor (%)	Estimate	45	45	45	45	45	45	45
	Actual	26.32	45.06	48.74	46.01	46.74	46.75	N/A
Availability Factor (3) (%)	Estimate (2)	94.79	94.79	91.59	92.93	86.97	87.00	93.74
	Actual	97.83	77.27	92.71	89.85	92.62	92.15	99.51

Source: NHPC.
Note 1: Figures for 2005 were collected from 1 October 2005 to 31 March 2006, and those for 2011 from 1 April to the end of October 2011.
Note 2: NHPC sets estimated figures for gross electric energy production and availability factor.
Note 3: Plant Load Factor = Net Electric energy Production / (Maximum Output X Hours per Year) X 100
Availability Factor = (Operation Hours per Year / Hours per Year)

The maximum output met the figures planned every year, and the plant load factor almost reached or exceeded the planned figures. The availability factor also almost reached the target except in 2006. The figures for the most recent two years were 92.62% in 2009/10 and 92.15% in 2010/11. According to the NHPC annual report, the average availability factor among all hydroelectric power plants owned by NHPC was 84.1% in 2009/10 and 85.2% in 2010/11. Those for Dhauliganga Power Station far exceeded these.

The total unplanned outage hours from 2007/08 to 2009/10 remained within the estimated hours (Table 4). Electric energy production reached around 90% of the estimate every year (Table 3) and exceeded the designed figure (1,134 GWh per year), so there has been no major effect seen on the operation of the power plant.

The major reasons for forced outages were mechanical failures: the non-opening of the wicket gate of the francis-type turbine[16], malfunction of resistance temperature detectors (RTDs)[17], and shear pin failure[18]. T here were no unplanned outages due to human errors or other factors.

[16] Spiral shaped inlet at the entry of the francis turbine. This adjusts the amount of water flow by changing the degree of openness to allow efficient turbine operation.
[17] Wire wound and thin film devices that measure temperature. The hotter they become, the larger or higher the value of their electrical resistance.
[18] A safety device designed to shear in the case of a mechanical overload preventing other parts from being damaged.

Table 4: Unplanned and Planned Outage Hours

Indicators			2005/06(1)	2006/07	2007/08	2008/09	2009/10	2010/1	2011/12(1)
Unplanned Outage Hours		Estimate (2006)	Actual						
		100 hrs/year	200.31	777.04	92.20	82.30	86.07	130.59	250.35
	Mechanical	90 hrs/year	200.31	777.04	92.20	82.30	86.07	130.59	250.35
	Human errors	0 hrs/year	0	0	0	0	0	0	0
	Others	10 hrs/year	0	0	0	0	0	0	0
Planned Outage Hours		Estimate(2)	1825:35:00	1825:35:00	2946:50:00	2477:20:00	4565:45:00	4551:10:00	2193:30:00
		Actual	277:42:00	8150:05:00	4104:50:00	5036:00:00	3834:15:00	3801:30:00	789:10:00

Source: NHPC.

Note 1: Figures for 2005 were collected from 1 October 2005 to 31 March 2006, and those for 2011 from 1 April to the end of October 2011.

Note 2: Total Planned Outage Hours refer to the total hours of planned outage of the four generation units. This estimate was set by NHPC.

Although the total outage hours far exceeded the plan from 2005/06 to 2008/09, they have been lower than estimate since 2009/10 (Table 4). This did not affect the amount of energy production. Major reasons for the planned outages were the annual maintenance of four units of generation facilities, less demand for power generation during the dry season, miscellaneous maintenance of breakdown equipment / parts and silt flushing of the reservoir every 15 days during the monsoon period. In some years the replacement of equipment parts was also among the reasons for planned outages.

The total volume of water inflow to the reservoir of the Dhauliganga Power Station remained at approximately 70 to 90% of the estimates (Table 5). The hydro utilization factor stayed at 64.9% (2010/11) to 84.55% (2009/10) against the estimate (61.26%). There has been no major effect up to now, and the annual energy production has almost been achieved.

The volume of silt in the reservoir was beyond estimate in 2006/07 and 2007/08, but has remained only 10% of the estimate since 2009/10. According to NHPC, the sharp decline in sedimentation since 2009/10 results from successful implementation of the catchment area treatment works, soil conservation works, river bank protection works, check-dam construction etc. (which were planned at the beginning of project design) together with a reduction of deforestation though improvements in local people's traditional ways of living and means of making a livelihood. Silt reduction in the reservoir is essential to secure full functioning power plants and electric energy production, which significantly contributes to the project sustainability.

Table 5: River Water Flow, Hydro utilization Factor and Sedimentation in the Reservoir

Indicators		2005/06(1)	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12(1)
Annual Total Volume of Inflow to the Reservoir (m^3 / year)	Estimate(2)	2,546.50	2,546.50	2,546.50	2,546.50	2,546.50	2,546.50	2,546.50
	Actual	258.57	2,202.33	2,224.86	2,170.33	1,865.75	2,430.65	N/A
Hydro Utilization Factor(3) (%)	Estimate(2)	N/A	61.26	61.26	61.26	61.26	61.26	61.26
	Actual	N/A	69.08	74.13	71.53	84.55	64.90	66.86
Volume of Sedimentation in the Reservoir (m^3 / year)	Estimate(2)	N/A	300,000	300,000	300,000	300,000	300,000	300,00
	Actual	N/A	410,000	340,000	180,000	30,000	30,000	N/A

Source: NHPC.

Note 1: Figures for 2005 were collected from 5 November 2005 (start of commercial operation of all four generation units) to 31 March 2006, and those for 2011 from 1 April to the end of October 2011.

Note 2: NHPC sets estimated figures.

Note 3: hydro utilization factor = Net electric energy production / electric energy which could have been generated during the particular year ×100

3.2.2 Qualitative Effects

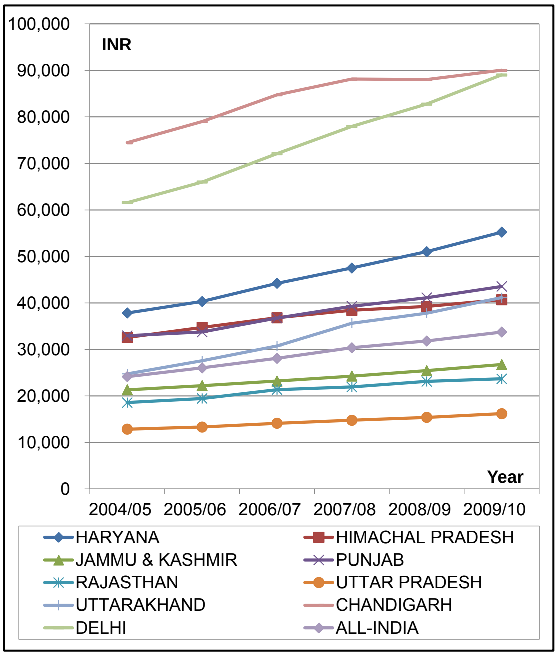
This project was intended to deal with growing power and energy demand in the northern region. However the installed capacity of the Dhauliganga Power Station (280 MW) had a share of only 0.86% at the start of its commercial operation in 2005/06, and this declined to 0.62% in 2009/10. The effect therefore was limited.

3.3 Impact

3.3.1 Intended Impacts

(1) Impact on Economic Development such as Employment Creation in the Northern Region

Figure 2 shows the per capita net state domestic product (NSDP) at constant prices and the per capita national net domestic product (NNDP). D elhi, Chandigarh, Haryana, Uttarakhand are among the fastest growing economies in the region. The per capita NSDP of Uttarakhand, where the Dhauliganga Power Station is located, was 24,740 rupees, which was almost same as NNDP (24,143 rupees). This grew as much as 41,126 rupees in 2009/10, which far larger than NNDP (33,731 rupees).



Source: Reserved Bank of India. "Handbook of Statistics on Indian Economy 2010-2011" (2011).

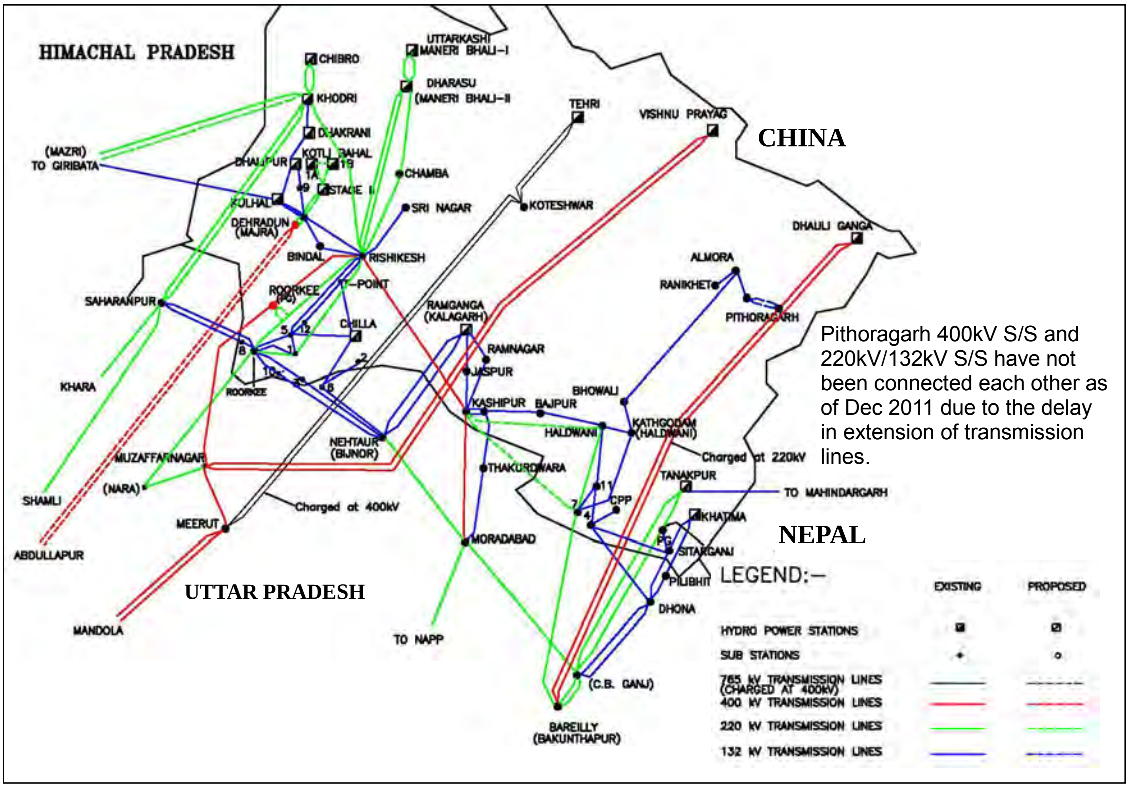
Figure 2: Per Capita Net State Domestic Product at Factor Cost - State-wise (At Constant Prices)

However, as described in the above 3.2.2, the installed capacity of the Dhauliganga Power Station had a share of 0.86% in 2005/06 and 0.62% in 2009/10, and therefore the impact in the northern region has been limited.

The electric energy produced at the Dhauliganga Power Station is supplied to the Bareilly 400 k V Substation [19] in Uttar Pradesh which is 233 km away through two double circuit lines (Figure 3). O ne of the two lines is connected to the Pithoragarh 220 kV Substation at a point 59 km from the power station, but as of December 2011, the substation had not yet started supplying electricity directly to the Pithoragarh District since the PGCIL had not completed the extension of transmission lines to reach the Pithoragarh 132 kV S/S from which the surrounding people should have received electric energy. T he electric energy therefore goes through Bareilly S/S, Haldwani S/S and other substations to reach entire northern region including Pithoragarh. It is therefore not possible to see the degree of the project's contribution to the Uttarakhand State itself.

The impact on economic development such as employment creation in the northern region has thus not been analyzed due to difficulties in measurement.

[19] The transmission line between the Dhauliganga Power Station and Bareilly 400 kV Substation was extended by the Northern India Transmission System Project with the JICA ODA assistance loan of 1996 (disbursed amount: 3,726 million yen). The executing agency was the Power Grid Corporation of India Limited (PGCIL). J ICA conducted an ex-post evaluation for the project in 2008 by employing a third-party evaluator.



Source: Power System Operation Corporation Ltd., Northern Regional Load Dispatch Centre (2011). Annual Report 2010-2011.

Figure 3: Power Map of Uttarakhand State

(2) Impact on Industrial Development in the Northern Region

As stated above (1), the impact on industrial development in the northern region has not been analyzed due to difficulties in measurement.

(3) Impact on the Improvement of People’s Living Standards in the Northern Region

As of December 2011, the electric energy produced at the Dhauliganga Power Station has not directly been supplied to the surrounding area in the Pithoragarh District. It instead goes to the Bareilly 400 kV Substation, the Haldwani Substation, and thence to other substations to be distributed to the entire northern region. It is therefore difficult to identify particular beneficiaries. The impact on the improvement of people’s living standards in the northern region has thus not been analyzed due to difficulties in measurement.

(4) Impact on Fuel Diversification for Power Generation in the Northern Region

As described above, the share of the installed capacity of the Dhauliganga Power Station is negligible, and therefore the impact on fuel diversification for power generation in the northern region has been limited.

As of March 2012, the installed capacity of hydro and thermal generation facilities accounted for 30% and 60% of the total capacity of the northern region.

3.3.2 Other Impacts

(1) Impacts on the Natural Environment

・ Impact on the entire catchment area

Although the project site was located in a sanctuary as stipulated by the Ministry of

Environment and Forests, there no valuable fauna and flora existed in the project site itself[20], and NHPC and the contractors were aware of the importance of minimizing adverse impacts on animals and plants during explosion works in the construction period. C ontractors undertook landscaping and restoration works for muck disposal sites and quarry areas, as stipulated in the contract agreement, both in and around the dam and power house.

Based on t he Environmental Action Plan completed by NHPC in March 1995, NHPC implemented i) a compensatory afforestation scheme, ii) a catchment area treatment plan, and iii) a rehabilitation & resettlement plan as follows. They also focused on the reduction of silt sedimentation in the reservoir.

i) Compensatory Afforestation Scheme

Prior to project implementation, the Uttar Pradesh Social Forest Department implemented a 7.4 m illion rupee compensatory afforestation scheme in 140 ha of non-forest land during 1994 a nd 1996. Seedlings / saplings were provided by the department.[21].

ii) Catchment Area Treatment Plan

1,571 ha of plantation with 1.85 million of seedlings, soil conservation works, check-dams (1,940 nos in total), agricultural terraces (370 ha), river training works, water detention tanks (167 nos), river bank protection (64 km in total) were planned and implemented by the Forest Department of Dehradun and implemented from 2001 to 2006, which at a cost of approximately 70 million rupees.

Life improvement programs, technical training in agriculture and free fuel supplies of LPG, diesel stoves, and electric heaters to replace firewood were also provided for local people living in upstream and in the area surrounding the dam, powerhouse and colonies.

iii) Rehabilitation and Resettlement Plan

NHPC improved the basic infrastructure required for a better living environment for local people, and it provided direct employment opportunities to members of the 37 fully affected families out of the total 581 project affected households (See (2) below for details).

A comparison of the remote sensing data[22] from 1999 and 2004 o btained during the site survey in this ex-post evaluation indicates that forest areas had rapidly increased in the catchment area and that soil erosion had been mitigated. Such positive impacts in the catchment area also had helped reduce the suspended load inflow into the reservoir consequently.

Forestry activity has been succeeded and integrated into the CSR program for the Dhauliganga Power Station. Between 2007 and 2011, 32,000 of trees, flowers and fruit trees have been planted in around the upstream area and in the areas surrounding area of the dam, powerhouse and colonies from 2007 to 2011.

・ Impact on Water Quality

NHPC regularly conducts water quality tests at the following six sites around the dam and power house area of the Dhauliganga Power Station: i) the confluence point of tailrace tunnel (TRT) with the main river channel, ii) downstream of the dam, iii) at the dam gallery, iv) at the tail end of the reservoir, v) at the service bay of the power station, and vi) upstream of the dam reservoir. The test parameters are: temperature, conductivity, salinity, pH, turbidity, total

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[20] Confirmed at the first appraisal in 1995, another environmental appraisal was carried out in the third appraisal in 2003. It was then concluded that there was no such protected or endangered species (JICA appraisal documents).

[21] Managed by Uttar Pradesh State as Uttarakhand Sate was separated in 2000.

[22] Provided by NHPC.

dissolved solids, chlorides, Ca, Mg, alkalinity, Nitrate- nitrogen, DO, COD, Iron, and bacteria etc. T here have been no major problems in the water quality tests, and thus no n egative impact has been observed.

(2) Land Acquisition and Resettlement

The total land acquired for the project was 166.7 ha (138.6 ha of forest land and 28.15 ha of private owned land), and the submergence area was 28.6 ha. 581 families around the reservoir and dam site were affected in the execution of the project ("project affected households"), out of whom 37 were "fully affected families for resettlement" (22 lost more than 50% of their lands / houses and 15 became houseless).

NHPC was open and shared all manners of information related to these families, and examined alternatives for the project affected households to choose which type of compensation they preferred. The local government also extended affirmative actions to the project affected people. As a result of a long-term comprehensive consultation process, 35 families out of 37 fully affected families for resettlement decided to resettle and rehabilitate their own livelihoods by themselves and received cash compensation for their land and property. The remaining two asked NHPC to provide accommodations to their satisfaction. N HPC provided job opportunities at the Dhauliganga Power Station to 37 members from the 37 families. The remaining 545 project affected households were provided with compensation for their land and property through the Land Acquisition Officer of the District. The total amount spent on compensation amounted to 66.99 million rupees (land: 29.5 million, houses: 17.4 million, fruit trees: 5.9 million, others: 13.19 million, and registration costs: 20,000 rupees).

The land acquisition and resettlement were executed as planned, and there was no delay to or effect on the project design caused by social impacts.

NHPC continued CSR activities after the construction was over, to sustain / promote further communication with project affected people and other people in the local area. Various assistances have been provided such as scholarships for children, eye camps, river bank improvement, blankets during wintertime and rice for poor villagers.

(3) Impact on Local People in Downstream of the Dam

A series of local surveys, focus group discussions, in-depth interviews and household interviews with the project affected people, was conducted in this ex-post evaluation. The survey outcomes suggested significant positive effects on the affected households and the community as a whole. Those surveyed reported a significant overall improvement in hygiene in their living environment, an increase in their income levels through new employment opportunities given to them, and improvements in their children's educational environment.

25 of 28 households said that resettlement had had good impact on their lifestyles and livelihoods, and 16 households felt very comfortable in their new neighborhoods. NHPC says that they reflect local people's views and take their opinions into the CSR plan every year. Consultation is on-going and actions taken when required.

Interview Survey with the Project Affected People

Survey Date: November 2011
Venue: Nigalpani, Chirkela, Tapovan, Jamuka villages of Dharchula town
Survey Method: The survey used household interviews, focus group discussions, and case studies to gather information.

The main focus of this survey was 37 "fully affected" and displaced households. However, nine of these households had moved out of their original villages and could not be reached.

Of the remaining 28 households covered, 18 household members were still employed at NHPC, while10 households had retired from jobs provided by NHPC. All the project-affected households were well compensated in the form of cash and employment as per the restoration and rehabilitation commitment of the project. They restored their livelihoods by purchasing new land and building houses which had the basic infrastructure of LPG and electricity supply facilities ready and available. Income stream analysis suggested that all 28 households had annual incomes above 300,000 rupees per annum.

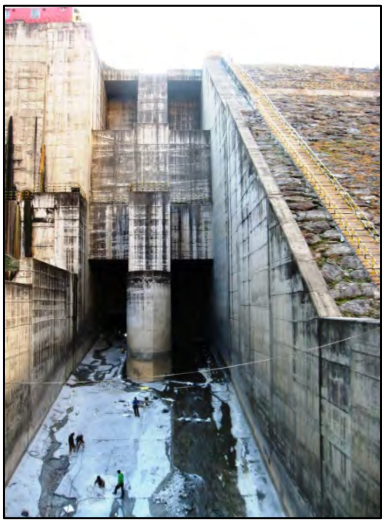
90% of the interviewed households agreed that resettlement has had a good impact on their lifestyle and livelihood. In the rehabilitation sites, around 60% of households felt very comfortable in their neighborhoods, and felt very secure while outside their homes. This indicates that project-affected households felt socially secure in the post-displacement period. Roads in and around the study villages however are in need of repair.

This project has largely achieved its objectives; therefore its effectiveness is high. However, there were constraints in evaluating to what extent this project contributed to the improvement of the electricity supply in the northern grid due to the fact that the installed capacity of this project made up less than 1% of the total. Adverse impacts on natural and social environment have remained at a minimum through a series of actions implemented by the executing agency. There have been positive impacts such as improvements in the natural environment and in people's living conditions in the upstream area.

3.4 Efficiency (Rating: ②)

3.4.1 Project Outputs

The aim of this project was to construct a 280 MW hydroelectric power station in the Pithoragarh District of Uttarakhand State. The major planned outputs were: reservoir (gross storage volume: 6.2 million m^3, max reservoir level: 1,348.5 above sea level), rock-fill dam (max height above river bed level 56 m, length of dam crest 270 m), spillway with three gated sluices (10 m high X 6 m wide), river diversion tunnel, headrace tunnel intake structure, de-silting chamber, surge shaft, pressure shaft, underground power house (4 X 70 MW with francis type of turbine, rated net head: 297 m), tailrace tunnel, tailrace surge gallery, consulting services (117 man/month), and a Panel of Experts (45 man/month).



Source: Evaluation Study Team

Picture 1: Spillway

Major changes in the actual outputs were of dam type and the number of gated sluices of the spillway[23]. Other changes were minor ones and most outputs were realized as planned.

As for the manning schedule of consulting services, 115 man/month was used against the planned 117, in which consultants conducted technical reviews and the finalization of the bid level of the project and of the tender documents. NHPC built a project office for supervision with in-house units for design, construction, quality control and monitoring.

[23] The dam type was changed to a concrete faced rock-fill dam mainly because of the physical difficulty in obtaining construction materials (clay core) around and in the suburbs of the project site, and because of the financial inefficiencies in purchasing and transporting raw materials from remote areas. Based on the technical advice of the POE, the dam design was changed, its technical viability confirmed. S lope failure on the right bank due to unforeseeable physical conditions also meant changes in spillway design. A two-bay spillway was constructed in place of a three-bay, and the requirement for the last bay was fulfilled by modifying an existing diversion tunnel into a tunnel spillway.

The Panel of Experts was comprised of foreign engineers: a geologist, a hydro-mechanical engineer, an electro-mechanical engineer, a civil engineer, an environmental expert, a hydrologist, and a hydraulist. Five of these were expected to visit the project site four times a year on average to solve any technical problems occurring during the construction period, to maintain quality management, and to give technical advice for smooth implementation. For this, 6.5 man/month was used against the planned 45. According to NHPC, the POE played a significant role in solving technical obstacles. They examined and confirmed technical viability in changing the dam type, and modifying the third spillway design. They gave technical advice on various issues of the plan, design and execution of the project, which significantly promoted the smooth project implementation process.

3.4.2 Project Inputs

3.4.2.1 Project Cost

The actual project cost was 47,541 million yen, which was 89.8% of the planned cost of 52,968 million yen[24]. The disbursed amount of ODA loan was 33,336 million yen in total against 35,871 million yen, which was also within the plan (92.9%).

