Study
on
Renovation & Modernization /
Complete Replacement
of
Old Coal based Thermal Power Stations
in India

Final Report

June 2012

Japan International Cooperation Agency

Electric Power Development Co., Ltd.

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Abbreviations

Short Title	Official Term
APDRP	Accelerated Power Development & Reform Programme
AWRS	Ash Water Recycle System
BOP	Balance Of Plant
BTB	Back TO Back (DC Interconnection)
CIL	Coal India Limited
COD	Commercial Operation Date
CP	Counterpart
CEA	Central Electricity Authority
DC	Designated Consumer
DPR	Detail Project Report
ECN&S	Energy Consumption Norms and Standards
ECS	Energy Saving Certificate
EIA	Environmental Impact Assessment
EPC	Engineering, Procurement and Construction
EPS	Electric Power Survey
ESP	Electric Static Precipitator
ERP	Enterprise Resource Planning
GDP	Gross Domestic Product
HVDC	High Voltage Direct Current
IDC	Interest During Construction
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau
LE	Life Extension
MoP	Ministry of Power
MPPGCL	Madhya Pradesh Power Generating Company Limited
MSPGCL	Maharashtra State Power Generation Company Limited
NAPCC	National Action Plan on Climate Change
NDCT	Natural Draft Cooling Tower
NLC	Neyvelli Lignite Corporation Limited
NSDP	Net State Domestic Product
O&M	Operation & Maintenance
ODA	Official Development Assistance
OEM	Original Equipment Manufacturer
OJT	On the Job Training
PAT	Perform, Achieve and Trade
PGCIL	Power Grid Corporation of India Limited
PH	Power House
PLF	Plant Load Factor
R&M	Renovation & Modernization
REC	Rural Electrification Corporation
RLA	Remaining Life Assessment
SLC	Standing Linkage Committee
SPM	Suspended Particulate Matter
TANGEDCO	Tamil Nadu Generation and Distribution Corporation Limited
UPRVUNL	Uttar Pradesh Rajya Vidyut Utpadan Nigam Limited
USAID	United States Agency for International Development
WB	The World Bank

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INTRODUCTION

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CHAPTER 1 INTRODUCTION

1.1 Background of the Study

India has experienced a sharp increase in power demand associated with its recent rapid economic growth. In 2010-11, the power supply shortage amounted to approximately 10.3%, while the peak demand shortage jumped to roughly 12.9%. This indicates that ensuring the power supply is a key challenge for the country. The installed power generation capacity in India amounts to 199,627 MW, as on March 31, 2012. This total breaks down to 131,353 MW (65.8%) from thermal power, 38,990 MW (19.5%) from hydro power, 4,780 MW (2.4%) from nuclear, and 24,503 MW (12.3%) from renewable energy. Thermal power generation is thus predominant in the overall generation. Because of India's abundant coal reserves, coal fired power generation is expected to remain the main source of power generation.

While new thermal power stations are being constructed by the central and state electric utilities, as well as by independent power producers, many aged and inefficient coal fired power stations continue to operate. Their inefficient operation is the cause of significant environmental burdens through de-rated power output and CO_2 emissions, for instance. This creates a need for 1) studying and analyzing aged coal fired power stations in order to develop a suitable and effective replacement policy and 2) considering the introduction of highly efficient and environmentally preferable coal fired power stations.

Moreover, India ranked 4th in global primary energy consumption in 2009 due to the country's rapid economic growth. Therefore, India's response to the climate change issue is part of the international agenda. According to the Copenhagen Accord of 2009, India presented a voluntary target to reduce the carbon intensity level by 20-25% on its 2005 levels. One of the eight national missions according to the National Action Plan on Climate Change (NAPCC) announced in 2008 is "enhanced energy efficiency," with the goal of reducing CO_2 emissions by 6.05 million tons before 2031. The Indian Ministry of Power (MoP) is implementing a CO_2 reduction policy based on the Energy Conservation Rules, 2012 to attain the national mission. In August 2011, the Government of India officially requested Japanese assistance to conduct this study in order to develop a policy for replacing aged domestic coal fired power stations.

The government of Japan has extended many forms of assistance to the power sector in India. Recent ODA loan assistance includes the Maharashtra Transmission System Project (2007–08, 16.749 billion yen), the Haryana Transmission System Project (2008-09, 20.9 billion yen), Micro, Small and Medium Enterprises Energy Saving Project (Phase I) (2008, 30 billion yen), Andhra Pradesh Rural High Voltage Distribution System Project (2011, 18.59 billion yen), Madhya Pradesh Transmission System Modernisation Project (2011, 18.475 billion yen), Micro, Small and Medium Enterprises Energy Saving Project Phase II (2011, 30 billion yen), and New and Renewable Energy Development Project (2011, 30 billion yen). Additionally, technical cooperation sought to assist human resource development through the study project for enhancing efficiency of operating thermal power plants in NTPC-India (2008–2011), as well as country-specific training programs.

This study aims to collect and analyze basic information in order to consider potential Japanese assistance to the power sector of India based on the request for assistance made by the Government of India and the past assistance programs conducted by Japan.

1.2 The Objective of the Study

This study aims to collect information and investigate the current status of old coal fired power stations in India in two categories, namely: (1) complete replacement, in which power stations/units are to be replaced (scrap-and-build) with highly efficient stations/units and (2) renovation and modernization (R&M), in which power stations/units are to be renovated and modernized to enhance thermal efficiency together with life extension. The findings will serve as basic information for considering Japanese ODA loan assistance and will be followed by due needs assessment with respect to complete replacement or renovation and modernization (R&M), together with cost-benefit analysis.

1.3 The Period of the Study

The study is to be implemented from January 13, 2012 to June 14, 2012.

1.4 Basic Policies of the Study

(1) Scope of the Study

1) Examine existing documents and information issued by the government and power sector in India together with interview surveys at relevant organizations
2) Select target power stations and units
3) Conduct a survey of the site space and infrastructure of target power stations
4) Conduct a survey of the target units (e.g., current operational status, maintenance status and heat rate)
5) Examine the replacement and R&M plans made by the executing agencies (state utilities)
6) Review the method for replacement and R&M
7) Estimate preliminary costs for replacement and R&M

The study is designed to propose a policy on replacement, and renovation and modernization of coal fired power stations/units through due investigation of the current status since an ODA loan project is envisaged for the replacement, and renovation and modernization of coal fired power stations/units based on the information collected during the study.

In case a project is focused on facility construction and equipment provision, the maintenance system shall be crucial. Therefore, information must be collected not only on the status of facilities, but also on the status of the maintenance, operation and management system.

Detailed investigations or planning for replacement and R&M is excluded from the study, since its main objective is to gain basic information for consideration of Japanese ODA loan assistance. While

the provision of information from counterparts is essential, either the scope of work for information exchange with the counterparts or for provision of technical information from the Japanese side is not included in the study.

1.5 Basic Policies on Technical Issues

(1) Basic Policies

1) Selection criteria and candidate power stations

   The selection criteria for candidate sites are as follows: units which started operation in the 1970s-80s; List of Power Stations with Excessive Deviation and Saving Potentials; stations/units listed in the National Perspective 11th and 12th Plans developed by CEA; units which suffer from low plant load factors; stations that include small and old units with output capacities around 100 MW; and unit types that are widely applied in India enabling widespread reproduction of the results obtained. According to the documents provided by JICA and these criteria, five (5) candidate power stations were selected: UPRVUNL Obra power station, MPPGCL Satpura power station, MSPGCL Khaperkheda power station, NLC (Neyvelli Lignite Corporation Limited) and TANGEDCO (Tamil Nadu Generation and Distribution Corporation Limited) Ennore power station.

2) Selection of target power stations

   The target power stations shall be determined in consultation with MoP and CEA, after the study team has explained the reasons for the selection.

3) The subjects of the study for R&M at the target power stations/units are the boiler, turbine, condenser, generator, and main equipment (feed water heater, boiler feed water pump, circulating water pump, main transformer, and main control system).

4) Information shall be collected regarding the site of the target power station (both of the power station and adjacent area), fuel, fuel receiving facilities, ash pond, cooling water, raw water supply, waste water, transmission lines (including trunk lines and substations), and access routes for transportation of large components.

5) For assessment of the efficiency of power station/units, the performance test procedure and past performance test result reports are to be obtained.

6) For each target power station, the financial situation of the corresponding state government and state electric utility is to be investigated.

7) The target power stations/units are also to be studied from environmental aspect.

8) Proposals are to be made for modernization and efficient operation of the facilities at the target power stations/units based on analysis and evaluation of the collected information. In addition, proposals are to be made for possible replacement by high efficiency power stations/units.

9) The approximate costs of the proposed replacement and R&M are to be estimated and the overall project costs are to be calculated.

10) Possible technical assistance, including training for O&M, is to be proposed based on the evaluation of target power stations and observations during field works.

1.6 Basic Policies for Administrative Issues

(1) Study Team

1) Structure of the study team member

In consideration of the scope of works, the team is composed of the following 6 members:

- Team leader/Coal fired power stations (overall plan) Noriyuki Shimizu
- Deputy team leader/Coal fired power station design (replacement, R&M) Morikuni Miyagi
- Facility survey and planning 1 (mechanical/replacement, R&M) Nobuchika Koizumi
- Facility survey and planning 2 (mechanical/O&M) Kiyomori Gima
- Facility survey and planning 3 (electrical/O&M) Koichi Meguro
- Financial analysis/environmental and social considerations Masahiro Tanimoto

The two mechanical experts are deployed for the tasks related to replacement and R&M, as well as O&M since survey and facility planning are to be focused on mechanical parts.

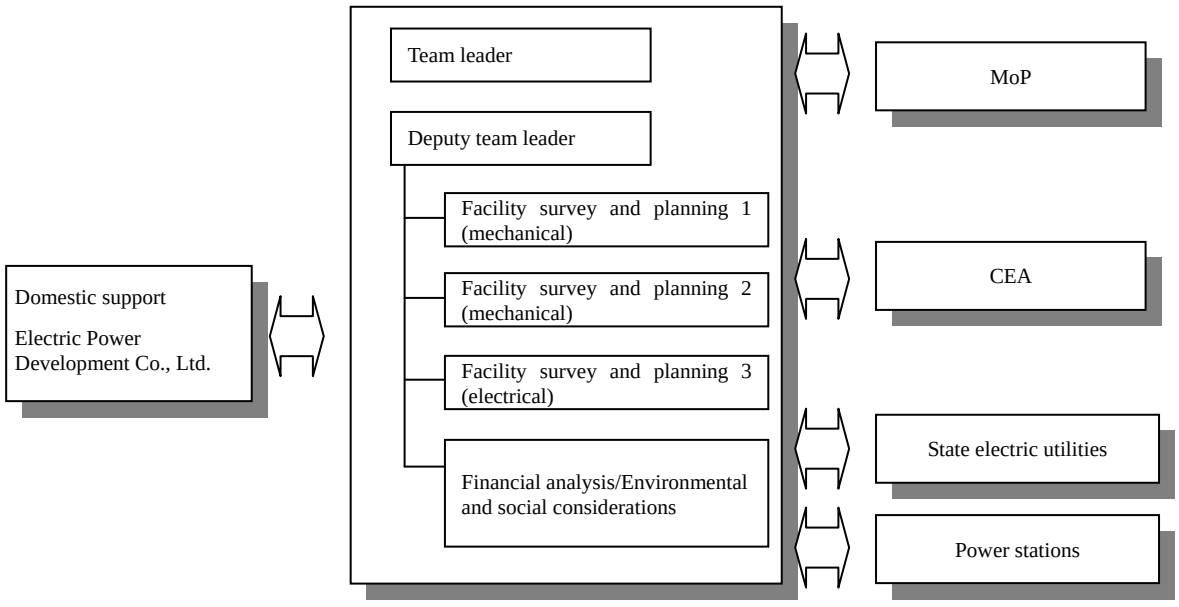

Fig.1.6-1 Structure of Study Team

(2) Counterpart Team

This study involves numerous organizations because the direct counterparts for the study are the state electric utilities which are owner agencies of the coal fired power stations, together with MoP and CEA acting as partners supporting the study activities. Therefore, mutual communication and collaboration among MoP, CEA and the state utilities are crucial for ensuring smooth implementation

of the study. A counterpart team needs to be found by clearly defining the key persons such as the contact persons and the persons in charge while the study is being conducted.

The state electric utilities are requested to form the counterpart team (CP team), since the study of existing coal fired units of the state electric utilities requires close coordination with those utilities, including the collection of facility specifications/drawings and operational data, and interview surveys regarding operation and maintenance. The CP team should comprise of a leader who is in charge of the overall project at the head office and a person in charge for each target power stations/units. Liaison officials from both MoP and CEA are also appointed.

The following is a list of the counterparts in this study.

- Ministry of Power (MoP)
- Central Electricity Authority (CEA)
- State Electric Utilities

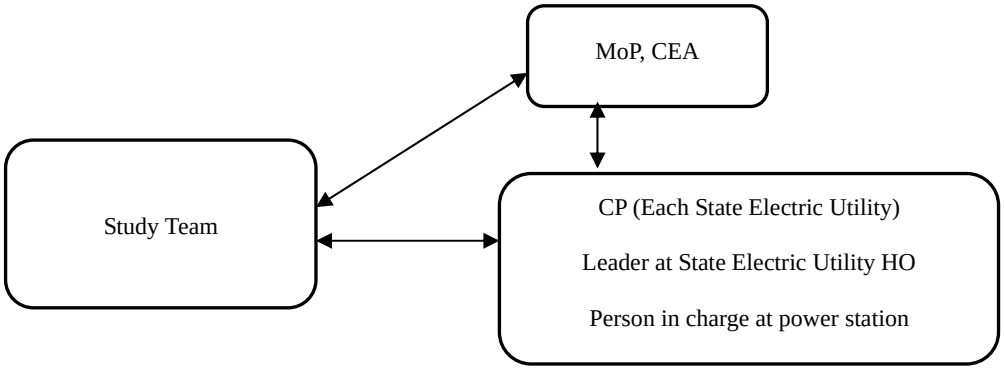

Fig.1.6-2 Counterpart Team

1.7 Target Power Stations/Units and Counterpart Team

(1) Target Power Stations/Units Selected

After the selection of the candidate power stations as described in **1.5 (1) 1)**, NLC informed JICA that there would be no need for the study team to study Neyvelli power station as a life extension program was already implemented for all units. In addition, the study team learned that TANGEDCO planned to replace Ennore power station with a new one, therefore Ennore power station was excluded from this study. Therefore, the candidate power stations turned to be UPRVUNL Obra power station, MPPGCL Satpura power station and MSPGCL Khaperkheda power station.

During field work phase 1, the candidate power stations were examined at the kickoff meeting held at JICA India Office on January 24, 2012 with attendance of MoP, CEA, three state electric utilities and JICA. At this meeting, MSPGCL proposed Parli power station and Bhusawal power station for the target power stations in place of Khaperkheda power station since it is operating at best performance in MSPGCL and does not need the study. Based on the discussion, all parties agreed and decided on the target power stations/units by study category, which is shown in Table 1.7-1.

Table 1.7-1 Target Power Stations/Units and Study Category

Target State	Target Power Station and Units	Study Category	Reasons for Selection
Uttar Pradesh UPRVUNL	Obra power station Units 1 to 8	Complete Replacement	Although plant life extension work has been implemented for Units 1 and 2, 44 to 45 years have already passed since the start of their operation. Therefore, complete replacement for Units 1 to 8 shall be examined.
Madhya Pradesh MPPGCL	Satpura power station Units 1 to 5	Complete Replacement	Complete Replacement for Units 1 to 5 shall be examined, since the units will be scrapped after the start of commercial operation of Units10 and 11, which are under construction now.
Maharashtra MSPGCL	Bhusawal power station Units 2 and 3	Complete Replacement	MSPGCL proposed this power station in place of the initially proposed Khaperkheda power station since Khaperkheda is one of the best power stations in MSPGCL, and therefore it is not necessary to conduct a study for replacement of Khaperkheda power station. Units 4 and 5 (500 MW each, sub-critical), which are under construction, will commence commercial operation this year and DPR for constructing Unit 6 (660 MW, super critical) is under preparation. MSPGCL considers further capacity expansion by replacing Units 2 and 3 utilizing existing infrastructure. Since the study will examine construction of a 660 MW unit, one fleet of the same size as Unit 6 can be established at Bhusawal power station together with the other fleet of 500 MW (Units 4 and 5).
	Parli power station Units 3 to 5	Complete Replacement or R&M	MSPGCL proposed this power station together with Bhusawal power station in place of Khaperkheda power station. Since capacity expansion was made by construction of Units 6 and 7 and is now underway by constructing Unit 8 in recent years, two possibilities were suggested by MSPGCL: 1) complete replacement of Units 3 to 5 together with already retired Units 1 and 2 for further capacity expansion, and 2) R&M for Units 3 to 5 with the background that R&M study is ongoing only for Unit 3 by assistance of WB.

(Source: JICA Study Team)

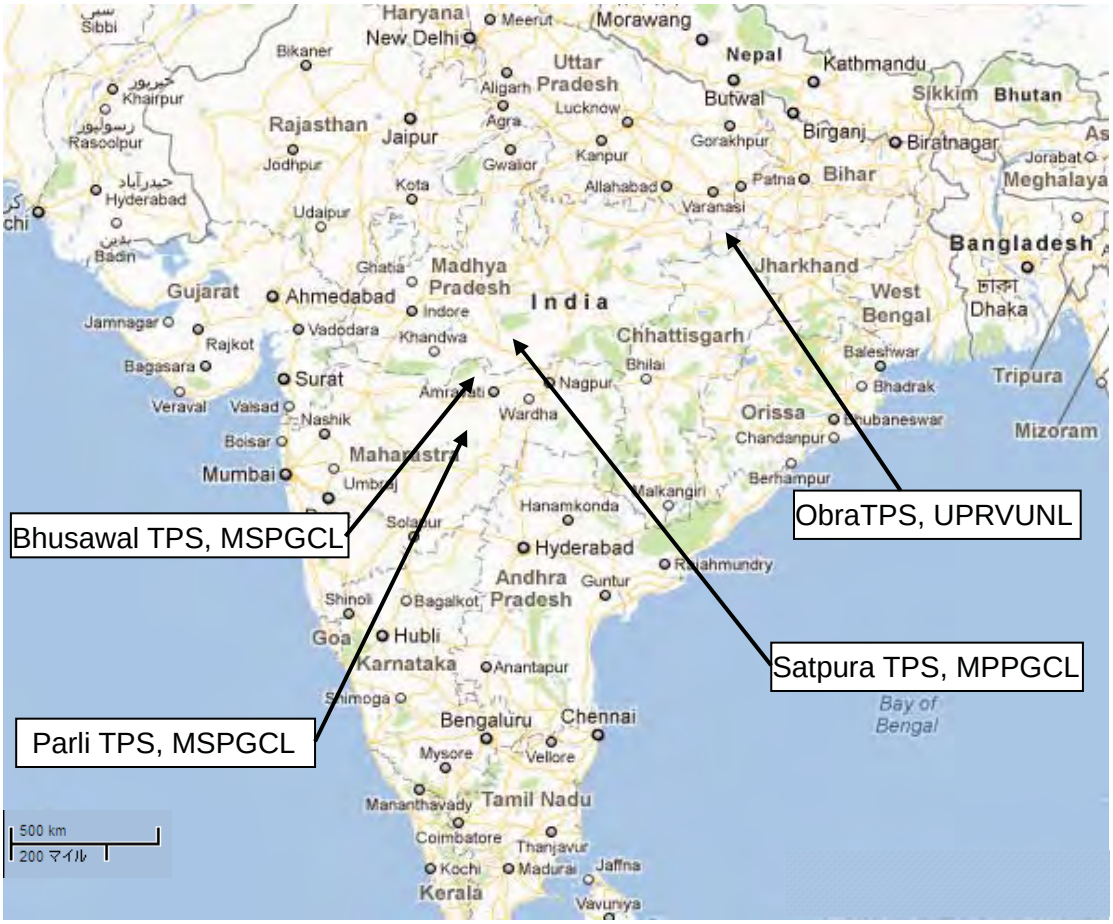

Fig.1.7-1 Target Power Station Location Map

(2) Counterpart Team

Through interactions among the concerned parties, the following counterpart team was identified with the key persons assigned for contact.

- Ministry of Power

Leader	Mr. Alok, Director (IC), MoP
Member	Mr. Sanjay Garg, Addl. General Manager, MoP

- Central Electricity Authority

Leader	Mr. T.P. Singh, Chief Engineer (TRM Divn)
Member	Mr. N.S. Mondal, Dy. Director

- UPRVUNL

Leader	Mr. R.P. Singh, Chief Engineer (Civil), Project Planning Monitoring & Management Unit
Member	Mr. R.K. Katiyar, Chief Engineer, PPMM

Obra Power Station

Mr. Maliendra Kumar (CGM)

Mr. R. D. Singh (CE Environment)	Mr. Anurag Ravi (SE PPMM)
Mr. M. N. Beg (SE CIVIL Lucknow)	Mr. Kailash Gupta (EE (Environment))
Mr. Rajeev Kr. Singh (AE PPMM)	Mr. Ashok Kumar (GM A)
Mr. P. Chaudhary (GM B)	Mr. B. S. Tewari (SE-I, BTPS)
Mr. S. B. Rai, SE-V (SE-V, BTPS)	Mr. Diwakar Swaroop (SE CIVIL)
Mr. R. C. Lai (SE-II, BTPS)	Mr. D. K. Mishra (SE-III, BTPS Elet.)
Mr. R. N. Singh (EE OGD-1 BTPS)	Mr. Rajeev Kumar (EE CIVIL)
Mr. V. K. Dinkar (EE BMD-1 ATPS Mech.)	Mr. R. K. Singh (EE TMD ATPS Mech.)
Mr. R. K. Singh (EE EMD-1 ATPS Elet.)	Mr. A. H. Khan (EE WTP BTPS WTP)
Mr. Ram Kumar (EE CPD ATPS Coal)	

- MPPGCL

Leader	Mr. Arvind Shrivastava, Officer On Special Duty (PRG)
Member	Mr. Khalid Nafees, EE (PRG)

Satpura Power Station

Mr. R.K. Date (Chief Engineer)	Mr. N.K. Saxena (Addl CE O&M-I)
Mr. A.K. Gupta (Sr. Chief Chemist)	Mr. A.K. Chakraborti (SE Opn-I)
Mr. Suresh Baribe (SE Mech Maint-I)	Mr. S.R. Gadhewal (SE Elect Maint-I)
Ms. Usha Diwan (Sr Accounts Officer)	Mr. P.K. Khare (Sr Chemist)
Mr. S.K. Dubey (E E IMD-I)	Mr. B.R. Ghogre (E E EMD-I)
Mr. S.K. Malviya (E E BMD-I)	Mr. M.W. Kukde (Account Officer)
Mr. Himanshu Pathak (A E TMD-I)	
Mr. Shailendra Wagdre (E E Civil maint)	
Mr. Deepak Kamavisdar (A E TMD-I)	

- MSPGCL

Leader	Mr. G.M. Pachare, Chief Engineer
Member	Mr. G.G. Bandgar, Dy C.E. (Works)

Parli Power Station

Mr. K.T. Nagdeve (C.E.)	Mr. A.M. Naik (A.E.)
Mr. A.P. Tayde (Dy C.E.)	Mr. A.H. Ashtikar (S.E.)
Mr. S.S. Jadhav (S.E. (O))	Mr. A.D. Chandurkar (E.E. T/M)
Mr. P.A. Amilkanthwar (S.E. (Ele))	Mr. J.K. Kannake (Sr. Manager F&A)
Mr. D.S. Naik (Exe. Chemist)	

Bhusawal Power Station

Mr. S.B. Waghmare (C.E.)	Mr. R.N. Patil (Dy. E.E.)

Mr.A.M. Bondre (Dy. C.E.)	Mr. V.P. Khadilkar (S.E.)
Mr. H.T. Mahajan (E.E.)	Mr. S.R. Gharpure (E.E.)
Mr. S.G. Chopade (S.E.)	Mr. S.B. Jamgade (E.E.)
Mr. S.K. Dhangar (E.E.)	Mr. A.B. Dhande (Dy. EE)
Mr. R.V. Zope (A.E.)	Mr. D.B. Jogdand (E.E.)
Mr. S.H. Londe (E.E.)	Mr. S.M. Mahajan (Dy. E.E.)
Mr. U.D. Deogade (Sr. Manager F&A)	Mr. S.P. Patil (Manager)
Mr. P.B. Shinde (Sr. Chemist)	Mr. Arun Birazdar (W.O.)
Mr. P.P. Patil (Exe. Chemist)	Mr. N.S. Kunwar (Sr. Chemist)
Mr. D.M. Kadale (E.E.)	Mr. A.M. Jawle (A.E.)
Mr. P.G. Yeole (E.E.)	Mr. S.S. Phalak (Dy. E.E.)

CHAPTER 2
OVERVIEW OF THE POWER SECTOR IN INDIA AND THE TARGET STATES

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CHAPTER 2 OVERVIEW OF THE POWER SECTOR IN INDIA AND THE TARGET STATES

2.1 Government Policy

(1) The Energy Conservation Rules, 2012

In order to improve the cost effectiveness of improvement in energy efficiency, on March 30, 2012, the Government of India notified the launch of so-called PAT (Perform, Achieve and Trade) Scheme, officially Energy Consumption Norms and Standards for Designated Consumers, Form, Time within which, and Manner of Preparation and implementation of Scheme, Procedure for Issue of Energy Savings Certificate and Value of Per Metric Ton of Oil Equivalent of Energy Consumed Rules, 2012, (Short title: The Energy Conservation Rules, 2012), which serves as a market based mechanism through cap and trade of energy efficiency. This scheme covers 478 Designated Consumers (DCs) of eight energy intensive industrial sectors. For the power sector, 144 power stations were selected as DCs, the biggest number among those eight sectors. The first cycle of the Energy Conservation Rules, 2012 is between April 2012 and March 2015, or a three year period. After this period, it will continue in three year cycles, and the baseline and target norms for the next cycle will be determined based on the achievements at the end of the previous cycle.

Along with the notification of the 2012 Energy Conservation Rules, the baseline energy consumption norms and standards (baseline ECN&S) at the beginning of the first cycle and the target energy consumption norms and standards (target ECN&S) to be achieved at the end of the first cycle were assigned to each designated consumer. For power utilities, the baseline ECN&S consist of the net heat rate (kcal/kWh) and net production output (million units), and the target ECN&S is set to be a net heat rate calculated based on the present deviation of net operation heat rate from the net design heat rate so as to make it closer to the net design heat rate. DCs who have performed better than the target energy consumption will be given Energy Saving Certificates (ESCs) that indicate the exact amount of energy in tons of oil equivalent improved from the target ECN&S. ESCs can be traded at the power exchange and are valid until the end of the next cycle. The value of a ton of oil equivalent, in which ESCs are priced, is fixed at 10,154 Rs/toe for 2011-12, and shall be reviewed every year.

