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

FEBRUARY 2004

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

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Preface

In response to a request from the Government of Republic of India, the Government of Japan decided to conduct and entrusted the Development Study on the Improvement of Power Distribution System of Andhra Pradesh in Republic of India to Japan International Cooperation Agency (JICA).

JICA sent a study team led by Mr. Kudo of Electric Power Development Co., Ltd. to India 5 times from October 2002 to February 2004.

The study team held discussions with the officials concerned of the government of Andhra Pradesh in Republic of India and conducted related field surveys. After returning to Japan, the study team carried out further studies and compiled the final results in this report.

I hope this report will contribute to improvement of power distribution system of Andhra Pradesh and to the promotion of amity between our two countries.

I also express my sincere appreciation to the officials concerned of the Government of Republic of India and Andhra Pradesh for their close cooperation throughout the study.

February 2004

Tadashi IZAWA
Vice President
Japan International Cooperation Agency

February 2004

Tadashi IZAWA
Vice President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

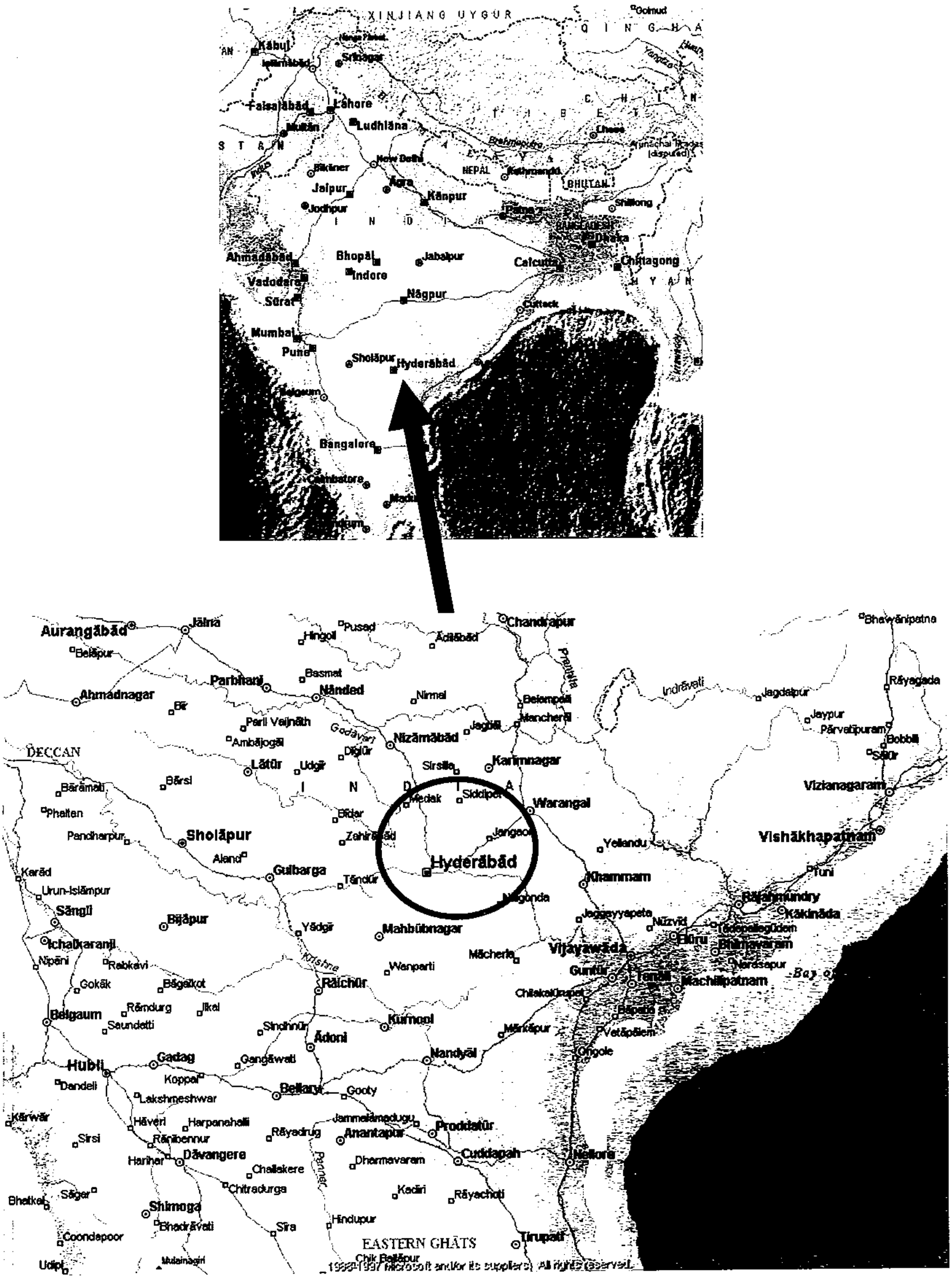
We are pleased to submit you the report of the Development Study on the Improvement of Power Distribution System of Andhra Pradesh in Republic of India.

This study was conducted by Electric Power Development Co., Ltd. under a contract to JICA, during the period from October 2002 to February 2004. The major contents of the report are the technically and economically feasible integrated approach for improvement of power distribution system in Andhra Pradesh, focussed on loss reduction and improvement of the quality of the power supply.

On this report, the field surveys were mainly carried out in the area around Hyderabad in Andhra Pradesh and integrated approach for Andhra Pradesh was suggested, however, in view of urgency to enhance electric system efficiency and boost of social and economical development in Republic of India, we recommend that the Government of Republic of India take this integrated approach as a highest priority and apply it to the whole of India.

We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, Ministry of Foreign Affairs and Ministry of Economy, Trade and Industry. We would also like to express our gratitude to the officials concerned of the Government of Republic of India and Andhra Pradesh, the Transmission Corporation of Andhra Pradesh, Andhra Pradesh Central Power Distribution Company Limited, JICA Delhi Office and Embassy of Japan in Republic of India for their cooperation and assistance throughout our field survey.

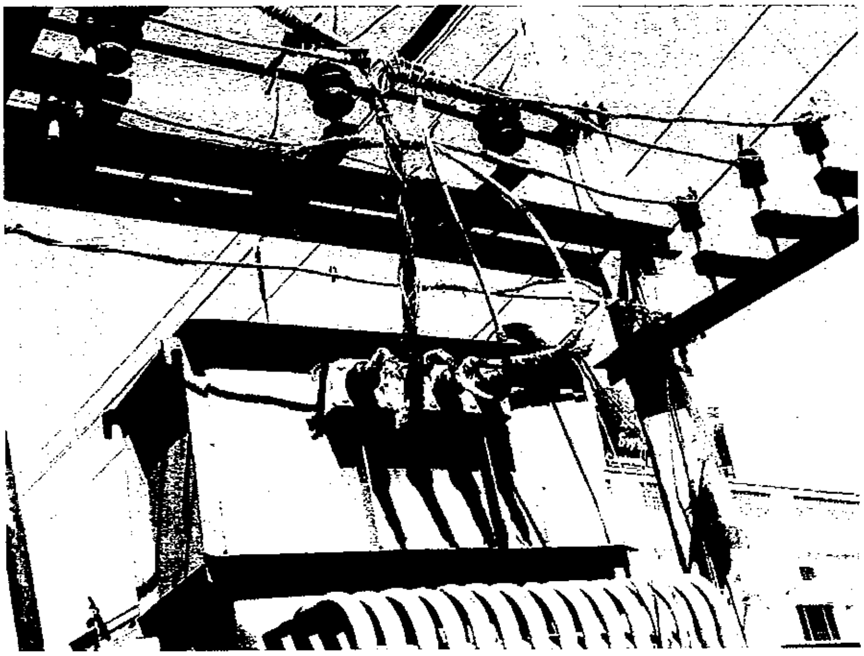
Yoshiyuki KUDO
Team Leader
Study Team



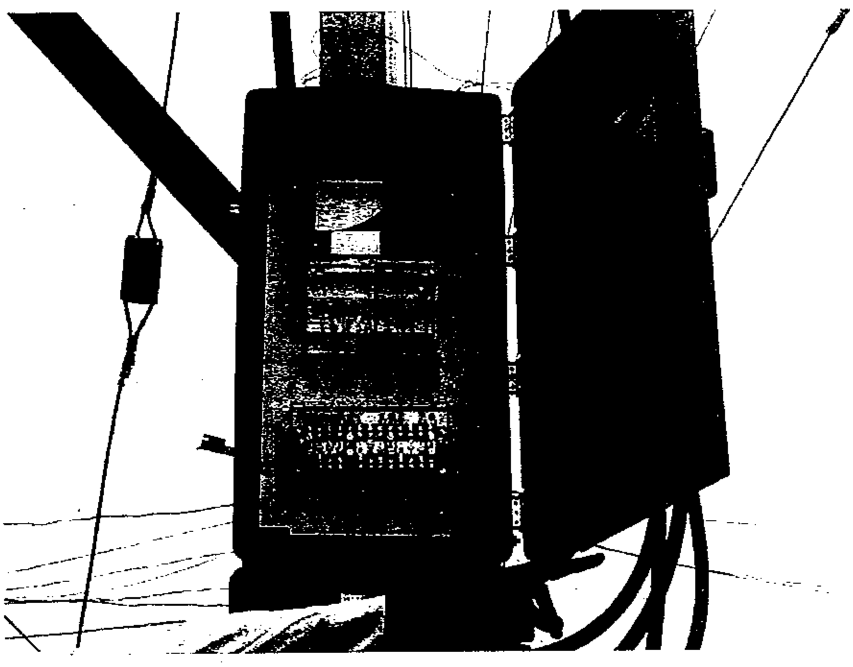
Area of the Study

First Workshop in Hyderabad (February 18, 2003)

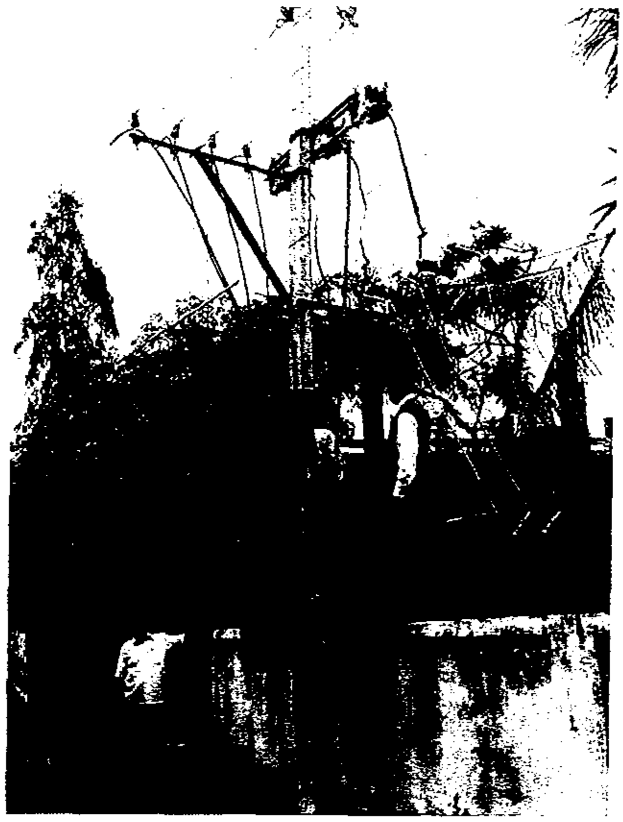
Technical Transfer in the Office of Ranga Reddy North



Conductor Connection for Distribution Transformer



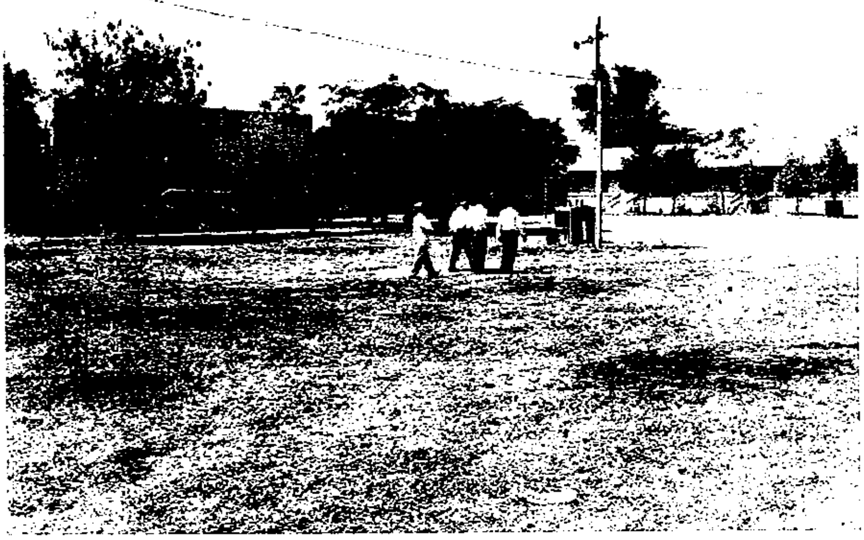
Watt-hour Meter



Installation of WHM

GIS Data Collection at Site

Computer Training Room (Corporate Training Institute)



Line Staff Training Center

The Development Study on the Improvement of Power Distribution System of Andhra Pradesh in India
(Final Report)

Contents

Abbreviation

A	ampere
AAE	Additional Assistant Engineer
AAO	Additional Account Officer
ABT	Available Basic Tariff
ACSR	Aluminum Conductor Steel Reinforced
ADE	Assistant Divisional Engineer
AE	Assistant Engineer
amp	ampere
AO	Account Officer
AP	Andhra Pradesh
APCPDCL	Central Power Distribution Company of Andhra Pradesh Limited
APDRP	Accelerated Power Development and Reform Program
APERC	Andhra Pradesh Electricity Regulatory Commission
APGENCO	Andhra Pradesh Generation Corporation
APL	Adjustable Program Lending
APSEB	Andhra Pradesh State Electricity Board
APTRANSCO	Transmission Corporation of Andhra Pradesh Limited
AS	Assistant Secretary
Ave. kW	Average kW
CB	Circuit Breaker
CBD	Central Break Down Group
CEA	Central Electricity Board
CGM	Chief General Manager
CIDA	Canadian International Development Agency
CIRE	Central Institute for Rural Electrification
CMD	Chairman & Managing Director
CMS	Customer Management System
CPDCL	Central Power Distribution Company of Andhra Pradesh Limited
CTI	Corporate Training Institute
DBMS	Database Management System
DCC	Distribution Control Center
DE	Divisional Engineer
DFID	Department for International Development
DISCOMs	Distribution Companies
DLF	Dispersal Loss Factor
DMS	Distribution Management System
DS	Deputy Secretary

DSM	Demand Side Management
DTR	Distribution Transformer
EA2003	Electricity Act 2003
EHV	Extra High Voltage
ENS	Energy Not Served
EPDCL	East Power Distribution Company of Andhra Pradesh Limited
ERO	Electricity Revenue Office
ESCI	Engineering Staff College of India
FOC	Fuse of Call
GC Breaker	Group Countered Breaker
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GPS	Global Positioning System
GSDP	Gross State Domestic Product
HDD	Hard Disk Drive
HT	High Tension (HV)
HV	High Voltage (HT)
Hz	hertz (cycles per second)
IPP	Independent Power Producer
IT	Information Technology
JAO	Junior Account Officer
JICA	Japan International Corporation Agency
kV	kilovolt = 10^3 V
kW	kilowatt = 10^3 W
kWh	kilowatt hour = 10^3 Wh
LAN	Local Area Network
LCD	Liquid Crystal Display
LDC	Lower Division Clerk
LOLP	Loss of Load Probability
LSTC	Line Staff Training Center
LT	Low Tension
LV	Low Voltage
M/M	Minutes of Meeting
MARS	Multi Address Radio System
Max. AMP	Maximum ampere
Min. AMP	Minimum ampere
MRB	Meter Reading Book
MU	Million unit = 10^6 Unit
MVA	Megavolt Ampere = 10^6 VA

MW	Megawatt = 10^6 W
NPDCL	North Power Distribution Company of Andhra Pradesh Limited
NPV	Net Present Value
OHP	Over Head Projector
OJT	On the Job Training
OP	Operation
PC	Personal Computer
PF	Power Factor
PLC	Power Line Carrier
PO	Personal Officer
PPA	Power Purchase Agreement
RCS	Remote Communication Server
RF	Radio Frequency
Rs	Rupee
RTU	Remote Terminal Unit
S/W	Scope of Work
SAO	Senior Account Officer
SCADA	Supervisory Control and Data Acquisition
SE	Superintending Engineer
SPDCL	South Power Distribution Company of Andhra Pradesh Limited
sqkm	Square kilometer
sqmm	Square millimeter
SRLDC	South Region Load Dispatch Center
SS	Substation
SVR	Step Voltage Regulator
SW	Switch
TBM	Tool Box Meeting
TDMA	Time Division Multi Access
TR	Transformer
UDC	Upper Division Clerk
V	volt
VD	Voltage Drop
VHF	Very High Frequency
WB	World Bank
XLPE	Cross linked Polyethylene

Summary and Recommendations of the Study

Contents

Summary and Recommendation of the Study

1. Study Period

From October 2002 through February 2004.

2. JICA Study Team

This study was carried out by Electric Power Development Co., Ltd. (J-POWER)

3. Purpose of the Study

The purpose of this study is the improvement of the distribution system in Andhra Pradesh, and eventual better customer service.

The study team also promoted the technical transfer to the counterpart personnel from APTRANSCO and power distribution companies. The study team considered it important that power distribution companies will replicate the study and will improve the distribution system by themselves.

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 lowness of the reliability and the chronic shortage of electric power supply have not been solved.

Also in Andhra Pradesh, electric power supply is shortage, and transmission and distribution loss rate is over 30%. And it is estimated that much of loss is due to the distribution section. So the improvement of the distribution system is strongly asked.

4. Strategy of the Study

For the improvement of the 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 system, covering all three elements.

In the meantime, to facilitate technical transfer, the study team has adopted a joint implementation with counterpart personnel from APTRANSCO and power distribution companies. 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 important that the study that is conducted by the study team will be replicated by personnel of power distribution companies, not only in other areas of CPDCL, but also of other distribution companies to eventually cover the whole of the state of Andhra Pradesh.