Table 6: Planned and Actual Project Cost

<table>
<tr><th rowspan="2"></th><th colspan="3">Plan</th><th>Actual</th></tr>
<tr><th>Foreign Currency (Mil. Yen)</th><th>Local Currency (Mil. INR)</th><th>Total (Mil. Yen)</th><th>Total (Mil. Yen)</th></tr>
<tr><td>1. Preparation works</td><td>-</td><td>1,410</td><td>4,075</td><td>686</td></tr>
<tr><td>2. Civil work</td><td>12,361</td><td>1,390</td><td>16,380</td><td rowspan="2">25,191</td></tr>
<tr><td>3. Metal work</td><td>523</td><td>-</td><td>523</td></tr>
<tr><td>4. Electro-mechanical work</td><td>8,033</td><td>-</td><td>8,033</td><td>6,146</td></tr>
<tr><td>5. Land acquisition</td><td>-</td><td>119</td><td>344</td><td>562</td></tr>
<tr><td>6. Administration costs</td><td>-</td><td>1,259</td><td>3,637</td><td rowspan="3">9,476</td></tr>
<tr><td>7. Tax and duties</td><td>-</td><td>857</td><td>2,476</td></tr>
<tr><td>8. Price escalation</td><td>2,746</td><td>2,266</td><td>9,293</td></tr>
<tr><td>9. Contingency</td><td>1,875</td><td>441</td><td>3,151</td><td>2,028</td></tr>
<tr><td>10. Consulting services / Panel of Experts</td><td>669</td><td>18</td><td>721</td><td>482</td></tr>
<tr><td>11. Interest during construction</td><td>4,355</td><td>-</td><td>4,335</td><td>2,970</td></tr>
<tr><td>Total</td><td>30,542</td><td>7,760</td><td>52,968</td><td>47,541</td></tr>
</table>

Source: JICA appraisal documents and NHPC.

Note 1: The cost estimate at the first appraisal in 1995 was deemed as the planned cost for plan-actual comparison in this ex-post evaluation. The exchange rate was INR 1 = JPY 2.89 (April 1995).

Note 2: Taking into consideration the fact that there had been wide ranges of fluctuation between the INR and USD, and the JPY and USD exchange rates during the project period, exchange rates applied for converting the actual cost into Japanese yen were taken from the average annual rates issued by IMF at the International Financial Statistics; Yearbook from 1995 to 2005.

Note 3: As there was no common definition of the expenditures of foreign currency and local currency, a comparison between planned and actual cost in two currencies was not viable.

Due to additional civil work after the slope failure on the right bank and construction of the tunnel spillway, together with road widening and the strengthening of bridges for the transportation of construction equipment and heavy machinery, the actual cost in Indian rupees, 18,589 million rupees, exceeded the planned project cost of 15,783 million rupees sanctioned by the Indian Government in 2000. However, the yen value steadily appreciated against the Indian rupee throughout the project implementation period, which resulted in a lower cost than planned when converted into Japanese yen.

[24] The cost estimate at the first appraisal in 1995.

3.4.2.2 Project Period

The actual project implementation period was 119 months from January 1996 (project start[25]) to November 2005 (project completion[26]) against the 105 months of planned project period from January 1996 to September 2004 (113%). This was slightly longer than planned.

Table 7: Comparison of Planned and Actual Project Period

	Plan	Actual
Signing of first loan agreement	Jan 1996	Jan 1996
Selection of consultants	Jan 1996 to July 1997	Sep 1996 to Jun 1997
Detailed Design Study	Jul to Dec1997	Jul 1997 to May 1998
Review of pre-qualification and tender documents	Sep to Dec 1997	
Preparation for tender	Dec 1997 to Jun 1999	Oct 1998 to Dec 1999
Services of Panel of Experts (POE)	Oct 1998 to Sep 2004	May 1998 to Oct 2005
Prequalification	Oct 1997 to Feb 1998	May to Oct 1998
Tender / contracts	Feb 1998 to Jun 1999	Oct 1998 to Feb 2000
Supplemental survey on Glacier Lake Outburst Flood (GLOF)	Jun 1997 to Mar 1998	2000 to 2001
Preparation works	Apr 1995 to Mar 1997	1998 to 2000
Civil works	Aug 1998 to Nov 2003	Jan 2000 to Jan 2005
Hydro-mechanical works	Jun 1999 to Feb 2003	Feb 2000 to Oct 2005
Electro-mechanical works	Jun 1999 to Oct 2001	Feb 2000 to Nov 2005
Extension of transmission lines and substation	Jun 1999 to May 2003	Dec 1997 to Jul 2005
Commissioning	Unit 1: Dec 2003 Unit 2: Mar 2004 Unit 3: Jul 2004 Unit 4: Sep 2004	Unit 1: Nov 2005 Unit 2: Nov 2005 Unit 3: Oct 2005 Unit 4: Nov 2005

Source: JICA appraisal documents and NHPC.

The major factor causing delay in construction start was the receipt of clearances from Central Government. NHPC was required to receive various clearances from relevant authorities: the Techno Economic Clearance (TEC) was issued in 1988 from the Central Electricity Authority (CEA) prior to JICA's involvement. Another clearance from the Public Investment Board (PIB) was issued in 1991. The last clearance from the Cabinet Committee on Economic Affairs (CCEA) was issued in 2000.

Time overrun of the construction period was caused by a delay of eight months in the spillway construction works due to slope failure on the right bank and the resulting design change. Delays were also caused by the change in surge shaft type, and the delay in the extension of transmission lines. Leakages were observed from the headrace tunnel when it was tested in March 2005, and repair works there lasted until July in the same year. The Power Grid Corporation of India Ltd (PGCIL) completed the extension works of the transmission lines to the Dhauliganga Power Station at the end of July 2005.

3.4.3 Results of Calculations of Internal Rates of Return (IRR) (for ODA Loan project)

3.4.3.1 Financial Internal Rate of Return

FIRR as calculated at the first appraisal (1995) and at the second appraisal (1997) was 7.24%. At the third appraisal (2003), it was recalculated as 8.5%. FIRR calculations were based upon the preconditions below. The result of recalculation of FIRR for the project at the

[25] The project start was defined as the signing of the first loan agreement.

[26] The project completion was defined as the commissioning date of commercial operation of all four generation units.

time of the ex-post evaluation was 8.93%[27].

	1st Appraisal and 2nd Appraisal	3rd Appraisal
FIRR	7.24%	8.5%
Cost	Construction cost, O&M cost	Construction cost, O&M cost
Benefit	Revenue of electricity sales	Revenue of electricity sales
Project Life	25 years after commencement of commercial operation	25 years after commencement of commercial operation

3.4.3.2 Economic Internal Rate of Return

EIRR as calculated at the first and the second appraisals was 12.83%. It was recalculated as 15.6% in the third appraisal.

Due to difficulties in collecting the necessary information and data regarding the benefits for the recalculation of EIRR, the ex-post evaluation did not undertake a recalculation of EIRR. The EIRR calculations at appraisals were based upon the preconditions below:

	1st Appraisal and 2nd Appraisal	3rd Appraisal
EIRR	12.83%	15.6%
Cost	Project cost	Construction cost excluding taxes and duties, O&M cost
Benefit	Cost required for alternative project implementation (construction cost and O&M cost of a coal thermal power plant at same scale)	Long-term marginal cost
Project Life	25 years after commencement of commercial operation	25 years after commencement of commercial operation

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

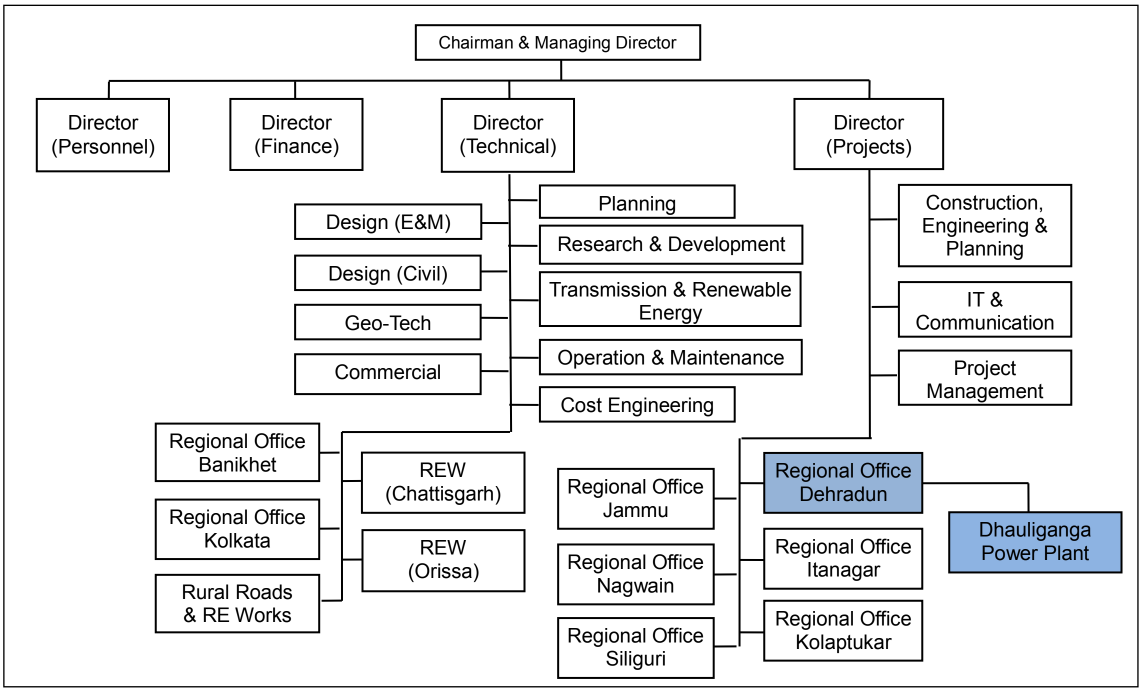
3.5 Sustainability (Rating: ③)

3.5.1 Structural Aspects of Operation and Maintenance

The operation and maintenance (O&M) agency of this project is NHPC Ltd. The total number of employees at NHPC was 11,000 as of November 2011, topped by the Chairman and Managing Director, Directors in personnel, finance, technical and projects departments were allocated and underneath them were regional offices and power stations. The total electric power generated by NHPC power stations increased year by year, from 12,567 GWh (2005/06) to 18,606 GWh in 2010/11. The following figure shows NHPC's organizational structure.

NHPC owned twelve power stations nationwide as of March 2011. Out of these, the Dhauliganga Power Plant was supervised by the Dehradun Regional Office located in the Uttarakhand State capital. The power station had 303 employees as of the end of November 2011: 68 executives including the general manager, chief engineer, senior managers, managers and others; 26 supervisors such as junior engineers; 201 highly skilled, skilled and unskilled workmen and eight paramedic staff. In addition, 270 local residents were also employed.

[27] NHPC submitted a project completion report to the Planning Commission of the Central Government at the end of October 2009, in which they calculated FIRR and EIRR as 9.05% and 9.27% respectively.



Source: NHPC

Note: Concerned departments are extracted related to this project.

Figure 4: Organizational Structure of NHPC

3.5.2 Technical Aspects of Operation and Maintenance

NHPC has received both international and domestic awards in the past. Thorough quality management, environmental management, and safety and health management has been applied at NHPC corporate office in Faridabad, at regional offices and power stations, and it has been certified for ISO9001:2008 (Quality Management System), ISO14001:2004 (Environmental Management System), OHSAS 18001:2007 (Occupational Health and Safety Management Systems) for its corporate office in Faridabad and for 14 locations including all power stations and a number of regional offices. NHPC has further gone ahead to integrate the above systems under the Integrated Management System (IMS)/PAS 99. NHPC was awarded 'Best Human Resource Management' in 2011 and others in India.

NHPC has provided training opportunities for its employees. A total of 145 staff participated in outside training courses, and 894 staff joined internal training programs in 2010/11. C ourses vary from technical skill improvement, to those covering environmental aspects, financial management, labor law etc. In 2010/11, 98.5% of O&M staff at the Dhauliganga Power Plant enrolled and completed training courses on O&M. NHPC even provides African trainees with training courses on operation and maintenance of hydroelectric power stations

Therefore, there is no particular problem in the technical aspects of NHPC.

3.5.3 Financial Aspects of Operation and Maintenance

Table 8 shows the O&M budget and expenditure of the Dhauliganga Power Plant from 2005/06 to 2011/12. According to Dhauliganga, they request budget allocation with minimum amount, and its corporate office then allocates the approved amount, which is part of reason for the fact that the actual expenditure exceeds budget every year. However, the Dhauliganga Power Station sells electric energy to the power utilities throughout the northern region, and its sales revenue is large enough to settle all the O&M cost.

Table 8: O&M Budget and Expenditure of Dhauliganga Power Station

Unit: Million Rs.

2005/06		2006/07		2007/08		2008/09		2009/10		2010/11		2011/12*	
Plan	Actual	Plan	Actual	Plan	Actual	Plan	Actual	Plan	Actual	Plan	Actual	Plan	Actual
453.4	592.6	1,207.1	1,292.8	1,228.8	2,188.5	1,308.5	3,046.3	2,146.9	2,288.1	2,180.3	3,968.6	2,258.9	1,628.4

Source: NHPC

Note: Figures for 2011were collected from 1 April to the end of October 2011.

As of 2011, the Dhauliganga Power Station sold electricity to eight states and two union territories (Delhi, Chandigarh, Uttar Pradesh, Jammu & Kashmir, Punjab, Jaipur, Rajasthan, Uttarakhand, Haryana, and Himachal Pradesh)[28]. Energy sales had increased steadily for consecutive six years, reaching 3,116 million Rs. in 2010/11 (Table 9).

The electricity tariff is decided based on the regulations of the Central Electricity Regulatory Commission[29], and the tariff for the electricity sold from Dhauliganga was Rs. 2.68 / kWh as of November 2011.

Table 9: Profit and Loss of Dhauliganga Power Station

Unit: Million Rs.

	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
Income	939.6	1,794.9	3,039.6	3,810.1	3,010.3	5,187.3
Of which energy sales	*903.8*	*1,744.8*	*2,028.9*	*2,265.7*	*2,837.1*	*3,116.2*
Expenditure	592.6	1,292.8	2,188.5	3,046.3	2,288.1	3,968.6
Of which generation administration and other expenses	*80.6*	*199.6*	*134.4*	*24s6.4*	*389.2*	*297.1*
Of which Depreciation	*200.0*	*410.8*	*403.9*	*471.6*	*976.5*	*938.7*
Profit before Tax	347.2	502.1	851.1	763.9	722.2	1,218.7
Profit after Tax (Net Profit)	347.0	494.5	794.2	761.6	721.6	1,150.7

Source: NHPC.

Profit and loss figures for NHPC and its subsidiary companies including Dhauliganga, shows that the whole group has increased sales and income as well as profit (Table 10). R eturn on Assets (ROA) has remained at around 4 to 5% (Table 11), which indicates that long-term profitability is secured.

[28] Energy sales to the Uttar Pradesh Power Corporation Ltd. and the Punjab State Electricity Board account for over 40%.

[29] The Central Government and State Governments have worked since late 1990 on power sector reforms resulting in the establishment of regulatory bodies, improvements in transparency and avoidance of political intervention in regulating tariff structures, improvements in the management of distribution companies by utilizing private investments, and the abolition of state subsidies. The Central Electricity Regulatory Commission (CERC) was established in July 1998, and the current electricity sales price follows a tariff structure for 2009 to 2014 as stipulated in the Notification No.L-7/145(160)/2008-CERC (dated 19 Jan 2009).

Table 10: Profit and Loss of NHPC Group

Unit: Million Rs.

		2007/08	2008/09	2009/10	2010/11
Income		34,298.3	40,720.4	57,945.5	59,507.4
	Of which energy sales	*29,821.0*	*35,334.9*	*51,638.7*	*49,166.6*
Expenditure		18,984.9	25,802.7	30,392.5	33,499.9
	Of which generation administration and other expenses	*3,235.7*	*3,690.8*	*2,919.0*	*5,851.5*
	Of which depreciation	*5,455.4*	*6,440.7*	*12,683.5*	*11,665.5*
Profit before Tax		15,313.4	14,917.7	27,553.0	26,007.5
Profit after Tax (Net Profit)		12,994.4	13,310.9	22,775.6	24,627.7

Source: NHPC. Annual Report (2008-09, 2009-10, 2010-11)

NHPC and its subsidiary companies have shown favorable figures in their current ratio and fixed ratio. Total equity has exceeded total liabilities, and the equity to assets ratio also shows good figures, which indicates a high solvency of the NHPC group. B udget allocation and financial back-up for the Dhauliganga Power Station is thus secured in the long-run.

Table 11: Major Financial Indicators of NHPC Group

	2007/08	2008/09	2009/10	2010/11	2011/12	Notes
Current Ratio	145.86%	135.68%	208.31%	142.87%	N/A	Current Assets / Current Liabilities
Fixed Ratio	143.44%	151.35%	128.78%	134.01%	N/A	Fixed Assets / Equity
Equity to Assets Ratio	57.58%	54.29%	56.95%	56.29%	N/A	Equity / Assets
Return on Assets	4.08%	3.57%	5.56%	4.92%	N/A	Ordinary Profit / Assets

Source: NHPC Annual Report (2008-2009, 2009-2010, 2010-2011)

The profit and loss, and financial status of NHPC and the Dhauliganga Power Station are deemed firm. There is no particular problem with financial self-sustainability since the operation and maintenance budget is firmly secured for this project

3.5.4 Current Status of Operation and Maintenance

(1) Power Station Facilities

Based on the technical manual, there are 211 check items including 49 items for generators and 27 f or rotors. Routine and major maintenance is conducted monthly and yearly respectively.

Routine and preventive maintenance is conducted daily, weekly and monthly, and major maintenance is conducted yearly at both power house and dam. As for annual maintenance for generators in 2010, for instance, 28 days were spent on maintenance for Unit 1, 25 days for Unit 2, 22 days for Unit 3, and 18 days for Unit 4.

It was confirmed during the field survey of this ex-post evaluation that Dhauliganga technical staff members continue to record data on O&M for all facilities of the power house and dam, and the condition remains good.

(2) Countermeasures for Sedimentation

NHPC and other state power bodies with hydroelectric power plants are fully aware of the serious operation risk caused by accumulated silt in reservoirs. Countermeasures were taken in the design of the Dhauliganga Power Plant with the addition of a de-silting chamber and silt ejector, and in the catchment area treatment works. Compensatory afforestation and technical guidance given to the local people were commenced prior to the construction of the Power Station, which also helped reduce the amount of the suspended load inflow from the upstream area.

In the site survey of this ex-post evaluation, it was seen that the volume of sedimentation in the reservoir has sharply declined from 410,000 to the present 30,000 m^3 (see 3.2.1). In addition to the collection of silt at the de-silting chamber, silt is ejected in the upstream area before full operation of dam during monsoon season, and silt in the reservoir is flushed every fifteen days during the same period. The Dhauliganga Power Station monitors and keeps records of the suspended sediment upstream of the silt ejector and tailrace tunnel every day in order that quick action may be taken in the case that any abnormal condition is found.

(3) Monitoring of Glacier Lakes

It was confirmed that there seven glacier lakes existed in the upstream tributary and the Dhauliganga river basin at the time of the first appraisal in 1994. In response to the suggestion that countermeasures against glacier lake outburst floods be taken immediately, JICA conducted the Dhauliganga Hydroelectric Power Project Special Assistance for Project Implementation (SAPI) in 2001. Then, the volumes and transitions of glacier lakes were observed and analyzed using digital satellite images from 1994 and 2000 taken by the National Remote Sensing Agency (NRSA). It was found that the size of the glacier lakes remained 1.0 to 1.2 million m^3, and that their volumes did not change very much. Since the inventory did not indicate any imminent potential hazard, it seemed that no immediate action was required, for example, in developing a detection system. However, it was recommended that inventories and analysis of the glacier lakes should be carried out periodically as this was not indicative of longer-term trends. In the case that a significant potential hazard in any of the glacier lakes in the Dhauliganga river basin be revealed, then the GLOF forecast warning system would be implemented without delay.

Up to present, NHPC has conducted remote sensing data collection every five years since 1994, but there has been no detection of any indicative features of outburst flood, or of increases or decreases in the area of glacier lakes. These lakes at present are not significant enough to have an adverse impact on the Dhauliganga Power Station. NHPC will continue to monitor the condition of the glacier lakes based on the recommendation drawn up in the SAPI study.

No major problems have thus been observed in the operation and maintenance system, therefore the sustainability of the project effect is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project was implemented to cope with growing power and energy demand in the northern region of India by the construction of a hydroelectric power plant. Its objectives were highly relevant to India's development plan and development needs, as well as to Japan's ODA policy, therefore its relevance is high. Since the key operation and effect indicators such as maximum output, plant load factor, availability factor, and electric energy production met the targets, this project has largely achieved its objectives. Thus its effectiveness is high. However, there were constraints on the evaluation of the extent to which this project contributed to the improvement of the electricity supply in the northern grid due to the fact that the installed capacity of this project makes up less than 1% of the entire grid. Adverse impacts on natural and social environment remained at a minimum thanks to various actions implemented by the executing agency. There were positive impacts such as improvements in the natural environment and in people's living conditions in the upstream area. Although there were some changes in design, such as dam type, the project outputs were realized mostly as planned. Although the project cost was within the plan, the project period slightly exceeded it and therefore the efficiency of the project is fair.

This project's organizational, technical and financial sustainability is high and the project is well operated and the facilities well maintained. In light of the above, this project is evaluated to be highly satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

Not applicable.

4.2.2 Recommendations to JICA

Not applicable.

4.3 Lessons Learned

(1) Project implementation mechanism with technical expertise fully utilized

A Panel of Experts was formed, comprising of a geologist, a hydro-mechanical engineer, an electro-mechanical engineer, a civil engineer, an environmental expert, a hydrologist and a hydraulist. There was slope failure on the right bank, which caused design changes. The POE provided various technical advices on countermeasures and modifications in the project design, and the executing agency took immediate action.

The establishment of POE within the implementation mechanism of the project helped to manage risks during the construction period, and to prevent further unexpected accidents. This contributed to smooth project implementation in terms of time management and technical process management. Transparency and accountability was also secured by making use of third-party people with technical backgrounds. This kind of technical mechanism can be taken into consideration at the project planning stage, and can be applied in other future projects.

(2) Holistic mitigation measures in land acquisition and resettlement, and coordination mechanism with relevant authorities and affected people

The executing agency of this project coordinated and cooperated well with the State Forest Department and other local government agencies. All information and required procedures for land acquisition and resettlement was disclosed to the affected people, and their opinions reflected into the plans. Thus people's understanding and cooperation was gained. Affected households received individual compensation, and basic infrastructure which improved their living conditions (road, water supply, electricity supply and LPG supply). All fully affected households obtained employment opportunities, with which they built stable livelihoods in the long run. Such efforts by the executing agency meant that there was no delay caused by land acquisition or resettlement.

When planning and implementing similar projects in the future, it is desirable that a suitable and comprehensive approach is examined and introduced as it was in this project where there was an emphasis on building firm relationships with local government agencies and with people in the project area.

