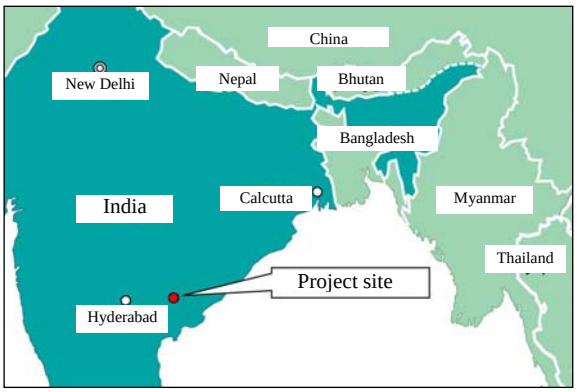
India

Kothagudem "A" Thermal Power Station Rehabilitation Project

Field Survey: July 2003

1. Project Profile and Japan's ODA Loan



Site Map

Overall View of Kothagudem "A" Thermal Power Station

1.1 Background

In its 8th 5-Year Plan (FY 1992-1996), the Indian government set the targets of eliminating power shortages, enhancing power generating facilities' capacity utilization ratios, improving power supply efficiency by reducing power transmission and distribution losses, ensuring fair electricity rates, and encouraging private sector participation.

As of the end of March 1993, the installed power generation capacity in Andhra Pradesh (AP) State was 5,080MW, of which 4,228MW was owned by the Andhra Pradesh State Electricity Board (APSEB). This was the third-largest capacity among state electricity boards in India following Maharashtra and Uttar Pradesh. However, looking at the supply-demand balance, the total amount of electricity provided in FY 1993, including the power supply from central organizations such as the National Thermal Power Corporation, was 3,920 MW, or only 80% of the estimated peak time demand of 4,908MW. In terms of energy amount, only 26,886GWh of electricity was supplied against the demand of 28,589GWh, causing a shortfall of 1,703GWh (6.0%). Therefore, power supply restrictions were imposed intermittently in AP State, which impeded economic development (especially manufacturing) in the state.

The Kothagudem "A" Thermal Power Station (60MW × 4 units) is located on the outskirts of Paloncha, which is 230km east of Hyderabad, the capital of AP State. Since it started operations in 1966, it has been playing a central role in thermal power generation by APSEB along with the more recently constructed Kothagudem "B" (110MW × 2 units) and "C" (110MW × 2 units) Thermal Power Stations. However, as more than 25 years had passed since the completion, the "A" Power Station had become so decrepit that the output had declined to 50MW/unit. Therefore, it needed rehabilitation (modernization).

1.2 Objectives

The objective was to ease power shortages expected to continue in Andhra Pradesh State by

rehabilitating the boilers, turbines, and power generators of Kothagudem "A" Power Station, and thereby contribute to economic development of the state.

1.3 Output

The planned outputs of the project were as follows:

[Thermal power generation equipment]

- Rehabilitation of 4 boilers
- Rehabilitation of 4 turbines
- Rehabilitation of 3 power generators*[1]

Among the total project cost of 6,262 million yen, 5,092 million yen (81% of the total project cost) is covered by the ODA loan, consisting of the entire foreign currency portion (4,847 million yen) and part of the local currency portion (equivalent to 245 million yen). The remaining portion is financed by the Indian side with the executing agency's own funds.

1.4 Borrower/Executing Agency

Borrower: The President of India

Executing Agency: Andhra Pradesh State Electricity Board (APSEB) *[2]

1.5 Outline of Loan Agreement

Loan Amount / Loan Disbursed Amount	5,092 million yen / 5,084 million yen
Exchange of Notes / Loan Agreement	December 1994 / February 1995
Terms and Conditions -Interest Rate -Repayment Period (Grace Period) -Procurement	 2.6% 30 years (10 years) General untied
Final Disbursement Date	April 2002

2. Results and Evaluation

2.1 Relevance

At the time of appraisal, as already stated, AP State was expected to continue to suffer a power supply shortage, and there was an urgent need to secure new power supply sources. At the same time, as the target power station (Kothagudem "A" Power Station) was becoming decrepit, rehabilitating it to recover its functions and have it contribute to correcting the supply and demand imbalance was consistent with government policy. The national development plan at that time set the goal of increasing power supply through various measures, such as "improving the capacity utilization ratio of power generating facilities." The "B" and "C" Power Stations at the Kothagudem Power Plant also required rehabilitation. However, the "A" Power Station was given higher priority because it

[1] One generator was excluded from the project because APSEB had already arranged to procure materials and machinery at the time of appraisal.