5. Elements of the Study

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

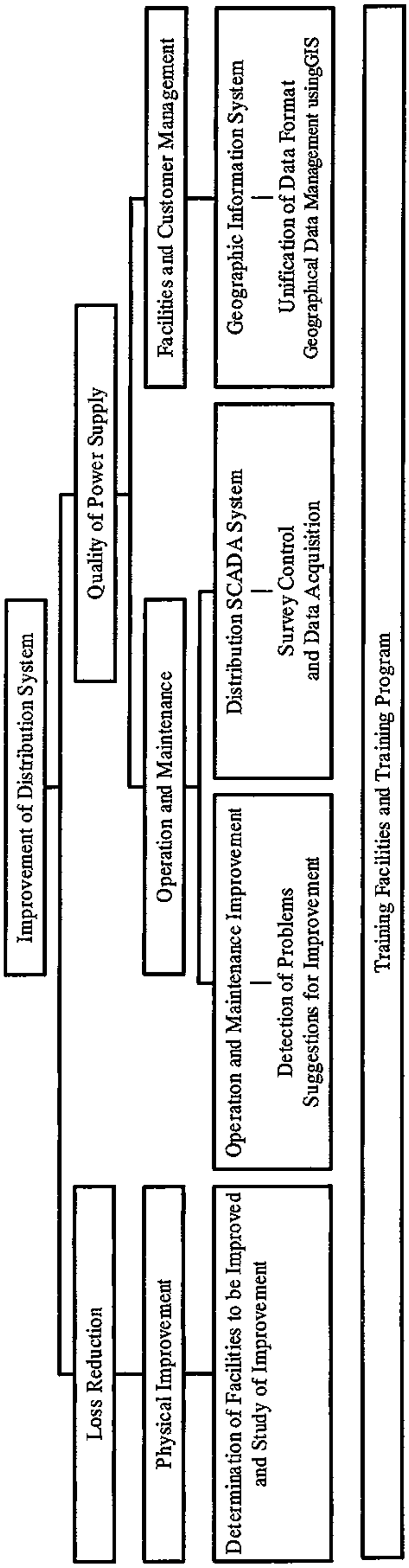


Figure1 Strategy of the Study

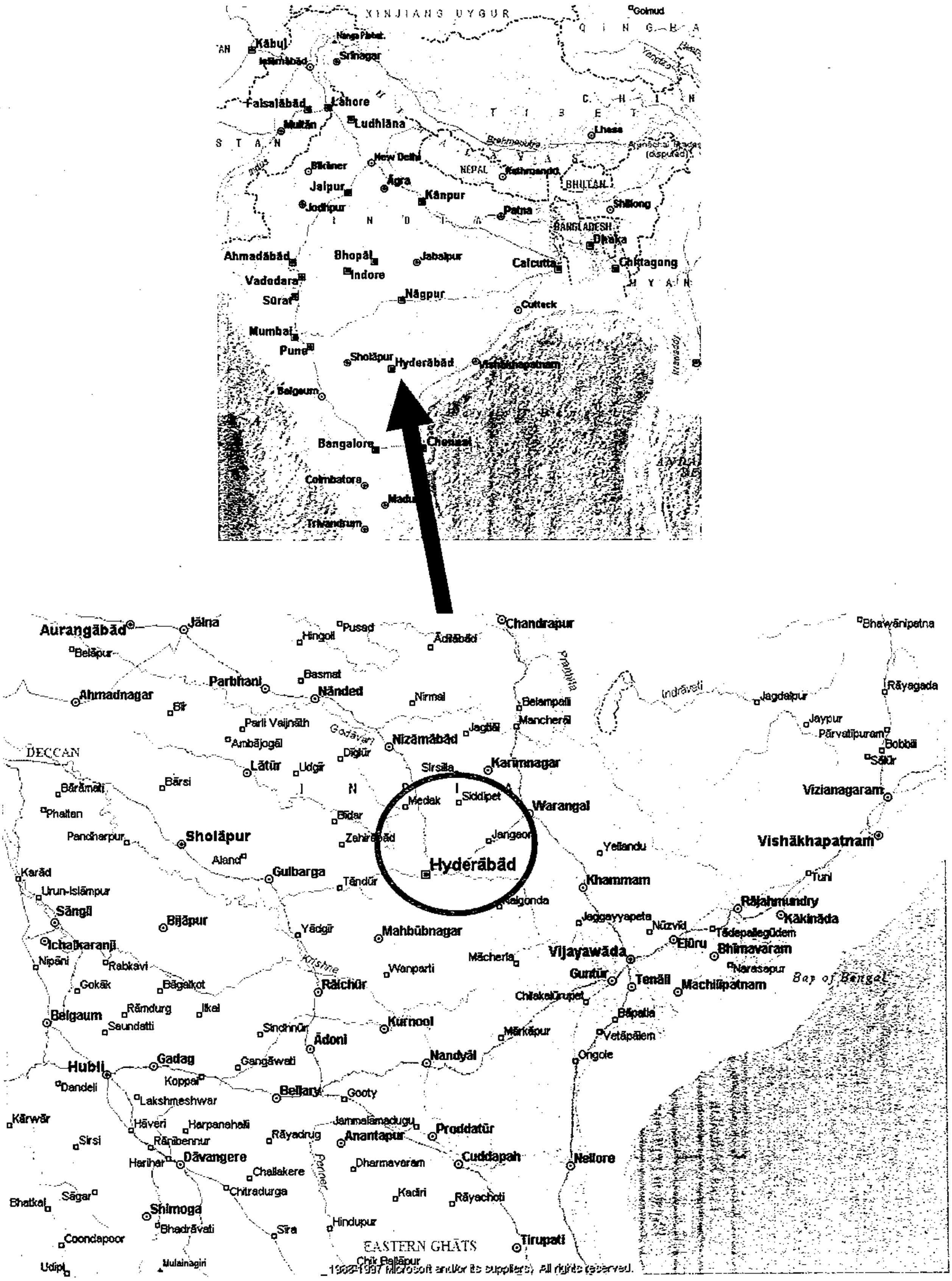


Figure 2 Area of the Study

6. Current Situation of the Distribution System in Andhra Pradesh

6.1 Operation and Maintenance of the Distribution Network

Some feeders stopped 100 times or more in 2002/03. Approximately half of outages, cause of outages are not identified.

DISTRIBUTION CODE will be enforced in 2004, after that, the voltage fluctuation to the customers, number and duration of outages and so on shall operate within the specified target value by it.

The manual arranged by APSEB which was the former organization before power industry reform, is still used.

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

The energized parts of distribution transformer and switch box are exposed without protective covers so that the general public may touch them easily.

6.2 SCADA System

The existing SCADA monitor the system and control up to the distribution substations. The further functions such as monitoring and controlling feeder current or transformer load, however, are expected to be equipped with the existing SCADA system. These functions indirectly realize load levelling of feeders in a substation and reduce feeder OHM loss.

6.3 Physical Improvement of Distribution Network

Although necessity of reducing energy losses of Low-voltage distribution facilities have been pointed out, at present the facility control is not adequate and the status of loads on each distribution transformer is not supervised constantly.

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

6.4 Facilities and Customer Management

Facilities data, such as a transformer and a distribution line, and customer data are managed by each substation and Section Office. However, there is no unification about a management data and the management method. Each substation and Section Office are carrying out by each method.

Distribution power companies downloads customers' data from the hand-held computer and manages at Electricity Revenue Office (ERO). These management data are service number, power demand, electricity charge, arrears, the date of the contract, etc. The data is represented by the figures.

6.5 Training Facilities and Program

Although APTRANSCO and APCPDCL have own training equipment and are carrying out the training program to an employee, they are insufficient of training equipment division computers, simulators, etc. Moreover, the safety-measures program etc. is not performed.

7. Results and Recommendations of the Study

As a result of investigation, the study team proposes to APTRANSCO and APCPDCL as follows in order to improve the power distribution system in the State of Andhra Pradesh and to improve customer service.

7.1 Operation and Maintenance of the Distribution Network

7.1.1 Reduction of the Number of Outages

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 adoption of a compression type clamp instead of the twist type joint used at the moment.

Approximately half of outages, the cause of outages are 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 makes a preventive plan for recurrence of the same problems.

7.1.2 Correspondence to the DISTRIBUTION CODE

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

7.1.3 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 the 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.

7.1.4 Rearrangement of Low Voltage Wiring

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

7.1.5 Safety Measures to 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.

7.2 SCADA System

7.2.1 Effectiveness of Distribution SCADA

The study team propose an improvement plan of the existing SCADA to introduce distribution supervisory control and data acquisition functions (distribution SCADA) and achieve the following items.

- Improve electricity supply reliability through reduction of the interruption period and outage time 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 load current on feeder, and in turn, improve the utilization rate of distribution feeder as well as reduce distribution losses.

7.2.2 Improvement Plan of Distribution SCADA

The existing SCADA mainly monitors and controls the facilities inside the distribution substations. But the existing SCADA 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 for 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. As for the communication method, Fiber Optic Cable or Radio Frequency is recommendable. Especially, Fiber Optic Cable has been already laid widely in the project area.

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. Below table shows an example of introduction phasing.

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

7.3 Physical Improvement of Distribution Network

7.3.1 Facility Control

Although necessity of reducing energy losses of Low-voltage distribution facilities have been pointed out, at present the facility control is not adequate. The study team recommends collecting and measuring following data and documents and updating them by constant maintenance.

- Status of loads on each distribution transformer
- Network management documents including connections between distribution transformers and LV lines
- Document of connections between customers and LV distribution lines.
- Document of facilities concerning span, size of LV lines

It 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 . When the above-mentioned management is done properly, parts cause for 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.

7.3.2 Implementation Plan

As energy loss of low-voltage distribution facilities in APCPDCL accounts for a larger portion. It is important to improve existing LV facilities. At the implementation of improvement, the study team recommends to shorten the length of LV line and reduce the capacity of distribution transformer.

Selecting an optimal method from the below makes improvement.

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

7.4 Facilities and Customer Management by Use of GIS

7.4.1 Utilization of GIS Data and Benefit

The study team recommends adoption of GIS in facilities and customer management. The aim of the adoption 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. Additionally, analyzing facilities and customer information by using GIS will prove effective for electric reliability and customer service.

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.

Concerning customers' data managed by Electricity Revenue Office (ERO), management items are service number, power demand, electricity charge, arrears, the date of the contract, etc. The data is represented by the figures. 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.

7.4.2 GIS Expanding Plan

When expanding the GIS system, it is necessary to update data, such as a new consumer, installation of new facilities, and change of facilities, every day. Since the amount of business for updating and managing data becomes large, it is necessary to create an exclusive management organization.

Moreover, since immense expense and staff training are required in order to install the GIS in all substations and Section Offices, the study team recommends installing GIS in a Division Office level. However, the data inputted into GIS everyday belong to substations and Section Offices. Then, it is necessary to establish the workflow for transmitting such data to Division Offices.

7.4.3 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

7.5 Training Facilities and Program

7.5.1 Recommended Training Program for the Distribution Network

Although introduction of new technology is also important for improvement of construction, maintenance, and operation for the distribution facilities, it is important to raise talented engineers and workers rather than that. The item to be required for the distribution facilities improvement is extracted based on the investigation conducted by present, and the training programs for the distribution network is summarized as one of the solution of the above extracted item. The study team proposes making this training programs for the distribution network, reflecting in existing training programs.

7.5.2 Recommendation for Training Program

The training program, which is executed at the regional office, should have effect in the perspective of accurate supervising for construction work and decreasing defective work. Thus the study team suggests additional training programs as follows.

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

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

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

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.

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 regarding 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 covered. For example, the intermediate course should be provided in 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' willness 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.

Chapter 1 Introduction

Contents

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-Power 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 mode of execution for the study through joint efforts 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.

The study team selected Ranga Reddy district and Medak district for the coverage area of the Study.

1.2.2 Elements of the Study

The Study comprises 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.

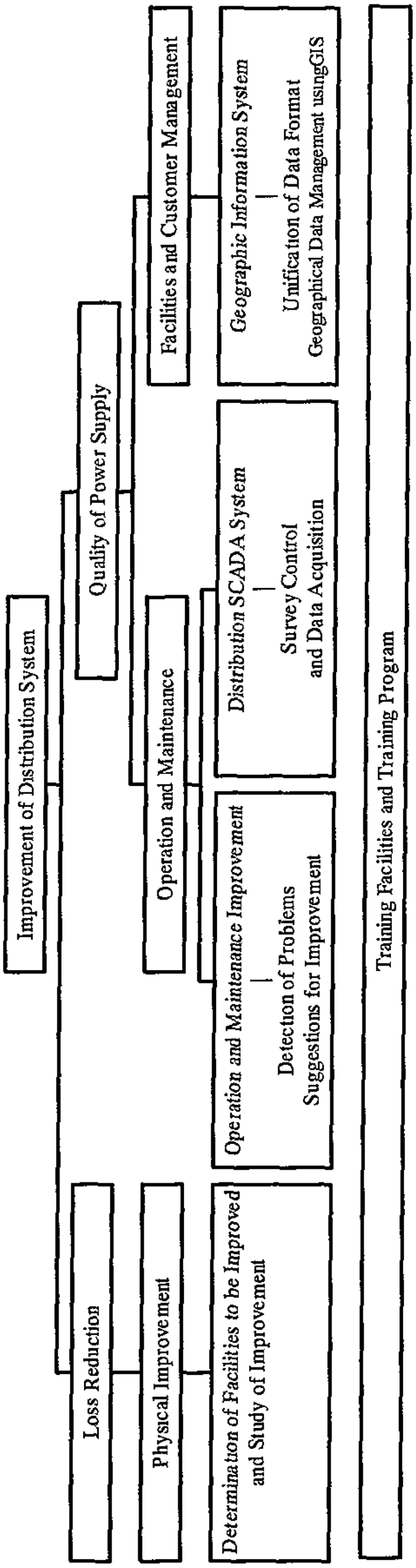


Fig. 1.1 Strategy of the Study

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.

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.

Chapter 2 Status of Power System in Andhra Pradesh

Contents

Chapter 2 Status of Power System in Andhra Pradesh

2.1 Social and Economic Situation in Andhra Pradesh

2.1.1 Population

The provisional population of the state as of March 2001 stood at 7.57 crores. In terms of population, the state ranks fifth in the country after Uttar Pradesh, Maharashtra, Bihar, and West Bengal. The share of the urban population of the total in the state slightly increased by 27.08% in 2001 compared to by 26.89% in 1991. The growth rate during the 1991 - 2001 period, which was 13.86%, was lower compared to the corresponding all of India growth rate of 21.34%. Andhra Pradesh is the fifth largest state in the country, accounting for 8.37% and 7.37% of the country's area and population, respectively. The density of population in the state is 275 persons/km^2 compared with 324 persons/km^2 in all of India. Of the districts, the density of Hyderabad continues to be the highest with 16,988 persons/km^2.

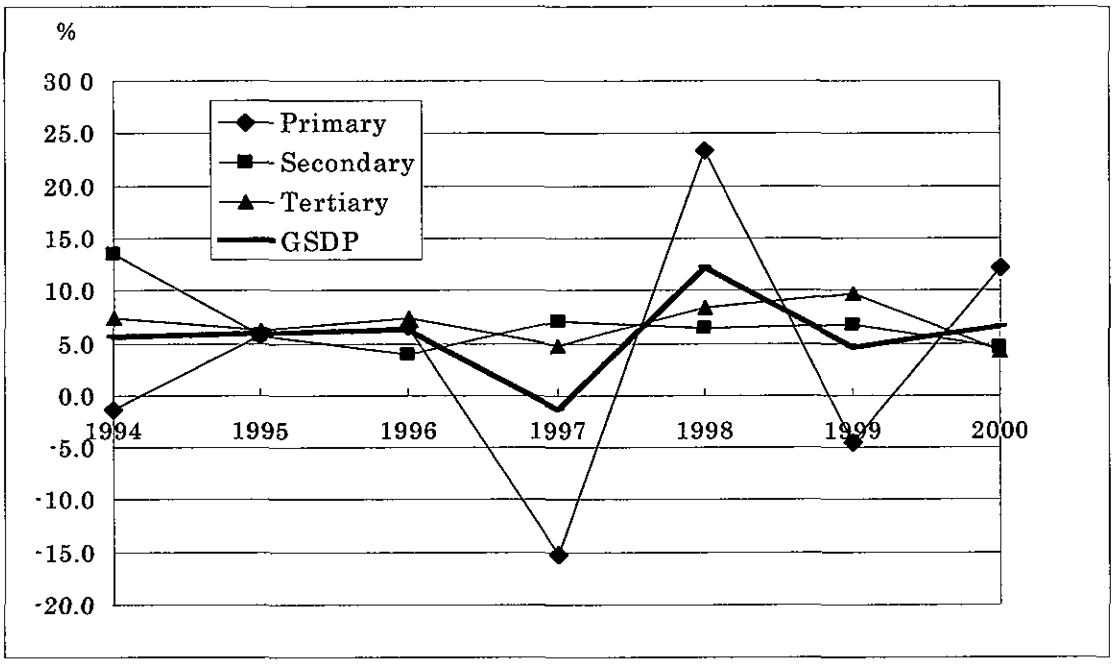
Table 2.1 Details of Population in Andhra Pradesh

District	Males	Females	Urban	Rural	Total	Density
Srikakulam	1,256,370	1,272,121	278,203	2,250,288	2,528,491	433
Vizianagaram	1,120,124	1,124,979	412,093	1,833,010	2,245,103	343
Visakhapatnam	1,903,894	1,885,929	1,511,840	2,277,983	3,789,823	340
East Godavari	2,445,811	2,426,811	1,136,714	3,735,908	4,872,622	451
West Godavari	1,906,104	1,890,040	747,458	3,048,686	3,796,144	490
Krishna	2,151,187	2,067,229	1,365,647	2,852,769	4,218,416	483
Guntur	2,220,305	2,185,216	1,231,233	3,174,288	4,405,521	387
Prakasam	1,549,891	1,505,050	466,709	2,588,232	3,054,941	173
Nellore	1,341,192	1,318,469	603,634	2,056,027	2,659,661	203
Kurnool	1,787,471	1,724,795	792,664	2,719,602	3,512,266	199
Anantpoor	1,859,502	1,779,802	920,079	2,719,225	3,639,304	190
Cuddapah	1,303,160	1,270,321	600,487	1,972,994	2,573,481	168
Chittoor	1,883,454	1,851,748	810,015	2,925,187	3,735,202	247
Rangareddy	1,806,199	1,700,471	1,868,138	1,638,532	3,506,670	468
Hyderabad	1,894,990	1,791,470	3,686,460	0	3,686,460	16,988
Nizamabad	1,161,907	1,180,896	422,533	1,920,270	2,342,803	294
Medak	1,347,241	1,315,055	384,675	2,277,621	2,662,296	274
Mahabubnagar	1,779,992	1,726,884	371,431	3,135,445	3,506,876	190
Nalgonda	1,646,555	1,591,894	429,458	2,808,991	3,238,449	227
Warangal	1,637,682	1,593,492	620,791	2,610,383	3,231,174	252
Khammam	1,299,245	1,266,167	508,048	2,057,364	2,565,412	160
Karimnagar	1,738,248	1,738,831	678,944	2,798,135	3,477,079	294
Adilabad	1,246,287	1,233,060	656,343	1,823,004	2,479,347	154
Total	38,286,811	37,440,730	20,503,597	55,223,944	75,727,541	275

(Source) Economic Survey 2001-2002, Planning Department A.P.

2.1.2 Economy and Industrial Structure

Gross State Domestic Product (GSDP) in the Year 2000-01 at a constant (1993-94) price is estimated at Rs. 84,777 crores, and accounts for 7.1% of all of India. Considering the sectoral composition of GSDP, the share of the tertiary sector is high compared with the other two sectors and accounts for 45.9% of total, followed by the primary sector that accounts for 30.3%, and the secondary sector that accounts for 23.7% (in Indian statistics, Mining and Quarrying belong to the primary sector). On the other hand, for the share of Gross Domestic Product (GDP), the composition in all of India is 26.3% for the primary sector, 24.8% for the secondary sector, and 48.9% for the tertiary sector. The share of the primary sector in Andhra Pradesh is larger than in all of India. In India, agricultural production greatly influences economic growth. However, considered globally, the productivity of the agricultural sector is low. Weather conditions also influence agricultural production due to lack of irrigation facilities. Figure 2.1 shows trend of the economic growth rate in Andhra Pradesh. The growth rate of the secondary and tertiary sectors is comparatively stable. However, the primary sector influences the state economy.



(Source) Economic Survey 2001-2002, Planning Department A.P.

Figure 2.1 Trend of Economic Growth Rate in Andhra Pradesh

Table 2.2 Comparison of GDP in Andhra Pradesh and all India

(Rs. crores at 1993 price)

Year	Andhra Pradesh (A.P.)		All India		Share of A.P.
	GSDP	G.R.(%)	GDP	G.R.(%)	
1993-1994	57,867		781,345		7.4
1994-1995	61,114	5.6	838,031	7.3	7.3
1995-1996	64,729	5.9	899,563	7.3	7.2
1996-1997	68,809	6.3	970,083	7.8	7.1
1997-1998	67,866	-1.4	1,016,266	4.8	6.7
1998-1999	76,116	12.2	1,082,469	6.5	7.0
1999-2000	79,553	4.5	1,148,500	6.1	6.9
2000-2001	84,777	6.6	1,193,922	4.0	7.1

(Source) Economic Survey 2001-2002, Planning Department A.P.