Penalties will be imposed on DCs who do not achieve the target ECN&S based on Energy Conservation Act 2001 and Energy Conservation (Amendment) Bill 2010. Those DCs can compensate for the shortfall by purchasing ESCs.

The baseline and target ECN&S for the first cycle period (April 2012 to March 2015) for the four (4) target power stations have been set as listed in the Table 2.1-1 below. If the proposed replacement and R&M of power stations/units can achieve their target ECN&S, construction costs could be reduced by selling ESCs resulting in improved project economy. However, the study team thinks there are some points to be clarified for calculation of ESCs in case of complete replacement as shown in **5.1 (2) 3) (b)**.

Using the fixed 10,154 Rs/toe, this report has converted the value of fuel cost reduction into amount of money.

Table 2.1-1 Target Energy Consumption at 2014-15

DCs	Baseline ECN&S (average of three years)		Target Energy consumption at 2014-15
	Net Heat Rate (kcal/kWh)	Net Product Output (Mil Units)	Net Heat Rate (kcal/kWh)
Parli TPS, MSPGCL	3,346	3,653	3,190
Bhusawal TPS, MSPGCL	3,218	2,801	3,107
Satpura TPS, MPPGCL	3,681	6,408	3,444
Obra TPS, UPRVUNL	3,731	4,466	3,601

(2) Improvement of Energy Efficiency by Renovation and Modernization

According to Perspective Plan for Renovation, Modernisation (R&M) and Life Extension (LE) of Thermal Power Stations (up to 2016-17) prepared by Central Electricity Authority (CEA), the main objective of R&M of thermal power units is to apply the latest technologies to the operating units for up rating, improvement in reliability and availability, reduction in maintenance requirements and easy maintenance. On the other hand, the life extension (LE) program focuses on plant operation beyond the original design life after carrying out a specific life assessment study of critical components and necessary modification/replacement of the components.

In India, investigation of R&M plan started in 1984. The number of units and improved output capacity (MW) successfully achieved by this R&M plan from the 7th Plan (1987-1991) to the 10th Plan (2002-2006) of National Electricity Plan are shown in Table 2.1-2 below.

Table 2.1-2 Number of R&M Units and Improved Output (MW)

No.	5-Year Plan	No. of Units	Capacity (MW)	Additional Generation achieved (MU/Annum)	Equivalent MW
1	7th Plan	163	13,570	10,000	2,000
2	8th Plan (R&M) (LE)	198 (194) (4)	20,869 (20,569) (300)	5,085	763
3	9th Plan (R&M) (LE)	152 (127) (25)	18,991 (17,306) (1,685)	14,500	2,200
4	10th Plan (R&M) (LE)	25 (14) (11)	3,445 (2,460) (985)	2,000	300

(Source: National Perspective Plan for Renovation, Modernisation and Life Extension of Thermal Power Stations (up to 2016-17))

The number of units for which R&M and/or LE was implemented was 538 in total and the improved equivalent output capacity was 5,263 MW.

In addition, improvement of energy efficiency has been included in this R&M plan since the 11th plan (2007-2011) with the following objectives.

- Life extension of power generating unit by 10-15 years
- Improvement of availability of power generating unit
- Sustained achievement of near-design (or better) maximum continuous rating (MCR)
- Improvement in energy efficiency of boiler, turbine, generator and auxiliaries, resulting in improvement of unit heat rate
- Achievement of lower auxiliary oil consumption necessary for unit start up after frequent emergency unit trip and for stable combustion
- Making critical spare parts available for aged facilities
- Incorporation of advanced control and instrumentation systems
- Reduction in emissions and improved environmental control
- Facilitating adoption of improved operations and maintenance practices

There are some thermal power plants for which R&M and LE are already being taken up by international financial cooperation organizations such as the World Bank and KfW (Germany). USAID has prepared and provided a guideline for R&M and LE.

2.2 Overview of Target State Power Sector's Economic/Financial Situation

(1) Population, Net State Domestic Product (NSDP) and Growth rate

1) The NSDP of Maharashtra (2009-10, current price) accounts for about 15% (8,200 billion Rs) of the entire India (54,800 billion Rs), the largest among all of the states in India. The Per-Capita NSDP (2009-10) of the state stands at 74,000Rs, significantly higher than the Indian national average (46,000 Rs).

2) The Per Capita NSDPs in Uttar Pradesh, the state with the highest population, and Madhya Pradesh, are in the range of 23,000-27,000 Rs, which is lower than the national average. However, the NSDP growth-rate (2009-10) in both states was high, recording values of 17-18%.

Table 2.2-1 Net State Domestic Product (NSDP) & Population

	NSDP (2009-10) *Note 1*	NSDP/ Whole India (%)	Per Capita NSDP (2009-10) *Note 2*	NSDP growth-rate (2009-10)	[Ref.] Population *Note 3*
Maharashtra	**8,200 billion Rs**	**15%**	**74,027**	**17%**	**0.11billion**
Uttar Pradesh	**4,500 billion Rs**	**8%**	**23,132**	**18%**	**0.20billion**
Madhya Pradesh	**1,900 billion Rs**	**3%**	**27,250**	**17%**	**0.07billion**
India-total	**54,800billion Rs**		**Ave 46,492**	**Ave 16%**	**India-total 1.21billion**

(Note 1) Net State Domestic Product at Factor cost (current prices): (Source: Reserve Bank of India)

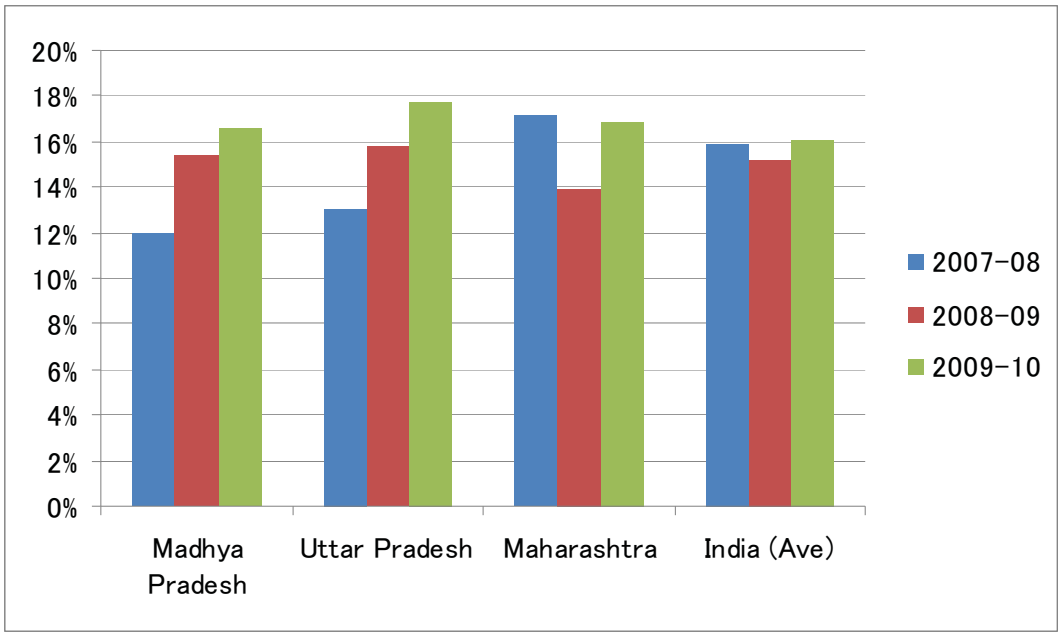
(Note 2) Per Capita Net State Domestic Product at Factor Cost (current prices): (Source: Reserve Bank of India)

(Note 3) 2011 Census ref: 1Rs=1.6JPY (12.2.2012)

(2) Net State Domestic Product (NSDP) Growth Rate for Recent Three Years (2007-2009)

1) The NSDP growth rates of Madhya Pradesh and Uttar Pradesh have increased for three consecutive years from 12-13% in 2007-08 to 17-18% in 2009-10. (This compares with an Indian national average of 15-16%.)

2) Maharashtra recorded 17% in 2007-08. Its growth rate decreased in 2008-09, but returned to 17% in 2009-10.

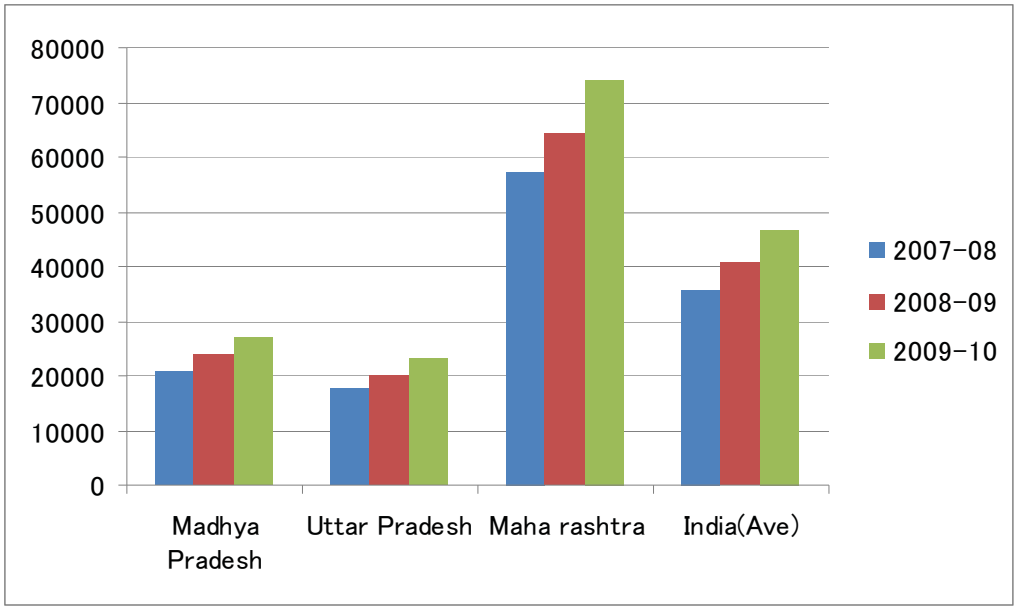


(Source: Reserve Bank of India)
Note 4: Net Domestic Power Product at Factor Cost (current prices)

Fig.2.2-1 Growth Rate of Net State Domestic Product *(Note 4)*

(3) Per Capita Net State Domestic Product (2007-08, 2008-09, 2009-10)

1) Per Capita Net State Domestic Product is increasing for the three states. The value for Maharashtra (70,000 Rs in 2009-10) is substantially higher than the Indian average (46,000 Rs in 2009-10). However, the values for Uttar Pradesh and Madhya Pradesh are much lower than the Indian average (standing at only 50-60% of the 46,000 Rs average value).



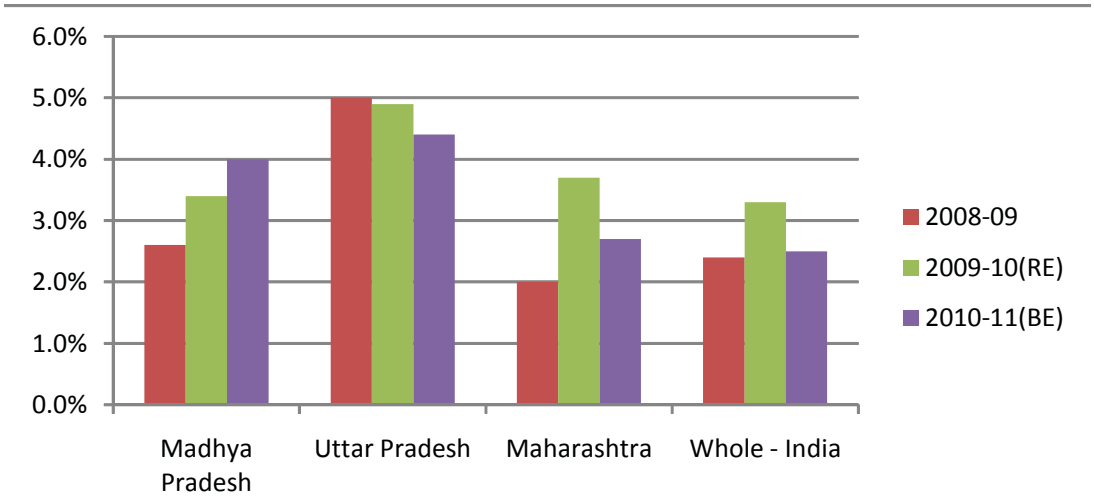
(Source: Reserve Bank of India)
Note 5: Per Capita Net State Domestic Product at Factor Cost (current prices)

Fig.2.2-2 Per Capita Net State Domestic Product *(Note 5)*

(4) Financial Situation (Gross Fiscal Deficit / State GDP, %)

1) The ratio (%) of Gross Fiscal Deficit for each state GDP is given in Fig 2.2-3. (According to the information of the Reserve Bank of India, all the states had Gross Fiscal Deficits in 2009-10 and 2010-11, although the 2010-11 figures are on a budgetary basis.) All three states have a Gross Fiscal Deficit and, while the figure for Maharashtra is close to the Indian average, that for Uttar Pradesh is high compared to the average.

	2008-09	2009-10(RE)	2010-11(BE)
Madhya Pradesh	2.6%	3.4%	4.0%
Uttar Pradesh	5.0%	4.9%	4.4%
Maharashtra	2.0%	3.7%	2.7%
Whole - India	2.4%	3.3%	2.5%



(Source: Reserve Bank of India)

RE: Revised Estimate
BE: Budget Estimate
Note 6
Gross Fiscal Deficit= Revenue deficit + Capital Outlay + Net lending – Non-debt Capital receipts

Fig.2.2-3 Deficit Indicator for State Governments:
Gross Fiscal Deficit/Gross State Domestic Product (%) *(Note 6)*

(5) Long-term Power Demand Forecast

1) According to the 17th Electric Power Survey (EPS), the power demand in 2016 is forecasted to be around twice of that in 2007.

Table 2.2-2 Power Demand Forecast (All India)

Item/Year	2007-08	2016-17	2021-22
Electrical Energy Requirement (GWh)	722,626	1,392,066	1,914,508
Peak Electrical Load (MW)	108,866	218,209	298,253

(Source: CEA 17th Electric Power Survey of India)

2) The Power Demand Forecast for the target states is as follows. It is forecast that power demand will increase by 30-45% from 2010 to 2016.

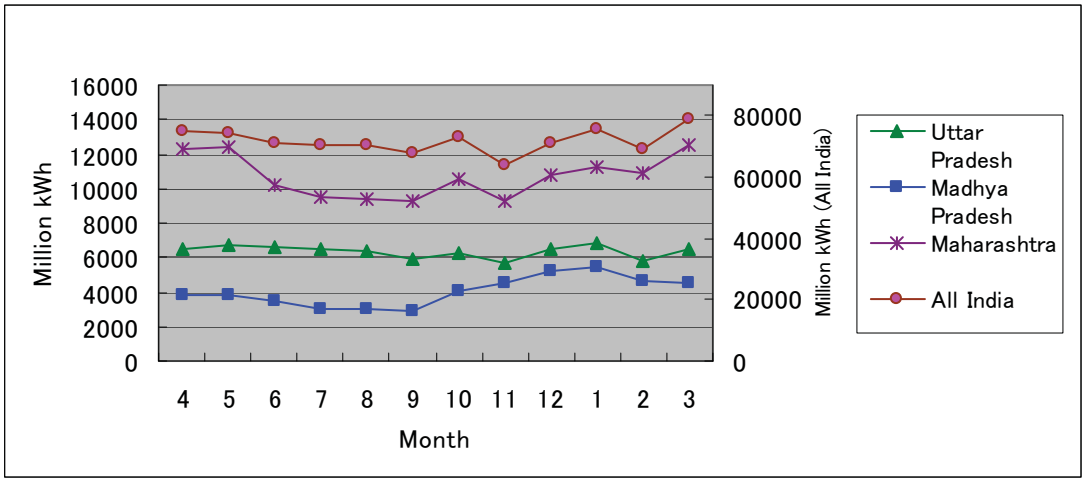
Table 2.2-3 Power Demand Forecast (Target States)

Item/Target States	Uttar Pradesh	Madhya Pradesh	Maharashtra
Electrical Energy Requirement (GWh)			
Year 2010-11*	76,292	48,437	128,296
Year 2016-17	110,665	70,445	167,227
Year 2021-22	150,157	98,987	219,910

(Source: CEA 17th Electric Power Survey of India,)
*CEA: Load Generation Balance Report (2011-12)

(6) Characteristics of Power Demand

1) National Indian power demand in 2010 remained stable throughout the year. The power demand trends in the target states also show stability, as illustrated below.



(Source: CEA Load Generation Balance Report)

Fig.2.2-4 Power Demand Trend (in 2010-11)

(7) Power Capacity of Target States

1) Total Indian power capacity in March 2012 amounted to 199,627 MW, of which more than 50% is coal fired capacity (MW) using abundant domestic coal.
2) While the development and promotion of hydro and renewable energy has a high priority, the status of coal fired power as the main source of energy remains unchanged.
3) Table 2.2-4 shows national installed power capacity and Table 2.2-5 target state installed power capacity.

Table 2.2-4 National Indian Installed Capacity

Sector	HYDRO	COAL	GAS	DIESEL	NUCLEAR	R.E.S	Total
State	27,380	49,457	4,715	603	0	3,514	85,669
Private	2,525	23,450	6,714	597	0	20,990	54,276
Central	9,085	39,115	6,702	0	4,780	0	59,683
Total	38,990	112,022	18,131	1,200	4,780	24,503	199,627
Ratio	20	56	9	1	2	12	100

(Source: CEA: Monthly All India Installed Generation Capacity Report as of March 2012) Unit: MW

Table 2.2-5 Installed Capacity of States

Target States	HYDRO	COAL	GAS	DIESEL	NUCLEAR	R.E.S	Total
U.P.	1,774	9,707	550	0	336	687	13,054
M.P.	3,224	4,549	257	0	273	477	8,780
MAHARASHTRA	3,332	15,014	3,476	0	690	3,630	26,142

(Source: CEA: Monthly All India Installed Generation Capacity Report as of March 2012) Unit: MW

(8) Electric Power Development Plans

1) In India, Five Year Plans have been drawn up by the Planning Commission since 1951, and these included electric power development planning. Under the 11th Five Year Plan 2007-11, 78,700 MW of capacity development is planned, with an average target GDP growth rate of 9%. However, at the end of March 2012, only 68.5% (53,922 MW) of the target value was reached.
2) The recent achievements/plans for electric power development in the target states are shown in Table 2.2-6 below.

Table 2.2-6 List of Completed/Ongoing/Planned Projects for Target State Utilities

Project Name	Status	Type	Capacity (MW)	Expected Date of Commercial Operation
Uttar Pradesh				
Paricha Ext Unit 5&6	Commissioned/2011	Coal	500	--
Harduaganj Ext Unit 8&9	Commissioned/2011	Coal	500	--
Anpara D Unit 1	Under Construction	Coal	500	2012
Madhya Pradesh				
Birsinghpur ext Unit 5	Commissioned/2007	Coal	500	--
Amarkantak Unit 5	Commissioned/2008	Coal	210	--
Shree Singaji Thermal Power (2 units)	Under Construction	Coal	1,200	Unit 1: March 2013
Satpura Thermal Power Station, Ext Units 10&11	Under Construction	Coal	500	Unit 10: Dec 2012, Unit 11:April 2013
Shri Singaji (2 units)	Under Preparation	Coal	1,320	--
Dada Dhuniwale (2 units)	Being Planned	Coal	1,600	--
Maharashtra				
New Parli Ext Unit 2	Commissioned/2010	Coal	250	--
Paras Ext Unit 1	Commissioned/2007	Coal	250	--
Paras Ext Unit 2	Commissioned/2010	Coal	250	--
Khaperkheda TPS Unit 5	Commissioned/2012	Coal	500	--
Bhusawal TPS Unit 4 & 5	Under Construction	Coal	1,000	2012
Chandrapur TPS Unit 8 & 9	Under Construction	Coal	1,000	2013
Parli TPS Unit 8	Under Construction	Coal	250	2013
Koradi TPS Unit 8, 9 & 10	Under Construction	Coal	1,980	2013
Being Planned				
Uran Gas Based Combined Cycle Power Plant (406 MW + 814 MW: Gas)				
Bhusawal TPS Unit 6 (1 × 660 MW)				
Nasik TPS Unit 6 (1 × 660 MW)				
Paras Thermal Power Project Unit 5 (1 x660 MW)				
Latur Coal Based Unit 1&2 (2 × 660 MW) or Gas Based CCPP Block-I & II (2 × 750 MW)				
Dhopawe TPS Project Unit 1 to 3 (3 x 660 MW)				
Dondaicha TPS Unit 1, 2, 3, 4 & 5 (5 × 660 MW)				

Project Name	Status	Type	Capacity (MW)	Expected Date of Commercial Operation
Coal Based Thermal Power Project near Kanpa (2 × 660 MW)				
Coal Based Thermal Power Project in Mendki (2 × 660 MW)				
Coal Based Thermal Power Project near Manora (2 × 660 MW)				

(Source: Each state utility's website)

(9) Transmission Facilities

1) The voltage levels of transmission facilities in India are generally 800 kV, 400 kV, 230/220 kV, 132 kV, 110 kV, and 66kV. In addition, 33 kV is also used in some areas.

2) Since the 1970s, inter-state transmission systems have been connected and power transmission systems in five regions (the Northern, Eastern, Western, Southern and North-East regions) have been developed. For these five regional systems, PGCIL (Power Grid Corporation of India Limited) built BTB (DC Interconnection, Back to Back) at four locations, as a first step toward the establishment of system interconnection covering the whole of India. As a result, the systems of all states and regions were completely interconnected by the end of 2001-02. However, the Southern Grid alone has not been operating synchronously with the other Indian Grids because the Grid connection is only through the HVDC link and HVDC back to back systems.

3) Based on the scheme established by CEA, PGCIL is planning to enable a transmission capacity of 42,000 MW at the inter-regional level by March 2012, the end of the period of the 11th Five Year Plan. The transmission facilities built up and enhanced so far are shown in Table 2.2-7.

Table 2.2-7 Growth of Transmission Sector since 6th Five Year Plan

At the end of	400 kV Transmission Lines (ckm)				220 kV Transmission Lines (ckm)			
	Central	State	JV/Pvt	Total	Central	State	JV/Pvt	Total
6th Plan (1982/4-1987/3)	1,831	4,198		6,029	1,641	44,364		46,005
7th Plan (1987/4-1992/3)	13,068	6,756		19,824	4,560	55,071		59,631
8th Plan (1992/4-1997/3)	23,001	13,141		36,142	6,564	73,036		79,600
9th Plan (1997/4-2002/3)	29,345	20,033		49,378	8,687	88,306		96,993
10th Plan (2002/4-2007/3)	50,992	24,730		75,722	9,444	105,185		114,629
11th Plan (2007/4-2011/12)	74,093	32,417	7,263	113,719	10,707	127,125	427	138,259

(Source: CEA: Status of transmission sector as on end of the month (2011-12))

(10) Transmission/Distribution Loss

1) Transmission/distribution loss in India was at the high rate of 32.5% in 2002. This loss results not only from technical/facility problems but also from power theft and unmetered consumption. In order to reduce loss, the Government of India has implemented the Accelerated Power Development & Reform Programme (APDRP) since 2002. Its main purpose is to designate

60ºdistribution areas nationwide as model areas, and to promote the setting up of meters for all consumers and the replacement of transformers.

2) Total national Indian transmission/distribution loss has been decreasing since 2003. The loss in 2008-09 was 25.5%.

3) The transmission/distribution losses in the target states (2009-10) are 32.3% in Uttar Pradesh, 35.6% in Madhya Pradesh, and 25.2% in Maharashtra.

(11) Power Tariffs

1) The power tariff for agricultural and domestic sectors is, as a political decision, at a level lower than average cost of supply. To make up for the loss, state governments allocated subsidies and higher tariffs for industrial/commercial customers. To address the structure of this negative margin, the Government of India established the Power Tariff Policy in 2006 and is formulating action aimed at reforming the power tariff system.

2) Table 2.2-8 below shows the gap between the average cost of supply and average tariff in the 20 major states.

Table 2.2-8 Financial Performance of 20 Major States, excluding Delhi and Odisha

1Rp= 100 Paisa

Items	2005-06	2006-07	2007-08	2008-09 (Provisional)
Average cost of supply (Paise/kWh)	367.71	391.90	404.97	432.65
Average tariff (Paise/kWh)	288.63	300.51	307.49	328.57
Gap between average cost of supply and average tariff (Paise)	79.08	91.40	97.49	104.07

(Source: Planning Commission: Mid-Term Appraisal of 11th Five Year Plan)

3) The gaps between average cost of supply and average tariff in the target states are as in Table 2.2-9 below.

Table 2.2-9 Financial Performance of Target States in 2008-09 (Provisional)

Items	Uttar Pradesh	Madhya Pradesh	Maharashtra
Average cost of supply (Paise/kWh)	457.30	492.49	450.05
Average tariff (Paise/kWh)	284.51	319.56	403.69
Gap between average cost of supply and average tariff (Paise)	172.79	172.93	46.36

(Source: Planning Commission: Mid-Term Appraisal of 11th Five Year Plan)

(12) Rural Electrification Policy

1) Rural Electricity Infrastructure and Household Electrification, implementation of which was begun by the central government in April 2005, were introduced for the purpose of achieving the National Common Minimum Programme goal of provision of access to electricity to all agricultural households. The scheme has mainly been implemented by the Rural Electrification

Corporation (REC), and the target is to increase the electrification rate at the household level to 100% by 2012.

Table 2.2-10 Rural Electrification (as of 2011-12)

Total No. of Villages	593,732
No. of villages Electrified	547,034
% of Villages Electrified	92.1%

(Source: CEA: Progress Report of Village Electrification as on 31-3-2012)

CHAPTER 3
FIELD WORK

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CHAPTER 3 FIELD WORK

3.1 Field Work - Phase 1

Field Work Phase 1 was conducted in the period between January 22 and 28, 2012.

On January 24, at the JICA India Office, MoP, CEA, three state electric utilities (UPRVUNL, MPPGCL and MSPGCL), and JICA participated in a joint kick-off meeting and confirmed the study procedures based on the Draft Inception Report, and decided on the target power stations/units as shown in Section **1.7 (1)** mentioned earlier.

To avoid overlap with existing projects, the study team checked projects in the Indian power sector supported by other financial cooperation organizations, i.e. World Bank, USAID, and KfW (Kreditanstalt fur Wiederaufbau).

The schedule of the field work phase 1 is shown in Table 3.1-1.

