JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

GOVERNMENT OF MAHARASHTRA,INDIA
DEPARTMENT OF IRRIGATION

MASTER PLAN STUDY

ON

PUMPED STORAGE HYDROELECTRIC POWER DEVELOPMENT

IN

MAHARASHTRA STATE, INDIA

FINAL REPORT

MARCH , 1998

ELECTRIC POWER DEVELOPMENT CO.,LTD.
PACIFIC CONSULTANTS INTERNATIONAL

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PREFACE

In response to a request from the Government of the Republic of India, the Government of Japan decided to conduct the Master plan study on the Pumped Storage Hydroelectric Power Development in Maharashtra state, the Republic of India and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent a study team, led by Mr.Terumi Ushijima of Electric Power Development Co., Ltd.(EPDC), and organized by EPDC and Pacific Consultants International Ltd., to the Republic of India five times from September 1994 to March 1998.

The team held discussions with the officials concerned of the Government of India, and conducted related field surveys. After returning to Japan, the team conducted further studies and complied the final results in this report.

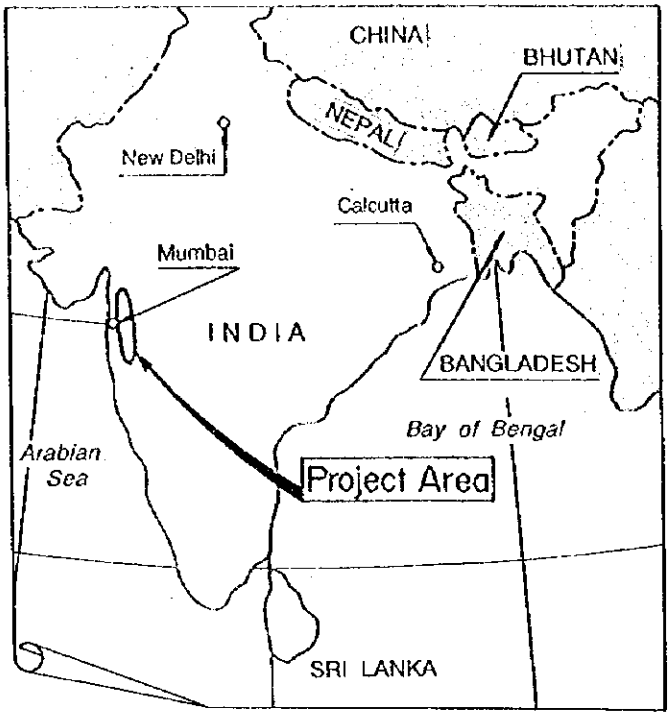
I hope this report will contribute to the promotion of the plan and to the enhancement of friendly relations between our two countries.

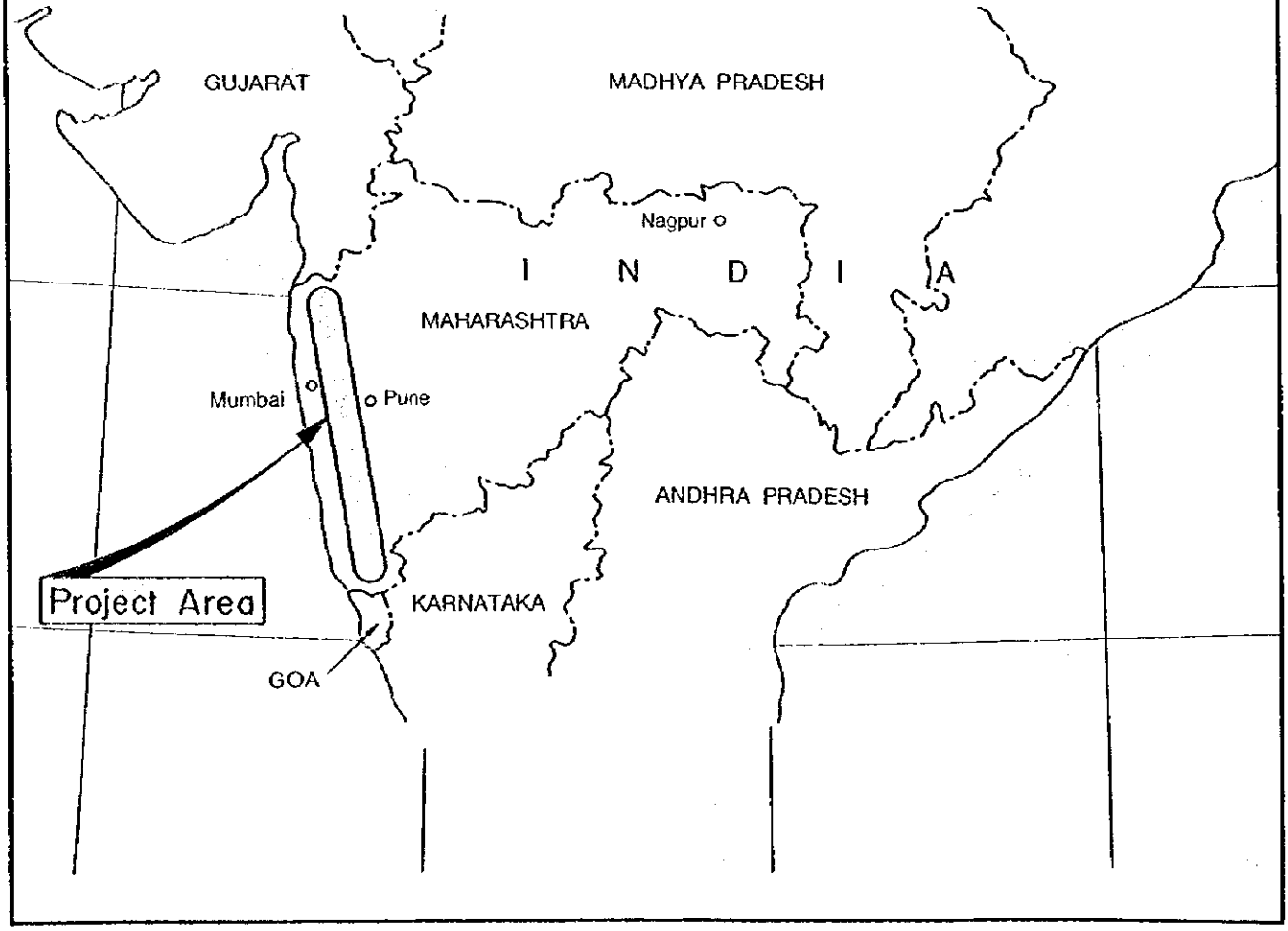
I wish to express my sincere appreciation to the officials concerned of the Government of India for their close cooperation throughout the study.

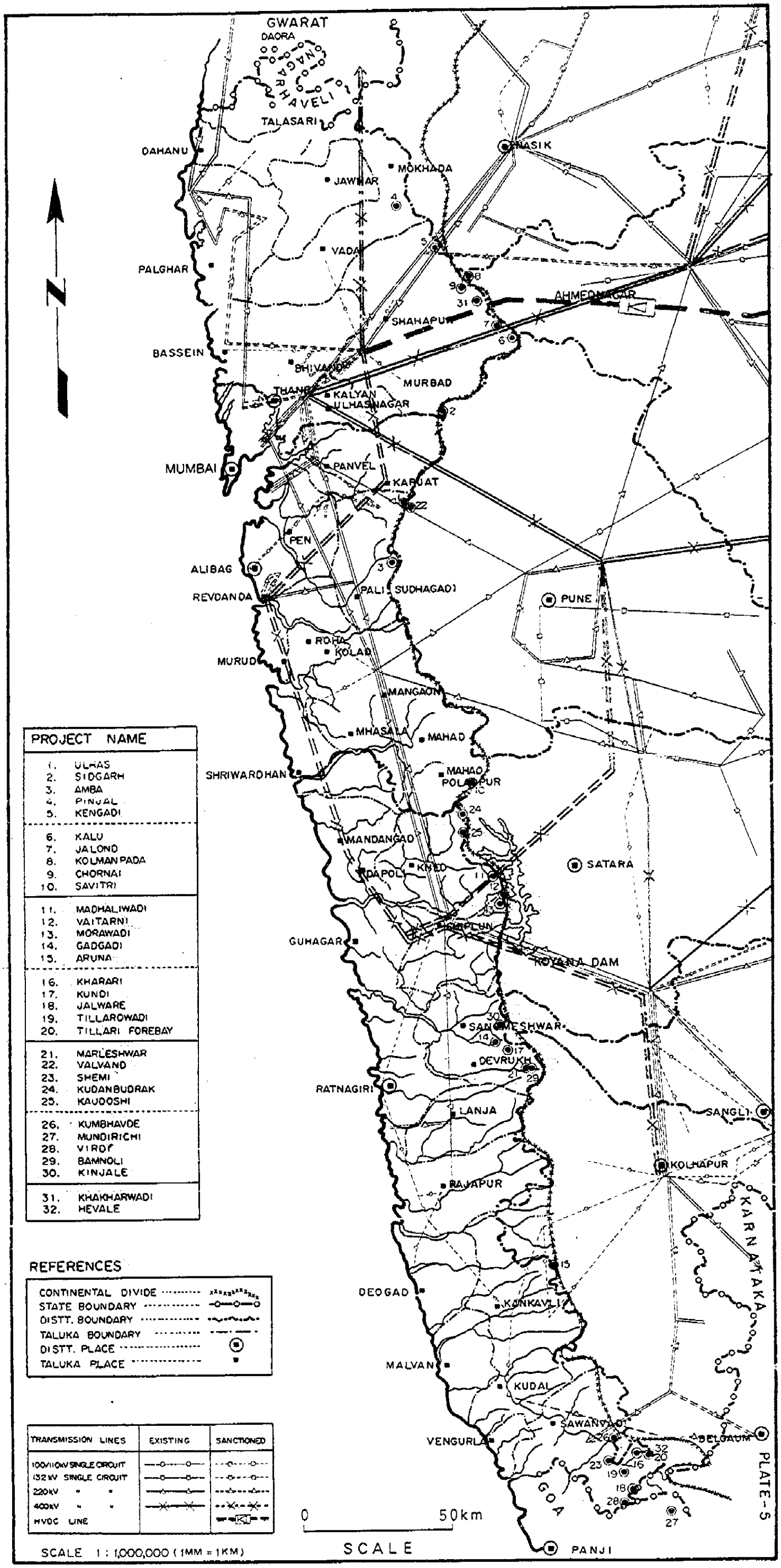
March 1998

Kimio Fujita
President
Japan International Cooperation Agency

LOCATION MAP







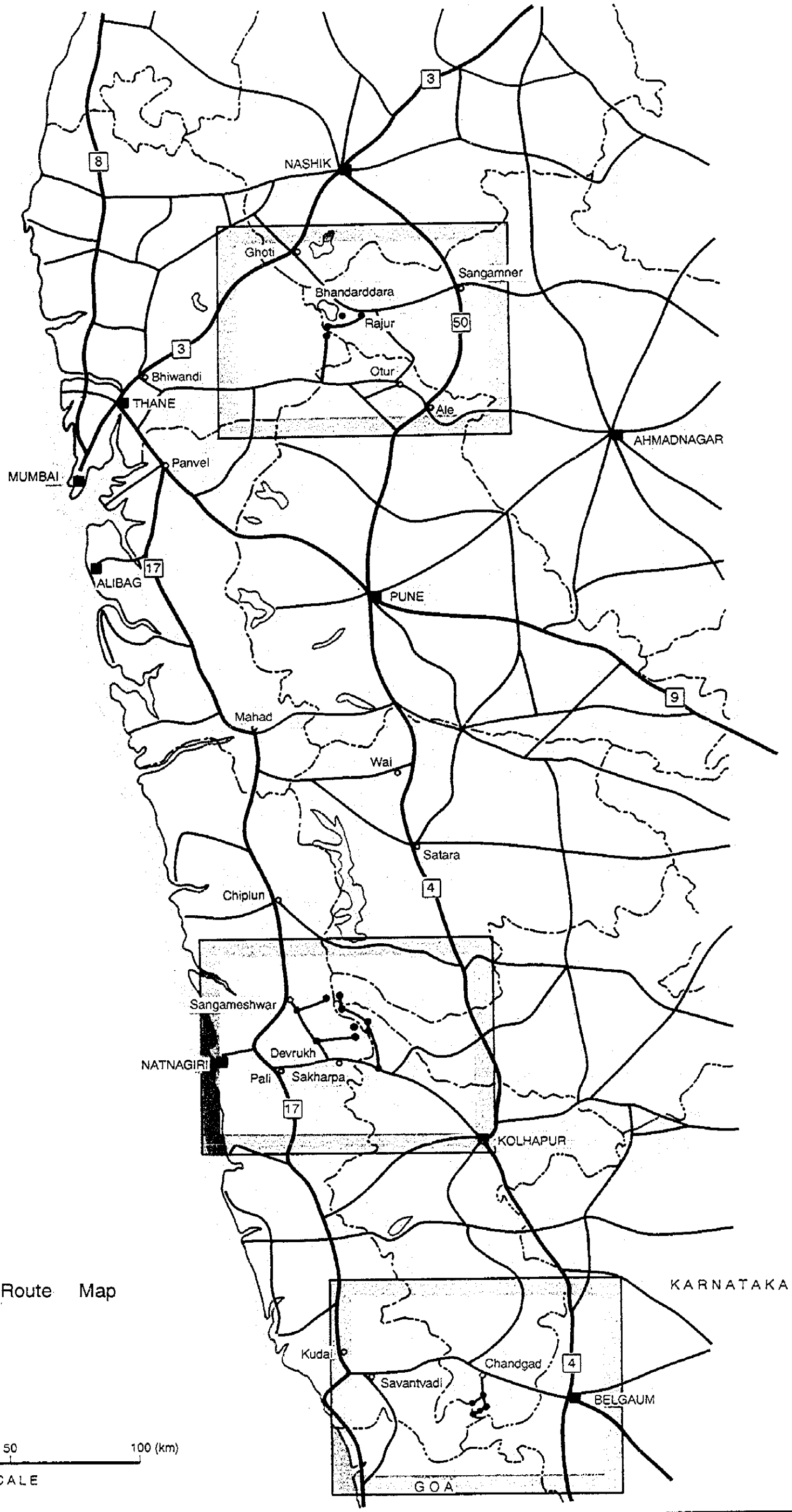
PROJECT NAME	
1.	ULHAS
2.	SIDGARH
3.	AMBA
4.	PINJAL
5.	KENGADI
6.	KALU
7.	JALOND
8.	KOLMANPADA
9.	CHORNAI
10.	SAVITRI
11.	MADHALIWADI
12.	VAITARNI
13.	MORAWADI
14.	GADGADI
15.	ARUNA
16.	KHARARI
17.	KUNDI
18.	JALWARE
19.	TILLAROWADI
20.	TILLARI FOREBAY
21.	MARLESHWAR
22.	VALVAND
23.	SHEMI
24.	KUDANBUDRAK
25.	KAUDOSHI
26.	KUMBHAVDE
27.	MUNDIRICHI
28.	VIROF
29.	BAMNOLI
30.	KINJALE
31.	KHAKHARWADI
32.	HEVALE

REFERENCES

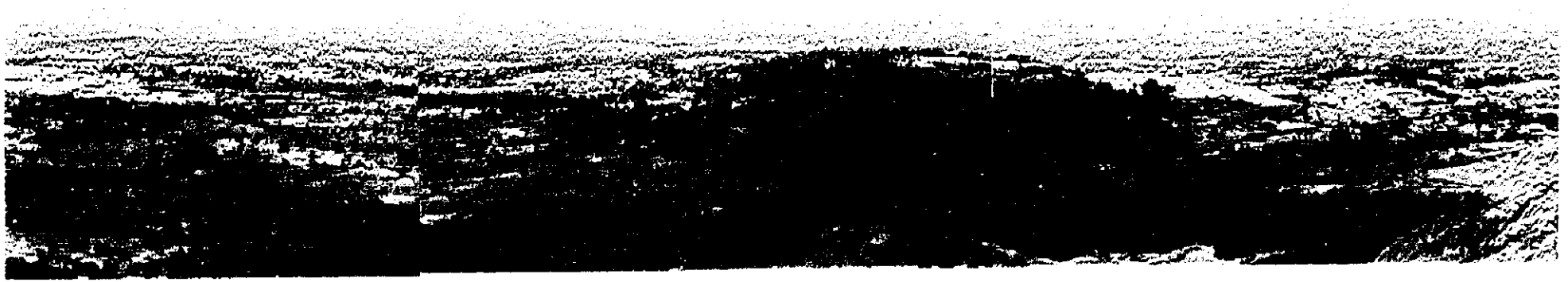
CONTINENTAL DIVIDE	
STATE BOUNDARY	
DISTT. BOUNDARY	
TALUKA BOUNDARY	
DISTT. PLACE	
TALUKA PLACE	

TRANSMISSION LINES	EXISTING	SANCTIONED
100/110kV SINGLE CIRCUIT		
132 kV SINGLE CIRCUIT		
220kV " "		
400kV " "		
HVDC LINE		

SCALE 1 : 1,000,000 (1MM = 1KM)