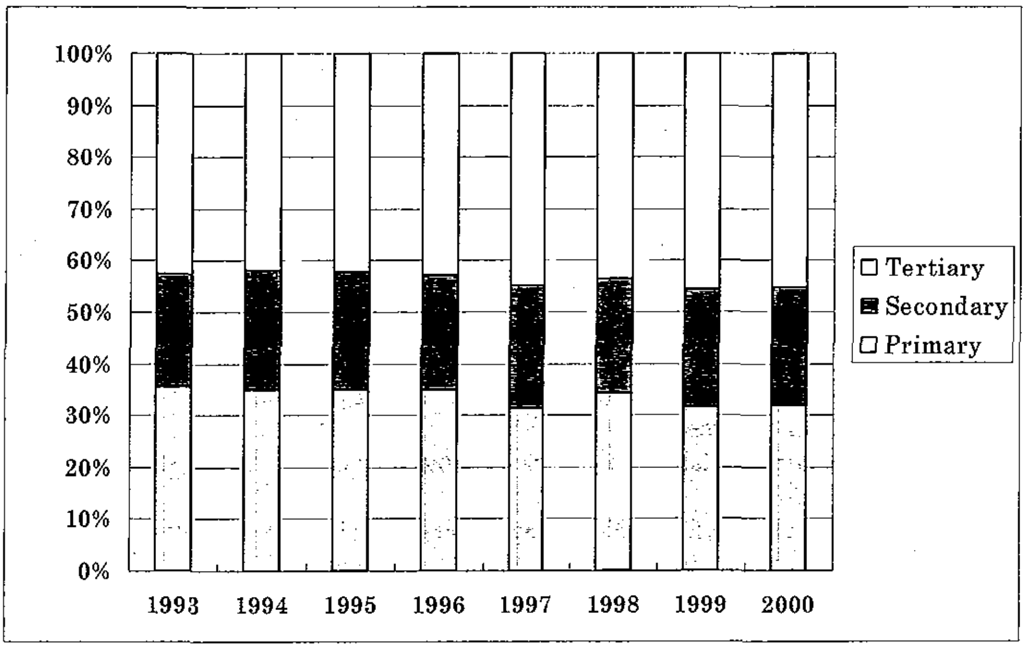


Figure 2. 2 Trend of industrial structure in Andhra Pradesh

The income per capita of Andhra Pradesh at the current price rose from Rs.14,878 in 1999-2000 to Rs.16,373 in 2000-01, registering a growth rate of 10.0%, while at a constant price (1993-94), it has risen from Rs.9,457 in 1999-2000 to Rs.9,982 in 2000-01, registering a growth rate of 5.5%. Table 2.3 shows a comparison of income per capita in Andhra Pradesh and all of India. Andhra Pradesh is slightly lower than all of India.

Table 2. 3 Comparison of income per capita in Andhra Pradesh and all India

Year	Current Prices (Rupees)				1993 Prices (Rupees)			
	A.P.	G.R.(%)	India	G.R.(%)	A.P.	G.R.(%)	India	G.R.(%)
1993-1994	7,447		7,698		7,447		7,698	
1994-1995	8,763	17.7	8,876	15.3	7,739	3.9	8,088	5.1
1995-1996	10,018	14.3	10,160	14.5	8,086	4.5	8,499	5.1
1996-1997	11,224	12.0	11,601	14.2	8,531	5.5	9,036	6.3
1997-1998	11,683	4.1	12,772	10.1	8,214	-3.7	9,288	2.8
1998-1999	13,993	19.8	14,396	12.7	9,162	11.5	9,643	3.8
1999-2000	14,878	6.3	15,562	8.1	9,457	3.2	10,067	4.4
2000-2001	16,373	10.0	16,487	5.9	9,982	5.6	10,254	1.9

(Source) Economic Survey 2001-2002, Planning Department A.P.

2.1.3 Economic Target

Andhra Pradesh has set itself an ambitious vision in January 1999. By 2020, the state will have to achieve a level of development that will provide its people with opportunities to achieve prosperity and well-being, and to enjoy a high quality of life. To achieve this vision, Andhra Pradesh has set the following targets.

- Eradicate poverty and take care of its old, infirm, and genuinely needy.
- Enable its people to learn, earn, and lead healthful and productive lives.
- Give its children a happy childhood and every opportunity to achieve their full potential.
- Empower and support its women and girls to fulfill their roles as equal shapers with men of the economy and society.
- Create the resources its people will need, such as capital and infrastructure, to transform their own futures.
- Enable its farmers, entrepreneurs, professionals to make agriculture flourish and build thriving industries and services businesses.
- Embrace innovation and the latest know-how to grow its crops, make its goods and provide high quality services.
- Safeguard its environment and make its villages and cities clean, green and safe to live in.
- Make its government simple, transparent, accountable, and responsive.

In the vision of 2020, the Andhra Pradesh economy will have to be stimulated to grow by 10.3% a year on average for the next 25 years. The income per capita will grow by 9.4% a year on average. Population growth will have to be contained to 0.8% a year. However, the average annual growth rate in GSDP during the first five years of the vision (1995-2000) works out as 5.5% against the target average annual growth rate of 5.7%. However, for two bad years (1997-98 and 1999-2000) due to drought, the average annual growth rate should have been greater than the target growth rate. The average annual growth rate in income per capita during the five year works out as 4.2% against the target growth rate of 4.4%. For population, the average annual growth rate works out as 1.27% against the target growth rate of 1.3%, a remarkable performance.

In the agriculture sector, the average annual growth rate during the first five years works out as 2.95% against the target growth rate of 3.7% due to drought. In the industry and service sectors, the average annual growth rates during the first five years works out as 6.1% and 7.3% against 5.3% and 7.0%, respectively. The performance of the both sectors is better than the target figures. During the first five years of 25 years of the vision, the performance of the state economy is satisfactory, despite two bad years due to failure of both monsoons. The targets during the second five years (2000-2005) are on a higher trajectory, with an average annual growth rate of 8.6% in GSDP at a constant price. It is necessary to accelerate growth in the growth engines identified to achieve the targets. As a quick estimate, the growth rate in GSDP at a constant price in 2000-01 works out as

6.75%.

Table 2.4 Targeted growth rate for economy in Vision 2020 (%)

Year	GSDP	Income per Capita	Population
1995-2000	5.7	4.4	1.3
2000-2005	8.6	7.6	0.9
2005-2010	10.9	10.1	0.8
2010-2015	12.4	11.7	0.7
2015-2020	14.0	13.4	0.5
Overall Annual G.R.	10.3	9.4	0.8

(Source) Economic Survey 2001-2002, Planning Department A.P.

Table 2.5 Targeted growth rate in Vision 2020 by sectors (%)

Year	Agriculture	Industry	Services
1995-2000	3.7	5.3	7.0
2000-2005	6.1	9.7	9.5
2005-2010	6.9	11.6	12.6
2010-2015	6.3	13.8	14.0
2015-2020	5.7	14.6	15.5
Overall Annual G.R.	6.0	11.0	12.0

(Source) Economic Survey 2001-2002, Planning Department A.P.

2.2 Situation of the Power Sector and Facilities

2.2.1 Situation of the Power Sector

(1) Administration of the Power Sector

The State of Andhra Pradesh (AP), the subject of the present 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 state government subsidies 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 (APTRANSCO) on February 1, 1999 and the Andhra Pradesh Generation Corporation (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, 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 400-kV, 220-kV and 132-kV 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 and supply. 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 form 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.

2.2.2 Status of Aid by Other Donors

(1) World Bank

The World Bank takes the initiative in power sector reform in Andhra Pradesh, providing not only monetary assistance for power system consolidation, but also policy assistance for the sector's privatization.

This assistance forms an integral part of the Adaptable Program Loan for 10 years, amounting to 1 billion dollars with DFID and CIDA as cofinancing partners. This APL has five tranches, and APL-1, the first tranche, has almost been completed. The Indian side prepared investment plans improve the distribution network, covering all of the 23 districts of Andhra Pradesh to implement APL-2.

APL-1 was broadly grouped into four packages, covering transmission, distribution network consolidation, meter installation and power sector privatization. The transmission included the new construction and extension of transmission lines and substations, and the distribution included the 33/11kV stretches requiring urgent care. Meter installation was aimed mainly at industrial users with high-precision meters and at borders between APGENCO/APTRANSCO/DISCOMs.

Technical assistance for the sector's privatization covered a wide range of areas, from institutional building and capacity building for newly created entities due to privatization, (APGENCO/APTRANSCO/DISCOMs) to the system design of the power market, tariff design and the management reform of power utilities.

As for APL-2 onward, the content of assistance is not clear because it is decided with the progress of the power sector reform and the organizational reform of the relevant entities.

(2) DFID

DFID provided technical assistance for the preparation of investment plans to improve the distribution network in three districts of Andhra Pradesh, Khamman, Mahabubnager and Nalgonda, as part of the Energy Efficiency Program. DFID also granted substation SCADA in Hyderabad, which is now in operation. In addition to the above hardware-side assistance, DFID has been providing technical assistance for power sector privatization, including, strategies for the privatization of distribution companies, tariff design for APERC and the institutional building of the privatized entities for organizational design, human resources and tariff collection.

DFID has also provided assistance for the Customer Management System, Consumer Analysis Tool and TIMS/MIMS to improve customer services and management efficiency.

(3) CIDA

CIDA has been providing technical assistance for demand forecasts, power/transmission/distribution planning, customer services and tariff design based on long-term marginal cost.

As part of the above technical assistance, CIDA provided 20 computers and technical transfers to the Indian counterpart under the guidance of consultants. The software provided includes a loss estimate model, a demand forecast model (regression analysis), an optimum generation-planning model and an optimum transmission-planning model.

The study now in progress is on loss estimate, selecting 10 districts from the 23 districts of Andhra Pradesh as agricultural demand and the rest of the districts as non-agricultural demand. For agricultural demand, two feeders were selected from each selected district, and for non-agricultural demand, one feeder was selected from each selected district. Measurement will be made on the selected feeders, amounting to 118 feeders. Measurement will also be made on irrigation pumps supplied by distribution transformers by installing energy meters. The pumps equipped with energy meter are such that four pumps for one distribution transformer will be equipped with an energy meter as a sample. More than 4000 energy meters will be installed. The meter installation is underway through outsourcing. Measurement was scheduled to be made monthly from December 2002 through December 2003 by outsourcing.

2.2.3 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%).

The details are given in Table 2.6

Table 2.6 Generating Facilities in Andhra Pradesh

	Installed Capacity (MW)	Share
APGENCO	5,628	70.5%
Thermal Generating	2,953	37.0%
Hydro Power	2,675	33.5%
Joint Sector	272	3.4%
Gas Fired Thermal	272	3.4%
Private Sector	1,077	13.5%
Gas Fired Thermal	779	9.8%
Wind Power	88	1.1%
Mini-hydro	60	0.8%
Co-Generation and others	150	1.9%
Share from Central Sector	1,000	12.5%
Total	7,978	100.0%

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

(2) Transmission lines and substation facilities

The transmission system of Andhra Pradesh consists of a large network of 440 kV, 220 kV and 132 kV transmission lines that connect between power stations and various load centers.

In addition, the 440kV transmission network constructed 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 33 kV sub-transmission lines, 11kV primary distribution lines and low voltage distribution lines.

The 33 kV lines connect 132/33 kV substations and 33/11 kV substations. Generally, overhead lines are used for distribution lines, however in the urban areas such as Hyderabad, the underground cables are also used for distribution lines. The aluminum conductor with 55sqmm sectional area is used for 11kV line and 34sqmm is used for low distribution lines, and underground cables are mainly 400sqmm 3-core XLPE cables.

Transmission and distribution facilities in Andhra Pradesh are shown in Table 2.7 and substation facilities are shown in Table 2.8.

Table 2.7 Transmission and Distribution Facilities in Andhra Pradesh (March 2001)

Discoms	District	400kV	220kV	132kV	33kV	11kV	L.T.	Total
EPDCL	Srikakulam	0	0	120	1,274	3,720	9,196	14,309
	Vizianagaram	7	40	492	566	4,420	10,807	16,332
	Visakhapatnam	0	550	359	1,334	4,474	12,463	19,180
	East Godavari	0	408	436	1,018	5,041	13,803	20,706
	West Godavari	0	216	414	1,335	6,611	17,450	26,025
	Total	7	1,215	1,820	5,526	24,267	63,718	96,553
SPDCL	Krishna	30	586	368	963	6,347	18,993	27,287
	Guntur	302	485	626	1,417	7,073	12,774	22,677
	Prakasam	0	535	517	1,423	7,419	18,144	28,038
	Nellore	0	599	248	1,359	8,101	17,332	27,640
	Chittoor	0	296	775	2,205	9,503	30,546	43,324
	Cuddapah	0	504	436	1,628	6,034	11,618	20,220
	Total	332	3,005	2,970	8,995	44,476	109,408	169,186
CPDCL	Anantpoor	0	594	642	2,328	11,867	22,883	38,314
	Kurnool	184	541	530	1,551	7,114	16,137	26,057
	Hyderabad	0	139	77	513	2,514	5,517	8,760
	(U.G. Cable)	0	0	21	36	212	16	285
	Rangareddy	193	457	517	1,225	8,502	24,050	34,944
	Mahabubnagar	177	405	457	1753.15	12,040	23,932	38,764
	Medak	0	264	637	1,668	8,462	18,739	29,771
	Nalgonda	0	1,168	603	1,877	11,207	31,016	45,871
	Total	554	3,569	3,484	10,953	61,918	142,289	222,766
NPDCL	Nizamabad	0	172	551	1,272	7,026	19,008	28,029
	Adilabad	0	100	414	1,061	8,292	18,710	28,577
	Warangal	0	87	692	1,590	9,501	29,402	41,271
	Karimnagar	0	376	1,232	1,455	7,431	33,839	44,333
	Khammam	0	1,078	601	1,157	6,981	15,337	25,155
	Total	0	1,813	3,491	6,535	39,231	116,296	167,366
	Total for A.P	893	9,601	11,765	32,008	169,893	431,711	655,871

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

Table 2.8 Substations in Andhra Pradesh (March 2001)

District	400kV	220kV	132kV	33kV	Total
Srikakulam	0	0	4	21	25
Vizianagaram	0	1	4	28	33
Visakhapatnam	0	3	10	55	68
East Godavari	0	2	6	60	68
West Godavari	0	2	8	75	85
Krishna	0	4	6	61	71
Guntur	0	2	9	71	82
Prakasam	0	2	9	66	77
Nellore	0	2	8	75	85
Chittoor	0	3	14	119	136
Cuddapah	0	6	6	93	105
Anantpoor	0	5	8	104	117
Kurnool	1	4	8	90	103
Hyderabad	0	0	5	61	66
Rangareddy	1	8	7	79	95
Mahabubnagar	0	2	7	101	110
Medak	0	3	14	144	161
Nalgonda	0	2	10	111	123
Nizamabad	0	1	5	64	70
Adilabad	0	2	9	103	114
Warangal	0	2	10	97	109
Karimnagar	0	3	3	53	59
Khammam	0	4	9	130	143
Total for A.P	2	63	179	1,861	2,105

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

2.2.4 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 states need an improvement plan.

The system loss rate in Andhra Pradesh is shown in Table 2.9.

Table 2.9 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 (Statics) 2000-2001, APTRANSCO

2.2.5 Power Balance

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. A summary of the order is given below.

(1) Load forecast

- The System peak demand in the year FY 2006-07 will be fixed at 10,575 MW and the energy requirement at 61,017 MU.
- For meeting the peak load and energy requirement, the installed capacity at the end of the planning period [2007] will be 13,639 MW.
- The annual capacity addition required will be as provided in the Table 2.10. The cumulative capacity required to be added between the period 2001-02 and 2006-07 will be 5,182 MW.
- Based on a capacity requirement of 5,182 MW, APERC approves the power procurement plan of APTRANSCO as detailed in Table 2.11, excluding the Srisailam Left Bank Project from the capacity addition to meet the peak requirement.
- Inclusion of new plants proposed in the approved power procurement plan does not construe approval of the Power Purchase Agreements for these new plants by APERC. Approval of PPA by APERC depends on the merits of the agreement and is not part of this order.

Table 2.10 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

Table 2.11 APTRANSCO Power Procurement Plan

(unit; MW)

	Projected Peak Demand	Capacity Retirement	Thermal Capacity Addition	Hydel Capacity Addition	Total Capacity Addition	Total Net Capacity
2001-02	8,927		CC-1 (213.4) + Simhadri-I (460) + MPP (72) + NEDCAP (80.3)	298 Sri Sailam	1,124	9,999
2002-03	9,061		Simhadri-Unit-II (460) + New Captive 84.4 + NEDCAP (46.2)	298 Sri Sailam	889	10,888
2003-04	9,513		NEDCAP (45.5)+ 98 Talcher	298 Sri Sailam	442	11,329
2004-05	9,763	560 (400 Eastern region and 160 Captive)	CC-2 (432) + MPP (54) + 98 Talcher		584	11,352
2005-06	10,143	169 Captive	CC-3 (359) + CC-4 (450.1) + CC-5 (213) + Talcher (98) + Ramgundam (134)		1,254	12,438
2006-07	10,575		385 RTPP + BPL (475.6) + 98 Talcher		959	13,398
Total (MW)		728	4,357	894	5,251	

(Source) APTRANSCO Submission January 2003, Table: Power Procurement Plan

(2) System reliability

- APTRANSCO has adopted a target Loss of Load Probability (LOLP) of 1% i.e. 87.6 hours/year as the measure of reliability in estimating reserve capacity. This is to take care of the probability of failure of plants during the system peak demand. They have also proposed that the Energy Not Served (ENS) should be at a level of 0.15% of the energy requirement by the end of FY 2007.

- In the Order dated July 29th 2002, APERC has adopted 14% reserve margin as earlier suggested by APTRANSCO to achieve targeted LOLP of 1% for the planning period FY 2002-2007. In the later submissions dated 28th January 2003, the licensee has worked out a reserve margin ranging from 13% in FY 2002 to 28% in FY 2007 to achieve the targeted 1% LOLP.
- APERC accepts the target of 1% LOLP and 0.15% of ENS as proposed by APTRANSCO, being the norms adopted by CEA for planning the capacity additions. However, to ascertain the reserve margin required for a target of 1% LOLP, the Commission has requested the Central Electricity Authority, as a technical consultant, to advise on the technical aspect of assessing the reserve margin and generating capacity requirement to attain LOLP of 1% and less than 0.15% ENS in the AP system. Based upon the information made available by APERC and APTRANSCO, studies have been carried out by CEA. CEA made the recommendations to AP Commission, that is, reserve margin of 30% in terms of rated capacity over peak demand of 29% of net capacity would give 1% LOLP and less than 0.15% ENS for the AP system.

2.2.6 Tariff-related Matters

This JICA development study considers tariff-related matters only with regard to a Case Study because the World Bank and other donors are already involved in this matter.

(1) Metering/Billing/Collection

CPDCL conducts metering/billing operations by spot billing using hand-held computers. Customers visit the offices of distribution companies to pay their bills.

In the meantime, APTRANSCO, on behalf of the four distribution companies, put out a tender for the Customer Management System with the closing date at the end of November 2002. This CMS is an integrated solution to customer services ranging from new connection, disconnection, billing/metering/collection to claim handling and other customer services, and the tender aims to develop this software and prepare the technical specifications of the necessary hardware. Once this system is established, field-level operations such as metering/billing using hand-held computers and customer services by customer centers will be organically linked with customer management by CMS, enabling improved customer services and monitoring illegal use of power and collection status. If this system is operated as intended, it will be an advanced system.

At field level or at the bottom of the organizational hierarchy, meter-reading books are piled one on another, making the working conditions difficult. In addition, it is not yet clear when the benefits of CMS will reach the field level. The study team proposes customer management using GIS. This would allow the recording of power consumption by customers on GIS, which would dispense with meter-reading books, thus improving working conditions; this would also identify irregular consumption by graphing consumption history. If appropriate measures are taken against these irregular consumers, commercial loss could be reduced.

(2) Tariff Structure

Technical assistance has been provided to APERC and other entities as part of the power sector reform by the World Bank, DFID and other aid organizations. CIDA has also provided the technical transfer of pricing based on long-term marginal cost.

A defect in the current tariff structure from the viewpoint of the power utilities is an extremely low flat rate applied to agricultural load, which does not allow power utilities to recover production cost, which makes them dependent on cross-subsidies from industrial users and state subsidies. It is a common opinion in the relevant circles that the ideal tariff should introduce a metered rate, and that the problem with the tariff is not easy to solve because of its relation to agricultural policy. APERC is continuing its study on future tariff structure.

Chapter 3 Operation and Maintenance of Distribution Network

Contents

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 Ranga Reddy and Medak Districts, and provided solutions to problems in the operation and maintenance of the distribution network.

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, but 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 results show that records of domestic and industry usés 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 observed.

In addition, the study team conducted a survey on outages, including the faults, maintenance, and load shedding for the 33 kV and 11 kV 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 system were identified.

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

3.2 Time Schedule of the Study

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 their solution.

The schedule for study on operation and maintenance is shown in Figure 3.1.

