Review of Renovation & Modernisation Implementation Experience from Pilot R&M Interventions in Thermal Power Stations in India

Prepared by:

WAPCOS Limited

Under

Technical Assistance to CEA for Addressing Barriers to Energy Efficient R&M of Coal Fired Generating Units

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India: Coal Fired Generation Rehabilitation Project

(March 2017)

CENTRAL ELECTRICITY AUTHORITY

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Abbreviations

ABB	Asea Brown Boveri
AC	Alternating Current
AHP	Ash Handling Plant
AOH	Annual Overhauling
AOP	Auxiliary Oil Pump
APC	Auxiliary Power Consumption
APH	Air Pre Heater
BSEB	Bihar State Electricity Board
BFP	Boiler Feed Pump
BHEL	Bharat Heavy Electricals Ltd.
BoP	Balance of Plant
BTG	Boiler, Turbine & Generator
C&I	Control & Instrumentation
CEA	Central Electricity Authority
CEP	Condensate Extraction Pump
CERC	Central Electricity Regulatory Commission
CHP	Coal Handling Plant
CM	Condition Monitoring
CO	Carbon Monoxide
CRH	Cold Reheat
CW	Cooling Water
DC	Direct Current
DCS	Distributed Control System
DCS max DNA	A type of Distributed Control System Software manufactured by BHEL
DDCMIS	Distributed Digital Control and Management Information System
DEH	Digital Electro Hydraulic
DESH	De Super Heater
DM	De Mineralized
DPR	Detailed Project Report
EE R&M	Energy Efficient Renovation & Modernization
EPC	Engineering, Procurement and Construction
ESP	Electrostatic Precipitator
FD	Forced Draft
GCV	Gross Calorific Value
GoI	Government of India
GRP	Generator Relay Panel
GSECL	Gujarat State Electricity Corporation Ltd.
GT	Generator Transformer
HFO	Heavy Fuel Oil
HPGCL	Haryana Power Generation Corporation Ltd.
HP Turbine	High Pressure Turbine
HVAC	Heating, Ventilation and Air Conditioning
HT	High Tension
ID	Induced Draft

IGV	Inlet Guide Vane
IPBD	Isolated Phase Bus Duct
IP Turbine	Intermediate Pressure Turbine
KBUNL	Kanti Bijlee Utpadan Nigam Ltd.- JV of BSEB & NTPC Ltd
kCal	Kilo Calorie
kW	Kilo Watt
kWh	Kilo Watt hour
LE	Life Extension
LDO	Light Diesel Oil
LLD	Liquid Level Detector
LP Turbine	Low Pressure Turbine
LT	Low Tension
LTSH	Low Temperature Super Heater
MoP	Ministry of Power
MOU	Memorandum Of Understanding
MPPGCL	Madhya Pradesh Power Generation Company Ltd.
MSPGCL	Maharashtra State Power Generation Company Ltd.
MU	Million Units
MW	Mega Watt
NA	Not Available
NDE	Non-Destructive Examination
NGT	Neutral Grounding Transformer
NTPC	National Thermal Power Corporation Ltd.
O&M	Operation & Maintenance
OEM	Original Equipment Manufacturer
PFC	Power Finance Corporation
PG	Performance Guarantee
PRDS	Pressure Reducing and De Superheating
PSPCL	Punjab State Power Corporation Ltd.
PLF	Plant Load Factor
R&M	Renovation & Modernization
RLA	Residual Life Assessment
RLA/CA	Residual Life Assessment / Condition Assessment
SCC	Specific Coal Consumption
SF_6	Sulphur Hexa Fluoride
SOC	Specific Oil Consumption
SPM	Suspended Particulate Matter
ST	Station Transformer
SWAS	Steam and Water Analysis System
TG	Turbo Generator
TOR	Terms of Reference
TPS	Thermal Power Station
UPRVUNL	Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd.
UAT	Unit Auxiliary Transformer
VCB	Vacuum Circuit Breaker
WBPDCL	West Bengal Power Developing Corporation Ltd.

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Executive Summary

In the Indian Power Sector, a large number of thermal power plants are old and have outlived their economical designed life. Many units in such plants are not able to generate power at their rated capacity and efficiency due to their deteriorated conditions. R&M of many of such units has been carried out in order to restore their rated capacities with an aim to improve their Plant Load Factors. The R&M of thermal power units was initiated way back in 1984 in structured manner and has been recognised as a cost effective option for restoring rated capacity in short duration and also to improve their performance parameters together with compliance of stricter environmental norms for environmental improvement. The Life extension of some old units has been done with an aim to extend their useful life by 15-20 years.

The R&M projects are marked with inordinate delays for various barriers including technical surprises, contractual disputes resulting in time and cost overruns. Recognizing the need to address such barriers in Renovation & Modernization of thermal power stations in the country, the World Bank financed the "Coal Fired Generation Rehabilitation Project" together with an objective to demonstrate that Energy Efficiency R&M (EE R&M) at old coal fired thermal power stations is possible with uprating of the units. Under the above project, CEA has implemented the "Technical Assistance Project for Addressing the Barriers to EE R&M of Coal Fired Generating Units in India" and appointed WAPCOS, as a consultant, for the study on "Review of Experiences from Pilot R&M Interventions in Thermal Power Stations in India" with the objective to review the R&M Implementation experience from Pilot R&M Interventions in thermal power stations in India to identify various barriers and challenges encountered in the past R&M projects implemented at various power utilities.

The power utilities have implemented the R&M projects at their units either through awarding the contract to Original Equipment Manufacturer or through competitive bidding. The implementation phase is a very significant part of an R&M project which involves design and engineering of various ordered equipments, supply of equipments, erection and commissioning works during the shutdown period of the unit including addressing of the technical surprises. As such, capturing and sharing of experiences in above aspects in R&M implementation at past R&M projects is of much significance especially for providing guidance and replication of learnings in future R&M projects. The units-1&2 of Ukai TPS, units-9&10 of Obra TPS, units-3&4 of GNDTP Bathinda, unit-1 of Muzaffarpur TPS, unit-5 of Bandel TPS, unit-1 of NTPC Talcher and units-1&2 of Panipat TPS have been covered for review of R&M implementation experience. The WAPCOS experts visited the thermal power stations for capture of the R&M implementation experience through interactions with power plant

engineers and also collected relevant data and information. Based on the interactions, available data/information and feedback obtained in various meetings and Workshop from the members of Task Force on Promotion of R&M, the report on Review of R&M Implementation Experience in Pilot R&M Interventions in India has been prepared by WAPCOS for sharing of R&M Implementation experience at R&M projects on the above units. The review includes the time and cost aspects, technical surprises, contractual arrangements and the performance achieved. This also includes the analysis of project management process and the areas where the actual project implementation deviated from desired objectives with reasons thereof considering implementation experience of various power stations.

During the interaction with various officials in the plant/utility headquarter, it was observed that the studies carried out were generally limited to the main plant only i.e. BTG and comprehensive assessment of the BoP areas was not carried out. The impact of this was reflected in the form of technical surprises or additional scope of work during the project execution resulting into time and cost over-run of the project. It is, therefore, suggested that comprehensive studies for all the major equipments of BTG as well as BoP of the unit should be done.

It has been observed that there has been delay in implementation resulting in time and cost overruns due to various factors such as delay in supply of critical items by the manufacturers, delay in appointment of sub-contractors, lack of sufficient experience of contractors/sub-contractors, contractual disputes and delay in resolution of contractual disputes, additional time taken in replacement of such sub-contractors, inadequate/poor man-power deployment and lack of coordination among various sub-contractors. The delays need to be contained to the minimum through proper planning and monitoring of various activities of the project.

The technical surprises during R&M implementation are inevitable. However, these can be minimized by due diligence done during initial stage of framing of proposals/preparation of Detailed Project Reports (DPR). The DPR needs to be prepared through experienced consultants on the basis of RLA studies. It is recommended to take care of the contractual part by identifying some major areas prone to surprises for which unit values can be kept in the contract to be utilized only if the need arises.

In certain cases, it is observed that normally O&M staff of the plant is entrusted with the additional responsibility of R&M works due to which they are not able to devote full time for the R&M works affecting the quality and timely completion of the work. It is, therefore, very essential to form an independent and dedicated team for executing the R&M works.

Further, it has been observed that in some R&M projects there have been problems in sufficient fund flow resulting in delay of payments to contractors consequently causing delay in R&M implementation. Therefore, allocation of sufficient funds should be made by the utilities well in advance to avoid stoppage of works on account of delay in payments.

It has also been observed that at some of the units, PG test has not been carried out. As such, it is not possible to evaluate the performance of these units. Also, it becomes essential to provide safeguard against shortfall in performance against guaranteed parameters. However, all out efforts should be made to conduct the PG test within three months after the unit gets stabilized.

The study has been done to capture the available experience in implementation for the R&M projects at various old thermal power stations. The experience made available through data/information and interactions during the visits by WAPCOS team to concerned power stations as well as the feedback from members of the Task Force has been consolidated and analysed. The experience has also been shared among the power utilities and other stakeholders during the Workshop organized by WAPCOS. The learnings and suggestions would provide a guidance to power utilities for taking up appropriate advance action for addressing the surprises, barriers, problems and challenges in implementation of the future R&M projects at their thermal power stations.

Chapter-1

Introduction

1.1 Introduction

The total installed capacity of India was 302,087.84 MW as on 31st March, 2016, out of which major share of 185,172.88 MW (61.29 %) is contributed by Coal based thermal power stations. This includes old thermal units commissioned way back in 1970s or even earlier which have already outlived their useful life and also those commissioned in early 1980s.

The following Tables give the status of Power Supply Position in various Regions of the country during the period from April-2015 to March-2016. Despite the installed capacity of more than 3 lakhs MW, there have been shortages in the Peak Demand and energy.

Table: 1.1 Peak Demand and Peak Met (April-2015 to March-2016)

S. No.	REGION	PEAK DEMAND	PEAK MET	Surplus(+)/Deficit (-)	
		MW	MW	MW	%
i	Northern Region	54474	50622	-3852	-7.1
ii	Western Region	48640	48199	-441	-0.9
iii	Southern Region	40445	39875	-570	-1.4
iv	Eastern Region	18076	17972	-104	-0.6
v	North Eastern Region	2573	2367	-206	-8.0
	ALL INDIA	**153,366**	**148,463**	**-4,903**	**-3.2**

Source: Central Electricity Authority (CEA). Lakshadweep and Andaman & Nicobar Islands are stand-alone systems, power supply position of these, does not form part of regional requirement and availability.

It is observed that there was Peak Deficit in all the Regions ranging from 0.6% to 7.1%. The deficit in Northern, Southern and North Eastern Regions was remarkably high compared to other Regions.

Table: 1.2 Power Supply Position (April-2015 to March-2016)

S. No.	REGION	REQUIREMENT	AVAILABILITY	Surplus(+)/Deficit (-)	
		MU	MU	MU	%
i	Northern Region	340,488	324,021	-16,467	-4.8
ii	Western Region	346,650	345,848	-802	-0.2
iii	Southern Region	288,004	283,473	-4,531	-1.6
iv	Eastern Region	124,608	123,635	-973	-0.8
v	North Eastern Region	14,487	13,736	-751	-5.2
	ALL INDIA	**1,114,235**	**1,090,713**	**-23,522**	**-2.1**

Source: Central Electricity Authority (CEA). Lakshadweep and Andaman & Nicobar Islands are stand-alone systems, power supply position of these, does not form part of regional requirement and availability.

While efforts are being made to develop maximum capacity through Central/State Power Sector Undertakings, large capacity additions through Private sector is also envisaged. Though there is full effort both at State and National level to develop new power projects, the R&M of old thermal units is also a cost effective option to bridge the gap in the power supply in the country.

1.2 Renovation & Modernization (R&M)

The objective of Renovation & Modernization (R&M) of thermal power plants is to equip the operating units with latest modified & augmented technology equipment/systems with a view to improve their performance in terms of output, reliability, efficiency and availability, reduction in maintenance requirements, ease of maintenance and minimizing inefficiencies. The R&M Programme is primarily aimed at Generation sustenance and overcoming problems such as rise in Heat Rate, Specific Coal Consumption & Auxiliary Consumption and reduced Gross Generation & PLF etc. The Life Extension (LE) Programme is meant for operation of the plant beyond their original Designed Life, after carrying out life assessment studies of critical components. R&M Programme was initiated in 1984 as a centrally sponsored programme during 7th Plan and the programme continued during the two Annual Plans 1990-91 & 1991-92. The R&M works continued during the 8th & 9th Plan. However, the same could not be sustained during 10th Plan.

Central Electricity Authority (CEA) has prepared a National Perspective Plan for execution of Renovation & Modernization (R&M) and Life Extension (L.E.) works at various State owned Thermal Power Stations in the country. The document in this respect was released by Honorable Minister of Power on 14.12.2009 on the occasion of Energy Conservation Day. The above said Perspective Plan provides for rehabilitation of the old thermal power units with an objective of Efficiency Enhancement, Life Extension, Up-rating and reduction in Greenhouse Gases, emissions by through modification and technology up-gradation. The table gives out the status of R&M and Life Extension upto 11th Plan Period.

Table 1.3: Renovation and Modernization (R&M) and Life Extension Programme (LEP) from 7th Plan onwards till 11th Plan

S. No.	Five Year Plan	No. of Units	Capacity (MW)	Additional Generation Achieved MU/Annum	Equivalent MW*
1	7th Plan	163	13570	10000	2000
2	8th Plan (R&M) (LE)	198 (194) (4)	20869	5085	763
3	9th Plan (R&M) (LE)	152 (127) (25)	18991	14500	2200
4	10th Plan (R&M) (LE)	25 (14) (11)	3445	2000	300

5	11th Plan (R&M) (LE)	72 (59) (13)	16146	5400	820

Source: Quarterly Review Report-Renovation and Modernization of Thermal Power Stations (January-March; 2016), CEA.
**Equivalent MW has been worked out assuming PLF prevailing during that period*

For the 12th Plan, 70 units with total capacity of 12066 MW for L.E. works and 65 Units with a total capacity of 17301 MW for R&M works have been identified as reflected below.

Table 1.4: Renovation and Modernization (R&M) and Life Extension Programme (LEP) for 12th Plan (2012-2017)

S. No.	Category	No. of Units Identified	No. of Units Achieved	Capacity Identified (MW)	Capacity Achieved (MW)
1	LE	70	18	12,066	2131.76
2	R&M	65	11	17,301	2060.50
3	Total	135	29	29,367	4192.26

Source: Quarterly Review Report-Renovation and Modernization of Thermal Power Stations (January-March; 2016), CEA.

1.3 Coal Fired Generation Rehabilitation Project

The World Bank has financed the "Coal-Fired Generation Rehabilitation Project-India" for demonstrating Energy Efficiency Rehabilitation & Modernization (EE R&M) at coal fired generating units through rehabilitation of 640MW of capacity across three States- West Bengal, Maharashtra and Haryana. The project would also try to address the critical barriers to large scale Energy Efficiency R&M in India. The project is funded through IBRD Loan of USD 180 Million and GEF grants 45.4 million out of which 7.5 million have been earmarked to technical assessment/studies. The project has two components viz.

a) Component-1: Energy Efficiency R&M Pilot Projects
b) Component-2: 7.5 million USD have been earmarked for Technical Assistance to address Critical Barriers to EE R&M. The sub-components for the technical assistance program (Component 2) would cover.

i) Support for design of Energy Efficient R&M projects
ii) Support for implementation of demonstration of EE R&M investments funded under Component-1 of the project
iii) Support for addressing barriers to implement EE R&M projects in India
iv) Support for strengthening of institutional capacities of the generation utilities and other relevant sector entities.

1.4 Technical Assistance Project for Addressing Barriers to Implementation of R&M in India

Under the sub-component (iii) of the component-2 (Technical Assistance) around US$ 1.1 million of GEF Grants are being made available to provide technical support to CEA aimed at addressing barriers to implementation of R&M in India. This component was to be

implemented through the Central Electricity Authority through appointments of Consultants including Implementation Support Consultant (ISC) to carry out following studies.

i) Review of Institutional Capacity and Implementation of Capacity Strengthening Interventions at CEA
ii) Reduction of barriers to R&M interventions in thermal power plants in India
iii) Developing markets for implementation of R&M scheme in thermal power stations in India
iv) Review of experience from Pilot R&M interventions in thermal power stations in India

CEA engaged WAPCOS Ltd on 23.07.2012 for undertaking study on "(iv) Review of experience from Pilot R&M interventions in thermal power stations in India". The objective of the study is sharing of experience mainly in procurement, implementation and improvement in performance parameters in Pilot R&M projects and other R&M/LE projects taken up during 11th plan and 12th plan.

The study covered the following activities.

a) Review of Procurement Experience including preparation of DPR, Bidding documents, etc.
b) Review of R&M Implementation Experience
c) Review of Experience in Strengthening of O&M Practices
d) Review of Post-R&M Experience in O&M
e) Dissemination of Learnings from Pilot R&M Interventions

1.5 Objective of the Assignment

The objective of the study is to gather the experience of units which have undergone R&M Implementation. The experience would give the details about the performance of these units in respect of various aspects. In addition, it will also bring out time and cost aspect, technical surprises, project management process of R&M Implementation stage, and how they were able to resolve the problems and challenges occurred during R&M works. In the report all the above aspects are highlighted which would help the other power plants which are planning to go for R&M of old units in future, this would help and guide them in saving time and money.

1.6 Scope of Work of the Assignment

a) Broadly, the review would include inter-alia the time and cost aspects, technical surprises, contractual arrangements and the performance achieved. The Consultant shall cover R&M Implementation Experience available at the above mentioned thermal power stations till two months before the scheduled timeline for submission of Draft Final Report on this activity.
b) The review of the R&M Implementation experience shall also include the analysis of project management process and identify the areas where the actual project implementation deviated from desired objectives and analyze the reasons for such deviations.
c) The Consultant is required to visit the selected thermal power stations to collect and compile the relevant information & documents to undertake the desired review and analysis.

d) Based on the review of R&M implementation experience, the Consultant shall prepare a report on R&M/LE Implementation Experience which may be helpful to the generating companies for carrying out the R&M works in future.

Under the assignment, the following thermal power units have been considered for review of implementation experience at the R&M projects.

Table 1.5: List of Thermal Power Stations considered for review of R&M Implementation Experience

S. No.	Unit No	Capacity (MW)	Thermal Power Station (TPS)	Name of Utility/State
1	1 & 2	2x120	Ukai TPS	GSECL/Gujarat
2	9 & 10	2x200	Obra	UPRUVNL/ Uttar Pradesh
3	3 & 4	2x110	Bathinda TPS	PSPCL/Punjab
4	1	1x110	Muzaffarpur	KBUNL/Bihar
5	5	1x210	Bandel TPS	WBPDCL/West Bengal
6	1	1x110	**Talcher TPS	Odisha
7	1 & 2	2x110	Panipat	HPGCL/ Haryana

** As per the meeting held at CEA on November 08, 2012 and Minutes of Meeting communicated by CEA vide their letter no. 2/52/TRM/CEA/2012/1888 dated 21.11.2012, Koradi TPS Unit 6 (1x210 MW) has been replaced by Talcher TPS Unit 1 (1x110 MW) for review of R&M Implementation Experience.

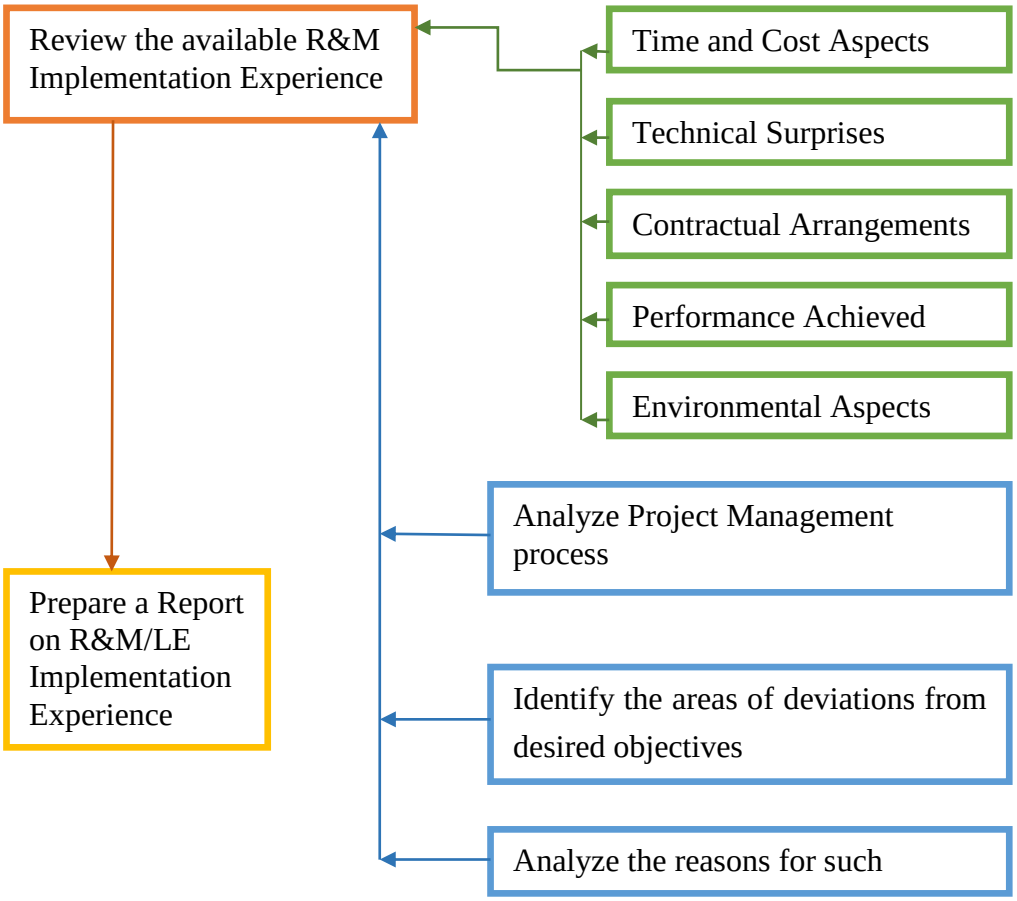
Chapter-2

Approach and Methodology

2.1 Approach and Methodology

WAPCOS Experts visited the thermal power stations to collect the relevant data/information for review and analysis relating implementation of R&M works of units in the thermal power stations as per Annexure-II of Appendix-A of the Contract. The following procedure was adopted by WAPCOS for execution of the assignment. The following Flow Chart briefly describes the.

a) Procedure for review:



b) Review of R&M Implementation Experience:

The review also covered time and cost aspects, technical surprises, contractual arrangements and the performance achieved. It also covered the R&M implementation experience available at the thermal power stations listed under the study. The review includes the analysis of project management process and identify the areas where the actual project implementation deviated from desired objectives and analyze the reasons for such deviations.

c) A questionnaire was circulated to the concerned power utilities and the thermal power covering the following aspects for collection of data/information:

I. Time & Cost Aspects
   i. Scope of works
   ii. Stipulated time in the contract for completion of various R&M works/activities
   iii. Actual time taken for completion of various R&M works/activities.
   iv. Whether there was any delay in executing the job. If yes, then for how much time it got delayed. Reasons for delay to be brought out.
   v. Total cost of R&M works along with Package wise /Item wise cost and analysis of Cost Over-run
   vi. Quantum of Penalty imposed on the Contractor if any

II Technical Surprises
   i. The type of technical problems encountered.
   ii. Steps taken to address the problems.
   iii. Whether help of any outside Agency/Expert taken to solve such problems.

III. Contractual Arrangement
   i. Whether it was a Turnkey job or the contract was divided into various packages
   ii. For awarding the contract, what practice was followed i.e. through press Tender or Limited Tender Enquiry or ICB
   iii. Names of various Tenderers who executed the jobs.
   iv. Whether credentials of various contractors were checked before issue of Tender documents and whether they fulfilled the Tender condition etc.
   v. Whether work was executed under the supervision of Project authorities or contract supervision was taken from outside agency
   vi. What was the penalty clause & if any, whether the same was imposed on the contractor for any delay or not
   vii. Whether all the contractors executed the work as per condition laid in Work Order or any breach of contract was there.
   viii. Whether PG tests were conducted. If yes, what is the status.
   ix. Whether any work was got done at the risk & cost of contractor or not
   x. Any disputes with the contractors

IV. After R&M works, what was the performance of each Unit in respect of important parameters such as PLF, Oil Consumption, Coal Consumption, DM Water Consumption, Auxiliary Consumption, Heat Rate, Reduction in no. of tripping, environment aspect etc. In case Guaranteed Performance not achieved, then what penalty was imposed/realized.