[2] As APSEB was divided into separate sectors due to the unbundling in 1999, the current executing agency (power generation sector) is Andhra Pradesh Power Generation Corporation Ltd. (APGENCO).

was constructed seven to eleven years before the other two power stations and had deteriorated considerably. *[3] Thus, this project was highly necessary and important to fulfill beneficiaries' needs and government policy, and therefore the project plan was sufficiently relevant.

In its 9th 5-Year Plan (FY1997-2001), the government stated its commitment to further promoting proper handling of electricity demand. Also, the project is consistent with the policy of developing the electricity sector mainly in remote regions under the 10th 5-Year Plan (FY 2002-2006) as well as the policy of increasing power generation and promoting efficient operation of the electricity system under the AP State Electric Power Development Plan (2020). Therefore, the project has remained highly relevant to the present.

2.2 Efficiency

2.2.1 Output

This project was implemented almost as planned.

2.2.2 Project Period

A comparison of the planned and actual schedules is presented below.

Item	Planned Completion	Actual Completion
Exchange of L/A	February 1994	February 1995
Consultant Agreement	September 1995	June 1996
Project Agreement	June 1997	October 1997
Rehabilitation of No.1-No.4 Units	January 2001	October 2000

The rehabilitation was completed earlier than initially scheduled. According to the executing agency, the main reason for the early completion is improving the efficiency of the procurement procedure.

2.2.3 Project Cost

The project cost was below the initial estimate. By currency, the foreign currency portion was 5,084 million yen against the estimated 4,847 million yen, and the local currency portion was 335 million Rs against the estimated 421 million Rs. The total cost in yen terms was 6,211 million yen against the estimated 6,262 million yen.

Both the consultants and contractors are highly evaluated by the executing agency. No problem has been reported concerning their supervising or constructing ability.

In summary, the project was essentially implemented as planned, and both the project cost and implementation period were within the initial estimated range. Therefore, the efficiency of the project implementation was high.

[3] The rehabilitation of Kothagudem "B" Power Station was completed in 2001 and that of "C" is scheduled to start in August this year (as of the time of this survey).

2.3 Effectiveness

2.3.1 Operational Indicators

We obtained data on power generation, thermal efficiency, plant load factor (PLF), capacity utilization ratio, etc. Every indicator has improved compared to before the project.

Operational Effectiveness Indicators of Kothagudem "A" Thermal Power Station

Indicator \ FY	1996	1997	1998	1999	Target	2000	2001	2002
Total Power Generation (GWh/y)	1,395	1,222	1,168	1,616	—	1,698	1,753	1,844
In-Plant Power Consumption (%)	9.02	9.07	9.07	8.52	8	8.19	8.03	7.70
Thermal Efficiency (%)	25.72	25.79	28.29	30.58	32.5	29.22	31.92	30.13
Plant Load Factor (PLF) (%)	66.37	58.13	55.58	76.63	65	80.74	83.39	87.71
Availability Factor (%)	93.06	77.39	72.47	93.47	—	90.00	91.75	95.10
Forced Outage Rate (%)	2.87	19.38	17.15	2.06	—	1.31	2.37	1.60

* Shaded columns indicate the actual period of rehabilitation. Source: APGENCO

Each indicator is analyzed below.

Maximum Output

As a result of rehabilitation, the output of the "A" Power Station's four turbines had recovered to around 60MW each, nearly the rated output level, in FY 2002.

Plant Load Factor (PLF)

PLF exceeded 87% in FY 2002. Since efficiency and output have increased since the rehabilitation, economical and stable operations have been realized. As a result, the need for operations has exceeded expectations and the PLF has improved.