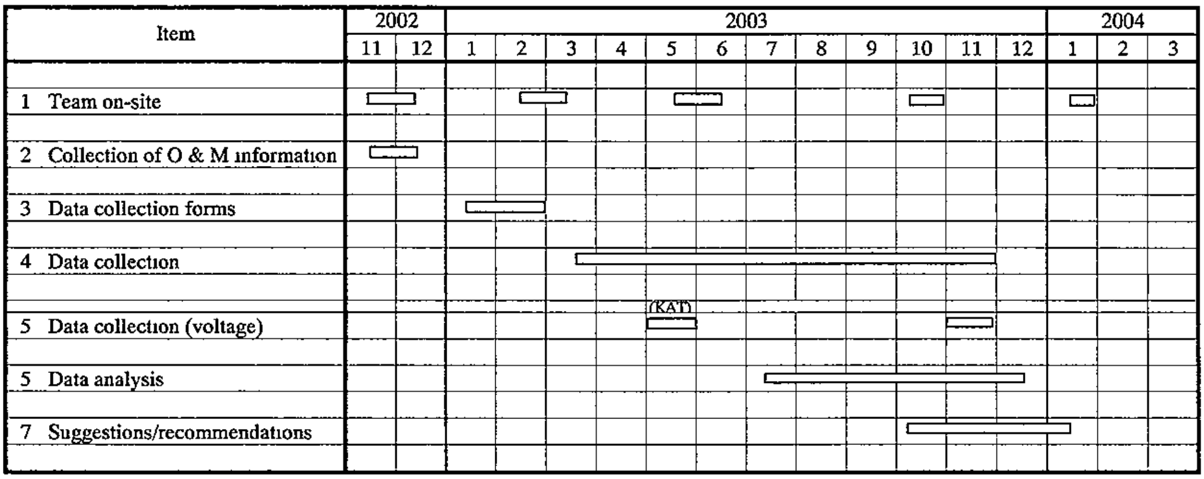


Figure 3.1 Schedule for study on operation and maintenance

3.3 Current Situation of Operation and Maintenance

3.3.1 Organization of Operation

The Operation Department of APCPDCL comprises a Corporate Office and 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.

Figure 3.2 shows the organization chart of APCPDCL's Operation Department

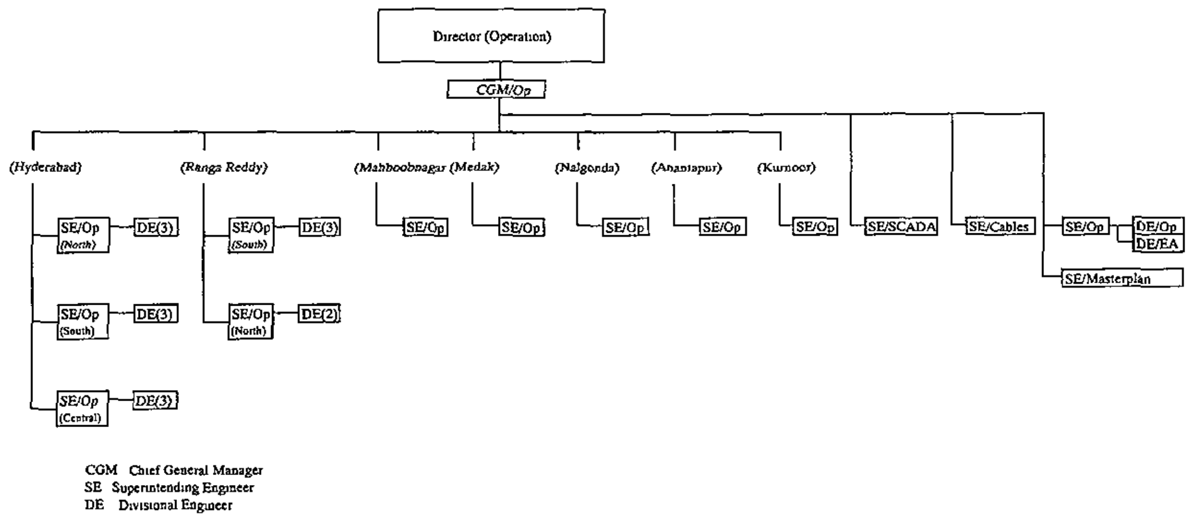


Figure 3.2 Organization chart of APCPDCL's Operation Department

Each Operation Circle is headed by a Superintending Engineer (SE), and several Divisional Offices are located according to the site condition. A Divisional Engineer (DE) manages the divisional office for the operation of the distribution system. Assistant Divisional Engineer(s) assists the DE.

Divisional Engineers (DE) for Technical, Meters, Transformers, Construction, Stores, etc, are nominated to assist the SE at the District Office, if required.

A section office is the unit organization of the operation and maintenance of the distribution facilities and carries out not only operation and maintenance of a 33/11 kV substation and distribution feeders but also meter readings of the customers, issue of bills, collection of charges and daily management of spare parts and tools.

Operation of substations is performed by three shift-personnel employed by contract.

Figure 3.3 shows the organization of Ranga Reddy South Operation Circle as an example.

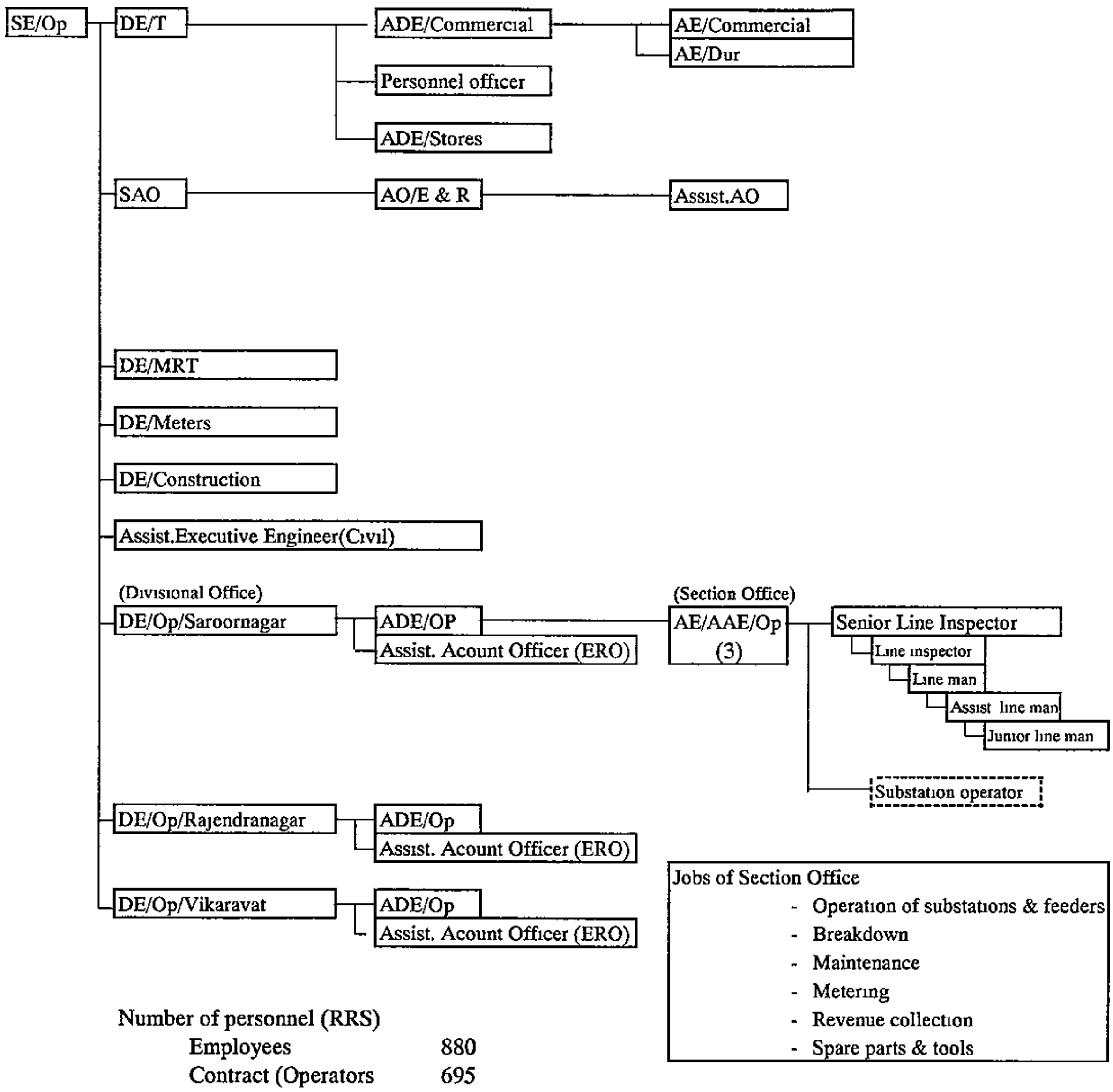


Figure 3.3 An example of organization of District Office (Ranga Reddy South Operation Circle)

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.

APTRANSCO's transmission system and APCPDCL's distribution systems should be operated as one system, so establishing an interface between both systems is very important. The details of the interface between the transmission and distribution systems are stipulated in the above GRID CODES; problems between the two systems have not been observed.

In APCPDCL, as there is no load despatch office, the operation wing deals with dispatch orders/information.

According to the OPERATION CODE of the GRID CODE, APCPDCL will, by the end of November of each year, provide APTRANSCO with the entire demand forecasts for the period covering December to March of the current year and the following two years, regarding active power, reactive power, daily energy requirements, peak demand, times of the day peak and the night peak and daily variation during holidays, the months when maximum agriculture load is expected and the month during which the agricultural load is minimum.

APCPDCL will also provide APTRANSCO with estimates of load that may be divided into discrete blocks with details of arrangements of this load shedding.

Similarly, discussion on outage plans of APTRANSCO and APCPDCL will start at the end of November, and a final overall outage plan will be released by March 1 each year.

In connection with frequency control, APTRANSCO will monitor the frequency of the transmission system and take action to ensure that they are within the acceptable limit in coordination with the Southern Region Load Dispatch Center (SRLDC) in Bangalore. APCPDCL will cooperate with APTRANSCO in managing the load.

Whenever the frequency is below 49.5 Hz, the drawals will be restricted to drawal schedules. When the frequency falls below 49.0 Hz, requisite load shedding will be arranged by APTRANSCO through APCPDCL.

APTRANSCO will carry out load flow studies from time to time to predict where voltage problems may be encountered and to identify appropriate measures such as changing transformer tap settings or using compensation equipment to ensure the voltage remains within the defined limits. According to these studies, APTRANSCO will maintain the specified voltage level at the interconnection points with APCPDCL.

APCPDCL will participate in voltage management by regulating their drawal and by installing compensation equipment as required.

3.3.2 Organization for Maintenance

Maintenance of the distribution system is being carried out by the maintenance crew of the section office.

It consists of:

Daily patrol

Scheduled maintenance as per annual schedule

Extraordinary maintenance due to patrol results or for repair

Scheduled maintenance involves pre-monsoon maintenance (PMI) of all the facilities, including 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.

3.3.3 Outline of Operation and Maintenance Manual

In connection with the operation and maintenance manual which has specified the foundations of operation and maintenance of the distribution system, the same manual arranged by APSEB, a 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.

3.3.4 Necessary Personnel and Training

As mentioned above, operation and maintenance are carried out by the same organization. Installation and extension of equipment are always performed but the arrangement of the necessary personnel seems not to correspond to the increase in the amount of business.

Despite enhancement of the technical capability of the operation and maintenance personnel and training of new employee are carried out, requirements are still not being met.

Training is dealt with in detail in Chapter 7, "Training Facilities and Program".

3.4 Current Situation of Operation of the Distribution Network

3.4.1 Outline of Power Facilities

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		445.02	20			821.50	2,937		185,595	
						Rejendranagar		218.00	16			1,030.67	2,614		90,214	
						Vikarabad		324.34	23			2,189.43	2,699		134,036	
						TTL(1)		987.36	59		230	4,041.60	8,250		409,845	
					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))		1,472.36	96		390	5,503.60	15,137		840,218	
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	1,109.0	551	8,462.37	13,823	1,019,256	501,432	
Grand TTL		1,195.86	26	2,146				3,141.36	260		941	13,965.97	28,960		1,341,650	

Source: APCPDCL

3.4.2 Power System Diagram

Power system diagrams of Ranga Reddy and Medak are shown in Figures 3.4 and 3.5.

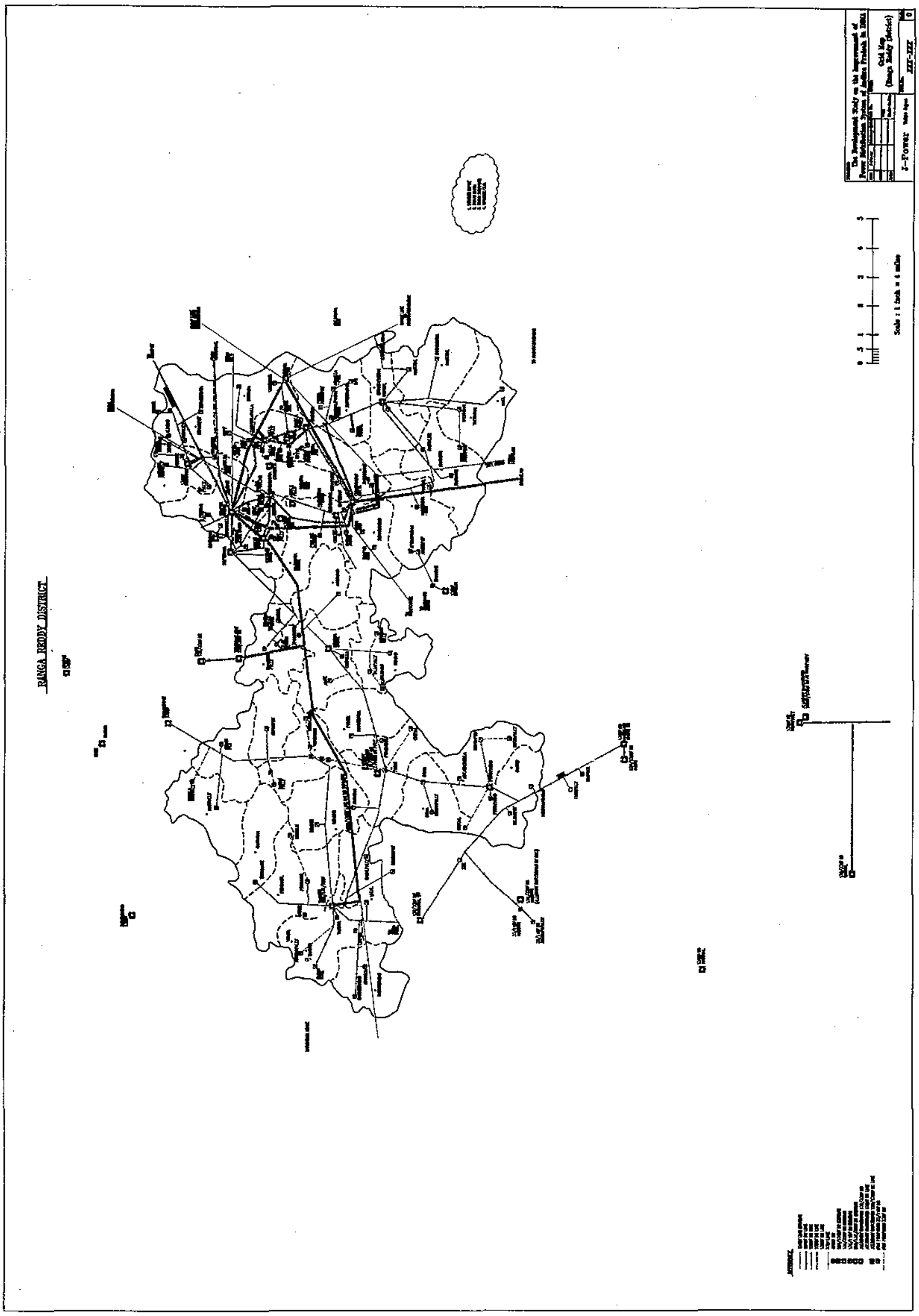


Figure 3.4 Grid Map of Ranga Reddy District

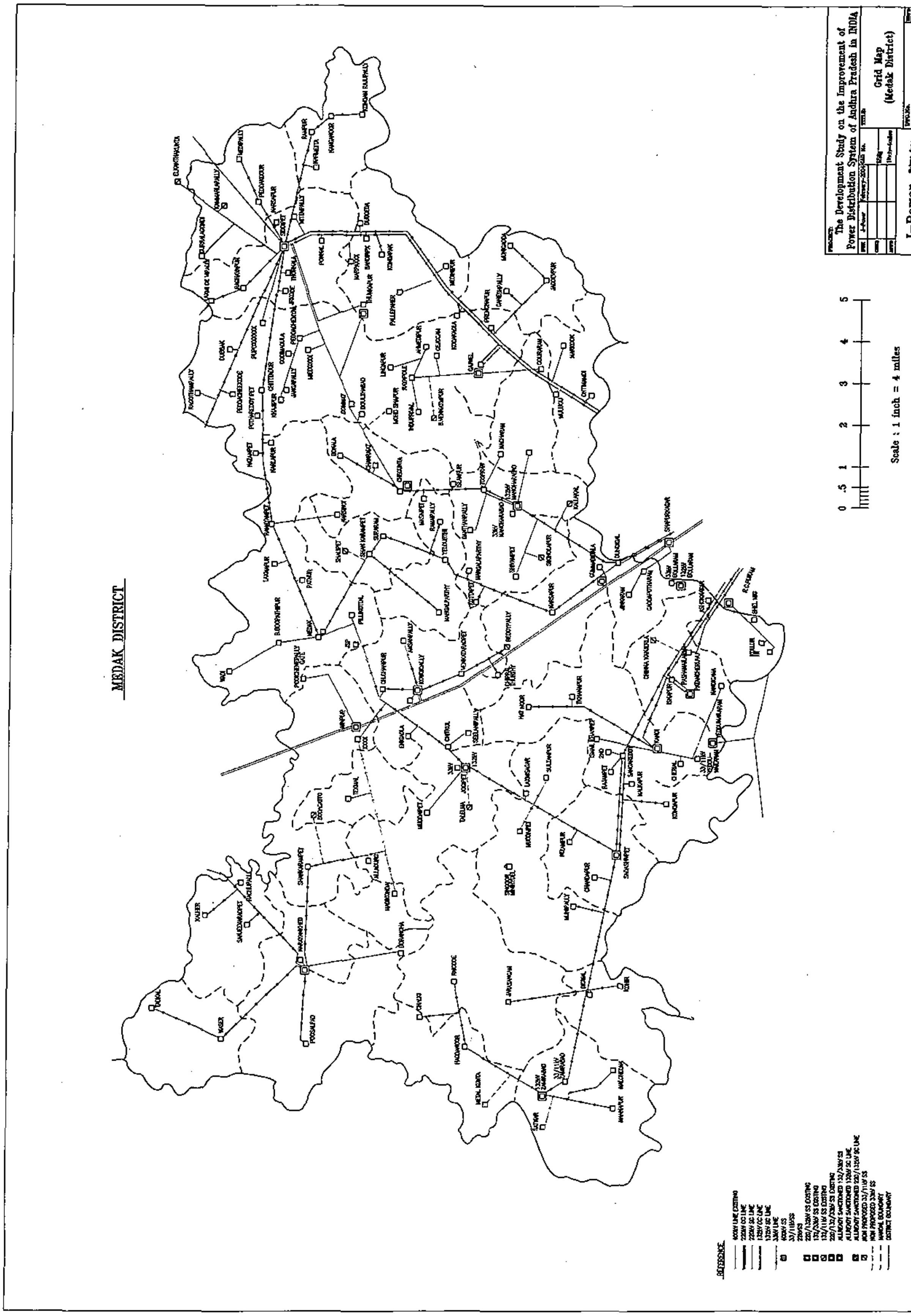


Figure 3.5 Grid Map of Medak District

3.4.3 Power Supply and Demand

(1) Operation Condition of Distribution System

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

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

		2001/2002	2002/2003	Apr. through Dec.. 2003
Peak Demand (MW)	APCPDCL	-	2620	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	2,278
	RR(N)	1,312	1,620	
	Medak	2,944	2,966	2,296
Energy sold (Million U) (1)	APCPDCL	12,486	13,224	10,428
	RR(S)	1,503	1,505	2,049
	RR(N)	9,18.4	1,215	
	Medak	2,188	2,251	1,760

U= kWh Source: APCPDCL

(1) Up to November 2003.