Table 3.1-1 Schedule of the Field Work Phase 1

				Item	Remarks
JAN	22	Sun		Departing from Japan Arriving at India	
	23	Mon	AM	11:00 Visit to JICA India Office	
			PM	Preparation of Kickoff Meeting	
	24	Tue	AM	11:30 Pre-Meeting (UP) 12:30 Pre-Meeting (MSP) 13:10 Pre-Meeting (MP)	
			PM	14:30 #1 Kickoff Meeting (MOP, CEA, State Utilities, JICA) Explanation of Inception report (contents of study)	
	25	Wed	AM	10:00 Visit to WB	
			PM	15:00 Visit to USAID	
	26	Thu		Holiday / Preparation of MOM	
	27	Fri	AM	12:00 Visit to KfW	
			PM	14:30 Japan Embassy	Delhi to Narita
	28	Sat		Arriving at Japan	

3.2 Field Work - Phase 2

This field work was conducted in the period between March 11 and April 5, 2012.

The study team visited the head offices of the three target state electric utilities to explain the purpose of JICA study and ask for their cooperation, and then conducted the survey on the target power stations/units. The schedule of the field work phase 2 is shown in Table 3.2-1.

After the survey on the target power stations, the study team had a wrap-up meeting with CEA and JICA in New Delhi to determine how the survey results should be put together.

Table 3.2-1 Schedule of the Field Work Phase 2

				JICA Study Team					
Month	Day			Shimizu	Miyagi	Gima	Meguro	Tanimoto	Koizumi
March	11	Sun	Activity	Arrival at Delhi JL749 NRT(11:25) - DEL(18:20)					
			Stay	Delhi	Delhi	Delhi	Delhi	Delhi	
	12	Mon	Activity	Meeting with JICA (10:30) AI659 Delhi(17:00) to Mumbai(18:55)	→	→	→	→	
			Stay	Mumbai	Mumbai	Mumbai	Mumbai	Mumbai	
	13	Tue	Activity	Visit to MSPGCL Head Office (10:00) AI442 Mumbai(15:00)-Aurngabad(15:50)				→	
			Stay	Aurangabad	Aurangabad	Aurangabad	Aurangabad	Aurangabad	
	14	Wed	Activity	Aurangabad to Parli P/S (car)					
			Stay	Parli P/S	Parli P/S	Parli P/S	Parli P/S	Parli P/S	
	15	Thu	Activity	Parli P/S Site Survey				→	
			Stay	Parli P/S	Parli P/S	Parli P/S	Parli P/S	Parli P/S	
	16	Fri	Activity	Parli P/S Site Survey				→	
			Stay	Parli P/S	Parli P/S	Parli P/S	Parli P/S	Parli P/S	
	17	Sat	Activity	Parli P/S to Aurangabad (car)	→	→	→	→	
			Stay	Aurangabad	Aurangabad	Aurangabad	Aurangabad	Aurangabad	
	18	Sun	Activity	Aurangabad to Bhusawal P/S (car)	→	→	→	→	
			Stay	Bhusawal P/S	Bhusawal P/S	Bhusawal P/S	Bhusawal P/S	Bhusawal P/S	
	19	Mon	Activity	Bhusawal P/S Site Survey				→	
			Stay	Bhusawal P/S	Bhusawal P/S	Bhusawal P/S	Bhusawal P/S	Bhusawal P/S	
	20	Tue	Activity	Bhusawal P/S Site Survey				→	
			Stay	Bhusawal P/S	Bhusawal P/S	Bhusawal P/S	Bhusawal P/S	Bhusawal P/S	
	21	Wed	Activity	Bhusawal P/S to Aurangabad (car) AI442 Aurangabad(16:20) - Delhi(17:55)				→	
			Stay	Delhi	Delhi	Delhi	Delhi	Delhi	
	22	Thu	Activity	IT 4375 Delhi(06:50) - Jabalpur(08:50) Visit to MPPGCL Head Office (11:00)				→	
			Stay	Jabalpur	Jabalpur	Jabalpur	Jabalpur	Jabalpur	
	23	Fri	Activity	Jabalpur to Satpura (06:00, Car) Satpura P/S Site Survey (14:00)				→	
			Stay	Satpura P/S	Satpura P/S	Satpura P/S	Satpura P/S	Satpura P/S	
	24	Sat	Activity	Satpura P/S Site Survey				→	
			Stay	Satpura P/S	Satpura P/S	Satpura P/S	Satpura P/S	Satpura P/S	
	25	Sun	Activity	Holiday				→	
			Stay	Satpura P/S	Satpura P/S	Satpura P/S	Satpura P/S	Satpura P/S	
	26	Mon	Activity	Satpura P/S Site Survey				→	
			Stay	Satpura P/S	Satpura P/S	Satpura P/S	Satpura P/S	Satpura P/S	
	27	Tue	Activity	Satpura P/S to Bhopal (Car) 9W 7141 Bhopal(19:15) - Delhi (21:50)				→	
			Stay	Delhi	Delhi	Delhi	Delhi	Delhi	
	28	Wed	Activity	AI-411 Delhi(08:05) - Lucknow(09:00) Visit to UPRVUNL Head Office (11:00) 9W 7075 Lucknow(14:50) - Delhi(15:50)				→	Arrival at Delhi NRT(11:30) - DEL(17:35)
			Stay	Delhi	Delhi	Delhi	Delhi	Delhi	Delhi
	29	Thu	Activity	SG 116 Delhi(09:35) - Varanasi(10:50) Varanasi to Obra P/S (Car)					→
			Stay	Obra P/S	Obra P/S	Obra P/S	Obra P/S	Obra P/S	Obra P/S
	30	Fri	Activity	Obra P/S Site Survey					→
			Stay	Obra P/S	Obra P/S	Obra P/S	Obra P/S	Obra P/S	Obra P/S
	31	Sat	Activity	Obra P/S Site Survey					→
			Stay	Obra P/S	Obra P/S	Obra P/S	Obra P/S	Obra P/S	Obra P/S
April	1	Sun	Activity	Holiday					→
			Stay	Obra P/S	Obra P/S	Obra P/S	Obra P/S	Obra P/S	Obra P/S
	2	Mon	Activity	Obra P/S to Varanasi (Car) 9W 724 Varanasi(15:10) - Delhi(16:35)					→
			Stay	Obra P/S	Obra P/S	Obra P/S	Obra P/S	Obra P/S	Obra P/S
	3	Tue	Activity	JICA ST Internal Wrap up					→
			Stay	Delhi	Delhi	Delhi	Delhi	Delhi	Delhi
	4	Wed	Activity	Meeting with JICA(10:00), CEA(11:30)					→
			Stay	Delhi to Japan JL740 Delhi(19:35) - NRT(06:55)	Delhi to Japan	Delhi to Japan	Delhi to Japan	Delhi to Japan	Delhi to Japan
	5	Thu	Activity						
			Stay						

3.3 Field Work - Phase 3

This field work was conducted in the period between May 1 and 12, 2012.

The study team explained the study results at the head offices of three target state electric utilities by using the Draft Final Report. The study team collected opinions from the state electric utilities, and discussed the results with CEA and JICA in the joint meeting on May 10, 2012.

The schedule of the field work phase 3 is shown in Table 3.3-1.

Table 3.3-1 Schedule of the Field Work Phase 3

				JICA Study Team					
Month	Day			Shimizu	Miyagi	Gima	Meguro	Tanimoto	Koizumi
May	1	Tue	Activity	Arrival at Delhi JL749 NRT(11:30) - DEL(17:35)	→	→	→	→	
			Stay	Delhi	Delhi	Delhi	Delhi	Delhi	
	2	Wed	Activity	**Meeting with JICA (15:00)**	→	→	→	→	Arrival at Delhi
			Stay	Delhi	Delhi	Delhi	Delhi	Delhi	JL749 (17:35)
	3	Thu	Activity	AI-411 Delhi(08:05) - Lucknow(09:00) **Visit to UPRVUNL Head Office (10:30)** 9W7039 Lucknow(17:50) - Delhi (18:50)	→	→	→	→	→
			Stay	Delhi	Delhi	Delhi	Delhi	Delhi	Delhi
	4	Fri	Activity	AI-865 New Delhi(10:00) - Mumbai(12:05) **Visit to MSPGCL Head Office (14:30)**	→	→	→	→	→
			Stay	Mumbai	Mumbai	Mumbai	Mumbai	Mumbai	Mumbai
	5	Sat	Activity	9W 307 Mumbai(11:15) - Delhi(13:15) Preparation of report	→	→	→	→	→
			Stay	Delhi	Delhi	Delhi	Delhi	Delhi	Delhi
	6	Sun	Activity	AI-9807 New Delhi(06:10) - 08:10(Jabalpur)	→	→	→	→	Leave Delhi JL740(19:35)
			Stay	Jabalpur	Jabalpur	Jabalpur	Jabalpur	Jabalpur	
	7	Mon	Activity	**Visit to MPPGCL Head Office (10:30)**	→	→	→	→	
			Stay	Jabalpur	Jabalpur	Jabalpur	Jabalpur	Jabalpur	
	8	Tue	Activity	AI-9808 Jabalpur(08:30) - New Delhi(10:25) Preparation of report **Meeting with JICA (12:30)**	→	→	→	→	
			Stay	Delhi	Delhi	Delhi	Delhi	Delhi	
	9	Wed	Activity	Preparation of report **Meeting with WB (14:00)**	→	→	→	→	
			Stay	Delhi	Delhi	Delhi	Delhi	Delhi	
	10	Thu	Activity	**JICA & CEA (15:00)** **at JICA office**	→	→	→	→	
			Stay	Delhi	Delhi	Delhi	Delhi	Delhi	
	11	Fri	Activity	Preparation of report	→	→	→	→	
				Delhi to Japan JL740 Delhi(19:35)					
	12	Sat		- NRT (06:55)					

CHAPTER 4
FINDINGS ON THE TARGET POWER STATIONS/UNITS

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CHAPTER 4 FINDINGS ON THE TARGET POWER STATIONS/UNITS

4.1 Parli Thermal Power Station Units 3 to 5 in Maharashtra

(1) Overview of Current Facilities and Operation

Parli power station (Address: Parli-Vaijnath, Dist: Beed, Maharashtra; at latitude 18.866819 north and longitude 76.522179 east) is located approximately in the center of Maharashtra state, and it takes about four hours by car from the nearest airport, Aurangabad.

Parli power station consists of decommissioned Units 1 and 2 (30 MW × 2), operating Units 3 to 5 (210 MW × 3), and Units 6 and 7 (250 MW × 2) located at a distance of about 2 km from Units 1 to 5. Unit 8 (250 MW × 1) is now under construction at the site adjacent to that of Units 6 and 7.

The main specifications and operational indices of Units 3, 4 and 5 are shown in Table 4.1-1 below.

Table 4.1-1 Plant Particulars of Parli Thermal Power Station

Items	Unit 3	Unit 4	Unit 5
Rated Output (MW)	210	210	210
Commercial Operation Year	1980	1985	1987
Boiler Manufacturer	BHEL	BHEL	BHEL
Turbine Manufacturer	BHEL	BHEL	BHEL
Cumulative Operation Hours (hrs) COD to end of 2011	195,336	182,090	171,592
Gross Electricity Generation (MU) per Year (2009, 2010)	2009:1,085.8 2010:1,127.3	2009:1,281.0 2010:1,095.7	2009: 1,340.1 2010: 1,066.3
Plant Load Factor (%)	2009: 62.91 2010: 54.06	2009: 64.71 2010: 60.68	2009: 69.63 2010: 54.06
Gross Thermal Efficiency (%)	2009: 31.25 2010: 31.88	2009: 31.27 2010: 32.01	2009: 30.73 2010: 30.36

(Source: Parli Power Station, MSPGCL)

PLF = (Power Generation per Year (MWh)) / (Rated Output (MW) x 24(h) x 365(d)) x 100

(2) Facilities for R&M and/or Replacement

1) Site for power generation facilities

The site of the power station consists of those for operating Units 3 to 5 and decommissioned Units 1 and 2. There is a linked turbine building for Units 3 to 5. Units 1 and 2 located at a distance of about 100 m from Unit 3 to the north are planned to be demolished in the near future.

The coal storage yard is located on the back (east) of the stacks for Units 3, 4 and 5.

The facilities of switchyard and its land are owned by MSETCL, the power transmission company.

There is no site available for a new 660 MW unit except for the site of the existing Units 1 to 5 inside the power station compound.

2) Coal transportation facilities

There is a railway coal transportation facility. Coal consumption at Parli power station was 4.7 million tons in 2010 (Units 3 to 5 consumed 2.6 million tons). It has the ability to receive 10,800 tons of coal per day.

3) Fuel supply

The power station uses domestic coal (raw coal and washed coal) and imported coal. As the coal supply has been unstable, the coal storage yard now has a coal stock for only 2 to 3 days of use. PLF and output are constrained because the power station receives lower calorie and higher ash content coal compared with the design coal.

4) Ash pond

The ash pond has an area of 445 ha and receives ash from Units 3 to 8. It is assumed that the present ash pond will be filled up by 2034.

The PH, the turbidity and the oil and grease content of the ash water from the ash pond are measured once a month and the measured values are summarized in the monthly report to CEA. The ash water is fully re-used. Excessive ash water which occurs in monsoon season is discharged to the small stream.

No liners or other components are installed at the bottom of the ash pond to prevent water penetration from the ash pond to the underground.

5) Raw water supply (cooling water, etc.)

Raw water is supplied via two routes: one is intake from Paithan dam located 9 km from the power station, and the other from Majgaon dam which is near the power station. This water is mainly used as makeup water for cooling towers.

6) Waste water

Waste water from the power station is transferred to the effluent treatment plant and then to the ash slurry pit after treatment to be used as slurry water.

7) Transmission lines

Transmission lines and the switchyard facilities including the land are owned by MSETCL, the power transmission company. The transmission voltage of Units 2 to 5 is 220 kV.

8) Access conditions for heavy load equipment

Parli power station has witnessed the transportation of heavy load equipment for 250 MW units in the past.

9) New project

A power generating unit of 250 MW as Unit 8 is under construction at the site located at a distance of about 2 km from Units 3 to 5.

10) Environmental regulations and social considerations

Major environmental regulations are as follows:

Criteria and current conditions of flue gas at stack outlets, waste water and noise

(a) Flue gas at stack outlets

Dust:

Parameters	Limits	Actual (Jan. 2012)
SPM (unit 3,4,5)	100 mg/Nm^3	153–249
SPM (unit 6,7)	70 mg/Nm^3	93,110
SPM (unit 8)	70 mg/Nm^3	-
*SO_2	80 t/day	276–331mg/Nm^3
*NOx	150 mg/Nm^3	137, 139
* State regulation		

(Source: Parli Power Station, MSPGCL)

(b) Waste water

Parameters		Limits	Actual (Jan. 2012)
Condenser Cooling	Temperature	Not exceed 5ºC of Intake	4.5–5ºC
	pH	6.50–8.50	8.75–9.44
	Cl_2	0.5 mg/l	2.61–2.74
Boiler Blowdown	Oil & Grease	20 mg/l	0.0
	Sus. Solids	100 mg/l	ND
	Copper	1 mg/l	0.01–0.04
	Iron	1 mg/l	< 0.01
Cooling Tower	Cl_2	0.5 mg/l	0.13–0.29
	Zinc	1 mg/l	ND
	Chromium	0.2 mg/l	ND
	Phosphate	5 mg/l	2.47–2.53
Ash Pond Water	pH	6.50–8.50	7.75
	Oil & Grease	20 mg/l	ND
	Sus. Solids	100 mg/l	132

(Source: Parli Power Station, MSPGCL)

(c) Noise

During daytime 55 dB (at the boundary of the power station)

During nighttime 45 dB (at the boundary of the power station)

(d) Environmental monitoring

Regulatory objectives (quality of ambient air and water) required by law are measured and the environmental monitoring report containing the measured data is submitted to CEA every month.

(e) Utilization of coal ash

The percentage of utilization of fly ash for 2010-11 was 77% (material for cement, brick). The power station aims at achieving the target set by the Ministry of Environment and Forestry in November 2009 (utilization of fly ash shall be 100% by 2014 for coal/lignite

thermal power stations in operation at that time or by 4 years after COD in the case of new power stations after that time).

(f) Problems concerning social circumstances

SPM of flue gas at stack outlets exceeds the regulations. The turbidity of ash water from the ash pond exceeds the limit.

11) Operation and maintenance

The operation and maintenance system is organized and managed by operation manager and maintenance manager who directly report to Chief Engineer of the power station. The power station operators are divided into five groups (eleven operators in one group) and work three shifts a day. The maintenance work is divided into three groups such as the boiler group, the turbine group and the R&M group. The number of employees at the power station is approximately 1,300 including the administration section and CHP (coal handling plant) section. (It has no affiliate companies.)

In order to evaluate the capability of operation and maintenance, the study team confirmed that operation manuals were properly prepared by the power station and a sample of the trouble handling manual in case of boiler tube leakage was obtained. Spare parts are controlled using the integrated software of enterprise resource planning (ERP). The power station has ISO9001 and ISO14000 certifications. However, it does not have OSHA certificate.

12) Training program

Training system is already established. Training period for operator is about one year. MSPGCL has two training facilities (Koradi training center and Nasik training center), including operation simulators. Operators are trained at the training center for about 22 weeks.

Each power station of MSPGCL has a sub training center.

(3) Evaluation

(3-1) Complete Replacement Plan

1) Replacement plan

Although MSPGCL is not planning to construct a new 660 MW unit power station with a capacity of 660 MW, the study team reviewed and created a plan to retire Units 3 to 5, demolish Units 1 to 5, and then construct a new 660 MW unit within the site. The estimated demolition work period is two and half years based on experience in Japan.

2) Replacement method

(a) Plot the removal site in consideration of work safety.

(b) Dismantle buildings and equipment, such as tanks.

(c) Excavate and remove the concrete mats of the unit bases to clear the site. The existing bearing piles in the ground will not be removed during the removal work and the layout of such bearing piles should be taken into account in the foundation design for the new unit.

Nevertheless, if some existing bearing piles interfere with new piles actually in spite of prior evasion by designing, such piles should be broken down by the drilling of new piles without excavation/removal in a separate work process.

(d) After the existing units are removed, the replacement work should be carried out according to the drawings and specifications.

3) Main particulars after replacement

The main particulars after replacement are shown in Table 4.1-2 based on the collected data.

Table 4.1-2 Plant Particulars of Parli 660 MW (same as Bhusawal conditions)

Items	New Unit
Rated Output (MW)	660
Boiler	Supercritical pressure, once-through, Reheat type.
Turbine	Tandem compound single reheat condensing turbine
Steam Conditions at Turbine HP inlet at Turbine IP inlet	 247 kg/cm^2 563ºC 40 kg/cm^2 593ºC
Plant Load Factor	85%
Unit Heat Rate (Unit Heat Rate at 85% PLF)	2130 kcal/kWh

(Source: Parli Power Station, MSPGCL)

4) Review of factors associated with replacement

(a) Site

The site where Units 1 to 5 and the switchyard currently stand will be used after these facilities are removed. Acquisition of a new site is not necessary. A Natural Draft Cooling Tower (NDCT) (approx. 150 m in diameter) will be installed at the site on which the existing cooling tower stands. The GIS switchyard will be adopted since it can save space.

As the switchyard is owned by MSETCL, the power transmission company, it is necessary to obtain approval from MSETCL. (See Attachment-1)

(b) Coal supply

The new unit will take over the coal linkage allocated to Units 3 to 5 at present. However, since the power generating capacity of the new unit increases, it will be necessary to make a request to Standing Linkage Committee for an additional coal linkage for the increased capacity.

In addition, the railroad transportation capacity from coal mines to the power station should be confirmed.

(c) Raw water supply (for cooling water, etc.)

Water for Units 3 to 5 currently in use has been secured. However, it is necessary to obtain approval from the state government for securing the quantity of the water intake from the

Paithan dam and the Majgaon dam due to the increase in the generation capacity of the new unit.

(d) Transmission lines

It is necessary to consider an expansion of the 400 kV switchyard facilities and the transmission lines by involving MSETCL.

(e) Ash pond

Since the existing ash pond will be shared by the new unit, extending the life of the ash pond should be considered. Liners have not been installed at the bottom of the ash pond.

(f) License

It is necessary to obtain licenses for environment, aircraft obstruction, and new unit construction from the state government.

(g) Financial situation

MSPGCL has been making stable profits for at least the past five years, and no specific problems have occurred in repayment of the loan.

5) Economic benefits of replacement

(a) Fuel saving by improved efficiency (ton of oil equivalent)

The efficiency particulars of the existing units are as follows.

Table 4.1-3 Parli Unit 3, 4 & 5 Fundamental Data for April 2011–February 2012

Generation	2,410.5 Million kWh
Heat rate	3,002 kcal/kWh
Auxiliary power consumption	12.56%
Coal GCV	3,338 kcal/kg
Coal price (2010–2011)	2,672.4 Rs/MT
Specific Coal Consumption	0.867 kg/kWh

(Source: Parli Power Station, MSPGCL)

Since the Detail Project Report (DPR) has not been made yet, the heat rate after replacement was assumed to be 2,130 kcal/kWh, which is equivalent to that of Unit 6 of Bhusawal power station. The efficiency will be improved by 29%. The heat rate improvement of 872 kcal/kWh is estimated to be an annual fuel reduction of 288,744 toe when calculated using the generation of 3,311.3 million kWh, which corresponds to 60% of the current average PLF of the existing units (210 MW × 3). It is equivalent to 293 crore according to the toe value in the Energy Conservation Rules 2012.

Reduction of CO_2 emission is estimated at 1,096,111 tCO_2.

(b) Increase in electricity supply by reduced forced outage of units (MWh)

The average forced outage rate of Units 3 to 5 for the past five years was 7.9%. The forced outage rate after replacement is assumed to be 3%. The increased power supply by the

replacement will be 283,298 MWh (660 MW × 8760 hrs × (7.9% - 3%)), assuming that the necessary amount of coal can be secured.

(c) Increase in electricity supply by reduced auxiliary power consumption
The auxiliary power consumption rate was 12.56% from April 2011 to February 2012 for Units 3 to 5. The auxiliary power consumption rate is assumed at 6.0% after the replacement. The improvement of power supply by the replacement will be expected.

6) Budgetary scale

Costs for removing the existing units	12 crore
Costs for constructing the new station	3,498 crore (IDC excluded)

7) Organizational structure for implementation

In order to carry out the necessary Japanese ODA loan procedures smoothly and effectively, it is necessary to hold a project promotion meeting, the members of which are to consist of state electric utilities, state electricity boards, and related state departments, in order to share the necessary information. It is also necessary for the state electric utility to take on leadership as the institution responsible for its implementation.

8) Environmental and social impact

It is considered that the new unit will pose no problems to the environment or society because it will be constructed at the site of the existing units, it will be highly efficient and it will release reduced emissions. It is also expected to create new employment and business opportunities for the local economy.

9) Subjects to be considered

(a) It is necessary to consult MSETCL regarding the use of the site for the switchyard. Detailed consultation will also be necessary for installing new transmission lines or using the existing lines.

(b) It is necessary to secure additional fuel (coal) and raw water for the increased output (from 630 MW to 660 MW).

(c) Licensing required for the replacement should be obtained (environment, etc).

(d) Because the current dust emission does not observe the limit of 100 mg/Nm^3, it needs to comply with the regulations after replacement.

(e) Since the liner has not been installed at the bottom of the ash pond, monitoring of well water close to the ash pond is recommended because there are concerns that water penetration from the ash pond may contaminate the underground water.

(f) Planning and implementation of training programs are required because the power station staff currently have no experience in operating a supercritical pressure steam power unit.

(g) DPR should be created to promote the project.

(3-2) R&M Plan

According to information from the World Bank, Parli power station is conducting the Remaining Life Assessment (RLA), the environmental impact assessment, and the social impact assessment with support of the World Bank.

Parli power station informed that RLA was conducted in February 2012 and the report will be submitted around May 2012. In addition, for the renovation and modernization (R&M) of Unit 3, bidding will be conducted for items to be renovated after receiving DPR from the outsourced consulting company and then the renovation work will be started.

1) The status of maintenance and major failures and problems in the past

   Major failures and problems which occurred at Units 3 to 5 between 2005 and 2010 are as follows. The major incident was boiler tube leakage. However, the number of tube leaks has been declining in recent years probably because wider areas of the boiler furnace sections than before is inspected during regular inspections and the station is being operated at a lower steam pressure under partial load operation.

   - Boiler tube leakage (W/W)
   - Reheater tube leakage
   - Eco tube leakage
   - LTSH tube leakage
   - H2 leakage (Generator)
   - Turbine bearing No.6 vibration high
   - HRH tube leakage
   - Generator casing H2 gasket leakage
   - Furnace pressure very high (wet coal)
   - Flash over occurred at 6.6 kV breaker of ID Fan

2) Major R&M in the past

   Major renovations and improvements to Units 3 to 5 since 1993 are as follows.

   - Renovation of Fly Ash Handling System (Unit 3)
   - Air heater seal modification (Unit 3)
   - Replacement of SH&RH spray control valve (Units 3, 4 and 5)
   - Replacement of 6.6 kV MOCBs by VCBs (Units 3 and 4)
   - Installation of pneumatic type of CMRHS (Units 3 and 4)
   - Retrofitting of MOCBs by VCBs (Units 3, 4 and 5)
   - Replacement of cold air gates & dampers and hot air dampers (Units 3, 4 and 5)
   - Up-grading of C&I system (Unit 3)
   - Installation of microprocessor based controller system (Units 4 and 5)

3) Planned R&M items

   An outsourced consulting company is conducting RLA for the boiler, turbine, generator, and major equipment (BOP) in order to assess aged deterioration and damage to equipment of Unit 3

in February 2012 and the report is planned to be submitted to the power station around May 2012. Subsequent procedures will be for creating and evaluating the Energy Audit Report, selecting and evaluating the R&M items, and creating DPR based on the selected R&M items. Then, bidding documents necessary for the R&M work will be created based on the DPR.

The power station plans to start R&M work for Units 4 and 5 based on the results of R&M for Unit 3.

Although the RLA report could not be obtained during this field work, planned R&M items, which were obtained from interviews, are as follows.

- R&M of Turbine (replacement of blade and up rating from 210 MW to 220 MW)
- R&M of BFP
- R&M of the CWP system (Unit 3)
- R&M of the air compressor
- Replacement of the coal pulverizer
- Replacement of IDF and PAF
- Replacement of ESP (Unit 3)

4) Review of R&M methods and the estimated costs

(a) Review of R&M methods

Since the investigation of R&M has been started by the power station, reviewing the investigation report and giving advice to the investigation results by the study team is considered useful for the power station for selection of R&M items.

(b) Estimated costs for R&M items

One of the effective efficiency improvement manners is an exchange of the turbine body. Efficiency improvements involving the exchange of the turbine body and related costs were reviewed and estimated under the following conditions.