Thermal Efficiency

Efficiency improved to 30.13% in FY 2002 and is coming close to 32.5%, the target set for this project.

In-Plant Power Consumption

The ratio had declined to 7.7% in FY 2002, achieving the target of 8% for coal thermal power plants in general.

Availability Factor

The ratio was 95.10% in FY 2002. As with PLF, since the efficiency and output have increased since rehabilitation, economical and stable operations have been realized. As a result, a higher-than-expected availability factor has been achieved.

Forced Outage Rate

The forced outage rate dropped to 1.60% in FY 2002, well below the national average of 11.30% in that year.

2.3.2 Contribution to the Improvement of AP State's Electricity Situation

As it is difficult to measure the impact of this project separately, we examined the impact of all electricity projects in AP State as a whole, including this project.

1) Improvement of power supply/demand situation

The power supply/demand situation in AP State for the period between FY 1994 and FY 2002 is shown below.

Peak Time Electricity Supply/Demand in AP State (Unit: MW)

FY	1994	1995	1996	1997	1998	1999	2000	2001	2002
Demand	5,224	5,576	6,132	6,592	7,280	7,672	8,043	7,929	7,645
Shortage	790	1,000	1,110	850	800	988	900	900	750
Gap (%)	15.1	17.9	18.1	12.9	11.0	12.9	11.2	11.4	9.8

Source: APTRANSCO

Power Supply/Demand in AP State (Unit: GWh)

FY	1994	1995	1996	1997	1998	1999	2000	2001	2002
Demand	31,588	33,133	35,975	39,666	41,172	46,890	48,017	48,176	49,361
Shortage	1,609	2,215	2,318	1,496	560	1,138	1,272	1,225	1,425
Gap (%)	5.1	6.7	6.4	3.8	1.4	2.4	2.6	2.5	2.9

Source: APTRANSCO

Comparing the data for 2002 with that for 1996, the year immediately before the rehabilitation, the peak time power shortage was reduced from 1,110MW to 750MW and the percentage of shortage to the peak time demand was halved from 18.1% to 9.8%.

The power surplus (power supply minus demand) improved from -2,318GWh in FY 1996 to -1,425GWh in FY 2002, and the percentage of shortage in relation to power demand significantly decreased from 6.4% to 2.9%.

Power generation at the sending end of Kothagudem "A" Thermal Power Station in FY 2002 was 1,702GWh, accounting for 3.6% of the total power generation in AP State.

Power Generation at the Sending End of Kothagudem "A" Thermal Power Station

Fiscal Year	1996	1997	1998	1999	2000	2001	2002
Power Generation at the Sending End (GWh)	1,270	1,111	1,062	1,478	1,558	1,613	1,702
Total Power Supply in AP State (GWh)	33,657	38,170	40,612	45,752	46,745	46,951	47,936
Percentage to the Total Power Supply in AP State	3.8%	2.9%	2.6%	3.2%	3.3%	3.4%	3.6%

Shaded columns indicate the period when the rehabilitation was performed intensively. Source: APTRANSCO

2) Increase in power consumption per person

Power consumption per person increased from 374kWh a year at appraisal (1994) to 510kWh in FY 2001.*[4]

2.3.3 Internal Rate of Return

APGENCO sets the electricity sales price for APTRANSCO (a transmission company established due to the unbundling of APSEB) at a level those results in neither profit nor loss (the price is determined by adding up the costs of power generation subject to government approval). Therefore, calculating the Financial Internal Rate of Return (FIRR) by the usual method (comparing the cash flow without the project with the cash flow based on the actual data obtained after project implementation) would not correctly reflect the profitability of this project. Therefore, we calculated FIRR by regarding the investment expenses as the cost and saved expenses as the benefit.*[5]

The recalculated FIRR stood at 12.1%, exceeding the estimate (11.6%) at appraisal. Assumptions for the recalculation are as follows.

