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.

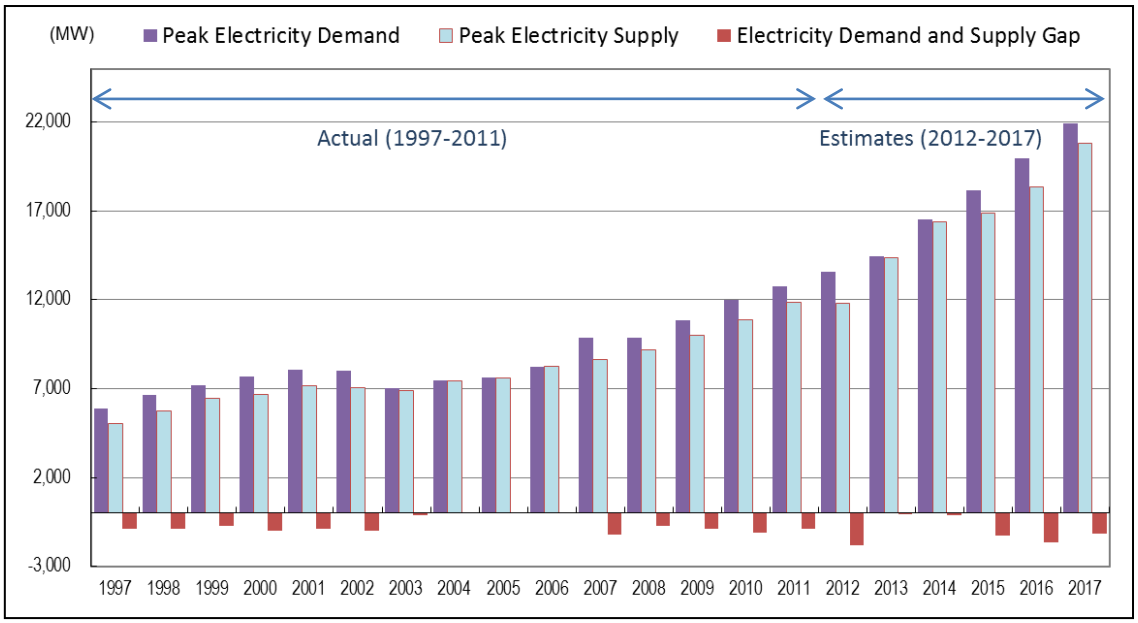
[5] The installed generation capacity of the Vizag Thermal Power Plant was designed at 1,040MW (520MW x 2 units).

[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. 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 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. In 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. Analysis of the performance of substations was thus carried out for the five substations under APTRANSCO.