(2) Daily Load Curves

Table 3.3 shows the summary of the daily load curves of the associated substations of the model feeders.

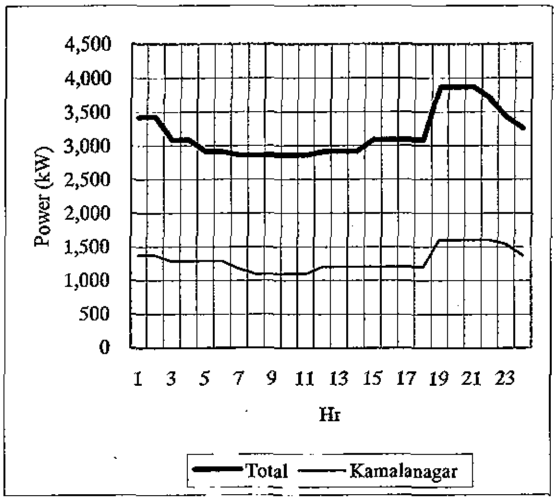
Table 3.3 Summary of daily load curves of the associated substations of the model feeders

Substation	Kothapet in Ranga Reddy		Kathedan in Ranga Reddy		Malkapur in Medak	
Category	Domestic & Commercial		Industry		Agriculture	
Date (*)	May-15-2002	Nov-20-2002	May-15-2002	Nov-20-2002	Nov-20-2002	May-21-2003
Maximum power (kW) (**)	3,872	3,672	12,720	12,860	3,035	1,890
Load factor (%)	82	83	85	86		63
Note	Flat base load is observed in daytime and lighting load is superimposed on it in the evening.		Following the base-load of nighttime, Almost flat industrial load is observed in daytime to the evening.		Three(3) agricultural feeders and an industrial feeder are outgoing from the substation. The former have load relief (shedding), so there is a complicated load pattern compared with other substations.	

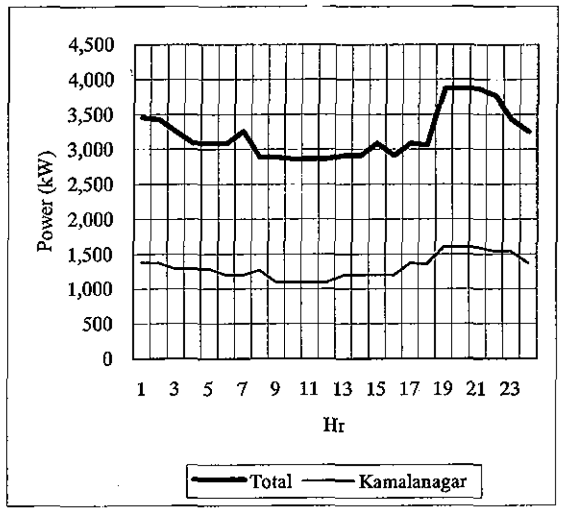
(*) Third Wednesday of May & November (**) Calculated from operation log with PF=0.9.

Figure 3.6 shows the daily load curves of the model feeders and the associated substations.

May-15-2002

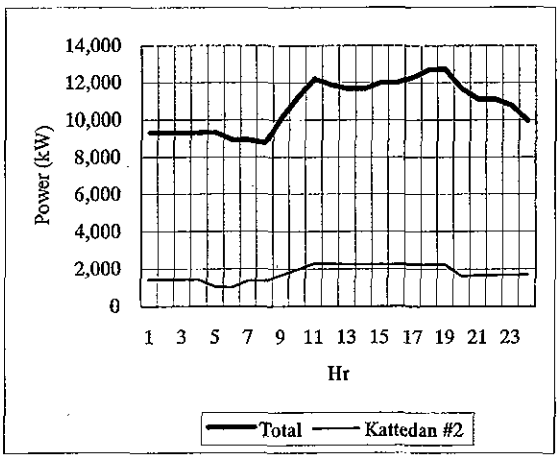


Nov-20-2002

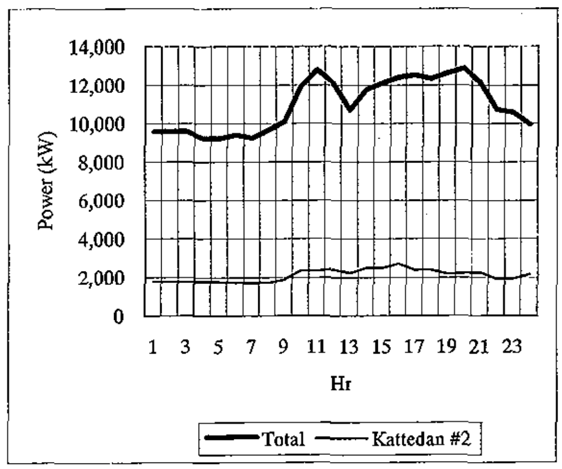


Kattedan (Industry)

May-15-2002

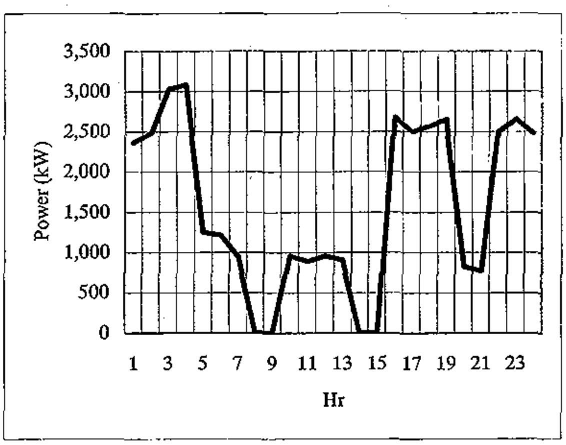


Nov-20-2002



Malkapur (Agriculture)

Nov-20-2002



May-21-2003

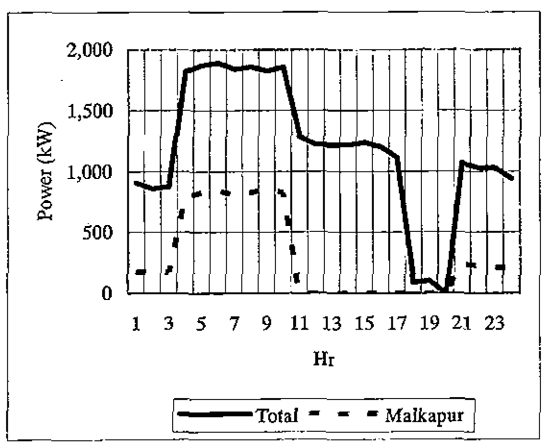


Figure 3.6 Daily load curves of the model feeders and the associated substations

(3) APCPDCL and District-wise Daily Load Curves

Figure 3.7 shows daily load curves of Ranga Reddy, Medak, Hyderabad and APCPDCL on November 20, 2002, May 21, 2003 and November 19, 2003. While APCPDCL maintains its daily load curve as flat as possible responding to an APTRANSCO's request, it is necessary to fulfill the demand of the evening peak of Hyderabad. Therefore, the daily load curves of Ranga Reddy and Medak are adjusted evenly compared with the daily load curves of the same substations.

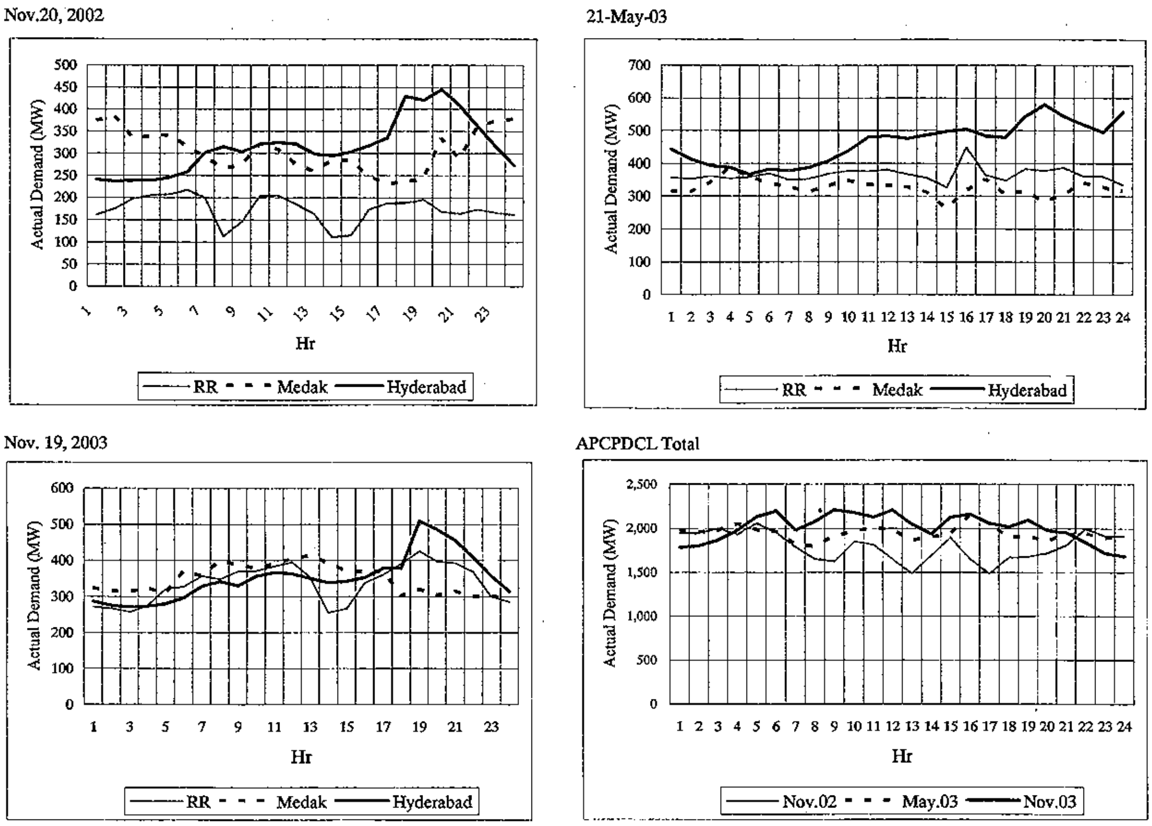
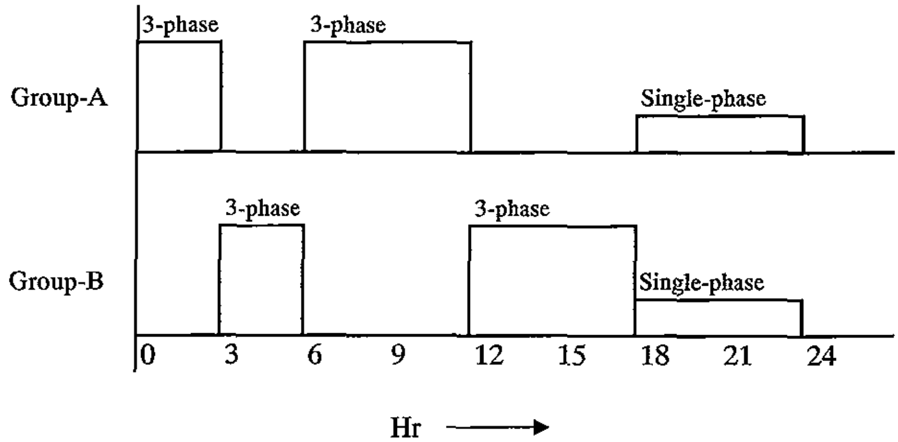


Figure 3, 7 Daily load curves of Districts and APCPDCL

3.4.4 Power Supply Pattern for Agricultural Load

Despite the electricity tariff for farmers being favorably compared with other categories, severe load shedding is imposed as a countermeasure against power shortage.

Figure 3.8 shows an example of the power supply pattern for the agricultural load, i.e. the agricultural load of a substation is divided into two groups, and 3-phase power for water pumps is supplied for 9 hours a day to Groups A and B, respectively, using different time schedules. In 2-phase power, one phase is disconnected at the outgoing terminal of the substation, and is provided for lighting from 18:00 to 24:00. For the rest of the time zone, no electricity is supplied.



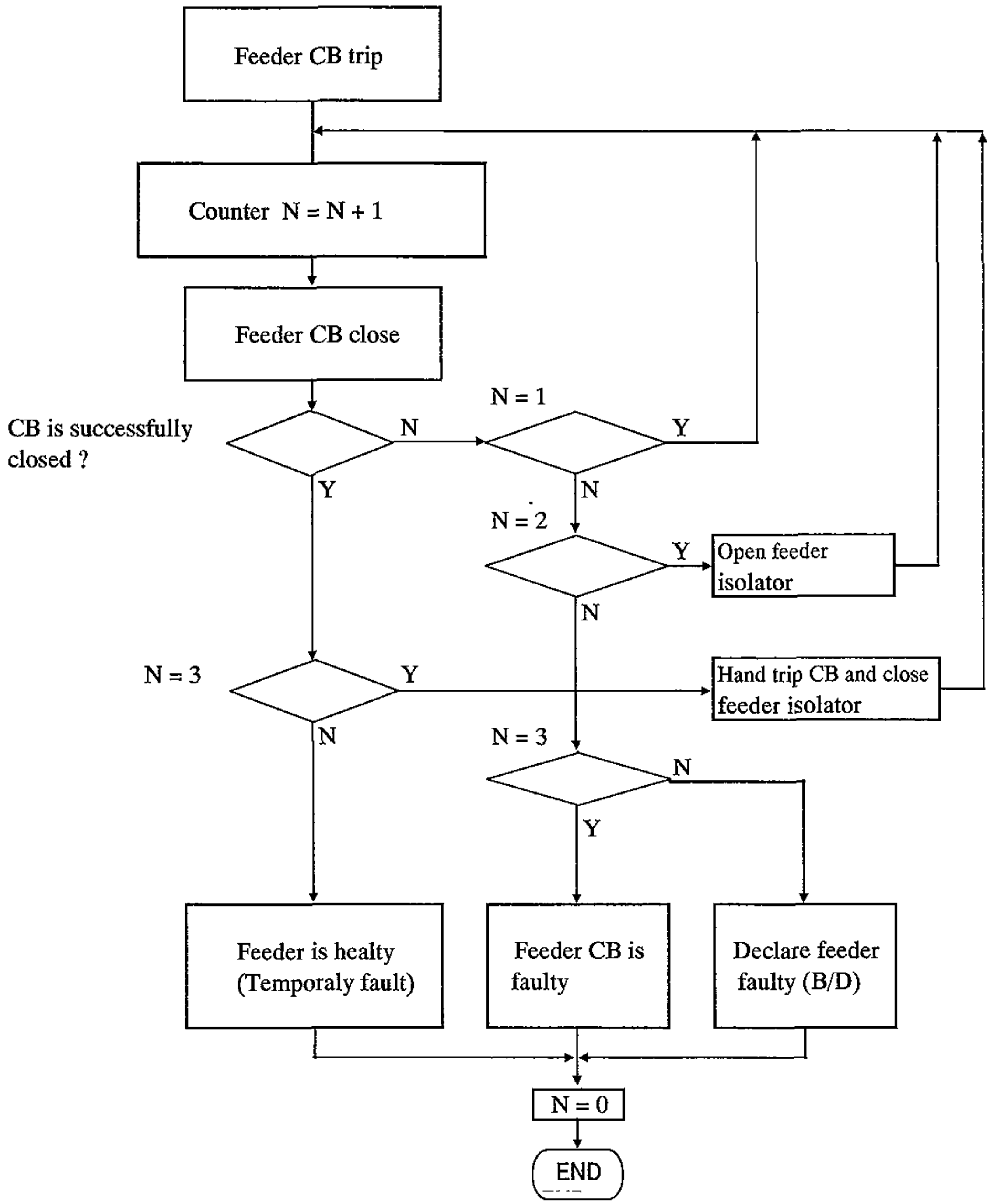
Note)
1 All the loads are divided into 2 Groups, Group-A and -B.
2 Each group is given 9 hours of 3 phases supply.
3 Single phase supply is given from 18:00 to 24:00.

Fig 3.8 Example of power supply pattern for agriculture

3.4.5 Restoration Pattern at the Time of Fault

Figure 3.9 shows the standard restoration procedure for a fault in a radial distribution feeder, which trips due to earth or over-current faults. These will be frequently occurring fault types in the distribution system.

Flow Chart



Circuit Configuration

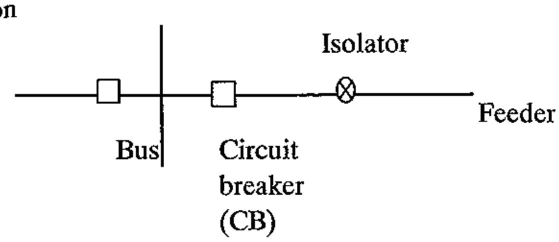


Figure 3.9 Standard restoration procedures for a fault in radial distribution feeder

The procedure in detail is:

(1) When a circuit breaker trips on over-current (O/C) or earth fault (E/L) indication, cancel the alarm, and note and reset the relay.

(2) Close the circuit breaker.

(3a) If the line (feeder) stands, restore to normal.

(3b) If the breaker trips, cancel the alarm, and note and reset the relay.

(4) Close the circuit breaker.

(5a) If the line stands, restore to normal.

(5b) If the breaker trips again, cancel the alarm, and note and reset relay. Open the line isolator.

(6a) Close the circuit breaker. If the breaker trips, the breaker is faulty.

Inform AE/M, ADE/SS, DE and SE of the breaker trouble,

(6b) If the breaker stands normally, hand trip the breaker and close the line isolator.

(7a) Close the breaker. If it stands, normalize the supply.

(7b) If the breaker trips, declare the line faulty.

Inform ADE/Lines, ADE/SS, DE/SS and SE.

3.4.6 Tolerances or Target of Supply Reliability

Table 3.4 shows the tolerance or target of power supply reliability.

Table 3.4 Tolerance or target of power supply reliability

	APTRANSCO Operation Code	IE Rules 1956
Frequency Variation	Upper limit 50.5 Hz Lower limit 49.5 Hz Statutory Limits: acceptable Upper limit 51.5 Hz Lower limit 48.5 Hz Extreme Conditions: Upper limit 52.5 Hz Lower limit 47.5 Hz Load shedding: When the frequency falls below 49.0 Hz requisite load shedding will be arranged by SLDC through the DISCOMs	Not More than 3 %, except with the written consent of the customers (Rule 53)

Voltage Variation	132 kV Maximum 145 kV Minimum 120 kV (CEA Standards) 33 kV +/- 9% 11 kV +/- 9% 0.4 kV +/- 6%	Not more than 6 %, except with the written consent of the customers (Rule 52)
Interruption	Preliminary Stage: No limit Final Stage: System Average Interruption Frequency Index (SAIFI)...18/yr System Average Interruption Frequency Index (SAIDI)... ...8 hours/yr	

Source: GRID CODE, 2001 for APTRANSCO & I.E. Rules, 1956

3.4.7 Telecommunications System

The corporate office and the district headquarters of APCPDCL will have the following communications, either PLC or Wide-Band, with the State Load Dispatching Center (SLDC) and the Sub-Load Dispatching Center (Sub-LDC) of APTRANSCO.

Administrative Channel

Express Channel

The 132kV substation (Master Substation) and the33 kV substations (Outstations) are linked with Point-to-Multipoint systems. PSTN Telephones are also used as backup.

The VHF system (PSTN Telephone), public and mobile phones, are provided for the maintenance of the distribution feeders. Outside the service areas of VHF and mobile phone, only public phones are available for communications between substations and the field. If the location of a fault is distant from a telephone, communication takes time and restoration of the fault will be delayed.

3.5 Operation and Maintenance Data of the Distribution Network

3.5.1 Subject Matters for the Study

A study was carried out on the quality of electricity, including the low voltage (L.V.) customers, such as frequency, voltage, number and duration of outages in Ranga Reddy and Medak Districts.

The collected data is shown in Table 3.5, Records collected.