Benefits (Saved expenses)	(1) Saved expenses of coal 0.18kg of coal was saved per 1kWh. The saved expenses are calculated by multiplying the saved volume by the coal price. (2) Saved expenses of fuel oil The executing agency's records show that 70.3 million Rs was saved in four years from FY 1999 to 2002. The annual average of saved expenses is assumed to be 17.5 million Rs, a quarter of the above amount. (3) Saved expenses of in-plant power consumption As with the above, 106.4 million Rs was saved in 4 years. The annual saved expenses are assumed at 26.6 million Rs, a quarter of the above amount.
Cost	Actual investment cost: 1,848.2 million Rs
Project Life	15 years
Others	Since the project facilities are not new, it is assumed power generation will decrease gradually from 2003.

2.4 Impact

2.4.1 Impact on Activation of Industries

Generally speaking, improving the electricity infrastructure leads to development of industries. The average annual growth rate of real GRDP of AP State between FY1998 and FY2001 was approximately 6.7%, exceeding the national average of 5.7%.

The increase in power supply and the extension of the plant service life brought about by the project is expected to help activate industries in AP State. This expectation is based on the fact that 25% of electricity sales in AP State is for industrial use, according to the data on electricity sales to customers by category, and the fact that electricity demand for industrial use is projected to grow 12.1% a year on average from FY 2000. However, the direct effects on industry are unclear.

[4] The Indian national average in 1999－2000 was 354kWh (Source: Annual Report on the Working of State Electricity Boards & Electricity Departments, Planning Commission). As for the rural electrification rate, which was initially planned to be used as an indicator, AP State had already achieved 100% by 1990.

[5] Saved fuel expenses are not the only benefit of this project. Other expenses, such as operation and maintenance expenses, would have been higher without the project. Therefore, the FIRR calculated by this method might be a little lower than the actual figure.

Changes in GRDP and Power Consumption in AP State

Fiscal Year	1994	1995	1996	1997	1998	1999	2000	2001
Real GRDP (10 million Rs)	61,114	64,729	68,809	67,866	76,116	79,605	85,522	88,765
Power Supply (GWh)	29,979	30,918	33,657	38,170	40,612	45,752	46,745	46,951

Source: Statistics by AP State Government, APTRANSCO (GRDP is based on fixed prices of FY 1993)

2.4.2 Other Environmental and Social Impact

1) Environmental impact

According to the interview with the executing agency, no particular problem such as air pollution, water pollution, noise or vibration has been reported in connection with the project. In the interview survey of the local residents*[6], too, no environmental problem was pointed out.

The following are issues that have been of concern from appraisal and those for which conditions have substantially changed, as well as the measures taken to address these issues.

Securing an industrial waste disposal site (ash pond)

At the time of appraisal, it was pointed out that "the ash pond would be filled up in two years." In order to address this problem, a new ash pond was constructed adjacent to the existing one in 1999. At the time of this survey, we were told that it would be two years before the new ash pond would be filled up.

After that, the executing agency is planning to make it possible to dispose of waste for another ten years by acquiring and utilizing government-owned forest land. In order to enhance the sustainability and environmental appropriateness of the project, the executing agency is required to start a procedure to systematically secure additional ash ponds in due time, including site acquisition and financing as necessary.

The executing agency is currently conducting a study on the reuse of coal ash as fertilizer jointly with the Ministry of Agriculture and local universities.

JBIC also conducted the "Simhadri Thermal Power Station Project (I)(II)" and interim monitoring survey in AP State, and is making proposals on effective use of coal ash, including strategies for developing a potential market and the use of coal ash products in road construction and agriculture.

Emission standard for suspended particulate matter (SPM)

The standard for SPM is becoming stricter every year. The standard set by the Andhra Pradesh Pollution Control Board was 150mg/Nm^3 (for power generation facilities with a rated output of 210MW or more) as of this evaluation, while APGENCO established its own standard of 50mg/Nm^3 in May 2003. According to the executing agency, two of four turbines of the target power station meet APGENCO's own standard, and the remaining two turbines are expected to satisfy the standard before long.

2) Impact on local residents

As this project rehabilitated the existing power station, it did not require relocation of the residents.