V. From Management view, what was the organization chart, Bar Chart, PERT etc. Whether the works were done according to that or slippage was there, Whether Supervisory services of outside Agency were taken. What was the Schedule of Review Meetings i.e. whether it was held weekly, fortnightly, monthly to assess the work progress.

VI. Whether various works were executed as per the contract or not. If not, the reasons for deviations to be examined. What were the barriers causing such deviations? WAPCOS Experts also conducted the review of the Environmental Monitoring

d) The listed thermal power stations were visited to interact with the concerned Project Authorities for discussion and collection of relevant data/information. The Table below gives the details of visits to thermal power stations made by the WAPCOS Team.

Table 2.1: Visits to Thermal Power Stations

S. No.	Unit No	Capacity (MW)	Name of Thermal Power Station (TPS)	Name of Utility/State	Date of Visit
1	1& 2	2x120	Ukai TPS	GSECL, Gujarat	28.10.2015 to 31.10.2015
2	9 & 10	2x200	Obra	UPRUVNL, Uttar Pradesh	22.11.2015 to 25.11.2015
3	3 & 4	2x110	Bathinda TPS	PSPCL, Punjab	18.10.2015 to 21.10.2015
4	1	1x110	Muzaffarpur	KBUNL, Bihar	26.11.2015 to 28.11.2015
5	5	1x210	Bandel TPS	WBPDCL, West Bengal	28.01.2013 to 30.01.2013 and 05.10.2015 to 09.10.2015
6	1	1x110	Talcher TPS	Odisha	Collected from NTPC Corporate Office, NOIDA
7	1& 2	2x110	Panipat	HPGCL/ Haryana	27.09.2012 to 29.09.2012 and 14.09.2015 to 16.09.2015

e) WAPCOS made presentation on the draft report prepared in the meetings of the Task Force on Promotion of R&M of thermal power stations in India.

f) Based on the review of R&M implementation experience and the available data/information, report on R&M/LE implementation experience has been prepared.

2.2 Dissemination of Learning from Pilot R&M Projects and other R&M Projects:

In order to disseminate the learning and experiences WAPCOS in association with CEA conducted a workshop in Delhi on 3rd February 2017 which was attended by authorities from various utilities and firms like CERC, World Bank, WBPDCL, HPGCL, MSPGCL, NTPC, PSPCL, UPRVUNL, GSECL, MPPGCL, KPCL, RRVUNL, OPGC, BHEL, KBUNL and ABPS Infra Ltd.

Chapter-3

Renovation & Modernization

Life assessment and life extension program helps to identify and implement strategies so as to ensure continued operation of the unit in a cost-economical way beyond the designed economic plant life. A team effort is needed between the utility and designer to ensure safe continued operation of steam generators with minimum unscheduled outages. A complete analysis combining the unit's operational data with design expertise and problem solving knowledge is a basic requirement for success of the R&M project.

3.1 Stages of R&M Cycle:

The various stages involved in R&M of a thermal power station are described below:

i. Early R&M Planning

The plant/units for implementation of R&M works are identified after analysis of the performance of the units. Key parameters such as Heat Rate, PLF, Auxiliary Power Consumption, Specific Coal Consumption, Specific Oil Consumption, Environmental Emissions etc. are regularly monitored. Identification at this stage is primarily on the basis of historical data of various performance parameters.

ii. R&M Project Assessment

During this stage, R&M project scope is defined keeping in view available data, results specialized testing and analysis, RLA/LE studies and cost-benefit analysis. Thermal power plant equipments are designed for about 25 years of operation as these are working under high Temperature and Pressure leading to metallurgical deterioration of the metals after prolonged operation. Apart from this, there may be early failures due to deviations in operation practices. As such, before undertaking any preparation of R&M project, assessment of the extent of equipment ageing/deterioration/residual life etc. needs to be made for which following studies/tests are required to be conducted for identification of the scope of R&M works:

a) Residual Life Assessment (RLA)
b) Energy Audit
c) Condition Assessment

iii. Development of Procurement Strategy

After defining the scope of R&M project, design specifications and different packages are decided. The procurement strategy covers Tendering, Pre-bid meetings, Evaluation of Technical and Commercial bids, Negotiation proceedings and finally award of work to suppliers/manufacturers in case of competitive bidding. In some cases, R&M works are awarded to the Original Equipment Manufacturers.

iv. R&M Project Implementation

The following activities are involved in implementation of R&M Projects:

a) Ordering of material required for R&M works and issue of work order for execution
b) Inspection of material
c) Receipt of material at site

d) Planning of Unit shutdown
e) Monitoring work

3.2 Residual Life Assessment and Conduction Assessment

The Residual Life Assessment and Conduction Assessment of various critical components of the thermal power unit is done to assess their remnant life. Since, the components are subjected to high temperature and they may prematurely fail due to unforeseen, stress concentrations and excessive temperature, corrosive and erosive environment. Local conditions and operational factors associated with the particular unit dictate the type and extent of damage in a component. Hence, even though a station has units of similar type, each unit needs independent study so that precise status of each component can be established.

Under the present conditions of escalating construction cost and environmental regulation, the option to extend the service life of the steam generating equipment is important to power utilities. Boiler pressure parts like super-heater tubes, steam pipes and headers operating in the creep range are designed for certain minimum lifetime. As units age, critical components may distress through mechanisms such as oxidation, corrosion, creep, fatigue and interaction of the above mechanisms. These components deteriorate continuously during service as a result of the above time dependent material degradation processes. A variety of techniques have been developed for the RLA/CA and applied to several real life case studies. Various methods of remaining creep life assessment may be classified into two categories.

a) Methods based on the operational history in which the expanded life of a component is calculated on the basis of operational history and standard material properties.
b) Methods based on post service examination and/or testing on the actual component. Since the lower bound stress-rupture properties are considered in the absence of precise knowledge of the material positioning with reference to the standard data, operational history based approach leads to pessimistic life assessment. However, such an exercise would be very useful in identifying the critical components that require closer surveillance.

3.3 RLA Methodology adopted for Boiler

The methodology begins with assessment of current condition, comparison of original to current design technology, review of history cards, visual inspection and NDE [Non-destructive Examination] tests at site during outage of the unit. Various examination techniques as detailed below are carried out during shutdown of the unit to evaluate the condition of the equipment. Specific sampling and analysis at laboratory is carried out for further evaluation of the components under study. The examinations are carried out in accordance with established and internationally accepted procedures using special equipment wherever necessary.

Approach for life assessment study involves review of operational history of equipment and analysis of records such as maintenance, overhaul, failures etc. This also requires visual & non-destructive examination, Dimensional Measurements and uniaxial creep rupture test. Assuming oxidation rates for a specific period, the average stress can be calculated for the ageing duration considered. With average stress value Larsen- Miller parameter can be

calculated for the particular material. With the Larsen - Miller parameter rupture life can be calculated using metal temperature values.

3.4 RLA for Turbine

3.4.1 Detailed metallurgical non-destructive examination is carried out on following parts of turbine.

i) Turbine Rotor shafts, discs, disc body attachment area, steam gland fins, inter stage sealing fins, thermal grooves, bores and journals.
ii) Moving Blades, shrouds and Tenons
iii) Casings – inner and outer, flanges, stubs, integral pipe welds
iv) Steam pipes – 'J' pipes, omega pipes, Main Steam and extraction pipes
v) Guide blades & carriers, turning segments, nozzle boxes, and gland boxes
vi) Valve assembly – Steam Strainers, Spindles, Valve Cones and diffusers
vii) Parting plane bolts, coupling bolts and other fasteners
viii) Bearing Assembly – Pedestals and Shells

3.4.2 The field investigation techniques adopted and the findings were time to time appraised on-the-spot to the concerned power plant executives, so as to enable them to take necessary action before boxing up of the TG set. The various Visual, Metallurgical and Non-Destructive Techniques employed are as under:

a) Visual Inspection

The components are first subjected to visual examination before and after cleaning their surfaces, using optical aid like illuminated magnifying glass, wherever found necessary, for features like gross dimensional changes, corrosion, pitting, breakage and cracks.

b) Non-Destructive Testing

The following Non-Destructive Testing techniques are adopted:-

a. Dimensional Measurements
b. Fluorescent/Dye Penetrant Test (DPT)
c. Wet Fluorescent Magnetic Particle Inspection (WFMPI)
d. Ultrasonic Test (UT)

c) Metallographic Examination

The following metallographic examination techniques are adopted:-

i. Surface Plastic Replication:

Metallographic examination by surface replication technique is carried out to assess the current microstructure condition of the components. Field replication technique is widely used as it is totally non-destructive in nature and is known to reproduce accurately the metallographic features such as distribution, size and morphology of the carbide precipitates and the micro-voids associated with the early stage of creep damage. In this technique, each of the spots chosen for examination is finely polished using portable Metallographic surface preparation equipment, etched with 3%.

ii. Hardness Measurements (HRD):

Hardness measurements provide a useful indication of the extent of microstructure degradation due to thermal exposure and creep damage in components operating at high temperature and pressure. In-situ hardness measurement is performed at selected locations prepared for surface replication.

Chapter-4

R&M Implementation Experience

R&M Implementation Experience study was carried out by visiting, collecting and interacting with the Thermal Power Plant authorities. R&M implementation experience at seven power stations of Pilot R&M Projects listed was reviewed. A Check List/Questionnaire prepared at the initial stage was supplied to the Project Authorities for collecting the available data/information in the form of Annexure-III. WAPCOS Experts visited all the Power Stations listed under the study. The Team conducted the analysis and review of various aspects of implementation R&M project which broadly covered the time & cost aspects, technical surprises, contractual arrangements, performance achieved, analysis of project management process and identifying the areas where the actual project implementation deviated from desired objectives and analyze the reasons for such deviations.

The questionnaire broadly covered Zero date of R&M project, Project schedule planned as well as actual achievement of the same. Data related to RLA study its findings and suggestions, brief scope of work, current status of the project.

Time and Cost aspects of the projects is covered in detail in the following chapters. Technical surprises encountered during R&M implementation in all the areas covered and the remedial measures taken. It also covers the project management process, the authorities involved in the project execution, key milestones achieved. It also covers problems faced due to contractor/sub-contractor, labor issues etc.

Definitions of some important terms:
Time Gap: It is defined as the time between DPR approval/acceptance and award of contract.
Zero Date: It is defined as the date of award of contract.
R&M Implementation Period: It is defined as the duration from Zero Date up to unit synchronization.
Lead Period: It is defined as the duration from Zero Date to unit shutdown date.
Shutdown Period: It is defined as the actual duration from unit shutdown up to unit synchronization.

4.1 Unit# 1 & 2 (2x120 MW) Ukai Thermal Power Station, GSECL, Gujarat

4.1.1 Background

The Ukai Thermal Power Station (UTPS) is owned and operated by Gujarat State Electricity Corporation Ltd. (GSECL). The station has total installed capacity of 850MW which is comprised of 2x120MW units each (unit#1&2), 2x200MW units each (unit#3&4) and 1x210MW (unit#5) and it is located near Ukai Dam on Tapi River in Tapi District of Gujarat. Ukai TPS unit no. 1 & 2 (2x120MW) were commissioned during the year 1976.

Both the units had completed their useful life of 20 years and were not operating at rated capacity. The units had low PLF and low efficiency. Both the units were in need of performance improvement and life extension of the plant particularly considering deterioration in coal quality, turbine problems like bending of HP rotor, HP & IP high eccentricity, poor turbine efficiency, boiler problems like frequent economizer tube failure, ID fan overloading, air ingress in the furnace, lower collection efficiency of ESP. the control system supplied by Instrumentation Limited was based on Russian technology, which was obsolete, and spares were not available in market and also with ILK, the original supplier. Most of auto control loops were not working. The machines were operating at low PLF of 56.5% and with higher station heat rate.

The contract was awarded to BHEL for carrying out comprehensive Residual Life Assessment (RLA), Condition Assessment (CA), and Performance Evaluation Test (PET) of 2x120MW units. RLA/CA of unit 1&2 was completed by BHEL during forced outage from 01.08.2003 to 30.04.2004 for unit-1 and during capital overhauling from 27.02.2003 to 17.06.2003 for unit-2. Final report of RLA/LE study was submitted by BHEL for both the units.

Proposed R&M works based on RLA/CA & PET recommendations and the scope of work had been concluded through protracted discussions/interaction with GSECL Engineers/Officers of P&P Department, Generation Department and site engineers by BHEL. Based on RLA study recommendations, discussions and negotiations, R&M and LE activities were finalized for achieving rated capacity of 120MW, life extension post R&M by 15-20 years and modernization of C&I by state-of-art Distributed Digital Control and Management Information System (DDCMIS). In order to operate the plant optimally and improve the PLF and availability, it was recommended to change the existing instrumentations to modern microprocessor based and Distributed Digital Control System (DDCS) along with field instruments, SWAS, UPS, emission monitoring system and instrument cables.

4.1.2 Scope of R&M/LE Works

The broad scope of supply covered design, engineering, manufacturing, inspection, factory testing, packing and forwarding and supply of O&M spares for boiler & auxiliaries, turbine-generator & auxiliaries, C&I, BoP and Electrical systems. The scope of services included unloading, storage, material handling at site, insurance, dismantling, erection, testing and commissioning of system/equipment. Performance Guarantee Test of boiler, turbine, C&I and BoP packages were also included in the scope of M/s. BHEL after the final commissioning of the units. The scope of work for carrying out renovation and modernization of major packages were as under.

a) Boiler & auxiliaries:

Replacement of water wall tubes, economizer coils/tubes, super heater tubes etc. included in this package was done.

b) Turbine & auxiliaries:

Replacement of turbine bearing numbers 1 through 7, replacement of inner and outer casing of HP turbine, replacement of rotor of IP and LP turbines, replacement of cartridges of BFP and replacement of CEP pump was done.

c) Generator:

Stator coil were rewound with Class F insulation and slip ring assembly was replaced.

d) Balance of Plant:

Fire Detection System with up gradation by installing new pumps in fuel oil station, replacement of air compressors, installation of new HVAC system, up gradation of ash handling system, water system, water treatment plant, make up water system and coal handling plant were included for R&M.

e) Electrical:

Replacement of 6.6kV VCB (Vacuum Circuit Breaker) circuit breakers used for operation of HT motors.

f) Control & Instrumentation:

Replacement of old control system with new Max DNA Distributed Control System (DCS) supplied by BHEL. Max DNA is a type of DCS developed by BHEL.

Table 4.1: Target Values after R&M for Ukai TPS

S. No.	Parameter	Target Values
1	Boiler Efficiency	85.5%
2	Heat Rate	2122+0.9% kCal/kWh
3	ESP outlet dust emission level	125 mg/Nm^3
4	Plant Availability	85% for first year

4.1.3 Time and Cost Aspects

The time aspects of the R&M works carried out at Unit#1&2 of Ukai Power Station was as follows.

Table 4.2: R&M Implementation Schedule for Unit# 1 of Ukai TPS

S. No.	Milestones	Target Date/ Month	Actual Date/Month
1	Date of RLA Study	Not Available	October 2003
2	Zero Date of R&M Project	29.03.2005	29.03.2005
3	Date of Shutdown for R&M	06.09.2005	06.09.2006
4	Date for completion of R&M works	28.11.2006	24.05.2008
5	Hydro Test	Not Available	01.09.2007
6	Boiler Light Up	Not Available	04.09.2007
7	Synchronization	28.11.2006	24.05.2008

Table 4.3: R&M Implementation Schedule for Unit# 2 of Ukai TPS

S. No.	Milestones	Target Date/ Month	Actual Date/Month
1	Date of RLA Study	Not Available	March 2003
2	Zero Date of R&M Project	29.03.2005	29.03.2005
3	Date of Shutdown for R&M	Not Available	12.08.2008
4	Date for completion of R&M works	28.06.2007	24.02.2010
5	Hydro Test	Not Available	February 2010
6	Boiler Light Up	Not Available	February 2010
7	Synchronization	28.06.2007	24.02.2010

As per contract the original duration of project for both the units was planned for 27 months for both the units from zero date out of which the 7 months was allocated for each unit shutdown i.e. for Unit-1 it was scheduled from 14th month to 20th month and for Unit-2, shutdown was scheduled from 21st month to 27th month but actual time taken to complete overall project was 59 months. The actual R&M implementation period of unit-1 was 38 months and that of unit-2 was 59 months. The Lead Period unit-1 was scheduled as 14 months and for unit-2 it was 20 months. Unit-1 was actually kept under shutdown for 20.5 months and unit-2 was under shutdown for 18 months. The project of both the units was mainly delayed due to delay in supply of critical materials by M/s. BHEL, performance of some of the sub-contractors were not up to the mark and some sub-contractors left the site without completing the works assigned to them and their replacement with new ones took long time.

Cost Aspect:

Competent authority had accorded an administrative approval for implementing major R&M and LE works and accepted BHEL's negotiated offer of ₹260/- crores (₹1.08/- crore per MW) for awarding R&M and LE works contract to M/s. BHEL being OEM on negotiable offer manner without inviting any tender as per Ministry of Power guidelines. The contract was awarded to M/s. BHEL for supply, erection, testing and commissioning of both the units, i.e. Unit# 1&2 as shown below: -

Table 4.4: Cost of R&M for Both the units of Ukai TPS

S. No.	Item	Estimated Cost (₹ Crores)
1	Supply of Material	210.05
2	Service	46.95
3	Civil Work	3.0
Total		**260.00**

70% of the fund for R&M/LE works was allocated by Power Finance Corporation, New Delhi at the prevailing norms of the PFC and balance funds were allocated from annual plan of the Gujarat Electricity Board. There was no cost overrun for this project.

4.1.4 Project Management Process

The project management process included description about the project execution team and in-charges of the concerned areas including that of the contractors also, package-wise subcontractors, coordination between project authorities and sub-contractors and any issues related during execution of the project like labor unrest etc. Drawings were approved before various works of R&M. The contractor submitted L1, L2 and L3 schedule prior to the project startup. Supply management was looked after by dedicated R&M team of the project.

Table 4.5: General Information

General Information	Unit-1	Unit-2
R&M Team for implementation of R&M Project.	A.C.E. (R&M), S.E.(R&M), E.E. (R&M), D.E & J.E (R&M)	
R&M Team of Contractor.	Every work package handled by supervisors and assisted by suitable engineering team	
Names of Sub-contractors-Package wise	As per Table 4.6 below	
Project Monitoring Process being followed	Through Consultant: Monitoring was carried out by authorized consultant M/s. Lahmeyer International, Gurgaon	
Issues related to Decision making, if any	Project authority jointly with consultant	
Whether all Contractors executed the work as per conditions laid in Work Orders or there was any breach of contracts	Yes, as per work order. No breach of contract	

Table 4.6: List of Sub-Contractors

Unit No. 1	Unit No. 2
a) Boiler & Auxiliary For Acid Cleaning Work M/s Aruchem, Chennai For Fabrication Work Panjab Engg. Sonagadh K. Ismil, Ukai **b) Turbine & Auxiliary** For Insulation Work M/s Om Insulation, Vadodara For Insitu. Machining Work M/s Stimex Engineers, Indore (MP) For Reaming Works M/s Sing Tools, Gajiabad (UP)	**a) 6.6 kV Switchgear** i. M/s Shraddha Factories, Sonagadh **b) Electrical Overhauling** i. M/s Masion Electricals, Delhi ii. M/s Shrddha Factories, Sonagadh iii. M/s Shanu Enterprise, Vyara **c) Ash Handling System** **Erection Work** i. K. Ismile, Ukai ii. M/s Engineering India Ltd., Sonagadh **d) Civil Work** M/s AB Engineers, Gandhi Nagar **e) Cable Tray Work** Roshni Engg. Ukai **f) For Water Treatment System** i. M/s IST, Sonagadh ii. Raj Engineering Surat **g) Coal Handling System** i. M/s Spectrum Engg. Vadodara ii. M/s Engineering India LTD., Sonagadh iii. M/s Chandra Construction, Bhopal

To execute the project properly and to coordinate between authorities and sub-contractors, regular meetings were held for project monitoring. Following table depicts the coordination.

Table 4.7: Coordination

S. No.	Description	Unit-1	Unit-2
i)	Scheduled of meeting held for monitoring the progress of work	Internal meetings were held almost daily	
ii)	Coordination among the utility and contractor	Meeting of project authority, main contractor & subcontractors were held	
iii)	Coordination among sub-teams of the contractor	Meetings done by main contractor M/s. BHEL	
	Issues & Problems faced		
i)	Any Labor Unrest during execution of work	No labor unrest	
ii)	Any other Issues	No other issues	

4.1.5 Technical Surprises

No major technical surprises occurred as per the plant authorities.

4.1.6 Problems/Challenges faced After R&M

Unit # 1

a) Temperature of Turbine bearing number 3 was constantly high during commissioning.
b) Up to 114MW load, two BFPs were running and thereafter to increase the load up to 120MW, three BFPs were required to run, despite the fact that the third BFP is standby equipment which is not run in normal times.
c) One CEP (Condensate Extraction Pump) was not able to maintain the De-Aerator level, therefore both of the CEPs were kept in running condition
d) Due to running of all three Boiler Feed Pumps and both the Condensate Extraction Pumps, the Auxiliary Power Consumption of the Unit has gone up.
e) High horizontal and vertical vibrations observed in Generator bearing numbers 6 and 7.
f) CBD (Continuous Blow Down) was kept continuously opened due to higher value of Silica content in steam.

Unit# 2

a) Eccentricity of HP Turbine was high
b) Bearing metal temperature of Turbine bearing numbers 3, 6 and 7 was high.
c) Two BFPs are not able to maintain the Boiler drum level at 120MW load therefore all three of them were kept in running condition.
d) One CEP was not able to maintain the De-Aerator level, therefore both of the CEPs were kept in running condition
e) Due to running of all three Boiler Feed Pumps and both the Condensate Extraction Pumps, the Auxiliary Power Consumption of the Unit was high.

4.1.7 Contractual Arrangements

The R&M contract was awarded to BHEL as they were the OEM of the plant. The liquidated damage was fixed as performance LD. There was the provision for performance guarantee tests in the contract as described below:

a. Liquidated Damage (LD)

Delay in supply of material beyond contractual schedule was subjected to liquidated damage (LD) at the rate of 0.25% of the order value of the respective unit of delayed material per week or part there of subject to maximum ceiling of 7.5% of total order value comprises of supply of materials, services and civil works for respective unit including BoP and Electrical. In case of failure of guaranteed performance parameters, LD charges were fixed at following rates.

Table 4.8: Liquidated Damage for Failure of Guaranteed Parameters

S. No.	Parameter Name	Parameter Value	LD in ₹
1	Output Power	120MW	₹26285/- for every kW shortfall in output power
2	Turbine Heat Rate	2122+0.9% kCal/kWh	₹53200/- for every kCal/kWh increase in guaranteed turbine heat rate
3	Boiler efficiency	85.5%	₹273000/- for drop of every 0.1% in efficiency
4	Collection efficiency of ESP	99.764%	₹273000/- for drop of every 0.1% in efficiency

The actual amount of LD recovered was ₹ 3.23 Crores/-.

b. Performance Guarantee (PG) Test

PG test on both units were to be conducted as per contract to prove the performance parameters within one month of commissioning based on mutually agreed PG test procedures, comprising of following points. However, the PG test has not yet been conducted since the unit failed to achieve the full load of 120MW and there is still some dispute going on between GSECL and BHEL officials.

(a) ESP Dust concentration of 125 mg/Nm^3 at outlet with 99.76% collection efficiency at 100% MCR with 12 fields in service.
(b) Gas distribution test inside ESP
(c) Gas flow measurement for / through the ESP
(d) Clean airflow test for Mills
(e) Performance test for auto control loops including ramp and step tests
(f) Condenser vacuum test

4.1.8 Performance Achieved

a. Benefits anticipated after implementation of R&M works

After implementation of R&M/LE works the generation was anticipated to increase by 30 MW per unit and station heat rate was anticipated to decrease from 2881.52 to

2481.87 kCal/kWh i.e. decrease in heat rate by 399.65 kCal/kWh and life of the units would be extended by further 15-20 years. This would also improve the plant load factor (PLF) from 56.5% to 80%. The payback period worked out to be 4 years & 4 months.

b. Performance Achieved

Unit-1 R&M was done from 06/09/2006 to 24/05/2008. The performance of Unit-1 before and after R&M is stated below. The Pant Load Factor (PLF) of 80% was to be obtained as planned after R&M works. The performance of 120 MW Unit # 1 & 2 before and after R&M Implementation, is given below.