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
1. Project Outputs	(1) Reservoir ・ Max level: 1,348.5m asl ・ Full level: 1,345m asl ・ Minimum level: 1,330m asl ・ Gross storage volume: 6.2 million m^3 ・ Live storage volume: 1.54 million m^3	(1) Reservoir As planned
	(2) Dam ・ Type: rockfill dam ・ Max height above river bed level: 56m ・ Length of dam crest: 270m (elevation: 1,351m asl)	(2) Dam ・ Type: concrete faced rockfill dam (changed) ・ Max height above river bed level: as planned ・ Length of dam crest: as planned
	(3) Spillway ・ Type: gated sluices with open chute and flip bucket ・ Design flood: 3,210m / s ・ Invert level of gated sluices: 1,307m ・ No and size of sluices: three (10 m high X 6 m wide)	(3) Spillway ・ Type: as planned ・ Design flood: as planned ・ Invert level of gated sluices: as planned ・ No and size of sluices: Two (changed) (10 m high X 6 m wide) and the existing diversion tunnel was modified to one tunnel spillway (crest level: 1,332.87 m, radial gate size: 9 m X 16 high).
	(4) River diversion tunnel at dam site ・ Shape: horseshoe ・ Diameter: 10m ・ Length between portals: 750m	(4) River diversion tunnel at dam site ・ Shape: as planned ・ Diameter: as planned ・ Length between portals：753.56 m (changed)
	(5) Headrace tunnel intake structure ・ Invert level：1,307m ・ No and sizes of inlets: Two (5m high X 5m wide)	(5) Headrace tunnel intake structure As planned
	(6) De-silting chamber ・ Length: 300m ・ No and size: Two (13.0m X 16.2m) ・ Minimum particle size to be removed: 0.2mm	(6) De-silting chamber ・ Length: 315m (changed) ・ No and size: as planned ・ Minimum particle size to be removed: as planned
	(7) Headrace tunnel (concrete lined) ・ Shape: horseshoe ・ Diameter: 6.5m ・ Length: 5,400m ・ Discharge capacity: 107 m^3 / s	(7) Headrace tunnel (concrete lined) As planned
	(8) Surge shaft (concrete lined) ・ Type: vertical shaft with a short riser shaft ・ Internal diameter: 15m ・ Depth: 95m	(8) Surge shaft (concrete lined) ・ Type: Restricted orifice (changed) ・ Internal diameter: 14m (changed) ・ Depth: 96m (changed)
	(9) Pressure shafts ・ No and type: two circular vertical shafts, partly concrete and partly steel lined ・ Diameter: 4.0m ・ Depth: 250m	(9) Pressure shafts As planned

Item	Original	Actual
	(10) Underground power house ・ Type of turbine: francis, vertical axis ・ Installed capacity: 280MW (70MW X 4 units) ・ Normal tail water level: 1,034m ・ Max gross head: 311m ・ Rated net head: 297m ・ Dimension of machine hall: 16.5m X 103m X 39m ・ Dimension of transformer cavern: 12m X 76m X 10m ・ Dimension of GIS cavern: 9m X 27m X 11m (11) Tailrace tunnel (concrete lined) ・ Type: Horseshoe ・ Diameter: 6.5m ・ Length: 445m (12) Tailrace surge gallery ・ Type: D-shaped curved ・ Diameter: 6.0m ・ Length: 280m (13) Consulting Services Foreign engineers: Total 117M/M (14) Panel of Experts Foreign engineers: Total 45M/M	(10) Underground power house ・ Type of turbine: as planned ・ Installed capacity: as planned ・ Normal tail water level: as planned ・ Max gross head: as planned ・ Rated net head: as planned ・ Dimension of machine hall: as planned ・ Dimension of transformer cavern: as planned ・ Dimension of GIS cavern: 10m X 27m X 11m (changed) (11) Tailrace tunnel (concrete lined) As planned (12) Tailrace surge gallery As planned (13) Consulting Services Foreign engineers: Total 115M/M (reduced) (14) Panel of Experts Foreign engineers: Total 6.5M/M (reduced)
2. Project Period	January 1996 to September 2004 (105 months)	January 1996 to November 2005 (119 months)
3. Project Cost		
Amount paid in Foreign currency	30,542 million yen	N/A
Amount paid in Local currency	22,246 million yen (7,760 million INR)	N/A (N/A)
Total	52,968 million yen	47,541 million yen
Japanese ODA loan portion	35,871 million yen	33,336 million yen
Exchange rate	1INR = 2.89 yen (As of April 1995)	1INR = 2.73yen (Average from 1995 to 2005)

India

Ex-Post Evaluation of Japanese ODA Loan
West Bengal Transmission System Project (I) (II)

External Evaluator: Keishi Miyazaki and Junko Fujiwara, OPMAC Corporation

0. Summary

This project was implemented to enhance the reliability of the transmission network system, to reduce transmission losses and voltage fluctuations, and to make intra-state electricity transmissions efficient through the provision of a competent electricity transmission network, the construction of new substations and the expansion of existing substations in West Bengal State. It has been highly relevant to India's development plan and development needs. Facilities provided under the project have been operated well, and the project has highly improved the reliability of the transmission network system, and has promoted reductions in transmission losses and in voltage fluctuation. The project has thus largely achieved its objectives, and its effectiveness is high. It is judged that the project has contributed directly indirectly to industrial development, employment creation and the improvement of people's living standards in the State. The project cost was within the plan, although the project period exceeded the plan, therefore the project efficiency is fair. The project sustainability is deemed high in the organizational, technological and financial aspects, and the O&M condition of project facilities and equipment is good.

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

1. Project Description

Project Location

Overview of Equipment
at Arambag 400 kV Substation

1.1 Background

The West Bengal State, with Kolkata as its capital, is one of the major states in the Eastern Region of India. Electricity demand in the State grew by approximately 7.3% per year on average from 1994/95 to 1998/99, and it was projected that it would keep growing at 6.5% on an annual basis from 1999/2000 to 2012/13. However, the State had seen apparent gaps between electricity demand and supply in 1990s: peak demand reached 2,749 MW in 1997/98, whereas the then installed generation capacity accommodated only 2,329 MW. In 1999/2000, the peak demand was 3,161 MW against the installed capacity of 2,577 MW. A lthough an adequate transmission network system in the State was a condition for a stable electricity supply in the Eastern grid[1] as well as in the North Eastern grid, the transmission capacity was not well enough developed to sustain the required load. With failures in the metering system, a low rate of payment, unauthorized connections and power theft, the State suffered from huge commercial losses. The communication systems at substations all over the State, in the hands of the executing agency of this project, the West Bengal State Electricity Board (WBSEB), were also not well developed, which made it difficult for the West Bengal State Dispatch Centre (WBSLDC) to discern the transmission status in real time.

1.2 Project Outline

The objective of this project was to enhance the reliability of the transmission network system, to reduce transmission losses and voltage fluctuations in West Bengal State. This was to be achieved through the provision of a competent electricity transmission network, the construction of new substations and the expansion of existing substations, thereby contributing to industrial development, employment creation and the improvement of people's living standards through rural electrification and promotion of home electric appliances in the State.

	First Phase	Second Phase
Loan Approved Amount / Disbursed Amount	11,087 million yen / 10,485 million yen	3,127 million yen / 2,251 million yen
Exchange of Notes Date / Loan Agreement Signing Date	Jan 1997 / Feb 1997	Mar 2002 / May 2002
Terms and Conditions Interest rate Repayment period (Grace period) Condition of procurement	2.3 % 30 years (10 years) General untied	1.8% 30 years (10 years) General untied
Borrower / Executing Agency	President of India / West Bengal State Electricity Transmission Company Ltd.	
Final Disbursement Date	May 2004	Aug 2009
Main Contractor (Over 1 billion yen)	RPG Transmission Ltd. (India), KEC International Ltd. (India), BHEL (India), Crompton Greaves Ltd. (India), W.S. Industries Ltd. (India), NELCO Ltd. (India)	
Main Consultant (Over 100 million yen)	Power Grid Corporation of India Ltd. (India) / Electric Power Development Company Ltd. (Japan) / Tokyo Electric Power Services Company Ltd. (Japan)	
Feasibility Studies, etc.	N/A	
Related Projects	Purulia Pumped Storage Project (I)(II)(III) (ODA Loan Project) Bakreswar Thermal Power Project (I)(II) / Bakreswar Thermal Power Station Unit 3 Extension Project (I)(II) / Bakreswar Thermal Power Station Units Extension Project (ODA Loan Project)	

Note: the West Bengal State Electricity Board (WBSEB) was unbundled on 1 April 2007 to become the West Bengal State Electricity Transmission Company Ltd. (WBSETCL) and the West Bengal State Electricity Distribution Company Ltd. (WBSEDCL).

[1] The Eastern grid was then comprised of West Bengal, Orissa, Bihar and Sikkim. As the southern part of Bihar became independent, as Jharkhand State, in 2000, the grid is now comprised of five states.

2. Outline of the Evaluation Study

2.1 External Evaluator

Keishi Miyazaki and Junko Fujiwara, OPMAC Corporation

2.2 Duration of Evaluation Study

Duration of the Study: August, 2011 – June, 2012
Duration of the Field Study: November 20 – December 19, 2011, March 11 - 21, 2012

2.3 Constraints during the Evaluation Study

Out of 31 intervened substations under this project, the Evaluators visited only four stations located in the Southern part of West Bengal State due to the fact that the substations are interspersed throughout the State and the Evaluators encountered severe time constraints during the evaluation study.

And it was also unable for the Evaluators to collect quantitative data at 26 substations out of 31 due to the fact that the intervened substations have not installed the data acquisition system for recording and monitoring the operation and effect indicators except the five pilot substations.

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

3.1 Relevance (Rating: ③[3])

3.1.1 Relevance with the Development Plan of India

The Eighth Five Year Plan of India, 1992/93 to 1996/97, laid emphasis on: i) improvements in the operation of existing thermal generation units and other plant and equipment, ii) reductions in the technical losses of the power system, iii) improvements in the financial performance of Central and State electricity, iv) the promotion of capacity additions to the existing installed generation capacity, v) the attracting of private investment in power development[4]. Out of the total investment in the public sector, 4,341 billion Indian rupees, the biggest proportion was investment in the energy sector, which at 1,155.6 billion rupees was at 26.6%. The share of electricity in the energy sector was 795.9 billion rupees, which amounted 18.3%[5].

The Government of India's Eleventh Five Year Plan, 2007/08 to 2011/12, was in place at the time of this ex-post evaluation study. In the Plan, the Government projected that the gross electricity requirement by the end of the Eleventh Plan on power would be 1,097 GWh; the estimation for peak demand was 158,000 MW. To fulfill the estimated electricity demand requirement, a capacity addition program was planned to secure an increase of 78,577 MW during the period[6]. The Plan also focused on the provision of an adequate inter-regional and intra-regional transmission capacity so as to consolidate and strengthen the national grid network towards a strong all-India grid. All distribution companies were urged to target a reduction of 3% per annum of their aggregate technical and commercial losses during the Plan period. The Government allocated 8,541.2 billion rupees for the energy sector, which comprised 23.4% of the public sector investment in the Plan. It was the social sector that shared the biggest amount: 1,123.4 rupees (30.2%), in the Plan.

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2 A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory
3 ③: High, ② Fair, ① Low
4 Planning Commission, Government of India. "Eighth Five Year Plan" (1992).
5 Oil (240 billion rupees: 5.5%), coal (105.1 rupees: 2.4%) and renewable energy (14.7 rupees: 0.3%) were also part of the energy sector.
6 Planning Commission, Government of India. "Eleventh Five Year Plan (2007-2012), Volume I Inclusive Growth" (2008).

The investment amount spent for West Bengal State was 97.6 billion rupees in the Eighth Five Year Plan, out of which 30.25 billion rupees were for the energy sector. In the Eleventh Plan, however, 176.3 billion rupees were allocated for energy sector investment out of 637.8 billion, which is the second to the social sector (237.8 billion).

It is thus concluded that this project was highly relevant to India's development plan and its power sector development plan at the time of project appraisal as well as at the time of the ex-post evaluation study.

3.1.2 Relevance with the Development Needs of India

The electricity demand of West Bengal increased approximately 7.3% per annum on average from 1994/95 to 1998/99, and it was projected that it would keep growing in the following years. Peak demand in 1997/98 reached 2,749 MW, while the then installed generation capacity was 2,329 MW, which left a peaking shortage of 420 MW. In order to reduce this demand/supply gap, an augmentation of transmission facilities was top priority. Frequent voltage fluctuation was also admitted as a problem, and it was urgently necessary to reinforce the transmission capacity and improve the reliability of the transmission network system in the State in order to provide a growing amount of electricity to consumers.

Since the project launch, power shortages in the State have remained severe: the power supply as of 2003/04 was 8,787.41 GWh against 13,807 GWh of power demand, while supply versus demand was 11,724 GWh against 17,840 GWh in 2006/07, and 15,497 GWh against 24,711 GWh in 2009/10. The State Government projects that power demand will continue to grow in the industry, agriculture and domestic sectors, and that the need to develop in order to cope with power demand and to improve the transmission system is high.

It is thus concluded that this project was highly relevant to the development needs for the reinforcement of transmission capacity in West Bengal State at the time of project appraisal as well as at the time of the ex-post evaluation study.

3.1.3 Relevance with Japan's ODA Policy

At the time of the first appraisal in 1996, economic infrastructure development, particularly for power and transport infrastructure, was a priority area in Japan's ODA strategy to India[7]. Later, in 1999/2000, implementation policy for JICA's overseas economic cooperation focused on assistance in the poverty sector, the environmental sector, and in economic and social infrastructure development for sustainable economic development.

In the current Country Assistance Program for India formulated by the Government of Japan in 2006/07 there is also an emphasis on economic infrastructure development, of which power sector is the highest priority[8] along with transportation sector.

It is thus concluded that the selection of this project was highly appropriate and relevant to Japan's assistance strategy.

This project was highly relevant to India's development plan, and to its development needs, as well as to Japan's ODA policy, therefore its relevance is high.

3.2 Effectiveness[9] (Rating: ③)

3.2.1 Quantitative Effects (Operation and Effect Indicators)

In order to assess the degree of attainment of this project's objectives: that is, to enhance the reliability of the transmission network system, to reduce transmission losses and voltage fluctuation, WBSETCL and JICA agreed to choose five substations out of the 31 under the

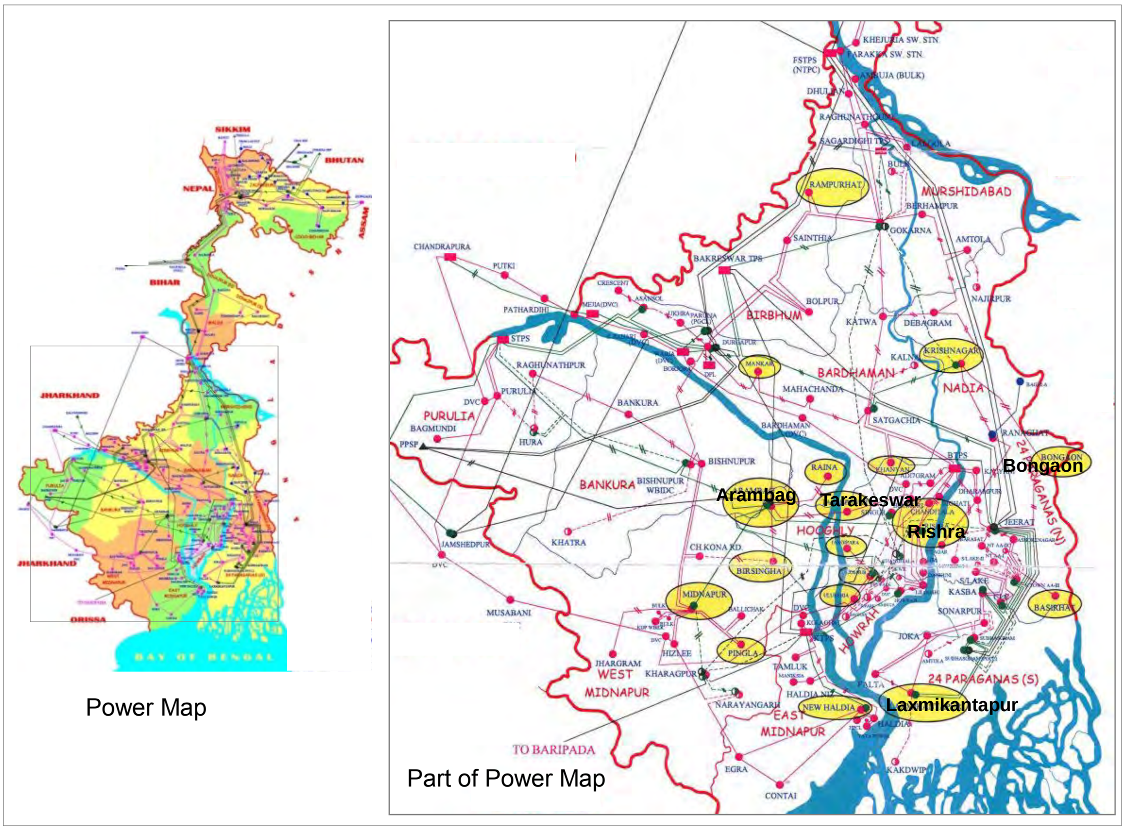
[7] The Ministry of Foreign Affairs. "Japan's ODA White Paper" (1998).
[8] The Ministry of Foreign Affairs. "Japan's Country Assistance Program for India" (2006).
[9] Rating for "effectiveness" also includes " impact".

project[10] to monitor specific measurable indicators. Their locations and details are shown in Table 1and Figure 1.

Table 1: Outline of Five Substations for Monitoring Operation & Effect Indicators

Substation	kV Ratio	Capacity in MVA	Actions under the Project
Arambag	400/220	315.0 x 3	Transformer (315 MVA, 400/220 kV) x 2, Transformer (160 MVA, 220/132 kV) x 1, 400 kV Bay x 7, 220kV Bay x 9, 132 kV Bay x 7
	220/132	160.0 x 3	
	132/33	31.5 x 2, 50.0 x 1	
Laxmikantapur	220/132	160.0 x 2	Transformer (160 MVA, 220/132 kV) x 2, 220 kV Bay x 5, 132 kV Bay x 4
	132/33	31.5 x 3	
Rishra	220/132	160.0 x 3	Transformer (160 MVA, 220/132kV) x 2, 220 kV Bay x 7, 132 kV Bay x 2
	132/33	50.0 x 3	
Bongaon	132/33	31.5 x 2	Transformer (31.5 MVA, 132/33 kV) x 2, Transformer (6.3 MVA, 33/11 kV) x 2, 132 kV Bay x 7
Tarakeswar	132/33	50.0 x 1	Transformer (31.5 MVA, 132/33 kV) x 2, Transformer (6.3 MVA, 33/11 kV) x 2, 132kV Bay x 7
	132/33	31.5 x 1	

Source: WBSETCL.
Note: kV Ratio and Capacity in MVA are those as of March 2011. Some substations were augmented with additional transformers or had a replacement of transformers due to heavy loading after the Project was complete.



Source: WBSETCL.
Note: Power map is as of March 2011. Substations circled in yellow are the ones under the Project, and the five substations are Arambag, Tarakeswar, Rishra, Bongaon and Laxmikantapur.

Figure 1: Power Map of West Bengal

[10] Electricity supply, electricity demand, availability factor, transmission loss, station use electricity, and peak load at sending point were recorded for monitoring when WBSETCL and JICA agreed to apply them as the operation and effect indicators in 2001. In this ex-post evaluation study, the evaluators also recorded planned outage hours, forced outage hours, outage rate for S/S, and outage rate in addition to the above indicators for T/L for a more comprehensive analysis on project effectiveness.

(1) Enhancement of Reliability of the Transmission Network System

WBSETCL owned 103 substations throughout West Bengal State as of November 2011, out of which 31 were newly constructed or augmented under the project. This large scale of intervention has brought more reliability to the transmission network in the State. The extension of major transmission lines has also increased the transmission capacity to a large extent.

The current condition of the five pilot substations and progress up to present are described below:

i) Arambag Substation

Arambag Substation was initially commissioned in 1995 as a 200 kV substation to connect with Santaldihi Thermal Power Plant - Arambag of 220 kV bay level transmission line and Arambag - Howrah line.

Arambag was then expanded with 400kV, 220 kV and 132 kV circuits along with 400/220 kV and 220/132 kV transformers under the project. The construction of 220 kV and a 132 kV switchyard was achieved through internal funding from WBSETCL. However, the construction of the 400 kV switchyard was achieved through JICA financial assistance. The Substation is the second 400 kV substation of WBSETCL and the largest in the State considering switchyard area.

Source: Study Team

Picture 1: Control Panels at Arambag S/S

The Substation sends out over 800 MW of energy from Kolaghat Thermal Power Plant, Bakreshwar TPT[11], Santaldihi TPT and Purulia Pumped Storage Hydro Power Plant[12] as shown in Table 2. Power demand was 200 MW in 2000/01, becoming four times this in 2009/10. At the 220 kV level, the station is connected through Midnapur S/S[13], Bishnupur S/S and Domjur S/S[14] through double circuit lines and the single circuit Rishra line[15]. At the 132 kV level, the station is connected in ring main with Birsingha S/S[16], Raina S/S[17] and Tarakeswar S/S through double circuit lines. Both electricity supply and electricity demand have reached the target, and it currently handles over 4,000 GWh of electricity per year (Table 2).

According to WBSETCL, the Substation will be augmented with additional transformers (315MVA, 400/220 kV x 1, and 37MVA, 132/33 kV x 1) in 2012/13 since the availability factor hit over 100% in 2010/11[18].

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[11] JICA has extended its ODA assistance loan to Bakreshwar Thermal Power Project (I) (approved amount: 27,069 million yen, approved date: 1993/94), Bakreshwar Thermal Power Project (II)(34,151 million yen, 1997/98), Bakreshwar Thermal Power Station Unit 3 Extension Project (I) (8,659 million yen, 1994/95), Bakreshwar Thermal Power Station Unit 3 Extension Project (II) (11,537 million yen, 1998/99), Bakreshwar Thermal Power Station Units Extension Project (36,771 million yen, 2002/03).

[12] JICA also extended ODA assistance loans to the engineering service for the Purulia Pumped Storage Project in FY 1987 (approved amount: JPY 628 mil), PPSP (I) in FY 1994 (JPY 20,520 mil), PPSP (II) in FY 2003 (JPY 23,578 mil), and PPSP (III) in FY2005 (JPY 17,963 mil).

[13] The substation was one of 31 substations under the project.

[14] Ditto.

[15] The line was extended under the project.

[16] Ditto.

[17] Ditto.

[18] Relevant data were provided by WBSETCL during the country survey in December 2011.

Table 2: Operation & Effect Indicators at Arambag Substation

Indicators	Target (2010/11)	Actual		
		(2008/09)	(2009/10)	(2010/11)
Electricity Supply (GWh)	2,939	2,541	3,526	3,909
Electricity Demand (GWh)	2,895	2,522	3,529	4,173
Availability Factor (%)	66.36	57.43	61.73	105.50
Transmission Loss (%)	0.5	0.73	0.11	0.10
Station Use Electricity (GWh)	29.393	N/A	N/A	N/A
Peak Load at Sending Point (MW)	533.07	726.20	791.77	876.35
Planned Outage Hours (Hours)	-	N/A	N/A	245:41
Forced Outage Hours (Hours)	-	N/A	N/A	327:10
Outage Rate for S/S (Nos/MVA)	-	N/A	N/A	0.117
Outage Rate for T/L (Nos/km)	-	N/A	N/A	N/A

Source: WBSETCL.

ii) Laxmikantapur Substation

Laxmikantapur is one of the oldest and most important substations of WBSETCL. Earlier, the Substation was comprised of 132 kV, 33 kV and 11 kV switchyards, then with JICA finance it was upgraded to 220 kV. According to WBSETCL, upgrading of the Substation enabled WBSEDCL to serve nearby rural areas which have witnessed a major growth in agriculture consumers in the last 5 years.

Both electricity supply and demand have reached, and far exceeded the target figures as shown in the table below, and the substation will also be augmented with an additional transformer (160MVA, 220/132 kV x 1) in 2012, adding to the two existing ones, as the availability factor hit 90% in 2010/11.