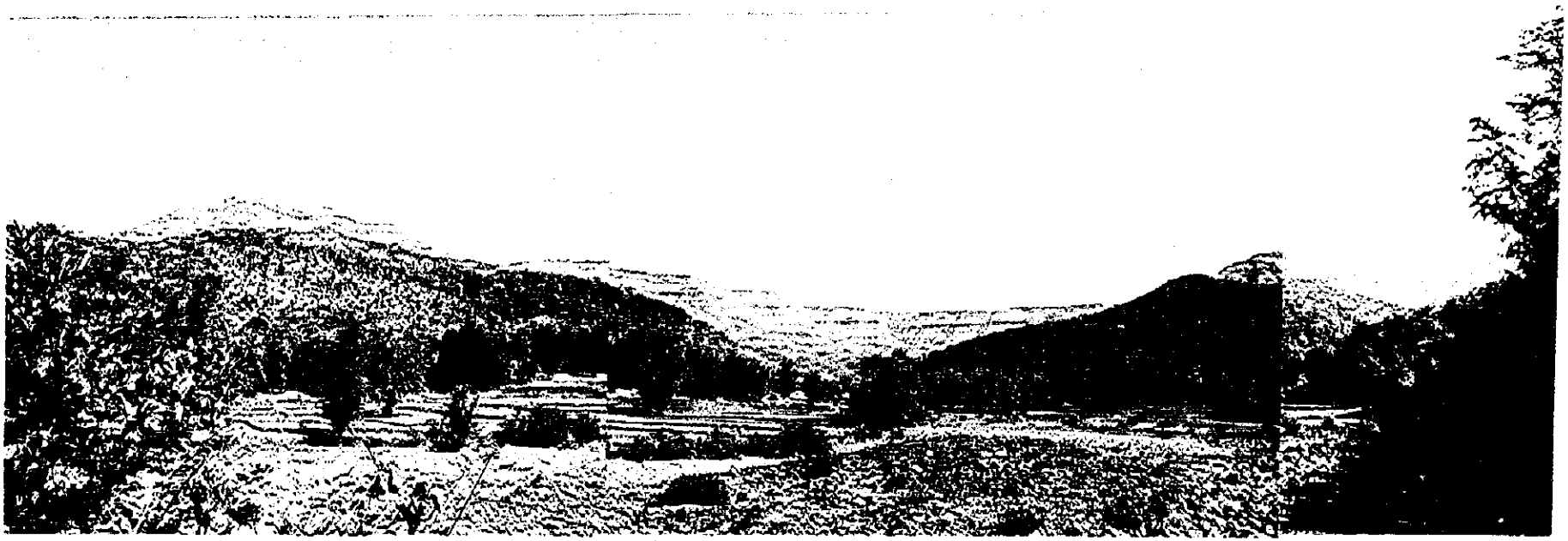

NASHIK
3
8
Ghoti
Sangamner
Bhandarddara
Rajur
50
3
Otur
Bhiwandi
THANE
Ale
AHMADNAGAR
Panvel
MUMBAI
17
ALIBAG
PUNE
9
Mahad
Wai
Satara
4
Chiplun
Sangameshwar
Devrukh
NATNAGIRI
Pali
Sakharpa
17
KOLHAPUR
KARNATAKA
Kudal
Chandgad
4
Savantvadi
BELGAUM
GOA
0
50
100 (km)
SCALE

Route Map



Jalond: Upper reservoir (Panoramic view from the left hill near Kumshet)

Mareshwar: Upper reservoir
(Panoramic view from the left bank of main dam)



Mareshwar: Lower reservoir
(View from the dam axis to reservoir area)

Tillari Forebay: Upper reservoir, Hevale: Lower reservoir and Upper reservoir
(Panoramic view from the left bank of upper reach)

Hevale: Upper reservoir
(Panoramic view from the top of the mountain to the east)

ABBREVIATION

1. Countries

GOI	Government of India

2. Domestic Organizations

GOMID	Government of Maharashtra, Irrigation Department
MSEB	Maharashtra State Electricity Board
SOI	Survey of India
SBI	State Bank of India
EIV	Economic Intelligence Unit
BNHS	Bombay Natural History Society
BSES	Bombay Suburban Electricity Supply Ltd.
MOP	Ministry of Power
CEA	Central Electricity Authority
SEB	State Electricity Board
NHPC	National Hydro Power Cooperation
NTPC	National Thermal Power Cooperation
TATA	TATA Electric Companies
DPC	Dabhol Power Company
MOEF	Ministry of Environment and Forests

3. International and Foreign Organizations

JICA	Japan International Cooperation Agency
OECF	Overseas Economic Cooperation Fund, Japan
IBRD	International Bank for Reconstruction and Development
WB	World Bank
ADB	Asian Development Bank
IMF	International Monetary Fund

4. Technical Terms

C.A.	Catchment Area
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
HWL	High Water Level
LWL	Low Water Level
IWL	Intake Water Level

TWL	Tailrace Water Level
SIL	Standard Intake Level
STL	Standard Tailrace Level
FRL	Full Reservoir Level
MDDL	Maximum Draw Down Level
EL	Elevation (m) above sea Level
EIA	Environmental Impact Assessment
P/S	Power Station
S/S	Sub Station
T/G	Turbine and Generator
T/L	Transmission Line
T/D	Transmission and Distribution
AC	Alternating Current
DC	Direct Current
cct	Circuit
S/Y	Switchyard
GIS	Gas Insulated Switchgear
O&M	Operation and Maintenance
IPP	Independent Power Producer
PIS	Preliminary Investigation Report

5. Measurement

(1) Length

mm	Millimeter
cm	Centimeter
m	Meter
km	Kilometer

(2) Area

cm^2	Square centimeter
m^2	Square meter
ha	Hectar
km^2	Square kilometer

(3) Volume

cm^3	Cubic centimeter
l	Liter
kl	Kiloliter

m^3	Cubic meter
MCM	Million cubic meter
BOE	Barrels of oil equivalent

(4) Weight

g	Gram
kg	Kilogram
ton or t	Metric ton
TOE	Ton oil equivalent
kgoe	Kilogram oil equivalent

(5) Time

s or sec.	Second
min	Minute
h	Hour
d	Day
M	Month
yr	Year
FY	Fiscal Year

(6) Meteorology

°C	Degree in centi-grade
°K	Degree in kelvin-grade
mb	Milibar
hp	Hecto Pascal

(7) Electrical Measures

V	Volt
kV	Kilovolt
A	Ampare
Hz	Hertz(cycle)
W	Watt
kW	Kilowatt
MW	Megawatt
GW	Gigawatt
kWh	Kilowatt hour
MWh	Megawatt hour

GWh	Gigawatt hour
kVA	Kilovolt ampare

(8) Others

Btu	British thermal unit
rpm	Round per minute
%	Percentage
Lu	Lugeon

6. Economic Evaluation Terms

GDP	Gross Domestic Production
GRDP	Gross Regional Domestic Production
B/C	Benefit Cost Ratio
B-C	Net Benefit
EIRR	Economic Internal Rate of Return
FIRR	Financial Internal Rate of Return
ARI	Accounting Rate of Interest
DSC	Debt Service Coverage Ratio
IDS	Interest During Construction
CIF	Cost, Insurance and Freight
FOB	Free on Board
IRR	Internal Rate of Return
EDR	Equalizing Discount Rate
SCF	Standard Conversion Factor
LRMC	Long-Run Marginal Cost
OCR	Ordinary Capital Resources
GAAP	Generally Accepted Accounting Principles
F/C	Foreign Currency
L/C	Local Currency
US$ or $	US Dollar
M.US$	Million US Dollar
USc or c	US cent
Rs	Indian Rupee
paise	Rs0.01
¥	Japanese Yen

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CHAPTER 1 INTRODUCTION

CONTENTS

LIST OF FIGURES

CHAPTER I INTRODUCTION

1.1 Foreword

This Study was started in September, 1994, as part of the technical cooperation provided by the Japan International Cooperation Agency (JICA) to establish a pumped storage hydroelectric power development program which will be subjective to the feasibility study in the future for Maharashtra State, India. The objectives of the Study were to produce a Master Plan for pumped storage hydroelectric power development and to conduct a Pre-feasibility Study accordingly regarding the several candidate sites.

Ministry of Environment and Forests (MOEF), Maharashtra State, advised that two of the three sites subjected to the Pre-feasibility Study were situated in environmental protection areas. The Ministry also instructed the suspension of the geological site investigation at these sites (December, 1995). Although aerial photography surveys were made at the three sites in question, the Indian Government did not provide permission for the taking out the resulting topographic maps from the country, thereby disabling the Pre-feasibility Study in Japan.

This Final Report is a compiling of the studies conducted at the sites and in Japan from September, 1994, to March, 1998. This Final Report consists of the following three volumes.

Volume I: Executive Summary
Volume II: Main Report
Volume III: Appendixes

1.2 Process and Background

Maharashtra State is situated in western India. With Mumbai, India's largest commercial city, the population of Maharashtra State is 78,700,000. Over the past five years, the power demand in Maharashtra State has increased at a high 8.5% annual growth. As of March, 1993, the maximum power demand was 6,828MW.

At the end of 1994, the installed capacity of the State was 9,324MW, approx. 81% of which was provided by thermal power, this mainly by coal-fired power plants. While the main role of the thermal power generation systems is to supply the base power, they are presently forced to control their output to meet the demand every minute. Consequently, the systems are significantly deteriorated.

Maharashtra State lacks appropriate sites for reservoir type hydro power plants which would be able to effectively respond to the peak demand. Contrarily, with steep mountains to the south and north, the topography of its western region provides many sites which would be appropriate for a pumped storage power project.

The power source of the State is currently concentrated into thermal/gas turbine power generation (81%). According to future development plans, the proportion of thermal/gas turbine power generation will be promoted even further.

Regarding the demand forecast, the difference between the peak load and off-peak load is expected to increase.

Therefore, installation of pumped storage power plant, with its excellent start-shutdown and load follow-up performance, enables the promotion of a highly efficient, regular and continuous load operation of thermal power generation facilities and prevents vary-load operation which is adverse for thermal power generation facilities. It is expected to ensure system safety and improve the system reliability, thereby improving the supply reliability and enabling the highly efficient operation of all related power source facilities.

The Indian Government requested the Japanese Government to conduct a Master Plan Study for a pumped storage hydroelectric power development in the Konkan Region, Maharashtra State, as part of a Project to achieve highly efficient power facility operation in that State.

The Japanese Government agreed to provide technical assistance for this Project and a JICA Preliminary Study Team was dispatched to India from January to February, 1994, with Mr. H. Adachi (Power Development Specialist, JICA) as its leader.

This Preliminary Study Team conducted a site reconnaissance, data collection for the study and also held discussion with Government of Maharashtra Irrigation Department (GOMID). The Scope of Work (S/W) and related Minutes of Meeting (M/M) for the Master Plan Study on Pumped Storage Hydroelectric Power Development in Maharashtra State, India were finalized, and formally agreed upon by the signing by the both parties of the said documents on11th February, 1994.

In order to carry out the study contemplated in the above S/W and M/M, JICA selected a consulting firm and awarded the works to the joint venture of the Electric Power Development Co., Ltd. (EPDC) and Pacific Consultants International (PCI), upon completion of a prescribed documentary examination.

The Study Team, formed in accord with the above Agreement and with Mr. T. Ushijima (EPDC) as its leader, began this Study in September, 1994.

The study team carried out such activities as data collection, review of the previous studied master plan study, hydrological survey, a geological investigation work, and environmental impact accessment.

The field work was carried out in cooperation with the team's counterparts from the GOMID. During the study, the study team transferred technical know-how to their counterparts through the field investigation and JICA invited two counterparts to Japan for technical training. All the work for this Study was completed by March, 1998.

1.3 Objectives, Scope and Contents of Study

1.3.1 Objective of the Study

The Study was carried out to produce a Master Plan for pumped storage hydroelectric power development and to conduct a Pre-feasibility Study of the candidate sites accordingly, thereby establishing a pumped storage hydroelectric power development program for the Feasibility Study in the future for Maharashtra State.

A further objective was to transfer technology related to pumped storage power generation to GOMID engineers.

1.3.2 Area and Scope of Study

(1) Area of Study

The Study was applied to the Konkan Region, a coastal area of Maharashtra State.

GOMID had previously identified pumped storage power project sites on the maps of Konkan Region (coastal district). The list provided by the Ministry of Power, Central Government, contained 23 sites ranging from Savitri which extended the highest head of 1,065 m, to Tillariwadi with the lowest head of 58 m. Location and capacity of 23 projects are indicated in **Fig. 1.3-1.**

The JICA Study Team identified 9 more sites utilizing the topographic map of the Konkan Region, thereby realizing a total of 32 sites for the Study.

(2) Scope of Study

The scope of the Study was a development study for a pumped storage hydroelectric power development.

The scope of Study was initially planned to be carried out in the following three stages;

1) Master Plan Study
2) Detailed Site Investigation
3) Pre-feasibility Study

However, the geological site investigation was partially canceled because parts of the study area were situated in forestry protection areas. Also, permission to take out the 1:10,000 topographic maps produced by the aerial photographic surveys which were carried out by Survey of India from the country was not granted by Government of India. Consequently, only 1) Master Plan study and 2) Detailed site study were carried out, this excluding some geological site investigation work.

1.3.3 Contents of Study

Contents of the Study to be performed are as follows:

(1) Master Plan study

(a) Preparatory work in Japan

(i) Collection and review of related data and information

(ii) Preparation of Inception Report

The Inception Report contained a policy statement outlining the general approach for the study and its execution methodology as well as a request to GOMID for assistance to facilitate the Study.

(b) 1st Field Survey

(i) Explanation of Inception Report and discussion

(ii) Collection of existing data

Materials, data, and documents regarding the following were acquired to carry out the Study.

a. Geologic maps of the candidated site
b. Hydrology and meteorology
c. Report of Preliminary Investigation Study prepared by GOMID
d. Power development data
e. Environmental study data

(iii) Power Survey

a. Power supply organizations including their management and systems
b. Existing power facilities in the western region and Maharashtra State
c. Existing and ongoing power development projects (including transmission and transformation projects)
d. Acquisition and examination of data and reports related to power demand forecast and power development plans
e. Forecast of daily load curve
f. Pumping energy resource (Constant output of thermal / nuclear power plants)
g. Validity of this Project based on the characteristics of a pumped storage power development project

(iv) Preliminary environmental study

a. Identifying problems of existing and ongoing power development projects concerning the environmental impact assessment
b. Confirmation of criteria for environmental impact assessment, and procedures accompanying environmental impact assessment
c. Confirmation of forest protection laws, and procedures accompanying clearance acquisition

d. Confirmation of water rights related laws, and procedures accompanying water rights acquisition
e. Activities of local environmental groups, professionals and environment NGO, and preparation of their list

(v) Preliminary study regarding the specifications of topographical survey

Discussions were held with the survey of India (SOI) to determine the specifications of the topographical survey and the following items were studied;

a. Availability of survey equipment and its precision
b. Availability of stereo plotting equipment and its precision
c. Availability of skillful surveyors
d. Other necessary items

The SOI is the only organization in India which carries out aerial photography survey and produces topographic maps. Therefore, the survey firm, who was contracted separately, was re-consigned to the SOI for this work. The Study Team determined the specifications for the survey works. Complete discussions were made with the survey firm to ensure smooth study execution.

(c) First Work in Japan

(i) Analysis of collected data

Materials and data collected during the primary site work was analyzed.

(ii) Formulation of Scheme

The formulation of schemes were carried out in this stage.

(iii) Preparation of primary inventory

a. Potential development schemes were extracted from the 32 sites based on existing topographic maps, hydrological and meteorological data. Estimation of available development scale and development cost, and schematic environmental impact assessment were also considered in this study.

b. Candidate sites for site reconnaissance were defined. (Jolond, Kinjale, Marleshwar, Tillari Forebay, and Hovale)

(iv) Finalization of topographical survey

Method, area and site of topographic survey were examined and the specifications of the survey were finalized for contracting accordingly. The cost of re-consignment and man-month of personnel required by the employer were also examined.

(d) Second Field Survey

(i) Site reconnaissance

The sites were surveyed on foot to conduct the following studies.

a. Identification and selection of suitable dam site
b. Confirmation of dam site configuration (including riverbed width and slope of abutment on both sides)
c. Identification of problems related to structure layout
d. Possible routes for access roads

(ii) Geological survey

The site were surveyed on foot to identify the geological characteristics of Maharashtra State in general and the geological problems associated to each project site.

(iii) Hydrological and meteorological survey

a. Site survey
   * Conditions of existing meteorological gauging stations and river flow (water level) gauging stations
   * Traces of flood at the candidate project sites
   * Study of locations where hydrology and meteorology observation instruments should be placed
b. Study of execution plan for hydrological and meteorological observations

(iv) Preliminary environmental surveys

a. Identification of current natural environment (topography, geology, water quality, vegetation, wild life, etc.)
b. Identification of current forest ecology
c. Identification of current social environment (population, industry, transportation, scenery, cultural assets, etc.)

(v) Collection of supplementary information

The information concerning cost estimate and economic evaluation were collected to supplement the information following the First Field Survey.

(vi) Procurement of survey equipment

The JICA India Office procured a set of survey equipment and granted GOMID. The JICA study team made a necessary advice in terms of technical points of view to the office for the procurement of equipment.

(f) Second Work in Japan

(i) Second Inventory Study

a. The Primary Inventory was reviewed according to the results of the site reconnaissance.
b. The Study Team carried out the preliminary study for capacity of reservoir and operation rule, the concept design of civil structure, the preliminary study of installed capacity and annual operation hours, the confirmation of pumping up energy, the preliminary cost estimate, the preliminary economic evaluation and the preliminary environmental impact assessment.

(ii) Selection of projects where the detailed site investigations would be conducted

The three most promising sites, Jalond, Marleshwar and Hevale, were selected as the sites to be conducted the detailed site investigation according to the results of the second inventory study.

(iii) Preparation of progress report

The Progress Report has been compiled based on the second site survey and the second study in Japan.

(iv) Technology transfer

The technology transfer to a counter part will be done in Japan upon request of GOMID.

(v) Preparation of Detailed Site Investigation's Specifications and Work Schedule

Specification of the Detailed Site Investigation and Work Schedule were prepared to define the scope of following studies.