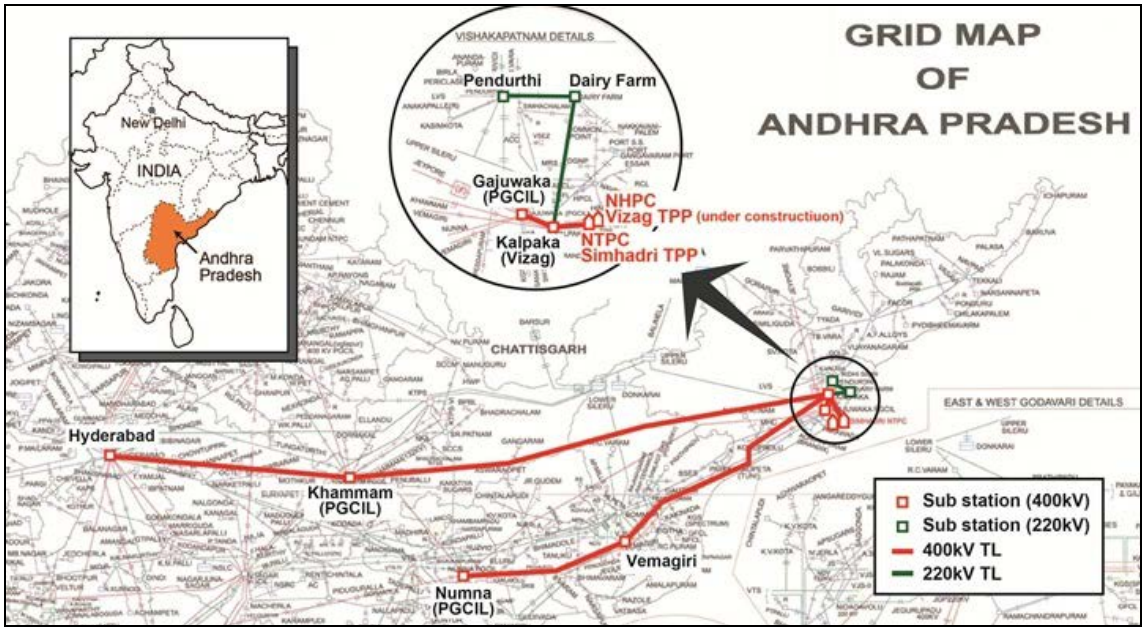


Figure 2: Project Site Map

[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 target. 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. In 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. However, 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.

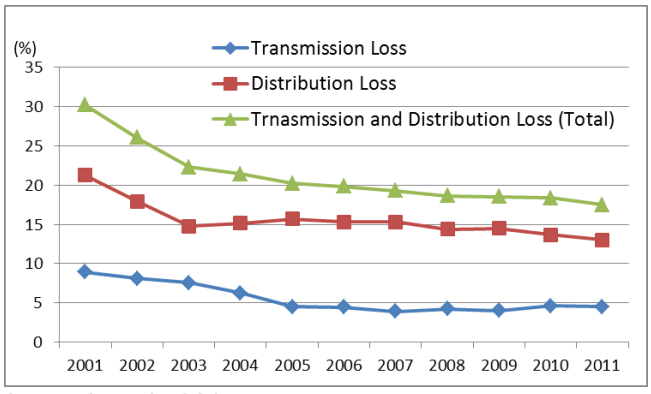





Vizag/Kalpaka Substation | Dairy Farm Substation | Hyderabad Substation

(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. Now, 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



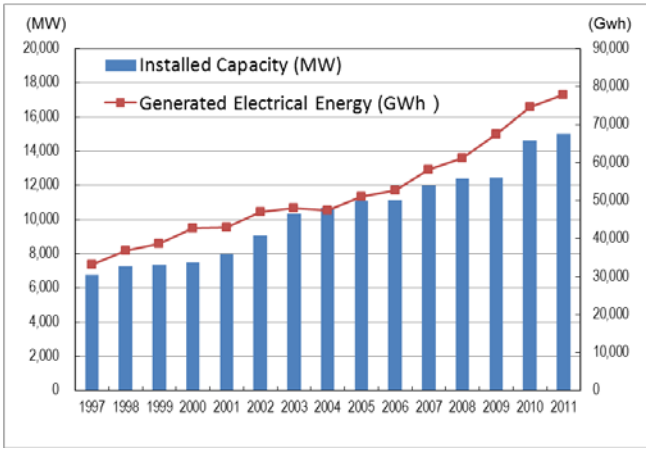
Source: APTRANSCO

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

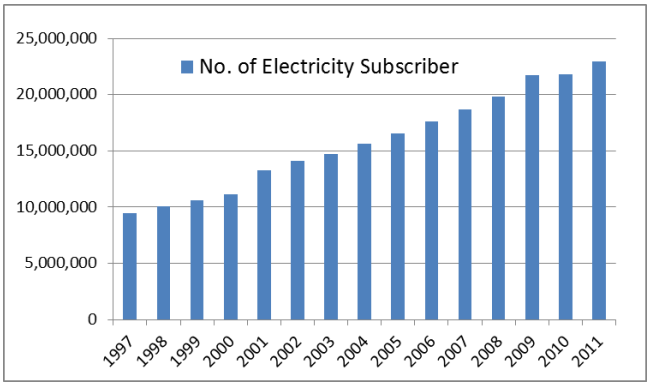
AP State has promoted the development of electric power resources for the mitigation of constant power shortages. The total installed power generation capacity of AP State increased 2.2 times from 6,764MW (1997) to 15,003MW (2011) and the annual generated electrical energy increased 2.3 times from 33,130 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 million in 1997 to 22.95 million in 2011 (Figure 5). The electricity consumption per capita expanded from 600kWh in 2006 to 950kWh. As 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 and 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.