One of the impacts of the Kothagudem Power Plant project as a whole, including other power stations that were not covered by the project ("B" and "C"), is employment of local residents at the

[6] Targeted about 30 residents in three locations several kilometers north, east and south of the premise of the power station.

power plant and related facilities. At present, about 3,000 persons in total are employed by the entire power plant, including the power stations "A" to "C," and 70-80% of them are local residents.

2.5 Sustainability

2.5.1 Executing Agency (APGENCO)

(1) Technical capacity and operation and maintenance system

The number of employees of the power plant has decreased from 450 at appraisal to 370 at present. There are eight departments under the Superintending Engineer, who has control of the whole organization. Workforce stability has been maintained. The power plant considers its technical staff to be sufficient in both terms of quality and quantity.

(2) Financial Status

The operation and maintenance expenses over the past three years (FY 1997-1999) were 288.5, 385.7, and 497.87 (million Rs), respectively. The executing agency says these amounts are sufficient to perform operation and maintenance activities in the present manner and the same level of budget will be secured for the future. The operation and maintenance expenses in FY 1999 were 497.87 million Rs, accounting for approximately 1.5% of APGENCO's total expenditure in the same year and 7.4% of the general administrative expenses.

Among the power generation costs, fuel expenses were kept around 950 - 1,000 Rs per ton in these years partly because of tariff adjustments by the government*[7]. There is no problem at this moment in procuring coal for fuel thanks to a coal mine with a rich reserve of coal in the vicinity. Since the electricity tariff is determined by adding up the costs required for power generation subject to approval of the Andhra Pradesh Electricity Regulatory Commission (APERC), APGENCO achieved a stable balance between income and expenditure. The electricity tariff has been gradually increasing over the past 3 years. *[8]

According to the financial statements for FY 1999, sales increased from the previous year while expenditure increased by a larger margin due to a rise in the depreciation cost associated with investment, resulting in an increase of the current deficit to approximately 2,040 million Rs. According to APERC, however, the financial conditions of the executing agency (APGENCO) and the transmission company (APTRANSCO) have been improving since FY 1999.*[9]

2.5.2 Operation and Maintenance Status

All facilities and machinery covered by the project are operating in good condition without any defect or fault. Maintenance activities, mainly daily inspections, are performed on a regular basis according to a previously determined plan. As evident by the excellent operational performance of the power station, project facilities are being operated and maintained at a sufficiently high level. Maintenance activities are outlined below.

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[7] The Standing Linkage Committee, consisting of representatives of the government, major producers and major consumers, meets on a quarterly basis to discuss and determine the tariff.

[8] The tariff (rupee) per kWh was 1.53 in FY 2000, 1.61 in FY 2001, and 1.83 in FY 2002. These tariffs are below the sales prices by independent electric utility businesses in the state and electric power companies in neighboring states.

[9] The person in charge (of electricity rates) at APERC said, "Subsidies from the government have also been decreasing. For the next year, the tariff will be determined at a level that will not cause any deficit based on the cost estimates. Subsidies are expected to be abolished in two to three years, but it will be possible to cover all expenses with sales only."

Classification of Maintenance Activities	Frequency
Regular Maintenance	Performed once a year for boilers, turbines, power generators and their accessories
Predictive Maintenance	Performed when necessary based on the result of daily inspections
Preventive Maintenance	Performed pursuant to instructions (manuals) of the manufacturers
Capital Overhaul	Performed once every 5 years and parts are repaired or replaced as necessary

In summary, the power station rehabilitated under the project is sufficiently performing its expected functions and no problem has arisen to date concerning the functioning of the facilities. Also, an appropriate system and adequate budget are ensured for the operation and maintenance of these facilities, and operation and maintenance activities are being carried out properly. The financial status of the executing agency has been improving. Therefore, this project is regarded as sufficiently sustainable.

3. Feedback

3.1 Lessons Learned

None.

3.2 Recommendations

None.

