JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

TRANSMISSION CORPORATION OF ANDHRA PRADESH (APTRANSCO)

THE DEVELOPMENT STUDY ON THE IMPROVEMENT OF POWER DISTRIBUTION SYSTEM OF ANDHRA PRADESH IN INDIA

FINAL REPORT

SUMMARY

FEBRUARY 2004

ELECTRIC POWER DEVELOPMENT CO.,LTD.
(J-POWER)
TOKYO-JAPAN

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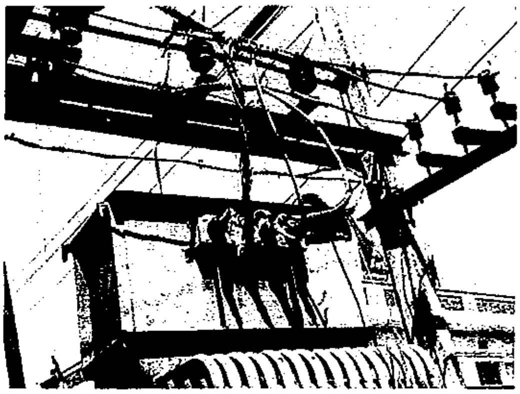
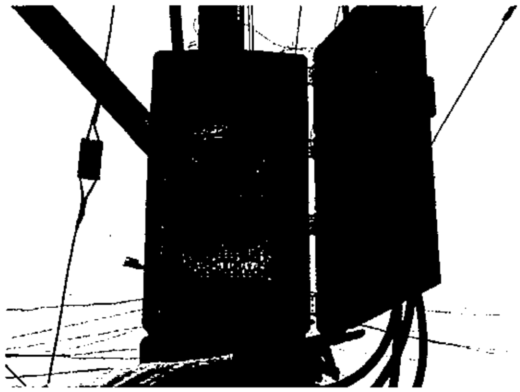
First Workshop

Technical Transfer (Ranga Reddy North)



Conductor Connection at DTr.



Watt-hour Meter

Installation of WHM

GIS Data Collection at Site

Computer Training Room (CTI)

Line Staff Training Center (LSTC)

Contents

Chapter 1 Introduction

Chapter 1 Introduction

1.1 Background of the Study

In India, the electric power generating capacity had been growth over 3 times for 20 years from 1981 to 2001. On the other hand, the low reliability and the chronic shortage of electric power supply have not been solved.

Also in Andhra Pradesh, electric power supply is insufficient, and also the transmission and distribution loss rate is reported over 30%. And it is estimated that much of loss is due to the distribution section. Therefore, the improvement of the distribution system is strongly required.

In response to a request of the Government of India (hereinafter referred to as "India"), the Government of Japan decided to conduct the Development Study on Improvement of Power Distribution System of Andhra Pradesh in India (hereinafter referred to as "the Study"). To implement the Study, the Scope of Work (hereinafter referred to as "S/W") was made and concluded by both Governments on May 2000.

Accordingly, the Japan International Cooperation Agency India (hereinafter referred to as "JICA"), the official agency responsible for implementing technical cooperation programs of the Government of Japan, undertook the Study in close cooperation with the Transmission Corporation of Andhra Pradesh (hereinafter referred to as "APTRANSCO").

The Study was conducted based on the Scope of Work signed between India, APTRANSCO and JICA at May 29, 2002, and based on the Minutes of Meeting signed between APTRANSCO, Central Power Distribution Corporation of Andhra Pradesh (hereinafter referred to as "APCPDCL") and JICA.

JICA commissioned Electric Power Development Co., Ltd. (hereinafter referred as to "J-POWER") implementation of the Study, and J-POWEWR conducted the Study from October 2002 through February 2004.

This report summarizes the results of the Study.

1.2 Purpose and Strategy of the Study

1.2.1 Purpose and Strategy of the Study

The purpose of this study is the improvement of distribution system in Andhra Pradesh, and better customer service. For the improvement of distribution system, the study team paid attention to the distribution loss reduction and the improvement of the quality of power supply.

For loss reduction and improvement of the quality of the power supply, there are three elements to be addressed: physical improvement of the distribution network, improvement of operation and maintenance, and improvement of facilities and customer management. Failure to properly address any of the above three elements will lead to failure to attain customer satisfaction. The study team has, therefore, adopted an integrated approach to address the problems faced by APTRANSCO and power distribution companies with regard to power distribution loss, covering all three elements.

In the meantime, to facilitate technology transfer, the study team has adopted a joint implementation with counterpart personnel from APTRANSCO and APCPDCL. Hence, active participation of the counterpart personnel is vital not only to the model study to be done by the study team but also to replication of the study by counterpart personnel in other areas.

The study team considers it is important that the study which is conducted by the study team be replicated by personnel of power distribution companies, not only in other areas of APCPDCL, but also of other distribution companies to eventually cover the whole of the state of Andhra Pradesh. To this effect, it is advisable that personnel of other distribution companies than APCPDCL participate in the replication of the study to be conducted by the counterpart personnel during the study period.

1.2.2 Elements of the Study

The Study comprises of the following elements. The strategy of the Study is shown in Figure 1.1.

- Improvement of operation and maintenance : detection of problems relating to operation and maintenance by analyzing operation/maintenance records and suggestions for improved operation and maintenance to assure better quality of power supply.
- A proposed improvement plan of the existing SCADA so that the distribution supervisory control and data acquisition (distribution SCADA) functions will be introduced and the following items achieved.
- Physical improvement of the distribution network basically below 33/11kV substations down to the consumer end : determination of facilities to be improved and cost estimates and timings of improvements for loss reduction.
- Facility and customer management using the Geographic Information System : digitization of facilities and customer information on a base map for improved facility management and customer service.
- Training facilities and training program : suggestion of new training facilities and programs concerning planning, construction, operation, restoration and maintenance of the distribution network.

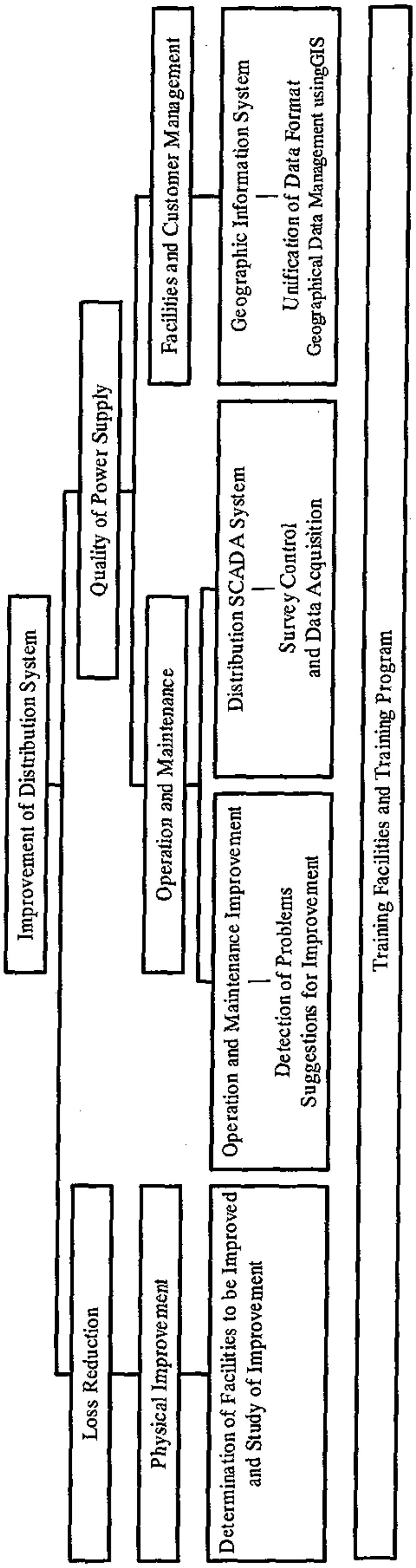


Figure 1.1 Strategy of the study

1.2.3 Objective of the Study

The study team selected three 11kV feeders for the study from Ranga Reddy district and Medak district, and conducted the following study.

- Concerning the operation and maintenance of the distribution network, the whole areas of both Ranga Reddy district and Medak district were selected.
- Concerning the SCADA system, the existing SCADA system and the relevant feeders to the existing SCADA system were selected.
- Concerning the physical improvement of distribution network, three 11kV feeders from both Ranga Reddy district and Medak district were selected.
- Concerning the facilities and customer management by use of GIS, sections from 33/11kV substations to the customers supplied through two distribution transformers for the above three feeders were selected.
- Concerning training facilities and program, CTI and LSTC were selected and at the same time ESCI and CIRE were also selected as a relevant facility.

The area of the Study is shown in Figure 1.2.

1.2.4 Execution Mode of the Study

As mentioned in 1.2.1, the Study had conducted through joint efforts by the study team and the counterpart personnel from APTRANSCO and APCPDCL. So APTRANSCO and APCPDCL provided counterpart personnel to correspond to each of the elements of the Study.

1.2.5 Seminars

The study team held two seminars in Hyderabad: one in February 2003 and the other in January, 2004.

The first seminar presented the methodology for the study.

The second seminar presented the results of the study conducted by the study team and of those by the counterpart personnel.

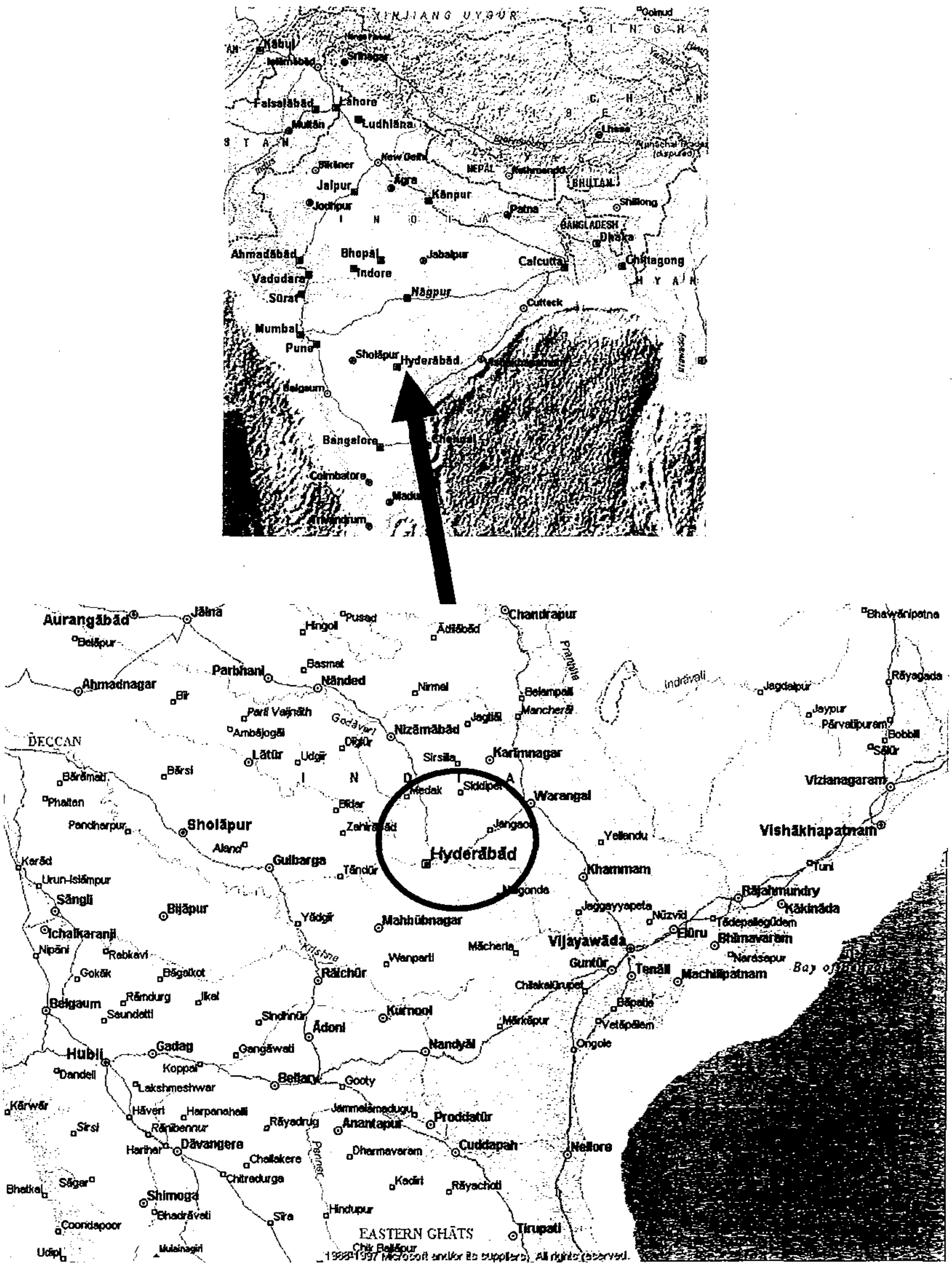


Figure 1.2 Area of the Study

Chapter 2 Status of Power System in Andhra Pradesh

Chapter 2 Status of Power System in Andhra Pradesh

2.1 Situation of the Power Sector and Facilities

2.1.1 Situation of the Power Sector

(1) Administration of the Power Sector

The State of Andhra Pradesh (AP), the covered area of this study, is situated in the southeastern part of India. It is the country's fifth largest state in terms of both area (about 275,000 km2) and population (about 76 million). For the 11 fiscal years from 1982/1983 to 1993/1994, the Andhra Pradesh State Electricity Board (APSEB, former APTRANSCO) was in almost sound financial condition, and hence it was not a financial burden on the state government, with subsidies from central government being small (about 1.8% of the total revenue of the APSEB on average).

However, the financial situation of the APSEB has since rapidly deteriorated due largely to the fact that the rates of transmission/distribution loss have remained high because of the delayed improvement of electrical facilities, that the APSEB has failed to raise the electricity tariff in proportion to the rising costs of electricity supply, and that the electricity tariffs for agriculture and irrigation have been set at much lower levels than those for industry. Since fiscal 1994/1995, the annual amount of state government subsidies to the APSEB has been 36% of the annual revenue of the APSEB (about 60 billion rupees in 2000/2001) on average. The business performance of the APSEB has declined sharply, and the portion of the state budget that can be appropriated for the improvement of the infrastructure other than electricity plants has decreased markedly. As a result, the delay in improving roads and water supply/sewer systems and implementing measures to relieve the poor has become a major social problem.

To solve this problem, Andhra Pradesh State enacted the Electric Sector Reform Act in April 1998, whereby the APSEB was divided into the Transmission Corporation of Andhra Pradesh Limited (APTRANSCO) on February 1, 1999 and the Andhra Pradesh Generation Corporation Limited (APGENCO) on February 28 of the same year. In addition, in line with the electric sector reform policy of the central government, the Andhra Pradesh Electricity Regulatory Commission (APERC) was established in March 1999 as a state government agency based on the Electric Sector Reform Act above. On April 2000, the distribution department (33 kV and lower) of APTRANSCO was divided into four regional distribution companies (DISCOMs): Northern Region of State, Andhra Pradesh Northern Power Distribution Company Limited (APNPDCL), for Southern (APSPDCL), Eastern (APEPDCL) and Central (APCPDCL). These distribution companies mainly operate at 33 kV and below and in the final phase of reform, and these DISCOMs are going to be privatized.

The division put an end to the vertical integration of the electric utility business, and the APERC assumed the leading role in carrying out electric sector reform to make the power sector sound.

Presently, the state has APGENCO, APTRANSCO, four DISCOMs, Central Power Generating companies, Power Grid Corporation of India Limited (POWERGRID), and several independent Private Power Projects (IPPs).

POWERGRID is mainly involved in setting up EHV transmission networks of 132 kV and above, which are mostly inter-state or inter-regional transmission systems for central power-generating companies and for the national grid system. On the other hand, APTRANSCO is mainly responsible for EHV transmission of 400kV, 220kV and 132kV levels within the state, for generation projects for Andhra State and for state power-system planning and improvement.

(2) The Electricity Act, 2003

The Electricity Act, 2003 ("EA 2003") became effective from June 10, 2003. The EA 2003 is a comprehensive document covering all aspects of electricity generation, transmission, distribution. The following electricity laws/acts have been repealed.

- Indian Electricity Act, 1910
- The Electricity Act, 1948
- The Electricity Regulatory Commission Act, 1998

Under the repealed laws, the Central and State Transmission Utilities were to undertake the functions of transmission, bulk purchase and bulk supply of electricity to distribution licensees. However, under EA 2003, the Transmission Utilities can only transmit electricity. Thus, APTRANSCO cannot buy and sell power; their main function now will be to transmit electricity.

The provision of the repealed laws will be applicable to APTRANSCO for a maximum period of one year from the date of commencement of the EA 2003, which is June 10, 2003. After the lapse of one year, that is, after June 10, 2004, the provisions of EA 2003 will apply.

2.1.2 Situation of Power Facilities

(1) Generating facilities

The total installed generating capacity of Andhra Pradesh was 7,978 MW as of March, 2001. APGENCO owned 5,628 MW (70.5%), of which 2,675 MW (33.5%) was hydro power and 2,953MW (37.0%) was thermal power. The private sector owned 1,077 MW (13.5%), of which 779 MW (9.8%) was gas thermal power, 88 MW (1.1%) was wind power, 60 MW (0.8%) was mini hydro power and 150 MW (1.9%) was co-generation and others. In addition, Andhra Pradesh shared from Central Sector 1,000 MW (12.5%).

(2) Transmission lines and substation facilities

The transmission system of Andhra Pradesh consists of a large network of 400kV, 220kV and 132-kV transmission lines that connect between power stations and various load centers.

In addition, the 400kV network laid by POWERGRID for evacuating power from the Ramagundam Thermal Power Station to the beneficiary states in the Southern Region including Andhra Pradesh is interconnected with the Andhra Pradesh power system in Ramagundan, Hyderabad, Nagarjunasagar, Vijayawada, Gooty, Cuddapah, Visakhapaatnam and Khamman.

(3) Distribution facilities

The distribution system is composed of 33kV sub-transmission lines, 11kV primary distribution lines and low voltage distribution lines.

The 33kV lines connect 132/33kV substations and 33/11kV substations. Although there are normally overhead lines, there are underground cables in Hyderabad City. The overhead lines are mainly 100 sqmm ACSR ,and underground cables are mainly 400 sqmm 3-core XLPE cables.

2.1.3 System Losses

The present status of the system loss rate in Andhra Pradesh is over 30%, and it is assumed that the distribution section loss rate is 20% of that overall. This loss rate is a very high compared with other countries. To reduce this value, AP needs an improvement plan.

The system loss rate in Andhra Pradesh is shown in Table 2.1.

Table 2.1 APTRANSCO energy balance sheet (2000-2001)

(unit: MU)

No	Item	1999 -2000	2000 -2001
1	Units Purchased from APGENCO	27,610	26,797
2	Units Purchased from other states and sources	16,137	17,700
3	Total Units handled by APTRANSCO (1+2)	43,747	44,497
4	Units soled by DISCOMS	27,604	29,768
5	Units Lost in the systems (3-4)	16,143	14,729
6	Percentage of Losses (5/3 x 100) *	36.90%	33.10%

* Technical and non-technical losses

(Source) Power Development in Andhra Pradesh (Statistics) 2000-2001, APTRANSCO

2.1.4 Current Power Balance and Power Demand-Supply Forecast

The current installed generating capacity of Andhra Pradesh shows a shortage compared to the estimated necessary capacity, and the shortage of generating capacity causes a shortage of electricity power supply.

The Andhra Pradesh Electricity Regulatory Commission (APERC) approved the new load forecast and supply expansion plan of APTRANSCO on April 8, 2003. The annual capacity addition required will be as provided in the Table 2.2.

Table 2.2 Andhra Pradesh power demand-supply forecast

(unit; MW)

	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07
Installed Capacity	11,519	11,623	11,846	12,525	12,946	13,639
Existing Capacity	9,210	9,220	9,235	8,646	8,457	8,457
Annual Additions required	2,309	94	207	1,269	610	693
Cumulative Capacity required	2,309	2,403	2,610	3,879	4,489	5,182

(Source) O. P. No. 179 of 2003, APERC, dated 8th April, 2003

Chapter 3 Operation and Maintenance of the Distribution Network

Chapter 3 Operation and Maintenance of the Distribution Network

3.1 General

The study team studied the quality of electricity, including frequency, voltage, and number and duration of outages in the Ranga Reddy and Medak Districts, and provided solutions to problems in the operation and maintenance of the distribution network. The study was carried out from November 2002 through February 2004 in the following three stages:

- Data collection
- Data analysis
- Identification of problems and making suggestions/recommendations for solution of them

The Southern India Grid, including APTRANSCO, is operating at the same frequency, and the frequency in May and November of 2002 and 2003 was studied. According to the study results for May 2002, the dry season, the estimated lowest value in number of minimum frequency was 47.7 Hz, which is barely above 47.5 Hz of the lowest limit in extreme conditions. However, in 2003 the frequency is maintained above 49.0 Hz as per Available Basic Tariff (ABT) which was enforced from January 2003, by carrying out severe load shedding.

The study team also studied the voltage of the model feeders, for domestic use, and for industry and agriculture. Analysis result show that records of domestic and industry uses at all times, late at night, in the daytime and at the evening peak for each customer were within the tolerance specified, and no problems were observed. However, for agriculture use, slightly bigger voltage variation compared with the standard was found. In addition, the study team conducted a survey on outages, including the faults, maintenance and load shedding for the 33 kV and 11kV feeders in Ranga Reddy and Medak. Approximately 25% of the records for existing feeders were studied and problems affecting the operation and maintenance of the distribution were identified.

The study team suggested solutions and recommended that APTRANSCO/APCPDCL to setup a system corresponding to the DISTRIBUTION CODE which will be enforced in 2004.

3.2 Current Situation of Operation and Maintenance

3.2.1 Organization of Operation

The Operation Department of APCPDCL comprises a Corporate Office and the District Offices (Operation Circle) that are located in each District. Two or more District Offices are located in Hyderabad and Ranga Reddy where there is a large population. Each Operation Circle is headed by a Superintending Engineer (SE), and several Divisional Offices are located according to site condition. A Divisional Engineer (DE) manages the divisional office for the operation of the distribution system. A section office is the unit organization of the operation and maintenance of the distribution facilities.