- Applying the latest technology of streaming passage to high-, medium- and low-pressure turbines
- Replacing the high-, medium- and low-pressure rotors, nozzle diaphragm, and inner casing during the renovation
- Reusing the existing main steam valve, high-, medium- and low-pressure outer casings, generator, condenser, and feed water heaters, etc.
- Setting the main steam flow to match that of the existing design. The steam flow generated from the boiler will be the same as the current state.
- It is estimated that the heat rate will be improved by approximately 5%.
- In the renovation process, measuring the dimensions of the turbine during the regular inspection takes half a month; manufacturing the turbine 18 months; and assembly of the turbine at the actual site approximately 3 months, excluding the trial run.
- Estimated costs are approximately 2 billion yen for one turbine unit including assembly of the turbine at the actual site.

5) Economic evaluation of R&M

(a) Fuel saving by improved efficiency (ton of oil equivalent)

The estimated efficiency improvement by turbine R&M is 5%, and the heat rate after the renovation is estimated to be 2,852 kcal/kWh. The heat rate improvement of 150 kcal/kWh is estimated to be the annual fuel reduction of 49,669 toe when calculated using the generation of 3,311.3 million kWh, which corresponds to 60% of the current average PLF of the existing units (210 MW × 3). It is equivalent to 50 crore when calculated using the value of toe of the Energy Conservation Rules, 2012.

Reduction of CO_2 emission is estimated at 188,551 tCO_2.

6) Subjects to be considered

(a) The renovation is required due to the deterioration of equipment, declined calorific values of coal, and increased ash content of the coal.

(b) It is required for the coal pulverizer, ESP, ash handling system and fans to be adjusted to the specifications of the coal that is currently consumed.

(c) Proper maintenance will also be required after the R&M.

(3-3) Prioritization of R&M to replacement

Generally speaking, since the age of Units 3 to 5 is around 30 years old, R&M may be prioritized against the replacement.

Which option, R&M or replacement, is to be selected shall be decided based on a techno-economic study considering investment costs, heat rates, fuel costs and environmental aspects. For R&M, investment cost is lower while heat rate improvement, fuel cost saving and improvement in emissions are lower. For replacement, investment cost is higher while heat rate, fuel cost saving and improvement in emissions are higher. In addition, the residual value, the removal cost and the lost income caused by shut down of the existing units must also be considered in this option. Since DPR for R&M is not issued yet and there is no DPR for replacement, the study team could not get enough information for the techno-economic study.

However, the study team assumes that the Management of MSPGCL considered these factors before initiation of the R&M study funded by the World Bank for Units 3 of this power station.

Since R&M study has been conducted and DPR for R&M is now under preparation for this power station, and it takes one year and a half for preparation of DPR for replacement plan for a new 660 MW unit, the option of R&M shall be prioritized for this power station in order to actualize the project earlier.

(3-4) Outline Table for Evaluation Result of Complete Replacement and R&M

Table 4.1-4 Outline of Evaluation Results for Complete Replacement

	Item	Contents
1	Replacement plan	Although MSPGCL is not planning to construct a new 660 MW unit, the study team reviewed and created a plan to retire Units 3 to 5, demolish Units 1 to 5, and then construct a new 660 MW unit within the site.
2	Main particulars after replacement	- Rated output (MW): 660 MW - Unit Heat Rate (at PLF: 85%): 2, 130 kcal/kWh - PLF: 85%
3	Review of factors associated with replacement	- Site: Acquisition of a new site is not necessary. The GIS system will be adopted for the switchyard since it can save space. As the site for the switchyard is owned by MSETCL, the state electricity transmission company, it is necessary to obtain approval from MSETCL. - Coal supply: The power generating capacity of the new unit will increase, and it is necessary to request an additional coal linkage for the increased capacity to Standing Linkage Committee. - Raw water supply (for cooling water, etc.): It is necessary to obtain approval from the state government for securing the quantity of water intake. - Transmission line: It is necessary to consider an expansion of the 400 kV switchyard facilities. - Ash pond: Extending the life of the ash pond should be considered. - Licenses: It is necessary to obtain licenses for new unit construction from the state government and authorities - Financial situation: MSPGCL has been making stable profits for at least the past five years.
4	Economic benefits of replacement	- The unit heat rate after replacement was assumed to be 2,130 kcal/kWh, which is equivalent to that of Unit 6 of Bhusawal power station. - The efficiency will be improved by 29%. - The heat rate improvement of 872 kcal/kWh is estimated to be an annual fuel reduction of 288,744 toe when calculated using the generation of 3,311.3 million kWh, which corresponds to 60% of the current average PLF of the existing Units 3 to 5 (210 MW × 3).
5	Reduction of CO_2 emission	- 1,096,111 tCO_2
6	Budgetary scale	- Costs for removing the existing units: 12 crore - Costs for constructing the new unit: 3,498 crore (IDC excluded)
7	Organizational structure for implementation (Executing agency)	- MSPGCL
8	Environmental and social impact	- It is considered that the new unit will pose fewer problems to the environment or the society because it will be constructed at the site of the existing units, it will be highly efficient and it will release reduced emissions even considering the increased generating capacity. - It is also expected to create new employment and business opportunities for the local economy.

	Item	Contents
9	Subjects to be considered	- Because the current dust emission does not observe the limit of 100 mg/Nm3, it needs to comply with the regulations after replacement. - The liner has not been installed at the bottom of the ash pond, and thus monitoring of water quality at wells close to the ash pond will be required because there are concerns that water may penetrate from the ash pond may contaminate the underground water. - Planning and implementation of training programs for operating a supercritical pressure steam power unit is required because the power station staff have no experience in operating a supercritical pressure steam power unit.

Table 4.1-5 Outline of Evaluation Results for R&M

	Item	Contents
1	R&M process	- Study for RLA (RLA was conducted in February 2012) - Preparation of Energy Audit Report - Selecting the R&M items - Preparation of DPR based on the selected R&M items - Preparation of bidding documents for the R&M work - Bidding and implementation of R&M works
2	The status of maintenance and major failures and problems in the past	- The major incident was boiler tube leakage.
3	Planned R&M items	- R&M of turbine (replacement with new type of blade and up rating from 210 MW to 220 MW) - R&M of BFP - R&M of the CWP system (Unit 3) - R&M of the air compressor - Replacement of the coal pulverizer - Replacement of IDF and PAF - Replacement of ESP (Unit 3)
4	Review of R&M methods and the estimated costs	- The study team investigated R&M activities of the station, reviewed existing investigation reports and offered advice which is considered useful for the station side in selecting R&M items based on the investigation results of the study. - Estimated costs for R&M items: Turbine replacement * Applying the latest technology of streaming passage to HP, IP and LP turbines * Replacing the HP, IP and LP rotors, nozzle diaphragms, and inner casings during the renovation * Reusing the existing equipment * It is estimated that the heat ratio could be improved by approximately 5%. * Measuring the dimension of the turbine takes 0.5 month, manufacturing the turbine 18 months, and assembly of the turbine at the actual site approximately 3 months. * Estimated costs are approximately 2 billion yen.

	Item	Contents
5	Economic evaluation of R&M	- The estimated efficiency improvement is 5% and the heat rate after the renovation is estimated to be 2,852 kcal/kWh. The heat rate improvement of 150 kcal/kWh is estimated to be the fuel reduction of 49,669 toe per year when calculated using the generation of 3,311.3 million kWh, which corresponds to 60% of the current average PLF of 60% of the existing units (210 MW × 3).
6	Reduction of CO_2 emission	- 188,551 tCO_2.
7	Subjects to be considered	- The renovation is required due to the deterioration of equipment, declined calorific values of coal, and increased ash content of coal.

(Source: JICA Study Team)

4.2 Bhusawal Thermal Power Station Units 2 and 3 in Maharashtra

(1) Overview of Current Facilities and Operation

Bhusawal power station (Address: Bhusawal Dist, Jalgaon Deepnagar, Maharashtra 425 307, at latitude 21.048237 north and longitude 75.841563 east) is located in the north of Maharashtra, and it takes approximately three hours by car from the nearest airport, Aurangabad.

Bhusawal power station consists of the decommissioned Unit 1 (58 MW) and operating Units 2 and 3 (210 MW × 2). Additional Units 4 and 5 (500 MW × 2) are under construction at the site adjacent to Units 2 and 3.

The main specifications and operational indices of Units 2 and 3 are shown in Table 4.2-1 below.

Table 4.2-1 Plant Particulars of Bhusawal Thermal Power Station

Items	Unit 2	Unit 3
Rated Output (MW)	210	210
Commercial Operation Year	1979	1982
Boiler Manufacturer	BHEL	BHEL
Turbine Manufacturer	BHEL (LMZ)	BHEL (LMZ)
Cumulative Operation Hours (hrs) COD to end of 2011	211,501.55	204,212.16
Gross Electricity Generation (MU) per Year (2009, 2010)	2009-10:1209.1 2010-11:1167.7	2009-10: 1507.6 2010-11: 1201.4
Plant Load Factor (%)	2009-10: 65.72 2010-11: 63.47	2009-10: 81.95 2010-11: 65.31
Gross Thermal Efficiency (%)	2009: 28.69 2010: 30.41	2009: 28.88 2010: 30.52

(Source: Bhusawal Power Station, MSPGCL)

PLF = (Power Generation per year (MWh)) / (Rated Output (MW) × 24(h) × 365(d)) × 100

(2) Facilities for Replacement

1) Site for power generation facilities

The site of the power station consists of those for operating Units 2 and 3 and decommissioned Unit 1. There is a linked turbine building for Units 2 and 3. Unit 1 is planned to be demolished in the near future.

The coal storage yard is located on the back (north) of the stacks for Units 1 to 3.

The facilities of the switchyard, on the south of Units 1 to 3, are owned by MSETCL, the power transmission company but the land is owned by MSPGCL.

There is no site available for a new 660 MW unit except for the site of existing Units 1, 2 and 3 inside the power station compound.

2) Coal transportation facilities

There is a railway coal transportation facility. Coal consumption was 2.3 million tons in 2010 and the receiving capacity of coal is 10,000 tons per day.

3) Fuel supply

The power station uses domestic coal (raw coal and washed coal) and imported coal. The price of imported coal increased to 7,535 Rs/t since November 2011. PLF and the output are constrained because the power station receives lower calorie and higher ash content coal compared with the design coal.

4) Ash pond

The ash pond has an area of 200 ha and receives ash from Units 2 and 3 now. It is assumed that the present ash pond will be filled up by 2018 since increased ash from Units 4 to 6 will be transported to the pond. Therefore, there is a plan to raise the dike of the pond to extend its life. In addition, fly ash utilization will be enhanced from current 70% to 100% by 2014.

The PH and the turbidity of the ash water from the ash pond are measured once a month and the measured values are summarized in the monthly report to CEA. The ash water is partially re-used and will be fully re-used as ash recycling water. The remaining ash water not re-used now is discharged to the small stream.

No liners or other components are installed at the bottom of the ash pond to prevent water penetration from the ash pond to the underground.

5) Raw water supply (cooling water, etc.)

Raw water necessary for the power station is taken from the Tapi reservoir located close to the power station. The water is mainly used as makeup water for the cooling towers.

6) Waste water

Waste water from the power station is transferred to the effluent treatment plant and then to the slurry pit after treatment to be used as slurry water.

7) Transmission lines

The transmission lines and the switchyard facilities are owned by MSETCL, the power transmission company. The transmission voltage of Units 2 and 3 is 132 kV.

8) Access conditions for heavy load equipment

Bhusawal power station has witnessed the transportation of heavy load equipment for 500 MW units which are currently under construction.

9) New project

There is a plan to construct a new 660 MW unit at the site adjacent to Units 4 and 5 (500 MW × 2). DPR for the new unit is under preparation.

10) Environmental regulations and social considerations

Major environmental regulations are as follows.

Criteria and current conditions of flue gas at stack outlets, waste water, and noise

(a) Flue gas at stack outlets

Dust:

Parameters	Limits	Actual (Jan. 2012)
SPM (unit 2, 3)	150 mg/Nm^3	203–143
SPM (unit 4, 5)	50 mg/Nm^3	–
*SO_2	80 t/day	17–18
*NOx	150 mg/Nm^3	139–140
* State regulation		

(Source: Bhusawal Power Station, MSPGCL)

(b) Waste water

Parameters		Limits	Actual (Jan. 2012)
Condenser Cooling	Temperature	Not exceed 5ºC of Intake	4ºC
	pH	6.50–8.50	7.5–8.5
	Cl_2	0.5 mg/l	0.0
Boiler Blowdown	Oil & Grease	20 mg/l	0.0
	Sus. Solids	100 mg/l	31–65
	Copper	1 mg/l	0.0
	Iron	1 mg/l	0.0
Cooling Tower	Cl_2	0.5 mg/l	0.0
	Zinc	1 mg/l	0.0
	Chromium	0.2 mg/l	0.0
	Phosphate	5 mg/l	0.0
Ash Pond Water	pH	6.50–8.50	7.5–8.8
	Oil & Grease	20 mg/l	0.0
	Sus. Solids	100 mg/l	19–45

(Source: Bhusawal Power Station, MSPGCL)

(c) Noise

During daytime 55 dB (at the boundary of the power station)

During nighttime 45 dB (at the boundary of the power station)

(d) Environmental monitoring

Regulatory objectives (quality of ambient air and water) required by law are measured and the environmental monitoring report containing the measured data is submitted to CEA every month.

(e) Utilization of coal ash

Coal ash from the power station is utilized at small scale brick factories (a dozen or so) in the vicinity (320 m^3/day). The power station aims at achieving the target set by the Ministry of Environment and Forestry in November 2009 (utilization of fly ash shall be 100% by 2014 for coal/lignite thermal power stations in operation at that time or by 4 years after COD in the case of new power station after that time).

(f) Problems concerning the social circumstances

SPM of flue gas at stack outlets does not comply with the regulations (150 mg/Nm^3) for Unit 2. Efforts to reduce SPM emission were made by applying ammonia injection system at Unit 3 in 2005 resulted in compliance with the regulation. The said system will be introduced to Unit 2 by December 2012.

11) Operation and maintenance

The operation and maintenance system is organized and managed by operation manager and maintenance manager who directly report to Chief Engineer of the power station. The power station operators are divided into five groups (seven operators in one group) and work three shifts a day. The station has several groups in charge of administration, new project (500 MW), and engineering (Operation, Coal handling, Ash handling, Mechanical, Electrical, and Civil Engineering).

In order to evaluate the capability of operation and maintenance, the study team confirmed operation manuals and maintenance manuals were properly prepared. Spare parts are controlled using the integrated software of enterprise resource planning (ERP). The power station has ISO 9001, ISO 14000 and OSHA certifications.

12) Training program

Training system is already established. Training period for operators is about one year. MSPGCL has two training facilities (Koradi training center and Nasik training center), including operation simulators. Operators are trained at the training center for about 22 weeks.

Each of MSPGCL's power stations has a sub training center and, especially, that of Bhusawal power station was highly ranked by both the state and CEA. Newly hired engineers receive 52 weeks of training including training at the training center.

(3) Evaluation

1) Replacement plan

MSPGCL originally planned to build a new 660 MW unit on the site where Unit 1 was demolished. However, because of insufficient area for the construction, MSPGCL changed the

plan to build it on the site adjacent to Units 4 and 5, which are currently under construction. The study team estimated a plan to retire Units 2 and 3, demolish Units 2 and 3 and construct a new 660 MW unit within the area for the facilities of Units 1 to 3 as well as the switchyard were removed. The estimated demolition work period is two years based on experience in Japan.

2) Replacement method

(a) Plot the removal site in consideration of work safety.

(b) Dismantle buildings and equipment, such as tanks.

(c) Excavate and remove the concrete mats of the unit bases to clear the site. The existing bearing piles in the ground will not be removed during the removal work and the layout of such bearing piles should be taken into account in the foundation design for the new unit. Nevertheless, if some existing bearing piles interfere with new piles actually in spite of prior evasion by designing, such piles should be broken down by drilling of new piles without excavation/removal in a separate work process.

(d) After the existing units are removed, implement the replacement work according to the drawings and specifications.

3) Main particulars after replacement

The main particulars after replacement are shown as Table 4.2-2 based on the collected data.

Table 4.2-2 Plant Particulars of Bhusawal 660 MW

Items	New Unit
Rated Output (MW)	660
Boiler	Supercritical pressure, once-through, Reheat type.
Turbine	Tandem compound single reheat condensing turbine
Steam Conditions at Turbine HP inlet at Turbine IP inlet	 247 kg/cm^2 563ºC 40 kg/cm^2 593ºC
Plant Load Factor	85%
Unit Heat Rate (Unit Heat Rate at 85% PLF)	2,130 kcal/kWh

(Source: Bhusawal Power Station, MSPGCL)

4) Review of factors associated with replacement

(a) Site

The sites where Units 1 to 3 and the switchyard currently stand will be used after these facilities are removed. Acquisition of new sites is not required. A natural draft cooling tower (NDCT) (approx. 150 m in diameter) will be installed at the site on which the existing cooling tower stands. The GIS switchyard will be adopted because it can save space.

As the switchyard is owned by MSETCL, the power transmission company, it is necessary to obtain approval from MSETCL. (See Attachment-2)

(b) Coal supply

The new unit will take over the coal linkage allocated to Units 2 and 3 (210 MW × 2) at present. However, since the power generating capacity of the new unit increases, it will be necessary to make a request to Standing Linkage Committee for an additional coal linkage for the increased capacity.

In addition, railroad transportation capacity from coal mines to the power station should be confirmed.

(c) Raw water supply (for cooling water, etc.)

Water for Units 2 and 3 currently in use has been secured. However, it is necessary to obtain approval from the state government to take water from the Tapi reservoir.

(d) Transmission lines

It is necessary to consider an expansion of the 400 kV switchyard facilities and the transmission lines by involving MSETCL.

(e) Ash pond

Since the existing ash pond will be shared by the new unit, extending the life of the ash pond should be considered. Liners have not been installed at the bottom of the existing ash pond. Therefore, the monitoring of well water close to the ash pond is recommended because there are concerns that water penetration from the ash pond to the underground may contaminate underground water. Further, the liner for preventing water penetration from the ash pond to the underground should be provided at newly built ash ponds.

(f) License

It is necessary to obtain licenses relevant to the environment, aircraft obstruction, and new unit construction from the state government.

(g) Financial situation

MSPGCL has been making stable profits for at least the past five years, and no specific problems have occurred in repayment of the loan.

5) Economic benefits of replacement

(a) Fuel saving by improved efficiency (ton of oil equivalent)

The efficiency particulars of the existing units are as follows.

Table 4.2-3 Bhusawal Unit 2, 3 Fundamental Data for April 2011–February 2012

Generation	2,074.5 Million kWh
Heat rate	2,805 kcal/kWh
Auxiliary power consumption	11.17%
Coal GCV	2,937 kcal/kg
Coal price	2,633 Rs/MT
Specific Coal Consumption	0.94 kg/kWh

(Source: Bhusawal Power Station, MSPGCL)

According to DPR, which is now under development by MSPGCL, the unit heat rate is 2,130 kcal/kWh. The efficiency will be improved by 24%. The heat rate improvement of 675 kcal/kWh is estimated to be an annual fuel reduction of 161,425 toe when calculated using the generation of 2391.5 million kWh, which corresponds to 65% of the current average PLF of the existing Units 2 and 3 (210 MW × 2). It is equivalent to 164 crore when converted by the toe value specified by the Energy Conservation Rules 2012.
Reduction of CO_2 emission is estimated at 612,792 tCO_2.

(b) Increase in electricity supply by reduced forced outage of units (MWh)

The average forced outage rate of Units 2 and 3 for the past five years was 4.6%. The forced outage rate after replacement is estimated to be 3%. The increased power supply by replacement will be 92,505 MWh (660 MW × 8760 hrs × (4.6%–3%)).

(c) Increase in electricity supply by reduced auxiliary power consumption

The auxiliary power consumption rate was 11.17% from April 2011 to February 2012 for Units 2 and 3. The auxiliary power consumption rate is assumed at 6.0% after the replacement. The improvement of power supply by the replacement will be expected.

6) Budgetary scale

Costs for removing the existing units	8 crore
Costs for constructing the new station	3,498 crore (IDC excluded)

Estimated land acquisition cost for a new 660 MW unit at Bhusawal power station that MSPGCL now plans to construct is 25 crore.

7) Organizational structure for implementation

In order to carry out the necessary Japanese ODA loan procedures smoothly and effectively, it is necessary to hold a project promotion meeting, the members of which consist of state electric utilities, state electricity boards, and related state departments, in order to share the necessary information. It is also necessary for the state electric utility to take on leadership as the institution responsible for its implementation.

8) Environmental and social impact

It is considered that the new unit will pose no problems to the environment or society because it will be constructed at the site of the existing units, it is highly efficient and it will release reduced emissions. It is also expected to create new employment and business opportunities for the local economy.

9) Subjects to be considered

(a) It is necessary to consult MSETCL regarding the use of the site for the switchyard. Detailed consultation will also be necessary for installing new transmission lines or using the existing lines.

(b) It is necessary to secure additional fuel (coal) and raw water for the increased output (from 420 MW to 660 MW).

(c) Licensing required for the replacement should be obtained (environment, etc).

(d) Because the current dust emission does not observe the limit of 150 mg/Nm3, it needs to comply with the regulations after replacement.

(e) Since the liner has not been installed at the bottom of the ash pond, monitoring of well water close to the ash pond is recommended because there are concerns that water may penetrate from the ash pond to the ground and contaminate underground water.

(f) Planning and implementation of training programs are required because the power station staff currently have no experience in operating a supercritical pressure steam power unit.

10) Outline table for evaluation result of complete replacement

Table 4.2-4 Outline Table for Evaluation Result of Complete Replacement

	Item	Contents
1	Replacement plan	The study team reviewed a plan to retire Units 2 and 3, demolish Units 2 and 3, and then construct a new 660 MW unit within the area from which the facilities for Units 1 to 3 as well as the switchyard are to be removed.
2	Main particulars after replacement	- Rated output (MW):660 MW - Unit Heat Rate (at PLF: 85%): 2,130 kcal/kWh - PLF: 85%
3	Review of factors associated with replacement and Subjects to be considered	- Site: Acquisition of new sites is not required. The GIS system will be adopted for the switchyard because it can save space. As the site of the switchyard is owned by MSETCL, the state electricity transmission company, it is necessary to obtain approval from MSETCL. - Coal supply: The power generating capacity of the new unit will increase, and it is necessary to request an additional coal linkage for the increased capacity. - Raw water supply (for cooling water, etc.): It is necessary to obtain approval from the state government to take water from Tapi reservoir. - Transmission line: It is necessary to consider an expansion of the 400 kV switchyard facilities and the transmission lines by involving MSETCL. - Ash pond: Extending the life of the ash pond should be considered. - Licenses: It is necessary to obtain licenses relevant to the environment, aircraft obstruction, and new unit construction from the state government. - Financial situation: MSPGCL has been making stable profits for at least the past five years.
4	Economic benefits of replacement	- The unit heat rate after replacement was assumed to be 2,130 kcal/kWh. - The efficiency will be improved by 24%. - The heat rate improvement of 675 kcal/kWh is estimated to be an annual fuel reduction of 161,425 toe when calculated using the generation of 2,391.5 million kWh, which corresponds to 65% of the current average PLF of the existing Units 2 and 3 (210 MW × 2).
5	Reduction of CO_2 emission	- 612,792 tCO_2
6	Budgetary scale	- Costs for removing the existing units: 8 crore - Costs for constructing the new station: 3,498 crore (IDC excluded)

	Item	Contents
7	Organizational structure for implementation (Executing agency)	- MSPGCL
8	Environmental and social impact	- It is considered that the new unit will pose minimal problem to the environment or the society because it will be constructed at the site of the existing units, it is highly efficient and it will release reduced emissions especially in terms of dust. - It is also expected to create new employment and business opportunities for the local economy.
9	Subjects to be considered	- Because the current dust emission does not observe the limit of 150 mg/Nm3, it needs to comply with the regulations after replacement. - The liner has not been installed at the bottom of the ash pond, and thus monitoring of water quality at wells close to the ash pond will be required because there are concerns that water may penetrate from the ash pond may contaminate the underground water. - Planning and implementation of training programs for operating a supercritical pressure steam power unit is required because the power station staff have no experience in operating a supercritical pressure steam power unit.

(Source: JICA Study Team)

4.3 Satpura Thermal Power Station Units 1 to 5 in Madhya Pradesh

(1) Overview of Current Facilities and Operation

Satpura power station (Address: Sarni, District: Betul, Madhya Pradesh, at latitude 22.111128 north and longitude 78.174591 east) is located in the southeast of the State of Madhya Pradesh, and it takes about six hours by car from the nearest airport, Jabalpur.

Satpura power station consists of Units 1 to 5 (62.5 MW × 5) called Power House 1 (PH-1), Units 6 and 7 (200 MW × 1, 210 MW × 1) called PH-2, and Units 8 and 9 (210 MW × 2) called PH-3. Currently, Units 10 and 11 (250 MW × 2) are under construction at the site adjacent to Unit 9. The commercial operation of Unit 10 is scheduled to start in December 2012, and that of Unit 11 in April 2013.

The main specifications and operational indices of PH-1 (Units 1 to 5) are shown in Table 4.3-1 below.

Table 4.3-1 Plant Particulars of Satpura Thermal Power Station

Items	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
Rated Output (MW)	62.5	62.5	62.5	62.5	62.5
Commercial Operation Year	1967	1968	1968	1968	1970
Boiler Manufacturer	B&W London	B&W London	B&W London	B&W London	B&W London
Turbine Manufacturer	GE	GE	GE	GE	GE
Cumulative Operation Hours (hrs) COD to end of 2011	293,798	295,758	285,212	286,179	278,986
Gross Electricity Generation (MU) per Year (2009, 2010)	2009:1,798.4 2010:1,761.1				
Plant Load Factor (%)	2009: 63.70 2010: 66.57	2009:65.08 2010:60.39	2009:67.46 2010:64.92	2009:65.45 2010:65.45	2009: 67.40 2010: 64.33
Gross Thermal Efficiency (%)	2009: 25.55 2010: 24.50	2009:24.18 2010.24.45	2009:23.38 2010:23.87	2009:23.01 2010:24.66	2009: 24.22 2010: 23.57

(Source: Satpura Power Station, MPPGCL)

PLF = (Power Generation per year (MWh)) / (Rated Output (MW) × 24(h) × 365(d)) × 100

(2) Facilities for Replacement

1) Site for power generation facilities

The site for the power station consists of PH-1 (Units 1 to 5), PH-2 (Units 6 and 7) and PH-3 (Units 8 and 9).

The coal storage yard is located approximately 1 km west of the power generation facilities.

According to MPPGCL's plan, after COD of Units 10 and 11 (250 MW × 2) which are currently under construction, PH-1generation facilities will stop their operations and will be demolished. Thereafter, a 660 MW unit will be constructed at the dismantled site.