Table 3: Operation & Effect Indicators at Laxmikantapur Substation

Indicators	Target (2010/11)	Actual		
		(2008/09)	(2009/10)	(2010/11)
Electricity Supply (GWh)	803	760	1,233	1,152
Electricity Demand (GWh)	791	759	1,180	1,116
Availability Factor (%)	53.56	80.92	88.53	90.02
Transmission Loss (%)	0.5	N/A	2.08	2.10
Station Use Electricity (GWh)	8.033	3.94	4.38	5.52
Peak Load at Sending Point (MW)	145.69	233.57	255.82	266.73
Planned Outage Hours (Hours)	-	N/A	N/A	120:01
Forced Outage Hours (Hours)	-	N/A	N/A	63:49
Outage Rate for S/S (Nos/MVA)	-	N/A	N/A	0.075
Outage Rate for T/L (Nos/km)	-	N/A	N/A	1.11

Source: WBSETCL.

iii) Rishra Substation

Earlier, the Rishra Substation had 132 kV and 33 kV switchyards, then with JICA funding the substation was upgraded to 220 kV level. Rishra is currently charged from one single circuit 220 kV feeder from the Arambag S/S and also directly fed from 220 kV T/L originating from the Bandel Thermal Power Station. The electricity supply has reached target, and the availability factor and peak load far exceed the target figures catering for the energy needs of industrial consumers in the vicinity of around 50 to 60 km (See Table 4). Forced outage hours have been on decrease.

Table 4: Operation & Effect Indicators at Rishra Substation

Indicators	Target (2010/11)	Actual		
		(2008/09)	(2009/10)	(2010/11)
Electricity Supply (GWh)	651	241	652	655
Electricity Demand (GWh)	641	222	606	598
Availability Factor (%)	43.41	50.34	59.37	66.33
Transmission Loss (%)	0.5	1.9	1.12	1.02
Station Use Electricity (GWh)	6.510	5.6	6.1	7.0
Peak Load at Sending Point (MW)	118.07	114.38	157.70	172.13
Planned Outage Hours (Hours)	-	N/A	1034:33	444:06
Forced Outage Hours (Hours)	-	N/A	357:12	277:46
Outage Rate for S/S (Nos/MVA)	-	N/A	0.055	0.0698
Outage Rate for T/L (Nos/km)	-	N/A	1.536	1.0267

Source: WBSETCL.

iv) Bongaon Substation

The Bongaon Substation was newly constructed under the project at 132 kV Bay level. Bongaon is currently charged from the Jeerat 400 kV S/S[19] and from Krishnagar 132 kV S/S[20] through 132 kV feeders. The electricity supply, availability factor and peak load have almost reached target, and the number of forced outage hours, and planned outage hours have slightly improved in the past three years (See Table 5).

Table 5: Operation & Effect Indicators at Bongaon Substation

Indicators	Target (2010/11)	Actual		
		(2008/09)	(2009/10)	(2010/11)
Electricity Supply (GWh)	255	148.5	165	227
Electricity Demand (GWh)	251	145	163.7	232
Availability Factor (%)	86.48	76.12	81.95	83.30
Transmission Loss (%)	0.5	0.11	5.39	0.27
Station Use Electricity (GWh)	2.553	0.936	0.960	0.948
Peak Load at Sending Point (MW)	46.31	42.05	45.90	48.07
Planned Outage Hours (Hours)	-	85	72	70
Forced Outage Hours (Hours)	-	55	50	46
Outage Rate for S/S (Nos/MVA)	-	0.34	0.27	0.29
Outage Rate for T/L (Nos/km)	-	0.06	0.07	0.06

Source: WBSETCL.

v) Tarakeswar Substation

Like the Bongaon Substation, the Tarakeswar Substation was also newly constructed under the project at 132 kV Bay level. Tarakeswar is charged from the Arambag 400 kV S/S through 132 kV transmission line. The main activities in its catchment are agricultural and so the demand for electricity in the area remains low compared with the industrial area where the Rishra Substation is located. The electricity supply and peak load thus remain lower than target. However, the availability factor exceeds target (See Table 6).

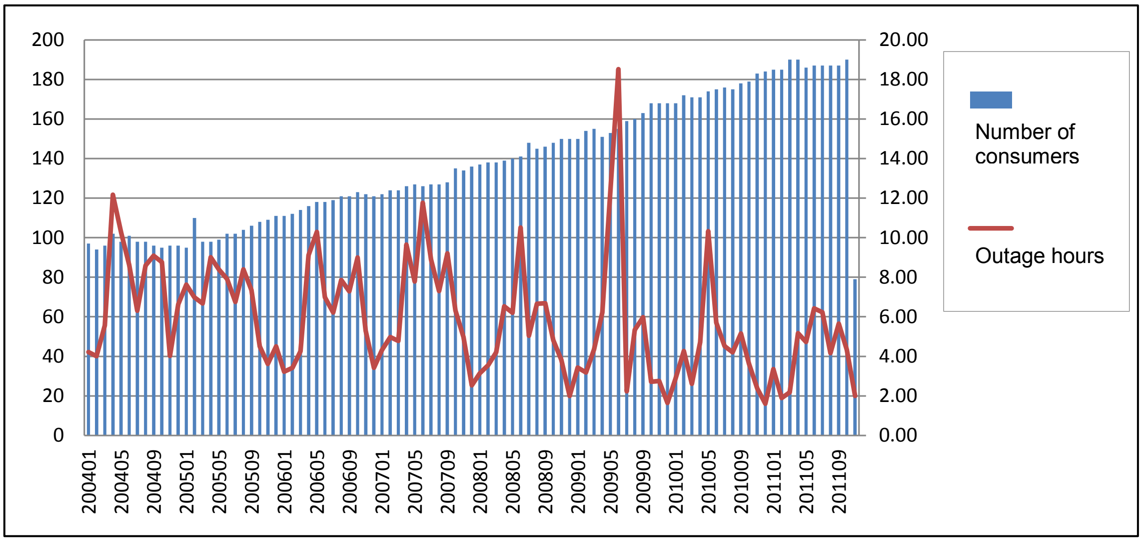
[19] The substation was under the project.
[20] Ditto.

Table 6: Operation & Effect Indicators at Tarakeswar Substation

Indicators	Target (2010/11)	Actual		
		(2008/09)	(2009/10)	(2010/11)
Electricity Supply (GWh)	340	116	185	218
Electricity Demand (GWh)	335	115	184	218
Availability Factor (%)	64.29	60.00	66.81	73.39
Transmission Loss (%)	0.5	0.37	0.37	0.18
Station Use Electricity (GWh)	3.405	0.143	0.09	0.07
Peak Load at Sending Point (MW)	61.75	43.23	48.84	54.91
Planned Outage Hours (Hours)	-	N/A	N/A	153
Forced Outage Hours (Hours)	-	N/A	N/A	866
Outage Rate for S/S (Nos/MVA)	-	N/A	N/A	0.294
Outage Rate for T/L (Nos/km)	-	N/A	N/A	0.117

Source: WBSETCL.

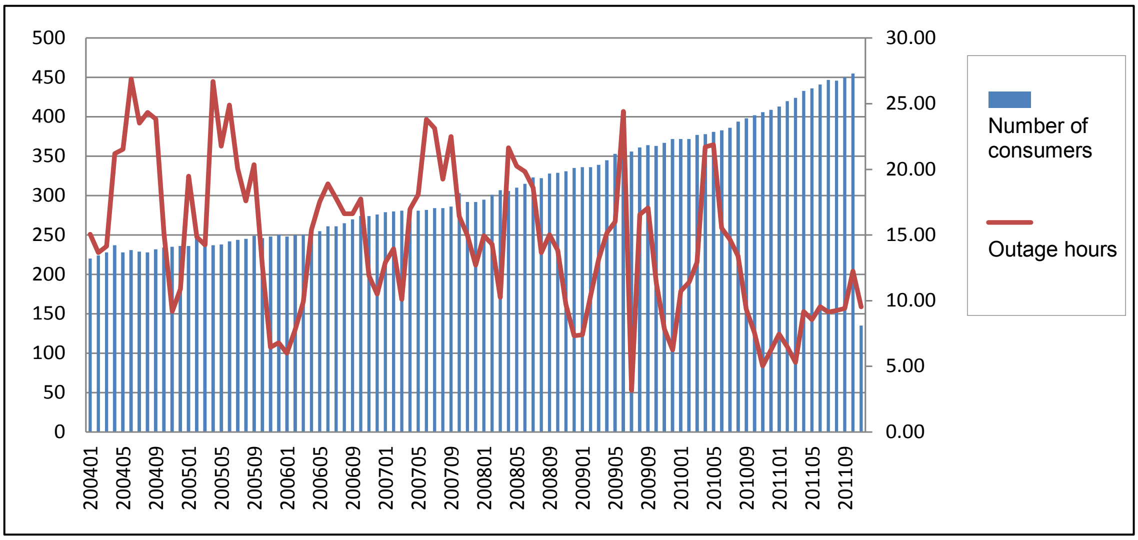
According to information obtained from WBSEDCL, the electricity supply in West Bengal State has improved to a large extent, and number of outages has sharply decreased in the past four years. In the State, approximately 5,000 consumers have contracts with WBSEDCL for over a 500 kVA contract demand. Out of these, 30 consumers are connected to 132 kV feeders, 200 consumers are connected to 33kV feeders, and 460 are connected to 11 kV feeders[21]. T he trends in numbers of consumers over 500kVA CD and the lengths of outage hours per consumer from January 2004 to December 2011 are shown by feeder in Figure 2 and Figure 3. The number of consumers with over 500 kVA CD on 33 kV and 11 kV feeders have doubled in the period, and the lengths of outage hours per consumer have decreased year by year although there have been seasonal fluctuations. As of the end of 2011, the average outage hours per consumer on 33 kV feeders were five hours per month, and that for 11 kV feeders was ten hours.



Source: Data collected at WBSEDCL.

Figure 2: Trends in the Number of Consumers over 500 kVA CD and the Length of Outage Hours per Consumer (33 kV Feeder)

[21] WBSETCL prioritizes electricity supply to large consumers connected to 132 kV or over, and they rarely experience power outages throughout a year. Consumers on 33 kV and 11 kV feeders, on the contrary, are affected most by power outages and voltage fluctuation.



Source: Data collected at WBSEDCL.

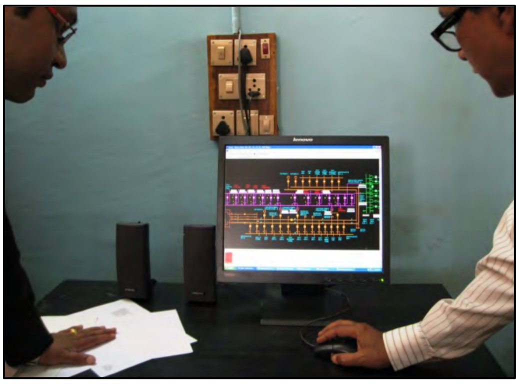
Figure 3: Trends in the Number of Consumers over 500 kVA CD and the Length of Outage Hours per Consumer (11 kV Feeder)

Several 33 kV substations experienced outages over 100 times in October 2011, whereas the rest saw outages 30 to 50 times at the most in the same moth. Many did not experience any outage. Outages on some 11 kV substations exceeded 200 times a month, while others experienced none or just a few[22].

Data collection was made possible at five pilot substations in a precise manner and in real time through computerization with a data acquisition system (DAS) procured under the project. Prior to the project, data had been manually recorded on log-sheets (See Picture 2). Thus the DAS has made it possible to continue the precise monitoring of power outage time and hours, and of outage points (See Picture 3). This will help WBSETCL improve their countermeasures in future for unplanned power outages and to promote the efficiency of recovery works. The microwave communication system installed at ten stations also helped WBSETCL to effectively communicate with WBSLDC.

Source: taken at Domjur S/S by the Study Team.

Picture 2: Log-sheet used at Substations without DAS



Source: taken at Rishra S/S by the Study Team.

Picture 3: Chief Engineer Operating DAS procured under the Project

[22] Data was collected at WBSEDCL during the country survey in December 2011.

As of March 2012 there are five substations where DAS is available. In 2012 WBSETCL will launch other pilot schemes at a substation to install DAS on a digital basis together with optical fiber communication systems. And they plan to install it in other substations if it is found successful.

(2) Reduction of Transmission Losses and Voltage Fluctuation

As of 2007/08 when unbundling took place, the transmission loss was 4.0% in the transmission network of WBSETCL. This has shown improvement year by year reaching 3.8% in 2009/10, and projected to be 3.5% in 2012/13[23]. This shows that West Bengal State has been doing better compared to the average for the whole country which is around 5 to 5.5%.

As for transmission losses at the five pilot substations, Arambag (0.1%), Bongaon (0.27%) and Tarakeswar (0.18%) were less than the target figure of 0.5% in 2010/11. Laxmikantapur hit 2.1% and Rishra 1.02%, which exceed the target, but are still less than the State average.

Apart from transmission loss, distribution loss in the State was improved from 24.6% in 2007/08 to 24.3% in 2009/10, and this is projected to improve up t o 22.0% in 2012/13. However, there remains much to improve, such as technical and non-technical losses, unauthorized connection and power theft.

(3) Efficient Transmission of Intra-state Electricity

The bus voltages of 33 kV distribution feeders of substations show that voltage fluctuation stays at a minimum between the worst case 25 kV and the best case 32 kV. For 11 kV feeders, the worst case was 8.36 and best case 10 to 11 kV.

3.2.2 Qualitative Effects

The Evaluators conducted interviews with bulk industry consumers connecting to 11 kV, 33 kV and 132 kV feeders during the country survey in December 2011. They said that they were content with the quality of services provided by W BSEDCL and the conditions of the electricity supply, as shown in the boxes below.

<table>
<tr><td colspan="2">Interview with bulk industry consumer (1)</td><td rowspan="8">
Mr. Sapan Kumar Ghosh. The company is located in Khadagpur, 120 km away from Kolkata.</td></tr>
<tr><td>Date</td><td>2 December 2011</td></tr>
<tr><td>Name</td><td>Mr. Sapan Kumar Ghosh, President</td></tr>
<tr><td>Corporate name</td><td>Khadagpur Metal Reforming Industries Ltd. (manufacturing of steel and other metals) Interview venue was WBSEDCL.</td></tr>
<tr><td>Supply voltage</td><td>11 kV</td></tr>
<tr><td>Contract demand</td><td>N/A</td></tr>
<tr><td>Monthly energy consumption</td><td>Approximately 50,000 kWh per month</td></tr>
<tr><td>Monthly energy charge</td><td>3.2 mil to 3.5 mil rupees per month</td></tr>
<tr><td>Contents</td><td colspan="2">“There are frequent unscheduled interruptions faced at the premises, ranging from 35 minutes to one hour; at least 4 to 5 times in a day. Such frequent disruptions in the power supply not only affect the production cycle but also damage the raw materials.”
“Due to the lengthier transmission lines from WBSEDCL sub-stations, the tail end voltage at his premises was low and to match the low voltage with a standard operating voltage level, he had installed automatic voltage boosters.”</td></tr>
</table>

23 Data obtained at WBSETCL in December 2011.

Interview with bulk industry consumer (2)	
Date	2 December 2011
Name	Mr. Sunil Gawande, President Mr. Mitra, General Manager (Electrical and Automation)
Corporate name	Bhushan Power & Steel Ltd. (manufacturing steel and other metals)
Supply voltage	33 kV
Contract demand	50,000 kVA
Monthly energy consumption	N/A
Contents	"Efforts made by WBSETCL in upgrading the existing 132 kV Rishra S/S to 220 kV level, helped them transfer the load and enabled them to have better load management. This has contributed to a reduction in such interruptions in power supply to a great extent in last three years." "Satisfied with the availability of power and with the reliability and quality of the services of WBSEDCL." "There are occasional momentary disruptions in power supply. This kind of disruption is more particularly observed during the night and this affects his entire production cycle.

Inside the factory. The company is located in the Rishra Industrial area (around 60 km from Kolkata), directly connected to Rishra Substation. They produce 35,000 tons of steel per month

Mr. Sunil Gawande

Interview with bulk industry consumer (3)	
Date	2 December 2011
Name	Mr. V. K. Goenka, Senior vice president
Corporate name	Jaya Shree Textiles (manufacturing textile)
Supply voltage	132 kV
Contract demand	10,000 kVA
Monthly energy consumption	N/A
Contents	"Jaya Shree Textiles in its existing form was founded 60 years ago, and has been connected by 33 kV transmission line from the Rishra EHV substation of WBSETCL. With the progress of the company in recent years, Jaya Shree Textiles chose a 132 kV level during 1999. Earlier, the annual turnover of the company was around 3.5 billion rupees and the total work force was less than 2,000 people. At present, however, the annual turnover has reached around 10 billion rupees, and there are close to 3,700 employees. The company has made remarkable progress over the years." "Much worried about rising electricity tariffs; especially for industrial consumers. He expressed his opinion that if the same trend continues in near future, most of the industries would migrate to other states. He was also worried about the generation mix in the State (comprising of 90% thermal power generation). The State Government should look for cheaper sources of power generation, such as hydro power and renewables and should strive to reduce the power tariffs as electricity is the major input source for industries.

Mr. V. K. Goenka. The company is located at the Rishra Industrial Area (around 60 km from Kolkata), and is connected to Rishra substation.

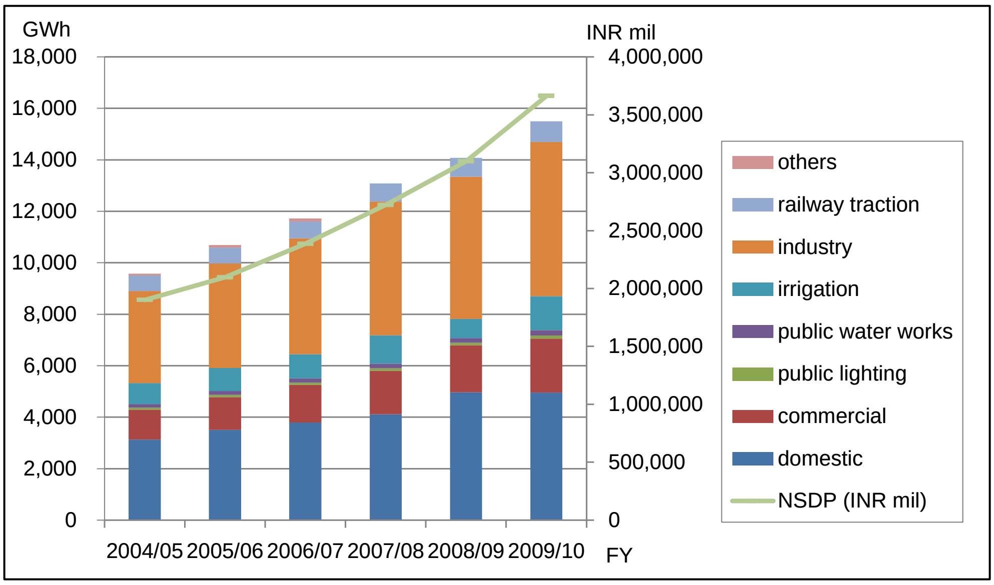
3.3 Impact

3.3.1 Intended Impacts

(1) Contribution to Industrial Development

The net state domestic product (NSDP) of West Bengal State has shown an annual steady growth from 1,900,730 million rupees in 2004/05 to 3,663,180 million rupees in 2009/10[24] (Figure 4). Energy consumption in the State, except the supply to CESC Ltd.[25] and DPSC Ltd.[26] also increased during the same period in line with NSDP from 9,581 GWh to 15,497 GWh. It is industrial and domestic consumers who have been the major sources of increasing consumption. Energy consumption b industrial consumers increased from 3,581 GWh to 5,995.3 GWh, and that of domestic consumers from 3,128 GWh to 4,595 GWh.

It is considered that this project has contributed to sustainment of the energy consumption required by rapidly increasing consumers while the State has seen industrial development through the improvement of the transmission network system, including the construction and augmentation of 31 substations.



Source: Data obtained at WBSETCL, Reserve Bank of India. "Handbook of Statistics on Indian Economy 2010-2011" (2011).
Note: Energy consumption excludes supply to CESC Ltd. and DPSC Ltd.

Figure 4: Growth of Net State Domestic Product and Energy Consumption

(2) Employment Creation through Industrial Development

Energy consumption has kept growing as NSDP of the State has shown steady growth as stated above, for which this project is deemed to have contributed. However, the Evaluators encountered constraints to examine the degree of impact on employment creation brought by the project as a whole. Although some companies such as Jaya Shree Textiles (See above 3.2.2) have increased the number of staff they expanded their business and increased the input voltage level as substations nearby were augmented under the project, quantitative analysis on the degree of direct and indirect impact on job creation was not possible.

[24] Reserve Bank of India. "Handbook of Statistics on Indian Economy 2010-2011" (2011).
[25] Begun as India's first fully integrated electrical utility, CESC Ltd. has generated and distributed electrical power in Kolkata and Howrah since 1899. It solely serves electricity to 2.5 million consumers in Kolkata and Howrah. CESC owns and operates four thermal power plants generating 1,225 MW of power, as well as a transmission and distribution system to supply electricity to consumers.
[26] Established in 1919, DPSC Ltd. is a power utility company whose main business is the distribution of electricity for public and private purposes in West Bengal and the generation and procurement of electrical energy.

(3) Improvement of People's Living Standards through Rural Electrification and the Promotion of Home Appliances

The Ministry of Power started rural electrification by launching *Rajiv Gandhi Grameen Vidhyutikaran Yojana* (RGGVY) in April 2005, targeting the completion of rural electrification within four years. As of March 2009, the rural electrification rate[27] in West Bengal State was 97.3% - a remarkable outcome achieved by implementation of the program.

This project did not intervene directly in rural electrification as it extended its finance up to 132 kV bay level transmission lines. This meant that the evaluators had difficulty in identifying any impact brought by the project to rural electrification and the promotion of home appliances. It was also not possible either to assess the improvement of people's living standards.

However, it is noteworthy that the census conducted in 2011 indicated a large population increase from 80.17 million in 2001 to 91.35 million in 2011[28], and that the number of domestic consumers increased from 3,128 GWh in 2004/05 to 4,959 GWh in 2009/10[29]. Energy consumption for public lighting, public water works, irrigation and railway traction is also on the increase[30]. This project has contributed to a great extent to the utilization of infrastructure necessary for people's lives and to improvements in their living environment.

3.3.2 Other Impacts

(1) Impacts on the Natural Environment

There was no major negative impact on the natural environment by this project.

(2) Land Acquisition and Resettlement

No land was acquired for the extension of transmission lines, while WBSETCL provided cash compensation for agricultural products, trees and so on which were affected by the right of way (ROW), based on Indian laws and regulations.

There was 109 ha area of private land acquired for the construction of substations, for which the State Government of West Bengal took responsibility. T here were no forests acquired, and no involuntarily resettlement occurred for the construction of substations.

(3) Unintended Positive/Negative Impacts

Not applicable.

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

3.4 Efficiency (Rating:②)

3.4.1 Project Outputs

This project was to provide a competent electricity transmission network, constructing new substations and expanding the existing substations throughout West Bengal State.

The project outputs planned at the first appraisal in 1996 were: the extension of transmission lines (400 kV level: one double circuit line for 12 km, 220 kV level: one single circuit line for 60 km and three double circuit lines for 14 km in total, 132 kV level: three single

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27 According to the new definition of 2004, a village would be classified if: 1) basic infrastructure such as distribution transformers and distribution lines were provided in the inhabited locality; 2) electricity were provided to public places like schools, local government offices, health centers, dispensaries, community centers etc, and; 3) the number of households electrified made up at least ten% of the total number of households in the village. The village electrification rate is thus different from the population or household electrification rate.
http://www.iea.org/country/Poverty_India/Electrification.pdf (Accessed in May 2012)

28 http://www.censusindia.gov.in/ (Accessed in May 2012)

29 Data obtained at WBSETCL in December 2011.

30 Energy consumption for public lighting, public water works, irrigation and railway traction increased from 82.39 GWh, 140.29 GWh, 814.59 GWh, and 602.62 GWh respectively in 2004 to 117.38 GWh, 207.07 GWh, 1,322.97 GWh, and 801.59 GWh in 2009.

circuit lines for 360 km and eighteen double circuit lines for 524 km), the construction and augmentation of substations (400 kV level: one, 220 kV level: eight, 132 kV level: 23), the installation of microwave communication systems at eleven substations, and the implementation of consultancy services (assistance in procurement, project progress review and monitoring, reporting: 100 M/M in total).