Table 4.9: Unit-1 performance Pre and Post R&M of Ukai TPS

Pre R&M						
Parameter	**Gross Generation**	**PLF**	**APC**	**SOC**	**SCC**	**Heat Rate**
Period	**MU**	**%**	**%**	**ml/ kWh**	**kg/kWh**	**kCal/ kWh**
2004-05	285.35	27.15	10.85	6.4	0.67	2765
2005-06	573.23	54.53	8.91	1.02	0.69	2879
2006-07	219.78	20.91	12.87	3.03	0.71	2978
Post R&M						
2008-09	157.886	24.53	14.46	66.81	0.54	2793
2009-10	532.732	50.68	10.85	12.83	0.88	2813
2010-11	694.32	66.05	11.46	8.088	0.76	2995
2011-12	626.29	59.41	10.81	1.46	0.74	2835
2012-13	493.99	46.99	10.69	4.44	0.733	2835.03
2013-14	222.44	21.16	12.38	2.12	0.735	2821.51

From the above Tables it can be observed that only PLF has improved, but no significance improvement in other parameters. The Specific Oil Consumption (SOC) value just after R&M is seen very high at 66.81 ml/kWh. The reason was due to frequent tripping of the Unit, as many as 62 times, during the year 2008-09 and Unit start up thereafter.

Table 4.10: Unit-2 performance Pre and Post R&M of Ukai TPS

Pre R&M						
Parameter	**Gross Generation**	**PLF**	**APC**	**SOC**	**SCC**	**Heat Rate**
Period	**MU**	**%**	**%**	**ml/kWh**	**kg/ kWh**	**kCal/ kWh**
2004-05	517.57	49.24	10.49	3.4	0.66	2723
2005-06	569.59	54.18	9.38	3.28	0.68	2876
2006-07	477.02	45.38	10.94	3.43	0.71	2990
Post R&M						
2010-11	694.32	66.05	11.46	8.088	0.74	2995
2011-12	739.06	70.11	10.27	1.032	0.734	2809.7
2012-13	607.71	57.81	10.87	1.406	0.734	2827.6
2013-14	128.95	12.26	13.19	1.145	0.75	2854.5

The above Table shows that only Gross Generation, PLF and Specific Oil Consumption (SOC) improved after R&M Implementation but other parameters remained more or less same.

4.1.9 Overall Remarks

It was suggested by the utility that major R&M of 120MW units needed to be dropped and were to be phased out and Sub-Critical units of adequate capacity could be contemplated. Based on the bad experiences of 120MW sets of Ukai TPS, major R&M of 120MW sets of GTPS have been dropped by GSECL. Critical materials were not supplied by BHEL as per the order schedule. Performance of some of the sub-contractors was not satisfactory. Some sub-contractors left site without completing the work assigned to them and their replacement with new ones took longer time.

4.2 Unit# 9 & 10 (2x200 MW) Obra Thermal Power Station, UPRUVNL, Uttar Pradesh

4.2.1 Background

The Obra Thermal Power Station is owned and operated by Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd. The station has total installed generation capacity of 1288MW which is comprised of 5x50MW (unit nos. 1 to 5), 3x100MW (unit nos. 6 to 8) and 5x200MW (unit nos. 9 to 13). The unit numbers 3, 4, 5 & 6 have been declared obsolete and the capacity of unit numbers 7 & 8 has been de-rated to 94MW from 100 MW. It is located in Sonbhadra District of Uttar Pradesh. Obra TPS unit number 9 and 10 (2x200MW) were selected for renovation and modernization works. Both the units had completed their useful life of 20 years and were not operating at rated capacity. Their PLF was also low with less efficiency.

Obra TPS unit 9 and 10 were taken for R&M and LE Programme. The contract was awarded to BHEL for carrying out comprehensive Residual Life Assessment (RLA) study of boilers of 2x200MW units. NTPC Ltd. was appointed as consultant for this project. RLA study of boiler of unit 9 was conducted by BHEL during 06.03.2007 to 13.03.2007 and that of unit 10 was done from 23.08.2006 to 04.09.2006. Final report of RLA/LE study was submitted by BHEL for unit 9 in March 2009 and that of unit 10 was submitted in August 2006. The R&M project was funded by Power Finance Corporation, New Delhi.

The RLA study was conducted for boilers of both the units following the scope of work as per IBR regulation. The boiler parts included were low temperature high thickness pressure parts, boiler pressure parts including tubing/coils and high temperature high thickness pressure parts. The RLA study of unit-9 boiler indicated that certain components viz. complete water wall, water wall platen coils, extended water wall, water wall hanger and screen tubes, SH radiant roof tubes, second pass SCW roof tubes, LTSH coils including terminal tubes, SH hanger and screen tubes, Platen SH and RH coils including steam cooled spacer, Platen SH inlet and outlet headers, RH inlet and outlet headers, LTSH (Low Temperature Super Heater) outlet header and DESH (De-Super Heater) were recommended for replacement during R&M for improving reliability and availability of boiler. The RLA study of unit-10 indicated that certain components viz. complete Water

Wall and extended Water Wall, Platen Water Wall, Water Wall hangers and screen tubes, Roof tubes, LTSH tubes, Platen SH and RH coils including steam cooled spacer, Platen SH inlet and outlet headers, RH inlet and outlet headers and DESH were needed to be replaced during R&M of this units.

4.2.2 Scope of Work for Unit-9 & 10

The scope of work included dismantling of old equipment except ESP, repair, servicing, replacement, erection, painting, testing, performance guarantee and commissioning of plant and handling over of units viz. Boiler, Turbine, Control & Instrumentation, Generator & Exciter, Balance of Plants such as CW Pump House, Switchgears, HT/LT motors etc. and ESP (new replacement however, civil work of ESP was done by UPRVUNL) in respect of refurbishment or overhauling, renovation, modernization and up rating of 5x200 MW units of Obra Thermal Power Station. BHEL (Contractor of R&M) was responsible for comprehensive insurance, Port and custom clearance and inland transportation etc. for imported items. To and fro transportation of any equipment which were required to be refurbished or overhauled at manufacturer's premises was also in the scope of work. Based on RLA/ LE study recommendations, discussions and negotiations, R&M and LE activities were finalized for achieving following parameters.

Table 4.11: Target values of Obra TPS

S. No.	Parameter	Target Values
1	Output Generation (Unit 9)	216 MW
2	Output Generation (Unit 10)	200 MW
3	Turbine Heat Rate (Unit 9)	2007.6 kCal/kWh
4	Turbine Heat Rate (Unit 10)	2040 kCal/kWh
5	ESP outlet dust emission level	100 mg/Nm^3
6	Collection Efficiency of ESP	99.827%
7	Auxiliary Power Consumption	<9%

a. General

Replacement of ceiling support structures, refractory and insulation, HP & LP valves, root valves, feed control valves in both high capacity and low capacity lines, drum safety valves, RH safety valves, straight piping of 20m length in MS, CRH & HRH piping. Replacement/correction of buck stays, vertical channel and corner links was done.

b. Boiler Pressure Parts

100% replacement of water wall along with water wall inlet and outlet headers is done. Overhauling/repair/replacement of damaged parts of Boiler drum internals was done. 100% replacement of Economizer assemblies along with inlet and outlet headers with supports was considered. Complete replacement of Platen super heater, Final super heater, Low Temperature Super Heater, Ceiling Super Heater and Wall Super Heater was done along with Super Heater Headers. 100% replacement of Reheater assemblies with headers and supports was done because of frequent failure of Reheater tubes.

c. Air and Flue gas system

100% replacement of baskets, seals, sector plates and gear box was done. Overhauling of PA system along with replacement of shaft assembly, impeller assembly, flange bearing

with bearing housing assembly, external bearing and bearing housing assembly, shaft seals, expansion joints, IGV assembly and coupling. Repair of cold air ducts was done. 100% replacement of hot primary and secondary air ducting along with supports & insulation was done. 100% replacement of flue gas ducting along with supports & insulation was done. All the dampers in cold and hot air ducts and in flue gas duct were replaced along with actuators. Two numbers scanner air fans were replaced.

d. Milling system

Replacement of six numbers existing raw coal feeders with dual belt Gravimetric feeder was done. 100% replacement of wind box was done. Complete replacement of fuel piping. Introduction of one more oil firing facility at CD elevation in addition to existing oil firing facility in AB and EF elevations for flame stabilization. All the 56 numbers of wall blowers and 24 numbers of LRSB's were replaced.

e. Turbine

100% replacement of HP turbine module. Replacement of rotor of IP and LP turbines was done.

f. Control and Instrumentation

Auto loop control for Boiler envisaged, Turbo supervisory instruments were installed and re-commissioning of auto loop controls for Turbo-generator was done.

4.2.3 Time and Cost Aspects: The schedule of the R&M works at Unit no. 9 & 10 of Obra Power Station is as follows.

Table 4.12: R&M Implementation Schedule for Unit# 9 of Obra TPS

S. No.	Milestones	Target Date/ Month	Actual Date/Month
1	Date of RLA Study	Not Available	06th to 13th March 2007
2	Zero Date	20.06.2006	20.06.2006
3	Date of Shutdown for R&M	30.09.2007	02.11.2008
4	Date for completion of R&M works	30.04.2008	26.06.2011 (Date of Synchronization)

Table 4.13: R&M Implementation Schedule for Unit# 10 of Obra TPS

S. No.	Milestones	Target Date/ Month	Actual Date/Month
1	Date of RLA Study	Not Available	23.08.2006 to 04.09.2006
2	Zero Date	20.06.2006	20.06.2006
3	Date of Shutdown for R&M	29.02.2008	22.03.2012
4	Date for completion of R&M works	31.08.2008	08.04.2016

The R&M implementation period for unit-9 was planned for 22 months but in actual it took 60 months to complete the project. Similarly, the R&M Implementation period for unit-10 was scheduled for 26 months but it took 118 months to complete the project. The Lead Period unit-9 was scheduled as 15 months but it actually was 28 months and that of unit-10 was fixed at 20 months but it actually was 69 months. Unit-9 was actually kept

under shutdown for 31 months against the planned duration of 7 months and unit-10 was kept under shutdown for 49 months against the planned duration of 6 months.

Reasons for Time Overrun

a. R&M of unit 9 got delayed due to dispute between BHEL and OEM of Turbine (Power Machine, Russia). The work was held up for about 1.5 years.
b. Delay in delivery of spares by BHEL for unit 9 also caused project delay.
c. After R&M was complete, high axial shift was detected in Unit 9 during operation and which is still persisting and BHEL has not solved the problem.
d. There was delay in starting of R&M work of Unit # 10 due to untimely delivery of spares which was due to lack of coordination among different units if BHEL.
e. Slow work progress was observed in Unit # 10 R&M due to inadequate manpower.
f. Labor unrest in BHEL vendors was also observed.

Cost Aspect:

The R&M project was funded by Power Finance Corporation, New Delhi.

Table 4.14: Cost Allocation for Unit# 9 of Obra TPS

S. No.	Item	Allocated Cost (₹ Crores)
1	Supply of material	172.07
2	Service	25.64
Total		**197.71**

Table 4.15: Cost Allocated for Unit# 10 of Obra TPS

S. No.	Item	Allocated Cost (₹ Crores)
1	Supply of material	167.44
2	Service	26.26
Total		**193.70**

Due to time overrun, the cost of spares/labor rates, IDC etc. increased and hence cost of R&M has also increased proportionately.

4.2.4 Project Management Process

a. General Information:

R&M Team for implementation of R&M Project included Chief Engineer (R&M), Superintending Engineer (R&M), Executive Engineer (R&M), Junior Engineer (R&M) and all other various mechanical, Electrical, C&I, Civil Circle officers & staff.

Table 4.16: R&M Team of Contractor

S. No.	Package	Contractor
1	Boiler	TPS Builder, Unified Power Project Ltd.
2	ESP	AM Erector
3	C&I	Power Mech & I.L. Kota
4	Turbine	M/s S.N. Singh
5	Electrical	M/s ABB, Siemens
6	CHP (but escaped)	M/s Tecpro
7	WTP & Cooling Tower	M/s Clear Water

b. Coordination

i. Scheduled of meeting held for monitoring the progress of work: As per requirement, meetings with BHEL at HQ, Lucknow and at Obra site were held.
ii. Coordination among the utility and contractor: BHEL is less cooperative.
iii. Coordination among sub-teams of the contractor: Not up to the mark

4.2.5 Technical Surprises

a) Hot spot found in Generator stator core of unit#10
b) TG auto loop control was initially not covered in the contract which was awarded separately to the concerned supplier.

4.2.6 Problems/Challenges faced after R&M

Unit 9 runs at high axial shift up to 0.98mm at 200MW load.

Deviations from Project:

a) First unit R&M (unit 9) started from 02-11-2008 deviating 2 years & four months due to non- availability of Turbine from BHEL side because of dispute between BHEL & turbine supplier M/s Power Machine, Russia. Axial shift problem exists from the beginning.
b) Only 9th unit could be uprated from 200 MW from 216 MW and rest four unit's R&M is now scheduled at 200 MW that is the name plate rating.
c) Unit 9 in respect of auto loop is not yet completed.
d) RGMO (Restricted Governing Mode of Operation) operation is faulty.
e) PG test of both the units have not been conducted till now.
f) Initially there was no provision of DCS max DNA (A type of Distributed Control System software) for TG auto loop which have been added later on for unit 10 and a separate order Rs. 54/- Cr for DCS max DNA have been placed on BHEL for units# 10, 11, 12 & 13.
g) Major fault in stator core of unit 10 was observed. A separate order has been placed to BHEL. The repair work will be completed near March 2016 as per BHEL.
h) BHEL are not accepting warranty clause of the R&M contract.
i) Six compressors were procured on assessment that air requirement is more for smooth operation of equipment.
j) Agencies of the BHEL were not available to work during following period.

Table 4.17: Area wise Project Delay of Obra TPS

S. No.	Area	From	To
1	Ash Handling works	July 2011	10-02-2015
2	0.4 kV LTMCC Modifications	July 2011	10-02-2015
3	WTP works	July, 2014	24-10-2014
4	6.6 kV switchgears	22-03-2012	20-02-2015
5	Coal Handling	Nov., 2013	Sept, 2015
6	No BHEL boiler agency to work	May, 2013	May, 2014

4.2.7 Contractual Arrangements

Single offer was made to BHEL in main works and others through open tender. Packages and Agencies

BTG & BoP : M/s. BHEL
ESP foundation work : M/s. Shehzade Khan & M/s. M.P. Agrawal, Obra
ESP control room civil : M/s. Shehzade Khan, Obra & M/s. IL Kota for UPS

Liquidated Damages (LD)

Two types of LD were included in the contractual arrangement, which are as follows.

a. **Liquidated Damages for Delay:**
In case of delay of project due to fault of BHEL from its scheduled time duration, the amount which was agreed to be paid as per the contract as LD was 0.25% of contract value of delayed unit price value per week of delay with an overall limit of 10% of contract value of delayed time.

b. **Liquidated Damages for Performance:**
It was agreed that after full loading of unit and stabilization, PG test was to be conducted within two weeks of first synchronization and all the guarantees related to performance of the unit as described in the "Guarantees" section of the offer were to be demonstrated and proved. If the guaranteed values were not achieved even after giving sufficient opportunity to BHEL to prove the guaranteed performances, then Liquidated Damages were to be imposed as per the following rates.
   i) In case of shortfall in capacity from guaranteed parameters during PG test, BHEL was to pay 0.02% of unit price value per 100 kW with a limit of 10% of unit price (Turbine Package).
   ii) In case of non-achieving for guaranteed Turbine Heat Rate during PG test, BHEL was to pay 0.2% of unit price (Turbine package) value per 1 kCal/kWh shortage with an overall limit of 10% of unit price value.
   iii) Total LD on performance taken together were not to be exceeded more than 10% of unit value.
   iv) Overall LD for shortfall in performance and delay in completion period taken together were not to be exceeded more than 15% of contract price.

LD Recovered: Rs 22/- Crore has been deducted till now as Liquidated Damage.

Performance Guarantees Test

PG test has not been conducted for any unit due to non-completion of some R&M works.

4.2.8 Performance Achieved

Pre and Post Performance of 200 MW Unit # 9 & 10 is given below.

Table 4.18: Unit-9 Parameters achieved Pre and Post R&M of Obra TPS

Pre R&M						
Parameter	**Gross Generation**	**PLF**	**APC**	**SOC**	**SCC**	**Heat Rate**
Period	**MU**	**%**	**%**	**ml/kWh**	**kg/kWh**	**kCal/kWh**
2005-06	936.119	53.43	11.84	3.13	0.86	3022
2006-07	865.33	49.39	11.75	4.2	0.91	3371
2007-08	873.877	49.74	12.27	3.75	0.92	3123
Post R&M						
2011-12	928.065	52.83	9.81	2.33	0.85	2700
2012-13	1408.374	80.39	9.47	2.1	0.78	2609
2013-14	1405.260	80.21	9.35	2.61	0.82	2508
2014-15	1557.800	88.92	9.98	3.15	0.92	2661

From the above table, it is observed that PLF has improved considerably. Also APC, SOC, SCC and Heat Rate have shown improvement.

Table 4.19: Unit-10 Parameters achieved Pre and Post R&M of Obra TPS

UNIT # 10 [210MW] Pre R&M						
Parameter > YEAR ∨	**Gross Generation (MU)**	**P.L.F (%)**	**APC (%)**	**SOC (ml/kWh)**	**SCC (kg/kWh)**	**Heat Rate (kCal/kWh)**
2009-10	964.05	55.03	12.48	3.08	0.94	3168
2010-11	921.66	52.61	13.00	4.30	0.88	2803
2011-12	731.07	41.61	11.84	1.30	0.85	2700
Post R&M (April to December-2016)						
2016-17	308.19	41.92	11.48	9.33	0.85	2586

4.2.9 Overall Remark/Suggestion on Execution of R&M works

i. Job wise materials and work scope should be given to contractor for more clarity and to avoid dispute regarding scope of work.

ii. Deliveries must be taken as per work progress instead of receiving 100% materials for all units.
iii. Original name plate ratings would have been completed instead of uprated 216MW for unit 9.

4.3 Unit# 3 & 4 (2x110 MW) GNDTP, PSPCL, Bathinda, Punjab

4.3.1 Background

The Guru Nanak Dev Thermal Power Station (GNDTP) at Bathinda has a total installed capacity of 440MW (4x110MW) in two stages. Stage I consists of two units of 110MW each i.e. Unit# 1 & 2 and Stage II comprises two units of 110MW each i.e. Unit# 3 & 4. Unit#3 was first commissioned on 29th March 1978 and Unit# 4 was first commissioned on 31st January 1979 thereby completely more than 20 years of service at the time of RLA study and were facing problems of ageing of critical components, non-availability of spares, obsolescence of technology and reduced performance parameters. To overcome these problems, GNDTP had proposed to carry out Residual Life Assessment study coupled with a study of Renovation, Modernization and Life Extension to achieve the overall objectives of improvement in

- Plant Load Factor
- Plant Availability
- Plant load to achieve rated capacity
- Efficiency improvement in Boiler, Turbine, Generator and auxiliaries
- Reduction in emission and improvement in operating environment around the plant area

Bathinda TPS Unit# 3 and 4 were undertaken for R&M and LE Program. The contract was awarded to Central Power Research Institute, Bangalore for carrying out comprehensive Residual Life Assessment (RLA) study of boilers of 2x110MW units. RLA study of Unit No# 3 was conducted in the year 2000 and that of Unit No# 4 was done in 2001. The conclusions and recommendations of RLA study are as follows.

Unit # 3*:*

It was recommended that refractory type water walls to be replaced with membrane type rifled tube water walls. It was recommended to replace 10-20% of Economizer, Super Heater and Reheater tubes by re-designed circuits to enable better distribution of Flue gas velocity and lower erosion rates. The capacity of water walls to be increased by 20% to account poorer heat transfer on account of ash burden of coal. It was recommended to replace the shell and tube APH by a rotary bi-sector APH. Individual burner tilting at each elevation was recommended. It was recommended to replace the manually controlled oil burner system with automatic remote operator controlled oil guns with flame igniters and scanners. It was recommended to replace badly eroded safety valves which were identified to be heavily passing with valves of modern design. Redesigning of FD fans to provide a higher secondary air pressure and ensure that the maximum efficiency point coincides with 90-100% MCR unit load. It was recommended to replace ID fans with re-designed and

oversized fans by 30% to handle higher flow of flue gas resulting in reduction of boiler puffing considerably. The design must also be ensured of operating point of fan at the highest efficiency point at 90-100% MCR of the unit. It was also recommended to re-design the PA fans with an increased capacity of 30% and with operating characteristics giving maximum efficiency at 90-100% MCR of the unit.

Unit# 4:

It was recommended that refractory type water walls to be replaced with membrane type rifled tube water walls involving replacement of wall heating surfaces, insulation and skin casing and support structures. It was recommended to replace 10-20% of Economizer, Superheater and Reheater tubes by re-designed circuits to enable better distribution of flue gas velocity and lower erosion rates. The combustion chamber and flue gas passages must be designed considering the properties of carefully chosen design coal. The capacity of water walls to be increased by 20% to account poorer heat transfer on account of ash burden of coal. It was recommended to replace the shell and tube APH by a re-designed tubular/rotary bi-sector APH in 2nd / 3rd pass. To replace the burner tilting mechanism with modifications to the present burner blocks, their nozzles and associated instruments. Individual burner tilting at each elevation was recommended. The coal burners must also be oversized by 20% to accommodate coal with ash content of 40-50%. It was recommended to replace the manually controlled oil burner system with automatic remote operator controlled oil guns with flame igniters and scanners.

4.3.2 Scope of Work

Based on RLA/LE study recommendations, discussions and negotiations, R&M and LE activities were finalized for achieving up-rated capacity generation of 120MW at STG gross output at 3% makeup and 0.1208 kg/cm^2 of condenser vacuum, Boiler efficiency of 87.5% (at 120MW), Turbine heat rate of 1990 kCal/kWh, ESP outlet dust emission level of $\leq$90 mg/Nm^3 and auxiliary power consumption of 8.5%.

Table 4.20: Target values of GNDTP Bathinda

S. No.	Parameter	Target Values
1	Output Generation	120 MW
2	Turbine Heat Rate	1990 kCal/kWh
3	ESP outlet dust emission level	$\leq$90 mg/Nm^3
4	Boiler Efficiency	87.5%
5	Auxiliary Power Consumption	8.5%

The major Scope of R&M works under various packages.

a) Boiler:

Complete replacement of existing indirect fired Boiler with direct fired BHEL make Boiler having membrane type water walls, Drum internals. Replacement of air heaters, flue gas ducting, fuel firing system. Up-gradation of milling system for direct firing, replacement of old drums type mills with bowl type vertical mills. Replacement of old ID/FD/PA Fans along with motors.

b) Turbine:
Replacement of HP, IP & LP rotors along with HP inner, IP inner & LP casing, Turbine gland sealing system, Turbine Lube Oil Coolers, impellers of CW pumps with stainless steel impellers, HP Heaters, tube nest of various LP Heaters, Condensate Extraction pumps with motors, control valves, Butterfly valves & RCVs.

c) Balance of Plant:
Replacement of old outdated ESP controllers with micro-processor based controllers & HVRs along with internals & rapping system. Addition of 2 nos. fields in each pass of ESP. Replacement of existing ash slurry lines with new ones, ash slurry pumps, seal water pumps & strainers in HP water line. Providing of additional clinker grinders.

d) Electrical:
Replacement of 220 KV Air Blast Circuit Breakers with SF6 Circuit Breakers, protection relays, Generator Field Breakers, pneumatic operating mechanism of 220 kV Isolators with motor operating mechanism & HT/LT cables. Retrofitting of 6.6 kV MOCBs with Vacuum Circuit Breakers.

e) Control & Instrumentation:
Replacement of Old Russian type C&I system with state of the art functionally distributed microprocessor based digital distributed control system. Providing of Furnace Safeguard Supervisory System (FSSS), Secondary Air Control System (SADC), Soot Blower Control System (SBCS), Automatic Turbine Run up System (ATRS), Electro-hydraulic Governing System (EHTC) & Turbine Protection System.