Table 3.5 Records collected

Item	Frequency	Voltage	Outage
Objectives	Data of APTRANSCO's LDC.	Each model system for domestic, industry and agriculture in Ranga Reddy and Medak. Voltages include 132 kV through L.V..	Number and duration of each outage due to fault, maintenance and load shedding in Ranga Reddy and Medak districts.
Period of the survey	May and November 2002.	Same as in the left. Regarding the L.V. customers, final measurements was made in November 2003.	April 2002 through March 2003.
Data collected	May and November 2002 and 2003.	Domestic: RR(S),Kothapet SS, 11kV Kamalanagar feeder, May and November 2002 and November 2003. Industry: RR(S),Kattedan SS 11 kV Kattedan #2 feeder, May and November 2002 and May and November 2003. Agriculture: Medak, Malkapur SS, 11 kV Malkapur feeder, May and November 2002. In September 2003 only for low voltage was measured.	33 kV 23 feeders 11kV 244 feeders

A concrete method for the collection of the outage records and the associated code lists is attached in Annex 3.1 and 3.2.

3.5.2 Fluctuation of Frequency

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

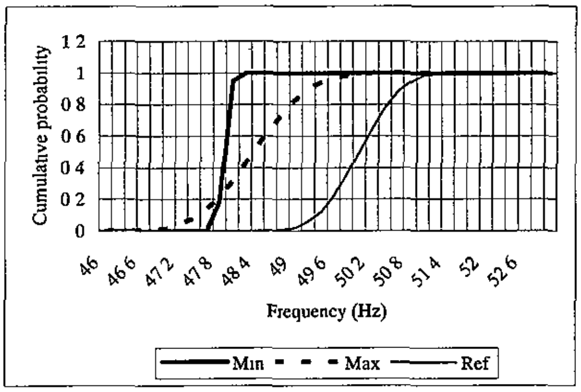
During the dry season, March through June, the Grid is obliged to operate at low frequency with severe load shedding (Load Relief) for the shortage of output of hydropower.

Therefore, May 2002 and 2003 of the dry season and November 2002 and 2003 when the water level is recovered were selected as study months.

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.

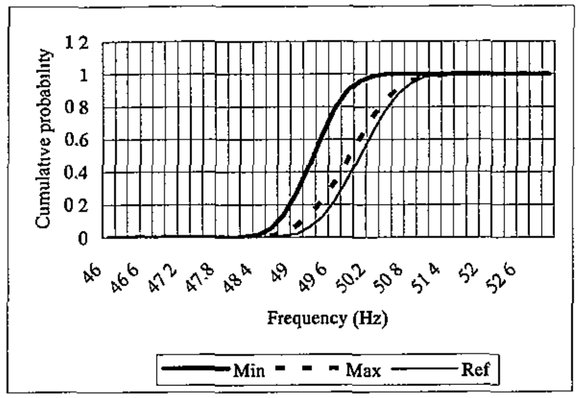
Records of frequency in May and November 2002 and 2003 are shown in Annex 3.3, and the cumulative probability of frequency is shown in Figure 3.10.

May-02-2002



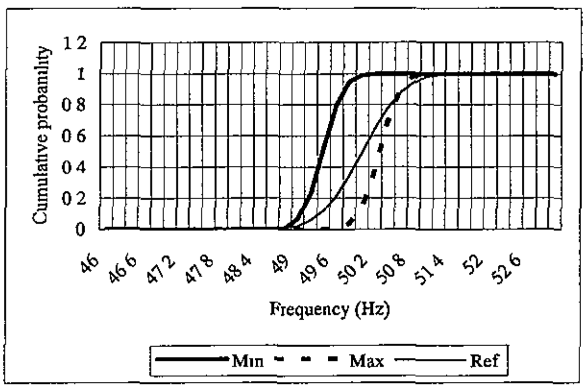
MIN ave= 47.87 max= 48.03 min= 47.70
MAXave= 48.34 max= 49.69 min= 47.00

Nov-02-2002



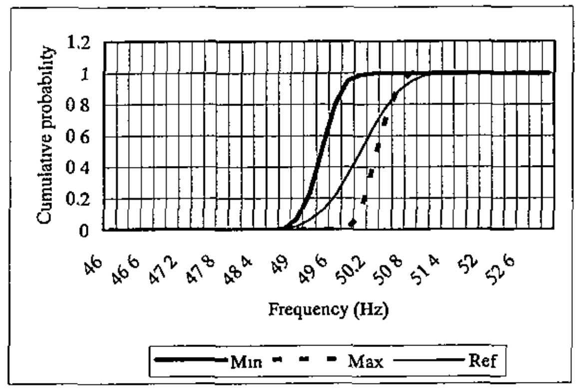
MIN ave= 49.26 max= 50.51 min= 48.45
MAXave= 49.84 max= 50.95 min= 48.74

May-03-2003



MIN ave= 49.38 max= 49.88 min= 48.88
MAXave= 50.28 max= 50.78 min= 49.77

Nov-03-2003



MIN ave= 49.26 max= 50.50 min= 48.50
MAXave= 49.84 max= 51.00 min= 48.70

Note) Unit= Hz

Figure 3.10 Cumulative probabilities of frequency in May and November 2002 and 2003

Figure 3.10 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 but in 2003 the frequency is 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 has started nationwide in India from January 1, 2003. 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.

3.5.3 Measurement of Voltage Fluctuation

Voltage measurements were carried out as shown in Table 3.6.

Table 3.6 Measuring point of voltage

	Domestic/ Commercial	Industry	Agriculture	Note
132 kV voltage	Bandlaguda 132 kV bus	Chandrayanagutta 132 kV bus	Kandi 132 kV bus	
33 kV voltage	Kothapet 33 kV bus	Chandrayanagutta 33 kV bus	Kandi 33 kV Bus	
11 kV voltage	Kothapet 11 kV bus	Kattedan 11 kV bus	Malkapur 11 kV bus	
Feeder Name	Kamalanagar feeder	Kattedan #2 feeder	Malkapur feedr	
Voltages for; Customer 1	Tr (Sarahda Nagar-Theater) Mr. K.Ramu;e	#6 HT Customer (3 ph)	#5 Tr. (3 ph) Indera Parwthi (5 Hp pump)	
Customer 2	Tr (Bhargara Rice Mill-Karita) Mr. Vijetra Shelters	#8 Chocolate factory (3 ph)		
Customer 3	Tr Sanscrit College			
132 kV Tap	Bandlaguda #1 Tr	Chandrayanagutta #1 Tr	Kandi #1 Tr	
33 kV Tap	Kothapet #1 TR	Kattedan 33 kV #1 Tr	Malkapur Tr	

The timing of voltage measurement is shown in Table 3.7

Table 3.7 Timing of voltage measurement

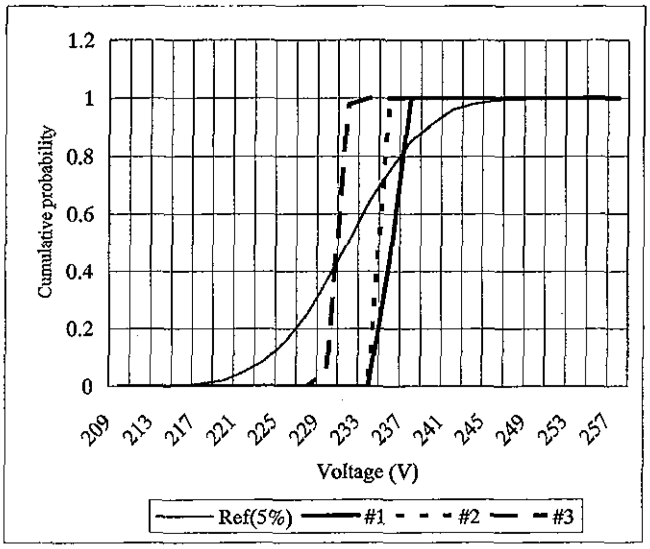
	Kothapet (Domestic/Commercial)	Kattedan (Industry)	Malkapur (Agriculture)
132, 33, 11 kV	May and November 2002.	May and November 2002.	May and November 2002.
132, 33, 11 kV and low voltage customer	November 2003.	May and November 2003.	Low voltage only for September 5 through October 4, 2003.

As an example of the voltage measurements, the results from the Kamalnagar and Kattedan #2 feeders in November 2003 are shown in Figures 3.11(a) and (b). Since the records of November 2003 was not be able to be used about Malkapur feeder, L.V. voltage records for September 5, 2003 through October 4, 2003 (30 days) were adopted for analysis. As shown in Figure 3.8 for agriculture feeder, the same is operated with a complicated pattern and 3 phase conductors are not energized always. Therefore, it has checked that current was flowing in the feeder and 38 cases fulfilled the condition were analyzed. The results are shown in Figure 3.11(c).

Kothapet Substation
11 kV Kamalnagar feeder
LV Customer ends

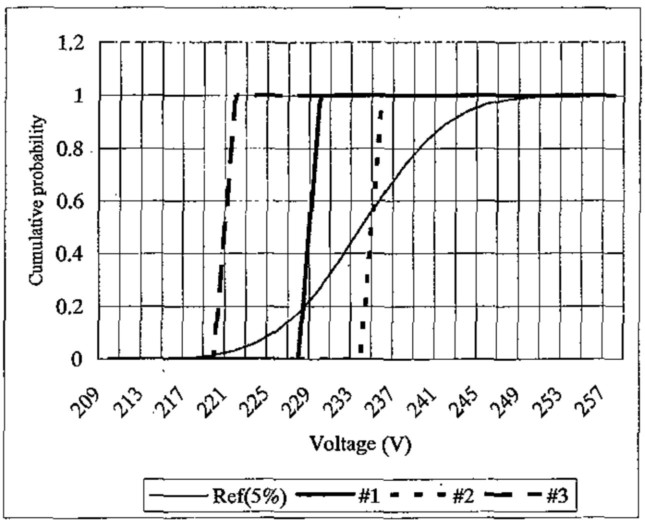
3 AM (V)

	#1(A)	#2(A)	#3(A)	Ref(5%)
Mean	235.00	234.00	229.90	231.00
SD	0.00	0.00	0.55	5.94
Max	235.00	234.00	231.00	242.50
Min	235.00	234.00	228.80	219.50



11 AM (V)

	#1(A)	#2(A)	#3(A)	Ref(5%)
Mean	228.00	230.00	219.90	231.00
SD	0.00	0.00	0.25	5.94
Max	228.00	230.00	220.40	242.50
Min	228.00	230.00	219.40	219.50



8 PM (V)

	#1(A)	#2(A)	#3(A)	Ref(5%)
Mean	220.00	219.00	219.60	231.00
SD	0.00	0.00	0.81	5.94
Max	220.00	219.00	221.20	242.50
Min	220.00	219.00	218.00	219.50

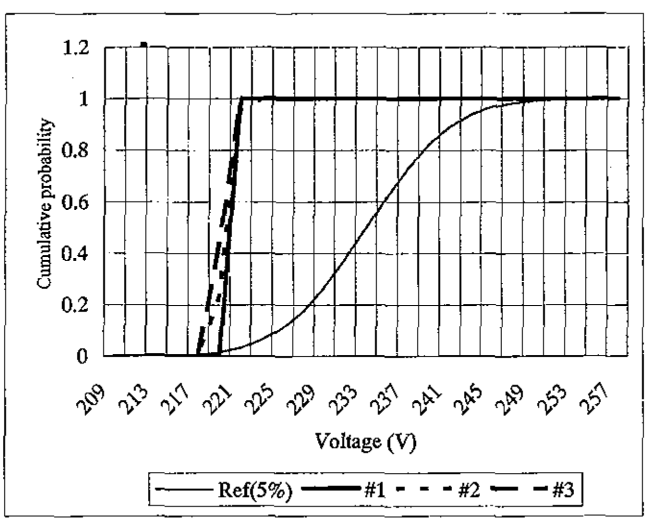
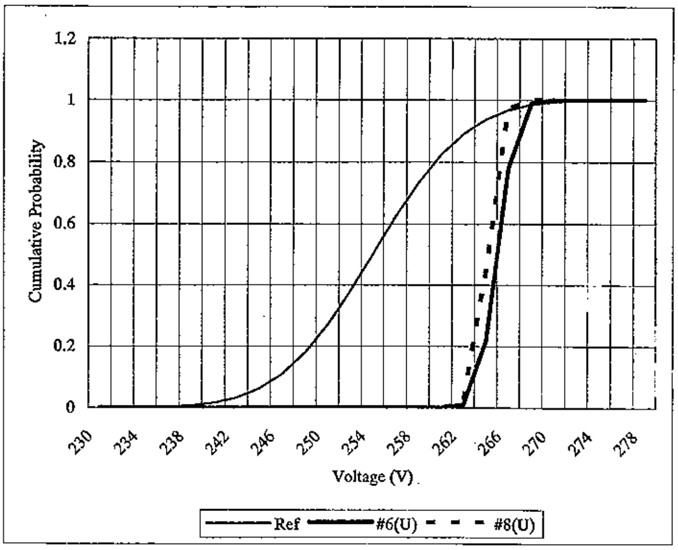


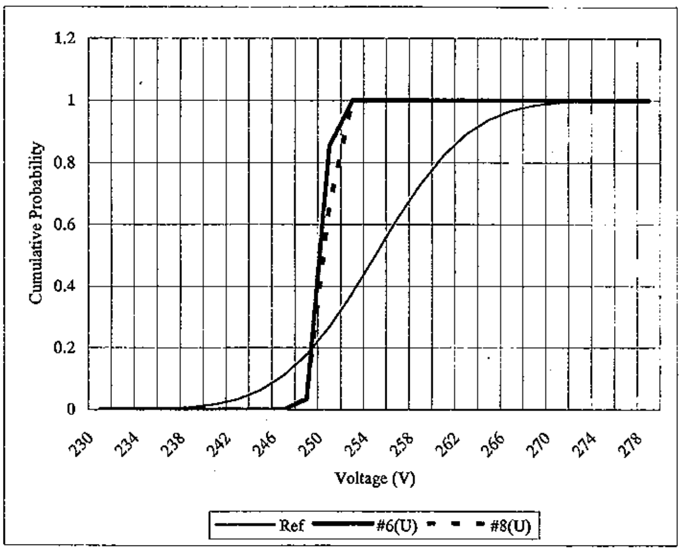
Figure 3.11(a) Voltage measurement result at end-customer of Kamalanagar feeder in Nov. 2003

Kattedan #2 Feeder
LV Customer Ends
November 2003



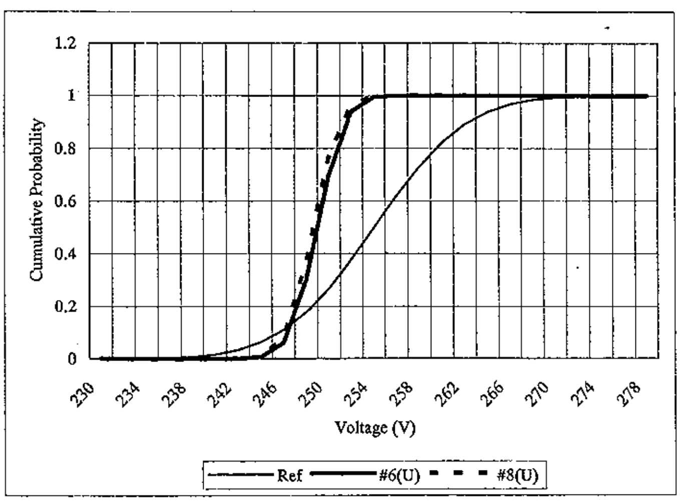
3 AM (V)

	#6(U)	#8(U)	Ref(5%)
Mean	265.00	264.13	254.00
SD	1.29	0.97	6.48
Max	267.52	266.04	266.70
Min	262.48	262.23	241.30



11 AM (V)

	#6(U)	#8(U)	Ref(5%)
Mean	249.27	249.63	254.00
SD	0.69	0.89	6.48
Max	250.62	251.38	266.70
Min	247.91	247.89	241.30



8 PM (V)

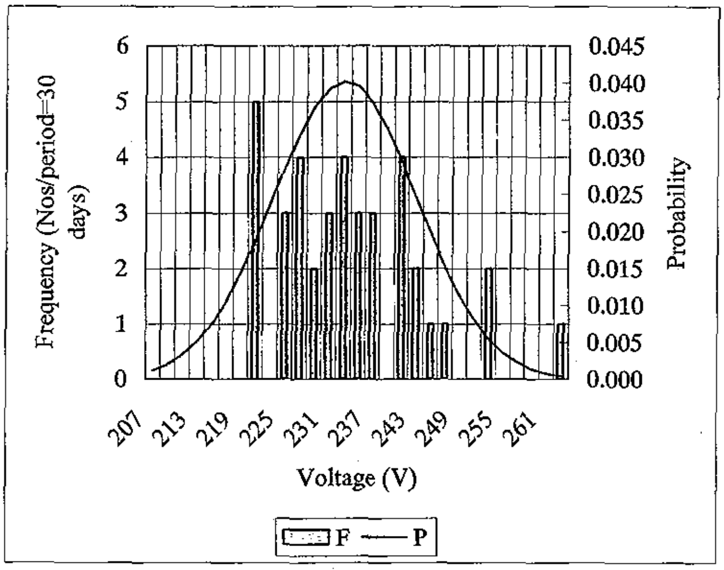
	#6(U)	#8(U)	Ref(5%)
Mean	249.00	248.67	254.00
SD	1.93	1.86	6.48
Max	252.78	252.32	266.70
Min	245.22	245.01	241.30

Figure 3.11(b) Voltage measurement result at end-customer of Kattedan #2 feeder in November 2003

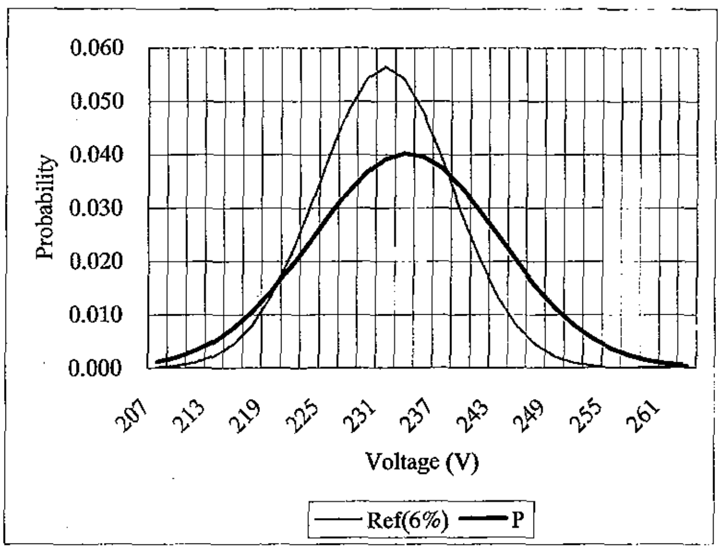
Malkapur feeder
LV Customer end
Sep. 05 through Oct. 04, 2003

(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



Voltage distribution(F) vs.
Probability(P)



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

Figure 3.11(c) Voltage measurement result at end-customer of Malkapur feeder in September 2003

The voltage at the customer ends of Kamalanagar and Kattedan #2 feeders in November 2003 were in the tolerance level of the reference voltages at 3:00, 11:00 and 20:00. It was found that the maximum voltage of Malkapur feeder was exceeded approximately 2.5% from the reference.

The details are shown in Annex 3.4.

3.5.4 Outage

Since there are many feeders in Ranga Reddy and Medak, it was anticipated that analyzing the collected records would be difficult due to the large volume of outages and time limitations. Therefore, before starting data collection work, the study team prepared a small booklet, "Guide for Data Collection and Data Input to Personal Computers" and held briefings for the presentation of the contents of the booklet in March 2003.

Outage records collected are:

23 feeders for the 33 kV distribution systems

244 feeders for the 11 kV distribution systems

These are equivalent to 25% of the existing feeders.

Results of data collection are summarized in Annex 3.5.

(1) Number of Outages

(a) Overall observation for the number of outages in the system

To obtain an idea of the number of outages of Annex 3.5, the distribution of the number of feeders is shown in Figure 3.12, in which the total number of outages of each feeder in 2002/03 is used as the parameter.