Source: Study Team

Picture 4: Microwave communication system at Howrah substation / WBSDCL

Resulting from the detailed survey, there were changes in the number of transmission lines for more effective and smooth inter connections, in the design of type of tower foundations and structures following the results of detailed soil surveys, and in the routing of transmission lines to mitigate adverse impact. The actual project outputs were: transmission lines (400 kV level: one double circuit line for 10.56 km, 220 kV level: one single circuit line for 73 km and two double circuit lines for 4.56 km in total, 132 kV level: 19 double circuit lines for 690.8 km with two single circuit lines associated), the construction and augmentation of substations (400 kV level: one extension, 220 kV level: six constructions, 132 kV level: 16 constructions and eight bay extensions), the installation of microwave communication systems was reduced at ten substations, the establishment of DAS at five substations including the procurement of equipment and materials, and the implementation of consultancy services for 110 M/M in total with additional assignment for monitoring the project impacts through the operation and effect indicators at five substations and drawing recommendations on monitoring methods.

3.4.2 Project Inputs

3.4.2.1 Project Cost

The actual project cost was 13,385 Japanese million yen, against the 28,322 million yen planned project cost, which is 47.3% of the planned cost. The disbursed amount of the Japanese ODA assistance loan was 12,736 million yen against the approved amount of 14,214 million, which was also within the planned budget (89.6%).

Table 7: Planned and Actual Project Cost

Items		Plan			Actual
		Foreign Currency (Mil. Yen)	Local Currency (Mil. Yen)	Total (Mil. Yen)	Total (Mil. Yen)
1	Transmission lines	1,651	789	4,128	2,788
2	Substations	7,595	1,613	12,659	8,704
3	Land acquisition	0	63	198	130
4	Taxes and duties	0	765	2,402	792
5	Administration	0	652	2,049	
6	Contingencies	694	239	1,445	
7	Consulting services	294	6	314	130
8	Price escalation	665	1,016	3,854	247
9	Interest during construction	1,274	0	1,274	594
Total		12,174	5,143	28,322	13,385

Source: JICA appraisal documents and WBSETCL.

Note 1: The planned project cost estimated at the first appraisal in 1996 was the planned cost for the plan-actual comparison in this ex-post evaluation. The exchange rate was INR 1= JPY 3.14 (May 1996).

Note 2: Taking into consideration the fact that there was a wide range of fluctuation between the INR and USD, and the JPY and USD exchange rates during the project period, the exchange rates applied for converting the actual cost into Japanese yen were taken from the average annual rates issued by IMF in the International Financial Statistics; Yearbook from 1995 to 2009.

Note 3: As there was no common definition for the expenditures of foreign currency and local currency, a comparison between the planned and actual costs in two currencies was not viable.

Based upon interviews with WBSETCL, it was seen that some components originally planned for international competitive biddings (ICB) were carried out through local competitive biddings (LCB), which contributed to the reduction in the bidding prices. Also, the yen value steadily appreciated against the Indian rupee throughout the project implementation period, which resulted in far lower costs converted into yen.

The actual project cost was thus lower than planned.

3.4.2.2 Project Period

The actual project implementation period was 153 months from February 1997 (project start[31]) to October 2009 (project completion[32]) against the 55 months planned project period from February 1997 to August 2001. This was far longer than planned (278%).

Table 8: Comparison of the Planned and Actual Project Periods

	Plan	Actual
Signing of the loan agreement of IP-P117	Feb 1997	Feb 1997
Procurement of equipment and construction	Mar 1997 to Feb1999	Jun 1997 to Jul 2004
Transmission lines	Mar 1999 to Aug2001	Aug 1999 to Dec2004
Substations	Mar 1999 to Aug 2001	Mar 2000 to Dec2005
Electrical works	Mar 1999 to Aug 2001	Mar 2000 to Mar 2006
Microwave communication	-	Jun 2003 to Nov2006
Operation and effect indicators	-	Jan2008 to Oct 2009
Project completion	Aug 2001	Oct 2009

Source: JICA appraisal documents and WBSETCL.

Major causes of delay in project implementation were: i) due to dialog with local residents taking longer than expected; ii) the fact that WBSETCL had to change the transmission route; ii) the type of tower foundations and structures had to be changed following the results of detailed soil surveys; iii) the fact that land filling work could not be carried out as scheduled during the monsoon months; iv) the commencement of construction work for substations was delayed because it took longer for land acquisition and bidding process. It took approximately four years from the signing of the loan agreement until the commencement of construction work. Substations and transmission lines commenced operations one after another between 2003 and 2007, but it was 2009 when WBSETCL completed all the project components including the launch of the microwave communication package, the planning and implementation of TQM and the procurement of equipment and materials for the operation and effect indicators.

The project period was thus significantly longer than planned.

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

3.4.3.1 Financial Internal Rate of Return

The original FIRR was 13% at the time of the first project appraisal in 1996, and this was updated to 10.4% in the second appraisal in 2001. Due to the fact that data needed for quantitative analysis was not available at WBSETCL, analysis for FIRR was not possible in this

[31] The project start was defined as the signing of the loan agreement of ID-P117.

[32] The project completion was defined as the actual completion of the entire scope of work as per the General Condition of Contract.

ex-post evaluation.

The FIRR calculation at appraisal was based upon the pre-conditions below:

- Cost: project cost (including interest) during construction, operation and maintenance cost.
- Benefit: reduction in transmission losses, additional units of electricity transmitted.
- Project life: 35 years after commencement of commercial operation.

3.4.3.2 Economic Internal Rate of Return

The original EIRR was 15% at the time of the first appraisal, and this was also updated, to 29.5% in the second appraisal. Due to the fact that data needed for quantitative analysis was not available at WBSETCL, analysis for EIRR was not possible in this ex-post evaluation.

The EIRR calculation at appraisal was based upon the pre-conditions below:

- Cost: initial investment cost and operation and maintenance cost, excluding taxes and duties
- Benefit: energy saving effects, induced effects, and alternative effects
- Project life: 35 years after commencement of commercial operation

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

3.5 Sustainability (Rating: ③)

3.5.1 Structural Aspects of Operation and Maintenance

The West Bengal State Electricity Board (WBSEB), which was this project's executing agency, was unbundled into the West Bengal State Electricity Transmission Company Ltd. (WBSETCL) and the West Bengal State Electricity Distribution Company Ltd. (WBSEDCL) in April 2007[33].

With this unbundling, WBSETCL succeeded this project. Since its establishment, WBSETCL has standardized policies, procedures and manuals, with which they have improved corporate management. The total quality management program (TQM) introduced under this project remains active at WBSETCL and 'quality circles' have been formed at substation level and compete each other to solve work-related problems through the identification of root causes and solutions, and the review and follow-up of activities. TQM has contributed greatly to the improvement of WBSETCL's management, and it was awarded ISO9001:2000[34] in 2009.

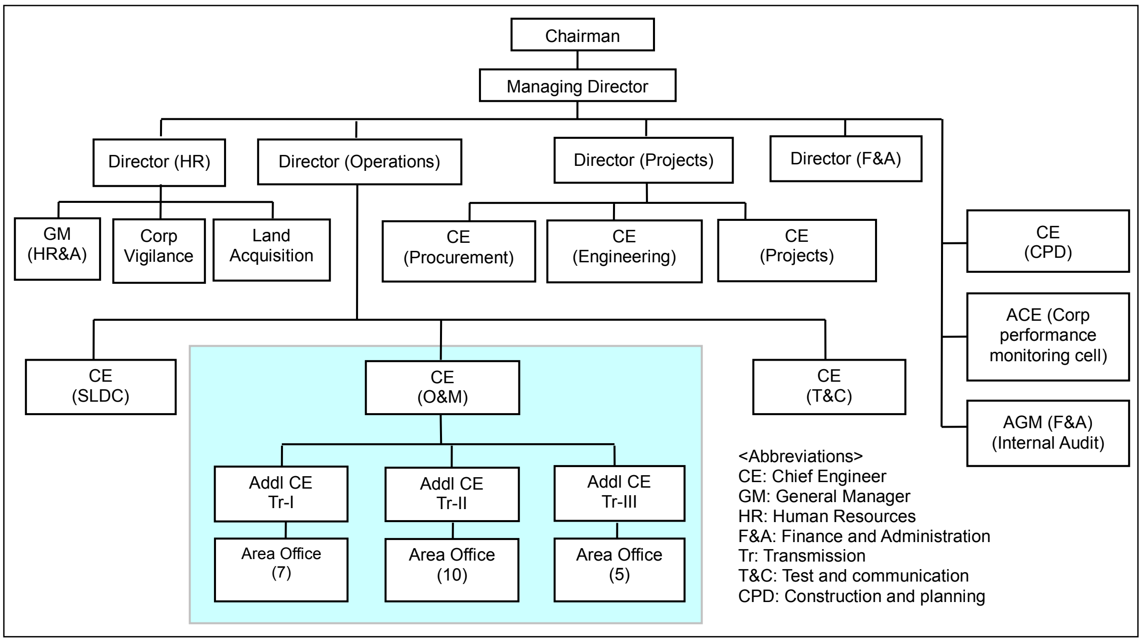
Source: Study Team
Note: The quality policy is also kept at other stations.

Picture 5: Quality Policy kept at Arambag Substation

[33] The Government of India and the State Governments have worked since the late 1990s on the establishment of the state electricity regulatory commissions, the establishment and disclosure of tariff regulations for transparency, the corporate reform of distribution companies through private investments, and the abolition of state subsidies. Unbundling WBSEB was part of a nation-wide power sector reform, and fourteen states had already completed the separation of power generation, transmission and distribution into separate corporations. It became obligatory to establish electricity regulation commissions at state level each with the role of regulating the tariff policies of public and private utilities by each state. Central Government initiated the Accelerated Power Development and Reform Programme (APDRP) in 2001 for the improvement of transmission and distribution network systems and the reduction of T & D commercial losses. The APDRP has been implemented up to present.

[34] A qualification for an organization to establish, document, implement and sustain the Quality Management System

As of 2011, there were 343 engineers at all levels, 18 staff at manager level, 156 staff at supervisor level 1,154 technicians, 203 supporting staff, 309 office staff, and 50 office attendants[35]. The monitoring of scheduled maintenance is conducted by the Chief Engineer for Transmission (O&M) and the staff at area offices underneath him (See Figure 5).



Source: WBSETCL. "Annual Report & Accounts 2010-2011 (2011).

Figure 5: Organization Chart of WBSETCL

WBSETCL has been better established since unbundling in 2007 and no particular problem has been observed in its structural aspects.

3.5.2 Technical Aspects of Operation and Maintenance

WBSETCL received the Best Power Availability Award in 2007/2008 as the sole power transmission utility, and its 13 EHV substations were awarded ISO9001:2000. WBSETCL has provided internal and external training opportunities to its staff. Consultation with staff to understand their training needs has often been conducted since establishment.

Data acquisition systems (DAS) have been installed at five monitoring substations under this project, with which the occurrence, frequency, time and place of power outages are precisely recorded, for instance, to analyze ways to solve problems. WBSETCL will launch another pilot activity in which they will introduce DAS at a substation in 2012, and there is no particular problem seen in the technical aspects of WBSETCL.

3.5.3 Financial Aspects of Operation and Maintenance

The operation and maintenance budget of WBSETCL as a whole for transmission and substation utilities has increased each year. The depreciation budget has been firmly secured in the total O&M budget and has been used to keep the facilities and equipment in good condition (Table 9).

(QMS). Process-approach is applied, and tangible processes in organizations are established, to understand mutual relations in order to improve the effectiveness of QMS. Certification is made for ISO9001:2000 when organizations are deemed to have applied a series of processes as a system in an appropriate way.

[35] Data obtained at WBSETCL in December 2011.

Table 9: Operation and Maintenance Budget of WBSETCL after Unbundling

Unit: Million Rs

	2007/08		2008/09		2009/10		2010/11		2011/12		2012/13	
	Plan	Actual	Plan	Actual	Plan	Actual	Plan	Actual	Plan	Actual	Plan	Actual
1. Transmission Expenses	127.18	126.92	138.10	175.00	169.00	191.12	191.10	239.99	229.72	-	244.36	-
2. Remuneration	483.90	550.30	774.00	1,081.96	849.00	930.59	1,269.15	1,150.13	1,256.55	-	1,380.60	-
3. Depreciation	871.70	817.02	1,057.10	897.53	1,230.20	1,118.93	1,403.30	1,200.12	1,260.34	-	1,567.39	-
4.Interest & Financial Charges	1,275.27	1,551.37	1,990.30	1,767.31	1,852.30	1,966.83	1,808.70	1,828.73	2,520.31	-	2,610.72	-
5.Provisions	2.90	6.48	124.50	245.59	137.10	541.28	144.20	420.75	983.44	-	758.83	-
6. Prior Period Adjustments (net)	-	-	-	(62.50)	-	30.40	-	0.64	-	-	-	-
7. Capital Expenses	8,398.40	6,711.18	7,165.40	5,118.42	8,729.30	2,851.94	9,278.60	4,363.02	8,104.76	-	9,245.03	-
8. Rebate on Prompt Payments	-	-	-	5.44	-	7.18	-	7.51	-	-	-	-
Total	11,159.35	9,763.207	11,249.40	9,228.75	12,966.90	7,638.27	14,095.05	9,210.89	14,355.12	0.00	15,806.93	0.00

Source: WBSETCL.

Regarding the profits and losses of WBSETCL, Table 10 shows the revenue from operations firmly increasing year by year. The financial self-sufficiency of WBSETCL is high as expenditure on transmission charges has been kept well below the revenue from operations. Depreciation has been sensibly spent on replacing and/or improving facilities and equipment for transmission lines and substations. Profit before tax and prior period adjustments have been secured at over 2,000 million rupees since 2008, and WBSETCL is deemed to have been in a favorable condition in terms of profit making since unbundling.

Table 10: Profit and Loss of WBSETCL

Unit: Million Rs

	2007/08	2008/09	2009/10	2010/11	2011/12
Income	4,369.4	6,740.2	7,295.6	7,655.4	N/A
Revenue from operations	*4,280.4*	*6,664.4*	*7,212.8*	*7,485.3*	*N/A*
Expenditure	3,549.6	4,538.2	5,177.7	5,490.4	N/A
Transmission charges	*353.1*	*423.7*	*661.3*	*588.7*	*N/A*
Depreciation	*817.0*	*897.5*	*1,118.9*	*1,200.1*	*N/A*
Profit before Tax and Prior Period Adjustments	819.7	2,202.1	2,117.9	2,165.0	
Profit before Tax	819.7	2,139.6	2,148.3	2,165.6	N/A
Profit after Tax (Net Profit)	813.2	1,894.3	1,746.8	1,744.9	N/A

Source: WBSETCL. Annual Report & Accounts (2010-2011, 2009-2010, 2008-2009, 2007-2008)

Table 11 shows that the net cash from operating activities between 2007 and 2010 remained stable (at more or less 5 billion rupees). Net cash flow has been on the increase since 2009, and no particular cash flow problems have been observed at WBSETCL.

Table 11: Cash Flow of WBSETCL

Unit: Million Rs

	2007/08	2008/09	2009/10	2010/11	2011/12
Net Cash from Operating Activities (A)	5,406.7	4,966.3	4,618.3	5,940.9	N/A
Net Cash Generated from Investment Activities (B)	-6,700.3	-4,568.2	-2,819.5	-4,249.7	N/A
Net Cash from Finance Activities (C)	1,511.4	-639.8	-1,295.9	-1,599.7	N/A
Net Increase (Decrease) in Cash & Cash (A+B+C)	217.8	-241.7	502.9	91.5	N/A
Cash & Cash Equivalents at the Beginning of the Year	231.8	449.6	207.9	710.8	N/A
Cash & Cash Equivalents at the End of the Year	4,49.6	207.9	710.8	802.3	N/A

Source: WBSETCL. Annual Report & Accounts (2010-2011, 2009-2010, 2008-2009, 2007-2008)

Regarding the financial status of WBSETCL (Table 12), fixed assets and fixed liabilities far exceeded current assets and current liabilities respectively, which reflects the nature of power transmission utilities that own a large amount of fixed assets and require long-term investment. A lthough liabilities stayed significantly larger than equity since unbundling, the analysis is that WBSETCL will continue to grow steadily as the equity to assets ratio has remained at approximately 30% every year (see Table 13). The equity growth rate shows an annual increase of over ten%, although it was down in 2010/11, which shows the company's firm growth.

Table 12: Balance Sheet of WBSETCL

Unit: Million Rs

	2007/08	2008/09	2009/10	2010/11	2011/12
Total Assets	33,536.7	38,270.1	41,249.8	43,927.5	N/A
Fixed Assets	*30,497.4*	*34,205.5*	*37,243.0*	*39,838.9*	*N/A*
Current assets, loans & advances	*3,039.3*	*4,064.6*	*4,006.8*	*4,088.6*	*N/A*
Total Liabilities	24,319.6	26,174.0	27,406.9	28,288.4	N/A
Current liabilities and provisions	*3,595.4*	*4,322.3*	*3,579.8*	*4,744.6*	*N/A*
Loan funds	*20,724.2*	*21,851.7*	*23,827.1*	*23,543.7*	*N/A*
Total Equity	9,217.1	12,096.1	13,842.8	15,639.1	N/A
Shared capital	*10140.0*	*11055.2*	*11055.2*	*11,055.20*	*N/A*
Government grants			*0*	*51.4*	*N/A*
Total Liabilities and Equity	33,536.7	38,270.1	41,249.8	43,927.5	N/A

Source: WBSETCL. Annual Report & Accounts (2010-2011, 2009-2010, 2008-2009, 2007-2008)

Table 13: Major Financial Indicators of WBSETCL

Indicators	2007/08	2008/09	2009/10	2010/11	2011/12	Note
Return on Assets (ROA)	2.44%	5.75%	5.13%	4.93%	N/A	Ordinary Profit / Assets
Current Ratio	84.53%	94.04%	111.93%	86.17%	N/A	Current Assets / Current Liabilities
Fixed Ratio	330.88%	282.78%	269.04%	254.74%	N/A	Fixed Assets / Equity
Equity to Assets Ratio	27.48%	31.61%	33.56%	35.60%	N/A	Equity / Assets
Equity Growth Rate	-	31.23%	14.44%	12.98%	N/A	-
Profit Growth Rate	-	168.65%	-3.82%	2.22%	N/A	-

Source: WBSETCL. Annual Report & Accounts (2010-2011, 2009-2010, 2008-2009, 2007-2008)

The financial status of WBSETCL is deemed fair and there is no pa rticularly serious problem with its financial aspect. The operation and maintenance budget is firmly secured for all the facilities and equipment including those of this project, and the financial condition of WBSETCL since unbundling has shown its growth.

3.5.4 Current Status of Operation and Maintenance

WBSETCL has exercised daily and monthly routine check-ups at each facility. Breakdown maintenance is carried out as and when required for the prompt restoration of the system. Annual maintenance is based upon preventative maintenance following the WBSETCL maintenance manual for all substation facilities and equipment and transmission lines. Condition-based predictive maintenance of EHV equipment is also carried out when scheduled.

The five monitoring substations under this project have been computerized and data acquisition systems (DAS) have replaced log-sheets, which required manual input. Outage hours, both forced and planned, are now recorded at second level, and other various data are recorded in real time and in a precise manner. This helps the analysis of and the solution of problems at substations. No particular problems have been found regarding the present status of the operation and maintenance of the project facilities.

No major problems have been observed in the operation and maintenance system, therefore the sustainability of the project effect is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project was implemented to enhance the reliability of the transmission network system, to reduce transmission losses and voltage fluctuations, and to make intra-state electricity transmissions efficient through the provision of a competent electricity transmission network, the construction of new substations and the expansion of existing substations in West Bengal State. It has been highly relevant to India's development plan and development needs. Facilities provided under the project have been operated well, and the project has highly improved the reliability of the transmission network system, and has promoted reductions in transmission losses and in voltage fluctuation. The project has thus largely achieved its objectives, and its effectiveness is high. It is judged that the project has contributed directly indirectly to industrial development, employment creation and the improvement of people's living standards in the State. The project cost was within the plan, although the project period exceeded the plan, therefore the project efficiency is fair. The project sustainability is deemed high in the organizational, technological and financial aspects, and the O&M condition of project facilities and equipment is good.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

In order to manage the transmission network system more efficiently and precisely, it is recommended that DAS be among the facilities pre-requisite to all substations developed near future. As the amount of information grows rapidly, the augmentation and installation of more advanced communication systems than microwave is highly desirable and is for immediate consideration.

4.2.2 Recommendations to JICA

The distribution losses in West Bengal State improved from 24.6% (2007/08) to 22.0% (2012/13 projected). There is still, however, space for improvement in reducing technical and non-technical losses, dealing with unauthorized connections, power theft and so on. It is recommended that JICA continue dialog with WBSETCL and related power utilities in the State to consider how the output, effectiveness and impact of this project can be further shared for the best interests and benefit of all kinds of consumers.

4.3 Lessons Learned

- Introduction of pilot activities in an appropriate manner and with the appropriate processes

In addition to the main components of this project, data acquisition systems (DAS) were introduced to five substations in the WBSETCL transmission network system for the measurement of the operation and effect indicators. Prior to that, human errors could have occurred at any time as data recording was less developed. WBSETCL can now analyze problems and examine solutions by detecting any failures in the transmission network. The DAS have helped WBSETCL improve quality management and technology, and have made their work more efficient. This has provided a good lesson for WBSETCL as a pilot activity. It was also realistic and more feasible to limit the number of substations to only five when introducing the DAS, which also helped WBSETCL to minimize costs and human resources in conducting this pilot activity.

It is thus desirable, when similar transmission projects are processed and implemented near future, to provide a comprehensive package with a viable volume of pilot activities for more effective infrastructure development through a thorough analysis of the financial condition and human resource allocation of the executing agency.

- Assistance for improvement of organizational sustainability

JICA has conducted the Special Assistance for Project Implementation for the West Bengal Transmission System Project (II), in which total quality management (TQM) was introduced and acquired by WBSETCL staff. WBSETCL created “quality circles” at substation level to improve management. The enhancement of the sense of responsibility of staff and increases in their awareness of the necessity of improving operation and maintenance has led to ISO9001:2000 certification and to other Indian awards.

Along with infrastructure development, it is thus desirable that institutional development and O&M improvement for the executing agency is taken into account in future project processing and project implementation.

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
1. Project Outputs	(1) Transmission lines ・400 kV D/C line x 1 (12 km) ・220 kV S/C line x 1 (60km), D/C line x 3 (14km) ・132 kV D/C & S/C line x 19 lines (884 km) (2) Substations ・400 kV S/S: 1 station (expansion) ・220 kV S/S: 6 new stations and 2 stations with expansion ・132 kV S/S: 16 new stations and 7 stations with expansion (3) Microwave Communication System ・11 stations (4) Consultancy service ・Assistance for procurement, project monitoring, and reporting:100 M/M in total	(1) Transmission lines ・400 kV D/C line (10.56km) ・220 kV D/C & S/C line x 3 (77.562km) ・132 kV D/C & S/C line x 19 lines (690.7975km) (2) Substations ・400 kV S/S: as planned ・220 kV S/S: 6 stations ・132 kV S/S 24 stations (3) Microwave Communication System ・10 stations (4) Consultancy service Assistance for procurement, project monitoring, monitoring of the operation and effect indicators and reporting:110 M/M in total
2. Project Period	February 1997 – August 2001 (55 months)	February 1997 - November 2006 (153 months)
3. Project Cost		
Amount paid in Foreign currency	12,174 million yen	Not applicable
Amount paid in Local currency	16,148 million yen (5,143 million Indian Rupees)	Not applicable Not applicable
Total	28,322 million yen	13,385 million yen
Japanese ODA loan portion	14,214 million yen	12,736 million yen
Exchange rate	1INR= 3.14 yen (As of May 1996)	1INR = 2.65 yen (Average between 1995 and 2009)

India

Ex-Post Evaluation on Japanese ODA Loan
Simhadri and Vizag Transmission System Project (I)(II)

External Evaluator: Keishi Miyazaki, OPMAC Corporation

0. Summary

The objective of this project was to reduce transmission loss and voltage fluctuation resulting from generation capacity additions in Andhra Pradesh (AP) State as well as to improve the reliability of the transmission system in areas where cyclones frequently occur. This was to be achieved by the construction of 400kV/220kV transmission lines between Simhadri Thermal Plant (1,000MW) and Vizag Thermal Power Plant (1,040MW) in Visakhapatnam and Hyderabad with substations (SS), thereby contributing to the expansion of industrial activity, employment, electrification in rural areas, and improvement of the living standards of the local populations.