There is no site available for a new 660 MW unit except for the site of the existing units of PH-1.

2) Coal transportation facilities

At PH-1, coal is directly transported from the mines by belt conveyor and by truck.

In addition, coal consumption at PH-1 was approx. 1.8 million tons in 2010 and 2011, and is currently receiving domestic coal (raw coal) at a rate of 6,500 tons per day.

3) Fuel supply

At present, there is a stable supply of coal from seven coal mines. Mining will start at two additional mines in the near future.

4) Ash pond

The ash pond has an area of 372 ha for the existing facilities (PH-1, 2, 3). The discharge water from the ash pond (ash water) is measured everyday in terms of PH and turbidity, and data is collected for reporting as a monthly average. Part of the ash water is reused for ash handling.

No liners are provided at the bottom of the ash pond to prevent water penetration from the existing ash pond to the underground.

There are two ash ponds, now under construction. One is 111 ha ash pond for PH-1, 2 and 3 and the other 130 ha for PH-4 (250 MW × 2). Bottom ash from the 660 MW unit will be dumped to the 111 ha ash pond, while fly ash is to be disposed to either the 111 ha or the 130 ha ash ponds.

The 130 ha ash pond is designed to prevent water penetration to the underground with HDPE (high density polyethylene) liner placed on the bottom. National Environment Research Institute, Nagapur is now studying the necessity of installing a liner in the 111 ha ash pond. The liner will be installed if it is recommended by the Institute. AWRS (ash water recycle system) is also planned to be installed at the two ash ponds so that the ash water can be recycled for ash handling.

5) Raw water supply (cooling water, etc.)
Raw water is supplied from the Satpura reservoir located near the power station. The water taken from the reservoir is used mainly for condenser cooling, and then returned back to the reservoir (a once-through system). The same system is also applied to PH-2 and PH-3. PH-4 adopts the natural draft cooling tower system.

6) Waste water
Waste water from the power station is sent to the neutralization plant to keep PH between 6.5 and 8.2, and then to the slurry pit for ash handling slurry water.

7) Transmission lines
While the switchyard facilities are owned by MPPGCL, the power generation company, the transmission lines outside of the switchyard is owned by MPPTCL, the power transmission company. Electric power from PH-1 (Power House 1) is transmitted from the 220 kV switchyard. The existing adjacent 400 kV switchyard has a tie line with the said 200 kV switchyard.

8) Access condition for heavy load equipment
Satpura power station has witnessed the transportation of heavy load equipment for 210 MW units in the past. Currently, construction work for PH-4 (250 MW x 2) is ongoing on the site adjacent to PH-3, and heavy load equipment is being transported to the construction area.

9) New project
A power house of 250 MW × 2 (PH-4) is now under construction on the site adjacent to PH-3. MPPGCL is planning to replace PH-1 with a 660 MW unit, and the draft DPR has already been created.

10) Environmental regulations and social considerations
Major environmental regulations are as follows:

Criteria and current conditions of flue gas at stack outlets, waste water and noise

(a) Flue gas at stack outlets

Dust:

Parameters	Limits	Actual (Jan. 2012)
SPM (unit 1 to 9)	150 mg/Nm^3	142–482
SPM (unit 10, 11)	50 mg/Nm^3	–
SPM (planned 660 MW)	50 mg/Nm^3	–
SO_2	–	–
NOx	–	–

(Source: Satpura Power Station, MPPGCL)

(b) Waste water

Parameters		Limits	Actual (Jan. 2012)
Condenser Cooling	Temperature	Not exceed 5ºC of Intake	34ºC return
	pH	6.50–8.50	8.2
	Cl_2	0.5 mg/l	–
Boiler Blowdown	Oil & Grease	20 mg/l	0.0
	Sus. Solids	100 mg/l	–
	Copper	1 mg/l	< 0.005
	Iron	1 mg/l	< 0.01
Cooling Tower	Cl_2	0.5 mg/l	–
	Zinc	1 mg/l	–
	Chromium	0.2 mg/l	–
	Phosphate	5 mg/l	–
Ash Pond Effluents	pH	6.50–8.50	8.8
	Oil & Grease	20 mg/l	–
	Sus. Solids	100 mg/l	< 100

(Source: Satpura Power Station, MPPGCL)

(c) Noise

85 dB (1 m from machine)

(d) Environmental monitoring

Regulatory objectives (quality of ambient air and water) required by law are measured and the environmental monitoring report containing the measured data is submitted to CEA every month (for SO_2 and NOx, no measurements are taken due to the low content of Sulfur and Nitrogen in the domestic coal used).

(e) Utilization of coal ash

The percentage of utilization of coal ash is about 25%. The power station aims at achieving the target set by the Ministry of Environment and Forestry in November 2009 (utilization of fly ash shall be 100% by 2014 for coal/lignite thermal power stations in operation at that time or by 4 years after COD in the case of new power station after that time).

(f) Problems concerning the social circumstances

The SPM emission at stack outlet is on the same level of the limit of 150 mg/Nm^3. The emissions at PH-2 greatly exceed the limit.

11) Operation and maintenance

The operation and maintenance system is organized. The operation and maintenance engineering groups directly report to Additional Chief Engineer (O&M)-I and Chief Engineer of the power station. The power station operators are divided in four groups (15 operators in one group) and work three shifts a day. The power station is composed of the administration section, operation section (including Coal handling, Ash handling), and maintenance section (Mechanical, Electrical, I&C).

In order to evaluate the capability of Operation and Maintenance, the study team confirmed that operation manuals are developed by themselves only for the unit startup operation (Cold start and Hot start). The procedures submitted by OEM are used as the other Operation & Maintenance manuals.

In addition, ISO 9001 and ISO 14000 certifications have not been obtained.

12) Training program

An introductory training course is provided for new employees, but there are no established training programs for later phases. Operators are trained mainly through OJT (On the Job Training).

(3) Evaluation

1) Replacement plan

MPPGCL is planning to retire and demolish the power generation facilities of PH-1 after the commercial operation of Units 10 and 11 (250 MW × 2), which are now under construction, has commenced, and then build a 660 MW unit within the site from which the existing facilities are to be removed. The study team has also reviewed the same plan. The estimated removal period is 1 year and a half, based on experience in Japan.

2) Replacement method

(a) Plot the removal site in consideration of work safety.
(b) Dismantle buildings and equipment, such as tanks
(c) Excavate and remove the concrete mats of the unit base to clear the site. The existing bearing piles in the ground will not be removed during the removal work and the layout of such bearing piles should be taken into account in the foundation design for the new unit. Nevertheless, if some existing bearing piles interfere with new piles actually in spite of prior evasion by designing, such piles should be broken down by the drilling of new piles without excavation/removal in a separate work process.
(d) After the existing units are removed, the replacement work should be carried out according to the drawings and specifications.

3) Main particulars after replacement

The main particulars after replacement are shown in Table 4.3-2 based on the draft DPR:

Table 4.3-2 Plant Particulars of Satpura 660 MW

Items	New Unit	
Rated Output (MW)	660	
Boiler	Supercritical pressure, once-through, Reheat type.	
Turbine	Tandem compound single reheat condensing turbine	
Steam Conditions at Turbine HP inlet at Turbine IP inlet	 240 kg/cm^2 45.54 kg/cm^2	 565ºC 592.8 ºC
Plant Load Factor	85%	
Unit Heat Rate (Unit Heat Rate at 85% PLF)	2,317kcal/kWh	

(Source: Satpura Power Station, MPPGCL)

4) Review of factors associated with replacement

(a) Site

The sites where the power generation facilities of PH-1 and the switchyard currently stand will be used after the facilities are removed. Acquisition of new sites is not required. A natural draft cooling tower (NDCT) (approx. 150 m in diameter) will be installed at the site in front of the switchyard for the existing PH-2. The GIS switchyard will be adopted since it can save space. Replacement work for the cooling water piping of the existing facilities of PH-2 and -3 may be required. (see Attachment-3)

(b) Coal supply

The new unit will take over the coal linkage allocated to PH-1 (62.5 MW × 5) at present. However, since the power generating capacity of the new unit increases to 660 MW, it will be necessary to increase the capacity of coal storage facilities and additional coal linkage should be secured. The draft DPR also indicates a need to make new allocations of coal supplies (Coal Linkage). The Coal Linkage is applied through CEA and MoP to Standing Linkage Committee (Long Term) chaired by the Additional Secretary in the Ministry of Coal. Based on the authorization/recommendations of SLC (LT), Coal India Limited (CIL) and/or the concerned coal companies issue a Letter of Assurance.

In addition, the railroad transportation capacity from the coal mines to the power station should be confirmed.

(c) Raw water supply (cooling water, etc.)

Water amount for PH-1 is now secured. However, due to the increased power generation capacity, an agreement must be obtained from the state government to take additional water from Satpura Reservoir.

According to the draft DPR, the water volume to be taken from Satpura Reservoir for a 660 MW unit is approximately 1,800 t/h.

(d) Transmission lines
The addition of yard facilities of 400 kV and transmission lines should be investigated jointly with MPPTCL, the power transmission company.

(e) Ash pond
A newly installed ash pond (shared among PH-1, PH-2 and PH-3; 111 ha) will be used for disposal of bottom ash from the 660 MW unit. Fly ash from the unit will be disposed to either the 111 ha ash pond or the 130 ha ash pond.
Liner is planned to be provided to the 130 ha ash pond to prevent water penetration from the ash pond to the underground, while National Environmental Research Institute is now studying the necessity to install a liner to the 130 ha ash pond.

(f) License
Environmental licenses, approvals for aircraft obstruction, and the state government's construction license for the new unit are now under preparation.

(g) Financial situation
MPPGCL has recorded losses for three fiscal years consecutively, and the accumulated loss has reached 1,299 crore.

5) Economic benefits of replacement

(a) Fuel saving by improved efficiency (ton of oil equivalent)
The efficiency particulars of the existing units are as follows.

Table 4.3-3 Satpura PH-1 (Units 1 to 5) Fundamental Data for April 2011–February 2012

Generation	1,504.7 Million kWh
Heat rate	4,046 kcal/kWh
Auxiliary power consumption	11.28%
Coal GCV	3,618 kcal/kg
Coal price	1,811 Rs/MT
Specific Coal Consumption	1.08 kg/kWh

(Source: Satpura Power Station, MPPGCL)

According to DPR developed by MPPGCL, the unit heat rate is 2,317 kcal/kWh. The efficiency will be improved by 43%. The heat rate improvement of 1,729 kcal/kWh is estimated to be an annual fuel reduction of 283,988 toe when calculated using the generation of 1,642.5 million kWh, which corresponds to 60% of the current annual PLF of the existing units PH-1 (62.5 MW × 5). It is equivalent to 288 crore according to toe value in the Energy Conservation Rules 2012.
Reduction of CO_2 emission is estimated at 1,078,059 tCO_2.

(b) Increase in power supply by reduced forced outage of units (MWh)
The forced outage rate of PH-1 for the past five years was 6.9% on average. The forced outage rate is estimated to be 3% after replacement. The increased power supply by replacement will be 225,482 MWh (660 MW × 8760 hrs × (6.9%-3%)).

(c) Increase in electricity supply by reduced auxiliary power consumption

The auxiliary power consumption rate was 11.28% from April 2011 to February 2012 for Units 1 to 5. The auxiliary power consumption rate is assumed to be 6.0% after replacement. The improvement of power supply by replacement will be expected.

6) Budgetary scale

Costs for removing the existing units	6 crore
Costs for constructing the new station	3,498 Crore (IDC excluded)

7) Organizational structure for implementation

In order to carry out the necessary Japanese ODA loan procedures smoothly and effectively, it is necessary to hold a project promotion meeting, the members of which consist of state electric utilities, state electricity boards, and related state departments, in order to share the necessary information. It is also necessary for the state electric utility to take on leadership as the institutions responsible for its implementation.

8) Environmental and social impact

It is considered that the new unit will pose no problem to the environment or society because it will be constructed at the site of the existing units, it is highly efficient and it will release reduced emissions. It is also expected to create new employment and business opportunities for the local economy.

9) Subjects to be considered

(a) Installation of new switchyard facilities or use of the existing transmission lines should be discussed in detail with MPPTCL, the power transmission company.

(b) It is necessary to secure additional fuel (coal) and raw water for the increased power output (from 312.5 MW to 660 MW).

(c) Licensing required for replacement should be obtained (environment, etc).

(d) Because the current dust emission does not observe the limit of 150 mg/Nm^3, it needs to comply with the regulations after replacement.

(e) Since there are concerns about water penetration from the existing ash pond to the underground, monitoring should be conducted on the well water near the ash pond.

(f) At present, due to no training programs established and no experience in operating the supercritical pressure power generation unit, it is especially important that a training program be developed and carried out.

(g) Financially, due to accumulated losses, countermeasures for repayment of the loan should be taken.

10) Outline table for evaluation result of complete replacement

Table 4.3-4 Outline Table for Evaluation Result of Complete Replacement

	Item	Contents
1	Replacement plan	MPPGCL is planning to retire and demolish the power generation facilities of PH-1 after the commercial operation of Units 10 and 11 (250 MW x 2) is commenced, and then construct a new 660 MW unit within the site. The study team has also reviewed the same plan.
2	Main particulars after replacement	- Rated output (MW):660 MW - Unit Heat Rate (at PLF: 85%): 2,317 kcal/kWh - PLF: 85%
3	Review of factors associated with replacement and Subjects to be considered	- Site: Acquisition of a new site is not necessary. The GIS switchyard will be adopted for the switchyard since it can save space. Replacement work may be required for cooling the water piping of the existing facilities PH-2 and PH-3 - Coal supply: It is necessary to increase the capacity of coal storage facilities and additional coal suppliers should be secured. - Raw water supply (for cooling water, etc.): It is necessary to obtain approval from the state government for securing the quantity of the water from Satpura Reservoir. - Transmission line: It is necessary to consider an expansion of the 400 kV switchyard facilities jointly with MPPTCL. - Ash pond: A newly constructed ash pond (shared among PH-1, PH-2, and PH-3; 111 ha) will be used. - License: Environmental licenses, approvals for aircraft obstruction, and a state government's construction license for the new unit are now under preparation. - Financial situation: MPPGCL has recorded losses for three fiscal years consecutively.
4	Economic benefits of replacement	- The unit heat rate after replacement was assumed to be 2,317 kcal/kWh. - The efficiency will be improved by 43%. - The heat rate improvement of 1,729 kcal/kWh is estimated to be an annual fuel reduction of 283,988 toe when calculated using the generation of 1,642.5 million kWh, which corresponds to 60% of the current.
5	Reduction of CO_2 emission	- 1,078,059 tCO_2
6	Budgetary scale	- Costs for removing the existing units: 6 crore - Costs for constructing the new station: 3,498 crore (IDC excluded)
7	Organizational structure for implementation (Executing agency)	- MPPGCL
8	Environmental and social impact	- It is considered that the new unit will pose fewer problems to the environment or the society because it will be constructed at the site of the existing units, it is highly efficient and it will release reduced emissions even considering the increased generating capacity. - It is also expected to create new employment and business opportunities for the local economy.

	Item	Contents
9	Subjects to be considered	- Because the current dust emission does not observe the limit of 150 mg/Nm3, it needs to comply with the regulations after replacement. - Monitoring of water quality of wells close to the ash pond will be required when the existing ash ponds are used for the 660 MW unit because the liner has not been installed at the bottom of existing ash ponds. - Planning and implementation of training programs for operating a supercritical pressure steam power unit is required because the power station staff have no experience in operating a supercritical pressure steam power unit. - Improvement of financial situation of MPPGCL is required to realize the project with new loans.

(Source: JICA Study Team)

4.4 Obra Thermal Power Station Units 1 to 8 in Uttar Pradesh

(1) Overview of Current Facilities and Operation

Obra power station (Address:U.P. Rajya Vidyut, Utpadan Nigam Ltd. Obra, Dist. Sonebhadra, Uttar Pradesh, at latitude 24.44211 north and longitude 82.980165 east) is located in the southeast of Uttar Pradesh, and it takes about 4 hours by car from the nearest airport, Varanasi.

Obra A power station consists of Units 3 to 6 (50 MW × 3, 100 MW x 1) and Unit 8 (100 MW × 1), these are already retired, and Units 1 and 2 (50 MW × 2), and Unit 7 (100 MW × 1) currently in operation.

The main specifications and operational indices of Units 1, 2, 6, 7, and 8 are shown in Table 4.4-1 bellow.

Table 4.4-1 Plant Particulars of Obra Thermal Power Station

Items	Unit 1	Unit 2	Unit 6 (already retired)	Unit 7	Unit 8 (already retired)
Rated Output (MW)	50	50	100	100	100
Commercial Operation Year	1967	1968	1973	1974	1975
Boiler Manufacturer	USSR	USSR	BHEL	BHEL	BHEL
Turbine Manufacturer	USSR	USSR	BHEL	BHEL	BHEL
Cumulative Operation Hours (hrs) COD to end of 2011	13,935	13,985	19,572	14,645	14,541
Gross Electricity Generation (MU) per Year (2009, 2010)	2009: 1,361.3 2010: 1,243.7				
Plant Load Factor (%)	2009: Nil 2010:65.63	2009: 8.46 2010:69.18	2009: 66.15 2010: 49.37	2009: 37.47 2010: 32.26	2009: 34.57 2010: 11.99
Gross Thermal Efficiency (%)	2009: 26.67 2010: 27.57				

(Source: Obra Power Station, UPRVUNL)

PLF = (Power Generation per year (MWh)) / (Rated Output (MW) × 24(h) × 365(d)) × 100

(2) Facilities for Replacement

1) Site for power generation facilities

The site of the power station consists of those for Obra A (Units 1 to 8) and Obra B (Units 9 to 13). There is a linked turbine building for Obra A and B.

The coal storage yard is located on the south east side behind the stacks of Obra A, which can be connected to the coal stock yard for Obra B in emergency. Further to the southeast, there is a railway for transporting coal.

The facilities of switchyard and its land on the northeast side of Obra A are owned by UPRVUNL.

There is no site available for a new 660 MW unit except for the site of existing units inside the power station compound.

2) Coal transportation facilities

There is a railway coal transportation facility. The annual coal receiving amount is approximately 5 million tons for Obra A and Obra B. the total coal consumption at Obra A is approximately 1.2 million tons in 2010-11.

3) Fuel supply

Obra A power station mainly uses domestic coal (raw coal) available in the surrounding area, and thus has a stable supply.

4) Ash pond

The ash pond has an area of 75 ha. Land preparation was minimized by developing the ash pond utilizing the natural terrain. Bottom ash from Obra A and B is transferred to the ash pond as slurry. Before the pond is filled up, the existing dike will be raised to provide capacity for 25 to 30 years (for Obra A and B).

Currently, an AWRS (Ash Water Recycle System) is under construction with expected completion in 6 months. Once completed, the ash treatment water will be used for recycling. Currently, discharge water from the ash pond (ash water) is treated through sedimentation before release into the nearby river. The discharge water from the ash pond (ash water) is measured once a month to monitor oil content, pH and turbidity.

The existing ash pond has a clay layer at the bottom to prevent penetration of ash water.

5) Raw water supply system (cooling water, etc)

Raw water is supplied from the Obra Dam located close to the power station. The water from the dam is mainly used for condenser cooling, and then returned to the dam (a once-through system). Obra B uses the same system.

6) Waste water

Waste water from the power station is released directly to the nearby river without treatment.

Currently, an effluent treatment plant is under construction, with expected completion in 6 months. After completion, waste water will be released after treatment.

7) Transmission lines

While the switchyard facilities are owned by UPRVUNL, the power generation company, the transmission lines are owned by UPPTCL, the power transmission company. The electric power from Obra A is transmitted from the 220 kV switchyard and that from Obra B from the 400 kV switchyard.

8) Access condition for heavy load equipment

Obra power station has witnessed the transportation of heavy load equipment for 200 MW units while the main road before branching out toward Rihand near the power station has been utilised for the transportation of heavy load equipment for 500 MW to 660 MW units.

9) New project

Near the existing power station (approximately 1.5 km to the northeast), the site of Obra C plant (660 MW × 2) exists. DPR for Obra C was already prepared. The approval of the EIA Report is expected within 6 months. Land has been secured, and part of it is being leveled.

10) Environmental regulations and social considerations

Main environmental regulations are as follows.

Criteria and current conditions of flue gas at stack outlets, waste water and noise:

(a) Flue gas at smokestack outlets

Dust:

Parameters	Limits	Actual (Jan. 2012)
SPM	150 mg/Nm^3	517–560
SO_2	–	453–488mg/Nm^3
NOx	–	240–247mg/Nm^3

(Source: Obra Power Station, UPRVUNL)

(b) Waste water

Parameters		Limits	Actual (Jan. 2012)
Condenser Cooling	Temperature	Not exceed to 5ºC to Intake	9.2ºC
	pH	6.50–8.50	7.09
	Cl_2	0.5 mg/l	–
Boiler Blowdown	Oil & Grease	20 mg/l	0.0
	Sus. Solids	100 mg/l	–
	Copper	1 mg/l	–
	Iron	1 mg/l	–
Cooling Tower	Cl_2	0.5 mg/l	–
	Zinc	1 mg/l	–
	Chromium	0.2 mg/l	–
	Phosphate	5 mg/l	–
Ash Pond Effluents	pH	6.50–8.50	7.35
	Oil & Grease	20 mg/l	2.5
	Sus. Solids	100 mg/l	108.8

(Source: Obra Power Station, UPRVUNL)

(c) Noise
The noise limit is 90 dB (1 m from machine)

(d) Environmental monitoring
Regulatory objectives (quality of ambient air and water) required by law are measured and the environmental monitoring report containing the measured data is submitted to CEA every month.

(e) Utilization of coal ash
Currently, ash is not efficiently used (utilization is around 10% total for Obra A and B) and the majority is disposed of in the ash pond. The power station aims at achieving the target set by the Ministry of Environment and Forestry in November 2009 (utilization of fly ash shall be 100% by 2014 for coal/lignite thermal power stations in operation at that time or by 4 years after COD in the case of new power station after that time).

(f) Problems concerning the social circumstances
The SPM emission exceeds the standards at the stack outlet. The SPM emissions are higher at Obra B and they exceeded 6,000 mg/Nm^3 at the stack outlet of Units 10, 12, and 13. ESP of Unit 11 is under R&M and ESPs of Units 10, 12 and 13 are planned to use R&M for reducing dust in accordance with the instruction of the state Pollution Control Board. The EIA report for Obra C describes the total amount of dust emissions of Obra A, B and C.

11) Operation and maintenance

The operation and maintenance system is managed by the engineering department, which is divided into an operation group, a maintenance group and a material management group. The power station operators are divided into four groups (seven personnel per group) and work in three shifts a day. The maintenance group is further divided into boiler/turbine, electrical, instrumentation, and material management sub-groups. The power station has an engineering department, an R&M department (including coal handling) and an administration department.

In order to evaluate the operation and maintenance capability, operation and maintenance manuals have been confirmed, while maintenance manuals are yet to be confirmed. Spare parts are managed (not by software). ISO 9001, ISO 14000 and OSHA certifications are obtained at head office but not yet at the power station.

12) Training program

The training system is already established by the company. The training period for operation and maintenance staff is about one year. Training facilities, including a simple simulator system, are installed in the power station area. The training program consists of lectures, manufacturer training, and simulator training at the power station and at NTPC facility.

(3) Evaluation

1) Replacement plan

UPRVUNL implemented major R&M for Obra Units 1 and 2 in 2009, resulting in an extended remaining life of 15 years. R&M for Unit 7 is now underway, with an expected life expansion of 5 more years. UPRVUNL expressed the opinion that decommissioning and replacing Obra A at this point is not appropriate considering the tight power demand in U.P. as well as the remaining life of Units 1, 2 and 7.

It was also confirmed that there is not sufficient space (particularly in the longitudinal direction from the turbine building to the stack) in order to remove the already-retired Units 3 to 6 and replace them with a new 660 MW unit.

Therefore, UPRVUNL suggested that the best option was to construct the newly-planned Obra C (660 MW × 2) and then decommissioned Obra A units when their lives expired. In this context, UPRVUNL requested the study team to include Obra C as a study target.

Based on the above considerations, the study team considered the construction of a 660 MW unit at a new site (Obra C site) near the existing power plant for the replacement instead of considering two units of 660 MW in order to keep consistency of the study for the other target power stations/units. This plan to develop a new power station close to the existing power station of Obra A and B is regarded as a form of replacement, as existing resources such as raw water, coal linkage and ash pond can be utilized for the new power station, with the exception of the land itself.

2) Replacement method

It is not necessary to dismantle existing units, since, in contrast to the typical replacement of old power units, a new 660 MW unit will be constructed at a new site. However, the existing Obra A resources can be utilized. Since the new construction will take place when the power station is still in operation, special attention is necessary when switching the cooling water systems.

3) Main particulars after replacement

The main particulars after replacement are shown in Table 4.4-2 below based on the collected data.

Table 4.4-2 Plant Particulars of Obra 660 MW

Items	New Unit
Rated Output (MW)	660
Boiler	Supercritical pressure, once-through, Reheat type.
Turbine	Tandem compound single reheat condensing turbine
Steam Conditions at Turbine HP inlet at Turbine IP inlet	247 kg/cm^2 540ºC 565ºC
Plant Load Factor	90%*
Unit Heat Rate (Unit Heat Rate at 85% PLF)	2,380 kcal/kWh *

(*CERC operative norms base)

(Source: Obra Power Station, UPRVUNL)

4) Review of factors associated with replacement

(a) Site

Land is already secured for construction of a 660 MW unit at Obra C site. Part of it is currently being leveled. (See Attachment 4) Actually the necessary land for two 660 MW units has been already secured by UPRVUNL.

(b) Coal supply

New coal handling facilities will be installed. Obra C has two dedicated coal mines and they will supply 10 million tones of coal per year, more than the coal requirement for a 660 MW unit and sufficient for two 660 MW units. Railway transportation capacity from the coal mine to the power station must be checked.

(c) Raw water supply system (cooling water, etc)

The necessary amount of raw water for Obra C is able to be taken from Obra Dam separately from Obra A and B, and this has been agreed on by the state government.

(d) Transmission lines

The plan for power transmission of Obra C is to install new 400 kV transmission facilities. The transmission lines will be designed and be constructed by the state electricity transmission company (UPPTCL).

(e) Ash pond

The existing ash pond will be shared. Therefore the remaining life of the ash pond needs to be reassessed. Raising the level of the dike to extend the service life is possible. Although there is no liner to prevent water penetration from the ash pond to the underground, a clay layer at the bottom of the ash pond could prevent penetration.

(f) License

Licences for environment, aircraft obstruction, and new power station construction have already been obtained from the state government for Obra C. The approval of EIA Report is expected within 6 months.