The operation of the power system in Andhra Pradesh is carried out using a Grid Code (GRID CODES) for APTRANSCO approved by the Andhra Pradesh Electricity Regulatory

Commission (APERC) on May 5, 2001. The Distribution Code (DISTRIBUTION CODE) for distribution lines has not yet been approved.

Maintenance of the distribution system is being carried out by the maintenance crew of the section office and it consists of daily patrol, scheduled maintenance as per annual schedule and extraordinary maintenance due to patrol results or for repair. Scheduled maintenance involves pre-monsoon maintenance (PMI) of all the facilities, which includes cutting obstacle trees, inspection of conductors, insulators and adjustment of the sag of conductors, if necessary. Extraordinary maintenance involves preventive maintenance, such as exchanging deteriorated insulators and fixing joints of conductors/branches. However, problems frequently occur in a certain feeders from not only manpower restrictions and budget, but also superannuation of equipment. In connection with the operation and maintenance manual, which specifies the foundations of operation and maintenance of the distribution system, the same manual arranged by APSEB which the former organization of electric organization reform, is still used noting that there is no significant change in the organization and operation methods on the spot.

3.2.2 Current Situation of Operation of the Distribution Network

Table 3.1 shows the outline of the power facilities in Ranga Reddy and Medak.

Table 3.1 Power facilities in Ranga Reddy and Medak

District	132 kV line		132/33 kv substation		Circle	Division	33 kV feeders		33/11 kv substation		11 kV feeders		Distribution transformer		Customer	
	Nos.	Total cct-km	Nos.	Capacity (MVA)			Nos.	Total cct-km	Nos.	Capacity (MVA)	Nos.	Total cct-km	Nos.	Capacity (kVA)	Nos.	Capacity (kVA)
Ranga Reddy		465.14	11	1,291	RR(S)	Saroornagar	13	445.02	20	205.05	81	821.50	2,937	265002	185,595	286,650
						Rejendranagar	13	218.00	16	169.3	64	1,030.67	2,614	150344	90,214	166,300
						Vikarabad	13	324.34	24	153.35	89	2,189.43	2,699	164935	134,036	211,950
						TTL(1)	39	987.36	60	527.7	234	4,041.60	8,250	580281	409,845	664,900
					RR(N)	Kukatpally	18	309.00	23	263.6	90	905.00	3,775	343,998	221,238	483,308
						Habsiguda	14	176.00	14	215.15	70	557.00	3,112	270,692	209,135	329,210
						TTL(2)	32	485.00	37	478.75	160	1,462.00	6,887	614,690	430,373	812,518
						TTL((1)+(2))	71	1,472.36	97	1,006	394	5,503.60	15,137	1,194,971	840,218	1,477,418
Medak		730.72	15	855	Medak	Sangareddy	48	690.00	48	317	187	3,170.40	3,813	268,779	193,633	
						Medak	25	524.00	55	427.3	179	2,808.37	4,284	347,650	134,087	
						Siddipet	15	455.00	61	364.7	185	2,483.60	5,726	402,827	173,712	
						TTL	88	1,669.00	164	1109	551	8,462.37	13,823	1,019,256	501,432	
Grand TTL		1,195.86	26	2,146			159	3,141.36	261	2,115	945	13,965.97	28,960	2,214,227	1,341,650	

An Outline of the operation condition of APCPDCL, Ranga Reddy and Medak are shown in Table 3.2.

Table 3.2 Outline of the operation condition of APCPDCL, Ranga Reddy and Medak

		2001/2002	2002/2003	Apr. through Dec. 2003
Peak Demand (MW)	APCPDCL	-	2,620	2,510
	RR(S)	243	228	236
	RR(N) (Unrestricted)	201(221)	240(262)	277
	Medak	-	456	468
33 kV Energy Input (Million U)	APCPDCL	17.184	17.303	13.253
	RR(S)	1.808	1.670	
	RR(N)	1,312	1.620	2,278
	Medak	2,944	2,966	2,296
Energy sold (Million U)	APCPDCL	12,486	13,224	10,428
	RR(S)	1,503	1,505	
	RR(N)	918.4	1,215	2,094
(1)	Medak	2,188	2,251	1,760

U=kWh Source : APCPDCL

(1) Up to November 2003.

3.3 Operation and Maintenance Data of the Distribution Network

3.3.1 Fluctuation of Frequency

The Southern Regional Grid including APTRANSCO operates using a unified computerized system of the Southern Regional Load Despatching Center (SRLDC), Bangalore.

During the dry season, March through June, the Grid is obliged to operate at low frequency with severe load shedding (Load Relief) for the shortage of output of hydropower. Therefore, May 2002 and 2003 of dry season and November 2002 and 2003 when the water level recovers were selected as months for study.

Specifically, it is considered that the daily maximum and minimum frequency records are normal distribution and the maximum and minimum frequencies of the each month are calculated using 95% probability.

The cumulative probability curves of frequency in May 2002 and 2003 are shown in Figure 3.1.

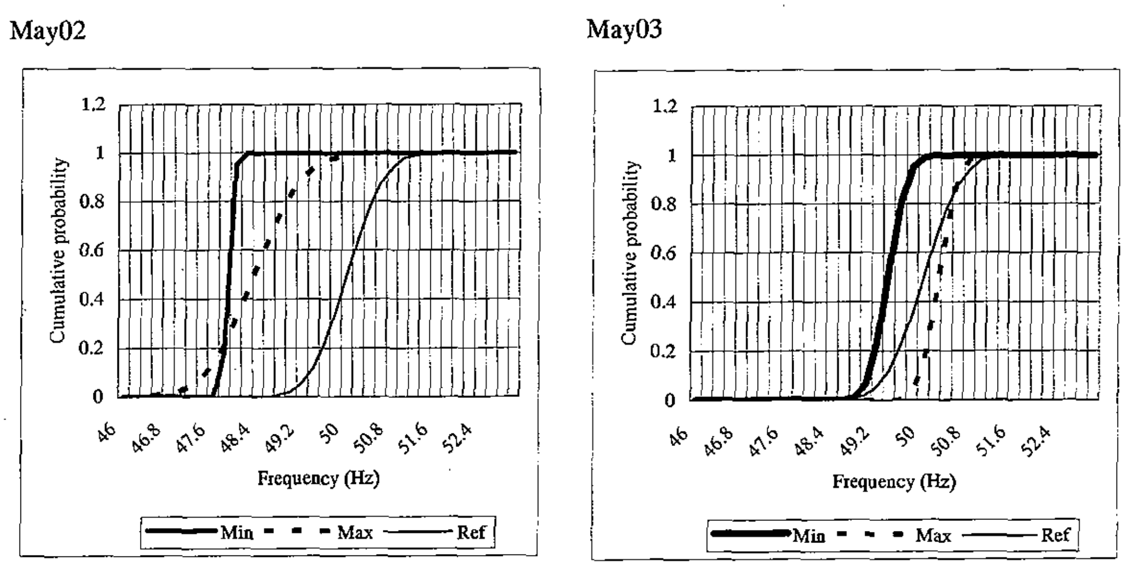


Figure 3.1 Cumulative probability curves of frequency in May 2002 and 2003

Figure 3.1 shows that in May 2002, the lowest record of the minimum frequency was 47.7 Hz, which is barely above the lowest limit in extreme conditions, 47.5 Hz, and it is clear that the power system in the dry season operated in a severe situation. However, but in 2003 the frequency was maintained above 49.0 Hz as per the Available Basic Tariff (ABT) which was enforced from January 2003, by carrying out severe load shedding.

ABT started nationwide in India from January 1, 2003. The tariff for import from the Central in normal conditions is Rs 2.08/kWh but it is hiked to 4.53, if the frequency drops below 49.0 Hz.

3.3.2 Fluctuation in Voltage

Voltage measurements were carried out at the following model feeders

Domestic: 11kV Kamalanagar feeder of the Kothapet substation in Ranga Reddy

(CODE : RBAN/KOT/F(KAM))

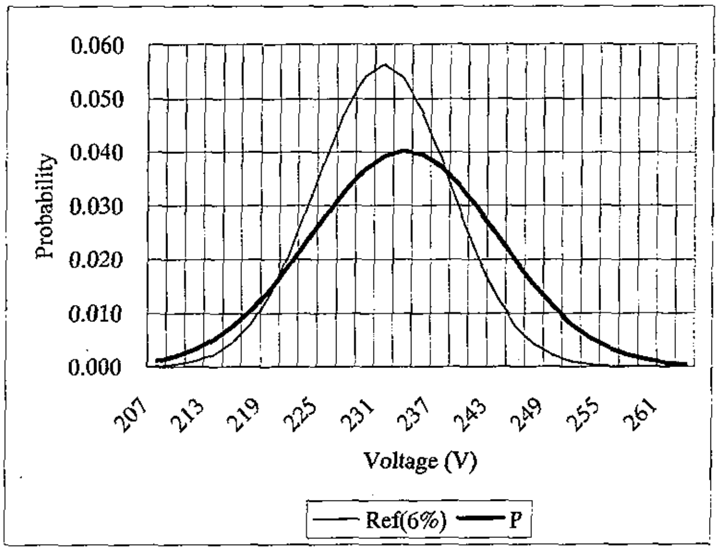
Industrial: 11kV Kattedan #2 feeder of the Kattedan substation in Ranga Reddy

(CODE : RCHA/KAT/F(KT2))

Agricultural: 11kV Malkapur feeder of the Malkapur substation in Medak

(CODE : MKAN/MAL/F(MAL))

As an example of the voltage measurements in November 2003, the voltage at the customer ends of the domestic and industry feeders were in the tolerance level of the reference voltage at 3:00, 11:00 and 20:00. It was found that as shown in Figure 3.2, the maximum voltage of Malkapur feeder was exceeded approximately 2.5% from the reference and it is considered that line length is comparatively long and load is fluctuated so a large voltage variation is occurred.



Malkapur feeder
LV Customer end
Sep. 05 through Oct. 04, 2003

(V)

	#1(A)	Ref(6%)
Mean	233.32	230.95
SD	8.87	7.07
Max	250.71	244.80
Min	215.93	217.09

Standard probability(Ref(6%)) vs. Probability(P)

Figure 3.2 Voltage measurement result of Malkapur feeder in September 2003

3.3.3 Outage

Outage records collected are:

23 feeders for the 33kV distribution systems

244 feeders for the 11kV distribution systems

These are equivalent to 25% of the existing feeders.

The number of outages of the feeder that showed the maximum in 33kV was 679 in 2002/03 and 789 for 11kV, respectively. However, the combination of 33kV and 11kV is more important for a customer, because either 33kV or 11kV outage will have an affect.

From the view point of combination of 33kV and 11kV, the maximum number is 1,117 outages and this is caused by a heavy power shedding applied to the agricultural feeder. Less power shedding is placed on domestic and industrial feeders than agricultural in general. The difference by the category was studied using the model feeders. Considering the effect on customers, the total number of outages of the 33kV incoming feeder and the 11kV feeder were taken into consideration.

Numbers of outages in combined feeders are:

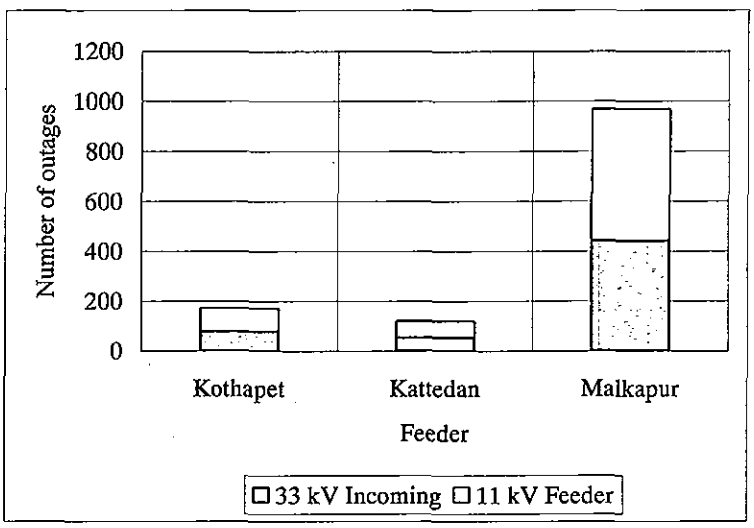
Kamalanagar feeder (Kothapet) 172

Kattedan #2 feeder (Kattedan) 141

Malkapur feeder (Malkapur) 968

The Malkapur feeder is much more greatly influenced by load shedding than the others.

Figure 3.3 shows the comparison of the number of outages of model feeders



Nos.

	Kothapet	Kattedan	Malkapur
33 kV Incoming	81	55	444
11 kV Feeder	91	67	524

Figure 3.3 Comparison of number of outages of model feeders

The study team analyzed the collected data for 14 of the 132kV substation systems, and the 132kV Bandlaguda substation (RBAN) in Ranga Reddy is introduced as a typical example.

There are 7 33/11kV substations in the RBAN system, and 28 11kV feeders are outgoing from the above 7 substations.

Figure 3.4 shows the feeder-wise number of outages with their causes in the RBAN system.

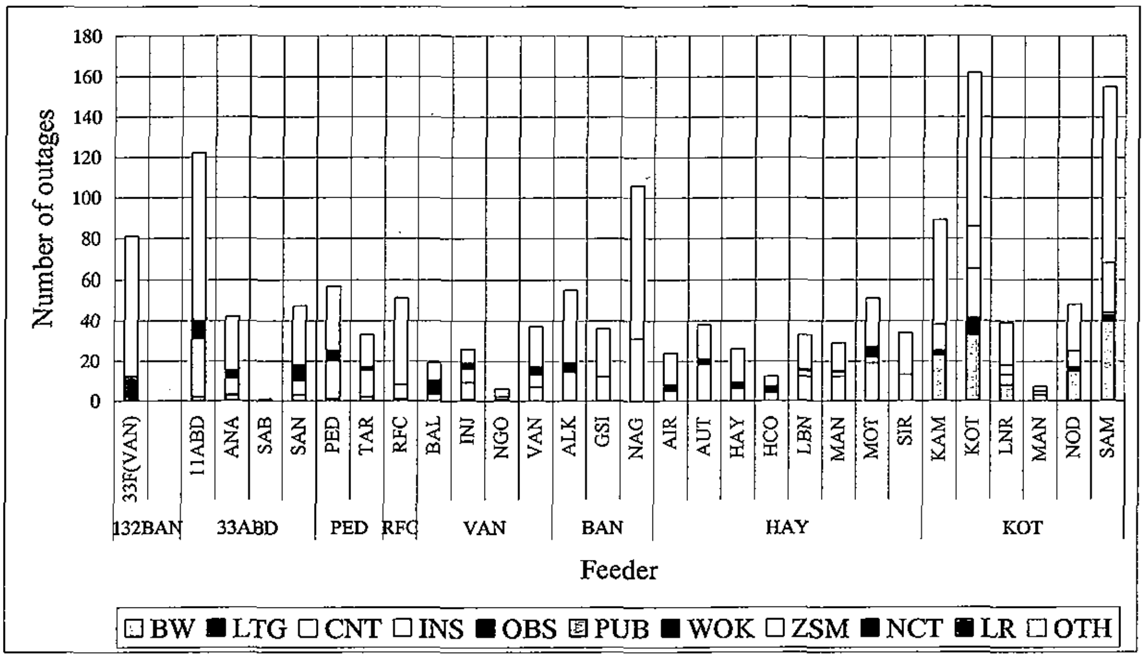


Figure 3.4 Feeder-wise number of outages with causes in the RBAN system

The total percentage of the number of outages of conductors, insulators and joints shows approximately 42% of the total of number of outages, and it is clear that maintenance of equipment is very important.

When the causes of outages are examined, some cases are not easy to explain. For example, 153 out of 280 outages of joints (JNT) are caused by contamination. Therefore, it is necessary to not only analyze the above cases, but also to elucidate OTH (others), which are not classified items and which account for 51% of total outages.

As a result of examination with APCPDCL, it becomes clear that the major causes of outages are trees and birds that contact the energized parts, contact the conductors at the mid span due to loose conductors, bad contact/connection of jumper conductors, and inferiority of insulators and so on. As mentioned in 3 (1), load shedding (load relief) is forcibly carried out in the ATRANSCO/APCPDCL system. For example, in AP in October 2003, poor inflows into the Krishna River affected hydro generation in the Sri Sailam and Nagarjunasagar power stations. Peak hour consumption went up to 7000 MW and power shortage was 700 - 1200 MW and two hours power cut on domestic and industrial sectors during peak hours except twin cities, Hyderabad and Secunderabad, was carried out.

3.4 Identified Problems and Solutions

Frequency is out of control matter for APCPDCL and no problems were observed on voltage for domestic and industry feeders. For agriculture feeder, a large voltage variation was found and it is suggested to examine the some countermeasures such as scattering of the loads, change of the conductor size and increase the number of circuits and so on.

3.4.1 Number of Outages

Analysis result shows that some feeders stopped 100 times or more in 2002/03 and proper countermeasures have to be taken. Table 3.3 shows the major causes of outages and considerable countermeasures for reducing the number of outages which obtained through the analysis of outage records and discussions with APCPDCL.

Table 3.3 Major causes of outages and considerable countermeasures

Causes	Description	Temporary measures	Permanent measures
Tree contact to the conductors		Reexamination of range and opportunity of trees cutting.	Adoption of insulated conductors for the span where there is a probability of tree contact to the conductor.
Bird contact to the charging parts			Adoption of insulated conductors
Loose conductors	Short circuit at the mid-span due to excess of sag.	(1)Adjustment of sag of a conductor. (2)Adoption of spacer.	(1)Insert the pole at the mid-span for reducing sag. (2) Increase the phase clearance. (3)Adoption of insulated conductors.
Bad connection of joint parts	Poor contact of twist type jointing.		Adoption of compression type clamp.
Inferiority on insulators		Exchange with excellent one	
Contamination of insulators	Due to salt or dust of factories.	Cleaning of insulators.	Adoption of longer leakage path insulators.

An insulated conductor is considered an effective means for reducing the number of outages. They should be used in locations where contact between trees and conductors are unavoidable by cutting trees or contact of conductors at the mid span is not solved by adjustment of their sagging.

Troubles of joints of conductors/jumpers frequently occur, but they can be solved by the adoption of compression type clamps instead of the twist type joint used at the moment. The annual average number and duration of outages per customer in Japan where insulated conductor and compressed type clamp are used are 0.2 times and 25 minutes, respectively.

As pointed out in 2 (c), an example of category of OTH/ OTH in the RBAN system, approximately 51 % of outages are classified as OTH/ OTH that are equipment and cause of outages are not identified. However, the outages cannot be reduced if their cause is not known. Therefore, APCPDCL should take actions such as making an accurate record of the outage and perform a patrol of distribution facilities as much as possible to identify the condition of equipment and cause of fault and make a preventive plan for recurrence of the same troubles. If the number of outages is reduced the duration of outages will also decrease as a result, the burden on the maintenance crew will also decrease, and therefore, it can be utilized for preventive maintenance and can result in improvement in the quality of maintenance.

3.4.2 Correspondence to DISTRIBUTION CODE

Since the DISTRIBUTION CODE will be enforced in 2004, after that, the distribution system of voltages, number and duration of outages and so on shall operate within the specified target value by it.

For this reason, the following measures will be necessary.

(a) Data collection and its analysis for understanding of the out put from the distribution system

(b) Setup the target value, if any

(c) Planning and execution of the countermeasures, if system output does not satisfy the specified value (target).

For utilization of this system effectively, to setup the data centers in the corporate office and districts and these are linked with communications channel, for example by Internet. It is necessary to train required personnel in parallel to the above.

In addition, out-sourcing should be considered if it takes time for preparation of the required system and training of the personnel.

3.4.3 Operation and Maintenance Manual

An operation and maintenance manual in conformity with the DISTRIBUTION CODE that will be applied from 2004 should be arranged as soon as possible. The same will be distributed to all offices concerning operation including substations and should be made so that the personnel in charge of the substation share common knowledge and a sense of thoroughness.

3.4.4 Rearrangement of Low Voltage Wiring

The present arrangement of a low voltage wiring, especially the branch part to customers, is very disorderly and management must be difficult. Rearrangement of the same wiring is suggested.

3.4.5 Safety Measures to the Public

It is observed that a passer-by may often unconsciously touch the bare energized terminals/ wires of a low voltage distribution/ switch box which its cover is kept opened and, in the rural area, some transformers are installed near the ground surface and charged parts are exposed without protective covers so that the general public may touch them easily.

Especially, in case the equipment is installed in or near a public road, it is recommended to take suitable measures urgently to prevent people approaching to the energized parts of the said equipment such as to install a fence surrounding the transformer or close the cover of the same box.

3.5 Recommendations

The study team found some problems through the study on the quality of electricity, frequency, voltage, number and duration of outages, in Range Reddy and Medak and presents suggestions to solve them.

(1) Correspondence to the DISTRIBUTION CODE

Since the DISTRIBUTION CODE deliberated now by APERC is due to be enforced in 2004, it is necessary that to construct a system to collect and analyze the data efficiently and train the necessary personnel as soon as possible.

(2) Reduction of the number of outages

Analysis results show that some feeders stopped 100 times or more in 2002/03 and proper countermeasures have to be taken to reduce this number. It is recommended to use insulated conductors in locations where contact between trees and conductors cannot be preventing by cutting along or contact of conductors at the mid-span that is not solved by adjustment of sagging.

Troubles of joints of conductors/ jumpers occur frequently and they will be solved by an adoption of a compression type clamp instead of the twist type joint used at the moment.

In the RBAN system, approximately 51 % of outages are classified as OTH/ OTH which is equipment and the cause of outages is not identified. However, the number of outages cannot be reduced if their cause remains unknown. Therefore, APCPDCL should take actions such as making an accurate record of outages and perform a patrol of distribution facilities as much as possible to identify the equipment and cause of faults and make a preventive plan for recurrence of the same problems.

(3) Operation and maintenance manual

An operation and maintenance manual that in conformity with the DISTRIBUTION CODE that will be applied from 2004 should be arranged as soon as possible. The same will be distributed to all offices concerning operation including substations and should be made so that even the personnel in charge of the substation share common knowledge and a sense of thoroughness.

(4) Rearrangement of low voltage wiring

The present arrangement of a low voltage wiring, especially the service wire to the customers, is very disorderly and management must be difficult. Rearrangement of the same wiring is suggested.