The project was highly relevant to India's development plan and development needs, as well as to Japan's ODA policy, and therefore its relevance is high. The performance of the substations either newly constructed or expanded by the project is generally good. The project objectives, such as the reduction of transmission losses, a narrowing of the electricity demand and supply gap, and the improvement of a stable electricity supply and general reliability have been largely achieved. Also, the project positively contributed to industrial development, the expansion of employment opportunities, and the improvement of people's living standards in AP State. Thus, its effectiveness is high.

The project cost was lower than planned, although the project period was longer than planned, and thus the project efficiency is fair. Project sustainability is deemed high in the structural, technical and financial aspects, and the O&M condition of project facilities and equipment is good.

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

1. Project Description

Project Site

400kV Transmission Line constructed by the Project

1.1 Background

Andhra Pradesh (AP) State is the southern Indian state with the 4th largest land area and the 5th largest population at the time of 1996. In AP State about 70% of the population is engaged in agriculture, and the electricity demand in this sector had been growing. For example, the sector share was approximately 40% of the electricity sales amount in AP State, which was more than the nationwide average of approximately 30%. Because of this, there has been a shortage of electricity supply for the industrial sector, and this has become a bottleneck in the economic development of AP State. In order to deal with this issue, in 1996, the government of AP State planned to implement two power generation development projects in Visakhapatnam, located in the southern part of AP State: the Vizag Thermal Power Plant Project (installed capacity: 1,040MW) by the Hinduja National Power Corporation (NHPC), an Independent Power Producer (IPP), and the Simhadri Thermal Power Station Project (installed capacity: 1,000MW) by the National Thermal Power Corporation (NTPC) using a Japanese ODA Loan. In order to utilize the electricity generated by the above two power plants, the construction of transmission lines and substations from the power plants to the power grid of AP State was necessary.

1.2 Project Outline

The objective of this project was to reduce transmission loss and voltage fluctuation resulting from generation capacity addition in Andhra Pradesh (AP) State as well as to improve the reliability of the transmission system in areas where cyclones frequently occur by the construction of 400kV/220kV transmission lines between Simhadri Thermal Plant (1,000MW) and Vizag Thermal Power Plant (1,040MW) in Visakhapatnam and Hyderabad with substations, thereby contributing to the expansion of industrial activity, employment, electrification in rural areas, and improvement of the living standards of the local populations.

	Phase I	Phase II
Loan Approved Amount / Disbursed Amount	10,629 million yen / 10,436 million yen	6,400 million yen / 5,476 million yen
Exchange of Notes Date / Loan Agreement Signing Date	October 1997 / December 1997	March 2002 / May 2002
Terms and Conditions Interest rate Repayment period (Grace period) Condition of procurement	 2.3% p.a. 30 years (10 years) General untied	 1.8% p.a. 30 years (10 years) General untied
Borrower / Executing Agency	President of India / Transmission Corporation of Andhra Pradesh Ltd. (APTRANSCO)	
Final Disbursement Date	February 2003	August 2009
Main Contractor (Over 1 billion yen)	None	
Main Consultant (Over 100 million yen)	Joint Venture of Lahmeyar International Gmbh (Germany)-Nippon Koei Co., Ltd.(Japan)	
Feasibility Studies, etc.	Feasibility Study was prepared by the Andhra Pradesh State Electricity Board (APSEB) in March 1994.	
Related Projects	• Srisailam Left Bank Power Station Project (I)(II)(III) (Japanese ODA Loan Project) • Srisailam Power Transmission System Project (I)(II) (Japanese ODA Loan Project) • Simhadri Thermal Power Station Project (I)(II)(III)(IV) (Japanese ODA Loan Project)	

2. Outline of the Evaluation Study

2.1 External Evaluator

Keishi Miyazaki, OPMAC Corporation

2.2 Duration of Evaluation Study

Duration of the Study: August, 2011 – June, 2012
Duration of the Field Study: November 27 – December 10, 2011, March 11 - 21, 2012

2.3 Constraints during the Evaluation Study

Since the operation and effect indicators for some of the substations could not be obtained, analysis of performance was limited.

3. Result of the Evaluation (Overall Rating: A[1])

3.1 Relevance (Rating:③[2])

3.1.1 Relevance with the Development Plan of India

At the time of the Phase I appraisal, the Indian Government's 8th Five Year Plan (1992/93-1996/97) was emphasizing: (i) the improvement of the plant load factor of existing plants, (ii) the reduction of transmission and distribution losses, (iii) the improvement of the financial capacity of power suppliers, (iv) promotion of the development of power resources, and (v) the promotion of commercial sources of energy. In the 8th Plan, a share of 18.3% (795.9 billion Rs.) of total public investment (4,341 billion Rs.) went to the electricity sector, which was the largest share of public investment overall. The 9th Five Year Plan of AP State (1997/98-2002/03) allocated a 22.9% development budget to the electricity sector, and approximately 61% of the electricity sector budget went to the transmission and distribution sub-sector. The development of the transmission and distribution sub-sector was a priority issue.

At the time of ex-post evaluation, the 11th Five Year Plan (2007/08-2011/12) of the Government of India estimated a 6,665.2 billion Rs. for power sector investment, which accounted for 32.42% of total investment in India including both the public and private sectors (20,561 billion Rs.). This corresponds to the largest share of the total investment in India. The 11th Plan set out power sector development strategies including (i) capacity development of the Central Electricity Regulatory Commission (CERC) and the State Electricity Regulatory Commission (SERC), (ii) reduction of transmission and distribution losses, (iii) the promotion of rural electrification, and (iv) the promotion of open access for private investors. The 11th Five Year Plan of the Government of AP State also prioritized power sector development, and it was planned that generation capacity would be expanded by an additional 5,485MW[3] in the 5 year period. Since the project aimed at alleviating the electricity demand and supply gap through the improvement of transmission efficiency and reliability in AP State, the project was consistent with the national power sector development strategy for the reduction of transmission and distribution losses and the promotion of rural electrification as well as with the development policy of AP State.

[1] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory.
[2] ③:High, ②:Fair, ①:Low.
[3] 3,053MW by Andhra Pradesh Generation Corporation Ltd. (APGENCO), 769MW by central government, 1,128MW by the private sector, and 535MW by non-conventional energy projects.

3.1.2 Relevance with the Development Needs of India

At the time of the Phase I appraisal in 1997, there was a shortage in the electricity supply for the industrial sector due to the growing electricity demand of the agricultural sector in AP State, the agricultural sector being the largest sector in the State. Thus electricity shortages had become a bottleneck in economic development. Transmission and distribution losses in 1997 were 38% which was quite high. It was estimated that even if the projects for Vizag and Simhadri Thermal Power Plants were completed in 2002, on schedule, AP State would still have 6.6% of electricity shortage at peak hours in 2002. Also, during that time, the Power Purchase Agreement (PPA) between the Andhra Pradesh State Electricity Board (APSEB)[4] and the Hinduja National Power Corporation (NHPC) was in the final stages of negotiation. One of the conditions stipulated in the PPA was that the Government of AP State would be obliged to provide the necessary transmission facilities connecting to Vizag Thermal Power Plant 6 months before the commissioning of the Unit 1 of the Plant. Furthermore, this project was expected to conduct generated electricity from not only from Vizag Thermal Power Plant (1,040MW) but also from Simhadri Thermal Power Plant (1,000MW) which was to be constructed using a Japanese ODA Loan of FY1996. Therefore, the necessity and urgency of project implementation were high.

However, due to the prolonged negotiation process relating to construction costs and the PPA, between the Government of AP State and HNPC, the construction of Vizag Thermal Power was not be completed by the time of the completion of this project. The Simhadri Thermal Power Plant was completed in 2004 on schedule. At present, the construction of Vizag Thermal Power Plant[5] is in progress through HNPC and it is expected that it will be completed in September 2013. After completion, it is planned that 85% of generated electricity from the Vizag Thermal Power Plant will be supplied to AP State, while the buyer for the remaining 15% is to be determined thorough Open Access Power Trading[6].

NTPC has furthermore expanded the installed capacity of the Simhadri Thermal Power Plant from the existing 1,000MW to 2,000MW (newly constructing additional generator Units 3 and 4), completing this in March 2012. Unit 3 (500MW) started commercial operation in December 2011, and it is planned that Unit 4 (500MW) will be commissioned in August 2012. From the additional 1,000MW, 60% of generated electricity will be supplied to the southern region apart from AP State going to places such as Tamil Nadu State, Karnataka State, Kerala State and Pondicherry. Overall, a total 1,452MW (the existing 1,000MW and an additional 452MW) out of the 2,000MW of the Simhadri Thermal Power Plant is to be utilized for AP State.

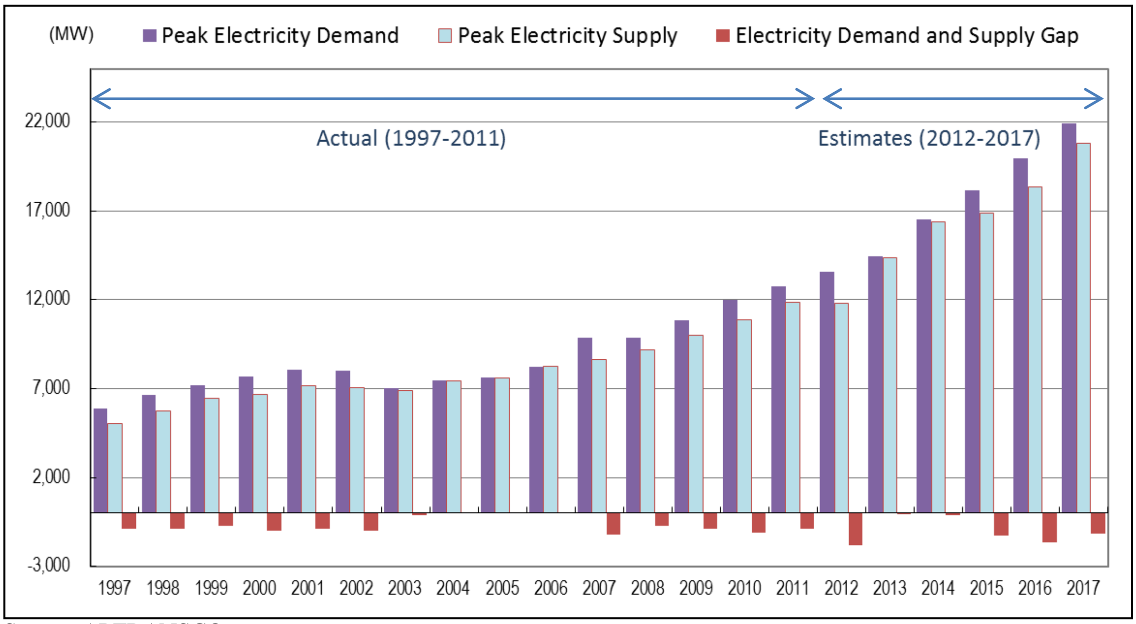
Although the Vizag Thermal Power Plant was not completed by the time of completion of this project, it is assumed that the realization of the feasibility of the Vizag Thermal Power Plant was there at the time of appraisal in 1997. If the construction of the Vizag Thermal Power Plant was not a prerequisite for this project, the construction of the Simhadri Thermal Power Plant was realized and the construction of transmission lines and substations connecting the plant and the transmission grid of AP State was necessary. Therefore, it is judged that the project was relevant to development needs at the time of appraisal.

[4] APSEB was unbundled by the Electricity Reform Act 1998 into generation, transmission and distribution entities and the AP Regularity Commission (APREC) was newly established.
[5] The installed generation capacity of the Vizag Thermal Power Plant was designed at 1,040MW (520MW x 2 units).
[6] 15% of generated electricity from the Vizag Thermal Power Plant is sold through tender with the participation of transmission and distribution companies and bulk users of AP State as well as of other states.

Construction of the NHPC Vizag Thermal Power Plant (As of December 2011)

The NTPC Simhadri Thermal Power Plant

At the time of the ex-post evaluation, although AP State has been making efforts to expand the power generation capacity, an electricity demand and supply gap of about 7% at peak hours (9.5MW) in 2011 was estimated, and even after the implementation of this project, the problem of power shortage has not been yet resolved. The electricity consumption per capita in AP State increased from 600kWh in 2006 to 950kWh at present, and a further growth of electricity demand is expected (Figure 1). Therefore, since AP State has shortages in electricity supply, the project has been necessary from the view point of the alleviation of the electricity demand and supply gap.



Source: APTRANSCO

Note 1: The figures from 1997 to 2011 are actual and the ones from 2012 to 2017 are estimates.

Note 2: The electricity demand supply gap in AP State was only resolved during three years from 2004, when the Simhadri Thermal Power Plant was completed, to 2006

Note 3: According to the forecast of APTRANSCO, after the completion of the Vizag Thermal Power Plant in 2013, the electricity demand supply gap in AP State will improve to 0.6% (95MW) in 2013 and 0.7% (121MW) in 2014 respectively.

Figure 1: Electricity Demand and Supply at Peak Hours in AP State

3.1.3 Relevance with Japan's ODA Policy

At the time of the Phase I appraisal in 1997, the Japanese Country Assistance Program for India had not yet been established by the Ministry of Foreign Affairs in Japan. H owever, based upon preceding studies and research, as well as on policy dialogue between the Japanese and Indian governments, economic infrastructure development, particularly for power and transport infrastructure, was among the priority areas of Japan's ODA strategy to India at that time[7].

This project has been highly relevant with India's development plan, development needs, as well as Japan's ODA policy, therefore its relevance is high.

3.2 Effectiveness[8] (Rating:③)

3.2.1 Quantitative Effects

(1) Operation and Effect Indicators

The major outputs of this project were: the new construction of two substations (Vizag/Kalpaka Substation (SS)[9] and Dairy Farm SS), the expansion of the existing 6 substations (Pendurthi SS, Gazuwaka SS, Vemagiri SS, Nunna SS, Khammam SS, Hyderabad SS), and the new construction of 400kV transmission lines (877km) and 220kV transmission lines (74km) (Figure 2).

Out of above 8 substations, three substations, Gazuwaka SS, Nunna SS and Khammam SS, are the property of and are managed by the Power Grid Corporation of India Limited (PGCIL) which is a central state-owned enterprise. I n this ex-post evaluation, the external evaluator tried to obtain data for the operation and effect indicators of these three substations under PGCIL thorough APTRANSCO, however, this could not be obtained. A nalysis of the performance of substations was thus carried out for the five substations under APTRANSCO.

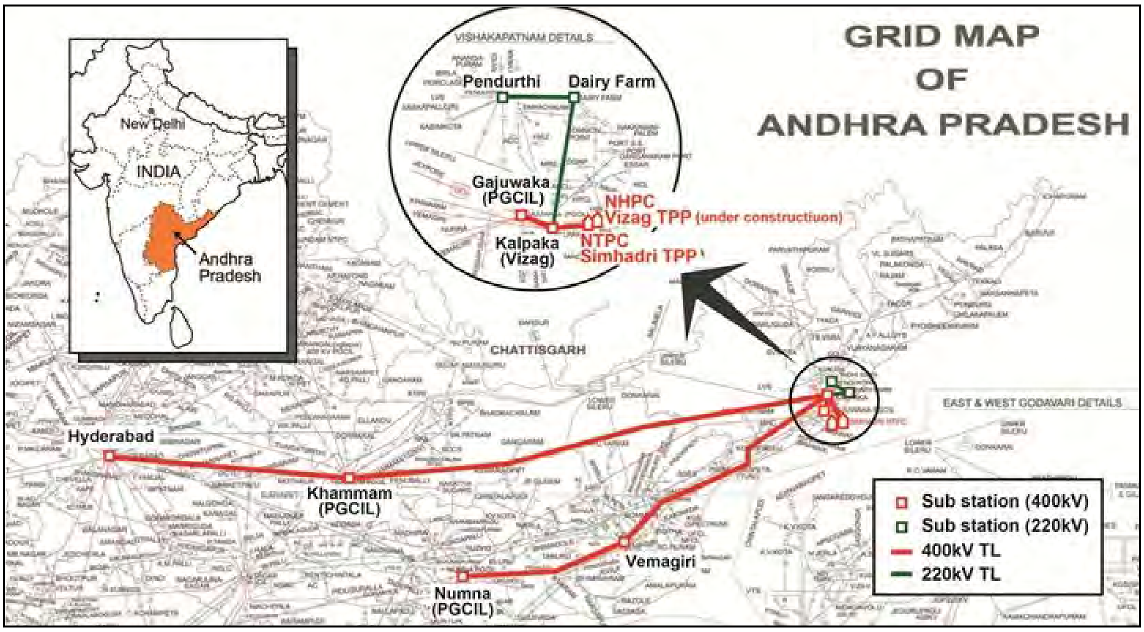


Figure 2: Project Site Map

7 Japan's ODA White Paper 1998, Ministry of Foreign Affairs (MOFA), Japan.

8 Sub-rating for Effectiveness is to be put with consideration of Impact.

9 In AP State, the Vizag Substation is commonly called the Kalpaka Substation, after Kalpaka village where it is located.

a) Vizag/Kalpaka Substation (New Construction)

The electricity supply, electricity demand and availability factors of Vizag/Kalpaka SS from 2005/06 to 2009/10 fully met the planned target figures. Transmission loss constantly decreased during the period from 2005/06 to 2009/10, and transmission loss in 2009/10 was mostly on t arget. According to APTRANSCO, the reason why transmission loss in 2010/11 was at a minus figure is that the energy meter recorded the wrong data. This may have resulted from negative numbers resulting in turn from damage to internal circuitry of the meters, wires or control cables from the current transformer (CP) and/or to potential transfer (PT) caused by harsh environmental conditions and construction/maintenance activities at grid substations. I n recent years, a special economic zone (SEZ) has been developed, with a large integrated steel plant, an oil refinery, fertilizer and zinc smelting plants, and the Vizag/Kalpaka SS supplies electricity to these bulk consumers. Therefore, the peak load at the sending point of the Vizag/Kalpaka SS is estimated to be 1,000MW, which exceeds the planned figures

Planned outage hours, meanwhile, have exceeded the planned figures. For example, planned outage hours in 2010/11 were 5,466 hours which was considerably greater than the plan. According to APTRANSCO, the available factor, that is the designed transformer capacity against a peak load, is over 90%. On the other hand, the Vizag/Kalpaka SS has sufficient capacity, except during peak hours, and the operation of a part of the transforming is suspended during non-peak hours. As a result, planned outage hours increased. Because of this, the actual station user electricity is much lower than planned (Table 1).

Table 1: Operation and Effect Indicators for Vizag/Kalpaka SS (400kV)

	Indicator		2005/06	2006/07	2007/08	2008/09	2009/10	2010/11*	2011/12*
1	Electricity Supply (GWh)	Plan	5,641	5,641	5,641	5,641	5,641	11,283	11,283
		Actual	7,742	8,123	7,742	8,533	8,521	8,417	6,541
2	Electricity Demand (GWh)	Plan	5,633	5,633	5,633	5,633	5,633	11,273	11,273
		Actual	6,692	7,588	7,508	8,501	8,290	8,424	6,101
3	Availability Factor (%)	Plan	48	48	46	27	48	54	60
		Actual	95.3	98.5.	73.9	99.4	91.6	89.9	n.a.
4	Transmission Loss (%)	Plan	1.6	1.6	2.5	2.5	2.5	1.5	1.5
		Actual	13.6	5.9	3.5	0.4	2.7	-0.1	6.7
5	Station Use Electricity (MWh)	Plan	3,500	3,500	3,500	3,500	3,500	3,500	3,500
		Actual	885	875	798	781	713	719	618
6	Peak Load at Sending Point (MW)	Plan	428	428	428	428	428	708	708
		Actual	1,000	1,000	1,000	1,000	1,000	1,000	1,000
7	Planned Outage Hours (Hour)	Plan	44	44	44	44	44	44	44
		Actual	1,336	1,397	23,473	7,363	1,983	5,446	n.a.
8	Outage Rate for Transmission Line (No./100km)	Plan	0.3	0.3	0.3	0.3	0.3	0.3	0.3
		Actual	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Source: JICA appraisal documents and APTRANSCO.

Note 1: The planned figures for Vizag/Kalpaka SS were set at the time of the Phase II appraisal in 2002.

Note 2: It is assumed that the Vizag Thermal Power Plant would be completed in five years after the completion of this project, and that the Vizag/Kalpaka SS would receive the generated electricity from the Vizag Plan. The planned figure for electricity supply was therefore increased from 5,641GWh to 11,283GWh in 2010/11 and the planned electricity demand was increased from 5,633GWh to 11,273GWh in 2010/11.

Note 3: The actual figures in 2011/12 are for 9 months from April to December 2012.

Note 4: The planned outage hours shown in Table 1 includes the outage hours for reducing the station use electricity. Also the planned outage hours is a cumulated outage hours of more than one transformer.

b) Diary Farm Substation (New Construction)

The availability factor, transmission loss and planned outage hours of Dairy Farm SS met the targets, but the electricity supply was below the planned target figures. Initially there was a plan to construct a special economic zone (SEZ) near the Dairy Farm SS, and the Dairy Farm SS was expected to supply electricity to this SEZ. H owever, this plan was changed and the

SEZ was constructed near the Pendurthi SS. Due to this, APTRANSCO modified the plan as the capacity of Pendurthi SS was expanded and the electricity supply to the SEZ was rerouted from the Vizag/Kalpak SS-Dairy Farm SS-SEZ to Vizag/Kalpaka SS-Pendurthi SS-SEZ. As a result, the electricity supply from the Dairy Farm SS is far lower than the planned figures (Table 2).

Table 2: Operation and Effect Indicators for the Dairy Farm SS (220/132/33kV)

	Indicator		2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
1	Electricity Supply (GWh)	Plan	687	687	687	687	687	721	721
		Actual	92	125	111	127	154	163	134
2	Electricity Demand (GWh)	Plan	685	685	685	685	685	719	719
		Actual	91	124	110	126	154	163	133
3	Availability Factor (%)	Plan	39	39	39	39	39	41	41
		Actual	28.4	33.0	31.8	31.8	37.5	44.3	61.4
4	Transmission Loss (%)	Plan	0.8	0.8	0.8	0.8	0.8	1.0	1.0
		Actual	0.7	0.6	0.7	0.6	0.5	0.5	0.7
5	Station Use Electricity (MWh)	Plan	900	900	900	900	900	900	900
		Actual	70	70	70	70	100	100	100
6	Peak Load at Sending Point (MW)	Plan	83	83	83	83	83	86	86
		Actual	25	29	28	28	33	39	54
7	Planned Outage Hours (Hour)	Plan	50	150	150	150	150	150	150
		Actual	0	0	9	6	18	7	0
8	Outage Rate for Transmission Line (No./100km)	Plan	1.9	1.9	1.9	1.9	1.9	1.9	1.9
		Actual	0.16	0.14	0.49	0.24	0.36	0.31	0.28

Source: JICA appraisal documents and APTRANSCO.
Note: The planned figures of Dairy Farm were set at the time of Phase II appraisal in 2002.

c) Vemagiri Substation (Expansion)

The electricity supply, electricity demand, availability factor, and transmission loss of the Vemagiri SS in 2010/11 fully met the planned target figures. In particular, the availability factor reached nearly 100%. The planned outage hours and the outage rate for the transmission line were below the planned figures (Table 3).