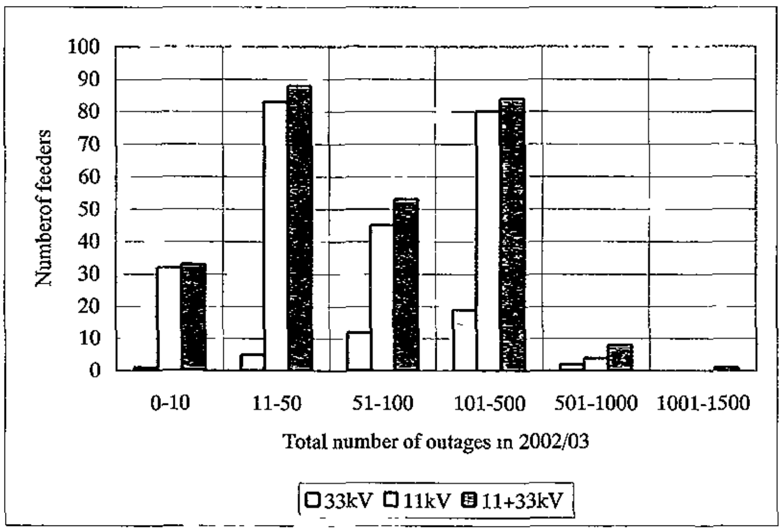


Figure 3.12 Distribution of number of feeders vs. total number of outages in 2002/03 of each feeder

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

From the view point of the combination of 33 kV and 11 kV, the maximum number was 1,117 outages and this is caused by heavy power shedding applied to the agricultural feeder.

To compare the difference between categories of feeders, domestic, industry and agriculture, the following model feeders were selected. Less power shedding is placed on domestic and industrial feeders than agricultural in general.

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

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

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

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

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

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

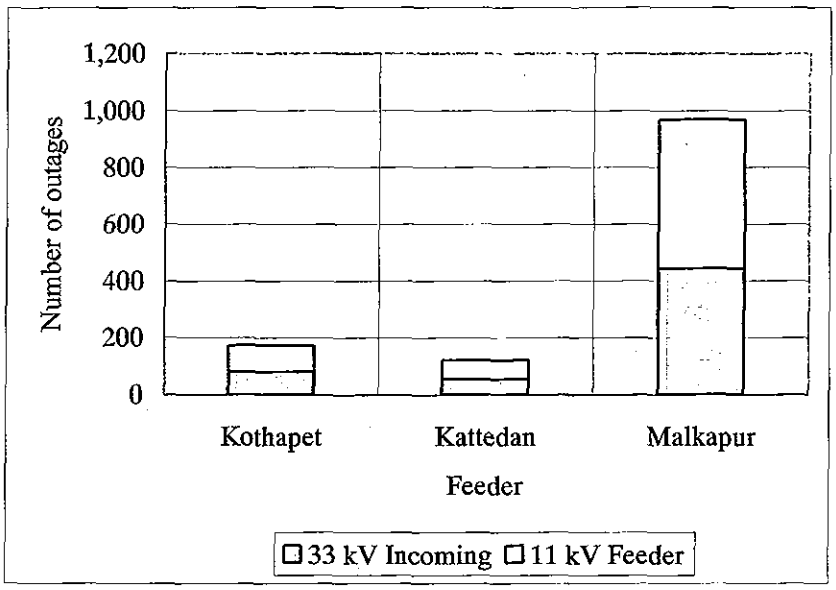
The results of comparison are shown in Figure 3.13.

Considering the effect on customers, the total number of outages of the 33 kV incoming feeder and the 11 kV feeder are 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.



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

Figure 3.13 Comparison of number of outages of model feeders

(b) Substation-wise Number of Outages

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

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

The Kamalanagar feeder, one of the three model feeders, is included in the above 11 kV feeders.

Figure 3.14 shows the feeder-wise number of outages with their causes in the RBAN system.

The code name of the equipment and causes of outages are as follows:

CODE and description

Equipment:

COND	: Conductor	OTH	: Others
INS	: Insulator	POL	: Support structure
JNT	: Joint	TR	: Transformer

Cause of outage:

BW	: Bad weather, heavy rain/strong wind	PUB	: Mistake by a 3rd party
LTG	: Lightning	WOK	: Mistake by a worker
CNT	: Contamination	ZSM	: Scheduled maintenance
INS	: Deterioration of insulator	ZEM	:Emergency (extraordinary) maintenance
ERE	: Improper erection/maintenance	OTH	: Others
OBS	: Contact with obstacles		

No. of outages

		BW	LTG	CNT	INS	OBS	PUB	WOK	ZSM	NCT	LR	OTH	TTL
132BAN	33F(VAN)	0	0	0	0	0	0	0	0	0	12	69	81
33ABD	11ABD	2	0	29	1	8	0	0	0	0	0	82	122
	ANA	3	0	8	0	4	0	0	0	0	0	27	42
	SAB	0	0	1	0	0	0	0	0	0	0	0	1
	SAN	3	0	7	0	8	0	0	0	0	0	29	47
PED	PED	1	0	19	0	4	0	0	0	1	0	32	57
	TAR	2	0	13	0	2	0	0	0	0	0	16	33
RFC	RFC	1	0	7	0	0	0	0	0	0	0	43	51
VAN	BAL	0	0	3	1	6	0	0	0	0	0	9	19
	INJ	1	0	8	7	3	0	0	0	0	0	7	31
	NGO	0	0	1	1	0	0	0	0	0	0	4	7
	VAN	0	0	7	6	4	0	0	0	0	0	20	42
BAN	ALK	0	0	14	1	3	0	1	0	0	0	36	55
	GSI	0	0	12	0	0	0	0	0	0	0	24	36
	NAG	0	0	31	0	0	0	0	0	0	0	75	106
HAY	AIR	0	0	5	1	2	0	0	0	0	0	16	24
	AUT	0	0	18	0	3	0	0	0	0	0	17	38
	HAY	0	0	6	1	2	0	0	0	0	0	17	26
	HCO	0	0	4	0	3	0	0	0	0	0	5	12
	LBN	0	0	12	3	1	0	0	0	0	0	17	33
	MAN	0	0	12	2	1	0	0	0	0	0	14	29
	MOT	0	0	19	3	5	0	0	0	0	0	24	51
	SIR	0	0	13	0	0	0	0	0	0	0	21	34
KOT	KAM	23	1	0	0	0	1	0	13	0	0	51	91
	KOT	33	8	0	24	0	0	0	21	0	0	76	162
	LNR	8	0	0	5	0	0	0	5	0	0	21	39
	MAN	3	0	0	2	0	0	0	0	0	0	2	7
	NOD	15	1	0	0	0	1	0	8	0	0	23	48
	SAM	40	2	0	0	0	2	0	24	0	0	87	155
	TTL	135	12	249	58	59	4	1	71	1	12	864	1,479

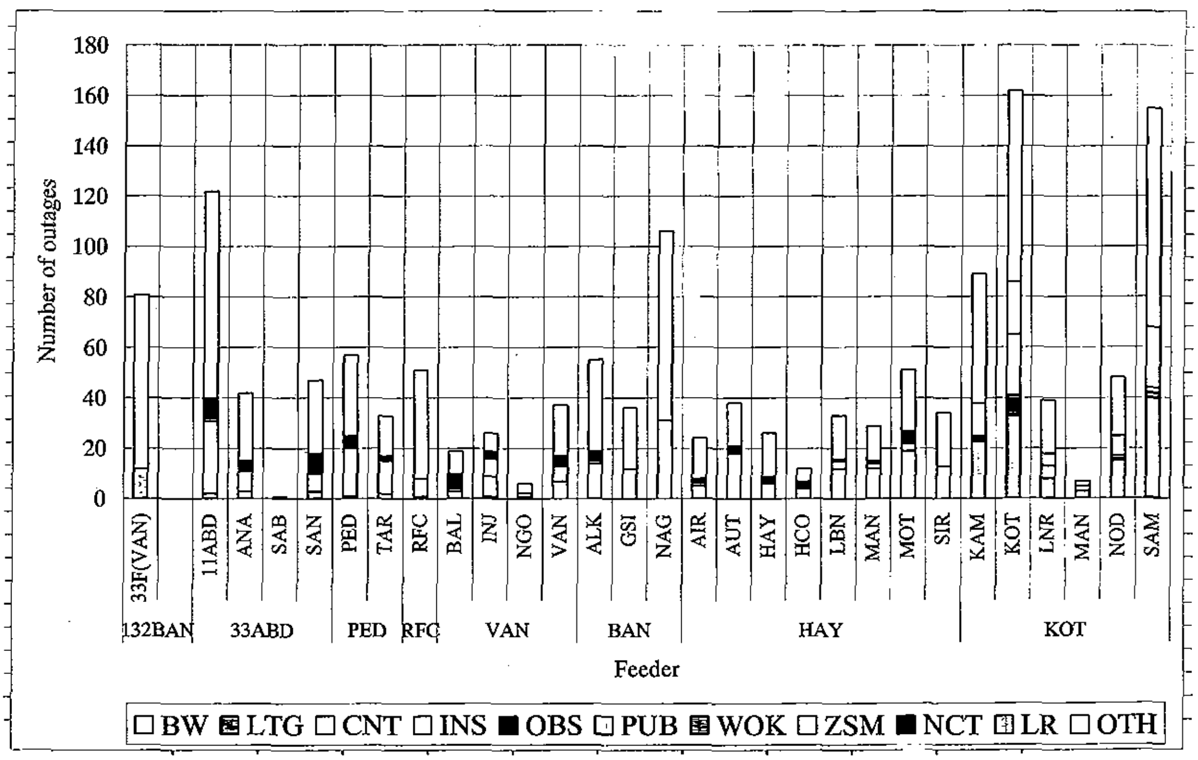
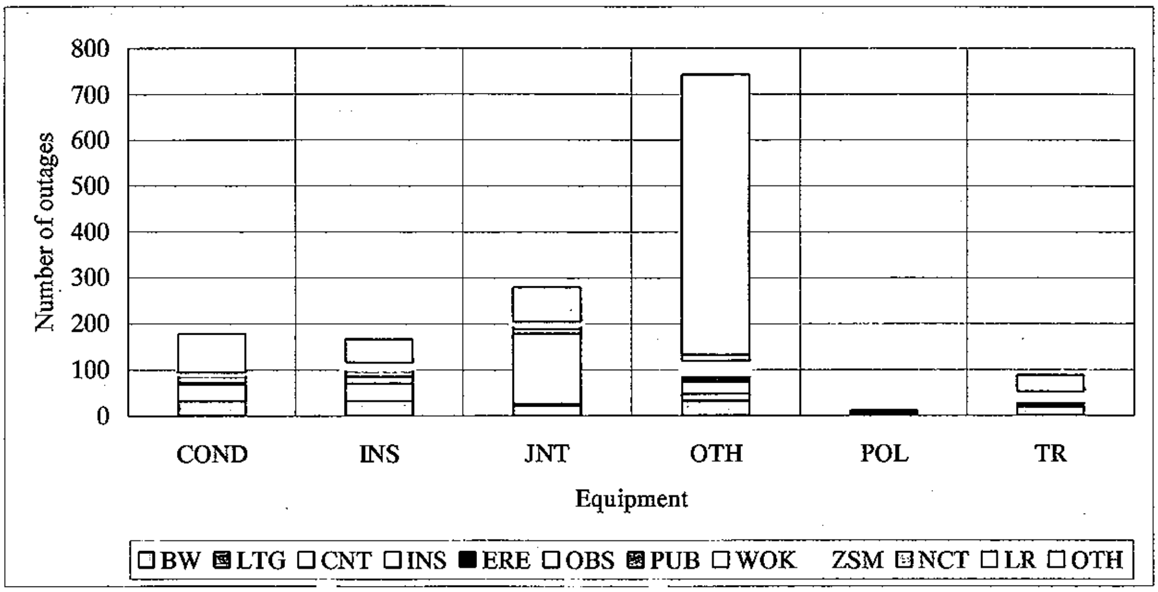


Figure 3.14 Feeder-wise number of outages with causes in the RBAN system

Figure 3.15 shows the equipment-wise number of outages with causes in the RBAN system.



	BW	LTG	CNT	INS	ERE	OBS	PUB	WOK	ZSM	NCT	LR	OTH	TTL
COND	32	0	36	4	0	20	0	0	3	0	0	82	177
INS	32	0	38	15	0	18	0	0	13	0	0	50	166
JNT	21	5	153	9	0	9	0	1	7	0	0	75	280
OTH	31	2	14	26	11	6	0	0	29	1	12	611	743
POL	0	0	1	2	0	2	4	0	0	0	0	2	11
TR	19	5	5	0	0	4	0	0	19	0	0	36	88

Figure 3.15 Equipment-wise number of outages with causes in 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 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 all 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, inferiority of insulators and so on.

(2) Duration of Outages

(a) Overall observation for the duration of outages in the system

In the same way as for the number of outages, the distribution of the number of feeders vs. the total duration of outages of each feeder in 2002/03 is shown in Figure 3.16.

Voltage-wise total duration of the feeders that showed the maximum is;

70,462 minutes for 33 kV feeders

119,433 minutes for 11 kV feeders

In case of a combination of 33 kV and 11 kV feeders, 153,472 minutes in total was found, and load shedding for the agricultural load is the major reason for the above duration.

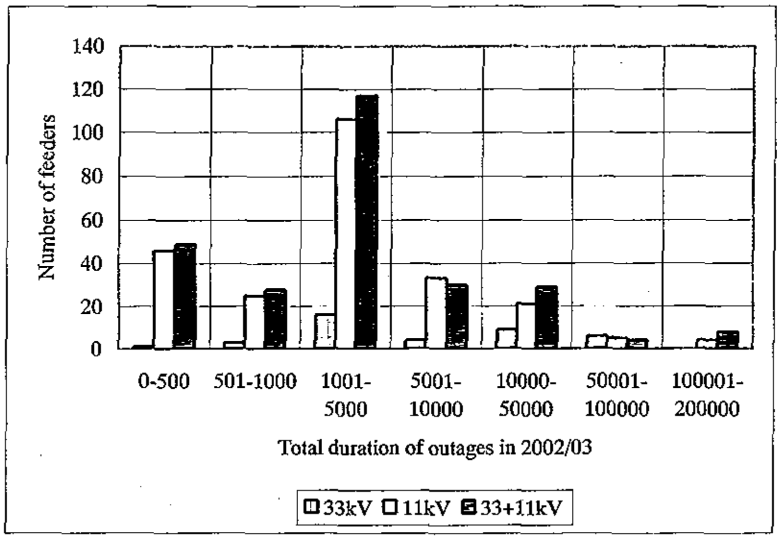
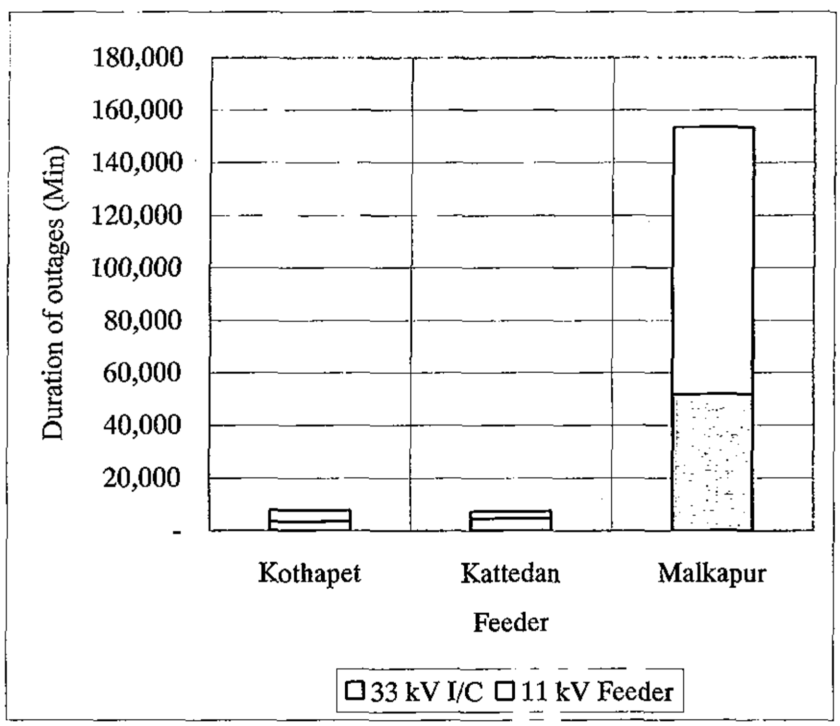


Figure 3.16 Distribution of number of feeders vs. total duration of outages in 2002/03 of each feeder

Similar to the number of outages, a comparison between domestic, industrial and agricultural feeders for the duration of outages was made. The same feeders for the number of outages were selected.



	Kothapet	Kattedan	Malkapur
33 kV I/C	3,646	4,774	51,854
11 kV Feeder	4,090	2,547	101,618

Figure 3.17 Comparison of duration of outages of model feeders

The results of comparison are shown in Figure 3.17. The combination of 33 kV and 11 kV feeders is:

Kamalanagar feeder (Kothapet) 7,736 minutes

Kattedan #2 feeder (Malkapur) 6,601 minutes

Malkapur feeder (Malkapur) 153,472 minutes

The Malkapur feeder is affected by load shedding for the agricultural feeder.

(b) Substation-wise duration of outages

Figure 3.18 shows feeder-wise duration of outages with causes in the RBAN system.

Duration of outages (Min

		BW	LTG	CNT	INS	ERE	OBS	PUB	ZSM	NCT	LR	OTH	TTL
132BAN	33F(VAN)	0	0	0	0	0	0	0	0	0	1,068	2,678	3,746
33ABD	11ABD	150	0	2,060	70	0	510	0	0	0	0	2,940	5,730
	ANA	260	0	470	0	0	300	0	0	0	0	1,890	2,920
	SAB	0	0	950	0	0	0	0	0	0	0	0	950
	SAN	250	0	660	0	0	590	0	0	0	0	1,900	3,400
PED	PED	15	0	928	0	0	240	0	0	20	0	881	2,084
	TAR	50	0	759	0	0	42	0	0	0	0	257	1,108
RFC	RFC	60	0	285	0	0	0	0	0	0	0	365	710
VAN	BAL	0	0	175	120	0	315	0	0	0	0	470	1,080
	INJ	50	0	460	340	370	175	0	0	0	0	440	1,835
	NGO	0	0	45	60	60	0	0	0	0	0	100	265
	VAN	0	0	400	280	400	115	0	0	0	0	915	2,110
BAN	ALK	0	0	72	2	0	9	0	0	0	0	576	661
	GSI	0	0	37	0	0	0	0	0	0	0	189	226
	NAG	0	0	88	0	0	0	0	0	0	0	1,710	1,798
HAY	AIR	0	0	32	5	0	10	0	0	0	0	156	203
	AUT	0	0	182	0	0	87	0	0	0	0	113	382
	HAY	0	0	51	2	0	16	0	0	0	0	79	148
	HCO	0	0	54	0	0	45	0	0	0	0	129	228
	LBN	0	0	138	12	0	10	0	0	0	0	293	453
	MAN	0	0	78	48	0	40	0	0	0	0	293	459
	MOT	0	0	240	20	0	33	0	0	0	0	175	468
	SIR	0	0	238	0	0	0	0	0	0	0	481	719
KOT	KAM	1,750	435	0	0	95	0	190	515	0	0	1,105	4,090
	KOT	1,300	105	0	415	0	0	0	920	0	0	3,570	6,310
	LNR	240	0	0	140	0	0	0	270	0	0	1,345	1,995
	MAN	95	0	0	90	0	0	0	0	0	0	60	245
	NOD	290	15	0	0	0	0	20	180	0	0	565	1,070
	SAM	1,148	25	0	0	155	0	135	1,080	0	0	2,518	5,061
	TTL	5,658	580	8,402	1,604	1,080	2,537	345	2,965	20	1,068	26,193	50,454