4.3.3 Time and Cost Aspects

a. Time Aspect

The schedule of the R&M works carried out at Unit# 3 of GNDTP, Bathinda is as follows.

Table 4.21: Schedule implementation of Unit# 3 project of GNDTP

Activities	Target Date	Actual Date
Year of RLA study	NA	2000
Zero date	22.12.2006	22.12.2006
Date of shutdown for R&M	01.12.2007	14.01.2010
Date of completion of R&M	25.09.2010	18.07.2012
Hydro Test	18.09.2010	04.05.2012 (Boiler) 22.05.2012 (R.H)
Boiler Light Up	20.09.2010	29.05.2012
Synchronization (Oil)	25.09.2010	18.07.2012
Synchronization (Coal)	13.10.2010	03.08.2012
PG Test	31.10.2010	23 & 24 May 2013 (ESP), 11 & 12 October 2013 (Boiler), 28 February 2014 (Turbine & APC) and 25 June 2015 (Revised ESP)

R&M implementation for unit-3 was planned for 44 months but it actually took 67 months to complete the R&M works due to delay in preparedness and finalization of various sub-contracts, delay in supply of Turbine and other critical items, slow progress of erection works due to inadequate experienced personnel deputed at site, lack of coordination among various units of BHEL at site and material shortage. The shutdown of the unit was planned for 33 months but it actually was shutdown for 30 months. The schedule of the R&M works at Unit# 4 of GNDTP, Bathinda is as follows.

Table 4.22: Schedule implementation of Unit#4 project of GNDTP

Activities	Target Date	Actual Date
Year of RLA study	NA	2001
Zero date of R&M Project	22.12.2006	22.12.2006
Date of Shutdown for R&M	01.12.2008	05.11.2012
Date for completion of R&M	25.06.2012	23.06.2014
Hydro Test	20.06.2012	12.11.2013
Boiler Light Up	22.06.2012	06.01.2014
Synchronization (Oil)	25.06.2012	23.06.2014
Synchronization (Coal)	04.07.2012	09.07.2014
PG Test	31.07.2012	24/25 June 2015 (Boiler), (Turbine, ESP & APC pending)

R&M implementation for unit-4 was planned for 66 months but it actually took 90 months to complete the R&M works due to delay in preparedness and finalization of various sub-contracts, delay in supply of Turbine and other critical items, slow progress of erection works due to inadequate experienced personnel deputed at site and lack of coordination among various units of BHEL at site. The shutdown of the unit was planned for 43 months but it actually was shutdown for 32 months.

b. Cost Aspect

Competent authority had accorded an administrative approval for implementing major R&M and LE works for an estimated cost of ₹465.36/- Crores for both the units. The contract was awarded to M/s. BHEL for supply, erection, testing and commissioning of both the units, i.e. unit# 3 & 4. The funds for R&M/LE works were allocated by REC.

4.3.4 Project Management Process

i. No separate team for R&M works was constituted. The work was looked after by maintenance personnel relating to their respective areas, in addition to their normal maintenance work. However, one R&M cell was created for coordinating all R&M activities under superintending engineer in-charge.

ii. EPC contract was given to BHEL, who got the work done through various subcontractors.

- R&M Team fort implementation of R&M project : By Project
- R&M Team of Contractor : M/s BHEL
- Names of Sub-contractor-Package wise : M/s BHEL
- Project Monitoring Process being followed : By Project Authorities

Coordination

a. Monthly review meetings were regularly held for monitoring the progress of the project.
b. Regular meetings at site were held between R&M team of the utility and BHEL.
c. Non availability of single in-charge of BHEL at site led to coordination problem between site in-charges of different BHEL packages as well among sub-contractors also.
d. No information about the subcontractors leaving the work incomplete or about their poor performances were furnished.

4.3.5 Technical Surprises

No technical surprises were reported.

4.3.6 Problems/Challenges Faced After R&M

a) Mill reject was excessive which was addressed by providing airport assembly of bigger mills, Size of airport is reduced and outer periphery of coal bowl was modified.
b) Operation of central valve of PRDS (Pressure Reducing and De-Superheating) was not reliable. PRDS header changed from CRH (Cold Reheat).
c) Cold air flow is not adequate due to space constraints as per the design.
d) Temperature differential of turbine MP top and bottom is high despite of providing extra insulation.
e) Excessive drop in Main Steam temperature from Boiler end to Turbine inlet persists continuously.
f) Frequent tripping of DCS controller while power supply changeover from main to standby persists despite taking various steps such as increasing the cable sizing, adjusting over/under voltage relay settings etc.
g) Switches fitted in CM lube oil tanks are not reliable, steps taken but the same cannot be resolved.
h) Frequent tripping (mal operation) of gravimetric feeders on CMMR sensors is happening.
i) O_2 analyzer is not commissioned due to space constraint, which requires a straight path.

4.3.7 Contractual arrangements

i. Procedure followed by Utility for awarding R&M Contract: EPC contract was given to BHEL.

ii. Payment Schedule: 10% Advance, 80% against receipt of Material/JVR & 10% on Performance Guarantees (PG) Test

a. Liquidated Damage (LD)

Delay in supply of material beyond contractual schedule was subjected to liquidated damage (LD) at the rate of 0.25% of the order value of the respective unit of delayed material per week or part there of subject to maximum ceiling of 7.5% of total order value comprising of supply of materials, services and civil works for respective unit including BoP and Electrical. In case of failure of guaranteed performance parameters, LD charges were fixed at following rates.

Table 4.23: LD for Performance Parameters of GNDTP, Bathinda

S. No.	Parameter Name	Parameter Value	LD in ₹
1	Output Power	120MW	₹1.5/- Lakh for every kW shortfall in output power
2	Turbine Heat Rate	2122+0.9% kCal/kWh	₹53/- Lakh for every kCal/kWh increase in heat rate
3	Boiler efficiency	87.5%	₹145/- Lakh for drop of every 0.1% in SG efficiency
4	ESP SPM level	$\leq$90 mg/Nm^3	₹1.0/- Crores for every 10mg/Nm^3 increase in SPM level
5	Auxiliary Power Consumption	8.5%	₹3.0/- Lakh for every 1kW increase in APC

The actual amount of LD recovered for both the units 3 and 4 was ₹ 45.67 Crores/-.

b. Performance Guarantee (PG) Test

PG test on both units were to be conducted as per contract to prove the performance parameters within one month of commissioning based on mutually agreed PG test procedures, comprising of following points.

a) ESP SPM level of $\leq$90 mg/Nm^3 at outlet
b) Boiler Efficiency of 87.5%
c) Unit up-rating from 110MW to 120MW
d) Auxiliary Power Consumption of 8.5%
e) Turbine Heat Rate of 1990 k Cal/kWh

PG test for Boiler, Turbine, ESP and APC have already been conducted for unit-3 but for unit-4 PG test of Boiler has been conducted but results have not yet been finalized and other performances like Turbine, ESP and APC are still pending.

4.3.8 Performance Achieved

Pre R&M and Post R&M performance of 110 MW Unit # 3&4 is given below:

Table 4.24: Unit-3 Performance Pre & Post R&M of Bathinda TPS

Pre R&M						
Parameter	**Gross Generation**	**PLF**	**APC (Stage II)**	**SOC**	**SCC**	**Heat Rate**
Period	**MU**	**%**	**%**	**ml/kWh**	**kg/kWh**	**kCal/ kWh**
2007-08	693.8	71.8	11.4	1.77	0.73	3084.21
2008-09	661.45	68.64	12.36	3.22	0.74	3168.739
2009-10	537.19	55.75	12.75	3.68	0.79	3267.52
Post R&M						
2012-13*	240.01	72.47	9.86	1.99	0.65	2687.43
2013-14	463.12	44.06	10.88	2.04	0.617	2577.64
2014-15	570.11	54.23	10.71	1.44	0.64	2658.25
2015-16	314.404	29.83	10.72	1.86	0.691	2825.74

**From 07/12/2012 to 31/03/2012*

From the above table it is observed that APC, SOC, SCC and Heat Rate have shown improvement after R&M while PLF has decreased mainly due to lesser Gross Generation.

Table 4.25: Unit-4 Parameters Pre and Post R&M of Bathinda TPS

Pre R&M						
Parameter	**Gross Generation**	**PLF**	**APC (Stage II)**	**SOC**	**SCC**	**Heat Rate**
Period	**MU**	**%**	**%**	**ml/ kWh**	**kg/kWh**	**kCal/kWh**
2008-09	622.58	64.61	12.36	4.74	0.747	3214.16
2009-10	611.22	63.43	12.75	5.37	0.801	3313.63
2010-11	428.67	44.49	14.87	10.18	0.823	3335.36
Post R&M						
2014-15*	29.64	5.53	10.66	0.73	0.66	2743.25
2015-16	199.281	18.91	10.72	3.42	0.696	2858.69

**From September 2014*

From the above table it is observed that APC, SOC, SCC and Heat Rate have shown improvement after R&M while PLF has decreased mainly due to lesser Gross Generation.

4.3.9 Overall Remarks

a. R&M specific vendors should be identified.
b. Integration of existing system with various new systems require specific expertise and familiarity, therefore, importance should be given to system study and study of site condition.
c. Project management guidelines for R&M works of various packages with time frame should be identified, defined and standardized.
d. L1, L2 and L3 schedules should be prepared and followed religiously.
e. Micro-level break-up of activities such as time period and cost required should be made available. This will help in making use of various Project Management Software.

4.4 Unit# 1 (1x110 MW) Muzaffarpur TPS, KBUNL, Bihar

4.4.1 Background

First started in 1985, Kanti Thernal Power Station has an installed capacity of 110×2 MW. Kanti Thermal Power Station is located in Kanti, Muzaffarpur, 90 km away from Patna, the capital of Bihar. It is managed by the Kanti Bijlee Utpadan Nigam Ltd (KBUN), a joint venture between NTPC and BSEB Patna. The majority shares of the Joint Venture Company are held by NTPC, with NTPC 64.57% and BSEB 35.43%.

Kanti Bijlee Utpadan Nigam Limited (KBUNL) Thermal Power Station, Muzaffarpur (MTPS) is a subsidiary of NTPC Ltd. consisting of 2x110 MW Units and it was established by BSEB. The first 110 MW Unit was commissioned on 31.03.1985 and the second unit was commissioned on 17.03.1986. Total running hour of Unit # 1 is 66202 and that of Unit # 2 is 69383.58. Unit #1 was shut-down on 14:25 Hrs. of 06.10.2003 and Unit # 2 was shut-down on 09.52Hrs of 03.10.2003. On the proposal of Govt. of Bihar for Renovation & Modernization & Life Extension of (2x110 MW Units) Muzaffarpur TPS & (2x110MW Units) Barauni TPS, a Memorandum of Understanding was signed amongst MOP (Govt. of India), Govt. of Bihar, NTPC, BHEL & BSEB on 29.05.2006. As per MOU, it was envisaged that the R&M of BTG & BOP of MTPS would be carried out at the cost not exceeding Rs1.25 Crores/MW.

MOP/Planning Commission recommended BHEL as implementing agency for the RLA & R&M / LE works and NTPC as Consultant. A Memorandum of Agreement (MOA) was signed amongst Government of Bihar, Bihar State Electricity Board (BSEB) and NTPC Limited on 26.12.2005 with an intent to promote a Joint Venture Company namely Vaishali Power Generating Company Ltd. (VPGCL). The objective of JVC was to Acquire, Establish, Operate & Maintain and take up the Expansion Project (500 MW) of the Muzaffarpur Thermal Power Station. NTPC & BSEB have equity participation of 51% and 49% respectively. VPGCL has been incorporated with the Registrar of Companies, Delhi & Haryana on 06.09.2006. Subsequently, the name of the company has been changed to Kanti Bijlee Utpadan Nigam Limited (KBUNL) on 10.04.08. KBUNL appointed NTPC Limited as Consultant to implement R&M program for 2x110MW Units of MTPS.

RLA Study: Conclusions and Recommendations

BHEL has carried out Residual Life Assessment Study of M/s KBUNL, Muzaffarpur TPS Boiler No-1, 110 MW, from 21st May 2008 to 2nd June 2008. The RLA study has been conducted only for the limited components not covered under R&M replacement.

i. Boiler:

Tie rod hanger support channel of riser tubes between RH inlet and outlet headers was found bent and twisted. The RHS steam cooled wall inlet header link tie rod hanger support (Just above the FSH outlet header) found broken, it was recommended for replacement. It was recommended for chemical cleaning.

ii. HP Turbine:

Cracks developed on rotor shaft in the first four heat relief grooves and in the stress relief fillet grooves in front of Curtis Wheel. HP Rotor cracked portion (i.e. Fillet, seal fin and

heat relief grooves) to be machined till the cracks removed. The fillet groove and front gland to be re-machined as per the modified geometry in order to minimize stress concentration.

iii. IP Turbine:

Recommended to replace the Parting plane studs/bolts with nuts of inner and outer casings as they might have lost their elasticity due to long service at high temperature and pressure. Both the Journals to be polished, Seals replacement and Valve spindles to be replaced. Modified integral shrouded blades were recommended for 17^{th} to 19^{th} stages along with moving wheels 9^{th}, 10^{th}, 11^{th}, $12^{th,}$ 13^{th}, 15^{th} & 16^{th} stages.

iv. LP Turbine:

Rubbing was observed on moving wheel No. 1 at the root of steam inlet side blades profile root above the disc. Axial clearances were to be maintained as per specifications to avoid further rubbing. As the journals had suffered with pitting they needed to be polished. Damaged bevel gears & lever bars were to be replaced. Both the Journals to be polished, axial clearances to be maintained and damaged bevel gear bars to be replaced.

v. LP Casing:

Rear gland steam pipe in bottom got punctured below the flange level. Same was to be replaced. The welding on deflector plate below the gland steam pipe was broken at front and rear gland region. These were to be weld repaired. On top casing right side parting plane front side rib had cracked. Three holes were made on the crack in the previous overhaul. The crack extended to total width of the rib. Cracks on LP casing to be metal stitched and repaired to avoid further propagation of cracks. Damaged gland steam pipe to be replaced and Cracks on LP casing to be metal stitched and repaired. New Guide wheels for 1, 1A, 2, 2A & 4, 4A and new modified guide wheels for 3 and 3A.

vi. Heaters:

Replacement with U-type HP heaters along with level controllers and 2 sets of LP heaters # 1, 1A & 2, 2A coils.

4.4.2 Scope of Work

The major scope of R&M works under various packages are as follows.

A. Boiler

100% Replacement of Furnace water wall, Extended water wall, Radiant Roof (First pass), damaged tubes and coils. Replacement of Burner Panel, Burner (wind box) assembly, Igniters, Flame scanners (BHEL Scan), Scanner/Seal Air Fan system, Replacement of feeders etc. shaft with bearing, expansion joints, Labyrinth seal assembly, IGV assembly, replaced for FD fan. Impeller, shaft with bearing, Labyrinth seal assembly, IGV assembly, lube oil pump, cooler & filter, lube oil system with integral valves replaced for PA Fan. Complete rotor assembly, Hydraulic coupling with connecting coupling & modified cooler, casing liner replaced for ID fans. Complete replacement with motor for seal air fans. Replacement of gates & dampers of cold/ hot/ Hot PA & flue gas. Replacement of all hot/ cold/ flue gas ducts along with expansion joints. Replacement of Wall Blowers & Furnace temp probe, soot blower MCC**.** Replaced for total boiler pressure parts/ducts. Replacement of all control valves of RH/ SH/ DESH & feed control station.

B. Turbine

Refurbishment of LP/ IP & HP turbines, shaft Turning Gear, governing valves including supply of required spares, gland sealing system. Replacement of HP heaters I & II. Refurbishment of De-Aerator, BFPs along with supply of two sets of Cartridges of modified design, Thrust Bearings & seals, Condensate Extraction pumps with suction strainers & accessories, Supply & Replacement of Condensate /drip booster pumps. Supply & replacement of tube bundles of lube oil, supply & commissioning of new Jacking Oil pumps, Supply of Oil centrifuge, Refurbishment of all valves & pumps with motors for central oil purification unit (COPU), AC AOP, DC AOP oil pumps, starting oil pumps.
Refurbishment of all valves on condensate system, Main steam valves at steam inlet and BFP discharge and suction valves along with NRV's.

C. Generator

Refurbishing of gas manifold valves of Generators including Liquid Level Detector (LLD), Supply of AC & DC seal oil pumps, Vacuum Pumps, Differential Pressure Regulators, seal oil coolers for air and hydrogen side along with control panel, Supply of new shaft seals. Refurbishment of generator bus-duct, air pressurization system and NGT.

D. Balance of Plant

Replacement of butterfly valves & rubber expansion. R&M of pre-treatment plant, Firefighting system, DM plant, chlorination plant, cooling tower, compressed air system, Air Conditioning system and Ash Handling system, fuel oil system, workshop, CW system, raw water system, wagon tipplers, vibro-feeder.

E. Electrical

CHP electrical system, 220/132 kV Switchyard & Transformers, R&M of ESP electrical system, LT& HT Switchgear replacement, HT/LT motors, AVR of one unit. Refurbishment of GT, UAT, ST&IBT. Replacement of GRP1 & GRP2 with microprocessor based numerical type dual protection relay panels including Generator Transformer & UAT Protection, Implementation of auto bus changeover scheme. Refurbishment of 17 nos. SF_6 breaker including supply of necessary spares & consumables for refurbishment.

F. Control & Instrumentation

Replacement of all field instrumentations, implementation of max DNA DCS, SWAS and Flue gas analyzers. Replacement of push button type operating system to computer based, LVS, R&M of control system of CW, AHP & CHP. R&M of Oil facility/ LDO/ HFO unloading systems.

4.4.3 Time and Cost Aspect

a. Time Aspect

Table 4.26: Unit#1 Project Schedule of Kanti TPS

Activities	Target Date	Actual Date
Date of RLA	NA	21/05/2008 to 02/06/2008
Zero date	21.05.2010	21.05.2010

Date of shutdown for R&M	Not Available	06.10.2003
Date of completion of R&M	15.04.2012	05.07.2013
Hydro Test	31.12.2011	24.01.2012
Boiler Light Up	28.03.2012	03.05.2012
Synchronization (Oil)	29.04.2012	05.07.2013
Synchronization (Coal)	15.07.2012	06.07.2013
PG Test	Not Available	Not Completed

The planned R&M implementation duration was 23 months but it actually was 37 months. The unit was shutdown since 06th October, 2003 but actual R&M was started only on 21st May, 2010 and R&M was completed on 05th July, 2013. The total shutdown duration of the unit was 117 months. The very long shutdown of the unit further deteriorated the associated equipments. The reasons for time overrun are as follows.

a. Delay in supply of spares such as Seal box cover, Drain trough, Burner panels, Radiant roof, Re-heater coils, BFP control valves etc. from BHEL.
b. Poor manpower mobilization from BHEL consumed a lot of time.
c. Delay in mobilization of sub-contractor.
d. Delay in repair of HP, IP and LP inner liners, HP control valves Servomotor and the delay in delivery of the same from BHEL, Hyderabad.
e. Delay in supply of Turbine rotors, LP 3 and 3A guide wheels from BHEL, Hyderabad.
f. Supply of Boiler parts from BHEL Trichy/Ranipet/Hyderabad and also non-sequential supply of materials from BHEL led to delay of the project.
g. Due to unavailability of fund for pre commissioning activities delay was caused in commissioning of unit and full loading.

b. Cost Aspect

Based on RLA/LE study recommendations, discussions and negotiations, R&M and LE activities were finalized for achieving rated capacity generation of 110MW at SH outlet steam flow of rated value that is 366 T/hr. of steam flow and unit availability of 80% for one year from the date of commissioning. Govt. of India through special plan of Bihar under BRGF had accorded an administrative approval for implementing major R&M and LE works of both the units of KBUNL, Muzaffarpur for an estimated cost of ₹471.80/- Crores for the units. The contract was awarded to M/s. BHEL for supply, erection, testing and commissioning of both the units. The actual unit completion cost of R&M works was Rs. 795.73/- Crores leading to a cost overrun of Rs. 323.93/- Crores. The reasons for this were as below.

a. Underestimation of some packages such as R&M of Ash dyke, Fire Fighting system in original DPR led to cost overrun of the project.
b. Technical surprises not envisaged in the DPR and their elimination led in cost overrun of the project.

c. Expenditure on Pre-commissioning, IDC, EDC, Contingency, Capital spares, Consultancy and works related to BTG but not in the scope of BHEL and work related to BOP but not included in DPR led in cost overrun of the project.

4.4.4 Project Management Process

No separate team for R&M works was constituted. The work was looked after by concerned O&M team. Amongst BHEL, AGM & Dy. Manager were involved full time to coordinate between different units of BHEL and with different Govt./non-Govt. agencies and onducting internal contractual meetings / execution progress meetings.

Review meeting: Project monitoring was done by project authorities through consultants by

i) Conductance of CRM with BHEL & its agencies
ii) Conductance of site meetings for execution progress, twice a week
iii) Conductance of meeting chaired by MD, BSPGCL twice in a month with higher authorities of BHEL & other contractors.

4.4.5 Technical Surprises

The technical surprises caused the utility Rs. 28.24/- Crores due to non-inclusion of various components at the time of finalization of DPR. Following are some of the technical surprises encountered by KBUNL.

- Installation of electrical actuators
- Installation of coal belt weigher
- Installation of Opacity meter
- Installation of online H_2 purity meter
- Replacement of ESP components
- Repairing of Boiler safety valves
- Replacement of PRDS valves
- Replacement of pipes and fittings of turbine
- Procurement of DC JOP and EOP control panels
- Procurement of SF_6 breakers
- Replacement of Copper flexibles for generator bus duct
- Replacement of LT power and control cables
- Procurement of Cast Resin type Excitation transformer
- Installation of new generator relay panels
- Parts of generator seal oil system replaced
- Purchase of fire tenders

4.4.6 Problems/Challenges faced after R&M

a) The grinding elements supplied by BHEL failed frequently before their useful/warrantied life.
b) LP Turbine blades numbers 4/4A failed.
c) LP Heater gasket found leaking, replaced.
d) Proposal for construction of new ash dyke under way

4.4.7 Contractual Arrangements

Procedure followed by Utility for awarding R&M Contract.

BTG Package : Awarded to BHEL as OEM on nomination basis

BoP Package : OEM/ST/Competitive bidding of LTE & OTE

Different packages were supplied by following agencies. BTG package was awarded to BHEL being OEM. Balance of Plant i.e. BoP package was awarded to the following companies through OEM/Competitive bidding.

Table 4.27: Package wise Contractor List

S. No.	Package	Contractor
1	BTG Package	M/s BHEL
2	Fire Fighting System	Thermosystems Pvt. Ltd.
3	PT Plant	VA Tech-Wabag
4	R&M of Wagon Tipplers & vibro feeders	ELECON ENGG.
5	Steel & 52 kg Rail	SAIL
6	MS Pipes for Ash Disposal	JINDAL INDIA LTD
7	Colling Tower	Paharpur Cooling Towers
8	R&M of Switchyard	ALSTOM T&D
9	Compressed Air System	ATLAS COPCO
10	Consultancy	NTPC Ltd
11	LT Power & Control Cable	Elkay Telelinks, KEI & Havells
12	Acid alkali tiling contract	Nu Calcutta constr.co
13	R&M of AC System	Voltas
14	SF_6 Breakers	Siemens India
15	R&M of LT Switchgear & Bus duct	GE LT
16	R&M of Chlorination Plant	Perfect Chloro Control
17	Procurement of shunting Loco	DLW VARANASI
18	R&M of HT Switch Gears	MEGAWIN SWITCHGEAR Pvt Ltd

a. Liquidated Damage

The quantum of LD were fixed at 0.5% per week for the delayed period beyond the total completion schedule for both the units i.e. 28 months subject to maximum of 5% of the contract value (i.e. 5% of Rs 212.792/- Cr). However, the LD has not yet been recovered which will be done once the contract between both the parties get closed.