* Geological Investigation
* Environmental impact assessment
* Investigation of re-location and its compensation

(2) Detailed Site Investigation

(a) Third Field Survey

(i) Presentation and discussion of Progress Report I

(ii) Environmental impact assessment

a. Natural environment survey (earth-sphere, hydrosphere, and biosphere, atmosphere)
b. Forest ecology survey (distribution of preservation forests, planning for logging, forests to be submerged and planting)
c. Social environment survey (population, industry, communication, transportation, water and its utilization, landscapes, sanitation, and cultural assets)

In the above surveys, the Bombay Natural History Society (BNHS) conducted the survey on Hevale, while GOMID carried out surveys for Jalond and Marleshwar.

(iii) Study for re-location and compensation

(iv) Study for Water Right Acquisition

(v) Hydrology and meteorology Study

a. Installation of hydrological/meteorological observation equipment
b. Execution of hydrological/meteorological observations

In the above surveys, GOMID performed the observation works and the observation data were provided to the Study Team Considering the distribution of existing observation sites, the locations of equipment installation will be determined based on discussion between GOMID and the Study Team.

(b) Fourth Field Survey

(i) Geological survey

Geological investigation works have been conducted at the Jalond, Marleshwar and Hevale sites.

During the investigation work, however, MOEF of Maharashtra State indicated that parts of project areas of Jalond and Marleshwar are included in the environmental conservation area, and that a part of the investigation works at Jalond was halted. The following studies were implemented in the geological investigation.

a. Seismic prospecting
b. Drilling work, permeability test and laboratory test
c. Observation and evaluation of boring cores

(ii) Environmental impact assessment

The environmental impact data surveyed by GOMID and BNHS were received, their contents were reviewed and discussed with GOMID and BNHS.

(iii) Re-location scheme and compensation study

The study results on re-location and compensation performed by GOMID and BNHS were received, their contents were reviewed and discussed with GOMID and BNHS.

(c) Fifth Site Survey

(i) Geological survey

a. Continuation of works performed in the fourth site survey.
b. Geological structure analysis

A site reconnaissance was conducted on Jalond, Marleshwar and Hevale sites and reviewed the results of geological site investigation works.

(ii) Hydrological/meteorological survey

The hydrological and meteorological data observed by GOMID were received and analyzed.

(iii) Environment impact assessment

The environment impact assessment conducted by GOMID and BNHS were received and discussed. The Study Team carried out site reconnaissances at Jolond, Marleshwar and Hevale to check the contents of the reports.

(iv) Re-location scheme and compensation study

The study results on re-location and compensation carried out by GOMID and BNHS were received and their contents were reviewed and discussed with GOMID and BNHS and discussed with GOMID and BNHS.

(v) Presentation and discussion of Progress Report II

The results of detailed site investigation were compiled in Progress Report II and submit it. The Study Team explained the report and discussed on it.

(3) Preparation of Final Report

(a) Third work in Japan

The additional geological investigation, the preliminary environmental impact evaluation and re-location/compensation studies were evaluated. A Final Report was prepared based on the results of the Master Plan Study and detailed site investigation and submitted.

1.4 Field Survey

The field survey was carried out in Maharashtra State, India.

The time period and contents of the field survey conducted by the Study Team are outlined below.

(1) First field survey

Period: From September 4th. to September 24th, 1994

Contents of survey:

- Submission and presentation of Inception Report
- Acquisition of existing data
- Power survey
- Preliminary environmental study
- Studies for preparation of topographic survey specifications
- Site reconnaissance (Savitri Site)
- Exchange of minutes of meetings

(2) Second field survey

Period: From January 9th to February 16th, 1995

Contents:

- Site reconnaissance (Jalond, Marleshwar, Kinjale, Tillan Forebay and Hevale sites)
- Power Survey
- Preliminary environmental study
- Hydrology study
- Exchange of minutes of meetings

(3) Third field survey

Period: from march 16th to March 30th, 1995

Contents:

- Submission and presentation of Progress Report I
- Environmental impact assessment
- Re-location and compensation study
- Water right acquisition study
- Hydrological and meteorological study
- Supplementary site reconnaissance (Chornai Site) and power survey at Koyna hydroelectric power station.

(4) Fourth field survey

Period: from September 27th to October 14th and from November 22nd. to December 6th, 1995

Contents:

- Planning of geological surveys at Jalond, Marleshwar and Hevale sites, contracting geological site investigation works, guidance and supervision of investigation works
- Preliminary environmental impact study; guidance and supervision of preliminary environmental impact study conducted by GOMID and BNHS
- Hydrological survey; advice and guidance on hydrological survey conducted by GOMID and BNHS
- Technology transfer
- Exchange of minutes of meetings

(5) Fifth field survey

Period: From February 25th to March 25th, 1996

Contents:

- Submission and presentation of Progress Report II
- Evaluation and analysis of geological investigation
- Hydrological survey; existing data and hydrological surveys conducted by GOMID were analyzed

- Results of environmental impact assessment conducted by GOMID and BNHS were received and their contents reviewed and discussed with GOMID and BNHS.
- Study of re-location and compensation
- Technology transfer
- Exchange of minutes of meetings

1.5 Personnel Related to Study

The personnel related to the study in Maharashtra state and member of JICA Study Team are listed below.

(1) GOMID

Mr. R. G. Kulkarni	Secretary (Irrigation)
Mr. M. V. Bhave	Secretary (CAD)
Mr. P. B. Umerani	CE (WR) & Jt. Secretary
Mr. V. C. Shahane	C.E. Irrigation Dept. Konkan Region
Mr. D. S. Taware	Chief Engineer (Electrical), Hydro Projects
Mr. B. P. Pawar	Deputy Secretary (HP) & Superintending Engineer
Mr. V. B. Khairmode	Superintending Engineer (Thane Irrigation Circle)
Mr. G. D. Bhoi	Superintending Engineer (Thane Irrigation Circle)
Mr. D. S. More	Section Engineer (Thane Irrigation Circle)
Mr. Hedaoo	Executive Engineer
Mr. J. P. Shah	Deputy Engineer
Mr. Siddaramayya	Deputy Engineer
Mr. V. A. Patil	Deputy Engineer
Mr. Tupsounder	Deputy Engineer
Mr. Hosalli	Sectioned Engineer Sectional
Mr. Waghmare	Sectioned Engineer
Mr. Saraf	Sectioned Engineer
Mr. Shivshankaran	Sectioned Engineer

(2) MSEB

Mr. R. V. Nadkarny	Chief Engineer (Transmission - Planning)
Mr. S. M. Mujvmdar	Executive Engineer
Mr. D. Y. Ghanekar	Deputy Chief Engineer, Nashik Thermal Power Station
Mr. R. G. Patil	Chief Engineer (Gen. O&M), Nashik Thermal Power Station
Mr. T. K. Shivraman	Superintending Engineer (Gen.), Uran Gas Thermal Power Station
Mr. P. R. Narasimhachar	Superintending Engineer (Gen.), Uran Gas Thermal Power Station
Mr. S. N. Joshi	Deputy Chief Engineer (Gen.), Uran Gas Thermal Power Station

(3) Embassy of Japan in India

Mr. Masato Fukushima	First Secretary

(4) JICA India Office

Mr. Minoru Sasao	General Manager
Mr. Hidekazu Kumano	General Manager
Mr. Masahiro Nomura	Deputy general Manager
Mr. Toshiaki Tanaka	Deputy General Manager
Ms. Nana Hosoi	Staff

(5) JICA Study Team

Mr. Terumi Ushijima	Team Leader (till March 1996)
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Mr. S. S. Vaishampayan	Geological Investigation Engineer (Seismic Props.)
Mr. Toshiro Wada	Electrical Engineer
Mr. Ryuhei Oyama	Electromechanical Design Engineer
Mr. Hideaki Morishita	Transmission Line Engineer
Mr. Sumio Tsuru	Environmental Engineer (till March 1996)
Mr. Teruhiko Tsumura	Environmental Engineer (from December 1997)
Mr. Sanpei Nakanishi	Environmental Engineer
Mr. S. D. Chawathe	Environmental Engineer
Mr. Takao Ozaki	Project Economist
Mr. Hidenori Yaguchi	Coordinator

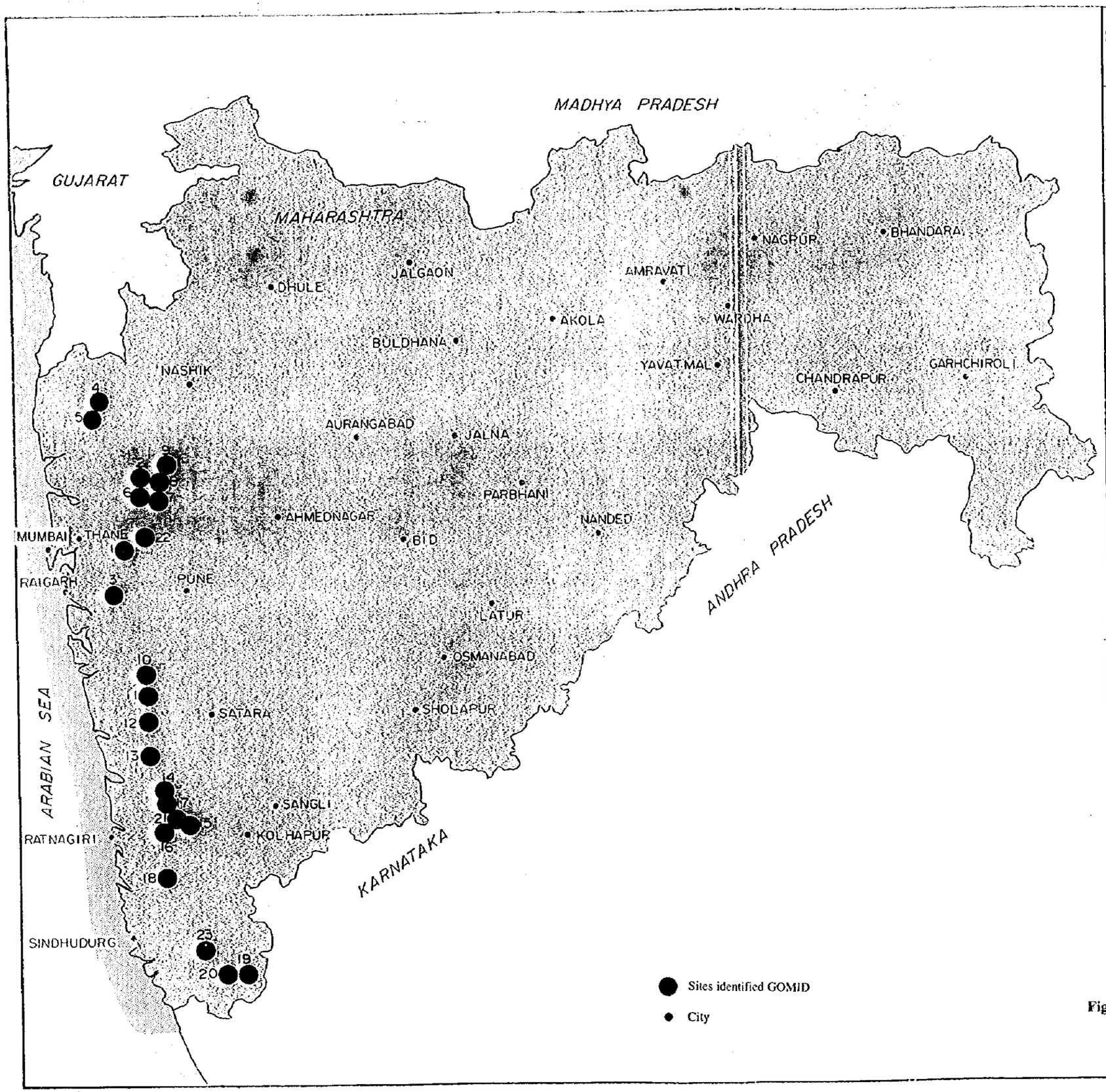
1.6 List of Data Collection

Preliminary Investigation Study (PIS) Reports prepared by GOMID.

Ulhas
Sidgarh
Pinjal
Kengadi
Kalu
Jalond
Chrnai
Savitri
Madhaliwadi
Vaitarni
Gadgadi
Aruna
Kharari
Kundi
Jalwara
Tillari Forebay
Marleshwar
Volvand
Shemi

(2) Others

The Wild Life Protection Act, 1972
The Water (Prevention and Control of Pollution) Act, 1979
The Environment (Protection) Act, 1986
The Protection of Civil Rights Act, 1995
Annual Report 1993-94, Ministry of Environmental and Forests
Forest (Conservation) Act, 1980, Rules of Guidelines



ST. NO.	NAME OF SCHEME IDENTIFIED	HEAD (m)	Probable Installed Capacity (MW)
1	2	3	4
1	ULHAS	584	1250
2	SIDGARH	648	500
3	AMBA	495	750
4	PINJAL	125	200
5	KENGADI	225	500
6	KALU	398	400
7	JALOND	598	1200
8	KOLMONDAPADA	481	1600
9	CHORNAI	452	1000
10	SAVITRI	1065	1000
11	MADLIWADI	512	900
12	BAITARNI	449	1800
13	MORWADI	407	2320
14	GADGADI	541	600
15	ARUNA	465	950
16	KHARARI	675	1050
17	KUNDI	537	600
18	JALVARA	555	2000
19	TILLARIWADI	58	60
20	TILLARIWADI Forboy	625	125
21	MORLESHWAR	697	2000
22	VALAVND	572	250
23	SHEMI	342	210
TOTAL			22265

Fig.1.3 -1 Location of Pumped Storage Projects in Maharashtra

CHAPTER 2 GENERAL FEATURES OF THE STATE OF MAHARASHTRA

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CHAPTER 2 GENERAL FEATURES OF THE STATE OF MAHARASHTRA

2.1 Geography

The state of Maharashtra is in the west central India with a western coast line along the Arabian Sea and bounded by the states of Gujarat on the northwest, Madhya Pradesh on the north and east, Andhra Pradesh on the southeast, and Karnataka on the southwest. Most of the area comprise the Deccan Plateau.

The third largest state of India, both in area and population, Maharashtra was formed in 1960 when the Marathi and Gujarati linguistic areas of the former Bombay State were separated. Bombay city became the capital of the new state.

Geographically, Maharashtra State is divided into five districts, Konkan, Desh, Khandesh, Marathwada and Vidarbha.

Konkan district is a coastal area. It is a narrow strip some 50 km to 60 km wide and 500 km long stretching from north to south between the Western Ghats mountains to the east and the Arabian Sea to the west.

Desh district is Maharashtra's central and most representative area. It comprises the Deccan Plateau. The principal rivers are the Godavari, Bhima and Krishna, which rise in the Western Ghats and flow southeastward to the Bay of Bengal.

Originating in Trimbakeshwar in Nashik District, the Godavari is the longest river and passes through the cities of Nashik, Kapargaon, Paithan, Gangakhed, and Nanded. The Godavari Valley is the historic cradle of Marathi culture. Here the modern Marathi language emerged.

The Bhima River originates in Bhimashanker and, joined by its tributaries the Kukadi, Pawana, Indirayani, Mula-Mutha, Neera, and Karha, it joins the Krishna River at Raichur in Karnataka State.

The Krishna River originates in Maharabaleshwar. Joined by its tributaries Venna, Koyna, and Panchganga, it runs through the cities of Wai, Sangli, Miraj, and Narsobawadi.

Khandesh district comprises the Tapi River Valley where alluvial bottomlands produce cotton, oilseeds, and tobacco. The area has been the object of rivalry as a frequently contested transitional zone between northern and southern India.

Marathwada district comprises Marathi-speaking districts that were part of the former princely State of Hyderabad. Dependence on agriculture as source of livelihood in this district than in any other.

Vidarbha district is easternmost area in the State of Maharashtra. It focuses on Nagpur, the third largest city in Maharashtra.

2.2 Climate

Maharashtra State is situated between lat.16°N. and lat.22°N. It lies in the monsoon zone with four clear seasons of summer, rainy season, autumn, and winter.

Winter temperature can soar above 40°C. However, being affected by the sea, the highest temperature along the coast ranges between 20°C to 25°C, although the humidity is high here. From mid-June to mid-October, Maharashtra State experiences heavy rainfall from the southeasterly monsoons. In Konkan, especially, the annual rainfall can reach some 2,500 mm to 3,500 mm.

2.3 Population

A 1991 census indicated the population of 78.7 million in Maharashtra State, and 843.9 million in India. The population of Maharashtra State was showing a 25% increase in ten years over the 62.8 million of 1981.

More than half of people in Maharashtra State are engaged in agriculture. Maharashtra State has also played a leading role in the India's march toward industrial development. The main factors supporting this industrial development are the State's geographic location, rich land, long coastline and good ports, its road and railway networks, funding, and abundant human resources and raw materials. Especially, the textile industry has the longest history in India. Maharashtra is also superior in both the fields of machinery production and chemical production. The official language of Maharashtra State is Marathi.

2.4 Macro Economy and Energy Sector

A bird's eye view of the energy sector and the power sub-sector is briefly presented herewith in a bid to articulate the background and economic environment where the prospective project would take place in the years to come.

2.4.1 Growth and Macro Management of Economy

In the 1980s, India kept in shape in economic performance with an average annual growth rate rising to more than 5 percent from about 3.5 percent in the 1960s and 70s. This was largely due to an accelerated growth in the industrial sector, gradual deregulation of industry, increasing public expenditure, the steady devaluation of the rupee, and the trade regime liberalization. In 1989, the GDP growth rate was 6.0 percent followed by 5.6 percent in 1990. With the economic growth achieved, India made considerable progress in alleviating poverty, attained self-sufficiency in many agricultural items and built a substantial industrial base.