(5) Safety Measures for the Public

It is often observed that the low voltage energized parts are exposed without protective covers so that the general public may touch them easily, therefore, it is recommended to take suitable measures urgently to prevent people from being injured.

Chapter 4 SCADA System

Chapter 4 SCADA System

The study was planned for the purpose of proposing an improvement plan of the existing SCADA system to introduce distribution supervisory control and data acquisition functions (distribution SCADA sytem) and achieve the following items.

- Improve electricity supply reliability through reduction of the interruption period and outage duration and improve availability of electric supply.
- Automatically change the transformer taps for maintaining desired voltages and switching on and off of capacitor banks for reducing reactive power, and optimally deliver loads to the feeders by monitoring and analyzing voltage and current on feeder, and in turn, improve the utilization rate of distribution feeder as well as reduce distribution losses.

To be more specific, the existing SCADA system is covering as far as the 11kV feeder circuit breakers in the distribution substation, and the distribution SCADA functions should be introduced into the existing SCADA system by the manners as shown below:

- Install remote-controlled switches with control device and voltage and current instrument devices on a feeder including voltage booster and capacitor banks.
- Connect the above-mentioned devices with the existing SCADA system through a new communication system.

4.1 General

This study includes the following steps:

- Assessment of the existing SCADA system
- Study on introduction of distribution SCADA system
- Proposal of distribution SCADA system

4.1.1 Assessment of the Existing SCADA System

The existing SCADA system is covering up to 11kV feeder circuit breakers in substations. First, the system configuration and its functions were studied. Based on the findings, the additional hardware and software that are required to introduce the distribution SCADA functions were identified. They were reflected in the proposed distribution SCADA system design.

4.1.2 Study of Distribution SCADA Introduction

The system configuration and introduction cost were studied and feasibility of introducing the system was also assessed on the proposal of distribution SCADA. Study area is the substations covered by the existing SCADA system and the feeders emanating from those substations, and the following items were studied.

- Follow up of the existing SCADA system assessment
- Design study
- Estimation of cost
- Study of introduction of distribution SCADA to feeders

4.1.3 Proposition of Distribution SCADA System

The plan for improvement of existing SCADA system was proposed with the following contents:

- Existing SCADA system and introduction of distribution SCADA functions
- Design of distribution SCADA system
- Introduction plan of distribution SCADA to feeders
- Cost

4.2 Assessment of Existing SCADA System

The existing SCADA system is covers up to the distribution feeder circuit breakers in the distribution substation. First, the system configuration and its functions will be studied. Based on this result, the additional hardware and software required will be identified in order to introduce the distribution SCADA functions, which will be reflected in the distribution SCADA system design.

At the first survey, the general functioning of the existing SCADA system was surveyed mainly based on the explanation document. The results are shown in Table 4.1.

Table 4.1 Functions of existing SCADA system

Items	Outline
a. Monitor and control area	The existing SCADA system covers Hyderabad, 10 municipals in Ranga Reddy In this area, the SCADA is centrally monitoring and controlling 13 EHV substations (220/132kV) and 93 middle voltage substations (3311kV) from the DCC (Distribution Control Center) at Erragadda.
b. Communication system (Refer to Figure 4.1)	The basic communication system for Hyderabad SCADA system is the state of the art Microwave Communication Network, comprising of two separate Networks. The primary backbone communication network on the Time Division Multi Access (TDMA) principle operating on 2.3 GHz frequency band connects the central station to all the nodal stations - 220/132kV stations. This will carry data of SCADA, voice communication etc. The Secondary Communication Network that is based on the Multiple Address Radio System (MAR) principle interlinks all the 3311kV substations to the nearest nodal station (TDMA station).
c. Outline of DCC Computer System (Refer to Figure 4.2)	The Master Control Center has ABB's S.P.I.D.E.R. System with three high end servers, namely, a main standby redundant SCADA application server pair and one for the DMS (Distribution Management System) application functions. Additionally, 2 remote communication servers are provided to control and acquire data from 33kV feeders emanating from EHV substations, incoming 33kV circuits and 33/11kV substations, through the substation RTUs. Furthermore, 4 monitoring dual workstations are also provided in the control room. Pole-type RTUs (not installed in reality) are envisaged for Feeder SCADA and Automatic Meter Reading functions. It is an integral unit comprising of an RTU, Radio Transceiver, equipment power supplies & backup battery supplies.
d. DMS Application functions	The following additional DMS function modules have been integrated into the S.P.I.D.E.R. SCADA software. -Emergency load shedding (for high voltage customer) -Load control (for high voltage customer) -Automatic meter reading (for high voltage customer) -Fault location -Load balancing -Automated mapping and facilities management (AM/FM) -Trouble call management system

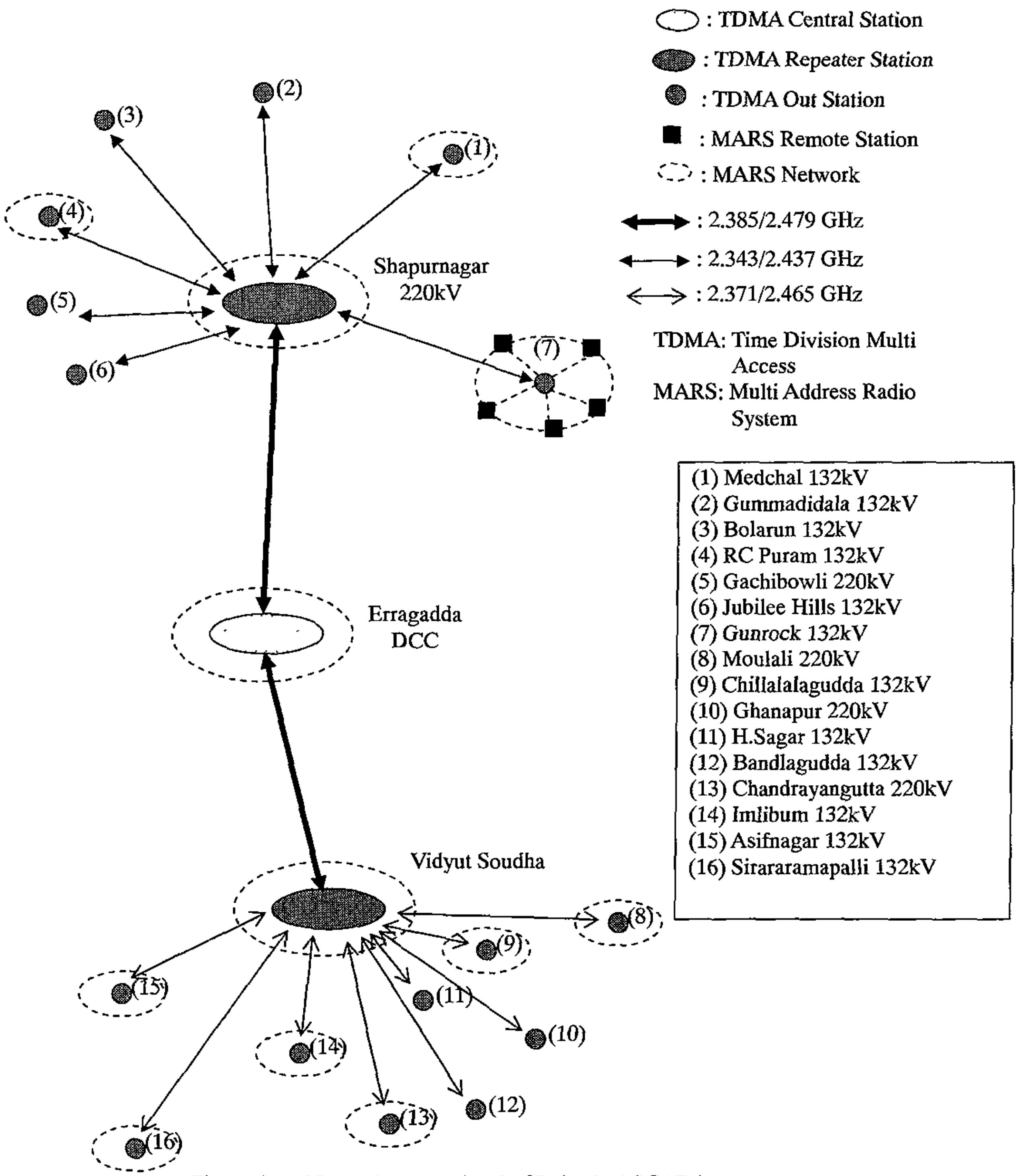


Figure 4.1 Network connection for Hyderabad SCADA system

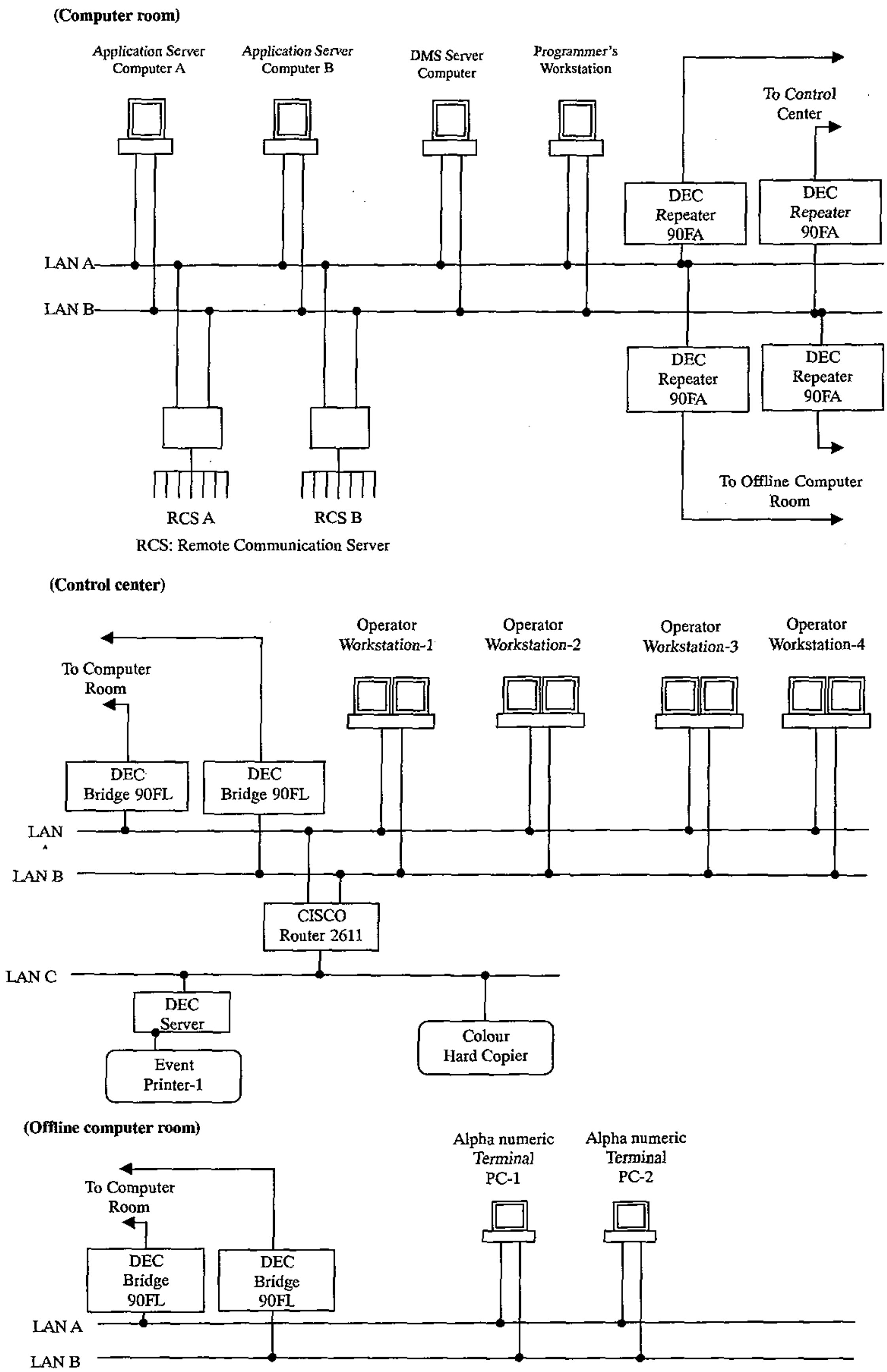


Figure 4.2 DCC computer system

4.3 Introduction of Distribution SCADA System

4.3.1 Area to be Covered

Among the substations (106) monitored and controlled by the existing system, the study was focused on 96 substations because the data of these 96 substations are available. The details of 106 substations are shown in Table 4.2.

Table 4.2 Details of substations number

<table>
<tr><td colspan="8">Total area</td></tr>
<tr><td colspan="8">106</td></tr>
<tr><td colspan="4">North</td><td colspan="4">South</td></tr>
<tr><td colspan="4">49</td><td colspan="4">57</td></tr>
<tr><td colspan="2">Hyderabad City</td><td colspan="2">Ranga Reddy</td><td colspan="2">Hyderabad City</td><td colspan="2">Ranga Reddy</td></tr>
<tr><td colspan="2">34</td><td colspan="2">15</td><td colspan="2">33</td><td colspan="2">24</td></tr>
<tr><td>EHT (132/33kV)</td><td>33/11kV</td><td>EHT (132/33kV)</td><td>33/11kV</td><td>EHT (132/33kV)</td><td>33/11kV</td><td>EHT (132/33kV)</td><td>33/11kV</td></tr>
</table>

4.3.2 Effectiveness of Distribution SCADA

As mentioned above, the existing SCADA system seems to monitor the system and control up to the distribution substations. The functions such as monitoring and controlling feeder current or transformer load, however, are expected to be present in the SCADA system. These functions indirectly realize load leveling of feeders in a substation and reduce feeder ohm loss.

In addition to these functions, the faulty zone sectionalization seems to be needed because the outage period is very long.

Therefore, loss recovery energy by balancing of feeder load and lost energy by outage are estimated as follows.

(1) Outage energy estimate

Lost energy (kWh) by outage is calculated for every feeder based on its fault data. The equation is as follows.

$$E\ (\text{kWh/year}) = MA \times V \times 3^{1/2} \times PF \times LF \times OPM/60 \times 12(\text{months})$$

MA : Maximum ampere for a month, V: 11kV, PF: Power factor 0.85,

LF : Load factor 0.7, OPM: Outage period for a month (minutes)

(2) Recovery energy by load balancing of feeders in a substation

Loss energies at maximum amperes and at leveled amperes are calculated as follows and recovery energy is derived as the difference between the two calculated energy values.

Em (kWh/year) = 3 x MA^2 x Ru x L x 24 (h) x 365 (days) x LF x DLF

MA: Maximum ampere, Ru: Ohm/ km, L: Feeder length (km),

LF: Loss factor = aF + (1-a) F^2 =0.553 at a = 0.3 F (load factor) = 0.7, DLF (Dispersal loss factor): 0.33 at flat load on feeder

El (kWh/ year) = 3 x LA x Ru x L x 24 (h) x 365 (days) x LF x DLF

LA: Leveled ampere, others are same as above.

4.3.3 Design

(1) Communication method

The communication methods between pole top RTUs and DCC (Distribution control center) are shown in Table 4.3. Every method has merits and demerits, respectively. In this survey, Radio and Fiber optic cable methods seem to be available from the view point of cost as studied in the following section and because a lot of fiber optic cables have been laid in Hyderabad. The Power Line Carrier (PLC) method is not available here because the distribution network is directly earthed and PLC cannot be used.

Table 4.3 Comparison of communication methods

Method	Merit	Demerit
Radio Communication	- No selection for cable route and it's number. - Freedom for places, where RTUs are installed. - Easy for increase of facility.	- Depending on transmission path. - Low reliability of transmission.
Control Cable	- Proper for the case where the number (par km) of switches is large. - Easy construction of cable.	- Not proper for the case where the distance between switches is large because of expensive cost - Need an amplifier, in some case.
Power Line Carrier (V_0 Signal)	- Can be adopted everywhere the distribution lines exist.	- Low reliability of transmission. - Some influence because of using distribution line. - Unusable for direct earth network.
Fiber optic cable	- High speed and large capacity for signal transmission. - Few number of cables because of large capacity par one cable.	- Need the special technique for cable connecting etc. - Impossible to make a small radial curve. - Low efficiency for small scale transmission signals.

(2) Faulty zone sectionalization

Figure 4.3 shows a mechanism for detecting a faulty zone. This function is expected to be equipped first while introducing distribution SCADA system.

- Step 1 : CB opens because of a fault on the section 2.
- Step 2 : CB closes and charges the section 1.
- Step 3 : The first SW tries to close.
- Step 4 : CB opens again because the fault remains in the section2. The first SW is locked not to close next.
- Step 5 : CB closes again and the first section is charged. The first SW, however, is not able to close because of lock mode.
- Step 6 : The SW tied to a neighboring feeder closes to charge a no-fault section.

Sectionalizing of Section 2 and Restoration of Un-fault Section

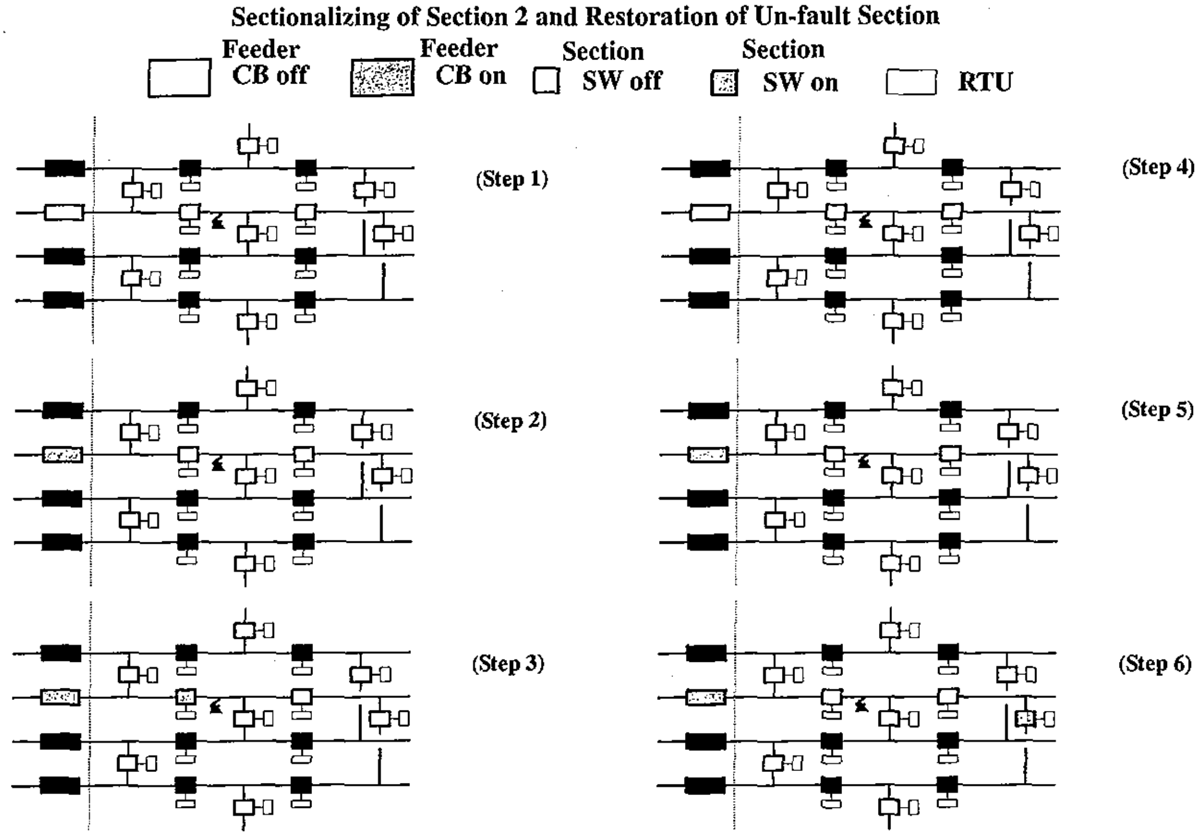


Figure 4.3 Faulty zone sectionalization method

(3) Load balancing by back up from a neighboring feeder

Figure 4.3 also shows an example of network connection for load balancing. Every section on a feeder can be also supplied with electric power from another feeder. Tie-line switches are usually open and they will be closed depending on feeder load conditions, namely, if a back up supply is available.

4.3.4 Cost Estimate

The NPV (Net Present Value) method is adopted in this cost estimation. This method is considered practical or theoretical when a social discount is difficult to decide.

(1) Costs of components

At first, the costs of components used in distribution SCADA system were surveyed in India and Japan. The results are shown in Table 4.7. Based on this table, every component cost is decided for economical estimate of system introduction.

(2) Benefits of system introduction

As for benefits of the distribution SCADA, three advantages are considered in this estimate as follows.

(a) Reduced outage period and recovery of supply energy and tariff income

The amount of outage energy is described in "4.3.2 (1)". But the amount of energy recovered depends on the number of sections on a feeder that are made by automatic switches. For example, if a feeder is separated into two sections by one automatic switch, the amount of power (kW) during outage period decreases by half and the outage period also decreases by half because the inspection zone is reduced by half. As a result, the outage energy (kWh) is reduced by quarter. This means that the energy is recovered by 3/4 by means of faulty zone sectionalization.

- ✓ Section Nos. = 2: Recovered energy 3/4 (1-1/4) (mentioned above)
- ✓ Section Nos. = 3: Recovered energy 8/9 (1-1/9)
- ✓ Section Nos. = 4: Recovered energy 15/16 (1-1/16)

(b) Loss energy recovery by load balancing of distribution feeders

The amount of loss recovery energy is described in "4.3.2 (2)". The procedure for load balancing seems to be difficult but the calculated amount is applied to the estimate.

(c) Reduced personnel expense

Distribution SCADA enables reduction of the service crew because the fault section can be isolated by remote- control facilities installed at a distribution control center. The crew can be reduced by about one person in every substation.

(3) Conditions for estimate

Conditions for approximate estimate are shown in Table 4.4 considering above (1) and (2). This table includes other values than cost and benefit such as social discount rate and price index increasing rate etc.