Table 4.28: LD for short fall in guaranteed parameters

S. No.	Description	Guaranteed value	LD
1	Boiler output at Super Heater Outlet	366 T/hr.	Rs. 27,75,765/per every Ton/hr. shortfall
2	Availability of unit for one year from the date of commissioning	80%	Rs. 7,05,000/per 0.5% shortfall

Above shortfall were not to exceed 7.5% of Rs. 212.792/- Crores (i.e. Ex-works contract value).

b. Performance Guarantee (PG) Test

Mutually agreed PG test procedures comprised of following points.

i. Boiler output at Super Heater Outlet to be 366 T/hr.
ii. Availability of unit for one year from the date of commissioning to be more than 80%

PG test have not been conducted yet since BHEL was to submit the revised Turbine PG test/demonstration which has not yet been submitted by them. However, Boiler PG test proposal has been finalized by both end i.e. between BHEL and NTPC Ltd.

4.4.8 Performance Achieved

Unit-1 R&M work was done from 21/05/2010 to 05/07/2013. The performance of the unit before R&M was not available with the authorities as the unit was under shut down since 06.10.2003. The performance after R&M is stated below.

Table 4.29: U#1 Performance Post R&M of KBUNL

Parameter	Gross Generation	PLF	APC	SOC	SCC	Heat Rate
Period	MU	%	%	ml/kWh	kg/kWh	kCal/kWh
2013-14	319.09	80.05	11.63	3.23	0.79	3087
2014-15	687.20	71.32	11.32	2.51	0.761	3001.29
2015-16	211.28	37.4	15.4	5.82	0.78	2978.82

4.4.9 Overall Remarks/Suggestions

(i) The R&M/ LE of Muzaffarpur TPS was of forced R&M in which many of the packages were under estimated/ not envisaged in DPR such as Fire Fighting system, Consultancy service, R&M of Ash dyke etc. There was only provision of Rs. 1.52 Cr for Firefighting in DPR whereas the awarded cost came to Rs. 10.22 Cr. The JV company (originally named Vaishali Power and subsequently renamed as KBUNL) placed the award to NTPC for R&M Consultancy Services at total cost of Rs. 11.97/- Crores on 22/06/2010. Similarly for R&M of ash dyke there was a mere provision of Rs. 5.62 Cr but as per NTPC engineering the cost estimate amounted to approximately Rs. 140.00 Cr. Further, In order to complete R&M works many proposals which were not covered in DPR but were felt necessary & the same were forced even after paucity of R&M fund. These are categorized under Apportionment cases which added extra financial burden of Rs. 16.40 Cr to KBUNL.

(ii) Non-envisaging of expenditure:

Expenditures such as pre commissioning, contingency, EDC (Expenditure During Construction), IDC (Interest During Construction) etc. were not envisaged in DPR which also added extra financial burden of Rs. 127.97 Cr.

(iii) Delay in completion of R&M:

As per the schedule BHEL was to complete R&M works by 15.08.2012 i.e. within 28 months of the award of contract for both the units. However, delay in completion of R&M works further increased EDC, IDC & contingency expenditure. The main reasons behind the delay were delayed supply of materials, non-sequential supply of materials from BHEL's manufacturing units, lack of coordination between BHEL site & manufacturing units, deviation from one to one replacement supply of materials and inadequate manpower deployed by BHEL's sub vendors etc.

Overall Suggestion:

R&M after long shut down of the unit was not viable. In case of 110MW unit of Muzaffarpur TPS, the Unit was kept under shut down since the year 2003 due to which many of the components were damaged/ degraded/ lost their life. Due to smaller size unit capacity there was also delay in completion of supplies by BHEL specially Turbine components.

4.5 Unit# 5 (1x210 MW) Bandel TPS, WBPDCL, West Bengal

4.5.1 Background

Bandel Thermal Power Station (BTPS) owned and operated by West Bengal Power Development Corporation Ltd has an installed capacity of 740MW, comprising of five units (3x100+2x210MW). It is located in Tribeni, Hooghly District, about 120km north-east of Kolkata. Unit#5 was commissioned on 8th October 1982. It had clocked 141420 hours i.e. an overall availability of about 67% till the RLA study was done by NTPC-Alstom Power Services Private Limited (NASL) in December 2006.

Conclusions and Recommendations of RLA study

As far as the component integrity was concerned, the Non-Destructive Study did not reveal any abnormality on the Boiler side. Most of the vulnerable sections like Super-heater and Re-heater coils had been replaced in the recent past. Although microstructure and destructive test results were not analyzed at the time of RLA, the unit found fit to run for about next five years without any major replacement of pressure parts, in case normal operating parameters were not exceeded. Oxide scale thickness was higher in some of the Re-heat coils, indicating high heat pickup in these areas.

It was observed that very frequent tripping and outage had occurred on account of electrical systems, controls, drum level, and Boiler fire out. A detailed review of electrical systems and control loops was suggested. Another area of concern was appropriate manning of station with properly trained and vigilant personnel, to save the unit from frequent tripping.

4.5.2 Scope of Work

The major scope of R&M works under various packages were as follows.

A. Boiler & Auxiliaries

Installations of new coal and oil burner system, Complete replacement of Platen SH, Primary SH (Horizontal Bank), Economizer, Front side water wall etc. Complete replacement of Wind box, Damper, Expansion joint and ducts in flue gas as well as air path along with soot blowing system. Installation of one new APH bank as well as complete tube replacement. New Seal Air fans, ID and PA fans were installed.

B. Turbine & Auxiliaries

Complete replacement of Turbine and its auxiliaries. Installation of Digital Electrohydraulic (DEH) governing system in place of Hydraulic governing system. Replacement of BFP cartridge, installation of new CEPs, overhauling of Drip pump, CW and RCW pump. Complete tube replacement of LP & HP heater, new De-Aerator, new Auxiliary PRDS, new Ejector, Gland Steam condenser and vent steam condenser and new HP-LP bypass system.

C. Generator

Complete replacement of existing generator by a new 215MW Generator having 0.85pf lag, 3000 rpm, terminal voltage 15.75 kV, water cooled stator winding, Hydrogen cooled rotor as well as stator core with other relevant parameters of existing Generator with bearings including bearing pedestal. Replacement of existing Generator/Generator Transformer protection system by dual redundant Numeric Relay based protection system including necessary replacement of CT and PT of desired accuracy.

D. Control and Instrumentation

Complete replacement of existing relay logic and Analog controlled open and closed loop automation system by new set of distributed digital control and management information system (DDCMIS) and existing flow elements, installation of new flow elements and Venturi for PA flow to mills.

E. Electrical

Supply and installation of new LT switchgear for CHP equipment, shifting of existing MCC and associated control to new CHP control room, PLC based control system in place of relay based system for coal feeding system for unit-5. Replacement of electromagnetic relay based protection systems of 25MVA, 132/6.6 kV Station Transformer at ECR by numerical relays. Repair of OLTC of two numbers 16MVA, 15.75/6.6 kV Unit Auxiliary Transformer and 25MVA, 132/6.6 kV Station Transformers which were inoperative since long and putting it into operation. Installation of new Battery bank, battery charger, DCDB, DC fuse board as source of DC system of switchyard and untit-5. Bus tie connection between new and existing DCDB. Replacement of three numbers manual LT breakers at existing lighting bus of unit-5 by air circuit breaker with in-built microprocessor based release.

Replacement of total illumination system of Boiler gallery with ID/FD and hopper, Burner front and Coal mill area of unit-5 with Energy Efficient lighting fixtures. Replacement of lighting distribution boards of Boiler area. Earthing of all electrical equipment and

connection to the station grid. Complete replacement of existing protection system of Generator, UAT, incomer and bus coupler breakers of unit bus and reserve bus, transformer feeders, motor feeders of 6.6 kV and 415V level by numeric relay based protection system including necessary CT and PT as per specific accuracy class and installation of energy meters. Supply and installation of DG set.

F. BOP

Addition of 12 number fields, Provision was introduced for parallel Ash of APH hoppers and ESP hoppers. Renovation of Dry Ash System was done. Modification of existing wet and dry fly ash evacuation system.

Replacement of idlers with its associated brackets of 23 numbers conveyor belts. Installation of 22 numbers pneumatically operated flap gates. Complete replacement of two numbers cross belt magnetic separator by in-line magnetic separator (ILMS) iron chutes, bins and electrical accessories etc. Complete replacement of existing eighteen (18) numbers old vibrating feeders by unbalanced motor type vibrating feeders of capacity 250 T/h. Design, supply and installation of eighteen numbers double rack and pinion gates.
Design, supply and installation of Dust Extraction system for crusher house, installation of dry fog type dust suppression system at all transfer chutes and plain water sprinkler type dust suppression system for stock pile. Construction of new CHP control room. Firefighting system modification work.

Table 4.30: Design & Target values of Key Parameters

Parameter	Target Value
Turbine heat rate	2345 kCal/kWh
Power Output	215 MW
Auxiliary Power Consumption	13 MW
ESP Emission at 100% BMCR*	$\leq$90 mg/Nm^3

*Note: The ESP emission to be taken without injection of Ammonia or any other chemical, with ESP outlet dust concentration with one out of four fields out of service in each gas path with worst coal firing under 100% BMCR.

4.5.3 Time and Cost Aspects

a. Time Aspect

Following R&M project schedule was adhered to. The RLA study of Boiler was conducted in December-2006 and energy audit was done in August-2007.

Table 4.31: Project Schedule of Bandel TPS

Activities	Target Date	Revised Target Date	Actual Date
Month of RLA study	NA	NA	December 2006
Zero date	14.03.2012	14.03.2012	14.03.2012

Date of shutdown for R&M	05.09.2013	02.12.2014	02.12.2013
Date of completion of R&M	30.05.2014	29.06.2014	25.08.2015
Hydro Test	Not Available	31.03.2014	02.12.2014
Boiler Trial Light Up	Not Available	29.04.2014	26.12.2014
Synchronization (Oil)	Not Available	30.05.2014	25.08.2015
Synchronization (Coal)	04.03.2014	Not Available	21.09.2015
PG Test	02.06.2014	30.07.2014	Nov., 2016

The R&M implementation period was planned for 26 months but it actually took 41 months to complete the R&M works. The unit was planned for shutdown for 9 months but it actually was shutdown for 21 months. The planned Lead Period was 16 months but it actually was 19 months. The DPR was approved in July, 2008, hence, the Time Gap was 44 months.

b. Cost Aspect

The project was funded through IBRD and GEF. The original estimated cost for R&M works was Rs. 652.20/- Crores, the expenditure incurred was Rs. 592/- Crores.

4.5.4 Project Management Process

The tenders for R&M works were invited through International Competitive Bidding (ICB) during December 2010. The total revised estimated project cost was Rs. 652.2 Crores. The main package BTG was awarded to M/s DHIC (Doosan Heavy Industries & Construction) Korea and M/s DPSI (Doosan Power System India) on 29.02.2012 at a cost of Rs. 531/- Crores i.e. Rs. 290.98 Crore + 37.58 Million Euros. The package for CHP was awarded to M/s Vinar System Pvt. Ltd. on 31.01.2013 at a cost of Rs. 26.63 crores. The package for electrical works was awarded to M/s ALSTOM T&D India Ltd. on 28.12.2012 at a cost of Rs. 16.31 crores. Special team of R&M implementation constituted comprising of DGM, Manager and Assistant Manager by WBPDCL. Contractor had formed their own R&M team. R&M work was given to various subcontractors. Material generally received in time. Regular meetings were held for monitoring the progress of works among utility & contractors. The entire R&M works were split into number of packages and was awarded to following companies through international competitive bidding process.

i. Main Plant Packages: Doosan Heavy Industries & Construction Co. Ltd. for Off-shore supply contract and Doosan Power Systems India Pvt. Ltd. for On-shore supply and service contract.
ii. Coal Handling Plant Package: Vinar Systems Pvt. Ltd. for Supply and Service contract.
iii. Electrical Package: Alstom T&D India Ltd. for Supply and Service contract.
iv. Ash Handling Plant Package: Macwaber Beekey Pvt. Ltd. for Supply and Service contract.

4.5.5 Technical Surprises

i. Due to non-availability of spiral tube of HP Heaters, new HP heaters were procured.

ii. Buck stays were found damaged which were replaced during R&M project.
iii. Replacement of all diamond spring of Boiler.
iv. Constraint of space for storing the dismantled scrap was solved by allotting additional area of WBPDCL outside plant premise.
v. Boiler side Super Heater Stage-II Attemperator was found with broken supports, it took a long time to place it in its designated position with all statutory formalities.
vi. Design of joints changed from bolted to welded construction and sent back to the workshop for necessary rectification for new APH structure.
vii. Special imported regrouting tool was required for removal of complete grouted TG foundation.
viii. Dimension of Generator Trunion was mismatched which was re-engineered and rectified.
ix. Grouting bolts of PA fan were found in damaged condition, regrouting was done.
x. Bearing fitting of PA fan was defective which was rectified at workshop and thereafter backlash of bearing was adjusted at site.
xi. Dynamic classifier vane re-orientation work was done at site.
xii. One expansion bellow at condenser area found damaged, part of which was replaced at additional cost.
xiii. Fouling detected in mill auxiliary parts, which was rectified.
xiv. After removal of drum internals, a few parts like vortex breaker, bridge bars of baffle etc. found missing, they were replaced on additional cost.
xv. Redesigning of ash evacuation line of APH hopper to main branch line was done.
xvi. Poor performance of main ejector led to reuse of old ejector after repairing.
xvii. Insufficient gap in nozzle of IP gland pipe and bearing pedestal number 2.
xviii. TG alignment coupling bolts were damaged, new bolts were procured from Skoda.
xix. Oil film clearance between journal of the generator rotor and the white metal bearing supporting the rotor journal was more than the recommended, therefore bearing number 6 was replaced by spare bearing after machining at the local workshop.
xx. Restraint support for critical piping was damaged, new restraint supports were fabricated at site.
xxi. Turbine governing oil system flushing problem due to non-supply of pipe and control/stop valves rectified at site by procuring from Rexroth.
xxii. Re-grouting of ID fan B foundation was done twice.
xxiii. Barring gear was not getting engaged which was replaced by spare barring gear assembly.
xxiv. Coal feeder jamming problem.
xxv. Modification of IP valve leg (left and right) struts.
xxvi. ESV preheating line flange gasket leakage.

4.5.6 Problems/Challenges Faced After R&M

a. Steam pressure was restricted to 110 kg/cm^2 due to leakage through flange due to failure of gasket in Main Steam pipe, which restricted the load to 100-120MW.
b. Re-tubing of HP heater was changed to replacement of three numbers HP heaters.
c. All diamond spring of Boiler was found damaged and therefore, the same was replaced.

d. Three numbers buck stay were found in damaged condition, which were replaced.
e. Construction of additional portion of AHP building.
f. Differential pricing of HP Heaters
g. Diamond spring replacement as per unit rate
h. Buck stay beams
i. Supply of steam drum internals
j. Rerouting of underground pipelines
k. Condenser bellow
l. Replacement of TG foundation bolts
m. Erection of baffle plates
n. Additional supply for pipe rerouting below APH hopper
o. Piping layout of Hydrant and Spray water system at miscellaneous area additional work for fire hydrant line
p. Erection service for PA fan foundation bolt
q. Service of additional lead (Disposing soil beyond 2 km)

4.5.7 Contractual Arrangements

i. Liquidated Damages (LD)

The LD applicable for this project was of following types.

(a) LD for delay on completion of all facilities (837 days): If the contractor failed to successfully achieve the completion of facilities within the time period stipulated for the reasons attributed to him, then LD had to be paid by the contractor. The applicable rate was agreed to be 0.1% of contract price per day of delay in successful completion of facilities as per the scope of work of the contractor under the contract.

(b) LD for extension of unit shutdown time (180 days): If the contractor failed to successfully install and pre-commissioning activities of Main plant package within the time period stipulated in the contract due to reasons solely attributable to the Contractor, then LD had to be paid to the employer by the contractor at the rate of 0.25% of the Contract price for each day of extension in shutdown (180 days). In case the shutdown was extended due to reasons attributable to WBPDCL, then the provision of LD for extension of unit shutdown was not applicable for the corresponding period.

(c) Total aggregated LD for failure to attain the guaranteed unit Heat Rate would be Rs. 1,20,00,000/- for every kCal/kWh shortfall for all three contracts.

(d) Total LD for failure to attain the guaranteed power output would be Rs. 50,000/- for every kW shortfall for all three contracts.

(e) Total LD across all three contracts for failure to attain the guaranteed auxiliary power consumption would be Rs. 50000/- for every kW increase.

(f) Rupees corresponding to 0.2% of total contract price for every complete 10mg/Nm^3 of increase in dust concentration level over the guaranteed value.

(g) Total aggregate ceiling of Liquidated Damage was 10% of Total Contract price.

(h) Failure to attain guaranteed value of each vibrator capacity at half percent (0.5%) of total price of connected equipment as established in the contract per one percent (1%) deficiency or part thereof in guaranteed capacity/performance requirement, subject to a ceiling of 5% of the concerned equipment price.

(i) Failure to attain guaranteed value of dry ash evacuation for fly ash from all ESP, AHP and stack hoppers using each vacuum pump at one percent (1%) of total price of connected equipment as established in the contract per one percent (1%) deficiency or part thereof in guaranteed capacity/performance requirement, subject to a ceiling of 5% of contract price.

(j) Failure to attain guaranteed value of each no load loss and load loss would be Rs. 38875/- for every complete 1kW increase in the guaranteed no load loss and load loss separately, subject to a ceiling of 10% of contract price.

ii. Performance Guarantee (PG) Test

PG test of unit no. 5 was agreed to be conducted as per contract to prove the performance parameters within 60 days from issuance of Completion Certificate. Completion Certificate was issued on 16th August, 2016. PG test was conducted in November, 2016. The terms agreed for PG test procedures comprised of following points.

(a) Turbine heat rate of 2345 kCal/kWh with an acceptable shortfall limit with LD of (+) 0.5%.

(b) ESP SPM level of $\leq$90 mg/Nm^3 at its outlet with an acceptable shortfall limit with LD of 100mg/Nm^3.

(c) Unit up-rating from 210MW to 215MW with acceptable shortfall limit with LD of (-) 0.5%.

(d) Auxiliary power consumption of 13000 kW with an acceptable shortfall limit with LD of (+) 0.8%.

(e) Coal vibrator capacity with 250T/h with an acceptable shortfall limit with LD of (-) 10%.

(f) Flow of dry ash evacuation of fly ash from all ESP, AHP and stack hoppers using each vacuum pump would be 35 T/h for a continuous period of three hours for each vacuum pump with an acceptable shortfall limit with LD of (-) 2.5%.

(g) Guaranteed no load loss at 75°C would be 3.9kW and load loss at 75°C would be 18.18kW of 2MVA transformer with an acceptable shortfall limit with LD of (+) 0.5% in both the cases.

4.5.8 Performance Achieved

Unit-5 R&M work was done from 02/12/2013 to 15/08/2015.

Table 4.32: Unit#5 Bandel TPS Pre and Post R&M Performance Parameters

Parameters	Pre R&M			Post R&M
	2011-12	2012-13	2013-14	2016-17
Gross Generation (MU)	1066.98	916.73	596.32	776.11
Peak Load (MW)	NA	205	195	225
PLF (%)	57.82	49.83	32.41	54.66
APC for Unit 1 to 5 (%)	11.63	11.54	12.82	12.08
SOC (ml/kWh)	4.7	4.01	12.08	5.22
SCC (kg/kWh)	0.88	0.84	0.88	0.693
Heat Rate (kCal/kWh)	3297.96	3007	3173	2285

4.5.9 Overall Remarks/ Suggestions

Instances of slow progress of work happened due to delayed payment to labor by some sub-contractors. There was also lack of coordination amongst intra departments. C&I activities suffered due to breach of erection contract between Siemens and Doosan. Non-availability of proper erection personnel of sub-contractor. Engineering reviews could not be done properly as Doosan did not submit realistic L-2 and L-3 schedule.
West Bengal Pollution Control Board (WBPCB) initially advised to raise the chimney height as capacity addition had occurred. Finally, this requirement was withdrawn after intervention of CEA in this issue. There was low participation in bidding process for R&M works.

4.6 Unit # 5 (110 MW) Talcher TPS (TTPS), NTPC, Odisha

4.6.1 Background

The Talcher Thermal Power Station (TTPS) at Talcher is owned and run by NTPC. TTPS was taken over by NTPC from Government of Orissa on 03rd June, 1995 for a total consideration of Rs. 356/- Crores. A Power Purchase Agreement (PPA) was signed between NTPC, Orissa State Electricity Board (OSEB) and Govt. of Orissa on 08th June, 1995 as per which the entire power generated from TTPS was to be supplied to OSEB. Subsequently, with the trifurcation of OSEB into three different entities, the responsibility for the purchase of power from TTPS under the above agreement vested with Grid Corporation of Orissa Limited (GRIDCO). As per the PPA, NTPC was required to undertake R&M of the station for the improvement of performance. The plant has a total installed capacity of 460MW and it is divided into two stages. The Stage-I comprises four units of 60MW each while Stage-II is comprised of two units of 110MW each. The unit-5 of 110MW was chosen for R&M implementation study. Unit-5 was first commissioned on 24th March 1982 and has completed more than 20 years of service at the time of RLA study. The unit was facing problems of ageing of critical components, non-availability of spares, obsolescence of technology and reduced performance parameters. To overcome these problems, NTPC proposed to carry out Residual Life Assessment study coupled with a study and implementation of Renovation & Modernization and Life Extension to achieve the following objectives:-

i) To improve/sustain availability
ii) To restore design efficiency/ Heat Rate
iii) Life extension of units
iv) Technology up-gradation of equipment/ overcome technology obsolescence and flexibility in operation & maintenance
v) Improve plant safety
vi) Improve environment conditions

TTPS R&M was taken in phases viz. Phase I, Phase II & Phase III, Switchyard R&M and Stage II ESP R&M. Unit-5 & 6 of Talcher TPS were undertaken for R&M and LE Programme in Phase-III of R&M implementation plan with an addition to some works based on RLA study reports in TG & auxiliaries of Stage-I units. Some schemes in BOP area common to both stage-I & II such as air compressors, ash dyke etc. were also covered in this phase.

4.6.2 Scope of Work

The major Scope of R&M works under various packages are as follows.

a) Boiler:
SADC system, Burner tilt mechanism, replacement of economizer coil, modification of APH, Mill, replacement of gates of PA system, replacement of impeller assembly without blades for FD fan, scanner air fan and igniter fans.

b) Turbine:
Replacement of TG & auxiliaries viz. LP rotor with blade and guide wheels, replacement of 13 cells of cooling tower.

c) Generator:
Replacement of rotor, Excitation system

d) Balance of Plant:
Installation of Chlorination plant, acquisition of land for new ash pond and its construction, compressed air system of Stage-I&II, refurbishment of CHP, replacement of ash pipelines, retrofitting of ESP

e) Electrical:
R&M of MCC, transformers & LT equipment's, procurement of motors, installation and commissioning of emergency DG sets.

f) Control & Instrumentation:
Installation of FSSS system for boiler control, installation and commissioning of Distributed Digital Control, Monitoring & Information system (DDCMIS). Replacement of all thermocouples and RTD with temperature transmitters (4-20mA) for uniformity and long durability. 110V AC supply was replaced with 24V DC, eliminating the supply mix-up (used for powering SADC dampers etc.). Obsolete

Hydra motor valves were replaced with single coil solenoid valves (field safety point of view) in boiler.

g) Fire Protection and HVAC system

h) Switchyard (Standalone package to BHEL under Switchyard R&M)

4.6.3 Time and Cost Aspects

a. Time Aspect

The R&M initiative was implemented in phases to ensure that the sole beneficiary GRIDCO continued to get power without extra shutdowns for R&M. The project was executed as per the unit availability during annual overhauling of the units. The R&M work for BTG was completed in the month of March 2008. The R&M of ESP under ESP R&M of Stage II) was completed for Unit-5 on 12th March, 2016. LHS cable laying for Fire Protection was taken up in October, 2010 during which trial operation of cable vault area was completed. Initially, the HVAC system was commissioned without PLC. Later on the PLC system was incorporated and the final commissioning of the system was completed in July, 2010. There are a total of 24 bays and 1 spare bay is present in the switchyard (11+1 of 132kV and 13 of 220kV). All the 13 bays of 220kV system were successfully charged after R&M. 4 of 11 bays of 132kV system were completed. One bay was charged on 10th July, 2010. Out of the remaining six bays unit 3 and 4 was completed in August 2010 and unit 1 & 2 was completed in October, 2010. Last two line bays linked with shutdown of GRIDCO and the same was completed in July 2010. No R&M work was envisaged in the spare bay. Bus conductors of 132kV and 220kV systems were replaced during annual overhauls.