Nevertheless, the Indian economy also had to bear the full brunt of adverse effects of the higher growth such as deterioration in the balance of payments, increased fiscal deficits and rising domestic and external borrowing. The GDP growth rate was 2 percent in the second half of 1991 largely due to a severe foreign exchange shortage associated with political uncertainty[1].

In the face of a severe balance of payment crisis, a new government launched the policy reform program to restore India's macro economy balance focusing on the investment regime, trade policies, the financial sector, taxation and public enterprises in July 1991. Initially, growth declined sharply in response to the devaluation and contractionary fiscal and monetary policies, with GDP growth downsized to 0.8 percent in FY1991 from 5.6 percent in FY1990. With the government's firm decision to maintain the thrust of that bold stabilization and structural policy package, the following FY1992 and 1993 proved to be the years of recovery for India. Again, on the macro economic front, real GDP growth rate recovered to 4 percent in the two consecutive years from 0.8 percent in FY1991 largely due to a strong rebound of agricultural production. Industrial production showed a moderate recovery because of the deflationary effects of the initial stabilization measures. The manufacturing sector growth rate recovered to 2 percent in FY1992 and 93 from negative 2 percent in 1991. Inflation fell in the last two years with 7 percent in FY1992 and FY1993 from a peak of 17 percent in mid-1991. External and fiscal imbalances have been reduced considerably.

Then, helped by an unprecedented sequence of good monsoons, a relaxation in fiscal policies and a robust supply-response to the reforms, growth gained momentum with real GDP at 6.6 percent and 6.2 percent (estimate) in the fiscal years of 1995 and 1996 respectively. Inflation as borne out by consumer price index was 9 percent in FY1996. The current account deficit has remained below 2 percent of GDP due to a robust export performance with the growth rates in excess of 20 percent for the past three consecutive years. Improvements in the capital account have been equally significant with foreign direct investment reaching US$2 billion in FY1995, 15 times higher than it was before ,

[1] India's foreign exchange reserves in mid-June 1991 was less than US$ 1.0 billion, only sufficient to finance two weeks of imports.

and stabilized portfolio investment amounting to US$2-3 billion, 10 percent of world portfolio investment in emerging markets. As such, the country's foreign exchange reserves increased to US$ 17 billion, that is 5 months of imports, and the debt service ratio declined from 30 percent of current account receipts in FY1990 to around 22 percent in 1996. The government budget deficit (fiscal deficit) was reduced from 8.3 percent of GDP in FY1990 down to 5.9 percent and 5.5 percent in FY1995 and FY1996. This achievement was well above the 3 percent of GDP the government primarily set as a target at the beginning of the stabilization and reform program. Meaningful fiscal adjustment has yet to take place.

Key Economic Indicators (1)

Population (1996)	956.6 million
GDP (1996)	US$322.9 billion
GDP per capita (1996)	US$337.5
Annual Real Growth Rate (1996)	6.2 %
Annual Rate of Inflation (1996)	9.0 %

Source: Economic Intelligence Unit, 1997

Key Economic Indicators (2)

Central Gov Fiscal Deficit as per GDP (1996)	-5.5 %
Current Account Balance as per GDP (1996)	-1.5 %
Debt Service Ratio (1996)	21.7 %
Unemployment Rate (1983)	8.3 %

Source: EIU, Asian Development Bank

The government's Common Minimum Program of June 1996 identifies the key challenges ahead, vis-à-vis, reducing the country's chronically high fiscal deficits, further liberalizing the economy, agriculture in particular, meeting the infrastructure requirements, and ensuring social justice. Numerically, the government has fixed a 7 percent GDP growth target for the 9th Five-Year Plan (FY1997-2002)[2].

India's growth path as borne out by annual real GDP is shown in **Fig. 2.4-1**.

[2] Source: *A World Bank Country Report*, WB, p.xxxii, 1996, *Country Report*, EIU, pp.22-30, 1997, *Trend in Developing Economies*, WB, pp.238-242, 1996

2.4.2 The Energy Sector, Policy and Issues

(1) A Bird's Eye View of the Sector

Endowed with substantial fossil fuel resources as well as significant hydropower potential, uranium deposits and non-commercial energy sources, India has limited energy resources when considered the large size of its economy and rapidly growing population. Commercial energy sources provide 60 percent of the total primary energy supply of 195.6 million TOE (ton oil equivalent) in 1990, while non-commercial sources such as firewood, other plant materials and biomass meet the rest[3]. Primary energy consumption is estimated at 159.6 mtoe (million TOE) in 1990 with the average annual growth rate of 6.2 percent in the 1980s, whereas final energy consumption was 129 mtoe. On the per capita basis, primary energy consumption was 237 kgoe (kilogram oil equivalent) with the average annual growth rate of 4.2 percent during the years 1980-1990 while final energy consumption was 156 kgoe increasing at 6.2 percent annually in the same period. India's overall primary energy balance is shown in **Table 2.4-1** and **Fig. 2.4-2**.

(2) The Energy Policy and Issues

(a) The energy sector

The country's energy shortage is partly due to the dispersed location of reserves and the transportation bottle-necks. As demand for energy rises at major consumption centers, the consequent burden on the nation's railroad system mounts, leaving pit-head stock piled up while shortages continue to exist. Owing to persistent coal and electricity shortage, the consumption of imported petroleum in absolute quantities increased, thereby contributing to the adverse effect on the current account of India. Between FY1986 and FY1991, India's oil and oil product imports increased by 17.5 percent per year to reach 30 million tons, while the cost of such imports increased annually by 3 percent to US$ 3.3 billion in FY1991. It is projected by the Government that the energy demand and supply gap will be widened to about 45 mtoe by the year 2000.

The sector issues will be summarized as follows: (i) relatively high energy elasticity of the economy and its increasing trend, (ii) poor demand management for energy reflecting considerable under-pricing of electricity tariffs (particularly for the agricultural consumers) relative to economic costs of supply, and low tariff collection rates, (iii) constraints of increasing indigenous oil supplies to meet the growing demand

[3] Source: Asian Development Bank, 1992

and consequent reliance on imports to fill the demand-supply gap, (iv) poor quality of coal and its geographically uneven distribution regarding emerging energy demand concentration, and (v) substitution of non-commercial forms of energy by commercial forms.

With due recognition of the foregoing, and part of the official strategy to increase energy self-reliance and reduce the energy supply-demand gap, the government is moving towards strengthening its energy strategy, managing demand more effectively, and augmenting domestic supply through appropriate policy initiatives, including energy conservation measures and investment. In this context, the policy goals are set to (i) increase energy availability by developing oil and non-oil energy sources, (ii) mobilize local energy resources to the maximum extent possible (renewable and non-renewable), and (iii) promote demand management for high energy use efficiency and energy conservation.

In order to realize these goals, the following approaches have been adopted by the government: (i) accelerate exploitation of coal, hydropower and nuclear power, (ii) intensify exploration for oil and natural gas, (iii) promote gas-flaring reduction, (iv) curb demand for oil products, including formulation of national transport fuel policy, (v) increase allocative efficiency by promoting demand management and fuel substitution through appropriate pricing and increased public awareness to pay, (vi) increase the productivity and operational efficiency of existing capacity, (vii) intensify research and development (R&D) of emerging renewable energy technologies such as biogas, wind-electric system, solar cookers and low-grade solar water heaters, and (viii) design and implement integrated rural energy programs that utilize locally available energy resources[4].

(b) The power sub-sector

The per capita electric power energy consumption level in India is only about 270 kWh per annum placing the country among the lowest in the world[5]. India experienced phenomenal growth in consumption rising from 82,367 GWh in 1980 to 184,222 GWh in 1990 with an average annual growth rate of 8.4 percent (excluding captive generation). The industrial consumers took the largest share of 46.9 percent followed

[4] India is the only country among the ADB's developing member countries (DMCs) with a separate ministry concerned with renewable energy.

[5] This compares with per capita electricity consumption levels of 433 kWh in the Philippines, 688 kWh in the People's republic of China, 1,070 kWh in Thailand, and 1,384 kWh in Malaysia. (Ref: Asian Development Bank, *Renewable Energy Development Project*, AR, 1996, p.2)

by agriculture (24.5 percent), domestic and residential (15.5 percent), others (including public lighting, public water works and railroad traction, 6.9 percent), and commercial (6.2 percent). In line with the economic recovery, particularly in the manufacturing and agriculture sectors, the growth rate of demand for electricity in FY1994 was somewhere around 13-14 percent.[6]

Despite significant progress in system expansion, power shortages remain one of the binding constraints to overall economic growth in India tapping as high as about 9 percent of total energy and 18 percent of peak capacity requirements in FY1992. In FY1995, a supply shortfall was alleviated a little while being downsized to 9 percent of peak capacity requirements.

Chronological data on the power sector and the demand-supply gap in Maharashtra are indicated in **Tables 2.4-2** and **2.4-3** respectively.

Private sector participation

In Maharashtra, the Enron Power Development Corp of the US, a group then known more for its natural gas operations than for power generation, signed a Power Purchase Agreement with the Maharashtra State Electricity Board (MSEB) in November 1993 to supply 2,050 MW in total at Dabhol after 1998. The Project was the fore-runner among eight projects which have been approved by the Cabinet committee on Foreign Investment. Scarcely had the proposal been cleared than the opposition political party in the state started a campaign against the project, while alleging that Enron had given kickbacks to some Congress leaders to approve inflated project-cost estimates for super profits. The state government newly came in place announced a scrapping of the project and the work at the site came to a halt. Against this allegiance and violation of contract taken by MSEB, Enron initiated arbitration proceedings in London under the contract it had signed with MSEB. The company had been dragged to court in India on various grounds, and after two years won all the cases filed against it.

Clearly the supply of electricity to the country has suffered a major setback not only because of this mismatch between Enron and the state government, but also because of the challenge to the model of private sector development for major hydropower projects. The key lessons learnt from this project would include that (I) in connection with foreign capital involvement in power development, the vulnerability of the local political arena to be threatened by opposition parties be explicitly evaluated prior to any

[6]DOP (Department of Power) estimate, November 1994

investment decision, and (ii) the regulatory framework and regulatory capacity of the government be strengthened to better deal with similar problems in the future.

Financial position of the state electricity boards (SEBs)

The fundamental obstacle to private sector investment in the power sector is the weak financial position of the SEBs. While the Electricity Act (1956) and other legislation allow a certain degree of managerial and financial autonomy for SEBs, this autonomy is often nominal as most state governments use SEBs to pursue non-commercial objectives, and particularly provide low priced, or free electricity to the agricultural sector to attract financial and political support. SEBs generally are prevented by their respective state government from charging commercially viable tariffs, and are not allowed to cut power from non-paying customers. State governments also tend to intervene with SEB's day-to day operations, thereby complicating the task of SEB management. Sequentially, the SEB's financial condition is one of the country's most serious structural constraints to the reduction of public sector deficit.

The ADB's recent study shows the estimated average cost of power supply for 17 major SEBs in FY1993, including fuel, operations and maintenance, depreciation on historical cost, and interest and administration cost was US$ 0.043/kWh (Rs. 1.33/kWh as per 1995 foreign exchange quotation), compared with an average tariff revenue of US$ 0.034/kWh (Rs. 1.06/kWh). The cost recovery of only 79.7 percent resulted in aggregate financial losses of US$ 1.4 billion for these SEBs[7]. The single most important reason for the dismal financial performance of most SEBs has been the heavy subsidization of agricultural customers, who accounted for 27.8 percent of the total consumption in FY1995. The average agricultural tariff has been projected to be US$ 0.007/kWh (Rs. 0.22/kWh). In order to solve such a financial problem, the Ministry of Power confirmed, through discussions with international lending institutions such as World Bank and ADB, to raise the agricultural tariff to US$ 0.014 /kWh (Rs. 0.50 /kWh). Thus, it is expected that the financial deficits of SEBs will be reduced by about 50% comparing with that in FY1995.

Financial performance of MSEB

Unlike other states in India, the pace of tariff reform in Maharashtra has been impressive in recent years, with the tariff level increasing at an average annual rate of 7.4 percent in real terms in the 1985-91 period. With the increase in tariff as well as the number of

[7] Ref. Asian Development Bank, *Power Transmission Sector Project*, AR, 1995, p.4

consumers served by MSEB[8], sales revenue increased by 16 percent per annum between FY1988 and 1992. Rate of return on net fixed assets after depreciation and debt services in 1992 was 3.5 percent which was well above the average of all SEBs in India. The statutory requirement that SEBs should not fully recover their costs but also generate a minimum 3 percent rate of return on fixed assets after interset expenses and receipt of subsidies from state government was met in Maharashtra besides 3 other SEBs, namely, Karnataka, Rajasthan, and Tamil Nadu in FY1995.

Nevertheless, it would be noteworthy that MSEB's long term attempt at strengthening its financial position could be undermined by two factors, inter alia, the state subsidy and a weak capital structure. In 1993, Rp. 3.7 billion of the state government subsidy was granted to MSEB to comply with the statutory stipulation of a 3.5 percent net return on assets. The net revenue would have been negative (about Rp. 2.3 billion) unless the state subsidy had not been granted to the Board. The weak capital structure of MSEB was represented with a very low debt equity ratio standing at 87:13 in 1992. A major consequence has been a high debt service burden for the Board, exacerbated by the increase cost of borrowing. While the debt service coverage ratio complied with the covenanted 1.2 in 1992, it would be yet lower as compared to the common practice applied in international lending institutions. The tariff table, power profile, and actual and projected financial statement of MSEB are attached as **Tables 2.4-4,2.4-5** and **2.4-6** respectively.

[8] In the FY1992, the number of power consumers grew 4.9 percent, rising from 8.8 million to 9.3 million.

Table 2.4-1 Overall Energy Balance (FY1981-90)

Primary Energy Supply (Commercial Energy)

Unit: '000 TOE

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Oil	33,858	33,887	37,381	40,203	42,738	45,956	60,133	53,787	62,205	59,920
Coal	61,965	63,148	69,137	69,591	76,196	81,005	86,709	89,788	90,806	100,830
N.Gas	2,000	2,661	3,059	3,727	4,455	6,365	7,220	8,325	10,905	11,277
Hydro	17,866	16,805	18,687	18,293	18,335	18,882	16,477	22,659	18,843	21,359
Nuclear	1,089	702	1,326	1,385	1,792	1,761	1,745	2,278	2,000	2,179
Supply Total	116,778	117,203	129,590	133,199	143,516	153,969	172,284	176,837	184,759	195,565
Consump. Total	76,264	77,793	81,292	85,045	87,525	94,295	109,029	102,783	112,551	128,883

Table 2.4-2 Chronological Data on the Power Sector

Installed Capacity (MW), FY1980-1990

All India

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Hydro	11,791	12,173	13,056	13,856	14,460	15,472	16,195	17,265	17,798	18,041	18,695
Coal	17,132	18,695	20,712	23,648	26,311	28,809	30,394	34,237	37,942	40,894	44,174
Diesel	166	178	176	179	177	180	168	145	153	153	153
Gas	274	439	559	575	575	1,012	1,199	1,199	1,602	2,358	2,820
Nuclear	850	860	860	1,095	1,095	1,330	1,330	1,330	1,565	1,565	1,565
Total	30,213	32,345	35,363	39,353	42,618	46,803	49,287	54,176	59,060	63,011	67,407

Source: Current Energy Scene in India: CMIE, 1994

Western Region

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Hydro	1,810	1,810	1,810	1,810	1,813	1,903	2,083	2,185	2,330	2,248	2,266
Coal	6,049	6,469	7,478	9,448	10,398	11,238	11,448	13,198	14,438	15,644	16,931
Diesel	3	3	3	3	3	3	3	4	4	4	4
Gas	54	174	294	294	294	726	726	726	726	717	717
Nuclear	420	420	420	420	420	420	420	420	420	420	420
Total	8,336	8,876	10,005	11,975	12,928	14,290	14,680	16,533	17,818	19,033	20,358

Maharashtra State

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Hydro	1,032	1,032	1,032	1,032	1,044	1,081	1,207	1,259	1,259	1,259	
Coal	2,337	2,547	2,967	3,177	3,597	4,017	4,017	4,227	4,415	4,625	44,174
Diesel	166	178	176	179	177	180	168	145	153	153	153
Gas	274	439	559	575	575	1,012	1,199	1,199	1,602	2,358	2,820
Nuclear	850	860	860	1,095	1,095	1,330	1,330	1,330	1,565	1,565	1,565
Total	30,213	32,345	35,363	39,353	42,618	46,803	49,287	54,176	59,060	63,011	67,407

Source: ADB "Electric Utilities Data Book", 1992

Annual Gross Generation (GWh), FY1980-1990

All India

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Hydro	46,541	49,564	48,373	49,958	53,948	51,035	53,840	47,444	57,867	54,631	56,837
Coal	60,713	68,747	77,913	84,435	96,957	112,540	125,451	145,813	154,895	172,803	187,644
Diesel	65	69	44	43	45	50	59	69	76	76	76
Gas	522	699	1,909	2,198	1,833	1,756	3,340	3,330	2,739	4,692	5,439
Nuclear	3,001	3,020	2,021	3,546	4,074	4,981	5,028	5,034	5,813	5,798	5,798
Total	110,843	122,101	130,263	140,177	156,859	170,350	187,783	202,092	221,396	238,002	255,796

Western Region

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Hydro	7,800	7,960	6,550	7,738	7,006	6,179	6,151	5,064	7,538	6,405	6,457
Coal	25,320	27,700	31,021	34,195	41,052	47,806	51,998	59,237	61,469	68,409	74,123
Diesel	0	0	0	0	0	0	0	1	1	1	1
Gas	60	23	1,145	1,594	1,294	1,128	2,580	2,562	1,923	2,215	2,215
Nuclear	1,774	1,963	1,470	1,857	1,928	1,960	2,000	1,604	1,900	1,752	1,752
Total	34,953	37,649	40,187	45,385	51,282	57,074	62,731	68,470	72,833	78,764	84,550