Table 4.4 Conditions for estimate

Item				Value	Remark
Social Discount				0.05	
Price Index Increasing				0.01	
Exchange Rate	Yen/US$			120	
	Rupee/US$			46.5	
	Yen/Rupee			2.58	
Facilities					
Feeder Number	Nos/SS (RR and Hyderabad)			6.00	
Feeder Length	km/Feeder(RR and Hyderabad)			6.50	
Construction Cost(Rs)					
Pole Mounted Device (per unit)	SW,RTU etc	Materials(India)	362,500	435,097	
		Construction(Japan)	72,597		
	SW,RTU etc (for PLC)	Materials(Japan)	480,878	551,212	
		Construction(Japan)	70,334		
	Radio Communication Device (GSM Mobile)	Materials(India)	13,500	15,000	
		Construction(India)	1,500		
Communication Line (per km)	Metanc Cable	Materials(Japan)	212,738	612,832	
		Construction(Japan)	400,094		
	Fiber Optic cable	Materials(India)	50,000	631,250	
		Construction(Japan)	581,250		
RTU etc. at SS, DCC (per unit)	For RF at SS (RTU)	Materials(India)	490,987	540,086	
		Construction(Japan)	49,099		
	For PLC at SS	Materials(Japan)	3,875,000	3,913,750	
		Construction(Japan)	38,750		
	MAR for RF at SS (MAR Master)	Materials(India)	300,390	330,429	
		Construction(Japan)	30,039		
	MAR for RF at SS (MAR Remote)	Materials(India)	61,572	67,729	
		Construction(Japan)	6,157		
	For Metallic Cable, Fiber at DCC	Materials(Japan)	9,687,500	9,803,750	
		Construction(Japan)	116,250		
	For PLC at DCC	Materials(India)	7,750,000	7,866,250	
		Construction(Japan)	116,250		
	RCS for RF at DCC	Materials(India)	2,859,912	2,976,162	
		Construction(Japan)	116,250		
Maintenannce(%)				3	
Benefit Estimate					
Tarrif(Rs/kWh)				5	
Outage Energy Reduction	kWh/Feeder/Y(RR and Hyderabad)			19,729	(*1)
Loss Energy Recovery	kWh/SS/Y(RR and Hyderabad)			97,096	(*1)
Woerkers' Number Reduction	Rs/SS/Y			120,000	One person

(*1): Refer to Annex 4.4

	Outage Energy (kWh/Y)	Loss Energy Recovery (kWh/Y)	Feder NO	SS NO
RR	4,772,941	6,287,610	179	35
Hyderabad	5,999,138	3,033,577	367	61
Total	10,772,079	9,321,187	546	96
Average	19,729 (kWh/Feeder/Y)	97,096 (kWh/SS/Y)		

4.3.5 Plan of Introduction

(1) Section number and number of pole-mounted automatic switches (SWs)

At first, the relation of section number and SW number is considered as follows. For example, in case of 2 sections per one feeder needs 1 SW for separation and 0.5+0.5 SW for 2 sections to be connected with neighboring feeders. Here, 0.5 SW means that 1 SW is connected with 2 feeders. As a result, isolation of 2 sections needs 2 SWs per one feeder. The relation is concluded on the basis of Table 4.5 as follows. The relation between section number and recovery energy is also shown in Table 4.5.

Table 4.5 Relation between section number and SW number and energy recovery rate

Section Number/feeder	SW Number/Feeder	Energy Recovery Rate
2	2	3/4
3	3.5	8/9
4	5	15/16

(2) Number of SWs and economical estimate

Based on Tables 4.4 and 4.5, cost and benefit were estimated by changing the number of SWs. The following table shows the result of a case of 2 to 5 per feeder SWs.

The estimate conditions are as follows:

- Cost only includes pole-mounted automated switches and its attached devices.
- Substation Nos. and Feeder Nos. are 96 and 546, respectively.
- Construction period is 5 years.

From this result, feeders of 2 or 3 sections seem to be available as shown in Table 4.6.

Table 4.6 Number of SW and economical estimate

(Million Rs)

Number of sections	No. of SW /feeder	Equipment Cost	NPV (20 Year)	Recovery Period
2	2	511	528	8 years
3	3.5	894	137	16 years
4	5	1,277	▲313	Over 20 years

(3) Policy for introducing distribution SCADA

(a) Number of sections

2 or 3 (Number of switches is 2 or 3.5 per feeder) .

(b) Communication method

Fiber optic cable or RF : depending on the site condition.

(c) Priority for introduction

Economical aspects are considerably different from substation to substation. Hence priority should be given to introducing the system to substations.

4.4 Recommendation on Distribution SCADA System

In this section, the more concrete ideas for distribution SCADA are studied. The previous section treated average data of substations and feeders in RR district and Hyderabad. This section treats more specific data of individual substations.

4.4.1 Functions of Existing SCADA System and of Distribution SCADA

The existing SCADA system mainly monitors and controls the facilities inside the distribution substations. But the existing SCADA system software includes the distribution SCADA functions such as DMS (Distribution Management System). This indicates an intention to introduce the concrete hardware for distribution SCADA in the future.

In addition to these software functions, the communication facility of RF also has some marginal capacity to add distribution SCADA function, and fiber optic cables have been already laid in urban area of Hyderabad. This also means that some infrastructure is already available for introducing distribution SCADA functions.

Table 4.7 shows DMS software functions and recommendable addressing policy.

Table 4.7 DMS functions and priority

Function	Priority	Situation and Recommendable Policy for Addressing
a. Emergency load shedding (for high voltage customer)	6	Priority is low, so consider introduction after the primary functions.
b. Load control (for high voltage customer)	4	This is concerning load leveling, so also consider introduction after the primary functions.
c. Automatic meter reading (for high voltage customer)	3	Priority is middle and if distribution SCADA is introduced, this function is easy to introduce. Hence consider introduction in the middle future.
d. Fault location	1	Priority is the highest and this is the most basic function, so consider introduction from the start.
e. Load balancing	2	Priority is the second highest and this is an important function, so consider introduction from the start.
f. Automated mapping and facilities management (AM/FM)	7	Priority is low but GIS is prevailing and is studied in this project, so better consider connecting GIS with distribution SCADA system.
g. Trouble call management system	5	This function is already installed independent of the existing SCADA as the following Call Center, so better consider interconnecting them with each other.

4.4.2 System Design

(1) Communication system

The ideas of communication system configuration will be able to consider as follows.

- Idea 1 : DCC directly communicates with the field device (pole-top SW, RTU).
- Idea 2 : DCC communicates through TDMA Repeater Station and /or TDMA Out Station.
- Idea 3 : DCC communicates through TDMA Repeater Station, TDMA Out Station and MARS Remote Station.

Table 4.8 shows the devices to be considered for every idea.

RF MARS has a security problem and is not able to be used for non line of sight communication.

Fiber optic cables are already laid to total length of 200 km in Hyderabad and its surrounding area.

As for cost, the following section treats. If that result is also considered here, the following methods are expected to be promising ones.

- Fiber optic cable (Case 1)
- RF Mobile System

(2) Equipped System Specification

As for the field equipment and the software functions, the following items are recommended.

- Isolated section number on a feeder should be 2 or 3.
- The software functions to be introduced in the first stage should be for, at least, Fault location and Load balancing.

Table 4.8 Communication methods and system configuration

Method		Pole-top Device	Installation of Com. Line	RTU etc. at SS, DCC
Idea1				
Fiber optic cable	Case 1 (Much infrastructure of fiber optic cable)	- Automated switch with RTU	- 1% of feeder length	- 10% improvement of RCS(Remote communication System) at DCC
	Case 2 (A little infrastructure)		- 10% of feeder length	
	Case 3 (Little infrastructure)		- 50% of feeder length	
Metallic Wire		- Same as above	- 100% of feeder length	
RF Mobile System		- Automated switch with RTU and RF communication device	(Not need)	- 50% of improvement of RCS at DCC
Idea2				
RF MARS		- Automated switch with RTU and RF communication device	(Not need)	- 50% of new MARS Master at SS and improvement of RCS at DCC
Idea3				
PLC (V0 Carrier)		- Automated switch with RTU	(Not need)	- New RTU at SS and DCC

4.4.3 Cost for Every System Configuration

Table 4.9 and Figure 4.4 show the result of economical estimate for the every system configuration in the previous section. The calculation premises are shown in calculation table and the prime items are as follows.

- Number of section switch is 2 switches/ feeder.
- Construction period is 5 years, substation number 96 and feeder number 546.
- Calculation premises are same as Table 4.4.

From this result, it is clear that the methods, which need no new communication equipment, such as Fiber optic cable (Case 1), RF Mobile System and RF MARS are economical and those investment recovery periods is estimated to be 9 to 10 years.

Table 4.9 Cost for every system configuration

(Million Rs)

Method		Equipment Cost	NPV (20 Year)	Recovery Period(Year)
Idea1				
Fiber optic cable	Case 1 (Much infrastructure of fiber optic cable)	598	418	10
	Case 2 (A little infrastructure)	815	145	16
	Case 3 (Little infrastructure)	1,778	-1,070	Over 20
Metallic Wire		2,911	-2,497	Over 20
RF Mobile System		530	503	9
Idea2				
RF MARS		573	450	9
Idea3				
PLC (V0 Carrier)		1,100	-216	Over 20

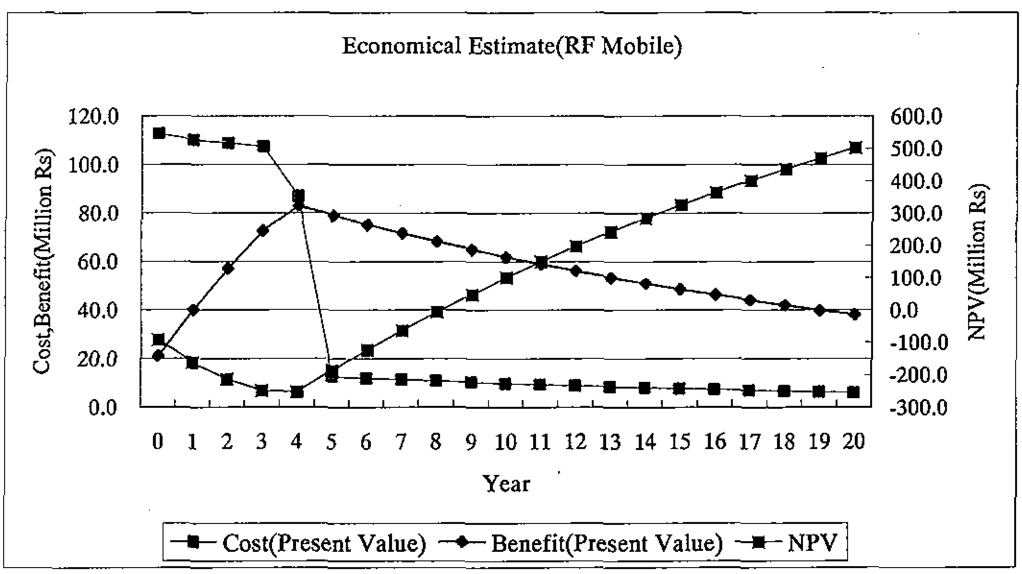


Figure 4.4 Example of economical estimate (RF mobile system)

4.4.4 Cost Estimate for Individual Substation

In this section, the possibility of loss recovery and outage energy is studied with respect to their amount. Here, the study team proposes starting to install the distribution SCADA in the order of more effective substations in RR and Hyderabad.

Cost and benefit estimate was made regarding to 4 substations from the viewpoint of recovery energy and 2 substations of which location is in the important area. The 4 substations consist of those of the largest amount and the least amount for RR and Hyderabad. The 2 substations in the important area are selected from a view point that a long duration of outage should not happen.

System configuration method is the most promising RF Mobile.

The results are summarized in Table 4.10 as follows.

Table 4.10 Result of cost benefit estimate

(Million Rs)

Substation name	Reason for select	Feeder Nos.	Length (km/F)	Loss recovery. + Outage energy (kWh/Y)	Equipment cost	NPV (20 Years)	Recovery period (Year)
Vanastalipram (Ranga Reddy)	Most recovery energy	4	19.8	1,311,352	5	71	1
Asif Nagar (Hyderabad)		9	8.5	530,505	10	21	4
NGRI (Ranga Reddy)	Around 100,000 kWh of recovery energy	6	2.2	188,987	7	4	11
Air Port (Hyderabad)		6	2.6	101,096	7	-2	Over 20
Mytrivanam	Important area	6	9.7	161,794	7	1	15
Srinagar		5	14.4	59,124	6	-3	Over 20

4.5 Recommendations

Based on this study, the following is recommended with respect to the introduction of the distribution SCADA.

- Outage period is considerably long, so the fault location function should be introduced. It will result in reduction of outage energy (kWh) and recovery of tariff income.
- Unbalance of feeder load (ampere) is considerable and its improvement will produce many benefits. Hence the load balancing function should be introduced in the first stage of the introduction of the distribution SCADA.
- The distribution SCADA system may be able to yield many other benefits because the operations on distribution feeder are almost manual.
- The number of isolated sections on feeder should be 2 or 3 from the economical viewpoint.
- As for the communication method, fiber optic cable or radio frequency is recommendable. Especially, Fiber optic cable has been already laid widely in the study area.
- RF using mobile telephone line is also recommendable because its infrastructure has been already provided. This RF method should be used in place of Fiber optic cable when it is expensive, or this RF might be necessary to be preferred.
- In the introduction of the system to substations on a continuous basis, selection of substations and the order of introduction are very important because the benefits of the introduction vary from substation to substation. Potentially very profitable substations exist in the project area. Table 4.11 shows an example of introduction phasing.

Table 4.11 Example of introduction phasing

Period	Area	Total Recovery Energy	Number of SSs
Phase I	Ranga Reddy	>500,000 kWh/Y	7
	Hyderabad	>200,000 kWh/Y	17
Phase II	Ranga Reddy	>200,000 kWh/Y	7
	Hyderabad	>100,000 kWh/Y	15
Phase III	Ranga Reddy	>100,000 kWh/Y	6
	Hyderabad	>50,000 kWh/Y	10
Phase IV	Ranga Reddy	Others	10
	Hyderabad	Others	10
Phase V	Ranga Reddy	Others	5
	Hyderabad	Others	9
Total			96

Chapter 5 Physical Improvement of Distribution Network

Chapter 5 Physical Improvement of Distribution Network

The present status of distribution loss rate in Andhra Pradesh states in India is about 20%. This loss rate is a very high value in comparison with other countries. In order to reduce the distribution loss, Andhra Pradesh states need an appropriate physical improvement plan of distribution network.

For grasping the existing status and identify problems, 3 model feeders were selected in two districts (Ranga Reddy and Medak) in Andhra Pradesh states. These feeders represent major categories, namely, domestic/ commercial, industrial and agriculture, respectively. Loss kWh, voltage and current of these feeders were measured and collected for analyzing and evaluating present situation and an improvement plan of the distribution network was made as follows.

5.1 Time Schedule of the Survey

Time schedule of the survey is as follows.

Table 5.1 Time schedule

Physical Improvement of Distribution Line

	Fiscal Year 2002			Fiscal Year 2003											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
Selecting model feeder		■													
Meter procurement			■	■	■	■									
Meter installation							■								
Loss measurment & data collction							■	■	■						
Survey of feeder data		■					■								
Analisys (loss calculation)								■	■	■					
Improvement plan									■	■	■	■	■		
Seminar		▲											▲		

5.2 Loss Measurements

5.2.1 Selection Model Feeder

Table 5.2 Feeder specification for measuring

Feeder specification for measuring

Category	Name of feeder	Name of substation (Division)	Number of DTR	Number of customer	Installing meter to pumpsets	
					Name of DTR	Number of pump sets
Domestic/commercial	Kamalanagar	Kothapet SS (Ranga Reddy)	39	3,650		
Industrial	Kattedan#2	Kattedan SS (Ranga Reddy)	78	529		
Agriculture	Malkapur	Malkapur SS (Medak)	15	743	Malkapur No 6 (63kVA)	16

5.2.2 Installing Site for Measuring, Number of Measurement, Measuring Devices

- Installing sites for measuring are outgoing part of the model feeder, secondary side of distribution transformer and customer's end. The study team decided to install the meters for measuring voltage at the longest end of low voltage line.
- Number of measurement is shown in Table 5.3.
- Measuring devices are electronic meter (including logging function) and electro-magnetic meter.

Table 5.3 Number of measuring meters

Number of measuring meters

Substation	Feeder	Category	Meter at mouth of feeder	Meter at DTR	Volt meter at Customer	Meter at pump set	kWh meter at customer
Kothapet	Kamalanagar	Domestic/Commercial	1	44	3	0	3,650
Kattedan	Kattedan #2	Industrial	1	78	8	0	465
Malkapur	Malkapur	Agriculture	1	15	1	16	842
TOTAL			3	137	12	16	4,957

5.2.3 Measuring Item

- Outgoing part of feeder (kWh, Maximum kW, Power factor, Voltage, Current)
- Secondary side of distribution transformer(kWh, Maximum kW, Power factor, Voltage, Current)
- Customer's end (Site of volt meter) (Voltage etc.)
- Customer's end (kWh)
- Customer's end (Pump set) (kWh)

5.2.4 Data Collecting

Data collecting was scheduled to be conducted every month from May to June. It was expected that the peak demand in this year would be measured. But because of the delay of meter installation, the study team were forced to measure for only one month, from the end of July to the end of August.

The study team brought back measured data to Japan during the third on-site survey at Hyderabad. But that was measured data for only one week and the rest of the data were sent to JICA staff via e-mail or other transportation system from counterpart in India.

After collecting these data, there were still missing data or insufficient data. At the 4th on-site survey, additional measurement and confirmation of missing data were conducted.

5.3 Survey of Technical Features of Feeders

Along with loss measurement, collection of feeder specifications (size of wires, length of lines etc.) was conducted as followed items.

5.3.1 Feeder Specification of Facility Wise

- High voltage distribution line (type of conductor, size, phase, length, electrical connection)
- Low voltage distribution line (type of conductor, size, phase, length, electrical connection)
- Distribution transformer (kVA, phase, category)
- Service wire (type of conductor, size, phase, length, electrical connection)
- Meter (Customer number, maker, Amp, type)

5.3.2 Specifications of Distribution Facilities

- High voltage distribution line (type of conductor and size wise impedance, resistance, reactance, allowable current)
- Low voltage distribution line (type of conductor and size wise impedance, resistance, reactance, allowable current)
- Distribution transformer (iron loss, cupper loss, nominal voltage and nominal current of each kVA)
- Service wire
- Meter (consumption kW of each phase and of each type)

5.4 Survey of Load Conditions

Results of past demand of 3 model feeders were surveyed. Surveyed items are as follows.

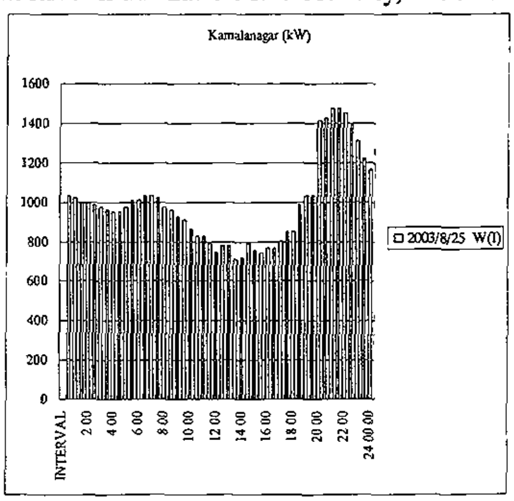
- Fiscal year and month-wise kWh (2000-2003)
- Fiscal year and month-wise kW (2000-2003)

5.5 Analysis and Evaluation

After installing meters, measurement had been performed and analysis and evaluation have been conducted about load curve, distribution energy loss and voltage drop at customer's end based on the obtained data. And also, using collected data (measured data, specifications of feeder, results of past demand etc.), analysis and evaluation about technical energy loss, voltage drop and over current has been conducted.

5.5.1 Load curve

Figure 5.1 show load curves of kW for one of model feeders from domestic/ commercial area. Compared to Japanese load curves, differences between peak load and off peak load are smaller than Japanese ones, and values of kW or current do not vary much over 24 hours are almost the same. This is very effective in utilization of electricity, but this also means energy loss would be larger.



Kamalanagar (Domestic/ Commercial) kW (2003/8/25 Monday)
Figure 5.1 Load curve (domestic/ commercial)

5.5.2 Distribution Energy Loss

Table 5.4 shows measuring results.

As measurement could not be made at the outgoing of the feeder, distribution transformer and customer's end meter for the same time period, energy loss rates could not be calculated on a unified basis.

While the average of total distribution energy loss rate is about 20%, the total loss from the outgoing of the substation to the customer's meter amounted to 3.3 to 24.4% in the measurement of this time.

Causes of this result are as follows:

- The measuring interval was short (1 month).
- Measuring of loads of all distribution transformers could not be made.
- There was some omission in reading of customers' meters.

In short, the results of measurement were not very accurate.

We can expect much improvement in loss measurement by conducting measurement continuously throughout the year without omission.

Excluding kWh data, other data (current, kW etc.) were used fully for grasping present status of load on subsequent distribution transformer and calculating technical loss, load factor, etc.

Table 5.4 Measuring result (energy loss)

(Substation - DTR)

Item	Outgoing of the feeder (a)	Secondary side of DTR (Total) (b)	Loss kWh (Substation - DTR) (a-b)	Rate of loss kWh ((a-b)/a)
Value of measuring kWh	193,110	169,399	23,711	12.3%
Measuring period	8/11 - 8/4	8/11 - 8/4	------	------

(DTR - Customer)

Item	Secondary side of DTR (Total) (c)	Customer's end (Total) (d)	Loss kWh (DTR - Customer) (c-d)	Rate of loss kWh ((c-d)/c)
Value of measuring kWh	651,824	572,954	78,870	12.1 %
Measuring period	7/29 - 8/12	7/29 - 8/12	------	------

Table 5.5 Measuring result (Energy loss) (Kattedan #2 feeder)

(Substation - DTR)

Item	Outgoing of the feeder (a)	Secondary side of DTR (Total) (b)	Loss kWh (Substation - DTR) (a-b)	Rate of loss kWh ((a-b)/a)
Value of measuring kWh (convert to 1 month)	1,341,308	1,298,562	42,746	3.2 %
Measuring period	9/12 - 10/16	9/10 - 10/14	------	------

(DTR - Customer)

Item	Secondary side of DTR (Total) (c)	Customer's end (Total) (d)	Loss kWh (DTR - Customer) (c-d)	Rate of loss kWh ((c-d)/c)
Value of measuring kWh (convert to 1 month)	1,298,562	1,296,624	1,938	0.15 %
Measuring period	9/10- 10/14	9/10 - 10/14	------	------

Table 5.6 Measuring result (energy loss) (Malkapur feeder)

(Substation - DTR)

Item	Outgoing of the feeder (a)	Secondary side of DTR (Total) (b)	Loss kWh (Substation - DTR) (a-b)	Rate of loss kWh ((a-b)/a)
Value of measuring kWh	59,460	54,128	5,332	9.0%
Measuring period	10/11 - 10/17	10/11 - 10/17	------	------

(DTR - Customer) (Measuring DTR of pump set)

Item	Secondary side of DTR (DTR SS VII) (c)	Customer's end (Pump set total) (d)	Loss kWh (DTR - Customer(pump set)) (c-d)	Rate of loss kWh ((c-d)/c)
Value of measuring kWh	1,409.4	1,402.0	7.4	0.5%
Measuring period	7/23 - 7/30	7/23 - 7/30	------	------

5.5.3 Voltage Drop at Customer's End

Since some of voltage drops exceeded the upper limit or the lower limit, adjustment of the sending voltage at the substation must be conducted more precisely.