Under Phase III R&M, initially, an attempt was made to award the FSSS package as single tender package, but it was not successful as the bid price quoted by them on 17th October 2007 was almost double the estimated price of the package. Due to this, retendering had to be done as ICB (International Competitive Bidding) on 17th March, 2009. Opening of Bid document took place on 14th September, 2009. The LOA (Letter of Award) was issued on 15th January, 2010 to M/s. NASL for implementing FSSS package. The date of implementation of FSSS was from 30th August 2011 to 14th October 2011.
Under Phase III R&M, for DDCMIS (C&I R&M) of stage II (2x110MW) units, NIT (Notice Inviting Tender) was issued on 03rd February, 2006. Opening of Bid took place on 25th May, 2006 and the LOA was issued on 27th November, 2006 to Yokogawa India Ltd for both the units for implementing DDCMIS package. The date of implementation of DDCMIS system was from 28th July, 2009 to 02nd September, 2009.

b. Cost Aspect

Based on RLA/LE study recommendations, discussions and negotiations, R&M and LE activities were finalized for achieving rated capacity generation for two units of 110MW at a cost of ₹ 264.50/- Crores which was funded by NTPC itself. The cumulative expenditure until 31st March, 2015 was ₹ 209.18/- Crores. The R&M was divided into various parts as follows and were awarded to different contractors to carryout different activities.

i. The augmentation of Ash Handling System (under Phase II R&M) was awarded to M/s. MATL at a cost of ₹ 10.75/- Crores on 8th May, 2004.
ii. R&M of switchyard (under Switchyard R&M) was awarded to M/s. BHEL on dated 15th October, 2004 at a cost of ₹ 29.18/- Crores (including taxes).
iii. Under Phase III R&M, upgradation of DCS system to DDCMIS for two units (2x110MW) was awarded to M/s. Yokogawa India Ltd on 27th November, 2006 at the cost of ₹ 15.58/- Crores (excluding taxes).
iv. Installation of SG critical components including FSSS of 2x110MW units (under Phase III R&M) was awarded to M/s. NASL on dated 15th January, 2010 at a cost of ₹ 19.14/- Crores (including taxes).
v. R&M work of ESP up-gradation (under ESP R&M) was awarded to M/s. BHEL on dated 01st February, 2013 at a cost of ₹ 34.29/- Crores.

4.6.4 Project Management Process

a. General Information

- NTPC has its own R&M Team for implementation of R&M project.
- Project Monitoring Process was followed by NTPC Project Planning & Monitoring.
- All Contractors executed the work as per conditions laid in work orders.

The project executing agencies for different packages were as follows. Different packages were awarded to various agencies as given below through international tendering process. Following is the list of area-wise executing agencies.

Table 4.33: Project Executing Agencies at Talcher TPS

S. No.	Package Details	Executing Agency
1	ESP retrofit	BHEL
2	SG critical components including FSSS	NTPC-ALSTOM Power Services Ltd. (NASL)
3	DDCMIS	Yokogawa India Ltd.
4	Economizer coil replacement	M/s GB Engineering Enterprises
5	APH modification	NASL
6	Turbine rotor for ST-I	M/s. GEPSIL
7	Condenser tube for ST-I	M/s. Multi Metals Ltd.
8	Condenser tube	M/s. Cubex Tubes Ltd.
9	LP rotor with Blade & guide wheels for Stage-II	BHEL
10	Guide wheel & Gland bodies for ST-II	BHEL
11	Moving blade & Blade wheels for ST-II	BHEL
12	HP rotor for ST-II	M/s. Skoda Power A.S.
13	Condenser tubes for ST-II	M/s. Multi Metals Ltd.

14	Voith geared variable turbo coupling	M/s. Voith Turbo Ltd.
15	Assembly for governing system for ST-II	M/s. Skoda Power A.S.
16	Refurbishment of 110MW HP Turbine rotor	BHEL
17	Moving blade & blade wheels (MPR)	BHEL
18	Moving blade & blade wheels (HPR)	BHEL
19	Voith Coupling	M/s. Voith Turbo Ltd.
20	Cooler for ST-II BFP	M/s. Voith Turbo Ltd.
21	Supply of ST-I CW pump with motor	M/s. WPIL
22	Chlorination Plant	M/s. Capital Controls India Ltd.
23	Land for New Ash Pond	Agency Govt. of Odisha
24	R&M of MCCs, Transformers & LT equipment	SIEMENS, AREVA T&D Ltd.,
25	DDCMIS of 2x110MW for ST-II	Yokogawa India Ltd.
26	SWAS system	Emerson Process Management
27	Supply & commissioning of compressed air system	M/s. Atlas Copco Compressor

b. Coordination

i) Schedule meeting held for monitoring the progress of work:
Monthly Engineering issues specific regular meetings were held in which major engineering issues discussed.

ii) Coordination among the utility and contractor:
Representatives of contractor were available at site for coordination of R&M work with NTPC. Following were the coordinating teams within utility (NTPC)

- Power Station
- Regional OS.
- Corporate OS -R&M
- R&M - Engineering.
- Contracts – Corporate & Site
- PP&M
- Corporate Commercial

4.6.5 Technical surprises

No specific technical surprises were brought out.

4.6.6 Problems/Challenges Faced After R&M

Ash dyke construction, although not a typical R&M package was included as one of the R&M package in Phase III R&M, mainly meant for 2x110MW units. Land acquisition was smooth and the construction was awarded to NBCC. At this point of time there were

protests from villagers (without sufficient grounds) and NBCC had to abandon the job after some time.

4.6.7 Contractual Arrangements

Phase II R&M works comprises R&M of units 1, 2 & 3, ESP of all four stage I units and associated auxiliaries. 29 schemes were approved at an estimated cost of Rs. 305/- Crores, which was approved by NTPC Board on 11.02.1999 and by GRIDCO in July 1999. Expenditure incurred was Rs. 256.9/- Crores till November 2005. 27 out of 30 schemes were already completed. Implementation of R&M of phase I & II had resulted in improvement of station PLF from 25.9% at the time of takeover to 88.5% in 2005-06 till November 2005.
Tendering Process was followed by Utility for awarding R&M Contract.

Liquidated Damages:

Under Phase III R&M, there was no provision kept for LD in the award of DDCMIS project which was awarded to Yokogawa India Ltd. C&I package from LOA date to contract closing was completed in record 23 months along with its PG tests. Provision for performance LD of ESP was kept in the contract, which is as follows.

Table 4.34: LD for ESP

S. No.	Guarantee Parameters	Rate of LD per ESP	Acceptable shortfall limit with LD
1	For every 0.01% shortfall in ESP efficiency from guaranteed value	Rs. 40,71,770/-	(-) 0.01% point from the guaranteed ESP efficiency point
2	For every kW increase in APC of ESP's from guaranteed value	Rs. 1,79,360/-	(+) 2% of the guaranteed APC
3	For every mmWC increase n pressure drop across ESP from guaranteed value	Rs. 5,86,140/-	(+) 2% of the guaranteed pressure drop across ESP
4	For every m^3/s increase in air leakage of ESP from guaranteed value	Rs. 9,61,270/-	(+) 5% of the guaranteed air in leakage

Each of the LD specified above were independent and were to be levied concurrently. The above values were proposed to be pro-rated for fractional parts of the appropriate unit of measurement. The total aggregate liability of the contractor to pay LD for failure to meet the guarantee was not to exceeded more than 10% of contract price.

Performance Guarantee Test: The PG tests of all the associated equipments have been completed.

4.6.8 Performance Achieved

The performance after implementation is given below.

Table 4.35: Performance achieved by Talcher TPS

Parameter	2001-02	2002-03	2003-04	2004-05	2005-06 (Till Nov'05)
PLF (%)	61.19	55.9	67.78	79.33	88.5
Availability (%)	63.75	72.62	72.95	85.59	93.53
Auxiliary Power (%)	11.57	11.47	10.73	10.57	10.02
Heat Rate (kCal/kg)	3149	3143	3000	2924	2915

The station PLF has improved from 25.90% at the time of takeover in the FY 1995-96 to 79.33% in the FY 2003-04 as an indication of successful R&M. Similarly, the Heat Rate at the time of takeover was 3882 kCal/kWh which also improved to 2924 during the year 2004-05. The Auxiliary power consumption at the time of takeover was 12.55% which was reduced to 10.85% in the year 2004-05. There was also a significant decrease in forced outage of the unit from 43% at time of takeover to 3.6% during the year 2004-05. Tube leakages in Boiler was 29 times at the time of takeover and which reduced to 6 during the year 2004-05.

4.6.9 Overall Remarks/Suggestions

In R&M of thermal power station, surprises during implementation are inevitable. However, these can be minimized by due diligence done during initial stage of framing of proposals/ preparations of DPR. In fact, it is worthwhile to take some additional time and do maximum detailing possible at the DPR stage itself. This will be much helpful in reducing wastage of time, energy and money during implementation because of surprise. Further, the contractual part can be taken care by identifying some major items which can crop up to surprises to be replaced after the equipment is opened. For these items unit values can be kept in the contract, to be utilized only if the need arises. R&M is all about learning, innovative and out of box thinking since there are so many constraints involved like cost, space, timing, engineering etc.

The benefits envisaged after performing successful R&M implementation were sustained unit availability and generation, the reliability of the unit has improved, life of the units have been increased by implementing technological up-gradation of equipments, flexibility of operation and maintenance, technological obsolescence have been overcome by replacing older equipments to get the spares of the new ones, improvement in plant safety and better environment management by installing new ESP.

4.7 Unit# 1 & 2 (2x110 MW) Panipat TPS, Haryana

4.7.1 Background

Panipat Thermal Power Station (PTPS) has a total installed generation capacity of 1360 MW comprising of four Units of 110 MW each, two Units of 210 MW each and two Units of 250 MW each. Unit # 1 was commissioned on 01.11.1979. HPGCL engaged Utility Powertech Limited [A joint venture of BSES & NTPC, NOIDA] for carrying out the RLA Study of Unit 1 to achieve the Life Extension for the next 15-20 years at the rated parameters. R&M / LE works was done by M/s Alstom and balance work by BHEL. The R&M work was awarded to BHEL at a cost of approximately Rs. 150/- Crore for uprating of the unit to 117.8MW as well as the R&M works. RLA Testing, and Condition Assessment of Unit-1, was carried out using state-of-the-art testing equipments, techniques and well established engineering methodology/practices. The Unit-1 was under shutdown for capital overhauling, retrofitting/replacement of Coal Feeders, Coal Mills, PA Fans, Burners etc. and LE/RLA Study in Oct-Nov-Dec, 2001. The unit was put under shutdown on 25.09.2007 for R&M and synchronized back on 04.11.2008 after R&M and uprating to 117.8MW.

RLA Study Conclusion and Recommendations:

The RLA/LE study of unit#1 was carried out by M/s. Utility Powertech Ltd., Noida from November-December 2001. The RLA study of unit#2 was initially conducted by M/s. ABB during the year 1999 who left the work due to breach of contract, later on the work was awarded to M/s. BHEL on 17.06.2002. The RLA study carried out for different equipment's are as follows. Refurbishment contract was awarded to ABB (now Alstom Power) at a cost of around Rs. 300/- Crores in 1997 for all the four units (unit-1 to 4) of PTPS. Work was started by Alstom Power on 21.01.1999 for unit-2, being the first target unit. It was required to be completed by 21.05.1999. But on 17.04.2000, the contract was unilaterally terminated by Alstom Power and abandoned the unit in open condition. Later restoration work was awarded to BHEL at a cost of Rs. 44/- Crore. Arbitration/court case with ABB (now Alstom Power) is still going on.

a. Boiler & Auxiliaries:

Boiler Drum, Down-comer pipes and bottom water wall ring header, boiler piping and support system, Headers, link pipes from economizer to boiler drum and ceiling Super Heater tubes found in healthy condition and recommended for continuous operation. It was recommended to replace the water wall panels, four corner tubes and respective buck-stays from elevation 13m to 37m. Economizer coils were recommended for complete replacement along with protective plates and their suspension. Replacement of LTSH coils along with its suspension were recommended along with complete replacement of pent house outer casing and skin casing. Complete replacement of boiler refractory and thermal insulation including furnace water wall, 2nd pass, hot air ducts, flue gas ducts and pent house was recommended. Replacement of two drum safety valves, two safety valves in MS line and four safety valves in cold and hot reheat lines were recommended.

b. Turbine & Auxiliaries:

Cracks found in LP casing, it was recommended to repair cracks of LP casing top and bottom by special welding technique/metal stitching methods. Turbine bearings numbers 1,

3, 5 & 7 found in damaged condition, it was recommended to replace these bearing. Drive and non-drive shafts of turbine barring gear found in damaged condition, replacement of these shafts were recommended. Condenser tubes found in choked/damaged condition, it was recommended to replace 25% of the tubes including plug tubes. Installation of online tube cleaning system for condenser tubes were recommended. Complete replacement of De-Aerator internals with replacement of manhole bolts and nuts together with the gasket were recommended. Overhauling of Lube oil, jacking oil pumps and seal oil pumps were recommended. It was recommended to repair the water chamber and replacement of heat exchanging tubes of existing coolers. It was recommended to replace existing tube bundle of HP heaters with superior quality/upgraded quality tube bundle.

c. Generator:

Recommended for installation and commissioning of new gas analyzer and hydrogen drier system for generator.

d. Electrical:

It was recommended to replace LT motors in phase manner which had burnt out. CT's needed replacement because of increase in the fault level. The protection relays for Generator & Transformer & 6.6 KV Switchgears need to be updated with digital microprocessor basis technology with programming facilities.

e. Control and Instrumentation:

Replacement of measuring instruments, TG instruments, draught gauges etc. flue gas analyzer for O_2 and CO measurements, SWAS system for online analyzing of steam and water quality, all C&I cables were recommended. Interlocks and protection panels including FSSS were recommended to be replaced with microprocessor based instruments. SADC system with expansion bellows should be replaced with latest technology in R&M stage. Replacement of feed water control valves, Attemperation control valves, station air differential pressure control valves to be considered. Following online instruments must be provided for individual stream including pressure in DM plant C&I system.

a) pH meter
b) Conductivity
c) Flow meter
d) Rota meter

4.7.2 Scope of Work

A. Unit# 1

a. Boiler:

Complete replacement of middle and lower air heater blocks of secondary air APH along with ferrules. 100% replacement of extended water wall, extended steam cool wall, water wall hanger tubes, water wall screen tubes, Super heater screen and hanger tubes, LTSH terminal tubes and Platen SH. Modified wind box arrangement with additional oil elevation. Installation of soot blower system and new ignition system with flame scanners. Uprating of coal mills and provision of Economizer bypass ducting.

b. Turbine:

Replacement of HP/IP/LP turbine's inner parts including rotor assembly, coupling bolts, inlet nozzles, seal housing suited for reaction blading in place of old impulse type blading. Re-babbitting of bearings. Replacement of HP evacuation valve and HP & LP seal steam valves. Overhauling and repairing of Governing system, bearing gear, Duplex oil filter, seal oil system, valves associated with feed water and oil system etc. Retrofitting of BFP, installation of modified nozzle and diffuser system in ejectors, replacement of tube nest of HP Heater- 1 & 2, LP Heater- 1 & 2, De-aerator header, HP drain flash tank, Expander.

c. Control and Instrumentation:

Installation of state of art Distribute Digital Control System. Replacement of transmitters, thermocouples, RTDs, actuators, transducers, Gas analyzers and gauges, instrumentation and control cables and junction boxes. Installation of new UPS with battery charger and batteries.

d. Electrical:

Rewinding of stator and rotor of generator. Installation of new Static Excitation System. Replacement of HT panels of critical auxiliaries with new SF_6 breakers. Replacement of various LT motors of different auxiliaries at boiler and turbine area.

e. BOP:

Installation of new compressed air system along with existing system. Overhauling of clinker grinder, jet pumps and refurbishment of firefighting system. Installation of new AHUs and its ducting. Retrofitting of ESP.

B. Unit# 2

a. Boiler:

Erection of APH. Uprating the capacity of milling system and retrofit of SADC system. Replacement of raw coal feeders and pipes, PA fans with motors and related ducting. Modification in wind box arrangement and coal piping.

b. Control and Instrumentation:

Installation of Pro control panels and commissioning of Distributed Digital Control System.

c. Electrical:

Replacement of existing MCC at Raw water, CHP and DM plant areas. Refurbishment of existing LT MCCs.

d. BOP:

Installation of Ash slurry pumps with drives and repair of ash slurry pipelines. Installation of two numbers Instrument Air driers and Debris Filter for CW system. Installation of new firefighting system with protections and alarms.

4.7.3 Time and Cost Aspects

The time and cost aspect of the units are described below along with PG test status and dates.

a. Time Aspect: The project schedule was as follows.

Table 4.36: Unit-1 Project Schedule of Panipat TPS

Activities	Target Date	Actual Date
Month of RLA study	NA	Nov.-Dec. 2001
Zero Date	31.07.2006	31.07.2006
Date of shutdown for R&M	Not Available	25.09.2007
Date of completion of R&M	25.02.2008	26.10.2008
Boiler Light Up	Not Available	16.08.2008
Synchronization (Oil)	Not Available	26.10.2008
Synchronization (Coal)	Not Available	04.11.2008
PG Test	Not Available	Boiler: 22.07.2009, Turbine:04.09.2009

Table 4.37: Unit-2 Project Schedule of Panipat TPS

Activities	Target Date	Actual Date
Year of RLA study	NA	1999
Zero Date	NA	23.05.1997
Date of shutdown for R&M	Not Available	January 1999
Date of completion of R&M	27.11.2002	10.03.2003
Hydro Test	Not Available	January 2003
Boiler Light Up	Not Available	20.01.2003
Synchronization (Oil)	Not Available	10.03.2003
Synchronization (Coal)	Not Available	10.03.2003
PG Test	Not included in the contract	

The planned R&M implementation period for unit-1 was 19 months and the actual was 27 months and the planned R&M implementation period for unit-2 was 69.5 months but the actual was 9 months since, unit-2 was under shutdown from January, 1999 and its R&M was initiated by ABB but due to some contractual difference between Panipat TPS & ABB, ABB left the work and the leftover was completed by BHEL and unit synchronized on 10.03.2003. The lead period for unit-1 was 14 months.

b. Cost Aspect

Based on RLA/LE study recommendations, discussions and negotiations, R&M and LE activities were finalized for achieving up-rated capacity generation for two units of 120MW from 110MW at a cost of ₹185/- Crores. The contract was awarded to M/s. BHEL for supply, erection, testing and commissioning of both the units.

4.7.4 Project Management Process

Table 4.38: Project Management Process by Panipat TPS

I.	**General Information**		
S. No.	**Description**	**Unit #1**	**Unit #2**
i.	R&M Team for implementation of R&M Project.	R&M Division under SE/M&T in coordination with various Maintenance Divisions under SE/O&M-I	R&M Division under SE/M&T in coordination with various Maintenance Divisions under SE/O&M-I
ii.	R&M Team of Contractor	M/s BHEL	M/s ABB & M/s BHEL
iii.	Project Monitoring Process being followed	By Project Authorities	By Project Authorities
iv.	Issues related to Decision making, if any	As per rules and regulations of HPGCL	As per rules and regulations of HPGCL
v.	Whether all Contractors executed the work as per conditions laid in Work Orders or there was any breach of contracts	Work order was not executed as per conditions laid in the contract	Work order was not executed as per conditions laid in the contract
II.	**Coordination**		
S. No.	**Description**	**Unit-1**	**Unit-2**
i.	Scheduled of meeting held for monitoring the progress of work	Regular Meetings were scheduled	Regular Meetings were scheduled
ii.	Coordination among the utility and contractor		
iii.	Coordination among sub-teams of the contractor		

Special R&M division was created in coordination with various maintenance departments. Divisions under SE/O&M-I. Project monitoring was being followed by project authorities/their consultants. The work order was not executed as per conditions laid down in contract. Regular meetings were held for monitoring the progress of work between utility and contractor & subcontractors. There was no labor unrest during the execution of works.

4.7.5 Technical Surprises

The technical surprises of unit#1 were as follows.

a) Erection of middle and bottom APH blocks
b) Overhauling of two coal mills as well raw coal feeders
c) Repair of High Pressure Control Valves (HPQCV) (Both Left &Right side)
d) Metal stitching of LP turbine of length 516”
e) Lifting and re-grouting of pedestal numbers 1 & 2 for turbine catenary foundation
f) Overhauling of PC piping of complete ESPs

4.7.6 Problems/Challenges Faced

a) The deviations mentioned above in "Technical Surprises" were the ones which were added during the course of R&M works.

b) Apart from the above, R&M works of unit#2 took very long duration because the main contractor M/s. ABB, left the work in the middle after opening the unit for the activities.
Later, after almost three years the contract was awarded to M/s. BHEL which completed the left out work.

4.7.7 Contractual Arrangements

The contractual arrangements of 110 MW Unit # 1&2 are given below:

Unit 1: The R&M work was awarded to M/s. BHEL being OEM.

Unit2: The R&M work was initially awarded to M/s. ABB through ICB who left the job due to breach in contract. Work order for revival of unit was awarded to M/s. BHEL being OEM.

a. Liquidated Damage

The quantum of LD was set not to exceed 1.8% of the total project cost due to delay in completion schedule of R&M works for both the units.

Table 4.39: LD for short fall in guaranteed parameters

S. No.	Description	Guaranteed value	LD
1	Turbine Heat Rate	2018 kCal/kWh	0.5% of total cost
2	Boiler Efficiency	NA	0.5% of total cost
3	Main Steam Flow	275 T/hr.	0.2% of total cost
4	Pant Availability	90%	0.2% of total cost

b. Performance Guarantee (PG) Test

PG test of both units were to be conducted as per contract to prove the performance parameters based on mutually agreed PG test procedures, comprising of following points.

(a) Uprating of unit from 110MW to 120MW at TG MCR
(b) Steam flow to be maintained at 275 T/ hr.
(c) Turbine Heat rate to achieve 2018 kCal/kWh
(d) Unit availability of more than 90% for 12 months after PG test

BHEL carried the PG test and proved the guaranteed performance of unit-1. Since the BHEL had only restored the stalled plant i.e. unit-2, hence PG test was not conducted.

4.7.8 Performance Achieved

Performance of both 110 MW Units #1&2 after implementation is given below:

Table 4.40 Unit-1 Performance Pre and Post R&M of Panipat TPS

Pre R&M						
Parameter	**Gross Generation**	**PLF**	**APC**	**SOC**	**SCC**	**Heat Rate**
Period	**MU**	**%**	**%**	**ml/kWh**	**kg/kWh**	**kCal/kWh**
2004-05	506.77	52.59	12.2	5.13	0.858	3554
2005-06	572.39	59.4	12.05	4.97	0.843	3508
2006-07	605.53	62.63	11.67	3.11	0.842	3342
Post R&M						
2009-10	815.15	79.08	10.41	1.95	0.84	3047
2010-11	504.6	48.9	10.76	4.08	0.902	3112
2011-12	820.28	79.27	11.33	2.89	0.909	2916

From the above Table it is observed that PLF, SOC and Heat Rate have shown improvement after R&M.

Table 4.41: Unit-2 Performance Pre and Post R&M of Panipat TPS

Pre R&M						
Parameter	**Gross Generation**	**PLF**	**APC**	**SOC**	**SCC**	**Heat Rate**
Period	**MU**	**%**	**%**	**ml/ kWh**	**kg/ kWh**	**kCal/ kWh**
1995-96	255.8	26.47	10.9	38.35	0.897	3881
1996-97	276.59	28.7	12.6	44.57	0.935	4006
1997-98	289.44	30.04	12.56	38.12	0.933	3950
Post R&M						
2003-04	699.37	72.38	11.05	6.33	0.813	3511
2004-05	571.82	59.34	12.2	5.22	0.858	3555
2005-06	680.81	70.65	12.05	5.07	0.843	3509

From the above Table it is observed that PLF, SOC, SCC and Heat Rate have shown improvement after R&M.