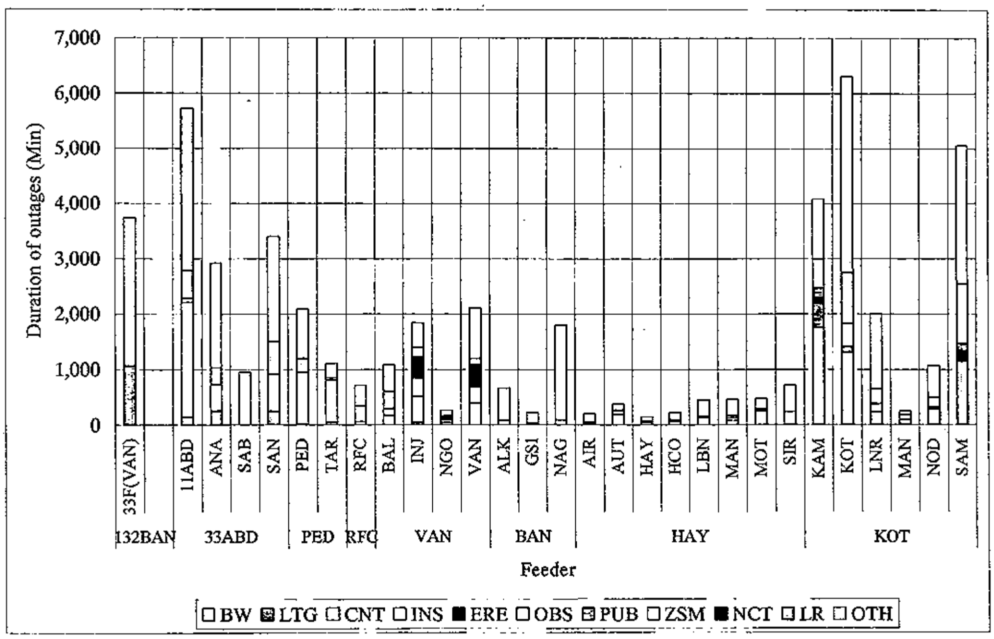
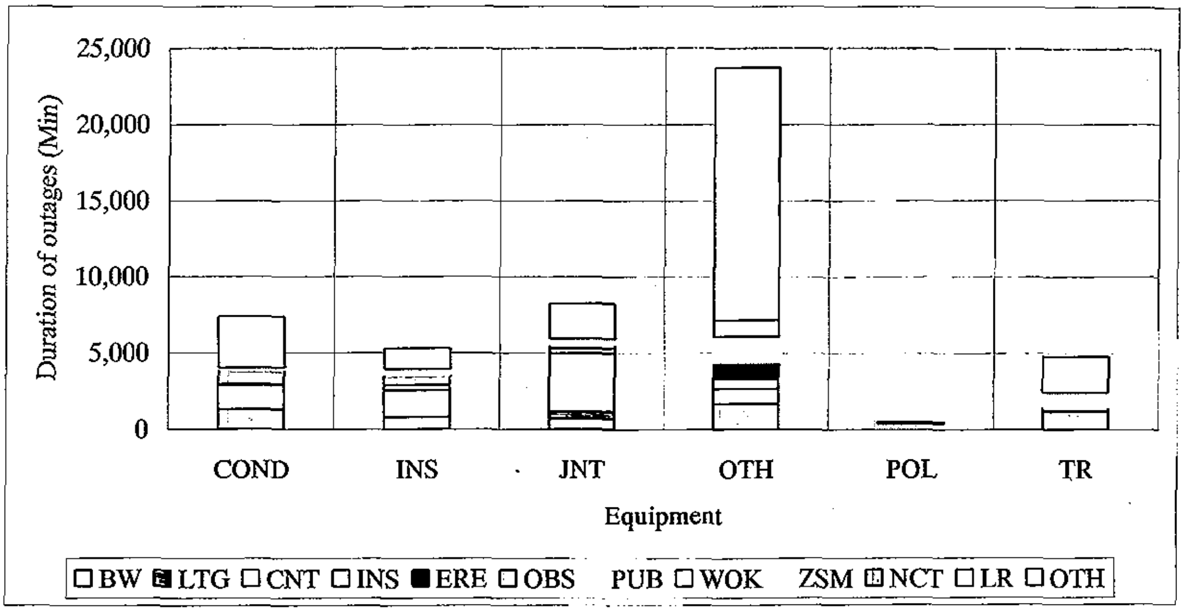


Figure 3.18 Feeder-wise distribution of outages with causes in the RBAN system

Figure 3.19 shows equipment-wise duration of outages with causes in the RBAN system.



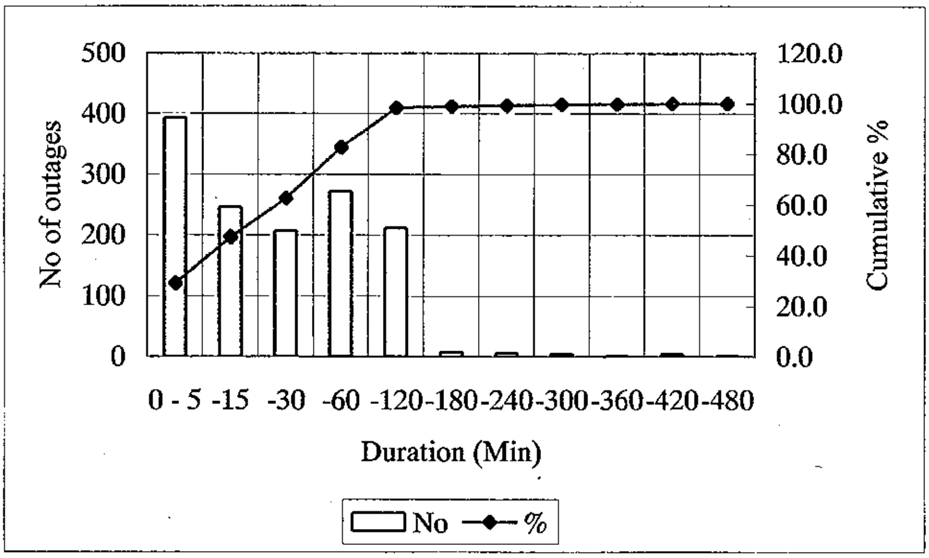
	BW	LTG	CNT	INS	ERE	OBS	PUB	WOK	ZSM	NCT	LR	OTH	TTL
COND	1,325	0	1,566	55	0	1,062	0	0	30	0	0	3,355	7,393
INS	830	0	1,725	339	0	748	0	0	300	0	0	1,376	5,318
JNT	700	490	3,795	335	0	309	0	2	325	0	0	2,292	8,248
OTH	1,700	10	966	650	950	208	0	0	1,630	20	1,068	16,528	23,730
POL	0	0	60	105	0	25	200	0	0	0	0	100	490
TR	1,163	80	200	0	0	185	145	0	680	0	0	2,342	4,795

Figure 3.19 Equipment-wise duration of outages with causes in the RBAN system

When an outage occurs, it is important to minimize the time required for restoration. Figure 3.20 shows the distribution of duration of outages of 11 kV feeder outages in the RBAN system;

Restored within 30 minutes	62.4 %
Restored within 120 minutes	98.2 %
Maximum duration of outage	435 minutes

Total number of outages except no duration records is 1,355.



Total number = 1,355

Figure 3.20 Distribution of duration of outages in the RBAN System

(3) Analysis Results of All the Feeders

Analysis results of all the feeders are attached in Reference-1 for reference.

3.5.5 Load Rejection

As mentioned in 3.5.2, fluctuation of frequency, load rejection (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 Srisailam and Nagarjunasagar Power Stations. Peak hour consumption went up to 7,000 MW and power shortage was 700 – 1,200 MW. A two-hour power cut on domestic and industrial sectors during peak hours except twin cities, Hyderabad and Secunderabad, was carried out.

3.5.6 Overload

Among the various distribution equipment, transformers are the most likely to become overloaded. The total number of outages of transformers in RBAN in 2002/03 was 88, of which 66 had causes other than overload. The details of the remaining 22 (25 % of all the transformer outages), which had the possibility of overload were 6 for OC actuated and 16 for category "others."

3.5.7 Inventory Control (Spare parts)

At the maintenance work or restoration of a fault, restoration time may be prolonged due to lack of spare parts required. The small quantities of spare parts that are in daily use are kept by the section office and large quantities are managed by the district office. If there is necessity, it is also possible to temporarily divert the materials for construction works that are always carried out in the same area.

3.5.8 Operation and Maintenance Manual

Since the operation and maintenance methods have not been changed fundamentally from before, the same manual of APSEB, the former organization of APTRANSCO/APCPDCL, is used as it is. It is found that some offices/substations have not been equipped with it.

3.6 Data Analysis

3.6.1 Frequency

The numerical estimated averages and minimum values of the minimum frequency in May 2002 were 47.87 and 47.7 Hz, respectively. The average maximum frequency of the same month was 48.34 Hz, and this frequency was much less than the standard of 50 Hz.

From the outage records, it is clear that severe load shedding was carried out to maintain the minimum frequency of 47.5 Hz above the minimum limit in extreme conditions,.

In November 2002, although the average minimum frequency recovered to 49.26 Hz, the average maximum frequency was only 49.84 Hz, so the system operated at a lower frequency than normal even during seasons other than the dry season.

From January 1, 2003, at least 49.0 Hz is maintained by having carried out ABT.

3.6.2 Voltage

The voltage problems including higher voltage class were not accepted in the cases of domestic (Kamalanagar) and industry (Kattedan #2) feeders in November 2003.

About agriculture (Malkapur) feeder, distance is long compared with the other feeders and the customer is located at the end of the feeder, therefore, a larger voltage variation of 15% is recorded than approximately 5% of the others.

3.6.3 Number of Outages and Duration of Outages

Although the outline of outages is explained in 3.5.4, the detailed analysis results are introduced here and problems are examined.

(1) Season and outages

Figure 3.21 shows the number of outages by season in 2002/03 and the peaks of outages are observed in May through July 2002 and March 2003. Since a conclusion cannot be drawn from the results of one year, it is necessary to monitor them continuously.

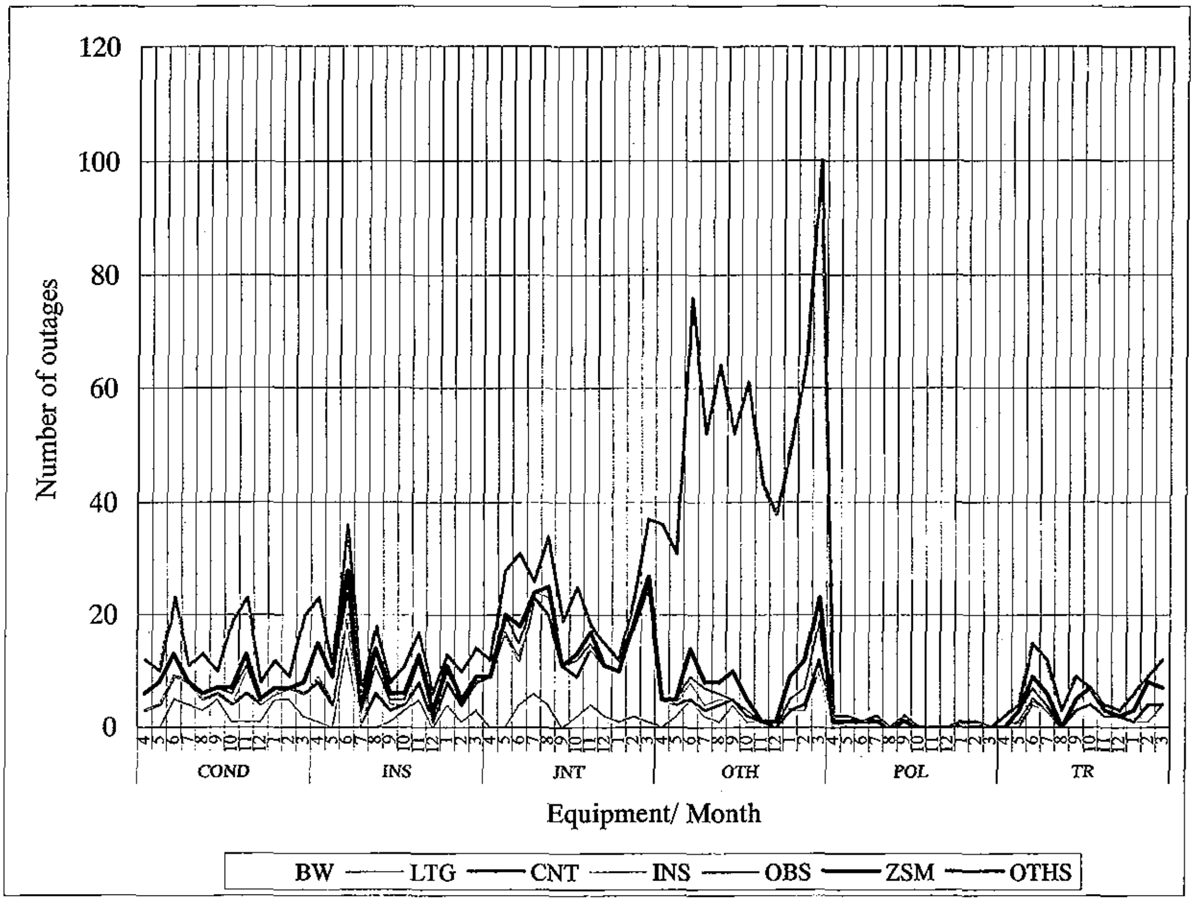


Figure 3.21 Month-wise number of outages in the BRAN sysem

(2) Month-wise Number of Outages due to Contamination

Figure 3.22 shows number of outages due to contamination and it is clear that the trouble of the joint (JNT) occurs frequently in May, July, August 2002 and February and March 2003.

This tendency needs to watched without a break, whether they are either accidental or dependent on the season. Moreover, it is unexpected that troubles occur more frequently on a joint than an insulator (INS).

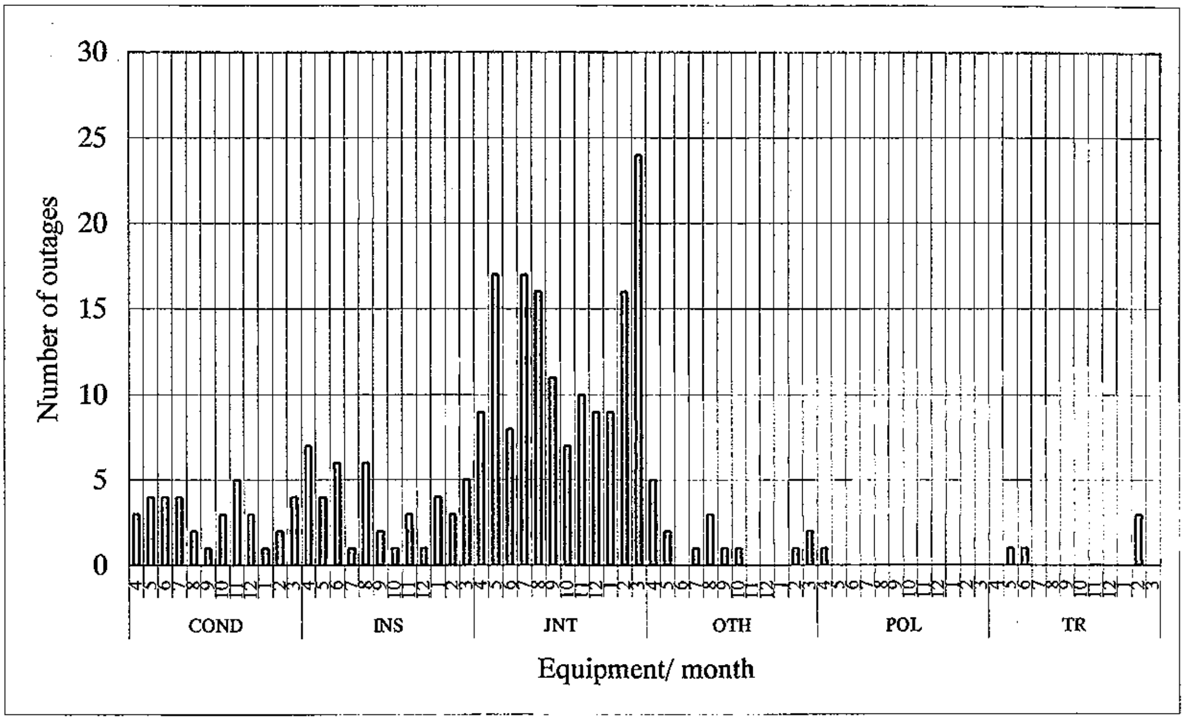


Figure 3.22 Month-wise number of outages due to contamination in the BRAN system

(3) Duration and Cause of Scheduled Maintenance

Duration and cause of the scheduled maintenance are shown in Figure 3.23.

Generally, it is considered that a scheduled maintenance is appropriated for an annual maintenance schedule and is intentionally carried out. However, the results of the study show that approximately 65 % of them are due to protective relay operation and less than 30 minutes of inspection period.

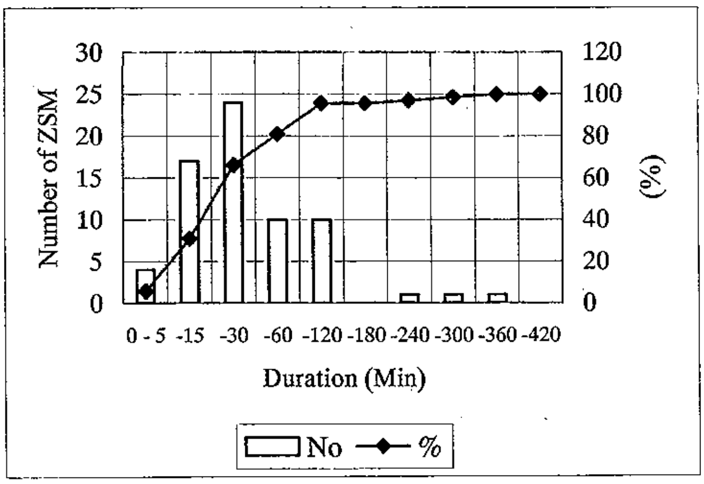
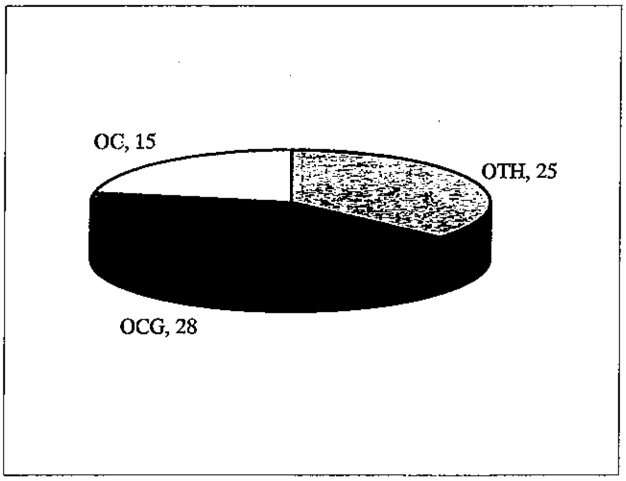


Figure 3.23(a) Outage duration of scheduled maintenance (ZSM)



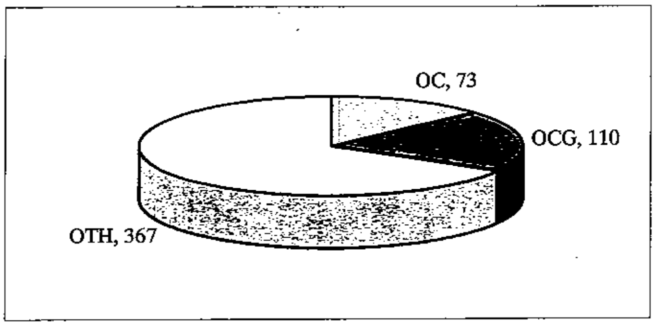
Total 68

Figure 3.23(b) Cause of scheduled maintenance

(4) Details of Unknown Causes and Equipment

The outages with unidentified equipment and causes are classified as OTH/OTH. Of 550 faults, 187 were caused by the protective relays operated.

Figure 3.24 shows details of OTH/OTH outages.



Total 550

Figure 3.24 Details of OTH/OTH outages

3.6.4 Over Load

The section office continuously monitors overload of transformers.

3.6.5 Inventory Control (Spare Parts)

As mentioned above, the district office and section office manage the spare parts by the authority regulations (Delegation of Powers), and no problems are observed.

3.6.6 Operation and Maintenance Manual

An operation and maintenance manual is a guideline for operation/maintenance of the substations and feeders but, for example, the operation manual for substations presently used is arranged at the time of

APSEB and same is commonly used from 200/132 kV to 33/11 kV substations.

Therefore, it is recommended to create new manual that is in conformity with the DISTRIBUTION CODE that will be applied from 2004. It also includes how to treat the new type of equipment and the point of being careful of each substation or feeder is specified. The same manual should be made issued so that the personnel in charge of operation of substation share common knowledge and thoroughness.