5.5.4 Technical Energy Loss

On the basis of the measured currents, specification of the feeders by facility and actual loads, technical energy loss of each of distribution facilities (11kV line, distribution transformer, low voltage line etc.) was calculated for the three model feeders. The results are shown in Figure 5.6.

Comparison of the calculated results and the energy loss rates in Japan shows that the loss rates of the distribution transformer and low voltage line rate of all the three feeders account for greater portions. It is necessary to lower these loss rates.

Kamalanagar

Loss (kWh/year)	kWh	%
11kV line	42,686	8.9%
DTR (iron loss)	121,589	25.4%
DTR (copper loss)	120,360	25.1%
DTR (total loss)	241,949	50.5%
Low voltage line	136,063	28.4%
Service line	7,158	1.5%
Meter	51,173	10.7%
TOTAL	479,029	100.0%

2002 kWh/year	8,669,040
Rate of loss kWh	5.5%

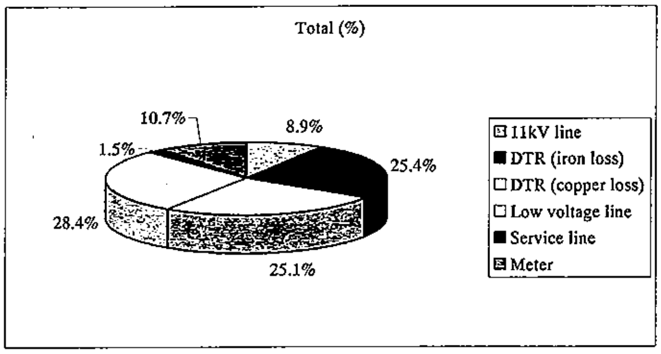


Figure 5.2 Distribution loss (technical loss)(Kamalanagar)

JAPAN (1997)

Item		Loss rate(%)	Total loss(%)
High voltage line	6kV line	2.82	55.4%
Low voltage line	DTR (iron loss)	1.04	20.4%
	DTR (copper loss)	0.68	13.4%
	Low voltage line	0.19	3.7%
	Service line	0.20	3.9%
	Meter	0.16	3.1%
	Total	2.27	44.6%
Total		5.09	100.0%

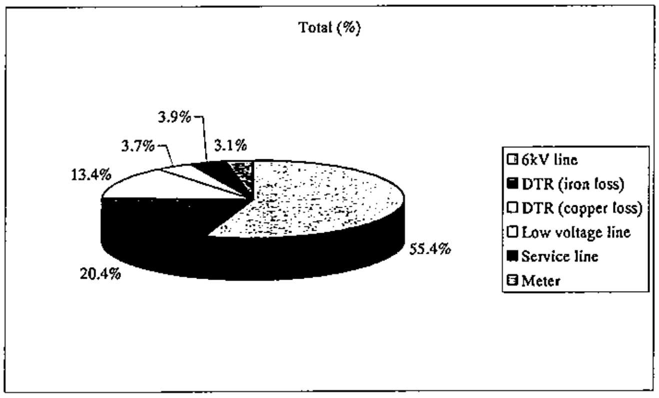


Figure 5.3 Distribution loss (technical loss)(Japan)

5.5.5 Voltage Drop, Over Current

On the basis of the measured currents, the feeder specifications by facility, actual loads, 10 years demand forecast, etc, voltage drops and over current by facility (11kV line, low voltage line, Service wire) was calculated. Results of analysis for one of the model feeders are shown in Table 5.7 and 5.8.

Table 5.7 Maximum voltage drop of Kamalanagar feeder (10 years)
(Shaded figures show Maximum VD of 11kV line or DTR network exceeds the allowable VD)

Voltage drop

			Max votage drop										
	Name of DTR	kVA	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Allowable VD	
11kV Line			83.7	87.0	90.5	94.2	97.9	101.8	105.9	110.1	114.5	119.1	660	(+-6%)
Low voltage line	KN-01	100	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.9	+-40V(+-20V)	(+-10%)
	KN-02	100	3.3	3.4	3.6	3.7	3.9	4.0	4.2	4.3	4.5	4.7	+-40V(+-20V)	(+-10%)
	KN-03	250	11.0	11.4	11.9	12.4	12.9	13.4	13.9	14.5	15.1	15.7	+-40V(+-20V)	(+-10%)
	KN-04	100	8.6	8.9	9.3	9.7	10.1	10.5	10.9	11.3	11.8	12.2	+-40V(+-20V)	(+-10%)
	KN-06	250	37.6	39.1	40.7	42.3	44.0	45.7	47.6	49.5	51.5	53.5	+-40V(+-20V)	(+-10%)
	KN-07	250	21.3	22.2	23.0	24.0	24.9	25.9	27.0	28.0	29.2	30.3	+-40V(+-20V)	(+-10%)
	KN-08	250	15.8	16.4	17.1	17.8	18.5	19.2	20.0	20.8	21.6	22.5	+-40V(+-20V)	(+-10%)
	KN-09	250	11.4	11.9	12.3	12.8	13.3	13.9	14.4	15.0	15.6	16.2	+-40V(+-20V)	(+-10%)
	KN-11	250	11.4	11.9	12.3	12.8	13.3	13.9	14.4	15.0	15.6	16.2	+-40V(+-20V)	(+-10%)
	KN-13	100	1.4	1.5	1.5	1.6	1.6	1.7	1.8	1.8	1.9	2.0	+-40V(+-20V)	(+-10%)
	KN-14	315	16.6	17.3	18.0	18.7	19.4	20.2	21.0	21.8	22.7	23.6	+-40V(+-20V)	(+-10%)
	KN-15	100	6.8	7.1	7.4	7.6	8.0	8.3	8.6	8.9	9.3	9.7	+-40V(+-20V)	(+-10%)
	KN-17	100	5.8	6.0	6.3	6.5	6.8	7.1	7.3	7.6	7.9	8.3	+-40V(+-20V)	(+-10%)
	KN-18	315	22.1	23.0	23.9	24.9	25.9	26.9	28.0	29.1	30.2	31.5	+-40V(+-20V)	(+-10%)
	KN-19	100	3.5	3.6	3.8	3.9	4.1	4.3	4.4	4.6	4.8	5.0	+-40V(+-20V)	(+-10%)
	KN-22	100	11.0	11.4	11.9	12.4	12.9	13.4	13.9	14.5	15.1	15.7	+-40V(+-20V)	(+-10%)
	KN-23	315	16.6	17.3	18.0	18.7	19.4	20.2	21.0	21.8	22.7	23.6	+-40V(+-20V)	(+-10%)
	KN-24	315	69.0	71.8	74.6	77.6	80.7	83.9	87.3	90.8	94.4	98.2	+-40V(+-20V)	(+-10%)
	KN-25	100	6.2	6.4	6.7	7.0	7.3	7.5	7.8	8.2	8.5	8.8	+-40V(+-20V)	(+-10%)
	KN-27	100	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	+-40V(+-20V)	(+-10%)
	KN-37	100	4.1	4.3	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	+-40V(+-20V)	(+-10%)

Table 5.8 Maximum current of Kamalanagar feeder (10 years)
(Shaded figures show Maximum Current of 11kV line or DTR network exceeds the allowable current)

Overcurrent

			Max. current										
	Name of DTR	kVA	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Allowable Current	
11 kV line			106	110.2	114.6	119.2	124.0	129.0	134.1	139.5	145.1	150.9	234	(55mm2)
DTR	KN-01	100	33	34.3	35.7	37.1	38.6	40.1	41.8	43.4	45.2	47.0	209	150%
	KN-02	100	132	137.3	142.8	148.5	154.4	160.6	167.0	173.7	180.7	187.9	209	150%
	KN-03	250	242	251.7	261.7	272.2	283.1	294.4	306.2	318.5	331.2	344.4	522	150%
	KN-04	100	61.6	64.1	66.6	69.3	72.1	74.9	77.9	81.1	84.3	87.7	209	150%
	KN-05	63	17.6	18.3	19.0	19.8	20.6	21.4	22.3	23.2	24.1	25.1	131	150%
	KN-06	250	246.4	256.3	266.5	277.2	288.3	299.8	311.8	324.2	337.2	350.7	522	150%
	KN-07	250	246.4	256.3	266.5	277.2	288.3	299.8	311.8	324.2	337.2	350.7	522	150%
	KN-08	100	136.4	141.9	147.5	153.4	159.6	166.0	172.6	179.5	186.7	194.1	209	150%
	KN-09	250	290.4	302.0	314.1	326.7	339.7	353.3	367.4	382.1	397.4	413.3	522	150%
	KN-10	63	17.6	18.3	19.0	19.8	20.6	21.4	22.3	23.2	24.1	25.1	131	150%
	KN-11	250	290.4	302.0	314.1	326.7	339.7	353.3	367.4	382.1	397.4	413.3	522	150%
	KN-12	100	17.6	18.3	19.0	19.8	20.6	21.4	22.3	23.2	24.1	25.1	209	150%
	KN-13	63	57.2	59.5	61.9	64.3	66.9	69.6	72.4	75.3	78.3	81.4	131	150%
	KN-14	315	255.2	265.4	276.0	287.1	298.5	310.5	322.9	335.8	349.3	363.2	522	150%
	KN-15	100	70.4	73.2	76.1	79.2	82.4	85.7	89.1	92.6	96.3	100.2	209	150%
	KN-16	63	30.8	32.0	33.3	34.6	36.0	37.5	39.0	40.5	42.2	43.8	131	150%
	KN-17	100	136.4	141.9	147.5	153.4	159.6	166.0	172.6	179.5	186.7	194.1	209	150%
	KN-18	315	312.4	324.9	337.9	351.4	365.5	380.1	395.3	411.1	427.5	444.6	657	150%
	KN-19	100	79.2	82.4	85.7	89.1	92.7	96.4	100.2	104.2	108.4	112.7	209	150%
	KN-20	160	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	334	150%
	KN-21	100	17.6	18.3	19.0	19.8	20.6	21.4	22.3	23.2	24.1	25.1	209	150%
	KN-22	100	123.2	128.1	133.3	138.6	144.1	149.9	155.9	162.1	168.6	175.4	209	150%
	KN-23	315	96.8	100.7	104.7	108.9	113.2	117.8	122.5	127.4	132.5	137.8	657	150%
	KN-24	315	299.2	311.2	323.6	336.6	350.0	364.0	378.6	393.7	409.5	425.9	657	150%
	KN-25	100	154	160.2	166.6	173.2	180.2	187.4	194.9	202.7	210.8	219.2	209	150%
	KN-26	100	17.6	18.3	19.0	19.8	20.6	21.4	22.3	23.2	24.1	25.1	209	150%
	KN-27	100	70.4	73.2	76.1	79.2	82.4	85.7	89.1	92.6	96.3	100.2	209	150%
	KN-28	100	17.6	18.3	19.0	19.8	20.6	21.4	22.3	23.2	24.1	25.1	209	150%
	KN-29	160	39.6	41.2	42.8	44.5	46.3	48.2	50.1	52.1	54.2	56.4	334	150%
	KN-30	160	35.2	36.6	38.1	39.6	41.2	42.8	44.5	46.3	48.2	50.1	334	150%
	KN-31	100	17.6	18.3	19.0	19.8	20.6	21.4	22.3	23.2	24.1	25.1	209	150%
	KN-32	100	26.4	27.5	28.6	29.7	30.9	32.1	33.4	34.7	36.1	37.6	209	150%
	KN-33	100	26.4	27.5	28.6	29.7	30.9	32.1	33.4	34.7	36.1	37.6	209	150%
	KN-34	63	8.8	9.2	9.5	9.9	10.3	10.7	11.1	11.6	12.0	12.5	131	150%
	KN-35	63	26.4	27.5	28.6	29.7	30.9	32.1	33.4	34.7	36.1	37.6	131	150%
	KN-36	100	13.2	13.7	14.3	14.8	15.4	16.1	16.7	17.4	18.1	18.8	209	150%
	KN-37	100	105.6	109.8	114.2	118.8	123.5	128.5	133.6	139.0	144.5	150.3	209	150%
	KN-38	160	22	22.9	23.8	24.7	25.7	26.8	27.8	29.0	30.1	31.3	334	150%
	KN-39	100	13.2	13.7	14.3	14.8	15.4	16.1	16.7	17.4	18.1	18.8	209	150%
Low voltage line	KN-01	100	16.3	17.0	17.6	18.3	19.1	19.8	20.6	21.4	22.3	23.2	175	(34mm2)
	KN-02	100	65.5	68.1	70.8	73.7	76.6	79.7	82.9	86.2	89.6	93.2	175	(34mm2)
	KN-03	250	137.5	143.0	148.7	154.7	160.9	167.3	174.0	180.9	188.2	195.7	175	(34mm2)
	KN-04	100	55.0	57.2	59.5	61.9	64.3	66.9	69.6	72.4	75.3	78.3	175	(34mm2)
	KN-06	250	245.2	255.0	265.2	275.8	286.8	298.3	310.3	322.7	335.6	349.0	175	(34mm2)
	KN-07	250	237.3	246.8	256.7	266.9	277.6	288.7	300.3	312.3	324.8	337.8	175	(34mm2)
	KN-08	250	98.1	102.0	106.1	110.3	114.8	119.4	124.1	129.1	134.3	139.6	175	(34mm2)
	KN-09	250	133.0	138.3	143.9	149.6	155.6	161.8	168.3	175.0	182.0	189.3	175	(34mm2)
	KN-11	250	143.6	149.3	155.3	161.5	168.0	174.7	181.7	189.0	196.5	204.4	175	(34mm2)
	KN-13	100	22.1	23.0	23.9	24.9	25.9	26.9	28.0	29.1	30.2	31.5	175	(34mm2)
	KN-14	315	137.2	142.7	148.4	154.3	160.5	166.9	173.6	180.5	187.8	195.3	175	(34mm2)
	KN-15	100	70.4	73.2	76.1	79.2	82.4	85.7	89.1	92.6	96.3	100.2	175	(34mm2)
	KN-17	100	117.7	122.4	127.3	132.4	137.7	143.2	148.9	154.9	161.1	167.5	175	(34mm2)
	KN-18	315	213.7	222.2	231.1	240.4	250.0	260.0	270.4	281.2	292.5	304.2	175	(34mm2)
	KN-19	100	50.3	52.3	54.4	56.6	58.8	61.2	63.6	66.2	68.8	71.6	175	(34mm2)
	KN-22	100	123.2	128.1	133.3	138.6	144.1	149.9	155.9	162.1	168.6	175.4	175	(34mm2)
	KN-23	315	96.3	100.2	104.2	108.3	112.7	117.2	121.9	126.7	131.8	137.1	175	(34mm2)
	KN-24	315	299.2	311.2	323.6	336.6	350.0	364.0	378.6	393.7	409.5	425.9	175	(34mm2)
	KN-25	100	86.4	89.9	93.5	97.2	101.1	105.1	109.3	113.7	118.2	123.0	175	(34mm2)
	KN-27	100	52.3	54.4	56.6	58.8	61.2	63.6	66.2	68.8	71.6	74.4	175	(34mm2)
	KN-37	100	69.6	72.4	75.3	78.3	81.4	84.7	88.1	91.6	95.3	99.1	175	(34mm2)
Service line			88										(14mm2)	

5.6 Improvement and Expansion Plan of Distribution Network

In order to reduce energy loss and to improve voltage drop and over current, improvement plans were conducted for every feeder and every facility together with counterparts. Particular plans are shown below.

Period of planning was set at 10 years in the improvement plans.

5.6.1 Substations for Distribution

After surveying current situation of each substation, almost all the substation did not exceed the allowable kW in this year.

As for feeders that might exceed the limit, improvement will be made by the following method.

- Considering evenly balanced load on respective feeders of a bank
- Considering to install new substation transformer
- Considering to install new substation

5.6.2 High Voltage Distribution Lines

After checking bottlenecks of 11kV line for 10 years, current of 11kV line in Kattedan #2 feeder will exceed allowable limitation in 2010, improvement plan was made as Table 5.9.

Table 5.9 Improvement plan of 11kV line

Cause of improvement	Improvement plan
The current flow in 11kV line at the outgoing part of the feeder will exceed the allowable current in 2010.	Add another 11kV line of 730 m to the outgoing part of Kattedan #2 feeder.

Generally, improvement plans to avoid any bottlenecks of voltage drop or over current are as follows:

- Up-sizing 11kV line or installing an additional 11kV line
- Shifting a part of load to another feeder
- Installing a voltage regulator when voltage drop is very large
- Installing a power capacitor at a point of excessively large load power factor.

5.6.3 Low Voltage Distribution Lines

Bottlenecks in distribution transformers and low voltage lines in coming ten years will occur as shown in Table 5.7 and 5.8.

Generally, improvement plans to reduce voltage drop or over current include

- Transferring a transformer to the center of loads
- Splitting a low voltage line(newly installing a transformer and dividing loads with the existing transformer)
- Share half of load to another newly transformer
- Up-sizing a low voltage line or installing an additional 11kV line to lower the current density.

Improvement is made by selecting an optimal method from the above-mentioned plans. Results are as shown in Table 5.10.

Table 5.10 Improvement plan of low voltage line

Kamalanagar

Name of DTR	kVA	Vd (V)			DTR current (A)			Low voltage line current (A)			Revised contents	
		before	after	subtract	before	after	subtract	before	after	subtract	before	after
KN-03	250	14.4	14.4	0.0	318.5	318.5	0.0	180.9	120.8	-60.1		+ Low voltage line30m*1*4
KN-06	250	37.6	7.2	-30.4	246.4	81.6	-164.8	245.2	81.6	-163.6	DTR250kVA	+ 11kV30m*8*3+DTR160kVA
KN-07	250	21.3	4.9	-16.4	246.4	50.0	-196.4	237.3	108.4	-128.9	DTR250kVA	+ 11kV30m*4*3+DTR160kVA
KN-08	100	20.7	3.2	-17.5	179.5	87.0	-92.5	129.1	45.1	-84.0	DTR250kVA	+ 11kV30m*5*3+DTR100kVA
KN-09	250	15	10.1	-4.9	382.1	382.1	0.0	175.1	92.1	-83.0		+ Low voltage line30m*3*4
KN-11	250	14.4	12.1	-2.3	367.4	367.4	0.0	181.6	117.0	-64.6		+ Low voltage line30m*3*4
KN-14	315	20.2	18.0	-2.2	310.5	143.6	-166.9	166.9	143.5	-23.4	DTR315kVA	+ 11kV30m*5*3+DTR160kVA
KN-18	315	22.1	8.0	-14.1	312.4	171.8	-140.6	213.7	97.8	-115.9	DTR315kVA	+ 11kV30m*5*3+DTR100kVA
KN-22	100	15.6	13.8	-1.8	175.4	175.4	0.0	175.4	120.7	-54.7		+ Low voltage line30m*1*4
KN-23	315	20.2	8.1	-12.1	117.8	57.8	-60.0	117.7	57.7	-60.0	DTR315kVA	+ 11kV30m*9*3+DTR63kVA
KN-24	315	69	18.6	-50.4	299.2	138.5	-160.7	299.2	138.3	-160.9	DTR315kVA	+ 11kV30m*11*3+DTR160kVA
KN-25	100	8.5	8.5	0.0	210.8	210.8	0.0	118.3	118.3	0.0	DTR100kVA	DTR 160 kVA

Legend of revised contents in Table 5.10 are shown in Table 5.11.

Table 5.11 Legend of contents of improvement in Table 5.10

Revised contents (symbol)	Revised contents
+11kV line 100m*3	Installing an additional 55mm^2 *3 wire 11kV line to install a new distribution transformer
+Low voltage line 100m*4	Installing an additional 34mm^2 *4 wire low voltage line to reduce resistance
+DTR100kVA	Installing a new 100kVA distribution transformer to divide the existing loads into two parts
DTR160kVA	Upgrading the existing distribution transformer to 160kVA

When improving distribution facilities, the time margin for distribution transformer and low voltage line after improvement is set at ten years. The criteria for upgrading wire size or installing a new distribution transformer are as shown in Table 5.12.

Table 5.12 Criteria of improvement of low voltage network

Cause of improvement	Contents of improvement
Exceeding voltage drop limit	If time margin of the existing distribution transformer is less than 3 years, install a new distribution transformer and divide existing loads into two parts. Otherwise upgrade size of wire or install an additional low voltage line.
Exceeding overload limit of distribution transformer	If time margin of the existing low voltage line is less than 3 years, install a new distribution transformer and divide existing loads into two parts. Otherwise upgrading kVA of the existing distribution transformer.

When installing a new distribution transformer, kVA of the distribution transformer is decided according to the criteria of Table 5.13.