Source: ADB: Electricity Utilities Data Book, 1993

Maharashtra State Electricity Board

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Hydro	4,928	4,991	4,478	4,727	4,369	4,003	3,669	3,266	4,413	3,879	3,943
Coal	9,200	10,812	11,182	11,831	12,433	16,093	17,068	19,842	19,427	21,345	22,800
Diesel	0	0	0	0	0	0	0	0	0	0	0
Gas	0	2	1,062	1,594	1,295	1,128	2,580	2,562	1,923	2,476	2,700
Nuclear	0	0	0	0	0	0	0	0	0	0	0
Total	14,128	15,105	16,722	18,152	18,097	21,224	23,317	25,670	25,763	27,700	29,443

Source: ADB: Electricity Utilities Data Book, 1993

End-Use Consumption (GWh), FY1980-1990

All India

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Domestic	9,246	10,439	12,091	13,224	15,505	17,257	19,321	22,819	24,767	26,533	28,558
Commercial	4,681	5,194	5,846	6,561	6,937	7,290	7,732	8,840	9,915	10,602	11,384
Industrial(LV & MV)	7,415	9,404	9,150	11,188	11,228	12,517	17,639	13,664	15,016	16,106	17,358
Industrial(HV)	40,554	43,659	43,816	45,905	51,396	54,362	52,617	55,515	60,395	64,454	69,029
Public Lighting	748	812	835	934	1,051	1,095	1,206	1,344	1,455	1,563	1,689
Traction	2,265	2,504	2,632	2,709	2,879	3,082	3,229	3,616	3,772	3,986	4,287
Agriculture	14,489	15,201	17,616	18,233	20,960	23,422	29,444	35,266	38,878	41,776	45,131
Public Water Works	1,534	1,673	1,757	1,828	2,064	2,106	2,561	2,945	3,252	3,473	3,720
Others	1,331	1,355	1,640	1,748	1,648	1,765	2,115	2,298	2,742	2,925	3,133
Total	82,367	90,245	95,585	102,384	114,067	122,999	135,948	145,611	160,196	171,422	184,221

Western Region

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Domestic	2,832	3,104	3,551	3,917	4,478	5,065	5,858	6,927	7,674	8,246	8,871
Commercial	1,470	1,651	1,824	1,903	2,055	2,217	2,304	2,748	2,834	3,045	3,276
Industrial(LV & MV)	2,265	2,562	2,757	3,062	3,203	3,446	3,848	3,745	4,188	4,500	4,842
Industrial(HV)	14,127	15,034	15,167	17,495	18,984	20,834	21,768	22,267	23,811	24,509	26,369
Public Lighting	272	284	303	339	373	402	431	450	453	486	523
Traction	1,015	1,011	967	950	1,090	1,108	1,110	1,272	1,378	1,481	1,593
Agriculture	3,406	3,591	4,226	4,532	5,709	6,167	7,308	9,450	11,015	11,835	12,733
Public Water Works	705	752	785	858	927	998	1,137	1,225	1,277	1,372	1,476
Others	333	367	293	324	323	352	471	336	477	512	551
Total	26,428	28,258	29,898	33,392	37,144	40,592	44,248	48,419	52,111	55,990	60,238

Maharashtra State Electricity Board (MSEB)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Total	12,803	13,812	14,469	15,884	15,932	18,915	19,975	21,181	23,666	25,681	26,823

Table 2.4-3 Demand and Supply Gap in Maharashtra (FY1985-93)

State	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94
Maharashtra incl. Goa									
Requirement	25,957	289,945	30,924	32,858	36,622	39,502	42,753	40,789	44,895
Availability	25,518	27,051	29,111	31,899	35,649	37,993	40,849	38,376	43,514
Surplus(+)/Deficit(-)	-439	-1,894	-1,813	-959	-973	-1,509	-1,904	-2,413	-1,381
Surplus(+)/Deficit(-)%	-1.7	-6.5	-5.9	-2.9	-2.7	-3.8	-4.5	-5.9	-3.1
All-India									
Requirement	170,746	192,356	210,993	223,194	247,762	267,632	288,974	278,045	323,252
Availability	157,262	174,276	187,976	205,909	228,151	246,560	266,432	254,634	299,494
Surplus(+)/Deficit(-)	-13,484	-18,080	-23,017	-17,285	-19,611	-21,072	-22,542	-23,411	-23,758
Surplus(+)/Deficit(-)%	-7.9	-9.4	-10.9	-7.7	-7.9	-7.9	-7.8	-8.4	-7.3

Source: Current Energy Scene in India, 1994

Table 2.4-4 MSEB Tariffs

(Units=Paisa/KWH)

Tariff Category	1980	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Average
Industrial	102.0	110.0	-	144.0	168.0	183.0	193.0	203.4	277.0	278.6	282.2	289.2	289.2	154.00
Commercial	57.0	65.0	-	75.0	91.0	89.0	91.0	99.0	137.1	137.0	137.0	140.0	140.0	182.99
Residential	37.0	40.0	-	44.0	46.0	47.0	48.0	60.0	66.0	66.0	66.0	68.0	68.0	82.98
Street Lighting	33.0	33.0	-	41.0	55.0	58.0	64.0	68.0	80.0	80.0	80.0	80.0	80.0	90.00
Agiculture	27.0	13.0	-	9.0	8.0	9.0	9.0	8.7	15.9	14.3	13.8	13.5	13.5	15.00
Public Water Works	42.0	49.0	-	74.0	76.0	81.0	86.0	93.3	117.6	122.1	121.7	125.2	125.2	-
Traction	40.0	50.0	-	60.0	78.0	85.0	79.0	101.0	139.0	143.0	143.0	145.0	145.0	-
Inter State	-	-	-	61.0	77.0	73.0	63.0	64.3	65.0	80.0	80.0	80.0	80.0	-
Licensees	-	-	-	-	-	-	99.0	109.0	NA	NA	NA	NA	NA	-
Ave Tariff Realisation	-	-	-	-	-	-	-	-	-	-	-	-	-	111.60

Source: Current Energy Scene in India, 1994

Table 2.4-5 MSEB Installed Capacity, Generation and Fuel Prices

FINANCIAL YEAR (Ending March'31)		1991-92 (ACT)	1992-93 (ACT)	1993-94 (PROJ)	1994-95 (PROJ)	1995-96 (PROJ)	1996-97 (PROJ)	1997-98 (PROJ)	1998-99 (PROJ)	1999-2000 (PROJ)
ESCALATION FACTOR										
Annual inflation rate		12.20%	9.50%	7.80%	6.90%	6.40%	5.90%	5.40%	5.00%	5.00%
Escalation factor		1	1.1	1.18	1.26					
DERATED CAPACITY (MW)										
Thermal		4,996	4,996	5,505	5,505	5,505	5,505	6,005	6,005	6,005
Hydel		1,296	1,296	1,308	1,369	1,402	1,655	2,405	2,405	2,655
GAS		672	672	912	912	912	1,032	1,032	1,032	1,032
Total Capacity		6,964	6,964	7,725	7,786	7,819	8,192	9,442	9,442	9,692
CAPACITY FACTOR (%)										
Thermal		55.44	56.12	56.22	61.53	61.77	61.77	61.77	61.60	61.60
Hydel		36.80	33.94	38.07	30.32	30.65	26.27	18.19	18.19	18.41
GAS		49.60	44.51	30.04	48.82	48.82	49.78	49.78	49.78	49.78
Total		51.41	50.87	50.06	54.55	54.68	53.09	46.09	49.25	48.51
ENERGY GENERATED (GWh)										
Thermal		24,265	24,560	27,111	29,670	29,790	29,790	29,790	32,405	32,405
Hydel		4,177	3,853	4,362	3,636	3,764	3,809	3,832	3,832	4,282
GAS		2,920	2,620	2,400	3,900	3,900	4,500	4,500	4,500	4,500
Total		31,362	31,033	33,873	37,206	37,454	38,099	38,122	40,737	41,187
Generation (Gross) (GWh)		31,362	31,033	33,873	37,206	37,454	38,099	38,122	40,737	41,187
Auxiliary Losses (%)		7.51	7.90	8.21	8.23	8.21	8.11	8.10	8.22	8.14
Auxiliaries consumption (GWh)	S	2,355	2,453	2,781	3,063	3,076	3,088	3,088	3,350	3,352
Net Generation (GWh)		29,007	28,580	31,092	34,143	34,378	35,011	35,034	37,387	37,835
Import (GWh)		8,225	9,036	9,629	12,059	12,451	12,795	17,157	22,307	28,296
Export (GWh)		1,235	327	65	65	65	65	65	65	65
Total available energy		35,997	37,289	40,656	46,137	46,764	47,741	52,126	59,629	66,066
Losses (%)		18.78	16.52	15.20	15.10	15.00	14.71	14.25	13.88	13.81
Losses (GWh)	S	6,759	6,162	6,190	6,977	7,022	7,034	7,439	8,283	9,131
Sales of Elecricity (GWh)		29,238	31,127	34,469	39,165	39,742	40,707	44,687	51,346	56,935
FUEL CONSUMPTION										
Coal (Kg/kWh)	S	0.77	0.80	0.80	0.81	0.81	0.81	0.81	0.81	0.81
Oil (ml/kWh)	S	5.03	5.64	5.88	6.02	6.02	6.02	6.02	6.02	6.02
GAS (m^3/kWh)	S	0.34	0.34	0.36	0.22	0.22	0.19	0.19	0.19	0.19
FUEL PRICES										
Coal (Rs '000/t)	S	0.52	0.62	0.70	0.71	0.71	0.71	0.71	0.71	0.71
Oil (Rs/l)	S	4.45	4.89	6.06	6.35	6.35	6.35	6.35	6.35	6.35
GAS/m^3	S	1.61	1.79	1.96	1.96	1.96	1.96	1.96	1.96	1.96
Average rate (Ps/kWh)(Sale in State)		109.12	137.43	154.74	180.07	180.30	193.31	204.48	216.79	228.73
Average rate (Ps/kWh)(Import)		84.30	103.80	131.43	162.39	158.60	174.04	190.81	202.17	210.17
Average rate (Ps/kWh)(Export)		76.56	87.53	87.54	100.67	100.67	107.72	113.10	118.76	124.70

Table 2.4-6 (1) MSEB Actual/Forecast Income Statement

(unit: Rs. million)

FINANCIAL YEAR (Ending March'31)		1991-92 (ACT)	1992-93 (ACT)	1993-94 (PROJ)	1994-95 (PROJ)	1995-96 (PROJ)	1996-97 (PROJ)	1997-98 (PROJ)	1998-99 (PROJ)	1999-2000 (PROJ)
REVENUE										
Sale of Electricity		32,850	43,063	53,395	70,589	71,721	78,763	91,448	111,392	130,310
Other receipts	S	518	368	2,306	2,352	2,399	2,447	2,496	2,546	2,597
Total Rev. from sale of power		33,368	43,431	55,700	72,941	74,120	81,210	93,944	113,938	132,907
Electricity Duty	S	1,408	1,474	1,632	1,854	1,880	1,919	2,095	2,397	2,656
Rev. subsidies and grants		1,996	0	802	0	0	0	0	0	0
Other income	S	911	1,412	0	0	0	0	0	0	0
Prior period Income	S	1,012	738	0	0	0	0	0	0	0
Total Revenues		38,695	47,055	58,134	74,795	76,000	83,129	96,040	116,334	135,563
EXPENSES										
Generation of Power (Fuel)	S	12,501	14,941	17,854	19,863	19,936	19,924	19,924	21,526	21,526
Purchasse of Power		7,005	9,550	12,656	19,582	19,747	22,268	32,737	45,097	59,471
Repairs and Maintenance	S	2,384	2,449	2,923	4,341	3,940	4,725	5,049	5,415	5,823
Employees cost	S	4,446	5,201	6,913	7,556	8,293	9,077	9,941	11,540	12,451
Admn. & General Expenses	S	616	678	331	538	1,266	1,317	1,370	1,477	1,588
Provision for Bad & Doubtful Debt				200	850	850	1,200	1,200	1,200	2,200
Depreciation	S	2,017	3,467	4,095	4,814	5,379	6,083	6,392	7,958	8,476
Other Debits & Extraordinary Items	S	240	335	0	0		0	0	0	0
Lease rent (Hydro Power stns.)				516	516	600	650	650	700	700
Lease rent (H. V. D. C.)									1,492	1,492
Electricity Duty		1,408	1,474	1,632	1,854	1,880	1,919	2,095	2,397	2,656
Prior period Expenditure	S	1,360	-327	0	0	0	0	0	0	0
Duty on Auxiliary Consumption		0	0	0	0	0	0	0	0	0
Total Operating expenses		31,976	37,797	47,120	59,913	61,890	67,164	79,359	98,802	116,382
Net Income before interest		6,719	9,258	11,015	14,882	14,110	15,965	16,681	17,532	19,181
INTEREST EXPENSES AND FINANCE CHARGES										
a) to State Govt. & World Bank	S	3,388	3,876	4,383	4,886	5,502	6,171	6,942	7,697	8,247
b) to Institution (incl. Bonds)	S	3,594	3,975	5,153	5,987	6,061	6,520	6,652	5,606	5,197
Intt. on Working Capital	S	41	35	35	35					
Other Finance Charges	S	484	560	604	645					
Total interest		7,507	8,446	10,175	11,553	11,563	12,691	13,594	13,303	13,444
Less interest capitalised	S	2,041	1,909	2,015	2,155	2,396	2,868	2,596	1,962	2,268
Interest charged to operations		5,466	6,536	8,160	9,398	9,167	9,823	10,998	11,341	11,176
Net income	S	1,253	2,721	2,855	5,484	4,943	6,142	5,683	6,191	8,005

Table 2.4-6 (2) MSEB Actual/Forecast Balance Sheet

(unit: Rs. million)

FINANCIAL YEAR (Ending March'31)	1991-92 (ACT)	1992-93 (ACT)	1993-94 (PROJ)	1994-95 (PROJ)	1995-96 (PROJ)	1996-97 (PROJ)	1997-98 (PROJ)	1998-99 (PROJ)	1999-2000 (PROJ)
Assets									
Fixed Assets									
Gross Fixed Assets	72,283	85,144	100,088	106,296	120,217	126,323	157,276	167,503	177,327
Less Accumulated dereciation	14,084	17,579	21,675	26,489	31,867	37,950	44,342	52,301	60,776
Net Fixed Assets	58,199	67,565	78,414	79,807	88,350	88,373	112,934	115,203	116,551
Cap. Expd. in progress	23,174	23,808	20,761	28,876	32,110	44,907	32,883	39,693	48,276
Advances for Capital Works	1,377	1,618	1,249	1,858	1,709	2,463	2,029	2,604	3,166
Other Assets including investment	159	171	171	171	171	171	171	171	171
Total Fixed Assets	82,909	93,163	100,595	110,712	122,339	135,913	148,017	157,671	168,164
Current Assets									
Cash and Bank Balances	830	1,473	2,108	5,116	10,165	7,499	8,672	4,965	2,977
Total stocks	3,047	3,375	3,723	4,103	4,520	4,983	5,494	6,057	6,678
Drs. for Sale of Power	13,166	17,148	16,641	20,589	20,919	22,972	22,862	27,848	32,578
Provision for Bad & Doubtful debts	988	1,124	1,324	2,174	3,024	4,424	5,624	6,824	9,024
Net Debtors	12,178	16,025	15,318	18,415	17,895	18,549	17,238	21,024	23,554
RE Subsidy receivable	0	0	0	0	0	0	0	0	0
Other Receivables	6,713	8,504	11,466	14,959	15,200	16,626	19,208	23,267	27,113
Total Current Assets	22,769	29,376	32,615	42,593	47,780	47,657	50,612	55,313	60,322
Inter-Unit Accounts	2	7	3	3					
Total Assets	105,680	122,546	133,213	153,308	170,120	183,570	198,630	212,984	228,485
Equity and Liabilities									
Equity	0	0	0	0	0	0	0	0	0
Consumer's contributions	6,137	7,250	8,419	9,646	10,935	12,288	13,709	15,200	16,767
Retained Earning (Losses)	3,806	6,527	9,382	14,866	19,808	25,750	31,433	37,624	45,629
Grants	50	220	220	220	220	220	220	220	220
Reserves	118	118	118	118	118	118	118	118	118
Net Worth	10,111	14,115	18,139	24,850	31,081	38,376	45,480	53,162	62,733
Long Term Debts									
a) State government loans	36,095	39,592	42,554	44,544	46,737	49,166	51,675	54,327	57,289
b) World bank loan			502	1,996	4,213	7,281	10,948	13,264	13,231
c) Other loans	28,924	30,504	33,686	39,457	45,166	44,314	42,502	39,380	36,838
Total Long Term Loans	65,019	70,096	76,742	85,997	96,116	100,761	105,125	106,971	107,358
Staff Superannuation Fund (G. P. F)	0	0	0	0					
Current Liabilities									
Account Payable	16,530	22,300	21,992	24,860	25,036	25,247	29,258	33,119	37,697
Deposits from Consumers	3,032	3,542	4,049	4,891	4,947	5,292	5,913	6,891	7,818
Accumulated Interest on govy. loans and other loans	10,679	12,286	12,085	12,504	12,734	12,688	12,648	12,635	12,673
Borrowings for Working Capital	300	206	206	206	206	206	206	206	206
Deficit in Funds	0	0	0	0	0	0	0	0	0
Total Current Liabilities	30,551	38,335	38,332	42,462	42,923	44,433	48,025	52,851	58,393
Total Equity and Liabilities	105,681	122,546	133,213	153,308	170,120	183,570	198,630	212,984	228,485