Table 3: Operation and Effect Indicators for the Vemagiri SS (400kV)

	Indicator		2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
1	Electricity Supply (GWh)	Plan	1,309	2,617	5,020	5,020	8,916	8,916	8,916
		Actual	n.a	2,009	1,830	4,467	9,832	11,587	9,560
2	Electricity Demand (GWh)	Plan	1,306	2,614	5,017	5,017	8,913	8,914	8,914
		Actual	n.a	1,936	1,760	4,423	9,752	11,422	9,389
3	Availability Factor (%)	Plan	17	17	27	27	38	38	38
		Actual	n.a.	98.1	98.9	99.6	98.2	99.4	99.8
4	Transmission Loss (%)	Plan	1.0	1.0	2.2	2.2	2.5	2.5	2.5
		Actual	n.a	0.3	2.6	0.9	0.8	1.4	0.7
5	Station Use Electricity (MWh)	Plan	2,300	2,300	2,300	2,300	2,300	2,300	2,300
		Actual	n.a	920	972	955	992	931	579
6	Peak Load at Sending Point (MW)	Plan	434	434	434	724	724	724	724
		Actual	n.a.	n.a.	n.a.	n.a.	n.a.	1,922	1,836
7	Planned Outage Hours (Hour)	Plan	44	44	44	44	44	44	44
		Actual	n.a	80	140	106	95	133	253
8	Outage Rate for Transmission Line (No./100km)	Plan	0.6	0.6	0.6	0.6	0.6	0.6	0.6
		Actual	n.a.	1.0	0.9	1.4	2.1	1.6	1.3

Source: JICA appraisal documents and APTRANSCO.
Note: The planned figures for the Vemagiri SS were set at the time of the Phase II appraisal in 2002.

d) Hyderabad Substation (Expansion)

No planned figures for the operation and effect indicators were set for the Hyderabad SS at the time of the Phase II appraisal in 2002. The electricity supply and demand constantly increased from 2005/06 to 2010/11, and the available factor was over 90%, except for 2007/08, which is quite high. Planned outage hours remain within the range of 2.5 and 18.6 hours, and they are lower than those for other substations. The reason why the transmission loss shows a minus figure is considered to be the same reason as for Vizag/Kalpaka SS. In general, the operational performance of Hyderabad SS is good (Table 4).

Table 4: Operation and Effect Indicators for the Hyderabad SS (400kV)

Indicator			2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
1	Electricity Supply (GWh)	Plan	—	—	—	—	—	—	—
		Actual	3,284	3,450	3,986	4,954	5,499	5,670	3,273
2	Electricity Demand (GWh)	Plan	—	—	—	—	—	—	—
		Actual	3,352	3,437	4,227	5,069	5,678	5,996	3,492
3	Availability Factor (%)	Plan	—	—	—	—	—	—	—
		Actual	93	90	77	93	90	95	93
4	Transmission Loss (%)	Plan	—	—	—	—	—	—	—
		Actual	-0.021	0.003	-0.061	-0.023	-0.033	-0.057	-0.067
5	Station Use Electricity (MWh)	Plan	—	—	—	—	—	—	—
		Actual	896	1,055	1,047	861	955	1,078	689
6	Peak Load at Sending Point (MW)	Plan	—	—	—	—	—	—	—
		Actual	560	540	699	720	810	858	840
7	Planned Outage Hours (Hour)	Plan	—	—	—	—	—	—	—
		Actual	42.6	15.4	8.2	12.7	6.2	2.5	15.9
8	Outage Rate for Transmission Line (No./100km)	Plan	—	—	—	—	—	—	—
		Actual	0.13	0.24	0.23	0.17	0.34	0.34	0.10

Source: JICA appraisal documents and APTRANSCO.
Note: The planned figures for the Hyderabad SS were not set at the time of the Phase II appraisal in 2002.

e) Pendurthi Substation (Expansion)

As in the case of the Hyderabad SS, no planned figures for the operation and effect indicators were set out for the Pendurthi SS at the time of the Phase II appraisal in 2002. The electricity supply and demand constantly increased from 2005/06 to 2011/12, and the availability factor was over 90%, which is quite high. One possible reason for the above good performance is that, as already explained in the analysis of the Dairy Farm SS, the electricity supply from the Pendurthi SS to the SEZ located near the Pendurthi SS has increased. Meanwhile, the availability factor in 2008/09 was recorded at 103%, which is over-loaded. Further capacity expansion of the Pendurthi SS is required. The planned outage hours range between 126 and 134 hours. Generally, the operational performance of the Pendurthi SS is good (Table 5).

Table 5: Operation and Effect Indicator of Pendurthi SS (220kV)

Indicator			2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
1	Electricity Supply (GWh)	Plan	—	—	—	—	—	—	—
		Actual	747	786	790	977	998	1,139	1,601
2	Electricity Demand (GWh)	Plan	—	—	—	—	—	—	—
		Actual	684	730	757	938	980	1,127	1,598
3	Availability Factor (%)	Plan	—	—	—	—	—	—	—
		Actual	96	96	98	103	73	90	95
4	Transmission Loss (%)	Plan	—	—	—	—	—	—	—
		Actual	8.3	7.1	4.1	3.9	1.7	1.0	0.2

Indicator			2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
5	Station Use Electricity (MWh)	Plan	—	—	—	—	—	—	—
		Actual	107	107	107.5	108	108	109	110
6	Peak Load at Sending Point (MW)	Plan	—	—	—	—	—	—	—
		Actual	190	190	194	204	216	267	281.8
7	Planned Outage Hours (Hour)	Plan	—	—	—	—	—	—	—
		Actual	131	126	130	128	132	126	134
8	Outage Rate for Transmission Line (No./100km)	Plan	—	—	—	—	—	—	—
		Actual	0.37	0.39	0.39	0.35	0.40	0.44	0.52

Source: JICA appraisal documents and APTRANSCO.
Note: The planned figures for the Pendurthi SS were not set at the time of the Phase II appraisal in 2002.

APTRANSCO plans to increase capacity at the Vizag/Kalpaka SS, the Vemagiri SS and the Hyderabad SS, where the availability factor exceeds 90%, by the installation of additional high capacity transformers.

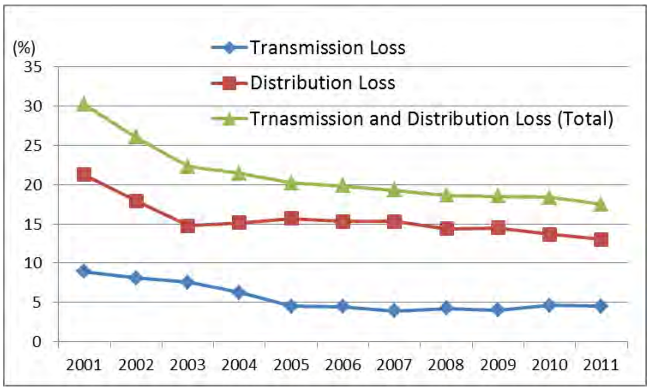

Vizag/Kalpaka Substation


Dairy Farm Substation


Hyderabad Substation

(2) Reduction of Transmission Loss

Transmission and distribution loss in AP State declined from 33% in 1997 to 17.5% in 2011. Transmission loss halved from 8.9% in 2001 to 4.5% in 2011 (Figure 3). This figure is very good in comparison to the Indian national average which was 27% in 2011. N ow, AP State is counted as one of the States with the lowest transmission loss in India. Possible contributing factors for the low transmission loss may not only the active investment in the development of transmission facilities



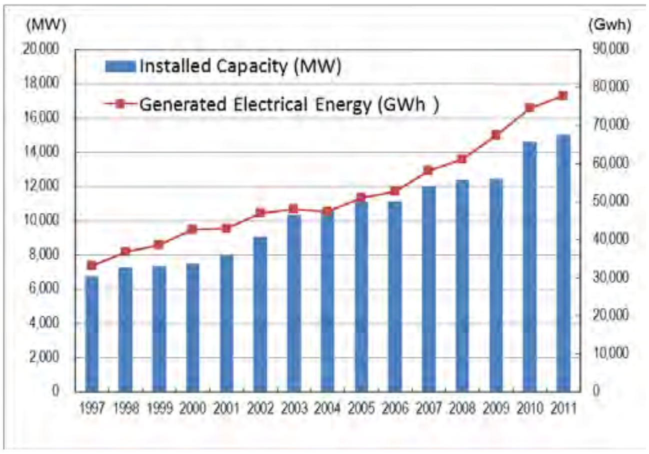
Source: APTRANSCO

Figure 3: Transmission and Distribution Losses in AP State

by the Government of AP State, including this project, but also the unbundling of generation, transmission and distribution after power sector reform in AP State and implementation of effective measures for reducing the non-technical loss such as stealing electricity[10]. Since this project was related to a part of the transmission network of AP State, it can be said that the project contributed to the reduction of transmission loss in the state.

(3) Mitigation of the Electricity Demand and Supply Gap

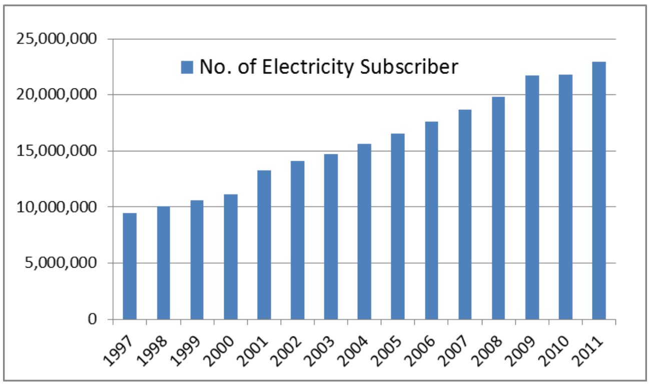
AP State has promoted the development of electric power resources for the mitigation of constant power shortages. The total installed power generation capacity of AP State increased 2.2 times from 6,764MW (1997) to 15,003MW (2011) and the annual generated electrical energy increased 2.3 times from 33,130 GWh/year (1997) to 77,764GWh/year (2011) during the 14 year period between 1997 and 2011 (Figure 4).



Source: APTRANSCO

Figure 4: Total Installed Capacity and Total Generated Electrical Energy in AP State

At the same time, the number of electricity subscribers increased 2.4 times from 9.48 m illion in 1997 to 22.95 million in 2011 (Figure 5). The electricity consumption per capita expanded from 600kWh in 2006 t o 950kWh. A s already shown in Figure 1, the electricity demand and supply gap in AP State had not been mitigated except for the three years from 2004 a nd 2006, soon after the completion of the Simhadri Thermal Power Plant in 2004.



Source: APTRANSCO

Figure 5: No. of Electricity Subscriber in AP State

However, As of December 2011, Simhadri Thermal Power Plant shared 10% of the total installed power generation capacity in AP State[11]. After September 2013, when the expansion of Simhadri Thermal Power Plant from 1,000MW to 2,000MW and the on-going construction of Vizag Thermal Power Plant (1,040MW) are completed, it is planned that at least 2,336MW of installed power generation capacity will be utilized for AP State through the project facilities. This is equivalent to 15% of the total installed generation capacity of AP State. Therefore, it can be seen that this project has played an important role in improving the power supply system in the State, and it is evident that the project contributed to mitigating the electricity demand and supply gap in the state.

[10] They are the introduction of automatic meter readers, reinforcement of penal rules for employees of the distribution companies, and improvement of billing and collection system of electricity tariff, etc.
[11] The installed power generation capacity of Simhadri Thermal Power Plant was 1,500MW as of December 2011.

3.2.2 Quantitative Effects

(1) Improvement of the Stability and Liability of the Electricity Supply

After implementation of the project, APTRANSCO improved capacity to provide a stable electricity supply, minimizing load shedding and voltage fluctuation. According to APTRANSCO, voltage has improved by 10kV on the 220kV transmission line between the Vizag/Kalpaka SS and the Khammam SS, by 16kV on the 220kV transmission line between the Khammam SS and the Hyderabad SS, and by 2kV on the 220kV transmission line between the Vizag/Kalpaka SS and the Vemagiri SS. Also the project included special measures to strengthen the design and the structure of transmission facilities located in the coastal areas which were frequently affected by cyclones coming in from the Indian Ocean. These measures included a stronger strong structure for towers through foundation engineering, a shorter distance between towers, an adjustment of tower angles to reduce wind drag, and the provision of stronger cross arms to withstand impact. They were implemented in the areas between the Vizag/Kalpaka SS, the Vemagiri SS and the Nunna SS. Because of this, transmission lines located in the coastal area became stronger in the event of cyclones, resulting in an improvement in the reliability of the system.

Also, the results of interview surveys with the Department of Energy of the AP State Government and distribution companies such as the Andhra Pradesh Central Power Distribution Company Ltd. (APCPDCL) and the Andhra Pradesh Eastern Power Distribution Company Ltd. (APEPDCL) indicate that it was recognized that the project had had a positive effect on the improvement of a stable electricity supply and the reliability of the power supply system in AP State. It was stated that AP State would have suffered more serious load shedding and power shortages in the central and eastern regions where electricity demand is high had the project not been implemented.

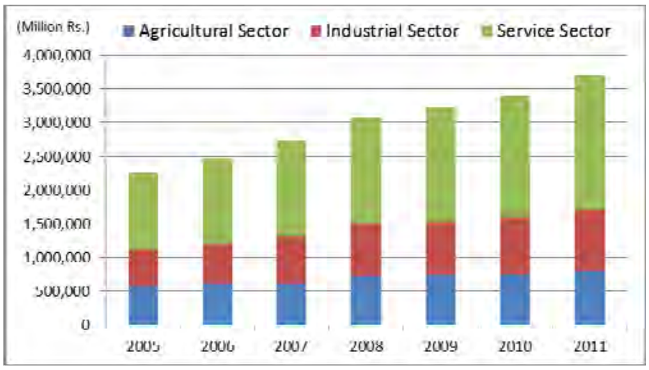
Therefore, it is concluded that the project has had a positive effect on the improvement of a stable electricity supply and on the reliability of the power supply system in AP State.

3.3 Impacts

3.3.1 Intended Impacts

(1) Industrial Development

The Gross State Domestic Product of AP State increased 1.7 times from 2,247 billion Rupees in 2005 to 3,710 billion Rupees in 2011 (Figure 6). In recent years the development of industrial estates has taken place in the state and the number of large scale industries such as textile, pharmaceutical, and machinery manufacturing industries is increasing. The number of enterprises is also expanding. According to interviews with the power distribution companies in AP State, it was recognized that the project has contributed to the promotion of industrial development in AP State through the stable electricity supply from Simhadri Thermal Power Plan to the power-consuming areas.



Source: Andhra Pradesh Socio Economic Survey 2011-12, AP State.

Note: Constant Price (2005).

Figure 6: Gross State Domestic Product of AP State

As stated in the ex-post evaluation report on Simhadri Thermal Power Station Project (I)(II)(III)(IV),[12] the above project contributed to the mitigation of the electricity demand and supply gap in AP State. It is therefore the case that this project, which aimed at supplying

[12] http://www2.jica.go.jp/ja/evaluation/pdf/2009_ID-P120_4_f.pdf.

generated electricity from the Simhadri Thermal Power Plant to AP State, is one of the contributing factors for the above mentioned impact.

Therefore, it is concluded that this project contributed to supporting the industrial development of AP State through the provision of a stable power supply to industries with a high demand for electricity.

(2) Employment Creation through Industrial Development

It is difficult to examine the project impact on employment creation through industrial development due to the relationship between the project scope and this effect. In interviews with the power distribution companies of AP State, it was stated that the project made a positive contribution to the expansion of employment opportunities in AP State by the promotion of industrial development through the provision of a stable power supply from Simhadri Thermal Power Plant to power-consuming areas.

(3) Improvement in people's living standards through Electrification and the Promotion of Home Appliances

According to statistical data based upon t he definition of electrification[13], AP State achieved 100% of electrification in 2001. However taking into account the settlements and habitats of low caste, outcaste (i.e. scheduled castes and scheduled tribes) and poor people, in reality, the electrification of AP State has not yet achieved 100%[14]. Nevertheless, the number of electricity subscribers has been increasing year by year, and the increase in additional new subscribers may lead to an improvement of living standards for those people who became able to receive the electricity supply service. This was due not only to capacity expansion of the transmission sub-sector, but also to capacity improvement of the generation and distribution sub-sectors.

Therefore, the project has a positive effect on the stability of the transmission system in AP State, and thus it can be said that the project has contributed to an improvement in people's living stands to some extent.

3.3.2 Other Impacts

(1) Impact on the Natural Environment

In India, environmental clearance and environmental impact assessment are not compulsory for transmission development projects. D uring project implementation, in February 2002, the project obtained forest clearance from the Government of AP State when a part of the 220kV transmission line between the Vizag/Kalpaka SS and the Dairy Farm SS was made to cross a reserved forest due to changes in the project scope. The process for obtaining forest clearance was followed appropriately, and no negative impact on the natural environment from the project has been observed.

(2) Land Acquisition and Resettlement

a) Land Acquisition

At the time of appraisal, it was estimated that 71.8h of land would need to be acquired for the construction of substations and transmission towers. In fact, 156ha of land was acquired

[13] According to the definition revised in February 2004, village electrification is defined as: (i) basic infrastructure such as distribution transformers and distribution lines provided in the inhabited locality as well as in the Dalit Basti/ hamlet where they already exist, (ii) electricity is provided to public places such as schools, the Panchayat office, health centers, dispensaries, community centers etc. and (iii) the number of households electrified should be at least 10% of the total number of households in the village (Source: Ministry of Power, vide letter No. 42/1/2001-D (RE) dated on February 5, 2004).

[14] The settlements and habitats low caste, outcaste, and poor people are called General Hamlets, Dalitwadas, Weaker Section Colonies, etc., They are usually isolated from the villages of the general populace. Although the electrification of these areas has not reached to 100%, the situation has improved and the rate reached 94-99% in 2011 (Source: Rural Electrification Progress 2001-2011, APTRANSCO).

by the project. The main reason for this increase was changes in the location of substations and towers due to project scope changes. The land acquisition process met the requirements of Indian law and regulations.

b) Resettlement of People

Since no resettlement of people took place for the project, no negative social impact associated with the resettlement of people was observed.

As explained above, the operational performance of substations newly constructed and expanded by the project was, in general, good, and the expected project effects such as a reduction of transmission loss, a mitigation of the electricity demand and supply gap, and improvements in the stability and reliability of electricity supply were achieved. The project also contributed to industrial development, to employment creation and to the improvement of people's living standards. Meanwhile, no ne gative impacts on the natural environment or social environment were observed. Therefore, it is concluded that the project produced its expected outcomes, its effectiveness with impact is high.

It can be assumed that if Vizag Thermal Power Plant had been completed in parallel with the completion of this project, Simhadri and Vizag Thermal Power Plants could have provided 14,800GWh[15] of annual electrical energy the AP State as a w hole after December 2005. However, in reality, the annual electrical energy provided has remained at 8,000GWh[16]. Considering this, had the construction of Vizag Thermal Power Plant been completed on schedule, the project effects and impacts at the time of this ex-post evaluation would have been much greater.

3.4 Efficiency (Rating:②)

3.4.1 Project Outputs

The project was implemented in two phases: Phase I consisted of the minimum components for transmitting generated electricity from Simhadri and Vizag Thermal Power Plants to the AP power grid, and Phase II consisted of components for improving the reliability of the transmission system. T he components of Phase I were further divided into Phase I-A and Phase I-B. T he components of Phase I-A were priority works that had to be completed 6 month before the completion of Unit 1 of the Vizag Thermal Power Plant (this was estimated as April 2000 at the time of appraisal). The remaining works were implemented under Phase I-B. Table 6 shows a comparison of the planned and actual project outputs.

Table 6: Planed and Actual Project Outputs

Item	Plan*	Actual
[Phase I-A] a) 400kV Transmission Line	・400kV DC line between Vizag Thermal Power Plant (TPP) – Vizag/Kalpaka SS (25km x 4 circuits) ・400kV DC line between Vizag/Kalpaka SS – Gazuwaka SS (PGCIL) (20km x 2 circuits)	・Cancelled ・4 km x 2 circuits
b) Substation	400kV feeder bays and bus at Vizag SS (14 bays)	・Same as planned
c) Other	400kV bay extension at Gazuwaka SS (PGCIL) (2 bays)	・Same as planned

[15] It is assumed that 8,000GWh of annual electrical energy is generated by Simhadri Thermal Power Plant (1,000MW) and 6,800GWh of annual electrical energy is generated by Vizag Thermal Power Plant (1,040MW), and that a total 14,800GWh of annual electrical energy is supplied to APTRANSCO.

[16] The annual electrical energy sold from Simhadri Thermal Power Plant to APTRANSCO is approximately 8,000GWh.

Item	Plan*	Actual
[Phase I-B] c) 400kV Transmission Line	・400kV DC line between Simhadri TPP – Vizag/ Kalpaka SS (30km x 4 circuits) ・400kV DC line between Vizag SS – Khammam SS (PGCIL) (390km x 2 circuits) ・400kV DC line between Khammam SS (PGCIL) – Hyderabad SS (200km x 2 circuits)	・4 km x 4 circuits ・364 km x 2 circuits ・198 km x 2 circuits
d) 220kV Transmission Line	・220kV DC line between Vizag/Kalpaka SS – Eximpark SS (30km x 2 circuits) ・E220kV DC line between Eximpark SS – Gazuwaka SS (PGCIL) (8km x 1 circuit) ・220kV DC line between Vizag/Kalpaka SS – Pendurthi SS (40km x 2 circuits) ・220kV DC line between Pendurthi SS – Garividi SS (65km x 1 circuit) ・220kV DC line between Gazuwaka SS – Pendurthi SS (31km x 1 circuit)	・All cancelled
e) Substation	・Vizag/Kalpaka SS: 400/220kV Transformer (315MVA x 2), 220kV feeder bays and bus (6 bays) ・Eximpark SS: 220/132kV Transformer (100MVA x 2)	・Same as planned ・Cancelled (location was changed to Dairy Farm)
f) Other	・Gazuwaka SS (PGCIL): 400/220kV Transformer (315MVA x 1) ・Pendurthi SS: 220/132kV Transformer (100MVA x 1) ・400kV bay extension at Khammam SS (PGCIL) (4 bays), Hyderabad SS (2 bays) ・220kV bay extension at Pendurthi SS (4 bays), Garividi SS (1 bay), Gazuwaka SS (PGCIL)(1 bay), Vizag Switching Station (1 bay)	・Cancelled ・Cancelled ・Cancelled ・Pendurthi SS (1 bay), Garividi SS (cancelled), Gazuwaka SS (cancelled), Vizag Switching Station (2 bays)
[Phase II] g) 400kV Transmission Line	・400kV DC line between Vizag SS – Vemagiri SS (180km x 2 circuits) ・400kV DC line between Vemagiri SS – Nunna SS (PGCIL) (160km x 2 circuits)	・167 km x 2 circuits ・140km x 2 circuits
h) Other	・Vemagiri SS: 400/220kV Transformer (315MVA x 2) ・Vemagiri SS: Bay extension (16 bays) ・Nunna SS (PGCIL): Bay extension (2 bays)	・Same as planned ・400kV (16 bays), 220kV (8 bays) ・Same as planned
i) Consulting Service	Foreign Experts: 120M/M Local Experts: 96M/M	Not available
Additional Scope	—	・220kV DC line between Vizag/Kalpaka SS - Dairy Farm SS (55km x 2 circuits) ・220kV DC line between Dairy Farm SS – Pendurthi SS (15km x 2 circuits) ・220kV DC line between Vizag/Kalpaka SS – Switching Station (4km x 2 circuits) ・Dairy Farm SS: 220/132kV Transformer (100MVA x 2)

Source: JICA appraisal documents and APTRANSCO.