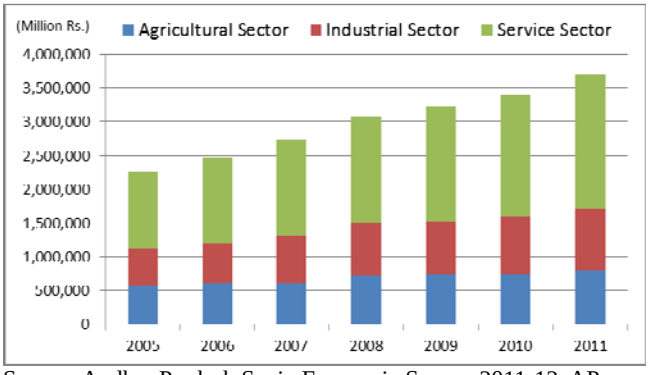
Therefore, it is concluded that the project has had a positive effect on the improvement of a stable electricity supply and on the reliability of the power supply system in AP State.

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 the 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. During 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 negative 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 whole 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. The components of Phase I were further divided into Phase I-A and Phase I-B. The 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 months 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. The organizational chart for APTRANSCO is shown in Figure 7.

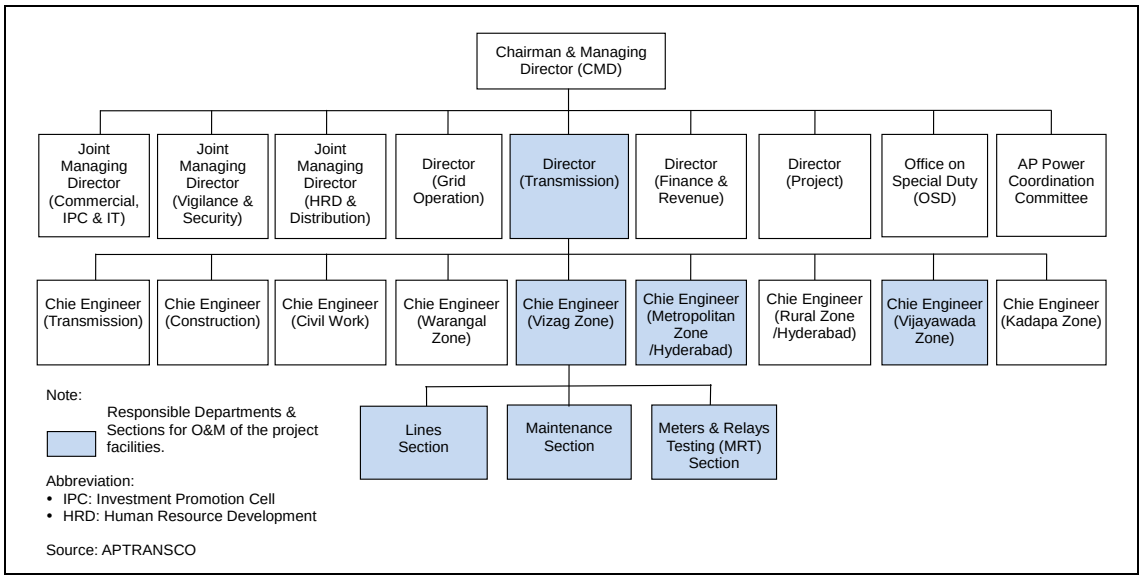


Figure 7: Organization Chart of APTRANSCO

The Power Grid Corporation of India Ltd. (PGCIL) is responsible for the O&M of the Gazuwaka SS, the Khammam SS and the Nunna SS. PGCIL is a central 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. Besides 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 particular 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 shortages of spare parts due to budget constraints were observed. However, as each 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 the 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. Also, 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)