Table 5.13 Criteria for selecting distribution transformer

DTR (kVA)	Current limitation when installing new DTR (A)		(reference) current for each degree of load (A)		
	growth rate 4% degree of load 150%	growth rate 1% degree of load 120%	100%	120%	150%
	Ranga Reddy	Medak			
63	89	96	88	106	132
100	141	152	139	167	209
160	226	243	223	268	335
250	353	380	348	418	522
315	444	478	438	526	657

5.6.4 Implementation Plan

All of the above-mentioned improvement plans are integrated and the works are to be executed in the coming ten years as shown in Table 5.14. Construction for improvement is executed when each facility exceed the allowable limitation of voltage drop or current. (Example of model feeders)

Table 5.14 Implementation plan (facility wise) (Kamalanagar)

Construction cost(Rs) (1,000Rs)

	Name of DTR	kVA	Revised contents		starting year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	total
			before	after												
11kV Line																
DTR & Low voltage line	KN-03	250		+ Low voltage line30m*1*4	8								12 7			12 7
	KN-06	250	DTR250kVA	+ 11kV30m*8*3+DTR160kVA	1	240 9										240 9
	KN 07	250	DTR250kVA	+ 11kV30m*4*3+DTR160kVA	1	196 1										196 1
	KN-08	100	DTR250kVA	+ 11kV30m*5*3+DTR100kVA	8								186 7			186 7
	KN-09	250		+ Low voltage line30m*3*4	8								38 2			38 2
	KN-11	250		+ Low voltage line30m*3*4	7							37 8				37 8
	KN-14	315	DTR315kVA	+ 11kV30m*5*3+DTR160kVA	6						217 9					217 9
	KN-18	315	DTR315kVA	+ 11kV30m*5*3+DTR100kVA	1	174 1										174 1
	KN-22	100		+ Low voltage line30m*1*4	10										13 0	13 0
	KN-23	315	DTR315kVA	+ 11kV30m*9*3+DTR63kVA	6						216 7					216 7
	KN-24	315	DTR315kVA	+ 11kV30m*11*3+DTR160kVA	1	274.5										274 5
	KN-25	100	DTR100kVA	DTR160kVA	9									163 9		163 9
			total	Current value		885 6	0 0	0 0	0 0	0 0	434 6	37 8	237 5	163 9	13 0	1,772 4
				Present value		885 6	0 0	0 0	0 0	0 0	340.5	28 2	168.8	110 9	8.4	1,542 4

(Price Rate=0 01/year, Discount Rate=0 05/year)

5.6.5 Cost and Benefit

Result of implementation of the improvement plan, and its cost and benefit are as shown in Table 5.15 – 5.16. Cost consists of construction cost of improvement plan in every year. Benefit consists of profit by reducing energy loss. (Example of model feeders)

Table 5.15 Cost of improvement plan for Kamalanagar feeder

Construction cost (1,000Rs) (1 000Rs)

	Name of DTR	kVA	starting year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	total
11kV line														
DTR & Low voltage line	KN-03	250	8								12 7			12 7
	KN-06	250	1	240 9										240 9
	KN-07	250	1	196 1										196 1
	KN-08	100	8								186 7			186 7
	KN-09	250	8								38 2			38 2
	KN-11	250	7							37 8				37 8
	KN-14	315	6						217 9					217 9
	KN-18	315	1	174 1										174 1
	KN-22	100	10										13 0	13 0
	KN-23	315	6						216.7					216 7
	KN-24	315	1	274.5										274.5
	KN-25	100	9									163 9		163 9
total	Current value			885 6	0 0	0 0	0 0	0 0	434 6	37 8	237.5	163.9	13 0	1 772.4
	Present value			885 6	0 0	0 0	0 0	0 0	340 5	28 2	168 8	110 9	8 4	1,542.4

(Price Rate=0 01/year, Discount Rate=0 05/year)

Table 5.16 Benefit of improvement plan for Kamalanagar feeder

Benefit by reducing loss energy (1,000Rs/year) (1,000Rs)

	Name of DTR	kVA	starting year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	total
11kV Line														
DTR & Low voltage line	KN-03	250	8								5 1	5 1	5 2	15.3
	KN-06	250	1	88 8	89 7	90 6	91 5	92 4	93 4	94 3	95 2	96.2	97 2	929 4
	KN-07	250	1	33.8	34 2	34 5	34 8	35 2	35 5	35 9	36.3	36 6	37 0	353.8
	KN-08	100	8								15.5	15 7	15 8	47 0
	KN-09	250	8								11 6	11 8	11 9	35 3
	KN-11	250	7							12 7	12.8	13 0	13 1	51 6
	KN-14	315	6						25 5	25 7	26.0	26 2	26 5	129 9
	KN-18	315	1	4 5	4 5	4 6	4 6	4 7	4 7	4 7	4 8	4 8	4 9	46.8
	KN-22	100	10										4 9	4 9
	KN-23	315	6						7 5	7 6	7 7	7 7	7 8	38 3
	KN-24	315	1	178.8	180 6	182 4	184 2	186 0	187 9	189 8	191 7	193 6	195.5	1,870 4
	KN-25	100	9									41 6	42 0	83 6
total	Current value			305 9	309 0	312 1	315 2	318 3	354.5	370 7	406.7	452.3	461 7	3,606 4
	Present value			305 9	294 2	283 0	272 3	261 9	277 7	276 7	289 0	306.2	297 6	2,864 5

(Price Rate=0 01/year, Discount Rate=0 05/year)

In addition to loss reduction, benefits include

- Improvement of quality of supply electricity (improvement of voltage drop, over current)
- Improvement of reliability of electricity supply due to reduced failures
- Improvement of customer services through the above-mentioned improvements.

5.7 Recommendations

5.7.1 Reduction of Energy Loss

As in the preceding analysis needs of reducing energy losses of low voltage distribution facilities have been pointed out. At present the control is not adequate as shown below:

- The status of loads on each distribution transformer is not supervised constantly.
- Some divisional offices do not have network management documents including connections between distribution transformers and low voltage lines. Some documents are not updated by constant maintenance.
- There is no document of connections between customers and low voltage distribution lines.
- Some divisions do not have any document of facilities concerning span, size of low voltage lines.

It, therefore, is necessary to compile lacking data, and give proper load control and voltage control by using estimated load, which is based on measurement or derived from the correlation formula of kWh-A (refer to clause 5.7.3 kWh-A managing).

When the above-mentioned management is done properly, parts causing electric excesses will be improved gradually. These improvements also serve as loss reduction measures. Improvement of bottlenecks of distribution facilities will reduce energy loss at the same time.

As energy loss of low voltage distribution facilities in APCPDCL accounts for a larger portion in comparison with the case of Japan, it is important, in improving existing low voltage facilities, to shorten the length of low voltage line and reduce the capacity of distribution transformer.

5.7.2 Measuring

As for measuring, we recommend to continue measuring for following reasons.

Accurate energy loss must be measured by measuring throughout the year. Especially, measuring energy loss of distribution transformer must be performed since energy loss of low voltage facilities is larger compared to Japan.

Measuring the load (kW), load current and etc. at distribution transformer must be conducted every month. By using these data and managing current and voltage drop properly, improvement of distribution facilities to reduce energy loss can be performed timely.

5.7.3 "kWh-A Managing"

In Japan, from a view point of ensuring efficiency in voltage control and load control of distribution transformer, "kWh-A managing" is carried for low voltage distribution network.

This managing method is to estimate the peak load current of a distribution transformer by using customer's electricity consumption (kWh). There is a strong correlation between the annual maximum current of the secondary side of a distribution transformer bank and the total consumption (kWh) of all customers in the bank in a domestic/ commercial area in a peak month.

Using measuring data of this survey, a formula of kWh-A correlation was calculated as shown below in an attempt to put the method to practical use at APCPDCL.

Using this formula, load management and voltage drop can be conducted in the office. And only when the data exceeding the limits are calculated, measuring in the field can be conducted. The need of improvement can be judged on the basis of the results of measurement. In this way, the efficiency of the management is enhanced significantly in comparison with the case wherein measuring is made on all the distribution transformers.

kWh-A correlation formula

$$\mathbf{Y = 0.0319X^{0.7994}}$$

Y : maximum current of secondary side of distribution transformer (A)

X: Total consumption of all customers in peak month (kWh)

Coefficient of correlation = 0.88

5.7.4 Install Fuses between Low Voltage Lines

Compared to Japan, APCPDCL has longer low voltage lines. Accordingly, when short circuit occurs on a low voltage line, the short-circuit current can not melt the fuse on the primary side of the distribution transformer because the impedance of long low voltage line is large. As the short circuit can not be detected, the short-circuit current may break down the transformer or a delay in detecting the trouble may endanger customers.

To avoid such situations, it is necessary to install fuses in the middle of a low voltage line when the fuse on the primary side of its distribution transformer can not be melted.

5.7.5 Installing Balancer

Energy loss is reduced by installing single phase 3 wire systems. However, it is essential to balance loads between both phases. It is also recommended to install a balancer at the end of a low voltage line of a relatively long length.

Balancer is a kind of autotransformer wherein two coils are connected in series. The balancer is installed at the end of a low voltage line, and its voltage compensating function provides buffering effects against unbalanced load.

5.7.6 Linking to GIS System

The present distribution network improvement project uses excel application programs for calculating energy loss, voltage drop and over current.

By linking these excel application programs to the Arc View application programs, specification data of distribution facilities that are saved in the Arc View application programs can be used in computation. Thus computation can be done without newly inputting data for computation.

5.7.7 Expansion Plan

Expansion plan is to be conducted by counterpart after project member finish technical transfer to counterparts. Counterparts will replicate this method to other feeder or other substation.

Chapter 6 Facilities and Customer Management by Use of GIS

Chapter 6 Facilities and Customer Management by Use of GIS

6.1 General

GIS stands for "Geographic Information Systems". GIS systems can display and analyze various data easily in computer maps. The aim of the adoption of GIS to Andhra Pradesh in India is to promote the efficiency of its management method of power distribution facilities and customer information; these are now managed by manual procedures in Andhra Pradesh, India. Additionally, analyzing facilities and customer information by using GIS will prove effective for electric reliability and customer service.

In this study, the study team introduced the GIS in the following three substations.

- Kothapet substation (Ranga Reddy district)
- Kattedan substation (Ranga Reddy district)
- Malkapur substation (Medak district)

6.2 Software

Adopted software "ArcView" from ESRI, USA has the largest worldwide market share in the GIS field and has been widely adopted in India. In considering the expansion of GIS to additional areas, the study team decided that ArcView would be the most appropriate tool for this project. As ESRI has the agent office in Hyderabad for software support, the study team benefited from the extended service support in Hyderabad. Mapworld, the company that created the base map in this project, are also utilizing the ArcView software.

6.3 Facilities and Customers Information Management

The distribution facilities data was entered into GIS with the following data;

Table 6.1 Facilities data

33/11kV Substation		name, capacity, feeder name
11kV line	Pole	pole No., material
	High voltage line	length, conductor size, material
	Auto breaking switch	pole No., breaking capacity
Pole-mounted transformer		pole No., transformer capacity
430V line	Pole	pole No., material
	Low voltage line	length, conductor size, material

Table 6.2 Customer data

Domestic	customer No., name, address, tariff category, meter data
Industry	Ditto
Commercial	Ditto
Agriculture	customer No., name, address, meter data, pump capacity

6.4 Technology Transfer

Figure 6.1 shows the flow of creation for prototype GIS.

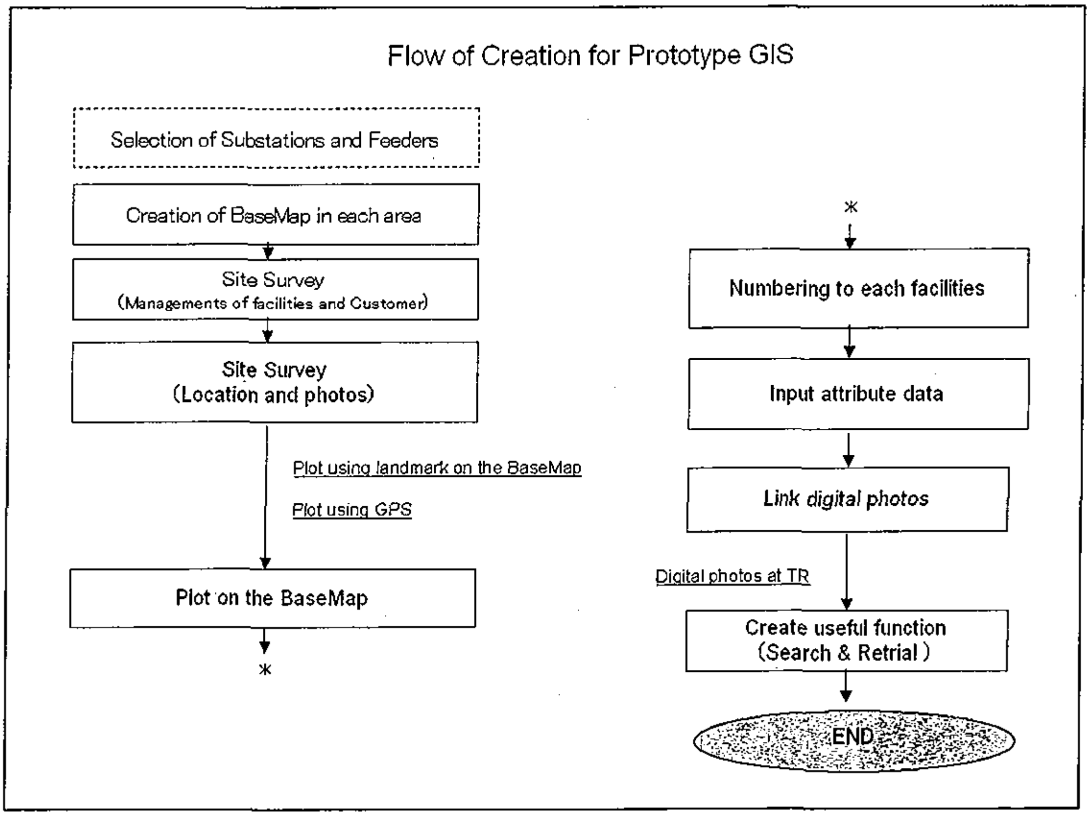


Figure 6.1 Flow of creation for prototype GIS

Data collection for the position was conducted by two ways. In case of the urban area such as Kothapet and Kattedan substation that has many landmark (road, building, park, river, etc.), the study team printed the base map on a scale of 1 : 2,000 - 3,000 and carried the map for the site survey. Then, the study team filled in the positions for the facilities and the customers directly on the map. After that, the study team input data to the ArcView in the office.

On the other hand, the study team measured every latitude and longitude for facilities and customers by using GPS in agriculture area because of no landmark. These data were input to ArcView in the office.

As for the specification of the facilities, the study team collected data from the facility book. As for the information of customers, the study team got data from MRB (Meter Reading Book).

The study team procured necessary equipments for distribution GIS and installed them at APTRANSCO, APCPDCL, and three section offices that are managing three substations. Table 6.3 shows the lists of equipment.

Table 6.3 Lists of equipments

Description	Qty	Specification
Computer	6	Pentium 4, CPU 2.4GHz 256MB RAM, 40GB HDD, 15 inch Monitor
Printer	3	A3-size, Color, Inkjet
Software	6	Microsoft Windows XP Professional
Software	6	Microsoft Office XP Professional
Software	6	ESRI ArcView Version 8.3
Digital camera	3	2.0 Megapixels, 3.0 Optical zoom
GPS	6	Accuracy 15m

6.5 Utilization of GIS Data and Benefit

Since GIS can display information on the map visually, it allows even new employees to easily recognize the company's facilities and view their general descriptions for the distribution system. Furthermore, through the back-end database, staff will have access to accurate data as well as obtain the ability to perform searches and analyze the various system data variables. GIS can also perform a vital improvement in efficient customer service in terms being able to quickly access customer data, and for dispatching field staff to handle such situations as outage.

The example of effects is as follows;

(1) Site work efficiency

- Maintaining a paper-based system hinders the ability to access data that reflects the real-world data. However, a GIS system provides strong benefits in terms of enabling ease of change and modification to data related to facilities and customers.
- When the distribution facilities should be replaced, it is necessary to confirm the local situation and to prepare an appropriate materials and devices. Using GIS system, site facilities specs are available in the office.
- During the operation for electric fuse and switchgear, it is helpful to have the No. of facilities in the site. Using GIS system, it enables to check the No. and location in the office to prevent from miss operation.

(2) Recognize facilities and customer location

- Improvements and accuracy in the planning of the electric system can be realized by storing the location of electric load and facilities' data on the map.
- It is possible to forecast future demands by analyzing the consumption data for each area.
- During shut-down, managers are able to focus service staff on the specific facility due to the GIS capability to correlate transformer to the customer's location.

(3) Assistance for electricity loss management and SCADA System

- Interface to electricity loss management and SCADA System

(4) Function for customer service

- Retrieval function allows for prompt and efficient customer service

(5) Asset management

- Practical use of Hyperlink function, reference of facilities by digital photos in the office

(6) Office efficiency

- Digitalization enables to reduce printed paper data storage and save paper resources

6.6 GIS Expansion Plan

After conducting the OJT for the GIS system in the selected three offices, the study team accessed the staff's organization and the technical level. Since they currently manage facilities and customer data under the present system, These staff are capable of taking on the responsibilities of GIS *management through proper training.*

It should be noted however that the cooperation from the consultant would be vital in expanding the GIS system – especially during the early development stages when efficient pre-designs will be necessary.

Furthermore, the supporting system will be required to integrate into the GIS system through a LAN network.

6.6.1 Recommended GIS Organization

The creation of a new division, "GIS Manager", to work with the "Facilities manager" and "Customer manager" will be crucial to optimizing the sharing of the benefits of the GIS system as shown in Figure 6.2.

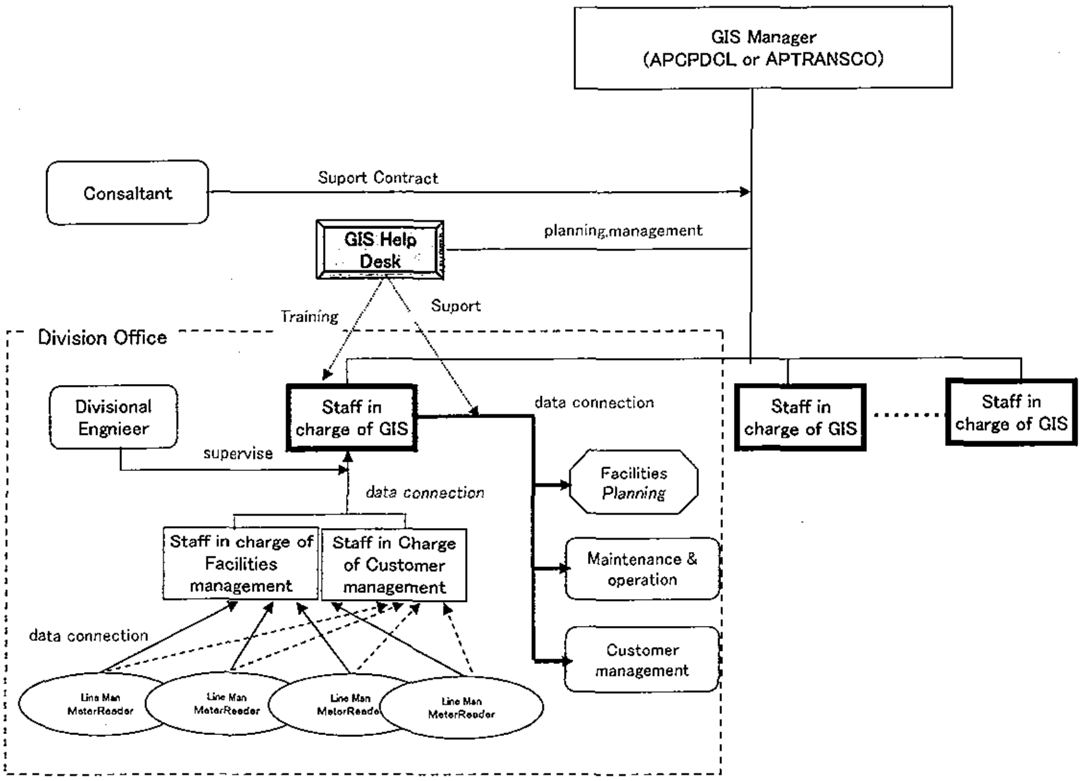


Figure 6.2 Organization for GIS expansion

6.6.2 Area of GIS introduction

Considering the availability of maps, the procedure of expansion for distribution of GIS should follow this step.

- First stage : Hyderabad
- Second stage : Ranga Reddy district
- Third stage : Surrounding districts of Ranga Reddy

In this report, the study team proposes the first stage plan in detail.

6.6.3 Necessary Manpower for GIS Creation

In this study, the study team created a distribution GIS for three target feeders supported by the Indian counterparts. Manpower required for these surveys are as follows.

- 11kV line survey : four people/day-one feeder
- Data input for 11kV line : one person/day-one feeder
- low voltage line and customer survey : one person/day-one distribution transformers
- Data input for low voltage line and customer : one person/day-one distribution transformers

There are three circle offices (Hyderabad North, Hyderabad South, Hyderabad Central) in Hyderabad and they are managing 64 substations. The number of total feeders in Hyderabad is 421 and average feeders at each substation are 6.6 feeders. In general, one feeder has 30 to 50 distribution transformers. Therefore, it is estimated that the number of total distribution transformers in Hyderabad is 17,000.

From the number of existing facilities (number of feeders and distribution transformers) and the results of our survey, the necessary man-months for the creation of the distribution GIS in Hyderabad is the following Table 6.4.

Table 6.4 GIS necessary man-months for GIS creation

Item	Man - day	Man - months
Site survey for 11kV line	421 feeder x 4 persons/day-feeder = 1,684 persons/day	84
Data input for 11kV line	421 feeder x 1 person/day-feeder = 421 persons/day	21
Site survey for low voltage line	17,000 DTR x 1 person/day-DTR = 17,000 persons/day	850
Data input for low voltage line	17,000 DTR x 1person/day-DTR = 17,000 persons/day	850
Total Man - months		1,805

(The working day for a month is 20 days)

6.6.4 The Main Equipment for GIS

The GIS system should be managed by the "Division Office", which is in charge of supervision of the "Section Office", due to its security and staff qualifications. There are nine Division offices in Hyderabad. When two desktop computers for the distribution GIS are setup in one office, 18 computers and 18 GIS licenses are necessary. Moreover, it is necessary to store data in Database Management System (DBMS) such as Oracle, Microsoft SQL Server, Informix, and IBM DB2. To connect this PC storing the DBMS to each Division office in the network, an application server is also necessary (for instance, ArcSDE).

In addition, to display the distribution GIS on a website, the software for website publishing is also required (for instance, ArcIMS).