Chapter-5

Analysis of R&M Implementation Experience

Based on the data/information supplied by the earmarked thermal power stations and the interaction held with the concerned officials of respective plants by WAPCOS team, analysis and review of various aspects if implementation of R&M works of different units, is carried out in this chapter. The review broadly deals with the following.

a) Time and cost aspects, technical surprises, contractual arrangements, plant/unit performance etc.
b) R&M implementation experience as a whole including the analysis of the project management process, areas where the actual project implementation deviated from schedule and reasons for such deviations.

5.1 Time and Cost Aspects

The time aspects of the R&M works carried out at various Thermal Power Stations for the specified units has been explained as under.

A. Time Aspects

i. Ukai TPS (Unit# 1 & 2 of 120MW each)

Even though RLA studies were carried out in March 2003, the erection work could be started in August 2008. This time gap between assessment of conditions of major equipment & start of implementation work is very large.

Time Schedule

As per contract the original duration of project for both the units was planned for 27 months for both the units from zero date out of which the 7 months was allocated for each unit shutdown but actual time taken to complete overall project was 59 months. The Lead Period unit-1 was scheduled as 14 months and for unit-2 it was 20 months. Unit-1 was actually kept under shutdown for 32 months and unit-2 was under shutdown for 18 months.

Reasons for Time Overrun

i) Material was not supplied by BHEL as per supply order schedule.
ii) Some of the sub-contractors left the work without completing the job and sufficient time was lost in rearranging their replacement (i.e. New contractors)
iii) Performance of some of the subcontractors was not up to the mark.

ii. Obra TPS (Unit# 9 & 10 of 200MW each)

RLA of 200MW unit-9 boiler was carried out from 6th to 13th March-2007 and that of unit-10 from 23rd August to 4th September 2006 respectively. The R&M implementation period for unit-9 was planned for 22 months but in actual it took 60 months to complete the project. Similarly, the R&M Implementation period for unit-10 was scheduled for 26 months but it took 118 months to complete the project. The Lead Period unit-9 was scheduled as 15 months but it actually was 28 months and that of unit-10 was fixed at 20 months but it

actually was 69 months. Unit-9 was actually kept under shutdown for 31 months against the planned duration of 7 months and unit-10 was kept under shutdown for 49 months against the planned duration of 6 months.

Reasons for Time Overrun

a) Subcontractors of BHEL were not available to carry out the works during following period.
b) Major fault in stator core of generator of unit no. 10 was observed. A separate order was placed to BHEL. After R&M works, the unit was synchronized on 08th April, 2016.

iii. GNDTP Bathinda (Unit# 3 & 4 of 110MW each)

R&M implementation for unit-3 was planned for 44 months but it actually took 67 months to complete the R&M works. The shutdown of the unit was planned for 33 months but it actually was shutdown for 30 months.

R&M implementation for unit-4 was planned for 66 months but it actually took 90 months to complete the R&M works. The shutdown of the unit was planned for 43 months but it actually was shutdown for 32 months.

Reasons for time over run

i) Delay in preparing & finalization of various sub-contracts
ii) Delay in supply of turbine & other critical items
iii) Slow progress of erection works due to lack of experienced personnel deputed for implementation
iv) Lack of coordination of various units of contractor
v) Material shortage

iv. KBUNL (Unit# 1 of 110MW)

Schedule completion time	:	24 months
Actual completion time	:	38 months
Time overrun	:	14 months

The unit was under shutdown since 06th October, 2003, the Zero Date of R&M project was 15th April, 2012 and the unit was synchronized on 05th July, 2013. The total shutdown duration of the unit was 117 months.

Reasons for delay

a) Delay on supply of repaired HP/IP & LP turbine rotors from BHEL Hyderabad.
b) Lack of sequential supply of material from different BHEL's manufacturing units.
c) Non-supply of proven design differential pressure regulator valves (DPRV).
d) Lack of adequate manpower mobilization at site.
e) Coordination gap between BHEL's manufacturing unit & site erection and commissioning units.
f) Unit was kept under shut down since the year 2003 due to which many components were damaged/degraded/lost its life.

v. Bandel TPS (Unit# 5 of 210MW), WBPDCL

Even though the RLA studies were carried out in December 2006, followed by Energy Audit in August 2007, the R&M project could be started as late as 14.03.2012. This time gap

between assessment of conditions of the major equipment and start of implementation is very large.

Time schedule

The R&M implementation period was planned for 26 months but it actually took 41 months to complete the R&M works, which was mainly because of technical surprises encountered during implementation work in Boiler, Turbine, Generator, BOP etc. The unit was under shutdown on 02nd December, 2013, Zero Date of R&M project was 14th March, 2012 and the unit was synchronized on 25th August, 2015. The unit was planned for shutdown for 9 months but it actually was shutdown for 21 months. The planned Lead Period was 16 months but it actually was 19 months. The DPR was approved in July, 2008, hence, the Time Gap was 44 months.

Reasons for time overrun

Technical surprises encountered during implementation works in Boiler, Turbine, Generator, BOP etc.

vi. Talcher TPS (Unit# 5 of 110MW)

R&M was conducted in phases at this unit. The date of implementation of FSSS was from 30th August 2011 to 14th October 2011. The date of implementation of DDCMIS system was from 28th July, 2009 to 02nd September, 2009.

vii. Panipat TPS (Unit# 1 & 2 of 110MW each)

RLA study of UNIT# 1 was carried out in December 2001. The R&M work were started during September 2007. Thus there was a gap of 69 months between RLA study carried out and start of R&M works. This period is very long, as a result the expected performance of unit after completion of R&M works was not achieved.

For unit#2, RLA study were done in 1998 and R&M works were started in January 1999 by M/s. ABB through ICB.

Time Schedule

- Unit#1 was shutdown for R&M works on 25th September, 2007 and it was synchronized on 26th October, 2008. The planned R&M implementation period for unit-1 was 19 months and the actual was 27 months and the planned R&M implementation period for unit-2 was 5 months but the actual was 9 months. R&M of Unit#2 was started in January, 1999 by ABB but due to breach of contract by M/s ABB, the work remained stopped for considerable time. Later on the work was awarded to BHEL being OEM. The work was again started on 17th June, 2002 and the unit was synchronized on 10th March, 2003.

Time Overrun

- Time overrun for Unit# 1 was 8 months & for Unit# 2 it was about 50 months for completing R&M works due to breach of contract by ABB.

Reasons for Delay

For Unit#1, some technical surprises were encountered during implementation of R&M works as given below due to which the R&M works got delayed.

a. Erection of Middle and Bottom APH Blocks
b. Repair of HPQCV Valves (L&R)
c. Metal Stitching of LP Turbine casing of length 516”
d. Lifting and re-grouting pedestal no. 1&2 of turbine for catenary formation
e. Overhauling of 2 number coal mills and RC Feeders
f. Overhauling of PC Piping and complete ESPs

For Unit#2, the delay was caused due to breach of contract by original contractor M/s. ABB Later on the work was awarded to BHEL being OEM.
The following Figure reflects the Time Aspect of the R&M works carried out at various Thermal Power Stations.

Table 5.1: Comparison of R&M Implementation Period

Unit/TPS	R&M Implementation Period	
	Planned	Actual
U#1 Ukai TPS	20	38
U#9 Obra TPS	22	60
U#3 GNDTP, Bathinda	44	67
Unit#1 Muzaffarpur TPS	23	37
U#5 Bandel TPS	26	41
U#1 Panipat TPS	19	27
U#2 Panipat TPS	Not Available	69.5

Note: (a) Wherever a single contract has been signed for more than one unit, the first unit taken for R&M has been considered for calculation of R&M project implementation period.

(b) Unit-2 of Panipat TPS has not been considered because of contractual dispute the implementation period was abnormally very high.

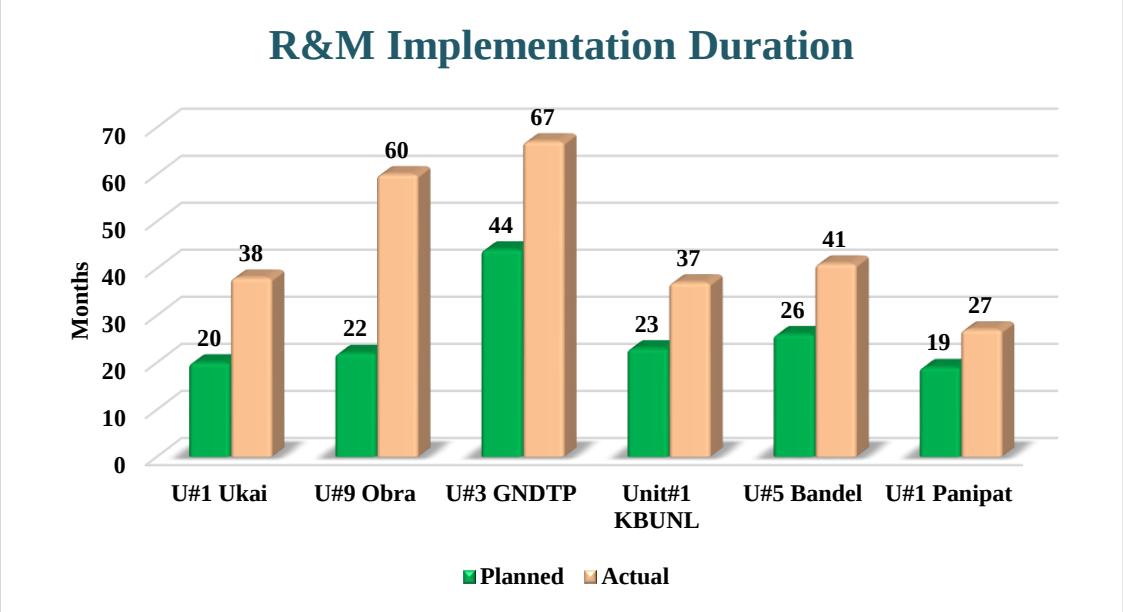


Figure 5.1: R&M Implementation Period Comparative Analysis

It is observed that actual R&M implementation period for different unit varies from 27 months (unit-1 of Panipat TPS) to 67 months (unit-3 GNDTP).

Table 5.2: Comparison of Shut Down Period

Unit/TPS	Shut Down Period	
	Planned	**Actual**
U#1 Ukai TPS	7	20.5
U#2 Ukai TPS	7	18
U#9 Obra TPS	7	31
U#10 Obra TPS	6	49
U#3 GNDTP, Bathinda	33	30
U#4 GNDTP, Bathinda	43	22
Unit#1 Muzaffarpur TPS	NA	37
U#5 Bandel TPS	9	21
U#1 Panipat TPS	NA	13
U#2 Panipat TPS	NA	50

The actual shut down period for R&M works varies from 13 months (U#1, Panipat TPS) to 31 months (U#9, Obra TPS). Unit-2 of Panipat TPS was shut down in January, 1999 for start of R&M works by M/s. ABB. However, the work was stopped in-between due to contractual disputes. Later on, it was got completed by BHEL and the unit was finally synchronized on 10.03.2013 on completion of all pending works. Thus, the unit remained under shut down for about 50 months.

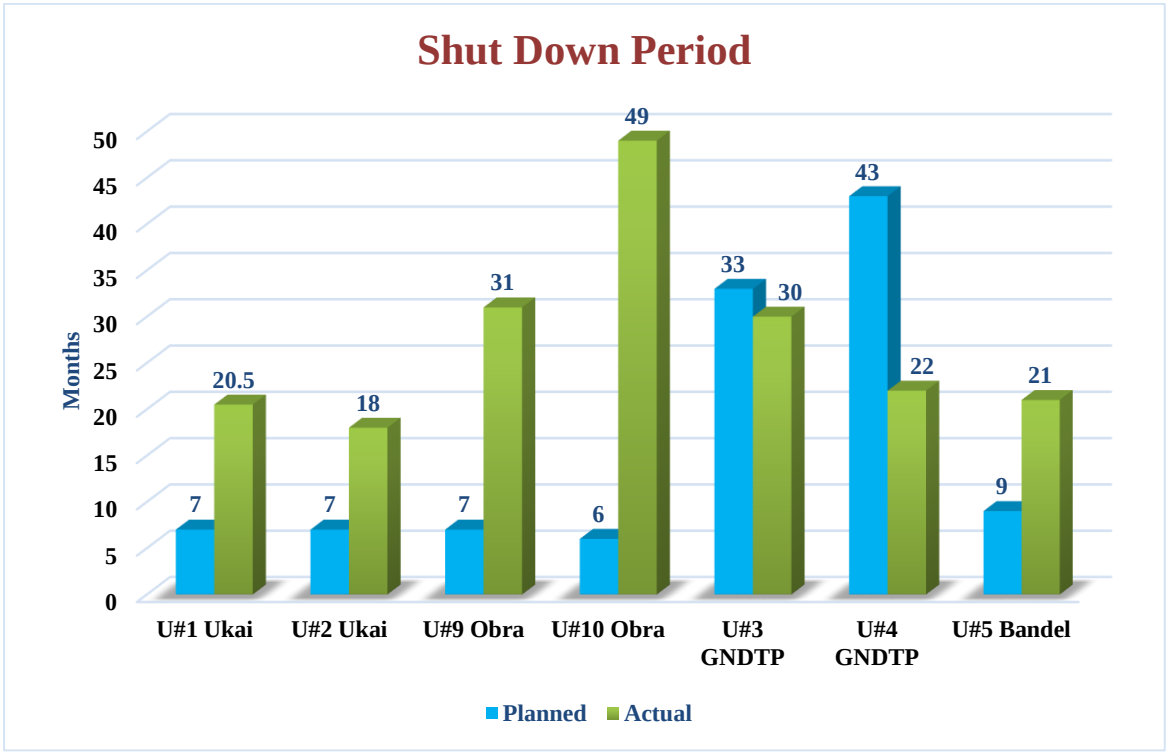


Figure 5.2: Comparative Analysis of Shut Down Periods

B. Cost of R&M works:

The cost of R&M works carried out at various thermal power stations have been observed as under.

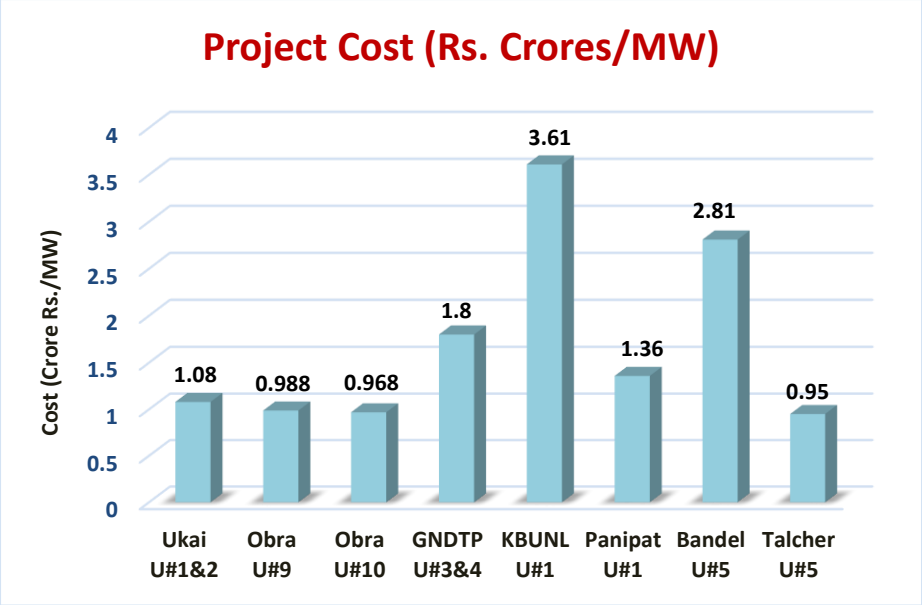


Figure 5.3: Comparative Analysis of Cost Aspect

The unit-wise analysis of the cost of R&M works is as under:-

i. Ukai TPS:

The schedule cost of R&M works for both unit no. 1&2 was Rs. 260/- Crore and there was no cost overrun.

ii. Obra TPS:

The estimated cost of project for unit-9 was Rs. 197.71/- Crores and that of unit-10 was 193.70/- Crores.

iii. GNDTP Bathinda TPS:

Package wise cost of R&M project (for both the units 3&4) for complete supply & services: Rs. 465.36/- Crore (Funding agency: REC)

Expenditure incurred till date: Rs. 383/- Cr: Work not closed yet.

Cost overrun: nil

iv. KBUNL TPS:

Estimated cost for R&M works: Rs. 471.80/- Crores

Actual completion cost: Rs. 795.73/- Crores

Cost overrun: Rs. 323.93/- Cr

Reasons for cost overrun:

Under estimation of some packages such as Ash dyke, firefighting system and technical surprises. Due to long shutdown of unit, damaged/degraded components had to be replaced.

v. Bandel TPS:

The initial project cost was Rs. 652.20/- Crores, the total expenditure incurred is Rs. 592/- Crores.

vi. Talcher TPS:

The allocated fund for the project was Rs. 264.50/- Crores for two units of 110MW and the expenditure was Rs. 209.18/- Crore till 31st March, 2015.

vii. Panipat TPS:

The cost project cost estimated to be Rs. 185/- Crore for two units.

5.2 Technical Surprises

The Technical Surprises faced by the Power Utilities along with the remedial measures as suggested by WAPCOS are given as under:-

Table 5.3: Technical Surprises and Remedial Measures Taken

S. No.	TPS/ Equipment	Technical Surprise	Remedial Measures
I.	**MAIN PLANT**		
A.	**Boiler and Auxiliaries**		
Ukai Unit# 1 & 2		a. Two BFPs are not able to maintain the Boiler drum level at 120MW load. b. One CEP not able to maintain the De-Aerator level	a. All the three BFPs kept in running condition. b. Both CEPs kept in running condition. c. Needs investigation.
GNDTP Bathinda Unit # 3&4		a) Mill reject was excessive b) Operation of Control Calve of PRDS was not reliable c) O_2 analyzer is not commissioned due to space constraint, which requires a straight path.	a) Problem addressed by providing airport assembly of bigger mills, Size of airport is reduced and outer periphery of coal bowl was modified. b) PRDS header changed from CRH c) Needs investigation
Bandel Unit# 5		a) Non-availability of spiral tube of HP Heaters, b) Buck stays were found damaged. c) Replacement of all diamond spring of boiler. d) Stage-II Attemperator found with broken	a) New HP heaters were procured. b) Replaced during R&M project c) The Diamond springs were replaced d) It took a long time to place it in

	supports, e) Design of joints changed from bolted to welded construction. f) Grouting bolts of PA fan were found in damaged condition, g) Bearing fitting of PA fan was defective h) Dynamic classifier vane required reorientation. i) One expansion bellow at condenser area found damaged. j) Fouling detected in mill auxiliary parts. k) After removal of drum internals, a few parts like vortex breaker, bridge bars of baffle etc. found missing. l) ID fan B foundation bolts were damaged.	its designated position. e) It was sent back to the workshop for necessary rectification. f) The bolts were replaced g) Rectified at workshop and thereafter backlash of bearing was adjusted at site. h) Reorientation work was done at site. i) Replaced at additional cost. j) Fouling rectified. k) Replaced on additional cost. l) Regrouting of foundation was done twice
Panipat Unit # 1	a) Erection of middle and bottom APH blocks	
B. Turbo Generator		
Ukai TPS# 1 **Ukai TPS# 2**	a. Temperature of turbine bearing number 3 is constantly high. b. High horizontal and vertical vibrations observed in Generator bearing numbers 6and7. a. Eccentricity of HP turbine is high b. Bearing metal temperature of turbine bearing numbers 3, 6 and 7 is high.	a. Shutdown for rectification could not be taken b. Generator was regularly monitored a. Shutdown for rectification could not be taken b. Generator was regularly monitored
Obra # 9 **Obra # 10**	a. Unit runs at high axial shift up to 0.98mm at 200MW load. b. Hot spot in Generator stator core c. TG auto loop control was not covered in the contract	a. Shutdown is awaited b. It was rectified by BHEL c. Awarded as a separate contract

Bathinda# 3&4	a) Temperature differential of turbine MP top and bottom is high despite of providing extra insulation b) Excessive drop in Main Steam temperature from boiler end to turbine inlet persists continuously	a) Problem not resolved b) Problem not resolved
Bandel U#5	a) Removal of complete grouted TG foundation b) Dimensions of Generator Trunion was mismatched c) Poor performance of main ejector. d) TG alignment coupling bolts were damaged. e) Oil film clearance between journal of the generator rotor and the white metal bearing supporting the rotor journal was more than the recommended. f) Barring gear was not getting engaged which was replaced by spare barring gear assembly.	a) The problem was solved with the help of special imported regrouting tools were required. b) Part reengineered and rectified. c) Reuse of old ejector after repairing. d) New bolts procured from SKODA. e) Bearing number 6 was replaced by spare bearing after machining at the local workshop. f) Replaced by spare barring gear assembly.
Panipat TPS # 1	a) HPQCV valves not functioning properly b) Pedestal numbers 1 & 2 for turbine catenary got rusted	a) Repair of HPQCV valves (Both L&R) b) Lifting and re-grouting of pedestal numbers 1 & 2 for turbine catenary formation

5.3 Contractual Arrangements and Performance Achieved

a. Contractual Arrangements

Different Utilities have made various contractual provisions to ensure achievement of Performance parameters and adhere to the Project Schedule. Some of the provisions are listed below:-

- Award of complete Package of R&M work to OEM
- Award of R&M work as Turn-key contract
- ICB (International Competitive Bidding) in smaller Packages viz. Implementation Support Consultancy, BTG Package, Electrical Package and CHP Package.

b. Liquidated Damages:

Different Utilities have made different provisions for Liquidated Damages. The Liquidated Damages for both Performance and Delay as provided by some of the thermal power stations are tabulated as under.

Table 5.4: Liquidated Damages for Non-Achievement in Performance

S. No.	Name of TPS	Heat Rate	Power Output	Live Steam Output	Boiler Efficiency	Plant Availability
		kCal/kWh	**MW**		**%**	**%**
1	Ukai TPS	2122+0.9%	120		85.5	80
	Chargeable Rate	₹53200/- for every kCal/kWh increase	₹26285/- for every kW shortfall		₹273000/- for drop of every 0.1%	
2	GNDTP	2122+0.9%	120		87.5%	
	Chargeable Rate	₹53/- Lakh for every kCal/kWh increase	₹1.5/- Lakh for each kW shortfall		₹145/- Lakh for drop of every 0.1%	
3	Bandel TPS	2456	215			
	Chargeable Rate	Rs120/-Lac per Kcal/kWh increase	Rs0.50Lac per KW shortfall			
4	NTPC Talcher TPS	2.5% of the Contract Price for each one percent (1%) weighted average deviation from the guaranteed performances				
	Weighted Factor [1.0]	0.25	0.2	0.1	0.25	0.2
5	Panipat TPS	2018	120	275 T/hr.	86	90
	Chargeable Rate [Max 1.8%]	0.5 % of Contract Price	0.4 % of Contract Price	0.2 % of Contract Price	0.5 % of Contract Price	0.2% of Contract Price

Recommendations: It is recommended to make the provisions for Liquidated Damages for Performance. However, the extent/level of chargeable rate should be decided by the Power Utility who alone can visualize the Scope and the local conditions.

Table 5.5: Liquidated Damages for Delay

Name of Power Station/Utility	Liquidated Damages For Delay [Chargeable rate[%] or Amount in Rs]	Maximum Ceiling
Ukai TPS	0.25% /Week or part thereof	7.5 % of total order value.
GNDTP	0.25% /Week or part thereof	7.5 % of total order value
Bandel TPS	0.1% of the Contract Price per day of delay in successful Completion of Facilities (750 days)	Max. 10% of the Contract Price
	0.25% of the Contract Price for each day of extension in shutdown period (180 days).	
Panipat TPS	0.25% of the Contract Price of the Unit delayed subject to max 5%	Max 6.8% of contract price. (Overall penalties for "shortfall in performance" and "delay in completion period")

Recommendations:

It is recommended to make the provisions for Liquidated Damages for Delay. However, the extent/level of chargeable rate should be decided by the Power Utility who alone can visualize the Scope and the local conditions.

a. Performance Achieved

- In case of Ukai, Panipat unit-1&2 and Obra unit-9 there was an increase in gross power generation and in case of Obra unit-10, Bandel TPS and GNDTP Bathinda there was decrease in power generation Post R&M.
- It can be seen that PLF of Ukai, Obra unit-9, Panipat unit-1&2 and NTPC Talcher increased but in case of Obra unit-10, GNDTP, Bandel and KBUNL TPS PLF decreased after R&M works.
- It can be seen that there has been improvement in APC of Obra, GNDTP, Panipat unit-1 and NTPC Talcher units but Ukai TPS and Bandel has shown increase in APC. APC of Unit-2 of Panipat TPS remained almost same.
- It is observed that SOC increased in Ukai, Obra unit-10 and Bandel units but it improved for Obra unit-9, Panipat unit-1&2 and GNDTP.
- It is observed that SCC of all the units improved after R&M works except unit-1 of Panipat TPS.
- It is observed that except Ukai units- 1&2, Heat Rate has improved for all other units.