Note 1: The planed outputs are based upon the outputs planned at the time of the Phase I appraisal (1997) and the Phase II appraisal (2002).

Note 2: In AP State, the Vizag Substation is commonly called the Kalpaka Substation, named after Kalpaka village where it is located.

Note 3: The three substations, Gazuwaka SS, Nunna SS and Khammam SS, are the property of and managed by the Power Grid Corporation of India Limited (PGCIL).

The main reasons for the change in project scope are as follows:[17]

- Due to the long delay in the construction of the Vizag Thermal Power Plant, some of the project components for Phase I-A and I-B had been cancelled at time of Phase II appraisal.
- Due to difficulties in land acquisition for the Vizag/Kalpaka SS at the location where it was originally intended, the location was changed to near the Simhadri Thermal Power Plant. Because of this, the length of the 400kV transmission line between Vizag/Kalpaka SS and Gazuwaka SS was shorter than in the plan.
- The naval and civil airport authorities objected to the construction of the substation, transmission towers and lines in Exim Park as their location was near to the Visakhapatnam airport[18] and it was feared that the transmission facilities might obstruct flight routes. The location of the substation was changed from Exim Park to Dairy Farm. Because of this change, project components relating to the construction of the substation, transmission lines and towers were cancelled, and new components for Dairy Farm SS were added.
- The construction of a 220KV transmission line between the Vizag SS, the Pendurthi SS and the Garividi SS was cancelled and removed from the project components as its construction was financed by APTRANSCO.
- Although it was initially planned that the Parawada SS would be constructed with finance from the Industrial Infrastructure Department of AP State, this plan was cancelled due to budgetary constraints in the department. Because of this, the construction of 220kV transmission lines between the Vizag/ Kalpaka SS and the Vizag switching gate was newly added as a project component.

The above mentioned changes in project scope were mainly due to the delay in construction of the Vizag Thermal Power Plant and the location change of the Exim Park SS due to the risk of interference of flight routes. Forecasting such events would have been difficult at the time of the Phase I appraisal in 1997. Therefore, these modifications of the project scope can be judged to be acceptable since they were made in order to cope with changes in the project environment. Also, they did not affect the realization of the project objectives.

However, if prior consultation and information sharing with the naval and civil airport authorities had been well organized, at least the delays associated with the location change of the Exim Park SS could have been minimized to some extent.

3.4.2 Project Inputs

3.4.2.1 Project Cost

The actual project cost was 15,750 million yen against 20,014 million yen planned cost, which was 79% of the planned cost (Table 7). The main reasons for the cost saving were: (i) a reduction of cost primarily due to low quotes in competitive bidding by vendors, (ii) the sum allocated for contingency was not exercised, and (iii) changes in the currency exchange rate.

[17] A comparison between the planned and actual project outputs by type of facilities is as follows: (i) the actual total length of 400kV transmission line was 877km against 1,005km (plan), (ii) the actual total length of 220kV transmission line was 74km against 174km, (iii) the actual installation of 315MVA transformers at Vizag/Kalpaka SS, Vemagiri SS and Gazuwaka SS was 4 units against 5 units (plan), (iv) the actual installation of 100MVA transformers at Eximpark SS, Pendurthi SS, Dairy Farm SS was 2 units against 3 units (plan), (v) the actual installation of switching facilities at Vizag/Kalpaka SS was 20 bays against 20 bays (plan), and (vi) the actual bay extension at 8 substations was 37 bays against 22 bays (plan).

[18] The Visakhapatnam naval air station is located in Visakhapatnam airport.

Table 7: Comparison of Planned and Actual Project Cost

Item	Plan*			Actual		
	Foreign (Mill. JPY)	Local (Mill. INR)	Total (Mill. JPY)	Foreign (Mill. JPY)	Local (Mill. INR)	Total (Mill. JPY)
1. Civil Works	24	1,149	3,069	1,747.5	462.2	2,903.0
2. Transmission Line & Substations	14,352	0	14,352	11,808.4	0.0	11,808.4
3. Consulting Services	607	18	655	252.8	23.3	311.1
4. Land Acquisition	0	26	69	0.0	42.9	107.3
5. Administration	0	66	175	0.0	0.0	0.0
6. Tax and Duties & Price Escalation	69	196	588	0.0	103.9	259.8
7. Contingency	303	56	451	0.0	0.0	0.0
8. IDC	655	0	655	361.1	0.0	361.1
Total	16,010	1,511	20,014	14,169.8	632.3	15,750.7

Source: JICA appraisal document and APTRANSCO.
Note 1: he planned project cost is based on the planned project cost at the time of the Phase II appraisal (2002).
Note 2: Exchange rate used: 1 Rp. =2.65 yen in January 2002 (Plan) and 1 Rp. =2.51 yen as annual average from 1997 to 2005 (actual).

3.4.2.2 Project Period

The actual project period was 97 m onths from December 1997 (signing of the loan agreement) to December 2005 (project completion) against 69 months from December 1997 and August 2003. This was longer than planned, at 141% of planed project period (Table 8).

Table 8: Comparison of Planned and Actual Project Period

Item	Plan	Actual
1. Signing of Loan Agreement	(Phase I) December 1997 (Phase II) May 2002	(Phase I) December 1997 (Phase II) May 2002
2. Land Acquisition	(Phase I) March 2000 – August 2001 (Phase II) April 2002 – March 2003	July 2000 – June 2001
3. Procurement (Transmission)	(Phase I) July 2000 – December 2001 (Phase II) June 2002 – March 2003	July 2000 – November 2004
4. Construction (Transmission)	(Phase I) July 2000 – March 2002 (Phase II) June 2002 – August 2003	August 2000 – July 2005
5. Procurement (Substations)	(Phase I) September 2000 – June 2002 (Phase II) May 2002 – March 2003	January 2001 – January 2005
6. Construction (Substation)	(Phase I) October 2000 – July 2002 (Phase II) July 2002 – August 2003	March 2001 – March 2005
7. Consulting Services	N.A.	May 1999 – June 2005
8. Project Completion	(Phase I) July 2002 (Phase II) August 2003	December 2005
9. Entire Project Period	December 1997 – August 2003 (69 months)	December 1997 – December 2005 (97 months)

Source: JICA appraisal document and APTRANSCO.
Note: The planned project period is based on the planned project period at the time of the Phase II appraisal (2002).

The reasons for the delay were: (i) delay in design and construction works due to the changes in project scope, (ii) the transmission lines passed over paddy fields and the construction of transmission facilities was limited to three months during the agricultural off season, which caused a delay, (iii) the prolonged process for crop compensation and rights-of-way, (iv) the prolonged process for obtaining clearance for placing the transmission lines over a railway crossing, (v) the time taken for the construction works for transmission facilities with long spans in difficult geographical locations such as valleys and forest areas, (vi) obtaining forest clearance for the construction of 220kV transmission lines between the Vizag/Kalpaka SS and the Dairy Farm SS that passed through a reserved forest, which took a long time.

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

3.4.3.1 Financial Internal Rates of Return (FIRR)

The result of the recalculation of FIRR for this project at the time of the ex-post evaluation was 11.7%, which was higher than the original FIRR of 9.0% at the time of appraisal. The main reason for this was the increase in electricity sales revenue through additional available electricity from the expansion of the Simhadri Thermal Power Plant. The FIRR calculation at appraisal was based upon the preconditions below:

<Preconditions of FIRR calculation at appraisal>

- Cost: Project cost, operation and maintenance cost, and electricity purchase cost
- Benefit: Revenue from electricity sales
- Project life: 35 years after project completion

3.4.3.2 Economic Internal Rates of Return (EIRR)

The EIRR at the time of appraisal was 10.0%. Due to difficulties in collecting the necessary information and data for a recalculation of EIRR, the ex-post evaluation did not exercise a recalculation of EIRR. The EIRR calculation at appraisal was based upon the preconditions below:

<Preconditions of EIRR calculation at appraisal>

- Cost: Project cost excluding tax and duties, operation and maintenance cost excluding tax and duties
- Benefit: Financial revenue
- Project life: 35 years after project completion

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

3.5 Sustainability (Rating: ③)

3.5.1 Structural Aspects of Operation and Maintenance

The operation and maintenance (O&M) agency of this project was Transmission Corporation of Andhra Pradesh Ltd. (APTRANSCO)[19]. The sections and departments responsible for O&M of the project facilities were the Metropolitan Zone Office in Hyderabad, the Vizag Zone Office and the Vijayawada Zone Office. At field level, staff of the Lines Section, the Maintenance Section and the Meters and Relays Testing (MRT) Section from each zone office took care of the facilities. Also, transmission engineers were allocated to the major substations to conduct O&M activities both for substations and for transmission lines. A chief engineer was stationed at each zone office to be responsible for O&M of the transmission facilities in each respective zone territory as well as for preparation and execution of the budget. The total number of staff working at the Vizag Zone Office was 367, including one chief

[19] APTRANSCO was established in February 1999 after the unbundling of the Andhra Pradesh State Electricity Board (APSEB) by the AP State Electricity Reform Act 1998 as an AP State owned transmission and distribution public corporation. Later, in April 2000, APTRANSCO was further restructured into a transmission company (APTRANSCO) and four distribution companies (DISCOMS).

engineer/head of zone office, seven superintendent engineers, 20 divisional engineers, 138 assistant divisional engineers, and 210 assistant engineers. According to APTRANSCO, the relevant number of staff was allocated to each respective department and section, and no particular problems were observed in the structural aspects of APTRANSCO. T he organizational chart for APTRANSCO is shown in Figure 7.

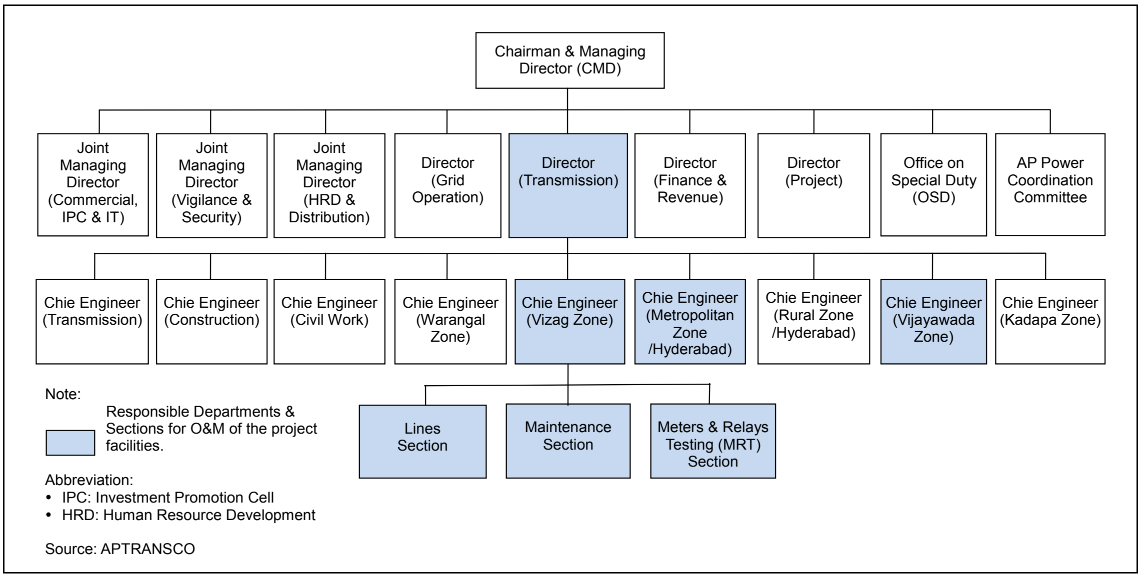


Figure 7: Organization Chart of APTRANSCO

The Power Grid Corporation of India Ltd. (PGCIL) is responsible for the O&M of the Gazuwaka SS, the Khammam SS a nd the Nunna SS. PGCIL is a cen tral government-owned enterprise established in 1992, which has a nationwide transmission grid. About 45% of the total generated electricity in India goes though the grid system of PGCIL. B esides this, the O&M of transmission facilities directly connected to the above three PGCIL substations is carried out by PATRANSCO.

There are no particular problems in the structural aspects of the O&M agency.

3.5.2 Technical Aspects of Operation and Maintenance

APTRANSCO has prioritized staff training. For example, 99 staff training courses with a total of 2,030 participants were planned in 2011/12. According to interviews with distribution companies such as APCPDCL and APEPDCL, their business relationships with APTRANSCO were good, and no pa rticular issue for their technical capacity was observed. APTRANSCO has received many awards from the Indian government and other organizations for its outstanding performance and technical capacity[20].

Therefore, there are no particular problems in the technical aspects of the O&M agency.

3.5.3 Financial Aspects of Operation and Maintenance

The O&M budget for the project facilities is shown in Table 9. In the past, difficulties such as sh ortages of spare parts due to budget constraints were observed. However, as eac h Zone Office is now given the responsibility to plan and execute their own O&M budget independently, the situation has improved. According to an interview with the chief engineer of the Vizag Zone Office, no problems with the O&M budget were observed.

[20] (1) The India Power Award 2008 and 2010 for the best "Overall Utility Performance", Council of Power Utilities, (2) 2nd Prize in the IEEMA Power Awards 2009 for Excellence in Power Transmission, (3) the 4th and 5th Enertia Award for Best Performing Utility (under Category III: Utilities and T & D Awards) (2010 and 2011).

Table 9: Operation and Maintenance Budget for the Project Facilities

Unit: Million Rupees

		2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
O&M Budget (including employment cost and administration cost)	Plan	171.1	172.7	165.6	178.2	254.5	281.7
	Actual	243.8	224.2	221.6	242.8	258.0	385.2

Source: APTRANSCO

Regarding the financial status of APTRANSCO in the 4 years between 2007/08 and 2010/11, APTRANSCO mainly financed the investment costs for development projects by borrowing. The Current Ratio was 79-88% and the Equity to Assets Ratio was 27-33%, which are not so high. APTRANSCO has maintained a certain level of profitability with a Return on Total of 2-3% and an Asset Return of Sales of 9-15% (Table 10). In AP State, the electricity tariff is renewed about every 4-5 years by the Andhra Pradesh Electricity Regularity Commission (APREC). As the tariff is based on t he current expenditure of APTRNACO, APTRANSCO is guaranteed a certain level of profit.

There were no particular problems in the financial aspects of the O&M agency.

Table 10: Financial Status of APTRANSCO

Unit: 100,000 Rupees

Major Operation Indicator	2007/08	2008/09	2009/10	2010/11
(1) Sales	67,541.69	74,257.10	81,659.21	95,452.19
(2) Operating Expenses	26,030.79	28,610.05	30,654.92	45,954.64
(3) Operating Income	41,510.90	45,647.05	51,004.29	49,497.55
(4) Depreciation	26,343.97	29,178.09	31,750.37	35,803.45
(5) Profit/Loss before Tax	15,166.93	16,468.96	19,253.92	13,694.10

Major Financial Indicator	2007/08	2008/09	2009/10	2010/11
I. Financial Performance				
A. Total Assets	341,553.90	370,939.84	414,515.28	495,838.24
B. Current Assets	178,717.15	249,494.60	178,533.43	198,749.00
C. Current Liabilities	218,394.65	282,143.94	225,771.29	238,627.39
D. Total Equity	111,420.37	118,188.54	125,960.27	132,124.17
E. Net Sales	67,541.69	74,257.10	81,659.21	95,452.19
F. Net Income after Income Tax	6,131.70	10,020.10	12,110.08	10,871.14
II. Financial Indicator				
Return of Total Assets (F/A)	2%	3%	3%	2%
Return on Sales (F/E)	9%	13%	15%	11%
Total Asset Turnover (E/A)	0.20	0.20	0.20	0.19
Current Ratio (B/C)	82%	88%	79%	83%
Equity to Assets Ratio (D/A)	33%	32%	30%	27%

Source: APTRANSCO Annual Report 2008-09, 2009-10. 2010-11.
Notre: The financial year of India starts from April and ends in March.

3.5.4 Current Status of Operation and Maintenance

The O&M activities of APTRANSCO are conducted according to the operation manual[21] and the Indian Electricity Grid Code 2010. Antennae activities are exercised in six stages from

[21] Reference Manuals on Operational Practices of EHV Substations & Lines and Commercial and Load Dispatch Operations.

daily routine maintenance to weekly, monthly, quarterly, semi-annual and annual. In each Zone Office, the following maintenance works are conducted: (i) Line Section: Normal and special patrolling, replacement of insulator stacks, provision of special quality anti-corrosive epoxy paint to structures and attending, (ii) Maintenance Section: Maintenance of bay equipment such as breakers, CTs, isolators, etc. and (iii) MRT Section: Testing of breakers, CTs, relays and energy meters. After project completion, there was corrosion of transmission lines caused by salt water damage. However, necessary measures were taken by APTRANSCO and the damaged lines coated. During the field survey by the ex-post evaluation team, visits were made to the Vizag/Kalpaka SS and the transmission facilities nearby, to the Dairy Farm SS, the Hyderabad SS, and the Gazuwaka SS under PGCIL. The operational status and O&M procedures of each facility were examined, and no particular problem found.

No major problems have been observed in the operation and maintenance system, therefore the sustainability of the project effect is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The objective of this project was to reduce transmission loss and voltage fluctuation resulting from generation capacity addition in Andhra Pradesh (AP) State as well as to improve the reliability of the transmission system in areas where cyclones frequently occur, by the construction of 400kV/220kV transmission lines between the Simhadri Thermal Plant (1,000MW) and the Vizag Thermal Power Plant (1,040MW) in Visakhapatnam and Hyderabad together with substation (SS)s. Thus a contribution would be made to the expansion of industrial activity, to employment and to electrification in rural areas, and also to an improvement in the living standards of the local population.

This project has been highly relevant to India’s development plan and development needs, as well as to Japan’s ODA policy, and therefore its relevance is high. The performance of substations either newly constructed or expanded by the project is generally good, and project objectives such as the reduction of transmission losses, narrowing of the electricity demand and supply gap, and the improvement of a stable and reliably electricity supply have been largely achieved. Al so, the project had positively contributed to industrial development, the expansion of employment opportunities, and the improvement of people’s living standards in AP State, and thus its effectiveness is high.

Project cost was lower than planned, and although the project period was longer than planned, the project efficiency is fair. Project sustainability is deemed high in the structural, technical and financial aspects, and the O&M condition of project facilities and equipment is good.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

It was revealed that some sub-stations failed to record accurate data for electricity transmission loss and recorded negative losses. Since technical data for electricity transmission loss is important for the operation of substations, investigations into the reasons for the recording of negative loss is recommended. This may include examination of the conditions of current transformers (CP) and/or potential transfer (PT) units, energy meters etc., as well as the implementation of corrective measures for recording actual energy usage and proper energy accounting.

It was also observed that older operational records were made manually and not properly maintained at some substations, which resulted in problems in the accessibility of data. This may affect the effective management of the substations. It is recommended that the executing agency improve record keeping at substations by modernizing the said procedure through the introduction of computer systems in order to contribute to effective management and an improvement in services.

4.2.2 Recommendation to JICA

None.

4.3 Lessons Learned

At the planning stage land utilization issues in the construction of substations and transmission lines/towers were basically solved by the concerned stakeholders including land owners, the Government of AP State and APTRANSCO. However during the course of execution, objections were raised from the naval and civil airport authorities that the suggested location of a substation might be an obstacle to air routes and violate the restricted spatial zone. Due to this, the construction of the substation at Exim Park had to be relocated to Dairy Farm.

In sensitive areas, such as near airports and military facilities, special care should be taken at the first prior consultation meetings in order that specific risks can be addressed at the inception stage.

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
(1) Outputs		
a) 400kV Transmission Line (DC Line)		
・ Vizag Thermal Power Plant – Vizag/Kalpaka SS	25km x 4 circuits	Cancelled
・ Vizag/Kalpaka SS – Gazuwaka SS (PGCIL)	20km x 2 circuits	4 km x 2 circuits
・ Simhadri Thermal Power Plant – Vizag/Kalpaka SS	30km x 4 circuits	4 km x 4 circuits
・ Vizag SS – Khammam SS (PGCIL) – Hyderabad SS	590km x 2 circuits	562 km x 2 circuits
・ Vizag SS – Vemagiri SS	180km x 2 circuits	167 km x 2 circuits
・ Vemagiri SS – Nunna SS (PGCIL)	160km x 2 circuits	140km x 2 circuits
b) 220kV Transmission Line (DC Line)		
・ Vizag/Kalpaka SS – Eximpark SS	30km x 2 circuits	Cancelled
・ Eximpark SS – Gazuwaka SS (PGCIL)	8km x 1 circuit	Cancelled
・ Vizag SS – Pendurthi SS	40km x 2 circuits	Cancelled
・ Pendurthi SS – Garividi SS	65km x 1 circuit	Cancelled
・ Gazuwaka SS – Pendurthi SS	31km x 1 circuit	Cancelled
・ Vizag SS - Dairy Farm SS - Pendurthi SS	—	70 km x 2 circuits (Additional Scope)
・ Vizag SS – Switching Station	—	4km x 2 circuits (Additional Scope)
c) Vizag/Kalpaka SS (New Construction)		
・ 400/220kV Transformer	315MVA x 2	Same as planned
・ 400kV feeder bay and bus	14 bays	Same as planned
・ 220kV feeder bay and bus	6 bays	Same as planned
・ 220kV bay extension	1 bay (Vizag Switching Station)	2 bays
d) Eximpark SS (New Construction)		
・ 220/132kV Transformer	100MVA x 2	Cancelled (location was changed to Dairy Farm)
e) Pendurthi SS (Expansion)		
・ 220/132kV Transformer	100MVA x 1	Cancelled
・ 220kV bay extension	4 bays	1 bay
f) Vemagiri SS (Expansion)		
・ 400/220kV Transformer	315MVA x 2	Same as planned
・ 400kV bay extension	16 bays	400kV (16 bays), 220kV (8 bays)
g) Hyderabad SS (Expansion)		
・ 400kV bay extension	2 bays	Same as planned
h) Garividi SS (Expansion)		
・ 220kV bay extension	1 bay	Cancelled
i) Nunna SS (PGCIL) (Expansion)		
・ 400kV bay extension	2 bays	Same as planned
j) Gazuwaka SS (PGCIL) (Expansion)		
・ 400/220kV Transformer	315MVA x 1	Cancelled
・ 400kV bay extension	2 bays	Same as planned
・ 220kV bay extension	1 bay	Cancelled
k) Khammam SS (PGCIL) (Expansion)		
・ 400kV bay extension	4 bay	Same as planned
l) Dairy Farm SS (New Construction)		
・ 220/132kV Transformer	—	100MVA x 2 (Additional Scope)

Item	Original	Actual
m) Consulting Services	Foreign Experts: 120M/M Local Experts: 96M/M	Not available
(2) Project Period	December 1997 – August 2003 (69 months)	December 1997 – December 2005 (97 months)
(3) Project Cost		
Amount paid in Foreign Currency	16,010 million yen	14,170 million yen
Amount paid in Local Currency	4,005 million yen (1,510 million Rupees)	1,580 million yen (632 million Rupees)
Total	20,014 million yen	15,750 million yen
Japanese ODA Loan Portion	17,029 million yen	15,912 million yen
Exchange Rate	1 Rupee = 2.65 yen (As of January 2002)	1 Rupee = 2.51 yen (Annual average of 1997-2005)