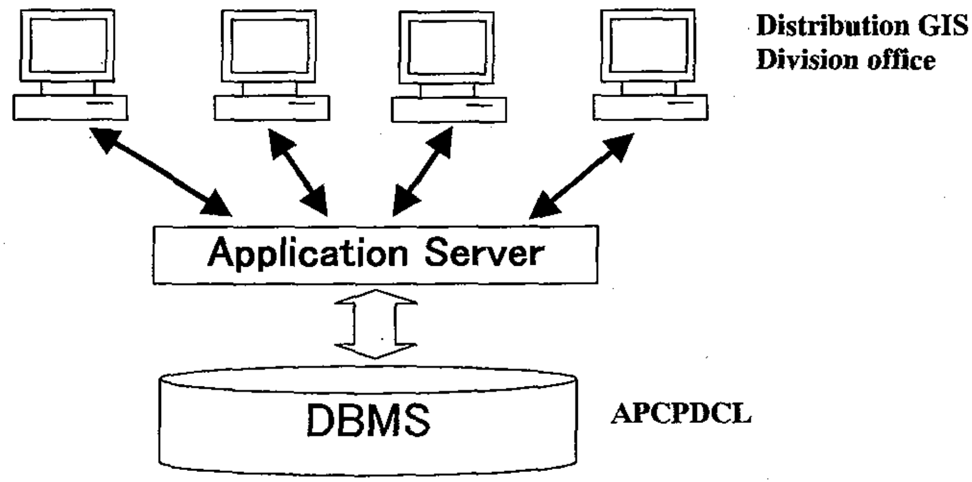


Figure 6.3 Image of GIS network

Table 6.5 Lists of main equipment for GIS

Equipment		Qty
Desk Top Computer	17 inch monitor	18 sets
Database Management System (DBMS)	Oracle, Microsoft SQL Server, Informix, IBM DB2, etc.	1 set
Software for GIS		18 licensees
Software for GIS Application Server		18 licensees
Software for Internet Web		1 set
Digital Map	Scale (1:5,000)	1 set

6.6.5 Necessary Cost

Table 6.6 Total estimate costs for the distribution GIS creation

Description	Qty	Unit cost (US$)	Total cost
Digital map	1 set	50,000	50,000
Desktop computer	18 sets	2,000	36,000
DBMS	1 set	4,000	4,000
Software for GIS	18 sets	4,000	72,000
Software for GIS application server	18 sets	10,000	180,000
Software for internet web	1 set	30,000	30,000
Other software (MS Office, etc)	18 set	1,000	18,000
Expenses for data collection	1,800 MM	100	180,000
Consultant fee	5 years	1,000,000	5,000,000
Total			5,570,000

6.6.6 Schedule of GIS creation

Table 6.7 Work schedule of the distribution GIS creation in Hyderabad

	1st year	2nd year	3rd year	4th year	5th year
(1) Establishment of GIS section in APCPDCL	■				
(2) Training for location survey of feeder to temporary employees	■				
(3) Location survey for all feeder	■				
(4) Data collection for information of DTR & Line	■				
(5) Entering feeder data into PC	■				
(6) Data check by consultants	■	■	■	■	■
(7) Staff training by consultants	■ ■	■ ■	■ ■	■ ■	■ ■
(8) Training for location survey of customers to temporary employees		■	■	■	■
(9) Location survey for all customers in Hyderabad North		■	■		
(10) Location survey for all customers in Hyderabad Central				■	
(11) Location survey for all customers in Hyderabad South					■
(12) Data collection for customers' information		■	■	■	■
(13) Entering customers' data into PC		■	■	■	■

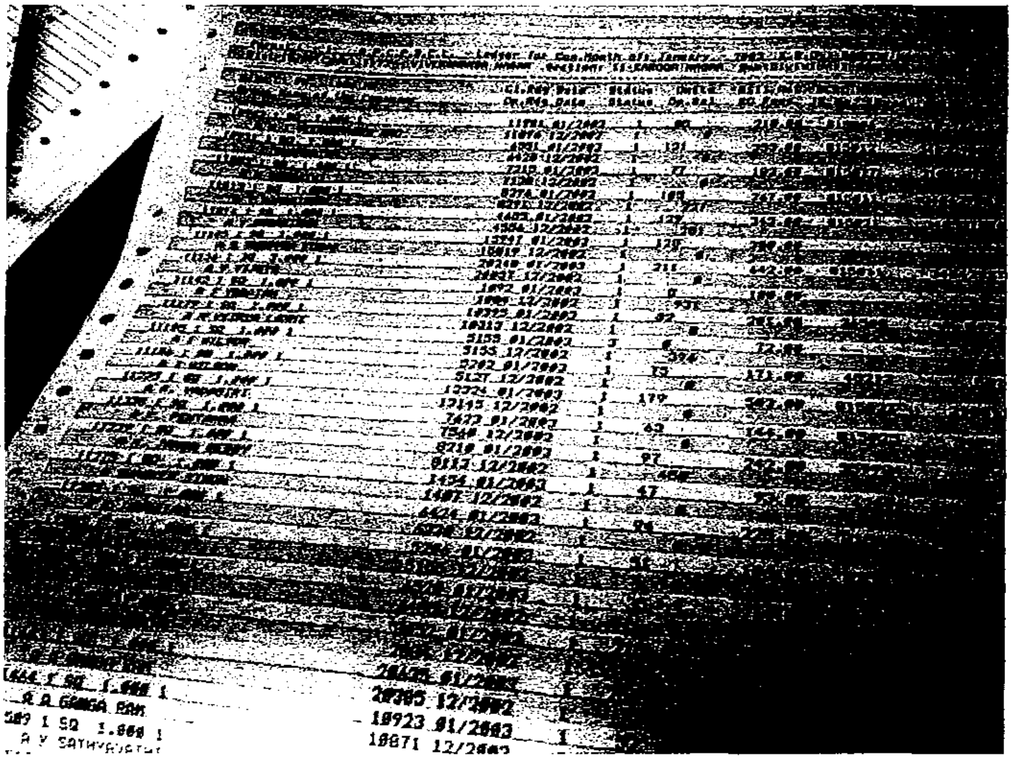
6.7 Future Application of GIS System

GIS systems recently being used in Japan are connected to the host computer via LAN and integrated with other systems in the firm. To fully utilize GIS, the location data of GIS should be connected to other system that handles new connection, designing, contract for works, and facilities maintenance and so on. This data sharing optimizes the total effectiveness of the office operation.

Figure 6.4 displays the example image of a GIS system used in Japan. The expansion plan for GIS should be considered as one of crucial programs in the electric utility business.

In this study, the study team examined the GIS introduction in the central power distribution company in the Andhra Pradesh. The distribution power company downloads customers' data from the hand-held computer and is managed by Electricity Revenue Office (ERO). These management items are service number, power demand, electricity charge, default of payment, the date of the contract, etc. The data is represented by the figures as shown in Photograph 6.1. By moving the data into GIS, it is possible to find the location of each facility and customer. Moreover, it is possible to retrieve a large demand region easily. In the analysis of the regional trend of electricity demand, the power distribution company can make an effective expansion plan.

By customizing the GIS, it is also possible to calculate the technical loss between arbitrary points instantaneously by inputting the specification data of the power line and the transformer. The support of a professional consultant is necessary for this customizing. GIS not only helps to confirm the locations of customers and the facilities but also is useful in improving the distribution network plan. It is difficult to measure the exact benefit of GIS introduction. However, the study team proposes to introduce the distribution GIS into APCPDCL step by step for an effective management of distribution network.



Photograph 6.1 Meter reading book of ERO

6.8 Recommendation

In this study, the study team proposed GIS introduction in APCPDCL for the management of distribution facilities and customers. Following items are our recommendations before the GIS introduction.

(1) Unified data format for management

At present, customer data and facility data such as transformer, distribution line and so on are managed in each section office and substation. Each office decides these management items and there is no common format for all offices. It is necessary to unite the management items for sharing information.

(2) Establishment of GIS organization

In this study, a prototype of the distribution GIS was created by the study team and Indian counterpart together. When a company introduces the GIS for management of power distribution system, every day you must update data for new customer, new installation, and modification of facilities. This work volume is very big. Therefore, it is necessary to establish new organization for the GIS management as shown in Figure 6.2.

(3) Report system

If a company set up a computer for GIS in all substations and Section offices, enormous cost and a lot of staff trainings are necessary. Therefore, the study team proposed to set up the GIS at Division office level. However, data for GIS come from substations and Section offices every day. So, it is necessary to create the workflow to transmit such data from substations and Section office to Division office.

(4) Training for PC operator

Staffs that are operating a personal computer in ERO and Division office have a possibility to resign the company because a lot of contract workers are operating a computer in the office. Hereafter, many employees have a chance to use a personal computer. It is necessary to have computer training for staffs.

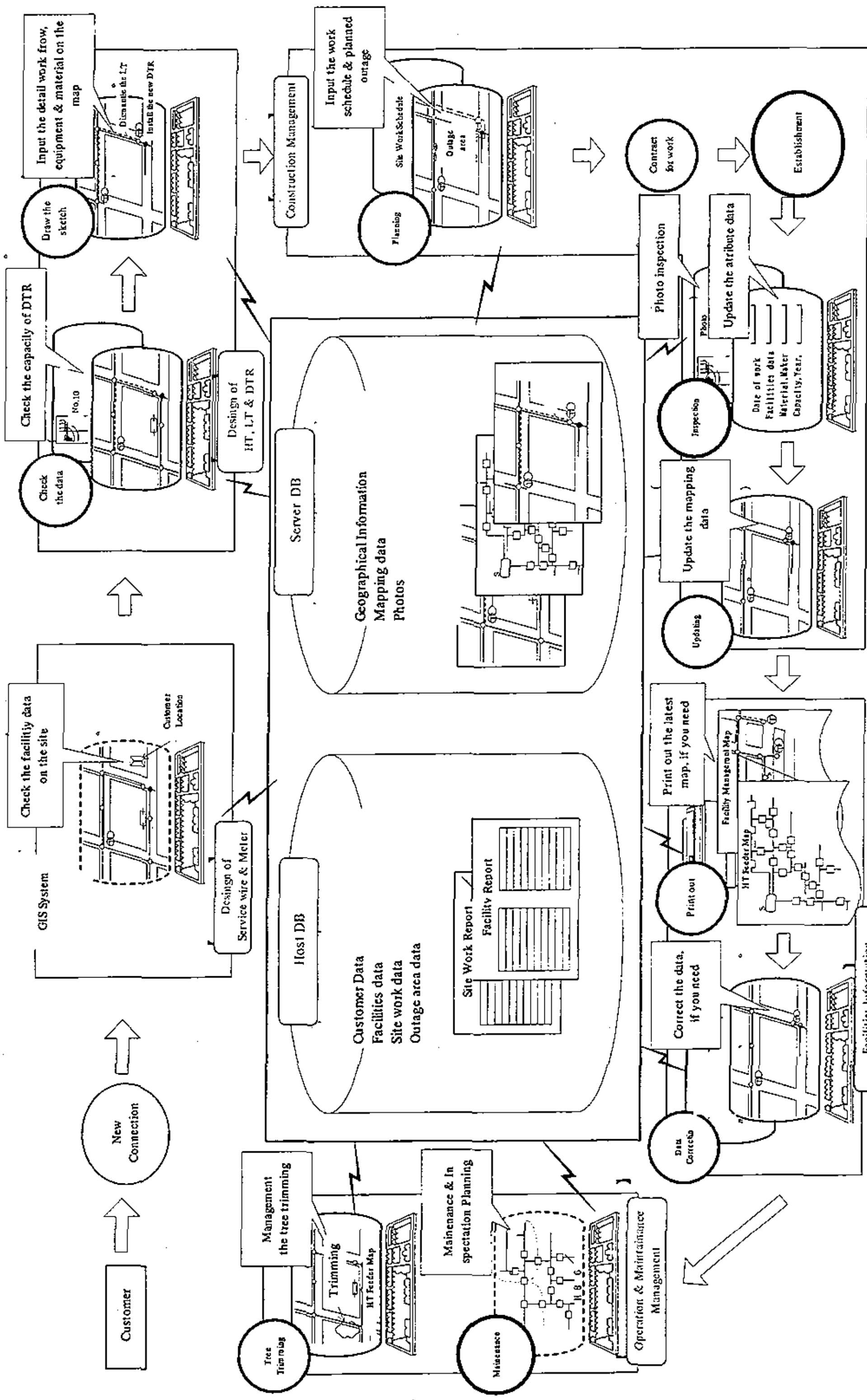


Figure 6.4 Images of GIS

Chapter 7 Training Facilities and Program

Chapter 7 Training Facilities and Program

7.1 General

This chapter explains the "Training Programs for the Distribution Network," which was decided based on the results of the investigation of the current conditions of the training facilities owned by APTRANSCO and APCPDCL, their training programs, and future expansion plans. The "Training Programs for the Distribution Network" aim to transfer Japan's technology to solve problems of the maintenance and management of the distribution facilities in APTRANSCO and APCPDCL.

7.2 Current Conditions of Training Facilities

7.2.1 Corporate Training Institute (CTI)

- CTI was established in 1991 to train engineers, accounts staff and administration staff.
- In the Human Resource Department and Projects of APTRANSCO, the Training and Planning Section is managed by a Chief Engineer (C.E.). CTI is part of the training section of APTRANSCO.
- In organization, CTI will be part of APTRANSCO, and four distribution companies called “DISCOMs” composed of CPDCL, NPDCL, EPDCL and SPDCL, which will share the working expenditure equally.
- CTI accepts and trains trainees from the above five companies.
- Training facilities comprise a lecture hall (two large and one small hall), a computer laboratory, a dining hall and a hostel block.
- There are approximately 35 CTI staff.
- In the technical section of CTI, there are two Divisional Engineers (D.E.) under a Superintending Engineer (S.E.). D.E Training is responsible for course coordination apart from computer courses and D.E Training & Development is responsible for computer courses and planning the programs, course materials and coordinating the dispatch of staff outside CTI training.
- Each D.E manages two Assistant Divisional Engineers (A.D.E.) called T.O.T. (Technical Officer Training) I, II, III and IV.
- The CTI site is 5 acres.
- The computers in the computer laboratory operate on Windows 2000.

7.2.2 Other Training Facilities

(1) Line Staff Training Center (LSTC)

- LSTC was established to train sub-engineers, distribution line staff, etc.
- LSTC belongs to CPDCL, and trains workers from CPDCL.
- The training facilities comprise a lecture hall (one large room and two small rooms), an executive lecture room, a dining hall and a hostel block for 30 persons.
- There are training poles and distribution lines in front of the buildings.
- There is a meter-testing laboratory, a transformer maintenance facility and a 33/11kV sub station near LSTC, which are used for practical training.
- There is four LSTC staff.

(2) Engineering Staff College of India (ESCI)

- Engineering Staff College of India (ESCI) was established in October 1981 by the premier body of professional engineers of India, the Institution of Engineers (India).
- The primary objectives of ESCI are to impart professional & need-based continuing education and training in frontier areas of engineering and management fields, simultaneously providing professional consultancy & technical services to the industry.
- The 70-acre sprawling campus of ESCI is about 15km from the center of Hyderabad city.
- ESCI has its main building and four hostel blocks which can accommodate up to 100 participants.
- Classrooms are equipped with sufficient audio-visual aids to conduct 5 concurrent programs.
- ESCI Information Center has about 6,000 books & reports and 85 periodicals including international journals.
- ESCI Center for Information Technology provides training and consultancy in information technology.

(3) Central Institute of Rural Electrification (CIRE)

- The Central Institute for Rural Electrification (CIRE) was established at Hyderabad in 1979 under the aegis of the Rural Electrification Corporation Limited (A Government of India Enterprise) to cater for the training and development needs of engineers and managers of the power and energy sector and other organizations concerned with power and energy.
- The complex of CIRE is over an area of about 17 acres, with administrative, teaching and hostel blocks.
- While the teaching block has 4 classrooms and 16 syndicate rooms, the hostel block has 38 double-bed occupation rooms with recreation facilities.
- The Institute has a library and is equipped with the latest teaching aids such as LCD, OHPs, slide projectors, computers, internet and e-mail.

7.3 Improvement Plan for Training Facilities

7.3.1 CTI

- Highly practical training that introduces a training relay panel as a power system simulator, which ties up with LSTC and uses its distribution training poles, etc, will be adopted.
- The application software of "Power Point" and "Video Demonstration" will be adopted because "Power Point" is now applied in computer laboratories only.
- All lecture halls will be equipped with air-conditioning.
- A larger lecture hall equipped with an audiovisual system will be constructed in addition to the existing lecture halls.

7.3.2 LSTC

- At LSTC, a new training program introducing personal computers will be adopted.

7.4 Existing Training Programs

7.4.1 Training programs of CTI

- CTI and DISCOMs are planning 104 training programs during 2003-2004.
- Lectures are given by trained engineers and officers from APTRANSCO, etc., or by an entrusted faculty from ESCI, etc.
- Since environmental problems have recently been emphasized, a new five-day training program entitled "Environmental & Pollution Problems in Transmission Lines & Sub stations" was conducted last year.
- The training program of CTI is divided into three major groups: training programs for engineers, training programs for accounts and administration staff, and practical computer training.
- An introduction training, which includes 66 programs for the newly recruited, is executed. This training program takes one month and includes site visits at the end of the training.
- Each lecture period is one hour and thirty minutes. As the daily schedule, lectures are from 9:30 to 12:45 in the morning and from 13:45 to 17:00 in the afternoon, including tea breaks and lunch time.
- The basic course, which includes learning the application software of Word, Excel and Power Point, etc, and several advanced courses are conducted in the computer laboratory. Each of these six-day courses can accept up to 20 persons.

7.4.2 Other Training Programs

(1) Line Staff Training Center (LSTC)

- LSTC is planning 20 training programs during 2003-2004. The training programs include technical matters, for example, "repairing transformer" etc., and customer service matters, such as "electric charges," "saving on electricity," etc.
- The training term is from a minimum of one day up to a maximum of 15 days.
- Lectures are conducted by trained engineers and officers from APCPDCL, etc.

- Each course can accept up to 30 persons, but courses concerned with safety can accept from 80 to 100 persons.
- Each training program is offered from four to six times per year, to meet the demand of CPDCL branches.
- LSTC cooperates with other parties such as the "Federation of Farmers Association," which is conducting a pilot project on farms. LSTC trains not only workers from CPDCL, but also workers from this association because trainees will become line staff, and they will maintain, operate, meter, bill and collect money for 33/11kV substations, 11kV feeders and low voltage lines by themselves.
- There are approximately 2000 persons taking training in 2002-2003.
- From November 2003, a course of "Mind Set Training" will be offered for the junior employee of CPDCL.

(2) Engineering Staff College of India (ESCI)

- ESCI has six training divisions: "Power & Energy", "Quality, Productivity & Environment", "Management & Technology", "Water Resources Development", "Rural & Urban Development," "Civil/ Transportation Engineering" and "Information Technology."
- ESCI is planning 32 training programs during 2003-2004.
- Continuing education programs have been formulated and these are open to serving engineers of public and private sector organizations as well as state and central government departments.
- ESCI also organizes & conducts tailor-made in-house programs to meet specific requirements of such organizations.
- ESCI conducts postgraduate diploma courses in Quality Management, Construction Management & Transportation Engineering.
- ESCI has core faculty in all the engineering and management disciplines comprising of very senior engineers, eminent scientists and teachers who have rich experience in respective fields, collectively representing several decades of professional experience.
- ESCI derives faculty services, (Visiting and Adjunct Faculty) from a large number of national and international organizations.

(3) Central Institute for Rural Electrification (CIRE)

- CIRE is planning 15 training programs during 2003-2004.
- CIRE has organized up to March 2003, 621 training programs and 12,224 officers from State Electricity Boards, Electricity Departments, Rural Electric Co-operatives, Banks, Rural Development Agencies etc. participated in various programs.
- CIRE also organizes seminars and workshops in collaboration with other organizations on topical themes.
- Tailor-made programs on specialized subjects can be conducted at a place of choice of the sponsoring organization.
- CIRE has set up an Energy Park to develop awareness of soft energy paths i.e. NRSE (New and Renewable Sources Energy) system by demonstrating the technical and economic feasibility of such systems. It has a Solar Photovoltaic Street Lighting System, Solar Photovoltaic Lantern, Solar Water Heating System, Solar Photovoltaic Pumping System and a 4-kW Wind Energy System with battery backup and Solar Cooker.

7.5 Recommendations

Recommendations of training for implementation of the distribution network are shown as follows.

7.5.1 Recommended Training Programs for the Distribution Network

Although introduction of new technology is also important for improvement of construction, maintenance, and operation of the distribution facilities, it is important to nurture additional talented engineers and workers. Items required for improvement of the distribution facilities are identified based on the present investigation and the training programs for the distribution network is summarized as one of the solutions as follows. The study team proposes reflecting this training program for the distribution network in the existing training programs. The contents of the training program are as follows.

- Safety
- Plan of distribution lines
- Construction of distribution lines
- Operating the distribution network
- Restoration of the distribution network
- Maintenance of the distribution network

7.5.2 Recommended Individual Training Programs

In order to raise customer satisfaction as shown in Figure 7.1, improvement of distribution facilities and personnel training are required. The study team combines with the proposal of the new training program in CTI and LSTC, and proposes methods by which such training programs permeate to cutting edge engineers and workers.

In order to satisfy customers as shown in Figure 7.2, new training programs are more effective, easier, and cost less.

(1) Suggestion to the CTI training program

CTI currently unifies and executes various training for engineers and officers who are considered "Non workers." However, this ties up engineers and officers from the regional offices during training and it is especially difficult for them to attend training of more than one week.

Instead, the faculty should be dispatched from CTI, and training of Assistant Engineers, who are especially busy at their office, should be executed in the regional office. This saves the travel time of A.E.s and avoids them having to be absent from their offices for long periods.

In addition, training programs executed at regional offices will be effective in accurate supervision of construction work and decreasing defective work. Thus the study team suggests training programs as follows.

- Distribution-work safety training
- Distribution-work completion-statutory-inspection training

(a) Distribution-work safety training

Work on the distribution system is conducted by distribution line workers and others. A.E.s and others conduct operation and maintenance of their distribution systems.

Work safety is not only a consideration for workers but also engineers, because engineers supervise work and are responsible for safety management.