Table 2.4-6 (3) MSEB Actual/Forecast Change in Financial Position (Fund Flow Statement)

(unit: Rs. million)

FINANCIAL YEAR (Ending March31)	1991-92 (ACT)	1992-93 (ACT)	1993-94 (PROJ)	1994-95 (PROJ)	1995-96 (PROJ)	1996-97 (PROJ)	1997-98 (PROJ)	1998-99 (PROJ)	1999-2000 (PROJ)
SOURCES									
Internal resources:									
Net Income Before Interest	6,719	9,258	11,015	14,882	14,110	15,965	16,681	17,532	19,181
Depreciation	1,992	3,495	4,095	4,814	5,379	6,083	6,392	7,958	8,476
Increase in Reserves	-7	0	0	0	0	0	0	0	0
Total Internal Resources	8,704	12,753	15,110	19,696	19,488	22,048	23,073	25,490	27,656
Consumers' Contribution	1,042	1,113	1,169	1,227	1,289	1,353	1,421	1,491	1,567
Grants	26	169	0	0	0	0	0	0	0
Equity	0	0	0	0	0	0	0	0	0
Borrowings:									
State Govt Loan	3,978	3,957	3,459	2,630	2,893	3,182	3,500	3,850	4,235
Project Loan (IBRD)			502	1,494	2,217	3,068	3,667	2,316	
Other Loans	4,370	5,146	7,489	10,408	10,138	4,622	3,116	2,767	2,812
Total Borrowings	8,348	9,103	11,450	14,532	15,248	10,872	10,872	8,933	7,047
Financing Gap	0	0	0	0	0	0	0	0	0
Int on Loans not Paid	1,032	1,608	-201	419	230	-46	-40	-13	38
Less: RE subsidy not received	0	0	0	0	0	0	0	0	0
Total Sources	19,153	24,746	27,528	35,874	36,255	34,227	34,737	35,901	36,308
Applications									
Investments:									
Proposed Projects:									
Chandrapur (LN-2544)	0	0	0	0	0	0	0	0	0
MPP-I (LN-3096)	0	0	0	0	0	0	0	0	0
Chandrapur 7 (LN-3498):									
HVDC Line	0	0	1,830	3,300	4,300	4,786	10,827	0	0
HVDC Terminal	0	0	0	0	0	0	0	0	0
Distribution Reinforcement	0	0	0	0	0	0	0	0	0
Other Capital Investment	12,680	13,736	9,698	11,631	12,706	14,871	7,669	17,612	18,968
Total Investment Program	12,680	13,736	11,528	14,931	17,006	19,657	18,496	17,612	18,968
Debt service:									
Principal Repayment	3,540	4,026	4,804	5,277	5,129	6,227	5,919	7,087	6,660
Interest Charged to Operations	5,466	6,536	8,160	9,398	9,167	9,823	10,998	11,341	11,176
Total Debt Service	9,007	10,562	12,964	14,675	14,296	16,050	16,917	18,428	17,836
Working Capital:									
Change in Current Liabilities:									
Accounts Payable	6,510	5,770	-308	2,868	176	1,211	3,010	3,861	4,577
Deposits from Consumers	485	500	506	843	55	345	622	977	927
Borrowings for Working Capital	-17	-94	0	0	0	0	0	0	0
Others	0	0	0	0	0	0	0	0	0
Change in Total Current Liabilities	6,979	6,177	199	3,711	231	1,556	3,632	4,839	5,504
Change in Current Assets:									
Stocks	96	328	348	380	417	463	511	563	621
Drs.for Scale of Power	2,902	3,846	-707	3,097	2,161	854	-1,310	3,786	2,530
Other Receivables	1,448	2,450	3,594	6,501	2,606	-1,240	3,755	352	1,858
Change in Total Current Assets	4,446	6,625	3,235	9,978	5,184	76	2,956	4,701	5,008
Net Increase (Decrease) in Working Capital	-2,533	448	3,036	6,267	4,952	-1,480	-676	-138	-496
Total Applications	19,254	24,746	27,529	35,873	36,255	34,228	34,736	35,902	36,308
	-2	-1	-1	1	0	-1	1	-1	0

Schedule 3b: Rate of Purchased Power (Ps/kWh)

Name of Station		1991-92 (ACT)	1992-93 (ACT)	1993-94 (PROJ)	1994-95 (PROJ)	1995-96 (PROJ)	1996-97 (PROJ)	1997-98 (PROJ)	1998-99 (PROJ)	1999-2000 (PROJ)
TATAS	S	142.36	171.72	217.39	265.00	265.00	317.00	317.00	317.00	317.00
TARAPUR		56.50	60.99	58.47	63.00	63.00	63.00	63.00	63.00	63.00
NTPC		63.22	86.06	83.65	79.00	0.00	0.00	0.00	0.00	0.00
RCF/ONGC		19.39	22.93			0.00	0.00	0.00	0.00	0.00
GEB		55.56	59.11			0.00	0.00	0.00	0.00	0.00
KAKRAPAR				223.70	230.00	230.00	230.00	230.00	230.00	230.00
KSTPS	K				52.00	52.00	52.00	52.00	52.00	520.00
VSTPS	V				97.00	97.00	97.00	97.00	97.00	97.00
KAWAS	K	0.00	0.00		210.00	210.00	210.00	210.00	210.00	210.00
GANDHAR	G	0.00			210.00	210.00	210.00	210.00	210.00	210.00
TAPP	TAPP				63.00	63.00	63.00	63.00	63.00	63.00
ENRON	ERON							240.00	240.00	240.00
Total		84.30	103.80	131.43	162.39	158.60	174.04	190.81	202.17	210.17

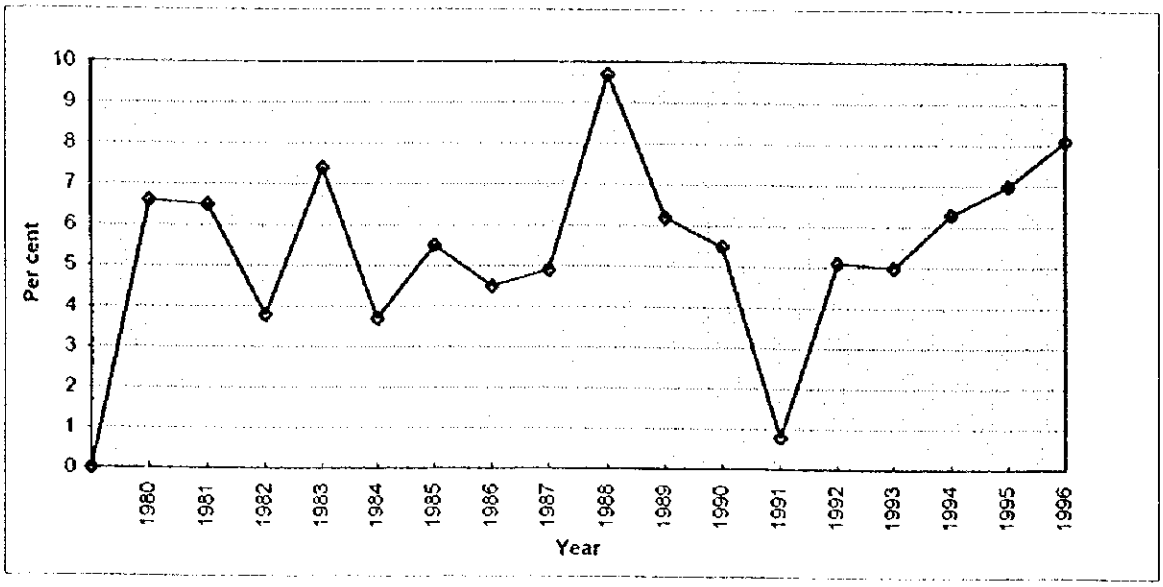

Fig. 2.4-1 Growth Rate of Real GDP

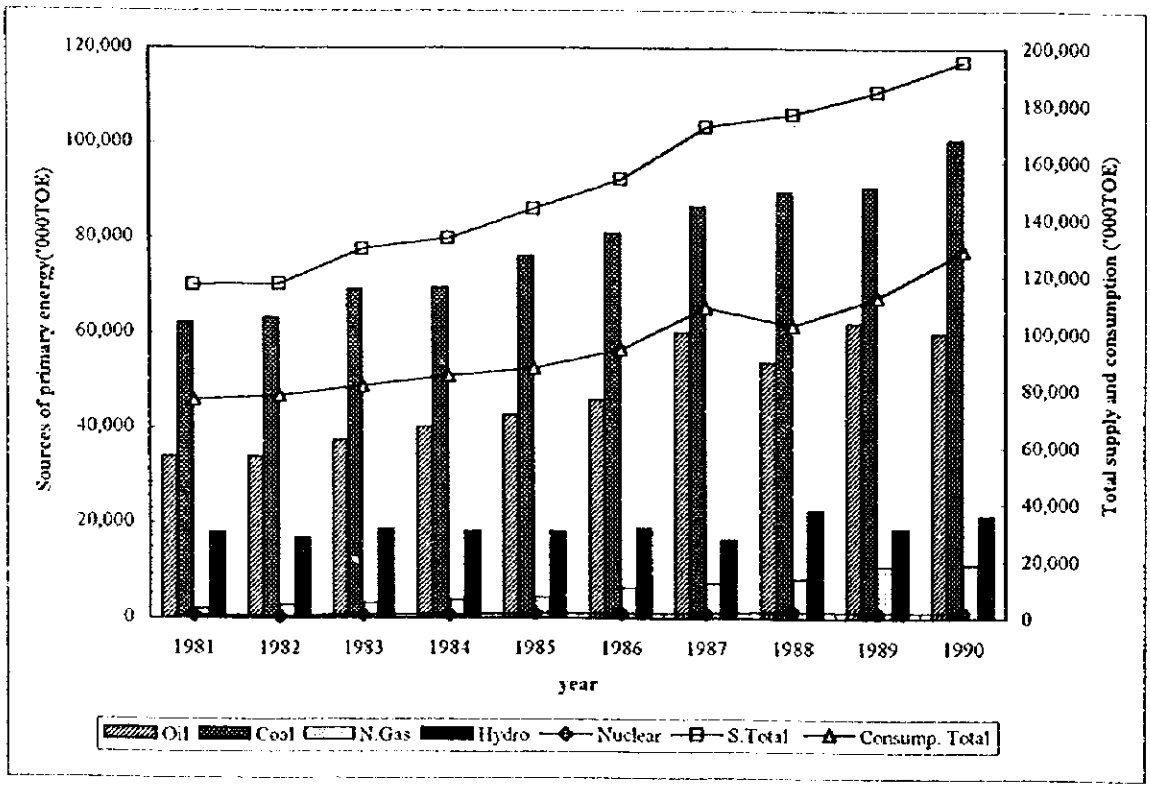

Fig. 2.4-2 Primary Energy Supply and Consumption (FY1981-1990)

CHAPTER 3 CURRENT STATUS OF ELECTRIC UTILITY INDUSTRY

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CHAPTER 3 CURRENT STATUS OF ELECTRIC UTILITY INDUSTRY

3.1 Current Status of Electric Power Supply

During the 10 years from 1982, the economic growth rate of India was approximately 5.3% in terms of her annual average. In this same period, the growth of electric energy consumption was 8.3%, with the elasticity of energy consumption to the GDP at 1.57. In terms of electric energy consumption per capita, however, as of 1992, it was 294 kWh. This is extremely low, being only 5.3% of the same value of Japan which was 5510 kWh. These figures indicate that India, being a typical agricultural country, has three quarters of her national population of 870 million people located in rural farming areas. Such a situation inevitably forces the electric energy consumption per capita to remain at a low value. The past fluctuations in India's GDP growth rates clearly show that agricultural production changes from one year to another, this in accordance with the prevailing meteorological conditions, while a high elasticity of electric energy to GDP indicates that rural areas are indeed undergoing rapid electrification.

Table 3.1-1 GDP, Electricity Consumption and Elasticity in India

Year	GDP 1990 Price Billion Rupees	Grows Rate (%)	Electricity Consumption (GWh)	Grows Rate (%)	Elasticity
1982	3,351.8	3.8	1,145.8	6.6	1.74
1983	3,600.8	7.4	1,232.2	7.5	1.01
1984	3,733.2	3.7	1,378.9	11.9	3.22
1985	3,937.4	4.5	1,491.1	8.1	1.8
1986	4,129.1	4.9	1,636.0	9.7	1.98
1987	4,326.1	4.8	1,776.1	8.6	1.79
1988	4,755.4	9.9	1,964.8	10.6	1.07
1989	5,067.9	6.6	2,148.3	9.3	1.41
1990	5,355.2	5.7	2,319.7	8.0	1.40
1991	5,381.3	0.5	2,435.2	5.0	10.00
1992	5,629.1	4.6	2,554.4	4.9	1.07
Average		5.3		8.3	1.57

Source: International Financial Statistics Yearbook 1995 by IMF / Energy Statistics and Balances of Non-OECD Countries 1990-1991, 1993 by OECD/IEA

3.2 The Organization of Power Utility in India

Electric power industry in India is managed by the government either central or regional. However, in some specific areas for historical reasons, it is managed by private firms including TATA Electric Companies Ltd. (Generating company) and Bombay Suburban Electric Supply Ltd. (BSES: Distribution company).

In addition, recently some foregin Independent Power Producers have been entering the power generating bussiness in India. Already Enron Power Development Corporation & General (USA) and Aranco Line Shipping Co. (Singapore) have planed to thermal power projects in the Maharashtra State. **Fig. 3.2-1** illustrates the organization of electric power industry in India.

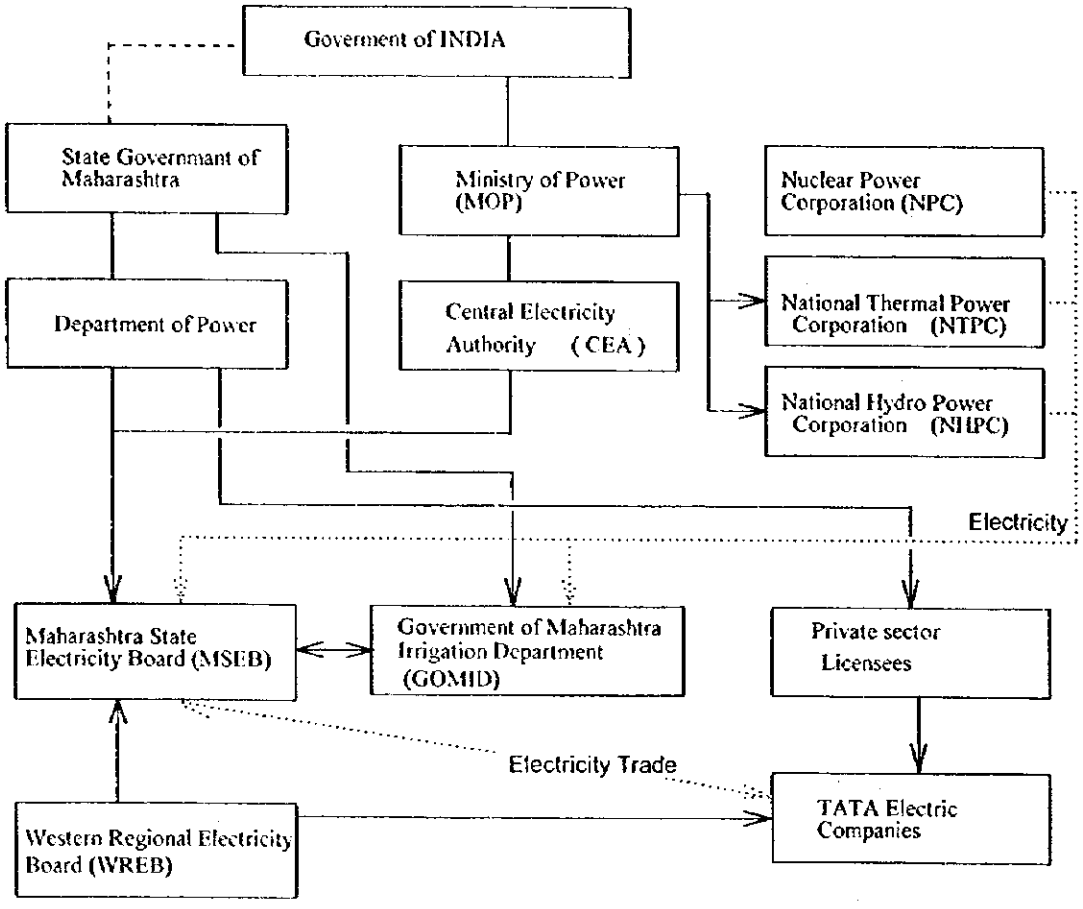

Fig. 3.2-1 The Organization of Electric Power Industry in India

In the central government, the Ministry of Power (MOP), that supervises the entire electric power industries, and the Central Electricity Authority (CEA), that controls all technical matters and those matters that require government approval or permission, cover the entire activities in India. Below each of the Regional Electricity Boards, there is the State Electricity Board that manages the actual electric power industry including demand forecast, electric power development plans and system operations in each State.

Besides above SEB's, there are National Hydroelectiric Power Corporation (NHPC) for hydropower development and operation, National Thermal Power Corporation (NTPC) for thermal power construction and operation and Nuclear Power Corporation (NPC) for construction and operation of nuclear power plant under contorol by Nuclear Department. They are incharge of the large project to across the states and complementary to SEB's activity. The generated electricity of these organizations are supplied to SEB's.