Comparison of Original and Actual Scope

Item	Planned	Actual
(1) Output		
Thermal power generation facility	Rehabilitation of 4 boilers Rehabilitation of 4 turbines Rehabilitation of 3 power generators	As planned As planned As planned
Consulting Service	(1) F/S evaluation (2) Evaluation and assistance for evaluation of bidding documents (3) Evaluation of the performance tests	(1) Not implemented (2) Not implemented (3) Partially implemented
(2) Project Period		
Exchange of L/A	Feb. 1994	Feb. 1995
Consultant Agreement	Jan. 1995 – Sep. 1995	Aug. 1995 – Jun. 1996
Project Agreement	Oct. 1995 – Jun. 1997	Oct. 1995 – Oct. 1997
Rehabilitation of No.1 Unit	Jul. 1997 – Mar. 1999	Jun. 2000 – Oct. 2000
Rehabilitation of No.2 Unit	Apr. 1998 – Sep. 1999	Aug. 1998 – Oct. 1998
Rehabilitation of No.3 Unit	Oct. 1998 – Jun. 2000	Feb. 1998 – Apr.1998
Rehabilitation of No.4 Unit	Jul. 1999 – Jan. 2001	Oct. 1998 – Dec. 1998
(3) Project Cost		
Foreign Currency	4,847 million yen	5,084 million yen
Local Currency	1,415 million yen	1,127 million yen
(denominated in local currency)	(421 million Rs)	(335 million Rs)
Total	6,262 million yen	6,211 million yen
ODA Loan Portion	5,092 million yen	5,084 million yen
Exchange Rate	1 rupee = 3.36 yen	1 rupee = 3.36 yen

Third Party Evaluator's Opinion on
Kothagudem "A" Thermal Power Station Rehabilitation Project

Mr. S.K.N. Nair
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Relevance

Capacity shortages are so acute in India's power sector that any addition to generating capacity is beneficial to the system and the economy that it serves. There are two factors that further enhance the relevance of the project under review. At the time of the rehabilitation, the units were thirty years old and the plant would have suffered further scaling down of capacity, even outright scrapping in a few years' time. By restoring the units to nearly the original designed capacity and extending their life by 15 years at a cost of Rs. 1.848 billion, the project has effectively postponed investment in new plant of 240 MW that, on current costs would have consumed an outlay in excess of Rs. 10 billion. Also, the net addition of 40 MW capacity has been achieved within an implementation period of 33 months (Feb. 1998 to October 2000), approximately half the time that a green field project would have entailed, in Indian conditions.

The second factor of relevance relates to the changes that have occurred in India's, and specifically Andhra Pradesh State's, power sector after this project was taken up for implementation. The State power sector is now overseen by an independent regulator who has promoted several reforms, one of them the introduction of merit order dispatch of plants, in their order of variable cost of generation. The plant under review is operating at better than the planned efficiency levels, which should guarantee a good ranking in this system of dispatch and hence continued high plant utilisation.

Sustainability

The high operation indicators registered by this plant attest both to the managerial skills of the executing agency and to the enlightened regulatory practices just referred to. Andhra Pradesh has consistently achieved the best Plant Load Factors among all public sector thermal plants – State as well as Central – in India for the last six years.

AP Genco's operational and implementation strengths could be put to gainful use to the national power sector, especially in the sector's newly liberalized structure. The generation segment is now opened up to free entry; phased introduction of competition is envisaged also for the distribution segment. As an instance of well-implemented plant rehabilitation, the project under review could serve as model to several other aging units that are marked out for renovation across India's power sector. The current Tenth Five-Year Plan (2002-'07) identifies 106 thermal units (total capacity 10,413 MW) for 'Renovation and Modernization' (R&M), to be taken up based on plant-specific 'residual life assessment studies'. Ambitious targets set for R&M in recent Five-Year Plans have remained under-fulfilled, chiefly owing to institutional and financing constraints. With the flexibility allowed by the new dispensation, the rehabilitated units can now be spun off to operate as Independent Power Projects that could cater to bulk or retail distributors and compete on cost and reliability parameters. This opens up scope for public: private partnerships in diverse forms. Under the new law, AP Genco itself could promote or partner such ventures not only in Andhra Pradesh but also beyond the State boundaries.