Thus, distribution work-safety training is executed for engineers as well as distribution line workers in the field and the lecture room. The training program includes training engineers in distribution-work safety management.

(b) Distribution-work completion-statutory-inspection training

Completion-statutory-inspection of the distribution line is necessary in order to improve the quality of its construction. Thus, the study team recommends that A.E.s, etc. in the regional offices conduct a completion-statutory-inspection. The training program includes training engineers for inspection items and inspection standards.

(2) Suggestion to the LSTC training program

LSTC currently unifies and executes various training for sub-engineers, distribution line workers, etc.

To enhance the reliability of the existing distribution system, the study team recommends executing the training programs as follows.

The study team suggests that LSTC adopts the same maintenance training manner as CTI. This would save travel time to attend the training and workers would not need to be absent from their offices for long periods. In addition, the study team suggests the training should be divided into two steps. The first step is that the workers are assembled at LSTC and the training program is executed there. The second step is that the training program is executed at each regional office through practical work.

Regarding the existing training program, the study team recommends separating training that can be performed at the regional offices from the training programs that are normally executed at LSTC, and then the faculty should be dispatched from LSTC to provide lectures at each regional office.

- Distribution-work safety training
- Patrol, inspection and measurement training
- Distribution line construction-standards training

(a) Distribution-work safety training

LSTC is planning to execute training called "Workshop on safety measures in the field," which is conducted for one day and consist of 12 items during 2003-2004.

It is important that the distribution-work safety training is executed for workers who are directly in charge of the work. The training is conducted not only in the lecture room, but also in the field, simulating the practical work. Thus the training program includes general safety education in addition to making the working plan, conducting a prevision of danger "Tool Box Meeting", setting "the keep-out area", setting safety signs, conducting voltage detection, setting and removing grounding fittings, etc.

(b) Patrol, inspection and measurement training

In order to reduce the number of power failures caused by the distribution system, it is important that a periodic patrol, inspection and measurement should be conducted. The training program includes training workers in how to perform patrols, inspections and measures for the distribution system.

(c) Distribution line construction-standards training

Approximately 50% of outage is caused by defective connection of conductors. Thus, it is expected that the reliability of the distribution line would be improved if the distribution line work were conducted accurately. The training program includes training workers in the manner of connecting conductors and fixing the conductor to the insulator using a binding wire.

7.5.3 Recommendation on Training Facilities

The investigation team proposes an expansion plan for training facilities of LSTC in order that APCPDCL executes the individual training program to upgrade maintenance and operation ability of site engineers and site workers in power distribution plants.

LSTC expansion plan consists of three major items.

- Construction of indoor training facilities (Computer laboratory)
- Reconstruction of outdoor training facilities (Facilities for practical skills training in power distribution plants)
- Preparation of materials and equipments for practical training in distribution network

The contents of each item are as follows.

(1) Construction of indoor training facilities (Computer laboratory)

Currently, LSTC does not provide any computer-applied training course. However, introduction of computers to power distribution plants is indispensable for plant management on site and customer service. Electronic data processing on maintenance/operation management and customer service will be advanced rapidly.

CTI has already started to provide the practical skills training course in personnel computers usage for advanced engineers. Also at LSTC, construction of computer laboratory should be recommended in order to provide field engineers and field workers with the computer-applied training program.

The outline of computer laboratory is as follows.

Table 7.1 Outline of new computer laboratory at LSTC (draft)

Items	Specifications	Quantity
Building		
Computer laboratory	20m x 20m, including air conditioner	400m^2
Computer console		
Computer	CPU ; Pentium 4 2.4GHz, Memory ; 256MB HDD ; 40GB ; CD-RW, 15-inch Color display	20
Operation software	Windows XP Professional	20
Application software	MS Office Professional	20
Color printer	Laser printer (A-3 compatible)	5
Overhead projector		1
LDC projector		1
Capture		1
UPS	3kVA	5
Fixture		
	Desk, Chair, Whiteboard, etc.	1 suite

The existing sanitary accommodations including a lavatory and others should be used. And such facilities should not be equipped in the laboratory.

(2) Reconstruction of outdoor training facilities (Facilities for practical training in distribution network)

Although LSTC has outdoor facilities for practical training in distribution network, the existing facilities are not sufficient because of the inadequate contents. They have some poles for climbing training and simulated line of 11 kV distribution line. Therefore, it has been proposed to replace the existing outdoor facilities with new one taking the following into considerations.

- To install high voltage simulated line of 33kV and 11kV (including straight and bending portion of 30° and 90°)
- To install low voltage distribution simulated line (including vertical intersection)
- To install board wall with integrating wattmeter and simulated service wire for service wire installing training
- To install transformers for three phase 315kVA, 250kVA, 160kVA, 100kVA, 63kVA, 25kVA, 3x15kVA and single phase 15kVA, which APCDDCL uses now, on the route of simulated line of high voltage distribution lines for practical maintenance training in transformer.
- To build three power poles for cable laying training of high voltage cable
- To build warehouse for storage of training materials and equipments

The outline of outdoor training facilities is as follows.

Table 7.2 Outline of outdoor training facilities (draft)

Items	Specifications	Quantity
33kV simulated distribution line	ACSR 55mm^2	50m
11kV simulated distribution line	ACSR 34mm^2	50m
Low voltage simulated distribution line	Three phase, four wire, 34mm^2	50m
Pole		
For high voltage	Height ; 9m	20
For low voltage	Height ; 8m	10
Wattmeter		
	For single phase (5-20A)	3
	For three phase (5-20A)	3
	For three phase (10-40A)	3
Pole-mounted transformer		
	Three phase, 315kVA	1
	Three phase, 250kVA	1
	Three phase, 160kVA	1
	Three phase, 100kVA	1
	Three phase, 63kVA	1
	Three phase, 25kVA	1
	3 x 15kVA	1
	Single phase, 15kVA	1
Warehouse for materials and equipments	15m x 10m	150m^2

Figure 7.3 shows the layout of new LSTC outdoor training facilities (draft).

(3) Preparation of materials and equipments for practical training in distribution network

The required materials and equipments mentioned at 7.5.2 are shown in Table 7.3.

Table 7.3 Materials and equipments for outdoor practical skills training

Items	Contents	Quantity	Remark
Equipments			
Hand-operated crimping tool		30	
Hand-operated cable cutter		30	
Tool box	Tools, helmet, safety shoes, groves	30 sets	
High voltage insulation tester		10	
Low voltage electroscope		10	
Handy high voltage electroscope		10	
High voltage phase checker		10	
Battery-type insulation tester		10	
Telestereoscope		10	
Safety belt		30	
Materials			
C cramp	For branching conductor		
	For $34mm^2$	6,000	5pieces / person x 20person / time x 12times / year x 5years
	For $55mm^2$	6,000	ditto
	For $100mm^2$	6,000	ditto
Straight sleeve	For connecting conductor		
	For $34mm^2$	6,000	5pieces / person x 20person / time x 12times / year x 5years
	For $55mm^2$	6,000	ditto
	For $100mm^2$	6,000	ditto
Conductor			
	For $34mm^2$	12,000m	10m / person x 20person / time x 12times / year x 5years
	For $55mm^2$	12,000m	ditto
	For $100mm^2$	12,000m	ditto

Materials just required for the distribution line construction-standard training are listed. The quantity is determined on 20 person / time, based on 12 times / year and for 5 years.

(4) Approximate cost of LSTC expansion plan

LSTC expansion plan has been explained in 7.5.3(1)-(3). The approximate cost for the plan is calculated in this section.

The results of the calculation are shown in Table 7.4.

Table 7.4 Approximate cost for LSTC expansion plan

Items	Specifications	Cost (thousand yen)
Indoor training facilities		18,500
Building	Including air conditioner	10,000
Computer apparatus		8,000
Fixture		500
Outdoor training facilities		5,000
Outdoor practical training facilities		3,000
Warehouse for materials and equipments		2,000
Training materials and equipments for outdoor training		64,000
Equipments		14,000
Materials		50,000
Total		87,500

Table 7.4 shows the approximate cost for the training facilities, materials and equipments for LSTC expansion plan. It excludes such operating expenses as instructor fee or travel and hotel charges of participants.

7.5.4 Suggestion Regarding the Training Implementation Method

The on-site survey shows that field engineers and workers are busy with their daily works, it is difficult in Hyderabad to go out in order to take a lecture in CTI or LSTC, which means that they receive insufficient training. On the other hand, since the reliability of distribution facilities must be improved in order to raise customer satisfaction, cutting edge engineers and workers who are responsible for maintenance, operation of these facilities and directly facing customers should be given sufficient training.

The following three steps are proposed as a method of providing training.

Upon this, two suggestions are presented as a way to train equally and periodically all of the employees of APCPDCL down to the field workers, as described below:

(1) Career Development Program

An investigation made of the attendance of site engineers and workers to training programs shows that only a small number of employees have undergone a training program organized in LSTC and that a further smaller number of employees have attended to more than one training program. As an example, a worker has attended to only one training program during his 20 years career.

The training programs offered in LSTC are modified every year in reply to the needs on site. A particular program is offered to a limited number of trainees selected according to their occupational positions.

However, as described above, the training programs offered in LSTC are not always so organized, in reality, as to continuously develop the abilities of individual workers.

The study team proposes a career development program aimed at improving the abilities of individual workers and developing their careers.

(a) Purpose

The purpose of the career development program is to offer to an individual worker a training program corresponding to the length of his career and his occupational position and at a time as required by his actual conditions.

(b) Implementation of the program

- ✓ Classify the existing training program into basic, intermediate and advanced courses.
- ✓ Impose a certain limit on the period during which employees can attend to a training course according to their length of career. For example, offer the basic course to employees whose career are for 5 years or less including newly recruited. The intermediate course is provided for employees whose career is for 6 to 10 years and the advanced course are provided for employees whose career is more than 10 years.
- ✓ Impose such a restriction that no trainee who does not finish a lower class course can attend to a higher class course.
- ✓ In principle, offer a training course to an employee so that he may undergo it in the first year of the period allocated to him. For example, the intermediate course should be provided for 6^{th} year employees.
- ✓ Offer a higher course to an employee who is promoted to a higher status, regardless of their length of career.

(c) Positive effects

The stipulation of trainees and training periods allows engineers and workers actually occupied by their daily tasks on site to have an equal opportunity to attend to a training program.

The classification of training programs and the need to attend to a specified training program for the promotion in status are effective in heightening trainees' will to learn.

(2) Training implementation method

At present, the field engineers and workers belonging to APCPDCL are intensively trained only in LSTC. However, as described above, the field engineers and workers are occupied by their daily tasks have difficulties in going to Hyderabad to attend to the training courses. Therefore, they have no opportunity to attend the training.

In order to make employees receive the training effectively and in equally, the study team suggests dividing the training implementation method into three stages as described below:

(a) Step 1

The new training program shown in 7.5.1 and 7.5.2 is carried out at CTI and LSTC.

(b) Step 2

In order that cutting edge engineers may shorten the period in which they are out of the office and attend training conveniently, engineers and workers are brought together in each divisional headquarters and training is provided by dispatch from CTI and LSTC.

(c) Step 3

Basic practical training facility for the distribution line is newly established in each divisional headquarters, and the faculty is dispatched from LSTC so that engineers and workers of the area concerned are able to attend lectures on practical training conveniently.

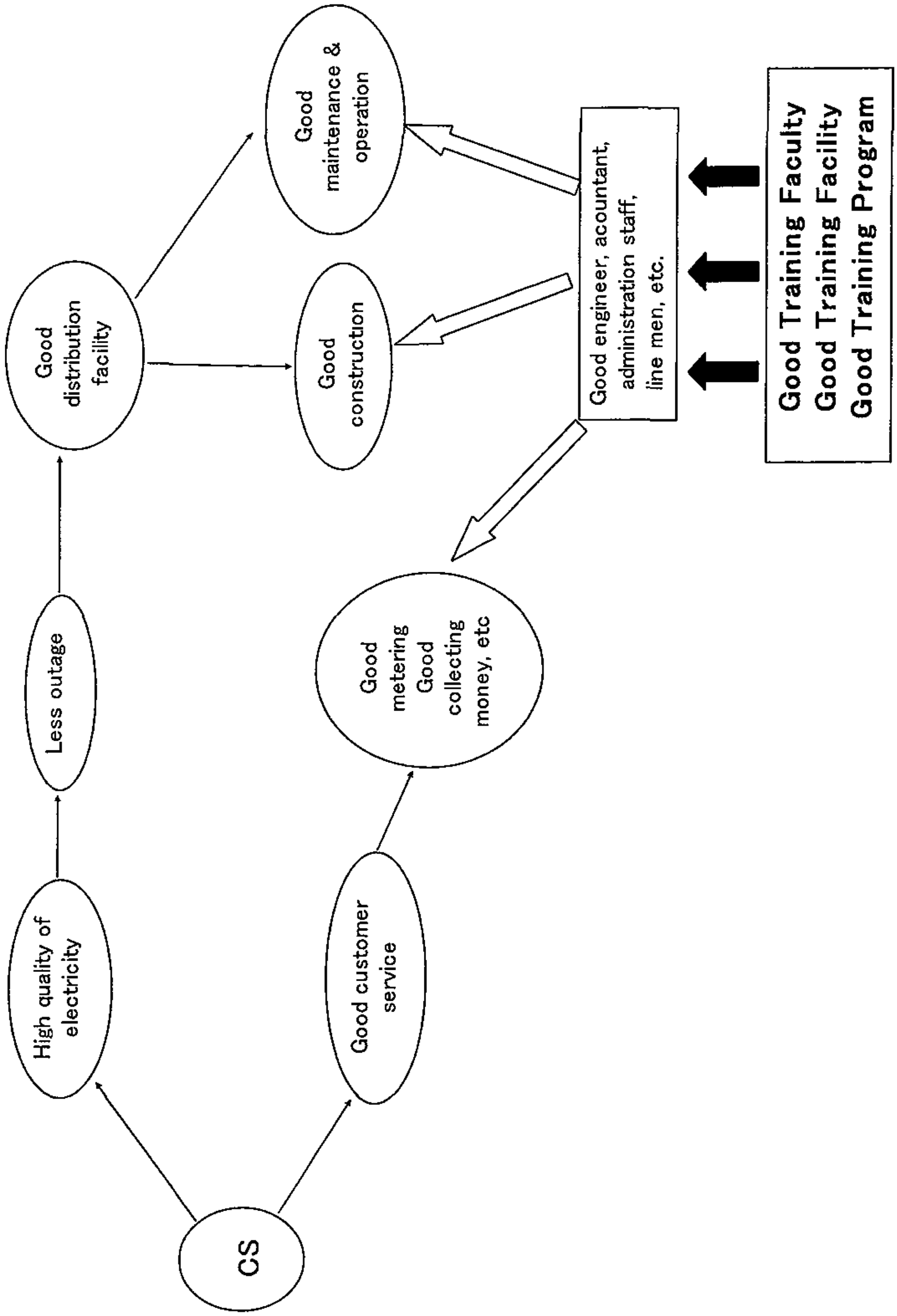


Figure7.1 Purpose of conducting training

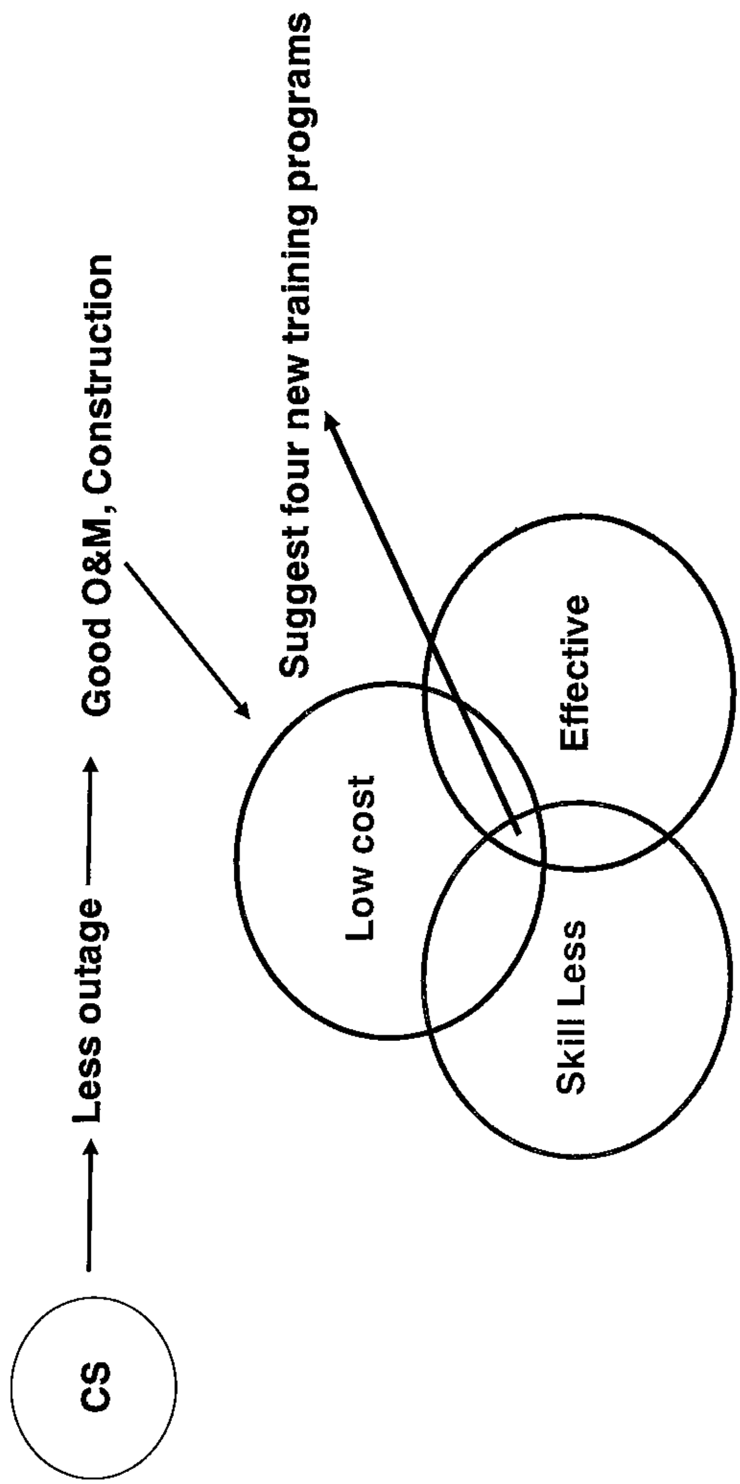


Figure7.2 Concept of the new training programs

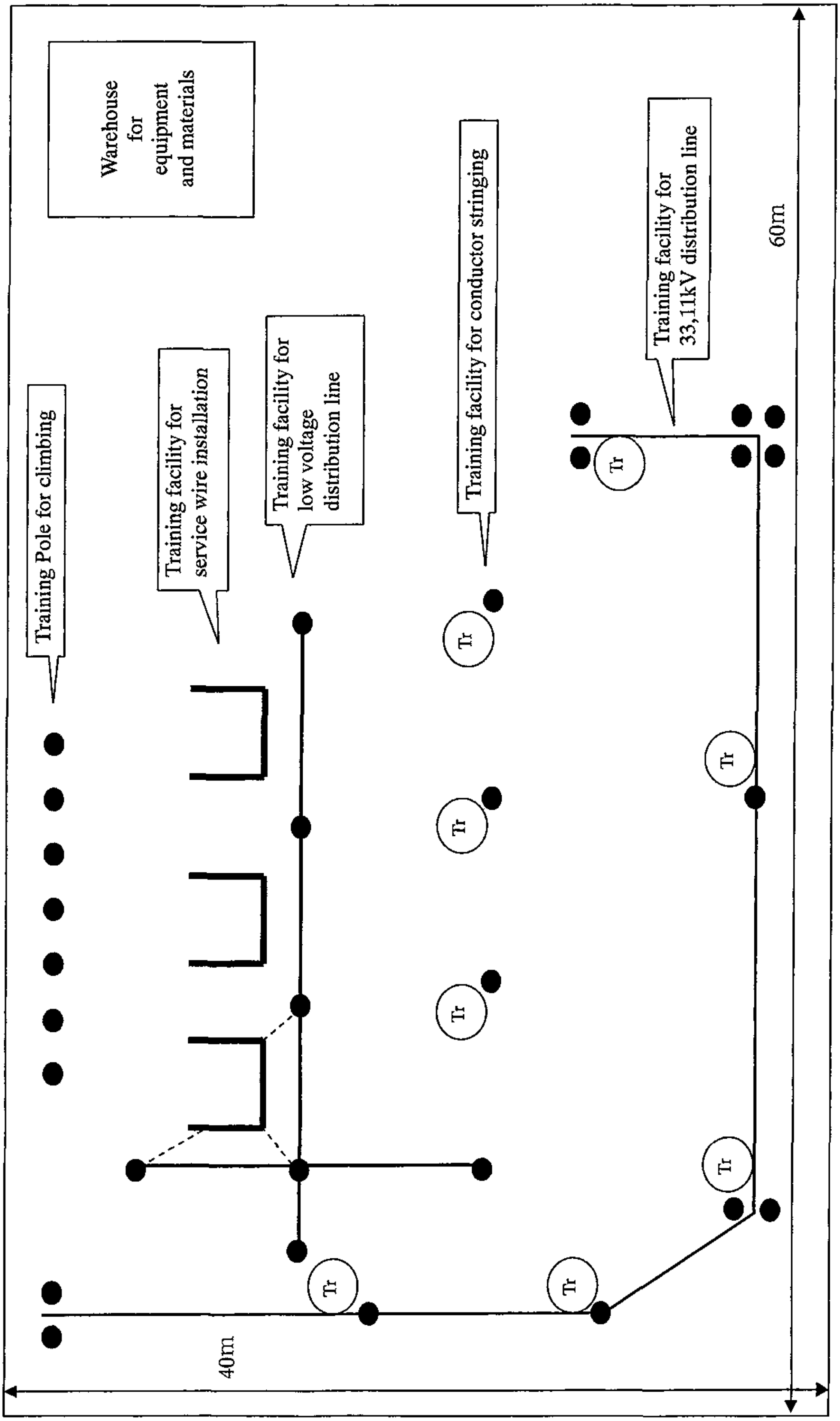


Figure 7.3 Outdoor practical training facilities for distribution network at LSTC (draft plan)

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