In the State of Maharashtra, the Maharashtra State Electricity Board (MSEB) controls system operations, including electric power demand forecast, system planning, system operations (including frequency and voltage control, and exchange of power with other States), construction and operation of thermal power plants, and operation of hydroelectric power plants in Maharashtra.

The MSEB has two regional central dispatchng centers of east and west to control and manage of system voltage, fequency and electricity trade with private company as TATA Electric Companies Ltd. In addition, MSEB has interconnection transmission lines among Gujarat, Madhya Pradesh, Andhra Pradesh, Karnataka, and Goa States across the state border. **Fig. 3.2-2** illustrates five Regional Electricity Boards (REB) in India, each REB made-up the power pool and electricity trade among the states are discussed and controled among REBs. MSEB is included the Western Regional Electricity Board together Gujarat SEB, Madhya Pradesh SEB. **Table 3.2-1** indicates the outline of five REBs.

As for the hydroelectric power generating facilities, GOMID (Government of Maharashtra Irrigation Department), our counterpart in this study, is in charge of planning and construction. When the construction of a new plant is complete, it is to be transferred to MSEB after the initial operations for a certain period of time.

There are 57 private power company in India, and most of them are distribution company. Only five companies are operating both power generation, transmission and distribution. In Maharashtra, there is also a private power company, named TATA Electric Companies Ltd. (1,606MW), which is not only connected with the MSEB system but also has its own power transmission lines, and has been performing the constructions and operations of its own thermal, as well as hydro electric power plants.

Table 3.2-1 A Summary of REB and SEB in India
(The end of March, 1992)

Regional Electricity Board State Electricity Board	Installed Capacity (MW)	Peak Demand (MW)	Power Sales (10^6kWh)	Per Capita Consumption (kWh)
Eastern REB				
Bihar SEB	1,392	1,396	7,094	110
Orissa SEB	1,602	1,271	-	175
West Bengal SEB	-	2,239	11,854	-
Northern RED				
Haryana SEB	1,756	1,660	9,820	432
Himachal SEB	518	366	1,688	198
Punjab SEB	3,311	3,286	17,383	620
Pajasthan SEB	2,775	1,989	12,967	213
Uttar Pradesh SEB	7,210	5,748	30,548	-
Delhi ESU	-	1,643	9,353	-
North Eastern REB				
Manipur ED	9.22	60	153	108
Meghalaya SEB	134	60	253	144
Southern REB				
Andhra Pradesh SEB	4,166	3,703	23,230	273
Karnataka SEB	2,970	2,724	-	338
Kerala SEB	1,927	1,576	8,008	185
Tami Nadu SEB	6,019	3,953	22,490	360
Western REB				
Gujarat SEB	5,593	4,091	24,005	429
Madhya SEB	3,284	3,022	15,134	254
Maharashtra SEB	9,390	6,864	43,239	492

Source: Profile of Power Utilities in India, April 1993 by Council of Power Utilities

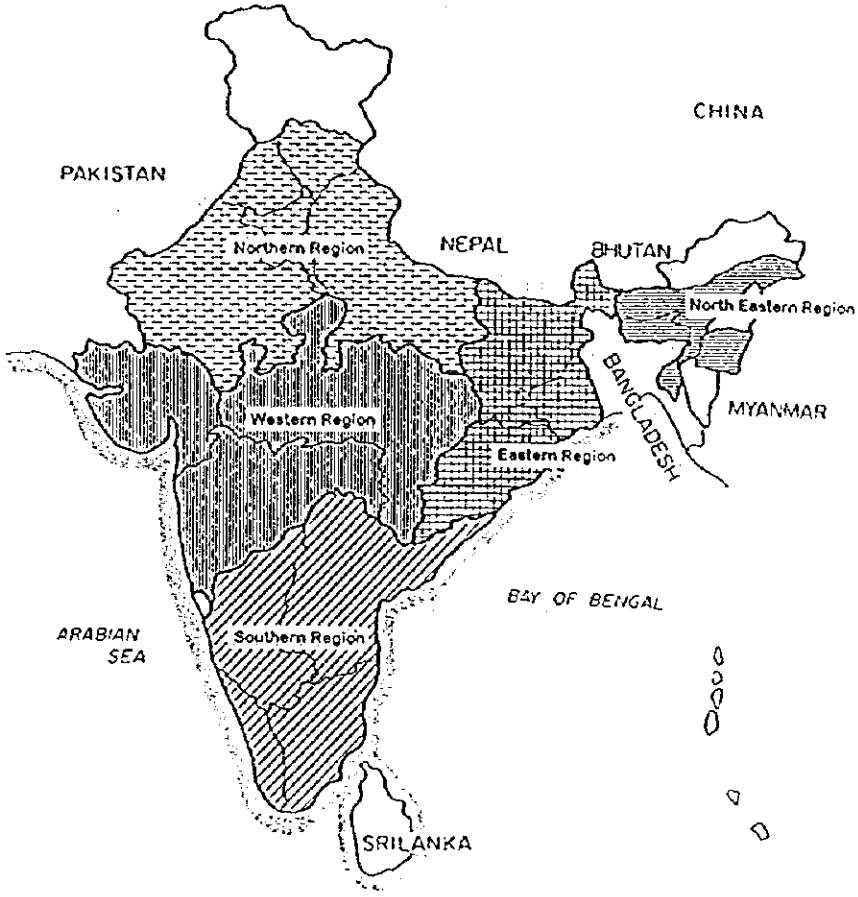

Fig. 3.2-2 The Configuration of the 5 Regional Electricity Boards

3.3 Current statas of Power Facility in Maharashtra

3.3.1 General

We have prepared a questionnaire before the first survey in India and performed a survey on the current situation of the electric power industry cooperated with Indian counterparts, namely, the State Government of Maharashtra Irrigation Department (GOMID), the Maharashtra State Electricity Board (MSEB), and TATA Electric Companies Ltd., (surveyed indirectly through TATA Consulting Engineers Co., Ltd.).

As a result, the following informations have been gathered.

3.3.2 Electricity Consumption in Maharashtra State

The Maharashtra State is the 3rd largest states in terms of area of states and its population in India. The electricity consumption in Maharashtra State is 15% of shear which is the largest state in India. It is 36,808 GWh on 1993 actual. The brake down is 17.6% of household, 43.0% of industry, 24.2% of agriculture, 15.2% of commercial and others. Most of electricity consumed in heavily populated area and industrized area of Munbai, Pune, Nagpur and its surrounding area. The Electricity Consuumption Record in Maharashtra State from 1983 to 1993 as shown in **Fig. 3.3-1**.

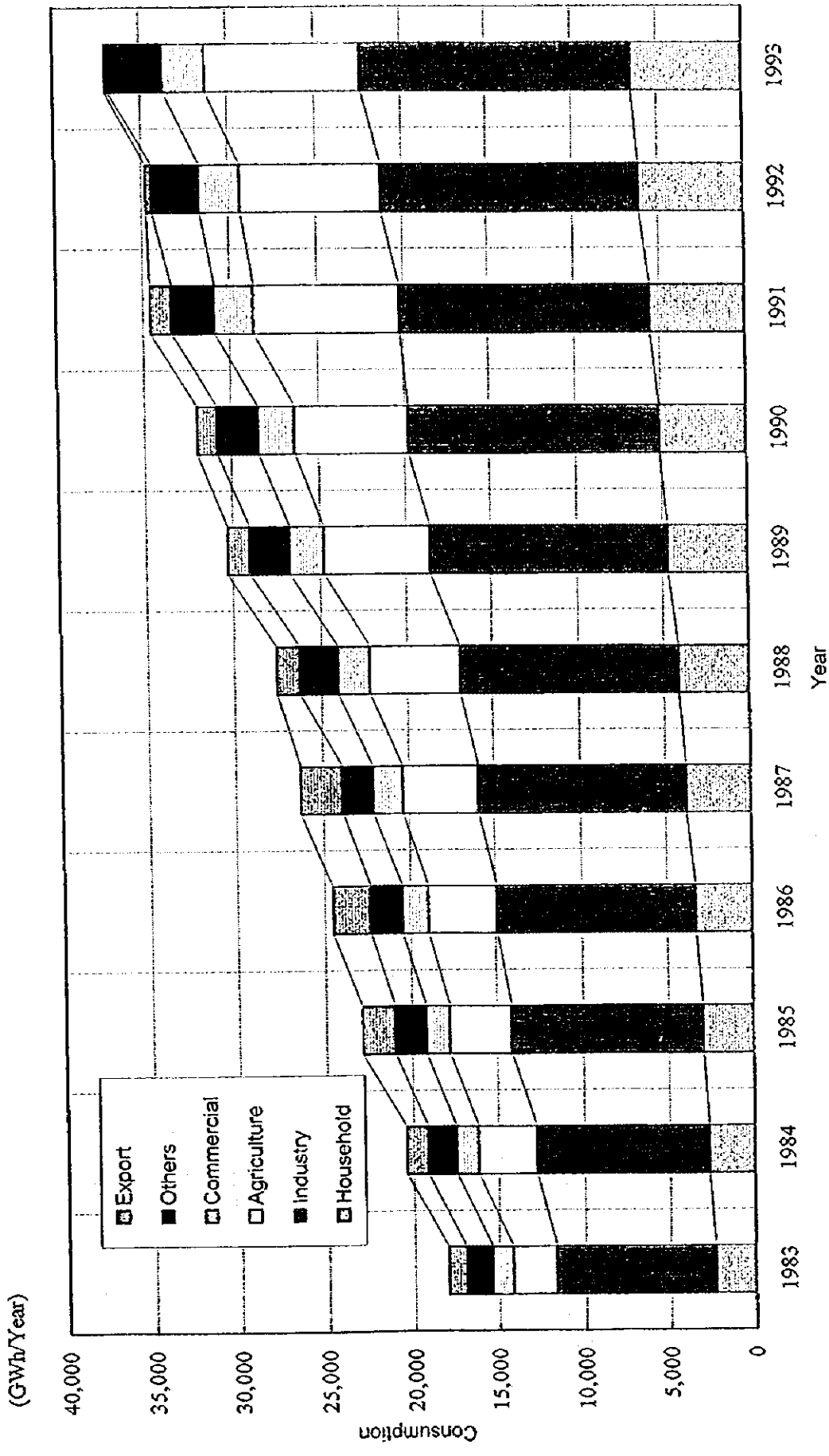

Fig. 3.3-1 Electricity Consumption Record in Maharashtra State (1983-1993)

3.3.3 Study of Existing Electric Power Facilities in the State of Maharashtra

In our first survey in India, we visited the head office of MSEB, TATA Consulting Engineers Co. Ltd., to disscuss about situation of existing electric power facilities in the State of Maharashtra based on our questionnare.

And we surveyed the Western Region Central Dispatching Center which operates or controls the western half of the power system of the State of Maharashtra. There, we investigated the facilities and had discussion with the staff members. We were given their daily load curves of the day of maximum demand and that of minimum demand in 1993.

In our second survey in India, we surveyed two kind of thermal plant as Uran CCGT Power Plant and Nashic Coal Thermal Power Plant. We investigated the situation and operation of the existing thermal power plant, which would supply base power in night time for pumped storage power plant.

Total installed capacity of the existing electric power facilities in the State of Maharashtra is 9,324 MW as of the end of 1994 consisting of hydro 1,589 MW (17%), thermal 7,545 MW (81%). In addition, MSEB has 1,548MW of the share of thermal power plant of NTPC, and nuclear power plant of NPC. The list of Existing Electric Power Facilities in the State of Maharashtra as shown in **Table 3.3-1 (a) and (b)**.

Most of electicity flows from the mine mouth coal thermal power plants in eastern part of the state to consumption area of Mumbai, Pune and its surrunding area in western part of the state, the proposion of power system is long distance one direction transsmission. And kind of generating facilities is base load up to 81% of thermal power plants.

Since the above conditions, the system operations as voltage and frequency control is very difficult. **Fig 3.3-2** shows an example of daily frequency curve, the system frequency fluctuates from 51.30 Hz in light load time to 48.4 Hz in heavy load time. This means the present shortage of a peak power generating facilities like a lage scale hydro power plants and pumped storage power plants.

Table 3.3-1 (a) List of Hydropower Station in Maharashtra State
(The End of 1994)

Name of Power Station	Owner	Capacity (No. x MW)	Installed Capacity (MW)	Commissioning Year
Bhandardara	MSEB*	1 x 10	10	1987
Bhatgar	Ditto	1 x 16	16	1974
Bhira Tail Race	Ditto	2 x 40	80	1988
Eldari	Ditto	3 x 7.5	22.5	1968
Koyna I & II	Ditto	4 x 65	260	1962 - I
		4 x 75	300	1968 - II
Koyna III	Ditto	4 x 80	320	1974
Koyna Dam Power House	Ditto	2 x 20	40	1981
Paithan	Ditto	1 x 12	12	1984
Pawshet	Ditto	1 x 8	8	
Pawana	Ditto	1 x 10	10	1988
Pench 1 & 2	Ditto	2 x 80	53 (Maharashtra share)	
Radhanagari	Ditto	4 x 1.2	4.8	1962
Tillari	Ditto	1 x 60	60	1987
Vaitarna	Ditto	1 x 60	60	1976
Vaitarna Dam Toe	Ditto	1 x 1.5	1.5	1987
Vir	Ditto	2 x 4.5	9	1972
Yeoteshwar	Ditto	1 x 0.075	0.075	
Kanher	Ditto	1 x 4	4	
Varasgaon	Ditto	1 x 8	8	1991
Bhatsa	Ditto	1 x 15	15	1991
Dhom	Ditto	1 x 2	2	
Sub Total			1295.875	
Bhira	TATA*	6 x 25	150	
Bhivpuri	Ditto	6 x 12	72	
Khopoli	Ditto	6 x 12	72	
Sub Total			294	
Total			1589.875	

Note: MSEB:Maharashtra State Electricity Board
TATA:TATA Electric Companies

Table 3.3-1 (b) List of Thermal and Nuclear Power Station in Maharashtra State (The End of 1994)

Name of Power Station	Owner	Capacity (No. x MW)	Installed Capacity (MW)	Commissioning Year
1. THERMAL				
Bhusawal Unit 1	MSEB	1 x 58	58	1968
Bhusawal Units 2 & 3	Ditto	2 x 210	420	1979,82
Chandrapur Units 1 to 4	Ditto	4 x 210	840	1983-84
Chandrapur Unit 5	Ditto	1 x 500	500	1991
Chandrapur Unit 6	Ditto	1 x 500	500	1992
Khaperkheda Ext. Units 1 &2	Ditto	2 x 210	420	1989,90
Koradi Units 1 to 4	Ditto	4 x 115	460	1974-76
Koradi Unit 5	Ditto	1 x 200	200	1978
Koradi Units 6 & 7	Ditto	2 x 210	420	1982,83
Nasik Units 1 & 2	Ditto	2 x 140	280	1970,71
Nasik Units 3 to 5	Ditto	3 x 210	630	1979-81
Paras Unit 1	Ditto	1 x 30	30	1961
Paras Unit 2	Ditto	1 x 58	58	1967
Parli Units 1 & 2	Ditto	2 x 30	60	1971,72
Parli Units 3 to 5	Ditto	3 x 210	630	1982,85,87
Uran Gas Turbine Units 1 to 4	Ditto	4 x 60	240	1983
Uran Gas Turbine Units 5 to 8	Ditto	4 x 108	432	1986
Uran WHRP Unit 1	Ditto	1 x 120	120	1994
Sub Total			6298	
Trombay Units 1 to 3	TATA	3 x 62.5	187.5	1956,57,60
Trombay Unit 4	Ditto	1 x 150	150	1965
Trombay Unit 5	Ditto	1 x 500	500	1984
Trombay Unit 6	Ditto	1 x 500	500	1990
Sub Total			1337.5	
Korba West Units 1 - 3	NTPC*	4 x 210	319 (Maharashtra share)	1983, 84,85
Korba STPs Units 4 - 6	Ditto	3 x 210	319 Maharashtra share)	1983, 84
Vindhyachal STPs Units 1 - 6	Ditto	6 x 210	382 (Maharashtra share)	1987 - 91
Kawas	Ditto		201 (Maharashtra share)	
Sub Total			1221	
Total			8856.5	
2. NUCLEAR				
Tarapur	NPC*	2 x 160	190 (Maharashtra share)	1969
Kakrapara	NPC	1 x 220	137 (Maharashtra share)	1992
Sub Total			327	
Total			327	
Grand Total			9183.5	

Note: *NPC: Nuclear Power Company *NTPC: Natioal Thermal Power Company

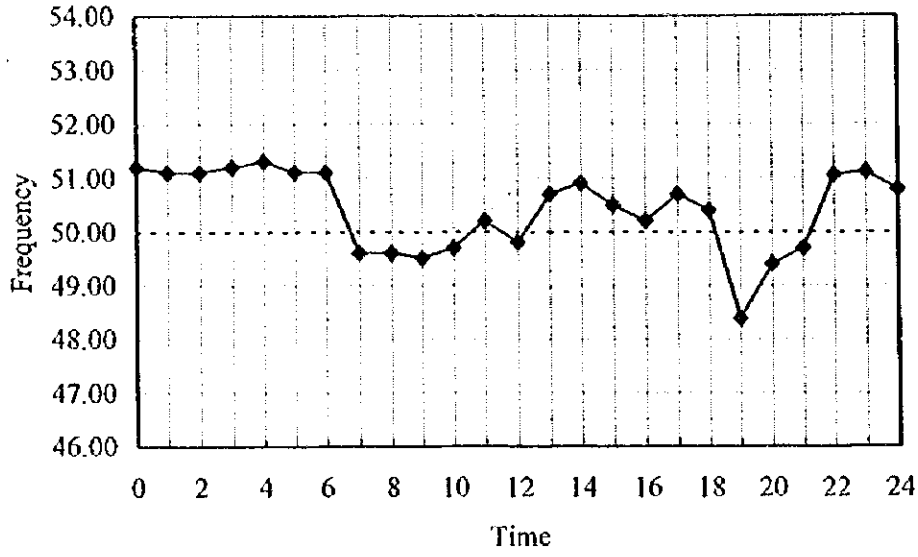

Fig 3.3-2 Example of Daily Frequency Record (Jan. 14, 1995)

CHAPTER 4 ELECTRIC POWER DEMAND AND SUPPLY PLAN

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4.1 Collection and Examination of Reports and Data on Demand Forecast and Electric Power Development Plans

Power demand projection and the study and coordination of power development projects in Maharashtra State are carried out by MSEB. Usually, the demand projection is carried out by MSEB itself. However, it was agreed with MSEB that the values of Maharashtra State as described in the 14th Power Demand Projection Report summarized and publicized by CEA, would be applied to this study.