(g) Financial situation

UPRVUNL has posted a cumulative loss of 454 crore while the current profit has been made in the last 3 months.

5) Economic effects of replacement

(a) Effect of fuel reduction due to improved efficiency (ton of oil equivalent)

The efficiency particulars of the existing facilities are as follows.

Table 4.4-3 Obra A (Units 1, 2 & 7) Fundamental Data for April 2011–February 2012

Generation	586.7 Million kWh
Heat rate	3,417 kcal/kWh
Auxiliary power consumption	19.12%
Coal GCV	3,128 kcal/kg
Coal price (2010–2011)	1,503 Rs/MT
Specific Coal Consumption	0.95 kg/kWh

(Source: Obra Power Station, UPRVUNL)

The heat rate specified in the DPR drafted by UPRVUNL in 2009 was 2,380 kcal/kWh and the efficiency will be improved by 30%. The heat rate improvement of 1,037 kcal/kWh is estimated to be an annual fuel reduction of 109,009 toe when calculated using the generation of 1,051.2 million kWh, which corresponds to 60% of the current annual PLF of the existing facilities (50 MW × 2 + 100 MW). It is equivalent to 111 crore according to the toe value in the Energy Conservation Rules 2012.

Reduction of CO_2 emission is estimated at 413,815 tCO_2.

(b) Increased generation by reduced forced outage of units

The average forced outage of Obra A (Units 1, 2, and 7) in the past 2 years was 10.9%. The forced outage rate after replacement is assumed to be 3%. The increased power supply will be 456,746 MWh (660 MW x 8760 hrs x (10.9%-3%)).

(c) Increase in electricity supply by reduced auxiliary power consumption

The auxiliary power consumption rate was 19.12% from April 2011 to February 2012 for Units 1, 2 and 7. The auxiliary power consumption rate is assumed at 6.5% after the replacement. The improvement of power supply by the replacement will be expected.

6) Budgetary scale

Power station construction cost 3,498 crore (excluding IDC)

UPRVUNL pointed out in the meeting at their head office that placing a 660 MW unit in the Obra A site is not economically feasible due to the enormous cost required to remove the existing foundations. In addition, in the meeting with CEA on April 4, 2012, CEA asked the study team to make a comparative cost study between removal and new land cases. Therefore, the study team conducted a rough estimation and considers that the economic impact of removal of existing facilities is not significant, as the estimated removal cost is in the range of 8 crore based on experience in Japan, compared to the land acquisition cost of 44 crore estimated.

7) Organizational structure for implementation

In order to carry out the necessary Japanese ODA loan procedures smoothly and effectively, it is necessary to hold a project promotion meeting, the members of which consist of state electric utilities, state electricity board, and related state departments, to share the necessary information. It is also necessary for the state electric utility to take on leadership as the institution responsible for its implementation.

8) Environmental and social impact

The necessary land for a 660 MW unit has been secured at Obra C site adjacent to the existing power station. It is considered that the new unit will pose minimal problem to the environment or the society because it is highly efficient. It is also expected to create new employment and business opportunities for the local economy.

In view of environmental aspects, early completion of the new power generation unit with the large capacity, the succeeding shut-down of Obra A after the retirement of each unit and implementation of R&M for Obra B are recommended since the impact of Obra B on the environment in terms of dust emission is greater than that of Obra A.

9) Subjects to be considered

(a) It is necessary to consult with UPPTCL, the power transmission company, regarding the installation of a new transmission line.
(b) Because the current dust emission does not observe the limit of 150 mg/Nm^3, it needs to comply with the regulations after constructing the new facilities.
(c) The EIA clearance must be obtained.
(d) Although the existing ash pond has a clay layer at the bottom of the ash pond, it is recommended that well water near the ash pond shall be monitored to confirm no penetration occurs.
(e) Planning and implementation of training programs is required because the power station staff have no experience in operating a supercritical pressure steam power unit.
(f) Repayment measures need to be devised due to the cumulative loss in the current financial standing.

10) Outline table for evaluation result of complete replacement

Table 4.4-4 Outline Table for Evaluation Result of Complete Replacement

	Item	Contents
1	Replacement plan	UPRVUNL implemented major R&M for Obra Units 1 and 2 in 2009 resulting in an extended remaining life of 15 years. R&M for Unit 7 is now underway with expected life expansion of 5 more years. Therefore, the best option is to construct the newly-planned Obra C (660 MW × 2) and then decommission the Obra A units when their lives expire. In this context, UPRVUNL requested the study team to include Obra C in the study target. Based on the above considerations, the study team considered a plan to construct a 660 MW unit at a new site (Obra C site) near the existing power plant for replacement.
2	Main particulars after replacement	- Rated output (MW):660 MW - Unit Heat Rate (at PLF: 85%): 2,380 kcal/kWh - PLF: 90%
3	Review of factors associated with replacement and Subjects to be considered	- Site: Land was already secured for construction of two 660 MW units as Obra C. - Coal supply: Obra C has two dedicated coal mines that will supply 10 million tones of coal per year, sufficient for two units of Obra C. - Raw water supply (for cooling water, etc.): The amount of water intake from Obra dam has been agreed with the state government separately from those for Obra A and B. - Transmission line: New 400 kV transmission facilities are planned to be installed for power transmission for Obra C. - Ash pond: The existing ash pond will be shared. Therefore, the remaining life of the ash pond needs to be reassessed. - License: The approval of EIA Report is expected within 6 months. Other permits have been obtained. - Financial situation: UPRVUNL posted cumulative loss of 454 crore.
4	Economic benefits of replacement	- The heat rate specified in the DPR drafted by UPRVUNL in 2009 was 2,380 kcal/kWh and the efficiency will be improved by 30%. - The heat rate improvement of 1,037 kcal/kWh is estimated to be the annual fuel reduction of 109,009 toe when calculated using the generation of 1,051.2 million kWh, which corresponds to 60% of most recent annual PLF of the existing facilities (50 MW × 2 + 100 MW).
5	Reduction of CO_2 emission	- 413,815 tCO_2
6	Budgetary scale	- Costs for constructing the new station: 3,498 crore (IDC excluded)
7	Organizational structure for implementation (Executing agency)	- UPRVUNL

	Item	Contents
8	Environmental and social impact	- It is considered that the new unit will pose minimal problem to the environment or the society because it is highly efficient. - It is also expected to create new employment and business opportunities for the local economy. - In view of environmental aspects, early completion of the new power generation unit with the large capacity, the succeeding shut-down of Obra A after the retirement of each unit and implementation of R&M for Obra B are recommended since the impact of Obra B on the environment in terms of dust emission is greater than that of Obra A.
9	Subjects to be considered	- Because the current dust emission does not observe the limit of 150 mg/Nm^3, it needs to comply with the regulations after construction of the new unit. - Although the clay seam at the bottom of the existing ash pond seems to be a natural countermeasure for preventing penetration, monitoring water quality at wells near the ash pond is recommended in order to ensure there is no penetration. - Planning and implementation of training programs for operating a supercritical pressure steam power unit is required because the power station staff have no experience in operating a supercritical pressure steam power unit. - Repayment measures need to be devised due to the cumulative loss in the current financial standing.

(Source: JICA Study Team)

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

TABLE OF CONTENTS

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

(1) Plans for Replacement and R&M

Through this study, the study team has concluded the plans for replacement and R&M as follows.

1) MSPGCL Parli power station

   R&M for Units 3 to 5 in terms of the steam turbine, coal pulverizer and ESP shall be taken up, considering the deterioration of unit heat rate due to aging, maintenance difficulties and human safety for coal pulverisers and current emission levels of dust beyond the limit respectively. Further detailed study shall be implemented after the DPR for R&M now under preparation by MSPGCL is issued for the final decision.

2) MSPGCL Bhusawal power station

   Units 2 and 3 and the already-retired Unit 1 shall be replaced with a supercritical 660 MW unit at their present sites.

3) MPPGCL Satpura power station

   Units 1 to 5 shall be replaced by a super critical 660 MW unit at their present sites by utilizing current resources such as raw water, coal linkage and the ash pond under expansion for the other units.

4) UPRVUNL Obra A power station

   One super critical 660 MW unit shall be constructed in the Obra C site, at a new location, by utilizing current resources such as raw water for Obra A (Units 3 to 6 and 8) and the ash pond for Obra A and B. In addition, other resources of coal linkage and raw water have already been secured for two units of Obra C separately from those for Obra A. Although the allocation of utilization between the existing and new resources has not yet been decided, the construction of another super critical 660 MW unit is also feasible considering further improvement of the total economies of the project. Units 1, 2 and 7 are to be retired in succession when their extended lives by R&M expire. The resources of these units can be utilized for further developing generation capacity in the future.

(2) Issues and Measures for Promotion of the Project

Although the issues for each power station are mentioned individually in **4. Findings on the Target Power Stations/Units**, general issues, mainly for replacement, are described below. Issues for R&M are described in **4.1 (3-2)**.

1) Indian side

   (a) Transmission Capability

   Output of the target power stations will be increased by the replacement studied in this report. Therefore an enhanced capacity for the switchyard and transmission lines is

required. Bhusawal power station has its own switchyard, while those of Satpura and Obra power stations are owned by the transmission companies concerned. In addition, transmission lines for all the power stations are owned by the transmission companies concerned. Therefore, close coordination with these transmission companies regarding modification and/or expansion will be required for smooth implementation of replacement.

(b) Requirements in resources

Output will be increased with the replacement. Discussion with and endorsement by the authorities concerned are necessary in terms of additional requirements for coal and raw water. A study on the remaining life and potential life extension of the ash pond will also be necessary before discussions with the authorities concerned.

(c) Environmental aspect

- Environmental Impact Assessment report is necessary for approval by the authorities.
- Existing ash ponds have no protection sheets to prevent water penetrating to the underground soil due to their older establishment. Installation of AWRS (Ash Water Recycle System) at minimum is preferable in order to minimize the impact on the environment. If the ash pond for the proposed 660 MW unit has no protection measures for penetration, the quality of underground water shall be monitored at existing wells, if any, or at newly-constructed wells, if there are no existing wells, in order to confirm that no penetration occurs. Further, in case of the construction of a new ash pond, a protection sheet and AWRS seem to be indispensable.

(d) Financial matters

The capability to repay project loans must be carefully studied based on the financial situation of each state electric utility.

(e) Improvement of O&M performance after completion of the project

Currently there are differences in operational and maintenance status among the target power stations. It is necessary to comply with the environmental regulations and maintain reliability of the power stations through better O&M practices after completion of the project. This is the first case of an introduction of a super critical 660 MW unit in particular for all the state electric utilities. Therefore, it is necessary to prepare consistent manuals, and the development of human resources is desired through introduction of advanced technology and O&M practices. (See **5.2** below)

(f) Process for Japanese ODA loan

In case a Japanese ODA loan is applied to the project, the executing organization will be the state electric utilities. They shall prepare a Detail Project Report (DPR) and an Environmental Impact Assessment (EIA) Report, and apply for the Japanese ODA loan to state and central governments in order to expedite the request of the Japanese ODA loan from the Indian side to Japanese side by utilizing this report as a supporting article. It is assumed that it will take about two and a half years from the start of preparation of the DPR and EIA to the request for a Japanese ODA loan to the Government of Japan.

It shall also be kept in mind that, based on the estimation made by the study team, it will take about 30 months before the start of construction after the signing of the Japanese ODA loan by following the JICA Procurement Guideline (selection of consultant, preparation of bidding documents, pre-qualification, tender evaluation, and award of EPC contractor) (See Attachment 6)

2) Japanese side, for an application for a Japanese ODA loan

(a) Prioritization of projects

Projects should be prioritized because it is difficult to apply all the projects to Japanese ODA loan projects at once in terms of Japan's ODA budget allocation. The following factors shall be considered for prioritization.

- The degree of study progress of the target project by the state electric utilities
- Financial situations of the state electric utilities and state government in terms of assurance of loan repayment
- Potential users of the newly-generated electricity (whether for industrial use or for general residential use such as rural electrification)
- Eagerness of the state electric utilities and state governments to apply Japanese ODA loans

(b) Expediting of Japanese ODA loan

Early information sharing of the project among the concerned parties is necessary for the smooth transaction of the Japanese ODA loan without delay upon its request from the Indian side.

(c) Justification of Japanese ODA loan provisions

Japanese ODA loans are decided through an Exchange of Notes between the Government of India and the Government of Japan, and the Government of India guarantees the repayment of loans. However, the justification for applying Japanese ODA loans shall be checked, because the state electricity board has already been restructured and the actual lessee of the loan will be the state electric utilities.

(d) Economic evaluation of new construction and replacement

In the case of Obra, UPRVUNL planned to construct the new units on a new site due to the high cost of removal of the existing units (especially the removal cost for the foundation). However the study team found that the estimated removal cost of 8 crore and the new land acquisition cost of 44 crore were sufficiently lower at the same level than the estimated construction cost of 3,498 crore for a new unit and was not a predominant factor in the economic evaluation of the project. The same situation can be seen in the case of Bhusawal, where the estimated removal cost is 8 crore and the new land acquisition cost is 25 crore, and both are sufficiently lower than the estimated construction cost of 3,498 crore. Therefore, replacement by the removal of existing units can be a practical option considering the slightly higher cost and depending on circumstances of the difficulty of new land acquisition in India.

3) Issues on both sides

(a) Prequalification for EPC contract

This will be the first case for the state electric utilities to introduce a super critical 660 MW unit. Therefore, careful attention is necessary for the EPC contract. Proper prequalification shall be made in order to invite capable EPC contractors. The following requirements may be noted for prequalification.

- Enough experience in contracts for supercritical power units with capacities at least the equivalent of 660 MW
- Successful operation records of super critical power units endorsed by the owners
- Sufficient maintenance service for the main equipment provided in the form of the timely supply of key spare parts and immediate assistance based on manufacturing factories inside India

(b) Energy Conservation Rules, 2012

As mentioned in **2.1 (1)**, the Energy Conservation Rules, 2012, were notified on March 30th 2012 with the aim of improving the economic viability of projects through the sales of the Energy Savings Certificates associated with efficiency improvements. Although the current rules can be sufficiently applied to cases like R&M where the power station output does not change and the construction period is relatively short (several months), the following concerns may arise when they are applied to projects that take about four years, such as the construction of new power units. Consultation with MoP and with BEE (Bureau of Energy Efficiency) is necessary for the actual application of the Energy Conservation Rules, 2012, to replacement projects considering the following points.

- Although the Energy Conservation Rules stipulate that the first cycle for achieving the targets is until 2014-15, benefits cannot be obtained in this cycle because it is assumed to take about ten years (36-42 months for Japanese ODA loan agreement, 30 months for the pre-construction stage, and 48 months for the construction stage) for power stations to be replaced through Japanese ODA loans.
- The Energy Conservation Rules are applied using a three year period as a single cycle. When the target ECN&C of the fourth cycle, during which benefits can be obtained, is set based on the baseline ECN&C of the third cycle in which the target unit is suspended, the ESCs values will be too small due to the decreased net electricity production of the third cycle.
- In addition, although the replacement will be completed and the efficiency of both the replaced new unit and the entire power station will improve during the fourth cycle, the current rules do not stipulate how to take into consideration and correct the increase in output by a replacement with a larger generating capacity.

5.2 Recommendations

The issues mentioned in **5.1 (2)** above should be addressed as per the measures proposed therein. In addition, as the replacement study involves the application of supercritical steam pressure technology which has just started being introduced in India and has never been introduced by any of the three state electric utilities (UPRVUNL, MPPGCL, MSPGCL), therefore, it is recommended that the officials concerned from each of the state electric utilities visit to Japan and get a training course on thermal power stations in Japan where this technology has been widely applied, in order to learn the specific equipment management and operational procedures for the technology, and to ensure the reliable operation and maintenance of the power station after replacement has been completed.

ATTACHMENTS

ATTACHMENTS

Field Work – Phase 1

Kickoff Meeting

Field Work – Phase 2

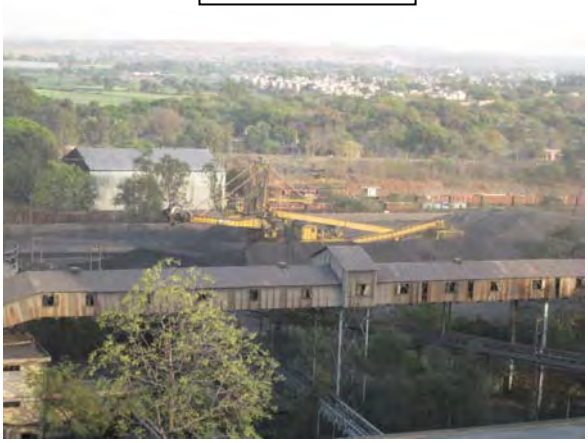
Parli Thermal Power Station Units 3 to 5

Meeting

Boiler

Turbine

ESPs



Coal Yard

Bhusawal Thermal Power Station Units 2 and 3

Meeting

Power Station Overview

Switch Yard

ESPs

Existing Ash Pond

Satpura Thermal Power Station Units 1 to 5

Meeting

Boiler & ESP

Control Room

Existing Ash Pond

New Ash Pond (under construction)

Obra Thermal Power Station Units 1 to 8

Meeting

Station Area & Obra Dam

Switch Yard

Boiler, ESP & Coal Yard

Existing Ash Pond

Field Work – Phase 3

Meetings

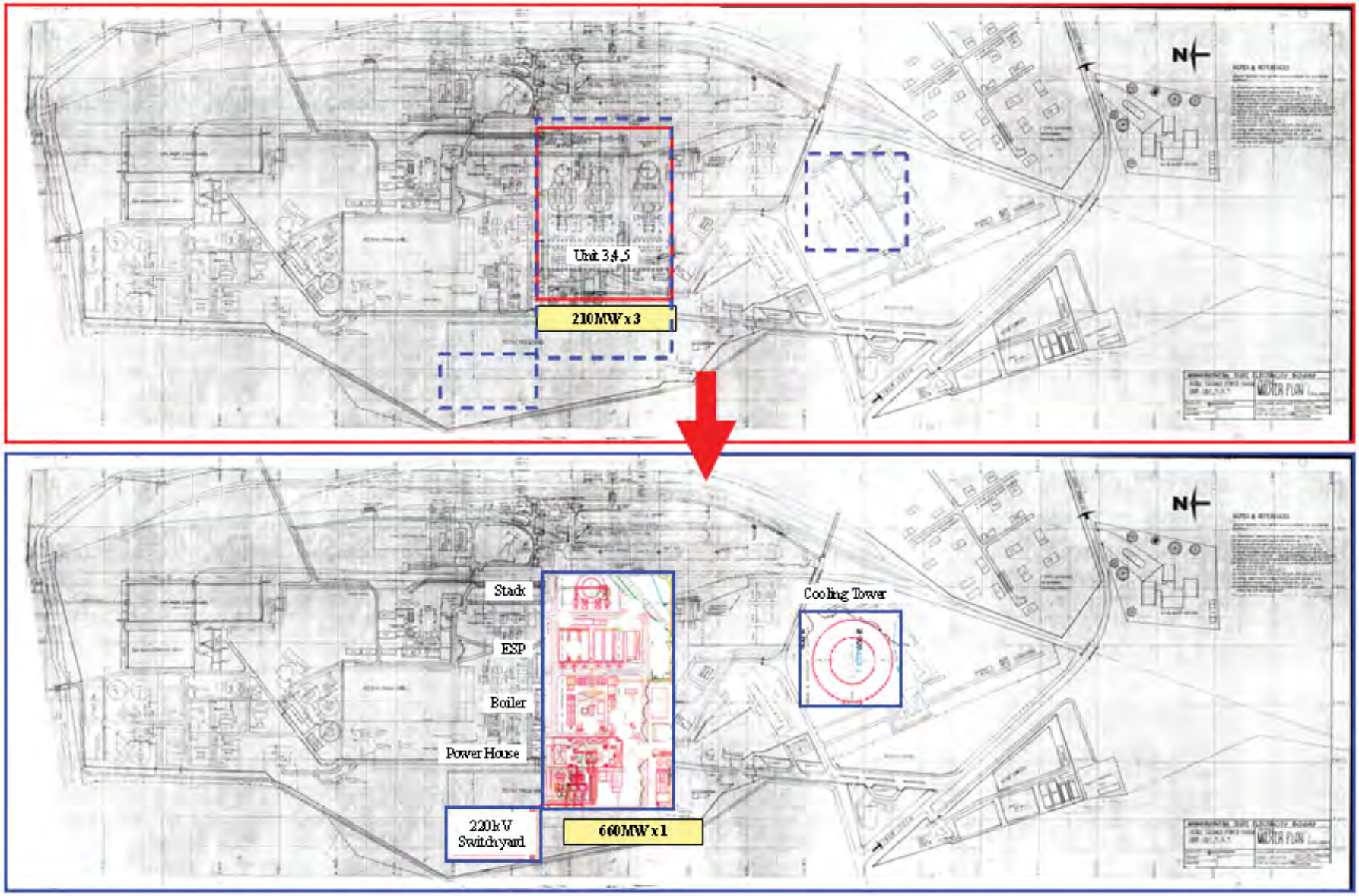
MSPGCL

MPPGCL

UPRVUNL

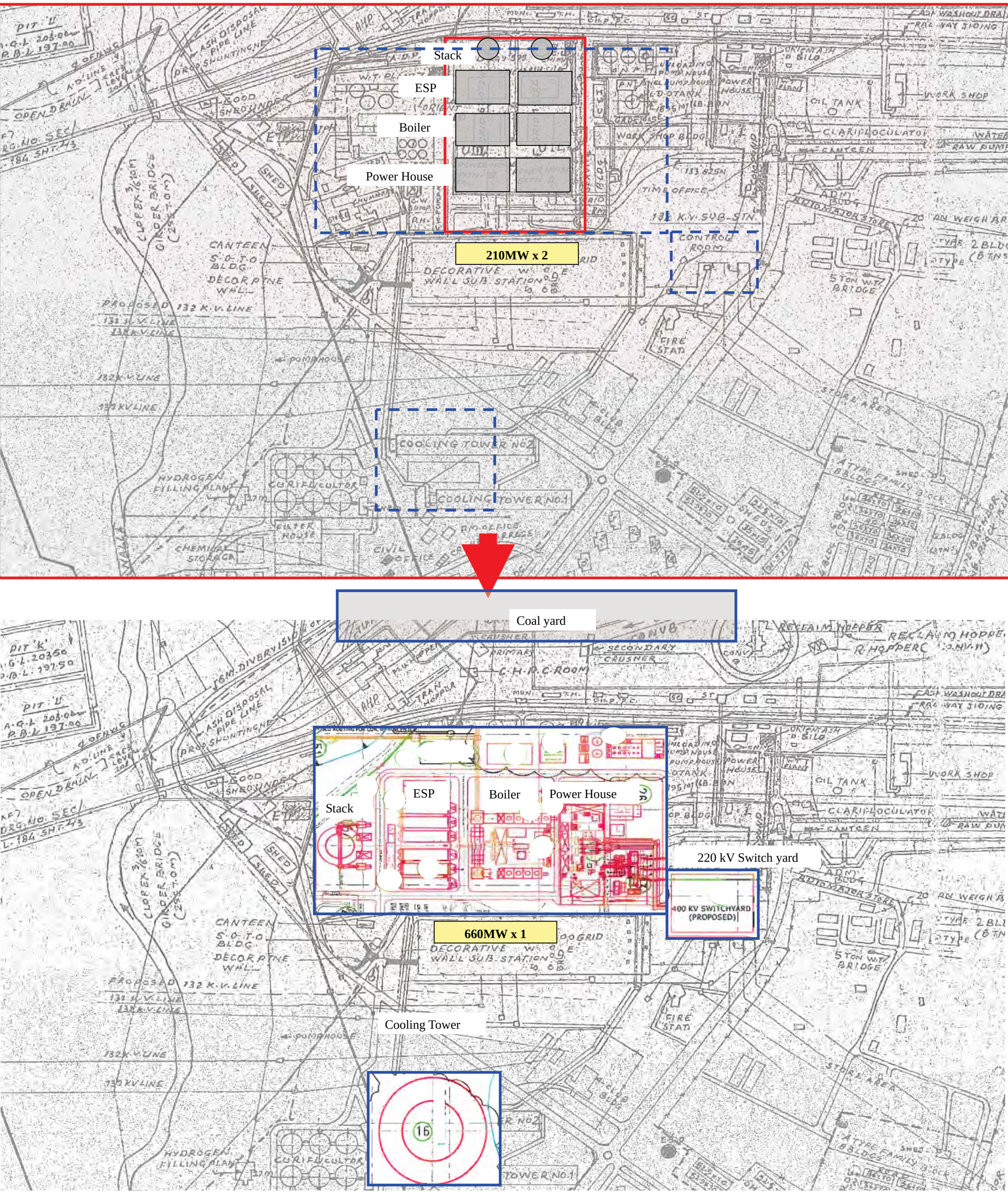
Parli Thermal Power Station (Complete Replacement)

Attachment-1



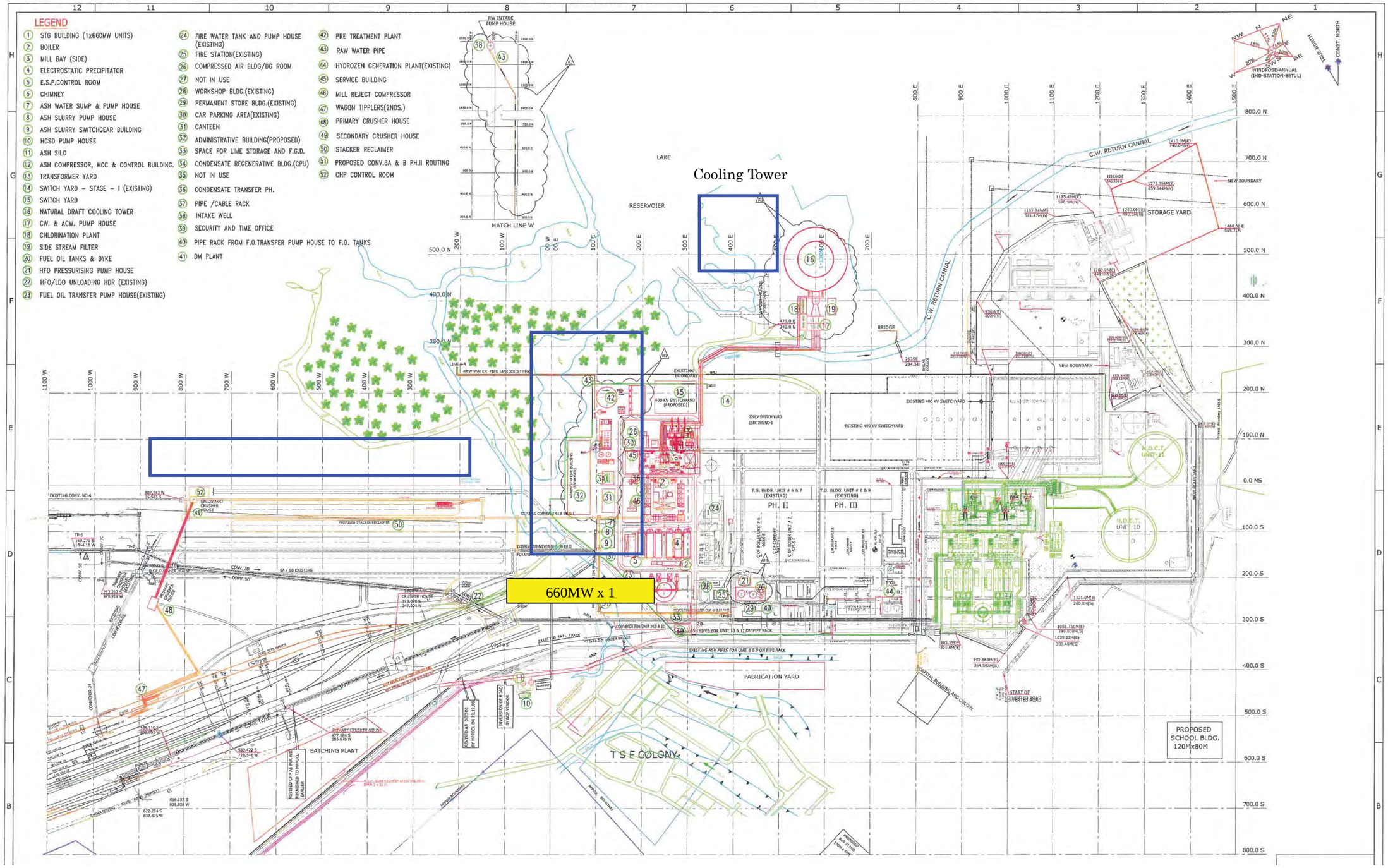
Bhusawal Thermal Power Station (Complete Replacement)