Fig 4.1-1 shows the projection of the max. demand in Maharashtra State up until 2010, as described in the 14th Power Demand Projection Report. According to the Report, the annual demand growth ratio is planned at 7% from 1995 to 2001, at 6% from 2002 to 2006, and at 5% from 2007 to 2010.

4.2 Study of Electric Power Development Projects in Existence and Progress

In Maharashtra State, hydro power projects are conducted by GOMID with the thermal power projects, distribution and transformation being conducted by MSEB. Power development projects are also carried out by a private sector, TATA. These power development projects are submitted to MOP after being coordinated by MSEB and examined by the supervisory organ, CEA (Central Government). **Tables 4.2-1 (a) and (b)** describe the existing and on-going power development projects.

The same procedures are also carried out for transmission and distribution facility expansion projects. As shown in the system diagram in **Fig. 4.2-1,** reinforcement of the 400kV distribution line in the southern part of the State and the construction of a DC transmission and distribution facility (+500kV, 1,500MW) between Chandrapur and Padge is currently planned to start operation in 1997.

4.3 Daily Load Curve Forecast

The daily load curve for the future demand in India is not available. Therefore, after discussion with MSEB, it was decided to produce the proportion of the curve based on the daily load curve record up to 1993, which was multiplied by the growth ratio of the max. demand from the 14th Power Demand Projection Report to assume the daily load curve for this study. Consequently, the actual daily load curve in 1993 was multiplied by the growth ratio described in **Fig. 3.3-6** (max. demand projection) to produce the future daily load curve.

The daily load curve for the max. demand in Maharashtra State presently peaks in the late afternoon due to the lighting load. It was assumed that the curve would not peak during the day time due to the commercial power consumption. The load structure would not, therefore, change despite the power demand growth. The produced daily load curve is shown in **Fig. 4.3-1**.

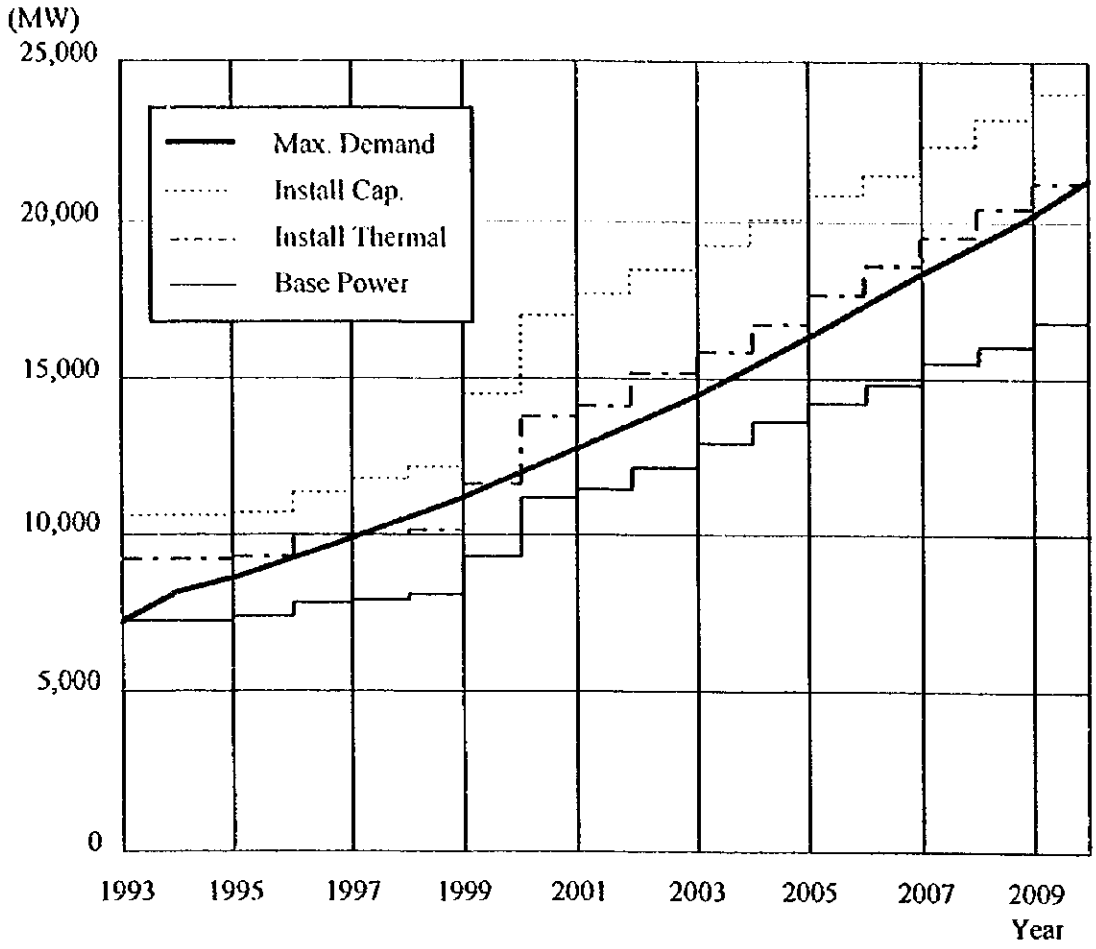

Fig. 4.1-1 Peak Demand Forecast
and
Generation Facility Development Plan of Maharashtra

Table 4.2-1 (a) Future Generating Capacity Additions upto 2002 in Maharashtra State

(Unit: MW)

Year	Public Sector	TATA/BSES	Central Sector	Private Sector	Total Installed Capacity	
	MSEB		TARAPUR/NTPC/NPC		Addition	Progressive
As on 1994	7593	1631	1548	0	0	10772
1995	133	492	123	0	748	11520
1996	69	150	136	0	355	11875
1997	394	0	0	0	394	12269
	8189	2273	1807	0	1497	13766
1998	1253	90	108	905	2356	14625
1999	0	0	162	2530	2692	17317
2000	250	0	54	250	554	17871
2001	0	0	163	660	823	18694
2002	0	0	0	0	0	18694
	1503	90	487	4345	6425	18694

Note MSEB: Maharashtra State Electricity Board,
TATA: TATA Electric Companies
BSES : Bombay Suburban Electric Supply Co., Ltd.

Table 4.2-1 (b) Future Generating Capacity Additions upto 2002 in Maharashtra State

Year		Owner	Fuel	Capacity (MW)	Total Installed Capacity Addition (MW)	Total Installed Capacity Progressive (MW)
As on 1994		MSEB				7593
		TATA/BSES				1631
		Maharashtra share				1548
		Private Sector				0
1995	Uran WH-U2	MSEB	Gas	120		
	Minor Hydro	Ditto	Hydro	13		
	Trombay Unit 1 to 3	TATA/BSES	Coal/Gas	-188		
	Trombay CCGT	Ditto	Gas	180		
	Dahanu 1 & 2	Ditto	Coal	500		
	Gandhar Units 1 to 3	Maharashtra share	Gas	123	748	11520
1996	Minor Hydro	MSEB	Hydro	69		
	Bhira PSS	TATA/BSES	Hydro	150		
	Gandrar WR 1 & 2	Maharashtra share	Gas	68		
	Sardar Sarvar	Ditto	Hydro	68		
	(Ganal Read Units 1 to 5)				355	11875
1997	Koyna Stage IV Unit 1	MSEB	Hydro	250		
	Uran WH-Unit 3	Ditto	Gas	120		
	Minor Hydro	Ditto	Hydro	24	394	12269
Capacity at The End of 8th Plan					1497	
1998	Koyna Stage IV Units 2 to 4	MSEB	Hydro	750		
	Chandrapur Unit 7	Ditto	Coal	500		
	Minor Hydro	Ditto	Hydro	3		
	Bhivpuri PSS	TATA/BSES	Hydro	90		
	Sardar Sarovar	Maharashtra share	Hydro	108		
	(River Bed units 1 & 2)					
	Dabhol Phase-1	DPC	Oil	695		
	Khaperkheda Unit 5	ARANCO	Coal	210	2356	14625
1999	Sardar Sarovar	Maharashtra share	Hydro	162		
	(River Bed units 3 to 5)					
	Dabhol Phase-2	DPC	LNG	1320		
	Khaperkheda Unit 6	ARANCO	Coal	210		
	Bhadravati Units 1 & 2	NDIL	Coal	1000	2692	17317
2000	Ghatghar PSS	MSEB	Hydro	250		
	Sardar Sarovar	Maharashtra share	Hydro	54		
	(River Bed unit 6)					
	Khaperkheda Unit 3	Ballarpur Industries	Coal	250	554	17871
2001	Vindhyachal Unit 7	Maharashtra share	Coal	163		
	Khaperkheda Unit 4	Ballarpur Industries	Coal	250		
	Nagodhane		LNG	410	823	18694
2002						18694
Capacity at The End of 9th Plan					6425	
	Total Capacity				7922	18694

Note: MSEB : Maharashtra State Electricity Board, TATA : TATA Electric Companies
BSES : Bombay Suburban Electric Supply, NDIL : Nippon Denso Ispat Ltd.
ARANCO : Aranco Energy Private Ltd., DPC : Dabhol Power Company

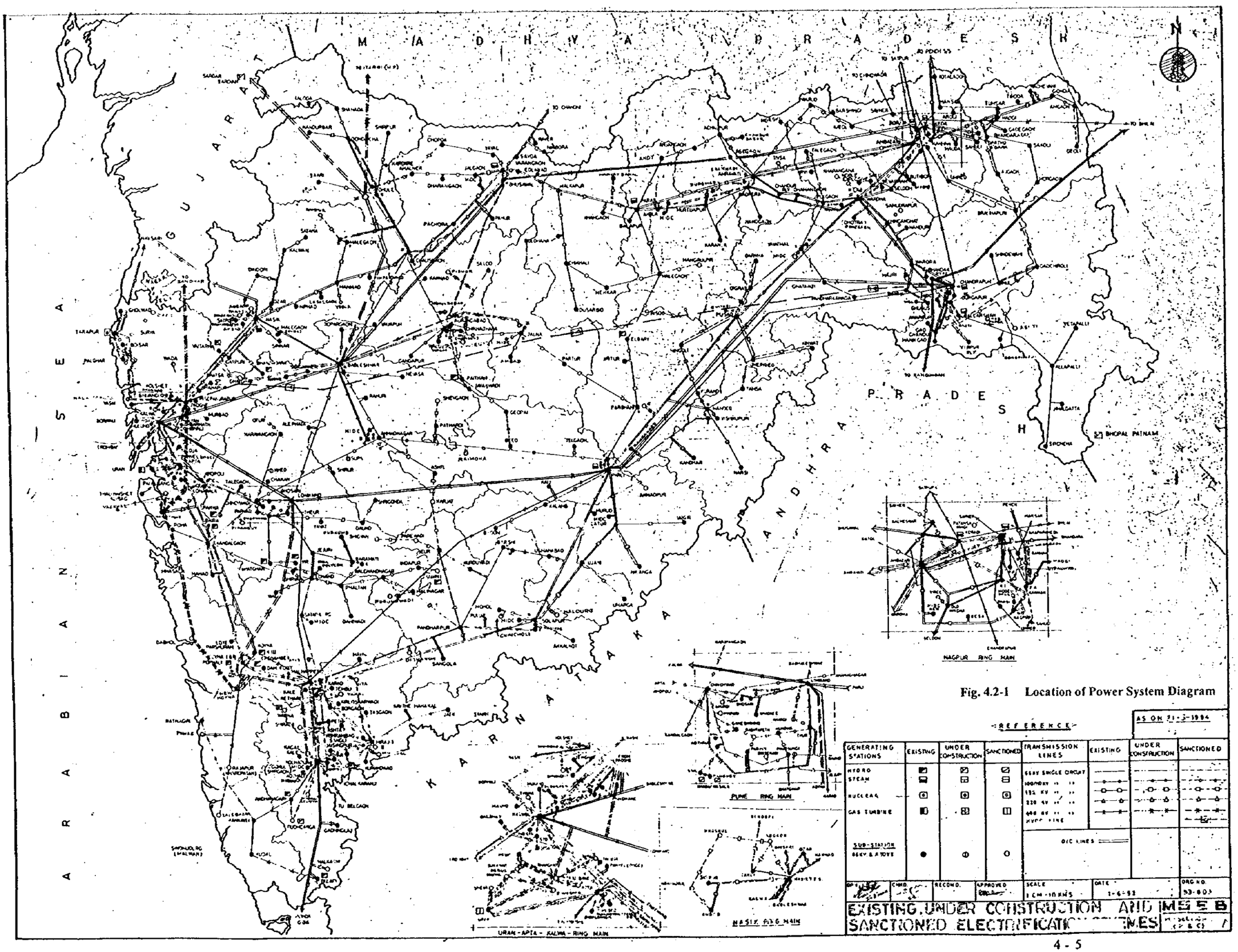

Fig. 4.2-1 Location of Power System Diagram

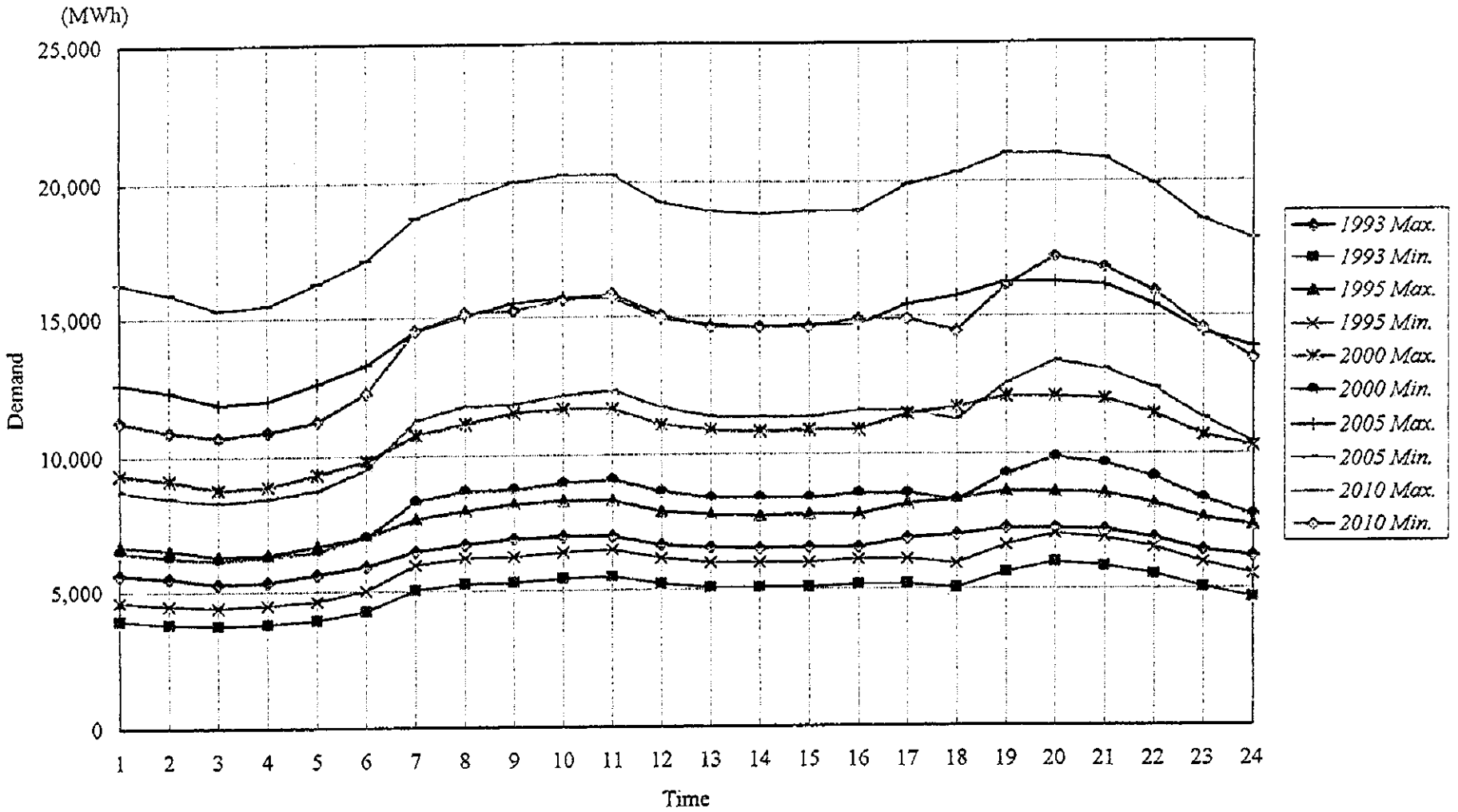

Fig. 4.3-1 Daily Demand Curve of Maharashtra Power System from 1993(actual) to 2010(forecast)