Attachment-2



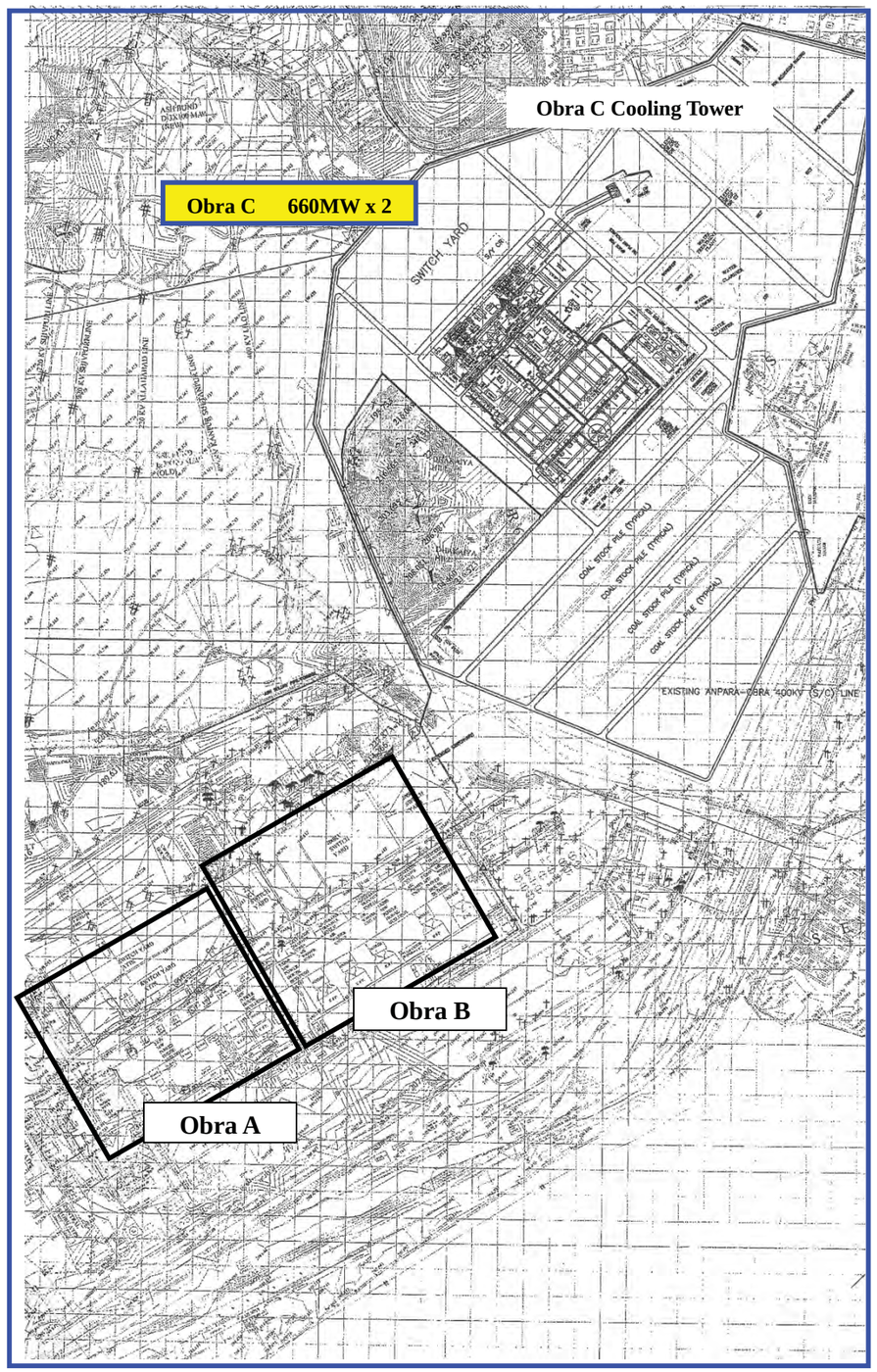
Satpra TPS Complete Replacement (Outline layout drawing)

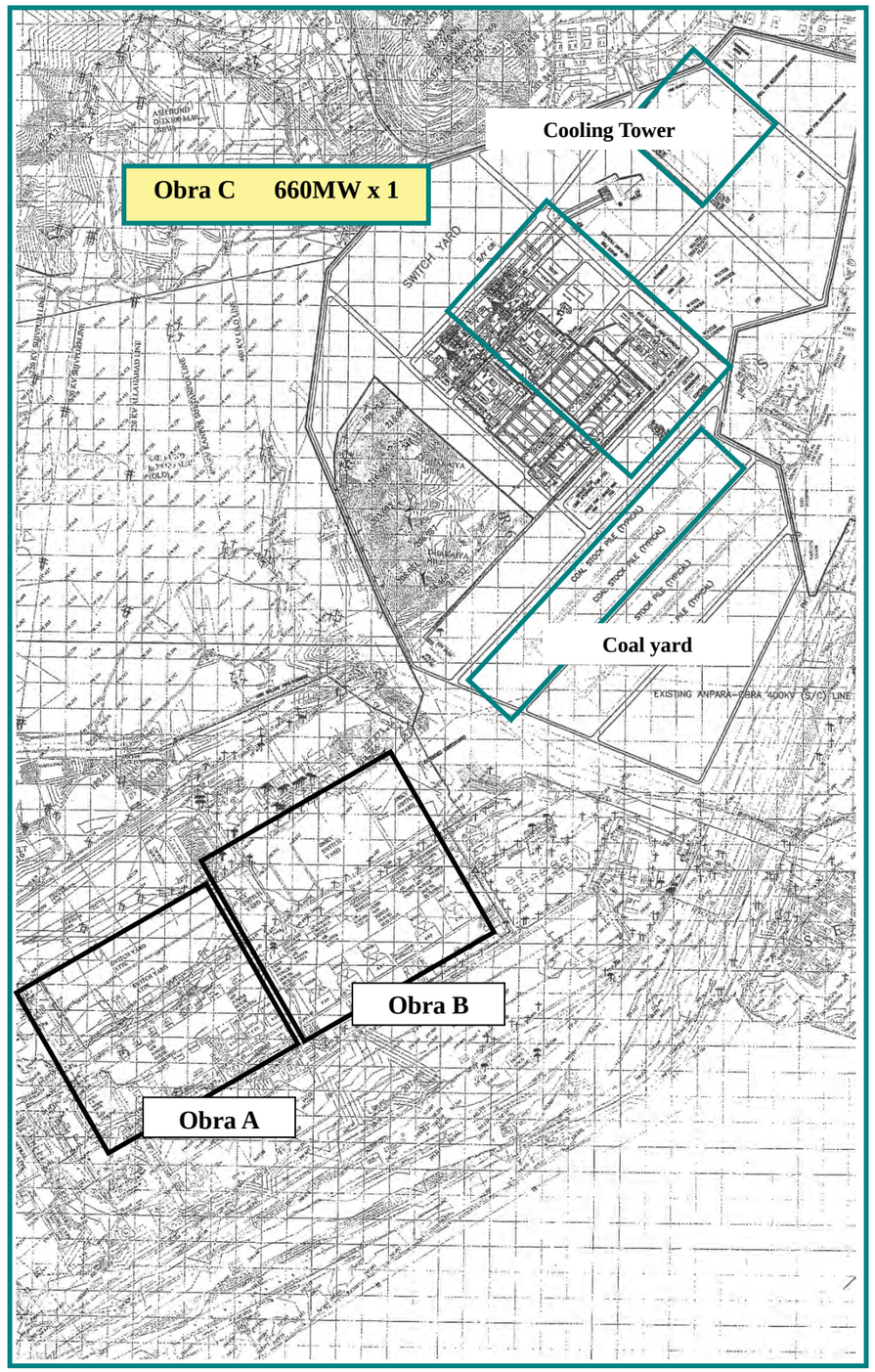
Attachment-3



Obra TPS Complete Replacement (Outline layout drawing)

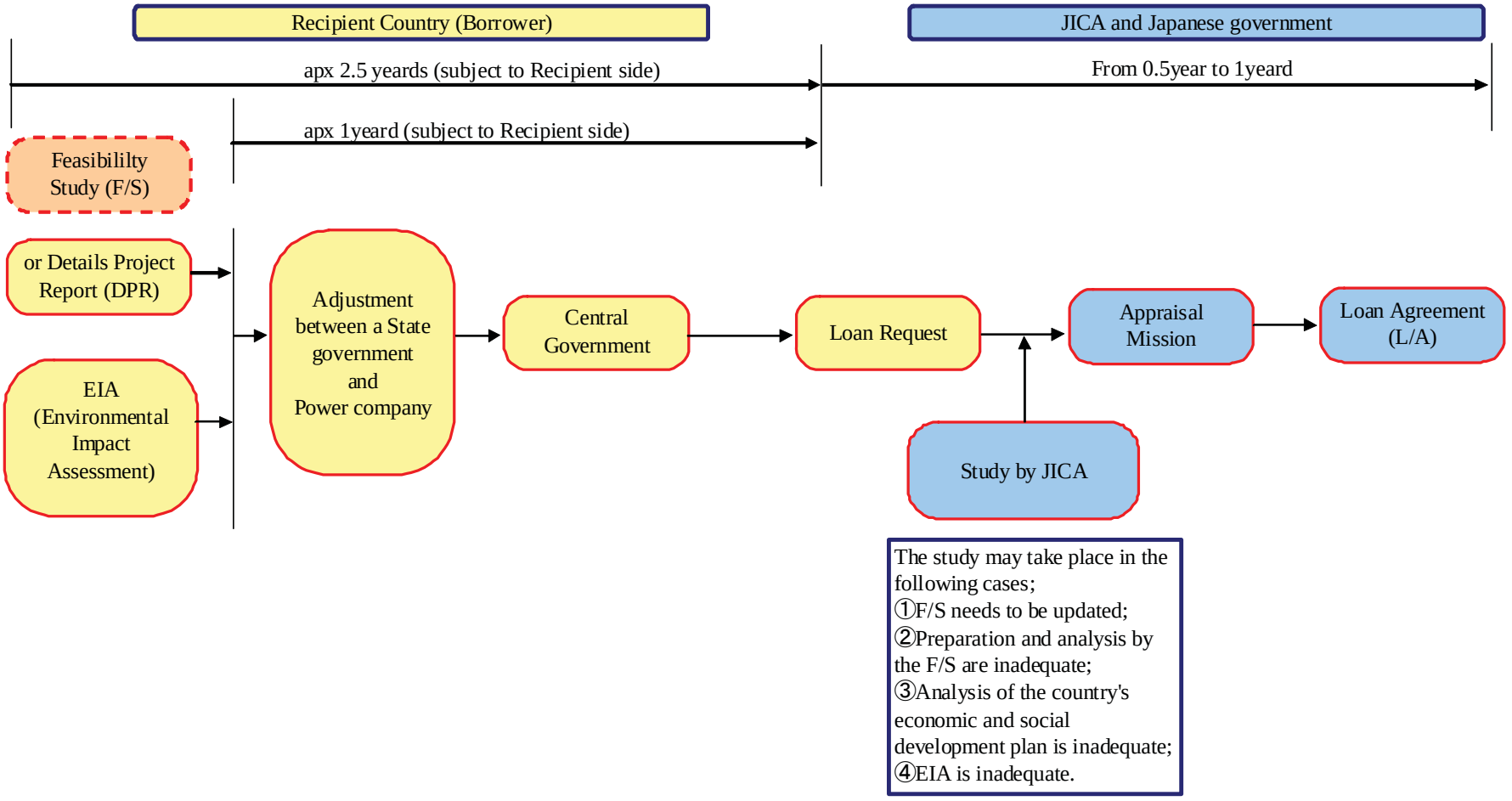
Attachment-4





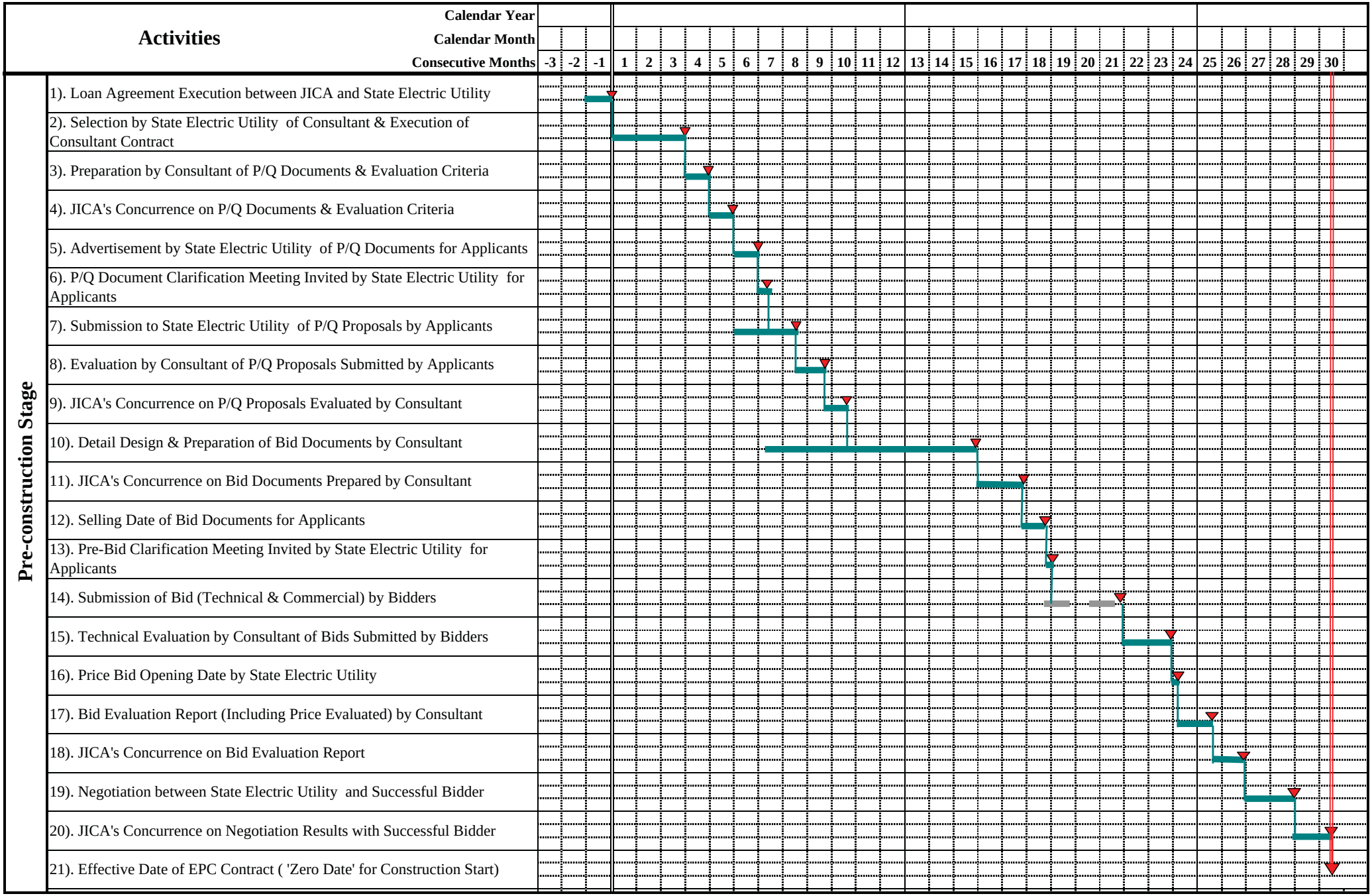
Attachment-5

ODA Loan Procedure



Estimated Pre-construction Schedule from ODA Loan Agreement

Attachment -6



Attachment-7 Minutes of Meeting: Kick off Meeting

The Study
on
Renovation and Modernization / Complete Replacement of Old Coal based Thermal Power Stations in India

Minutes of Meeting
of
Kick Off Meeting

JICA, JICA Study Team ,
Ministry of Power (MOP), CEA, UPRVUNL, MPPGCL, MSPGCL

Mr. N S Mondal
Director
CEA
India

Mr. Noriyuki Shimizu 17/02/2012
Leader
JICA Study Team
Japan

DATE	:	**24th January 2012**
VENUE	:	**JICA India Office Meeting Room in Delhi**

1. Welcome Note

Mr. H. Suzuki /Senior Representative /JICA New Delhi Office presented welcome note as follows.

1) JICA granted large scale of amount to India on various projects and recently activities in India is transportation (ex. Delhi Metro). Next focusing subject is power sector and water supply.

2) First yen loan for power sector started in 1980s including power station as well as transmission and distribution. However, power sector situation is historically changing.

3) JICA and Indian Government have dialog looking into how we react to generation side for the aging existing power plants to increase efficiency and raise the cost performance.

4) This study takes few months but it is the first step to find actual projects of yen loan activities and realize new projects for generation side.

2. Opening Remarks

Mr. Sanjay Garg / Addl. General Manager/ MoP presented welcome note as follows.

1) India has to reduce specific energy consumption by 20 to 25% compared to year 2010 in order to maintain energy security including coal resources.

2) Efficiency enhancement is applied to all areas. Regarding coal, we have a plan to apply super critical technology in place of sub critical technology during 13th Plan onwards.

3) JICA proposed an idea of complete replacement of aged small capacity power generating units to Indian government. Indian government agreed for further studies

4) R&M is for efficiency enhancement but at the same time possible for enhancement of capacity under shortage of possible time and with minimum investment.

5) India's cooperation with JICA is variety in power sector such as coal, hydro, renewable, energy efficiency, etc. compared to the other fund agencies like World Bank, USAID and KfW.

6) National program may be made after out come of this study.

7) After this study wherever qualified projects are there, JICA assistance to them will be proposed within 2012.

8) R&M programs are to be applied for implementation of PAT scheme with their strict time line.

9) It was requested to provide interim report within 19 to 20 days, after study the projects are under the PAT scheme so that it is possible for MOP to process under 2012 funding itself.

3. Presentation of CEA for R&M

1) Mr. Mr. T P Singh / Chief Engineer (TRM Divn.) gave a brief historical background and present status of R&M in India. He expressed main reasons for nonachievement of target for R&M mainly due to non availability of Venders, skilled man power among others. There after a presentation was presented by N.S. Mondal, Director, CEA.

4. Presentation of JICA Study Team

1) Mr. Shimizu explained about example of Japanese R&M and complete replacement

5. Presentation on Current Status of State Utility Power Stations

1) OBRA (U.P.)

1) Mr. B S Tiwari/Superintendent Engineer presented actual status of Obra power station's R&M and life extension (LE)

2) Issues of R&M are as follows.

- Unit No. 9 turbine was renovated and planned to uprate from 200MW to 216MW. However, there were many problems occurred. BHEL did not overcome yet those issues even by Siemens support. Unit 9 is operating at 180MW at present.
- Turbine uprating in terms of capacity is strongly not recommendable.

2) SATPURA (M.P.)

1) Mr. B C Joshi/Executive Engineer presented actual status of Satpura power station's R&M and life extension (LE)

2) Units no. 10 (250MW) and 11 (250MW) of Satpura P/S are under construction. Those will have commercial operation in August 2012and November 2012 respectively. After COD of the new units, units no. 1 to 5 will retire due to state pollution control board requirement (particle emission). Mr. Sanjay Garg (MOP) suggested nos. 1 to 5 are potential candidates for complete replacement.

3) Issues of R&M are as follows.

- Contract was concluded for Amarkantak 120MW Turbine with BHEL/Siemens but it was suddenly broken up. It is now under high court arbitration
- Equipment order for turbine parts was made. But delivery of the ordered equipment is more than 16 months delay.

3) MAHARASHTRA

1) Mr. G J Girase/Director(Finance) presented actual status of Mahagenco power station's R&M and life extension (LE)

2) Khaperkheda power station is one of the best power station in Maharashtra, therefore MAHAGENCO proposed Bhusawal P/S for the candidates for complete replacement and

Parli P/S for the candidates for complete replacement and/or R&M under JICA study.

6. Target Stations/Units

Target Stations / Units were selected by discussion after each state utility's presentation as follows.

a) U.P.:	OBRA P/S	Units 1 to 8	Complete Replacement (660MW SC)
b) M.P.;	SATUPRA P/S	Units 1 to 5	Complete Replacement (660MW SC)
c) MAHARASHTRA :			
	BHUSAWAL P/S	Units 2 and 3	Complete Replacement (660MW SC)
	PARLI P/S	Units 3, 4 and 5	Complete Replacement or R&M

7. Explanation of Draft Inception Report

1) Schedule of study

- JICA Study Team (JICA-ST) explained outline of the study schedule based on draft Inception Report.
- #2 Field Work (site survey) will be carried out from 11th Mar to end of Mar.2012 (tentative). Power station visit sequence will be 1st MAHARASHTRA (3rd week of Mar.), 2nd M.P. (4th Week of Mar.), and the last U.P. (5th week of Mar.)

#2 Field Work detail schedule will be sent to State Utilities by 3rd of February

2) Questionnaire sheet

- Questionnaire (investigation sheets) are to be selected for the respective candidates confirmed considering specific features appropriate to complete replacement and R&M. Questionnaire sheets will be sent to State Utilities by end of January.

2) Assistance provided by State Utilities

- State Utilities agreed to assist logistics and accommodation for Field Works by JICA-Study Team.

Attachment

(1) Attachment-1: Agenda
(2) Attachment-2: List of Attendance
(3) Attachment-3: Presentation materials
(4) Attachment-4: Inception Report (draft)

Attachment-1

Detailed Program
Joint kick-off meeting for JICA Study on Renovation & Modernization / Complete Replacement of Old Thermal Power Stations in India

Date: Jan 24, 2012
Time: 2.30 p.m. to 5.30 p.m.
Venue: JICA New Delhi Office

Members from JICA H.O., Tokyo

1 Ms. Makiko Hashizume, Country Officer, JICA Head Office, Tokyo
2 Ms. Ai Tachikawa, Country Officer, JICA Head Office, Tokyo

Members from JICA India Office

1 Mr. Hiroshi Suzuki, Senior Representative, JICA India Office
2 Mr. Kazuyoshi Ohnuma, Representative, JICA India Office
3 Ms. Shashi Khanna, Sr. Development Specialist, JICA India Office

Members of JICA Consultant Team

1 Mr. Noriyuki Shimizu, Senior Advisor (Thermal Power Int'l Business Management Dept.), J-Power, Tokyo
2 Mr. Morikuni Miyagi, Office Dy. Director (Thermal Power Engg. Office, Int'l Business Development Dept.), J-Power, Tokyo
3 Mr. Nobuchika Koizumi, Dy. Director (Thermal Power Engg. Office, Int'l Business Dev. Dept.), J-Power, Tokyo

Sl.No.	Particulars	Name / Designation / Organization	Duration	Actual Duration
1	Introduction			
	Welcome Note by JICA New Delhi Office	Mr. H. Suzuki /Senior Representative /JICA New Delhi Office	10 Minutes	10 Minutes
	Opening Remarks by Ministry of Power (MoP)	Mr. Sanjay Garg/ Addl. General Manager/ MoP	10 Minutes	10 Minutes
	Brief Introduction for R&M of Thermal Power Plants by Central Electricity Authority (CEA)	Mr. T P Singh /Chief Engineer (TR&M Divn.) & Mr. N S Mondal/ Director /CEA	20 Minutes	25 Minutes
2	Presentation on JICA Study	Mr. N. Shimizu/ Senior Advisor /J-Power, Tokyo	20 Minutes	25 Minutes
3a	Presentation on Current Status of OBRA Thermal Power Plant by U.P. State Utility	Mr. B.S. Tiwari/Supdt Engineer supported by Mr. P. Chowdhary, General Manager(R&M) /UPRVUNL	15 Minutes	50 Minutes
3b	Presentation on Current Status of Satpura Thermal Power Plant by M.P. State Utility	Mr. B C Joshi /Exe. Engineer / MPPGCL	15 Minutes	45 Minutes
3c	Presentation on Current Status of Khaperkheda Thermal Power Plant by Maharashtra State Utility	Mr. G J Girase / Director (Finance) supported by Mr. G G Bandgar, Dy Chief Engineer (R&M)/ MSPGCL	15 Minutes	45 Minutes
4	4.1 Explanation of Inception Report 4.2 Q & A session about Inception Report 4.3 Discussion about Each Thermal Power Station 1. OBRA TPS (U.P.) 2. Satpura (M.P.) 3. Khapekheda (Maharashtra) 4.4 Questionnaire about Study & Preparation of Answers by the State Utilities 4.5 Get information about Counterpart officials of CEA & State Utilities 4.6 Schedule of the Study	Mr. M. Miyagi/ Office Dy. Director / J-Power, Tokyo	60 Minutes	15 Minutes
5	Closing Remarks by MoP	Mr. Sanjay Garg/ Addl. General Manager/ MoP	5 Minutes	The items were cancelled by the time constraint
6	Closing Remarks by CEA	Mr. T P Singh /Chief Engineer (TR&M Divn.) / CEA	5 Minutes	
7	Closing Note by JICA Consultant Team	Mr. N. Shimizu/ Senior Adviser /J-Power, Tokyo	5 Minutes	
8	Closing Note by JICA New Delhi Office	Mr. H. Suzuki /Senior Representative /JICA New Delhi Office	5 Minutes	

Attachment-2

ATTENDED BY

MOP	Mr. Sanjay Garg/ Addl. General Manager
CEA	Mr. T P Singh / Chief Engineer (TRM Divn.),
	Mr. N S Mondal/ Director
State Power Utilities	
UPRVUNL	Mr. P. Chowdhary/ General Manager(R&M)
	Mr. B.S. Tiwari/ Supdt Engineer
MPPGCL	Mr. B C Joshi /Exe. Engineer
MSPGCL	Mr. G J Girase / Director (Finance)
	Mr. G G Bandgar/ Dy Chief Engineer (R&M)
JICA	Mr. H. Suzuki /Senior Representative /JICA New Delhi Office
	Mr. K. Oonuma
	Ms. M. Hashizume
	Ms. A. Tachikawa
	Ms. S. Khanna
JICA Study Team	Mr. N. Shimizu
	Mr. M. Miyagi
	Mr. N. Koizumi

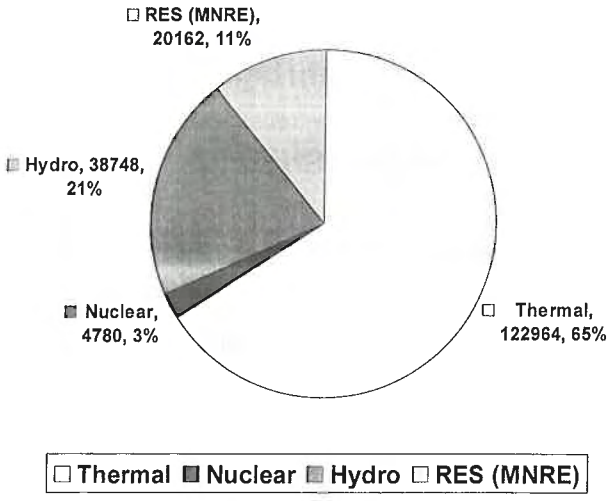
Renovation & Modernisation
and
Life Extension
of
Thermal Power Stations

Central Electricity Authority

Total Installed Capacity

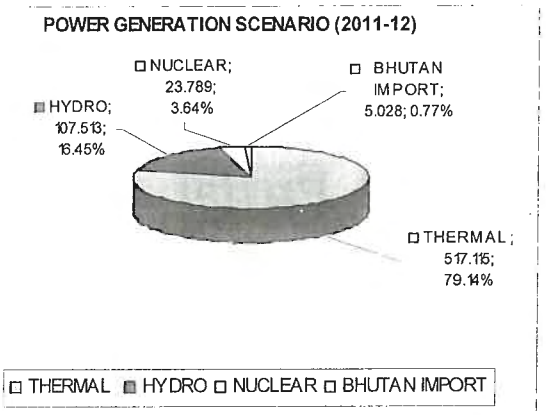
1,86,654 MW

(As on 31-12-2011)



Power Generation

Total Generation
April to Dec-2011 - 653.446 BU



Power Shortages

– **During the Year 2010-11**

- **Peak Shortage - 10.3 %**
- **Energy Shortage - 7.5 %**

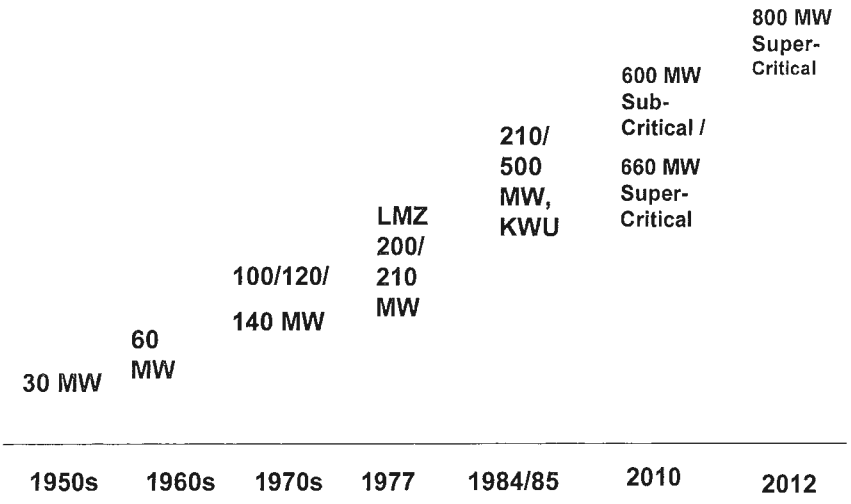
During the Period April- Nov 2011-12

- **Peak Shortage - 10.6%**
- **Energy Shortage - 7.4%**

Broad Strategies to Mitigate Power Shortages

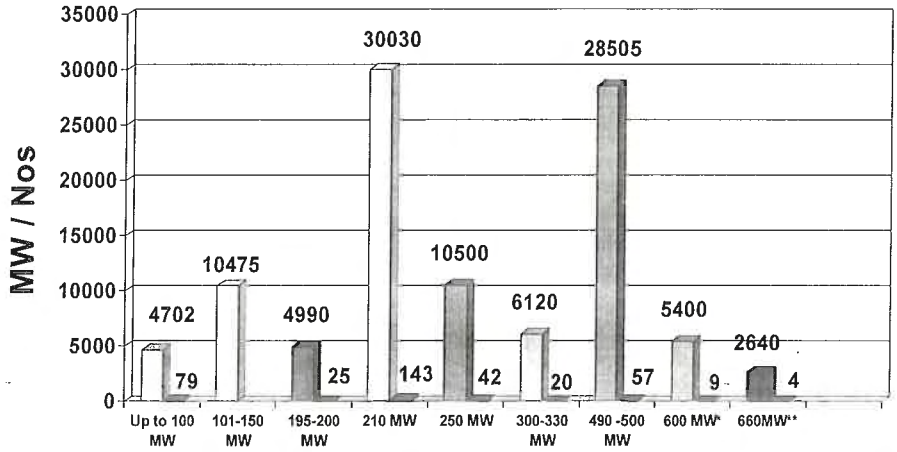
- New Capacity Addition through Green Field and Expansion Projects
- R&M/LE of Existing Units
- Demand Side Management
- Renewable Energy Sources (RES)

Growth of Unit Size in India
(Thermal Plants)



Distribution of Coal / Lignite Based Thermal Units Sizes

(As on 15.12.2011)



- The First unit of 600 MW capacity (Rajiv Gandhi - Hisar) commissioned in March 2010
- The First unit of 660 MW capacity (Mundra - Adani) commissioned in December 2010

Age Profile of Large Size Thermal Units

Capacity Range (in MW)	> 15 years but <20 years	>20 years but < 25 years	>25 years but < 30 years	> 30 years
200/210 LMZ	8	15	26	19
200/210 KWU	26	20	20	-
500	7	12	1	-

Objective of R&M Programme

- To restore rated capacity and design parameters such as Heat Rate.
- To make the operating units well equipped with modified/ augmented latest technology.
- To overcome technological obsolescence and non-availability of spares.
- To improve the performance parameters in terms of PLF, Efficiency, Forced Outages, Availability and Reliability.
- To reduce maintenance requirements and enhance the ease in maintenance
- Compliance of stringent environmental norms, safety and other statutory requirements.

Objective of LE Programme

- Extension of useful economic life of generating units by another 15 - 20 years.
- To focus on full load operation of the unit beyond their original design life.
- To restore rated capacity and design parameters such as heat rate.
- Uprating of generating unit.
- Improvement beyond design parameters.

Cost of R&M / LE Works

- Cost of R&M /LE works depend on the scope of the works.
- Estimated cost of unit for complete R&M/ LE works limited to 50% of cost of new unit.
- Cost of main Plant (BTG) limited to 50% cost of new BTG unit.
- The Pay Back period should be from 5 to 7 years.

Methodology for Implementation

1. Implementation by the utilities

R&M Works

i) Through A Rolling Plan

- Implemented in a phased manner.
- Results in minimizing unit shut down requirement and thereby loss in generation.
- However, it results in extended execution over a long period of time
- Benefits accrued can not be co-related with the activities carried out and investment made.

ii) Through Comprehensive R&M Scheme

- Implemented in a single stretch in single Shut Down
- It is preferable due to well definable & quantifiable benefits.

LE&U Works

Through Comprehensive LE Scheme (Based on RLA Studies)

- Covering the Complete Plant

2. Implementation through Private Sector Participation

(i) Option 1:- Lease, Rehabilitate, Operate and Transfer (LROT)

- A Private Promoter (PP) would take over the power station on a long - term lease, say 10 years or more.
- PP would invest and carry out the R&M of the power station and would takeover its operation & maintenance.
- Ownership of the plant will remain with the utility throughout.

(ii) Option 2:- Sale of Plant

- Power utilities could offer power stations for outright sale to private parties.
- The present worth of the plant would have to be assessed which could be the reserve price for the sale.

(iii) Option 3:- Joint Venture between Power utility and public or private companies.

- A new company will be formed as a joint venture (JV) of the state power utility/ State Government and selected private/public collaborator.
- The JV company would undertake the R&M/ LE works and own, operate and maintain the power station.

Time Frame of Various Activities

a. Appointment of consultant	- 3 months
b. RLA/ EA	- 6 months
c. Finalising the Scope of R&M/LE Works	- 3 to 4 months
d. Preparation of DPR	- 6 to 8 months
e. Placement of Order of R&M/LE Works	- 6 to 8 months
f. Supply of material/Items	- 16 to 20 months from placement of order
g. Shut Down of unit	- 6 to 8 months

R&M & LE programme
7th Plan and onwards

- A centrally sponsored R&M programme was initiated in 1984 in structured manner.
- The programme continued during the two annual plans 1990-91 and 1991-92.
- The momentum for R&M works continued during 8th & 9th Plan.
- The momentum could not be sustained during 10th Plan.

Plan-wise Achievements

S. No	Plan	Year	No. of TPS / No. of Units	Capacity (MW)	Additional Generation Achieved MU/ Annum	Equivalent MW
1	7th Plan & 2 Annual Plans	85-86 to 89-90 & 90-91, 91-92	34 / 163	13570	10000	2000
2	8th Plan (R&M) (LEP)	92-93 to 96-97	44 / 198 43/(194) 1 (4)	20869 (20569) (300)	5085	763
3	9th Plan (R&M) (LEP)	97-98 to 2001-02	37 / 152 29/ (127) 8/ (25)	18991 (17306) (1685)	14500	2200
4	10th Plan (R&M) (LEP)	2002-03 to 2006-07	9/ 25 (14 out of 57 planned) (11 out of 106)	3445 (2460) (985)	2000	300

R&M Programme as per National Perspective R&M Plan (2007-17)

Programme	11th Plan (2007-12)	12th Plan (2012-17)
Life Extension Programme (LEP)	7318 MW (53 units)	16532 MW (72 units)
R&M Programme	18965 MW (76 units)	4971 MW (23 units)
Total	26383 MW (129 units)	21503 MW (95 units)

Achievement During 11th Plan

Programme	Completed till Dec, 2011	Likely to be Completed
Life Extension Programme (LEP)	1171 MW (12 units)	230 MW (2 units)
R&M Programme	14855 MW (59 units)	110 MW (1 units)
Total	16026 MW (71 units)	340 MW (3 units)

On-going Life Extension Projects

(already under Shut Down)

Sl. No	Name of TPS & Unit No	Utility	Executing Agency
1.	Obra TPS unit - 11 (200 MW)	UPRVUNL	BHEL
2.	Harduaganj TPS Unit - 7 (110 MW)	UPRVUNL	BHEL
3.	GND TPS, Bhatinda Unit - 3 (110 MW)	PSPCL	BHEL
4.	Barauni TPS unit - 7 (110 MW)	BSEB	BHEL
5.	Muzaffarpur TPS Unit - 1 (110 MW)	KBUNL	BHEL
6.	Amarkantak Extn Unit - 1 (120 MW)	MPPGCL	NASL
Total 6 units (760 MW)			

Reasons for Gaps in Achievement of R&M/LE Targets During 10th & 11th Plan

1. Delay in supply of equipment by the OEM.
2. Delay in taking shut down for implementing Life Extension works.
3. Non-availability of Dedicated R&M Team.
4. Poor Financial Condition of State Power Utilities.

Revised Tentative R&M / LE Potential during 12th Plan

- Originally identified R&M / LE works – 21,503 MW (95 units)
- Likely Slippage from 11th Plan – 9,567 MW (51 units)
  - LEP – 5,777 MW (37 units)
  - R&M – 3,790 MW (14 units)
- Revised R&M and LE programme – 31,070 MW (146 units)
  - LEP – 22309 MW (109 units)
  - R&M – 8761 MW (37 units)

Unit Sizes Covered

500 MW	–	20 (33%)
200/210 MW	–	76 (52%)
110 MW	–	13 (5%)
Gas Turbine	–	2960 MW (10%) various units sizes

Units taken up for E E R&M through External funding

Sl. No.	Name of Utility	Name of Station	Unit No.	Year of Comm.	Capacity (MW)	Remarks
1	HPGCL	Panipat	3	1985	110	World Bank funded
2	HPGCL	Panipat	4	1985	110	World Bank funded
3	WBPDCL	Kolaghat	One Unit	1990	210	Likely KfW funded
4	WBPDCL	Bandel	5	1952	210	World Bank funded
5	MSPGCL	Nashik	3	1979	210	KfW funded
6	MSPGCL	Koradi	6	1982	200	World Bank funded
7	MSPGCL	Bhusawal	2	1979	210	Likely W.B. fund
8	MSPGCL	Chandrapur	1	1983	210	Likely W.B.fund
9	MSPGCL	Chandrapur	2	1984	210	Likely W.B.fund
10	MSPGCL	Parli	3	1980	210	Likely W.B.fund

Drivers for E E R&M

1. Availability of Fuel, Land & Water is becoming more difficult for new power projects.

2. Coal is an exhaustible natural resource. Hence, its saving by way through efficiency enhancement is desirable. R&M results lower specific coal consumption.

3. R&M is one of the most cost effective measure for getting additional generation. The operation of old units becomes more economical after R&M.

4. Additional generation from old units becomes available in very short duration.

5. The benefits accrued from R&M in a typical 200/210 MW unit include: -
   - Increased output by about 4- 8%
   - Improved unit heat rate by 10-15%
   - Extended Plant Life by about 15-20 years.

Contd/...

6. There is a shift from 'Generation Maximisation' to 'Generation Optimisation' with efficiency enhancement. Efficiency enhancement of about 8-10% is feasible in the existing LMZ units.

7. Increased emphasis on Environment for clean technology. The environmental norms are getting more and more stringent.

8. Under the Perform, Achieve & Trade (PAT) Scheme of BEE, a target of saving of 3.1 Million Tonnes of Oil Equivalent (ToE) by the end of three years cycle, has been fixed for the Power Sector. Thermal power plants have been notified as Designated Consumers (DC). They have to achieve a notified reduction in fuel consumption in Tonnes of Oil Equivalent (ToE). The date of implementation of PAT scheme is likely to be notified by Central Government very shortly.

Steps taken by MOP / CEA for Facilitating the R&M / LE Programme

1. **In Dec,2009, a National Perspective Plan was formulated for R&M / LE works during 11th & 12th Plan.**

2. **CEA has issued guidelines for R&M and LE works of thermal power stations in December, 2009.**

3. **Apart from PFC/ REC, external funding from World Bank and KfW have also been arranged to finance LE programme of some utilities at their identified TPSs.**

4. The preparation of DPRs for LE works at 7 units of 210 MW by M/s Evonik-Germany, with grant from KfW under Indo-German Energy Forum, is completed at Unit-3 Nasik of Mahagenco, Unit 1 ,2 & 3 of Kolaghat TPS of WBPDCL and Unit-1, 2 & 3 of Bokaro 'B' TPS of DVC. Mahagenco & WBPDCL have accepted the DPRs while the acceptance for DPRs from DVC is still awaited.

5. For the preparation of standard documents for R&M with grant from KfW Bank in Phase – II activity under Indo – German Energy Forum, the selection of consultant is completed and the contract with the consultant is likely to be signed very shortly.

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6. **Technical studies would be carried out for mitigation of barriers to the R&M in India with grant from GEF/ World Bank.**

8. **A Task Force, under the Chairmanship of Member (Thermal), CEA has already been constituted for promotion of R&M works in India with members from NTPC, DVC, MSPGCL, WBPDCL, HPGCL, APGENCO, CERC, PFC, WORLD BANK & KfW. The 1st meeting of the Task Force was held on 15-12-2011.**

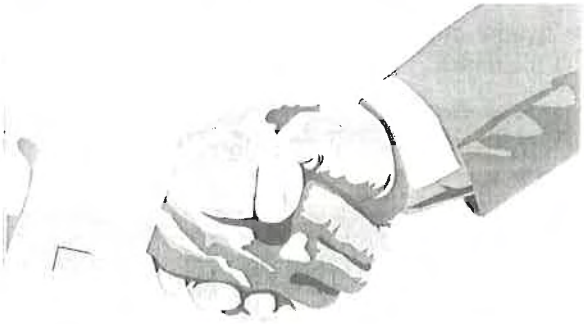
9. **CEA has prepared three Base Papers viz Allocation of power from unallocated quota of Central Pool to the State Power Utilities, Formulation of proposal for Assessment of vendor capacity & Formulation of proposal for financial arrangement to carry out LE works during 12th Plan. The papers have been sent to the State Utilities and stakeholders for consultation.**

10. **Interactions have been done with following manufacturers/ vendors for assessment of their capacity and interest for R&M works.**
    - i. M/s Doosan Heavy Industries & Construction, Korea
    - ii. M/s L&T
    - iii. M/s Alstom Power Limited, U.K. (with M/s NASL)
    - iv. M/s Toshiba, Japan
    - v. M/s Dong Fang Electric Corporation, China
    - vi. M/s Seimens Ltd
    - vii. M/s GE Energy, India

11. **Under Phase-II, Detail Technical Studies would be carried out by M/s JCOAL at three selected thermal units for identification of scope of R&M works.**

12. **JICA Study on Renovation & Modernization / Complete Replacement of State sector old inefficient coal based thermal power station in India has been initiated.**

धन्यवाद



Thank you

JV project

1. Kanti Bidyut Utpadan Nigam Ltd

Lease Projects (O&M)

1. 156 MW CCCP Gas based power plant, Hazira, Gujarat with Evonik
2. 116 MW co-generation plant at Haldia in West Bengal for L&T and HPL.
3. 150 MW co-generation plant at Bathinda, Punjab, HPM-Jiont venture .
4. 4x 600 MW CCGT at Jharsoguda– Sterilite Energy Ltd.

Main Features of the R&M Phase-I Programme

- No. of TPS covered : 34
- No of units covered : 163
- Total Capacity involved : 13570 MW
- Average PLF of 163 units (before R&M) : 46%
- Anticipated PLF after completion of R&M : 53%
- Anticipated additional generation after R&M : 7000 MU/annum
- Year of completion : 1990-91
- Total expenditure incurred : Rs 1066 crores
  - Central Loan Assistance : Rs. 402 crores
  - State Plan Resources : Rs. 664 crores
- Actual PLF after completion of R&M : 56%
- Anticipated additional generation after R&M : 10000 MU/annum

RETIREMENT OF VERY OLD UNITS

- Consider for retirement of all non-reheat units of 100 MW or less rating. However, those units on which major R&M/LE activities have been undertaken and are performing well, such units may continue to operate for another 10 years from the date of post R&M/LE to enable them to recover the expenditures incurred.
- Larger size units can also be considered for retirement on economically non-viability on case to case basis.
- The retirement may be prioritized according to their level of performance, say unit heat rate deviating more than 20% to be retired first and subsequently those units with deviation of 15% & 10% from their design heat rate.
- The SEBs/ GENCOs may identify new generating capacity to be added as substitute for older units so that overall installed capacity is not affected.

Study on R&M / Complete Replacement of
Old Coal based Thermal Power Stations in India

Typical Cases of R&M and Complete Replacement of Coal-fired Power Stations in Japan

Noriyuki SHIMIZU

J-POWER

What is J-Power?

- Electric Power Development Company, Ltd.
- The largest wholesale electric power company in Japan
- Initially founded by the Japanese Government in 1952 and fully privatized in 2004
- Domestic wholesale installed capacity: 16,993MW
  - ✓ Coal: 8,412 (7 TPSs), Geo-thermal: 15, Hydro: 8,566
- Other power business installed capacity: 1,149MW
- Global power business
  - ✓ Consulting service: 320 projects in 63 countries, 1962 - India; 17 projects – Sipat (NTPC), JICA Study (NTPC)
  - ✓ IPP: 3,708MW(share eq.) by 29 projects in 6 countries

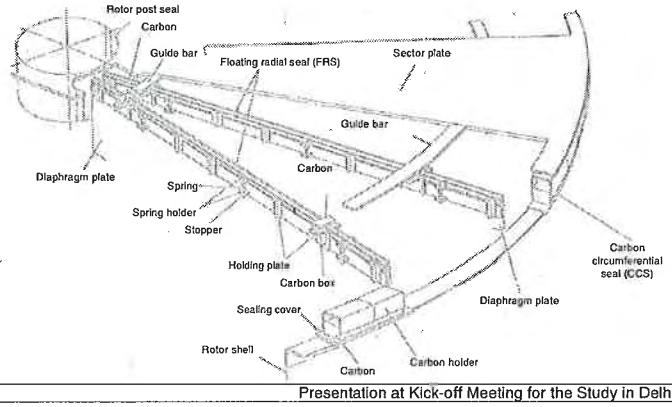
What is J-Power? (cont'd)

Typical R&M Case Study - APH

Application of FRS/CCS at existing 250MW coal fired power units :

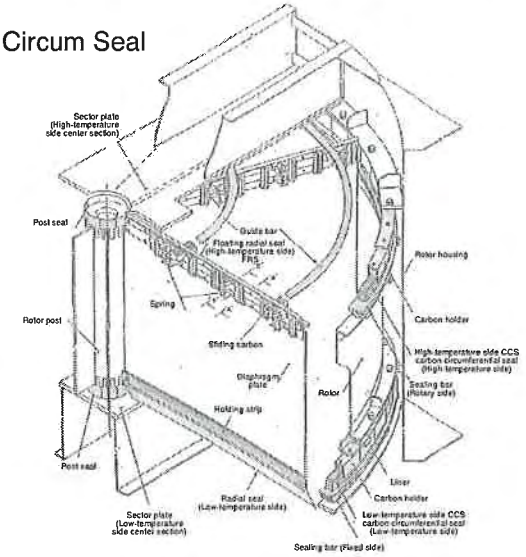
air leakage ratio 10→5%

Floating Radial Seals



Typical R&M Case Study - APH (cont'd)

Carbon Circum Seal

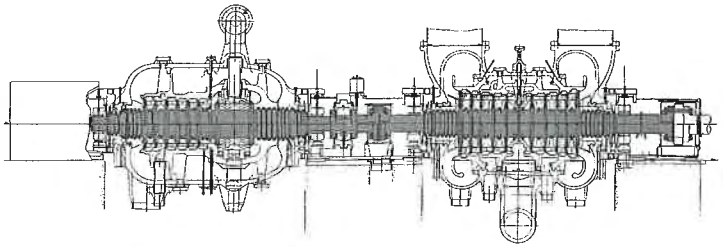


Typical R&M Case Study - Turbine

Application of latest technologies to replacement of turbine rotors, HP&IP, at a 700MW unit:

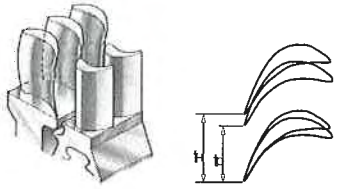
HR improved by 1.36%

- High load blade
- Advance Vortex Lean Nozzle Blade (AVN)
- Continuous Cover Blade (CCB)
- Improved diaphragm packing

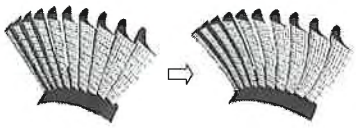


Typical R&M Case Study – Turbine (cont'd)

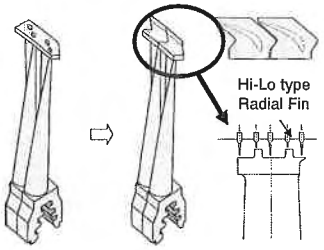
- High load blade



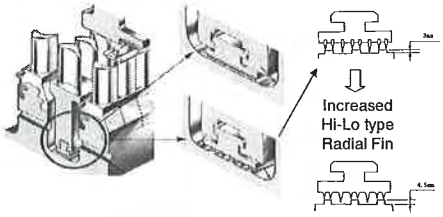
- AVN



- CCB



- Improved diaphragm packing



Complete Replacement - Isogo TPS

- Initially commissioned in 1969 (2x265MW) in urban area of Yokohama City
- Replaced/repowered in 2009 (2x600MW)
- Replacement under operation of old units
  - ✓ in the same area of 12 ha
  - ✓ Build (New #1), Scrap (Old #1&2) and Build (New #2)
  - ✓ replacement work 1996 – 2009
- Why replaced?
  - ✓ to meet Yokohama City Environmental Improvement 21st Century Plan
  - ✓ to meet increasing power demand in metropolitan area
  - ✓ to cope with aged facilities
- Apply the latest USC/environmental technology

Technical Features of Isogo TPS

- USC
  - ✓ New #1; 25MPa/600/610
  - ✓ New #2; 25MPa/600/620
- Environmental control
  - ✓ Flue gas treatment;
    Dust: ESP
    SOx: Activated coke dry type FGD
    NOx: SCR
  - ✓ Waste water treatment system
  - ✓ Coal/ash scattering control;
    Coal: Indoor type silo & air-floating belt conveyor
    Ash: Indoor type silo
- Measures for small area of 12 ha
  - ✓ Tower type boiler and tall silos/tanks

Performance Improvement

		Old Units	New Units
		#1, #2	#1, #2
Generation			
Output	MW	2 x 265	2 x 600
Efficiency	gross HHV %	38	43
Environmental			
SOx	ppm	60	20, 10
NOx	ppm	159	20, 13
Dust	mg/m3N	50	10, 5

Replacement Milestone

Old 2x265MW

1996

New 2x600MW

2009

Replacement Milestone (cont'd)

- Sep 1996: Start replacement work
  (reduce coal storage area → remove existing outdoor BOP and construct coal silo)
- Jul 1998: Start construction, New #1

Replacement Milestone (cont'd)

- Nov 2001: Start demolition, Old #1&2
- Apr 2002: COD, New #1
- Mar 2004: Complete demolition, Old #1&2

Replacement Milestone (cont'd)

- Oct 2005: Start construction, New #2
- Jul 2009: COD, New #2