5.4 Project Management Process

I. Ukai TPS

a) A special project management team consisting of Additional C.E. (R&M), Senior Engineer (R&M), Executive Engineer (R&M), Divisional Engineer (R&M) and Junior Engineer (R&M) respectively was constituted so that R&M works of 120MW unit# 1 and 2 could be executed timely and efficiently.
b) The entire R&M project was split into number of packages as under.
c) Every package for work was handled by separate supervisors and assisted by suitable engineering team. Regular internal meetings with project authorities and main/sub-contractors were also held for monitoring progress of work and coordination among utilities and contractors.

The formation of special R&M team and coordination meetings were useful in proper implementation of the project.

II. Obra TPS

a) A special project management team consisting of Chief Engineer (R&M), Superintending Engineer (R&M), Executive Engineer (R&M), Junior Engineer (R&M) and some officials from Electrical, Mechanical, C&I and Civil circles, respectively.
b) R&M project was split into following packages.
c) Internal meetings were also held with contractors for monitoring progress of works. Also meetings were held with BHEL, at utility head quarter Lucknow and Obra TPS as per requirement.

d) Coordination meetings were also held between utility and contractors as well as with sub-contractors. But these were not very fruitful because BHEL and some other contractors/sub-contractors were less cooperative.

Although, special R&M team was formulated, yet required cooperation of main/sub-contractors could not be obtained effectively.

III. GNDTP, Bathinda

No separate R&M team was constituted. The R&M implementation work was mainly looked after by plant maintenance personnel relating to their respective areas, in addition to their normal maintenance works. However, one R&M cell was created under a Superintending Engineer In-charge, for coordinating all R&M activities. There has been considerable delay in the implementation of the R&M project as there was no special team to closely monitor the progress and take timely action to minimize delays.

IV. Muzaffarpur TPS

a. No separate team for R&M works was constituted. The work was looked after by concerned O&M team.
b. Amongst BHEL, AGM & Dy. Manager were involved full time to coordinate between different units of BHEL and with different govt./non-govt. agencies and conducting internal contractual meetings / execution progress meetings.
c. Project monitoring was done by project authorities through consultants by
   i) Conductance of CRM with BHEL & its agencies
   ii) Conductance of site meetings for execution progress, twice a week
   iii) Conductance of meeting chaired by MD, BSPGCL twice in a month with higher authorities of BHEL & other contractors.

V. Bandel TPS

Special team of R&M implementation constituted comprising of DGM, Manager and Assistant Manager etc. by WBPDCL. Contractor had formed their own R&M team. R&M work was given to various subcontractors. Material generally received in time. Regular meetings were held for monitoring the progress of works among utility & contractors. However, Instances of slow progress of work happened due to delayed payment to labor by some sub-contractors. There was also lack of coordination amongst intra departments.

VI. Talcher TPS

a) R&M Team fort implementation of R&M project was formed by NTPC
b) Project Monitoring Process was followed by NTPC R&M Division
c) Scheduled meetings were held for monitoring the progress of work. Monthly Engineering issues discussed in regular meetings.
d) For coordination among the utility and contractor: Representatives of contractor were available at site for coordination of R&M work with NTPC authorities.

VII. Panipat TPS

a) Special team and a separate R&M division was formed under SE (M&T) in co-ordination with various maintenance divisions under SE (O&M-I).
b) The contractor BHEL and M/s. ABB had also formed their respective R&M teams.

c) Project monitoring process was followed by project authorities themselves or through their consultants.
d) Regular meetings were held between R&M team/utility and the contractors/sub-contractors.

5.5 Deviations from Project Implementation

5.5.1 Ukai TPS

No deviations intimated.

5.5.2 Obra TPS

Following deviations from the original scope of work were carried out.

(i) First unit R&M (unit 9) started from 02-11-2008 deviating 2 years & four months on availability of turbine from BHEL side because of dispute between BHEL & turbine supplier M/s Power Machine, Russia.
(ii) Only 9th unit could be uprated from 200 MW to 216 MW. But, in unit- 10, 11, 12 & 13 the original name plate rating (200MW) is to be restored.
(iii) Unit 9 in respect of auto loop is not fully completed.
(iv) RGMO operation is faulty.
(v) No PG test on 216 MW till now.
(vi) Initially there was no provision of DCS max DNA for TG auto loop which have been added later on for unit 10, 11, 12 & 13 and a separate order Rs. 54 crore for DCS max DNA have been placed on BHEL.
(vii) Major fault in stator core of unit 10 was observed. A separate order has been placed to BHEL. The repair work completed and unit was synchronized on 08th April, 2016.
(viii) BHEL are not accepting warranty clause of the R&M contract.
(ix) 06 nos. compressors were procured on assessment to meet the air requirement for smooth operation of equipments.

5.5.3 Bathinda TPS

No deviations intimated.

5.5.4 Muzaffarpur TPS

Addition of Electrical/ Mechanical/ C&I works/ supplies, consultancy service, supply of crusher rotors amounting to approximately Rs 28.24 Cr were added apart from the original scope of work, since these were technically required for completion of R&M works.

5.5.5 Bandel TPS

Following deviations from the original scope of work were carried out.

i. Re-tubing of three HP heaters was done. Replacement of spiral coil of HP heater could not be done as it is not manufactured by reputed agency.
ii. All diamond springs of boiler were found damaged, so the same were replaced.
iii. Buck stays were replaced as three numbers boiler buck stay structures found in damaged condition.
iv. Construction of additional portion of AHP building cost was huge as the cost increased by 38.21%.

5.5.6 Talcher TPS

In R&M for stage-II (2x110MW) units, C&I R&M as envisaged for major package and critical components of boiler as a small package. However, during execution of C&I R&M, the need was felt for FSSS system. Thus, a full-fledged FSSS system package was introduced and clubbed with boiler critical components.

5.5.7 Panipat TPS

Following deviations from the original scope of work were carried out.

i. Erection of Middle and Bottom APH Blocks.
ii. Repair of HPQCV Valves (L&R).
iii. Metal Stitching of LP Turbine casing of length 516”
iv. Lifting and re-grouting pedestal no. 1&2 of turbine for catenary formation.
v. Overhauling of 2 No. coal mills and RC Feeders.
vi. Overhauling of PC Piping and complete ESP

5.6 Summary

The R&M implementation experience by different thermal power stations are summarized below:

- R&M of Ukai TPS got delayed due to delay in supply of critical equipment. The units could not attain full load without running additional BFP and CEP pumps. PG test of the units is still pending due to some contractual issues with the OEM. Therefore, R&M for other units/plants was dropped by GSECL.
- Delay in completion of R&M of Unit-9 and 10 of Obra TPS was due to non-sequential supply of critical equipment by OEM. Technical surprises like hotspot in Unit-10 generator caused further delay and cost escalation. All the performance parameters of unit-9 improved after R&M works, thus it is really appreciable. Unit-10 is still under stabilization but it has also shown improvement in performance parameters after R&M works. PG test of the units have not yet been conducted due to some left out jobs.
- R&M work at GNDTP Bathinda got delayed due to delay in planning and finalization of sub-contractors, delay in supply of critical equipment by OEM, slow work progress due to inexperienced personnel of the contractor and lack of coordination among various stake holders. Technical surprises as discussed earlier also led to time and cost escalation. Except gross generation and PLF, all other parameters of unit-3 and 4 improved after R&M works. PG test for Boiler, Turbine, ESP and APC have already been conducted for unit-3 but for unit-4 PG test of Boiler has been conducted but results have not yet been finalized and other performances like Turbine, ESP and APC are still pending.
- The unit-1 of Muzaffarpur TPS of KBUNL was shut down since 2003. RLA was conducted in 2008 and R&M was started in 2010 i.e. after 7 years of shutdown. This led to further deterioration of components and equipment leading to escalation of project cost and time overrun. PG test of the unit is not conducted yet.

- The project delayed due to delayed labor payment of some sub-contractors at Bandel TPS. C&I activities delayed due to breach of contract between sub-contractors. L2 and L3 schedules were not submitted by main contractor due to which engineering reviews could not be done. The unit is under stabilization but still it can be seen that SCC and Heat Rate values have improved tremendously. PG test of the unit was conducted in November, 2016.

- R&M at NTPC Talcher was conducted in phases i.e. during long shutdown and annual overhauling and in different packages. Some of the packages were completed in record time of 35 days. The expenditure incurred was less than the estimated cost of the project. All the performance parameters viz. PLF, Availability, APC and Heat Rate improved tremendously after takeover of the unit by NTPC from OSEB. The life of the unit has increased by implementing technological up-gradation of equipment.

- R&M of Unit-1 of Panipat TPS was completed and PG test of Boiler and Turbine was successfully done. R&M of Unit-2 of Panipat TPS was started in 1999 but due to some contractual breach by M/s. ABB, the work got delayed and the same was again awarded to OEM i.e. BHEL. PG test was not included in the contract. All the performance parameters of Unit-1 improved except SCC after R&M works. All the performance parameters of Unit-2 improved except APC after R&M works.

- The benefits envisaged after performing successful R&M implementation were sustained unit availability and generation, the reliability of the unit has improved, life of the units have been increased by implementing technological up-gradation of equipment, flexibility of operation and maintenance, technological obsolescence have been overcome by replacing older equipment to get the spares of the new ones, improvement in plant safety and better environment management by installing new ESP.

- It was suggested by Ukai TPS that R&M of 120MW units needed to be dropped by GSECL. It was pointed out that critical materials were not supplied by BHEL as per the order schedule. Also performance of some of the subcontractors was not satisfactory and some contractors left the site without completing their work assigned to them. Their replacement with the new subcontractors took long time resulting into undue delay of the project.

- Instances of slow progress of work happened at Bandel TPS due to delayed payment to labor by some sub-contractors. There was also lack of coordination amongst intra departments. C&I activities suffered due to breach of erection contract between Siemens and Doosan. Non-availability of proper erection personnel of sub-contractor. Engineering reviews could not be done properly as Doosan did not submit realistic L-2 and L-3 schedule. West Bengal Pollution Control Board (WBPCB) initially advised to raise the chimney height as capacity addition had occurred. Finally, this requirement was withdrawn after intervention of CEA in this issue. There was low participation in bidding process for R&M works.

Chapter-6
Recommendations

After studying and analyzing the R&M implemented at various thermal power stations, recommendations have been made in view of time and cost aspects, technical surprises, contractual arrangements and the performance achieved by these units. In order to avoid/minimize the time and cost overrun and efficiently carryout the implementation of R&M works, the following recommendations are made based on the study of data/information supplied by various TPS and interaction with the concerned authorities during visits of the WAPCOS experts to the respective power stations.

a) Normally, the shutdown period for R&M works should be in the range of 6 to 8 months depending on the scope of work. However, it has been observed that actual shutdown period taken for R&M works varies from 13 to 30 months from unit to unit. The shutdown period needs to be minimized to the extent possible through proper planning and monitoring. Accordingly, necessary advance preparation for arranging the material/equipment and engaging of contractors may be made by the utilities.

b) Technical Surprises during R&M implementation are inevitable. However, these can be minimized by due diligence done during initial stage of framing of proposals/preparation of Detailed Project Reports (DPR). The DPR needs to be prepared through experienced consultants on the basis of RLA/CA studies. The major areas prone to technical surprises be identified and unit values can be kept in the contract to be utilized only if the need arises.

c) It has been observed that PG test of Ukai TPS, Obra TPS, KBUNL Muzaffarpur and has not been carried out after R&M. As such, it is not possible to evaluate the actual performance of the concerned unit. However, it becomes essential to provide safeguard against shortfall in performance against guaranteed parameters. The all out efforts should be made to conduct the PG test within three months after the unit gets stabilized after re-commissioning of the main plant i.e. BTG and also any of the BoPs covered in the scope of R&M contract. The Utilities have made provisions for Liquidated Damages for shortfall in Performance in Heat Rate [For every kCal/kWh increase], Power Output [For every kW shortfall] and Boiler Efficiency [For specified level of percentage drop]. Some utilities have made provisions for the Liquidated Damages chargeable against specified deviations from guaranteed parameters as percentage of the contract price.

d) It has been observed that in certain cases the Contractors/Subcontractors left the work without completion of job. Due to this, delay was caused in completion of R&M works. To safeguard against this, the Utilities have made provisions for Liquidated Damages for Delay at the chargeable rate of 0.25% /week or part thereof subject to 5% to 7.5% of the contract value. The provision of liquidated damages

should be kept in the contracts and the extent/level of chargeable rate should be decided by the power utility depending upon the scope of work.

e) A dedicated R&M team for implementation should be formed at the plant level for efficient and timely execution of the R&M project. In certain cases, it is observed that normally maintenance staff of plant is given the additional responsibility of R&M works due to which they are not able to devote full time for the R&M works affecting the quality and timely completion of work. It is, therefore, very essential to form an independent and dedicated Team for executing the R&M works.

f) Delivery of materials/equipment must be sequential and as per the progress of work to avoid unnecessary dumping of material/equipment at project site in order to avoid problems due to storage space availability and deterioration of condition of the equipment/material.

g) Project management guidelines for R&M works of various packages with time frame should be identified, defined and standardized. L1, L2 and L3 schedules should be prepared and followed religiously. Micro-level break-up of activities such as time period and cost required, should be made available. This will help in making use of various Project Management Software.

Appendix-I

Terms of Reference

1. Background

1.1 India currently has an installed generation 173,626 MW (as on 31.03.2011), of which 93918 MW (54 percent) is coal-fired contributing major share of total generation. While much of the 1970s (and older) vintage units have been or need to be retired, many of the coal-fired power plants (NTPC as well as state utility owned plants) that were commissioned in and before early 1980s are now due for rehabilitation and life extension.

1.2 CEA has prepared a National Perspective Plan for facilitating the R&M (Renovation & Modernization) and L.E. (Life Extension) works at various thermal power stations in the country. Through the Perspective Plan, efforts would be made to facilitate rehabilitation of the old thermal plants with an objective of efficiency enhancement, life extension, up-rating and reduction in Greenhouse Gases emissions by repair, replacement, modification and technology up gradation. Fifty three (53) units with a total capacity of 7318 MW of Life Extension (LE) works & seventy six (76) units with a total capacity of 18965 MW for R&M works have been identified for the 11th Plan. Similarly for the 12th Plan, LE works on seventy two (72) thermal units of total capacity 16532 MW and R&M works on twenty three (23) units of total capacity 4971 MW have been identified under the above National Perspective Plan.

1.3 The World Bank has financed the "Coal-Fired Generation Rehabilitation Project" for demonstrating energy efficient rehabilitation and modernization (EE R&M) of coal fired generation units through rehabilitation of 640 MW of capacity across three states- West Bengal, Haryana and Maharashtra. The project would also address critical barriers to large scale EE R&M in India. The project would be funded through IBRD loan of US$ 180 million and GEF grants of US$ 45.4 million. The project has two components:-

Component-1: Energy Efficiency R&M Pilots Using US $ 180 million of IBRD loan and US $ 37.9 million of GEF grants:

This component would fund Energy Efficient R&M of 640 MW capacity comprising Bandel TPS Unit-5(210 MW) of WBPDCL, Koradi TPS Unit-6(210 MW) of Mahagenco and Panipat TPS Unit-3&4 (2x110 MW) of HPGCL. The World Bank has earmarked US$ 180 million of IBRD loan and US $ 37.9 million of GEF grants for the Component-1.

Component-2: Technical Assistance to address Critical Barriers to EE R&M:

The World Bank has earmarked US $ 7.5 million GEF Grant for the Component-2. The sub-components for the technical assistance program would cover:

i. Support for design of Energy Efficient R&M projects.
ii. Support for implementation of demonstration of EE R&M investments funded under Component-1 of the project.
iii. Support for addressing barriers to EE R&M projects.
iv. Support for strengthening of institutional capacities of utilities.

1.4 Under the sub-component (iii) of the component-2 (Technical Assistance) around US$ 1.1 million of GEF Grants are being made available to provide technical support to CEA aimed at addressing barriers to implementation of R&M in India. This component would be implemented through the Central Electricity Authority through appointments of Consultants including Implementation Support Consultant (ISC) to carry out following studies –

i) Review of Institutional Capacity and Implementation of Capacity Strengthening Interventions at CEA
ii) Reduction of barriers to R&M interventions in thermal power plants in India;
iii) Developing markets for implementation of R&M scheme in thermal power stations in India;
iv) Review of experience from Pilot R&M interventions in thermal power stations in India.

1.5 Ministry of Power, GOI vide letter No. 10/1/2009-IC dated 07.01.2009 have conveyed in-principle approval for the above proposed project under the title "National Programme for R&M". CEA has been identified as the Project Implementing Agency for sub-component (iii) of Component -2 for Technical Assistance. The sub-component (iii) would be implemented under the title **"Technical Assistance to CEA for Addressing the Barriers to Energy Efficiency R&M of Coal Fired Generating Units in India"**.

1.6 CEA has already appointed Implementation Support Consultant who is assisting CEA in appointing the Consultants for the above four studies and in co-ordination amongst CEA & various Consultants and monitoring of Consultant's works & Pilot R&M projects funded by World Bank.

1.7 The World Bank is supporting pilot energy efficiency focused R&M interventions at Unit-5 of Bandel TPS, Unit-6 of Koradi TPS (Maharashtra State Power Generation Company Limited) and Units 3 & 4 of Panipat TPS. In addition, similar pilots are also being taken up under KfW funding at Nasik TPS (Maharashtra), Bokaro 'B' TPS (Damodar Valley Corporation) and Kolaghat TPS (West Bengal) under Energy Efficiency R&M Programmee under Indo-German Energy Forum. The National Electricity Policy envisages that Renovation & Modernization (R&M) for achieving higher efficiency levels needs to be pursued vigorously and all existing generation capacity should be brought to minimum acceptable standard. Hence, the Pilot energy efficiency focused R&M projects have been facilitated to gain an experience from these Pilot R&M projects and to implement the same at other thermal power stations in India.

2. Assignment & Broad Scope of Work

The main objective of the assignment is to procure Consultant who inter-alia would review the experience of the activities which have been carried out in the Pilot R&M Projects during different stages of preparation and implementation of these projects and would prepare reports for dissemination of the experience across Utilities in India. The consultant will also review the implementation experience at other R&M projects taken up by the utilities during 11th Plan and 12th Plan.

The main task of the Consultant would be to facilitate CEA in sharing of experience on Pilot R&M projects and other R&M/LE projects taken up during 11th plan and 12th plan. For this, CEA would require support from the Consultants in the following manner but not limited to:

a) Review of Procurement Experience including preparation of DPR, Bidding documents, etc.;

b) Review of R&M Implementation Experience;
c) Review of Experience in Strengthening of O&M Practices;
d) Review of Post-R&M Experience in O&M;
e) Dissemination of Learnings from Pilot R&M Interventions.

3. Detailed Description of Tasks

Work would be undertaken in the manner as given below:

3.1 Review of Procurement Experience for Pilot R&M Projects

a) The Consultant shall analyse and review the procurement experience in awarding R&M works for Pilot R&M projects funded by the World Bank and KfW. The Consultant shall, especially, look into the DPR, Bidding documents, Qualification Requirements, Performance Guarantees and Project Schedule. The Consultant shall also review the Evaluation Criteria including Project Schedule and Performance Parameters and the impact of these on the overall level of competition and price bid discovery. For review of the procurement experience, the Consultant shall cover all the R&M related procurement activities completed till May 2014 at the identified thermal power stations as part of study.

b) The Consultant shall carry out analysis of bidding process followed by the power generating companies in selection and procurement of consultants/suppliers to undertake the required R&M interventions. The Consultant shall also analyse and review the key steps undertaken to ensure competitiveness in the bidding process and suggest the possible options to improve the competitiveness in the bidding process.

c) The Consultant shall examine the various other factors that may have affected the procurement outcome at the Pilot R&M Projects of World Bank and KFW; and also analyse the problems faced while finalizing the contract(s) for Pilot R&M Projects.

d) The Consultant is required to visit the selected thermal power stations to collect and compile the relevant information and document to undertake the desired review and analysis.

e) The Consultant shall prepare and submit a report on learnings from the procurement experience from the Pilot R&M Projects of the World Bank and KfW projects for dissemination purposes for future R&M projects.

f) The review exercise will be limited to the thermal power stations as mentioned in the **attached list of projects as Annexure I.**

3.2 Review of R&M Implementation Experience

a) The Consultant shall review the available R&M Implementation Experience at thermal units in various thermal power stations as **mentioned in Annexure-II.** . Broadly, the review would include inter-alia the time and cost aspects, technical surprises, contractual arrangements and the performance achieved. The Consultant shall cover R&M Implementation Experience available at the above mentioned thermal power stations till two months before the scheduled timeline for submission of Draft Final Report on this activity.

b) The review of the R&M Implementation experience shall also include the analysis of project management process and identify the areas where the actual project implementation deviated from desired objectives and analyse the reasons for such deviations.

c) The Consultant is required to visit the selected thermal power stations to collect and compile the relevant information & documents to undertake the desired review and analysis.

d) Based on the review of R&M implementation experience, the Consultant shall prepare a report on R&M/LE Implementation Experience which may be helpful to the generating companies for carrying out the R&M works in future.

3.3 Review of Experience in Strengthening O&M Practices

a) The Consultant shall review the interventions of Operations & Maintenance (O&M) strengthening practices undertaken by the concerned power generating companies – WBPDCL, MSPGCL and HPGCL.

b) The Consultant shall review the strengthening interventions undertaken by the utilities for enhancing O&M practices across the various facets including technology, O&M planning, conditional monitoring, preventive maintenance, O&M procedures, enhancement in technical & managerial skills of O&M personnel and infrastructure/facilities improvement etc.

c) The Consultant shall indicate the benefits accrued on account of the various strengthening interventions in O&M practices undertaken at these thermal power stations.

d) The Consultant shall list out the drawbacks/shortcomings faced in the O&M practices followed by power generating companies after implementation of the strengthening interventions and suggest possible measures for further improvements.

e) The Consultant may be required to undertake visits of above mentioned power generating companies for the purpose of the review of the experience in strengthening O&M practices.

f) Based on the review and discussion with the generation utilities, the Consultant shall prepare a report on strengthening of Operation & Maintenance (O&M) practices followed by these power generating companies for the purpose of sharing the learnings/experience.

3.4 Review of Post - R&M Experience in O&M

a) The Consultant shall review and share the Post - R&M Experience in O&M after the plant has been in operation for a considerable time (say about six months) after completion of R&M works at the thermal power stations as **mentioned in Annexure III**. The review will include Post -R&M review of the operational performance of the generating units where R&M interventions have been undertaken **till eight months before the scheduled timeline for submission of**

Draft Final Report and indicate the improvements in their operational performance.

b) The Consultant shall list out the problems/challenges faced in O&M of thermal unit after implementation of the R&M interventions and suggest suitable measures for further improvements in the units.

c) The Consultant may be required to make visits to listed thermal power stations for the purpose of review of the Post- R&M experience in O&M.

d) Based on the review of O&M experience, the Consultant shall prepare a report on Post R&M experience in O&M at the listed thermal power stations for the purpose of sharing the experience for future R&M units.

3.5 Dissemination of Learning from Pilot R&M Interventions and other R&M Projects

a) The Consultant in association with CEA will conduct One (01) workshop in Delhi for sharing of experience with different stakeholders on R&M activities carried out at Pilot R&M projects and other R&M Projects.

b) The Consultant shall submit Fifty (50) copies and soft copies in CD's of all Final Reports to CEA for sharing experience with the future R&M projects.

4. Deliverables and Tentative Time Schedule for completion of task

4.1. The contents and break-up of the deliverables/reports will have to be agreed with CEA. The assignment is likely to commence in May 2012 and the tentative time schedule for completing the various activities is as under:

S.No	Deliverable	Timeline (Tentative)
1.	Inception Report	June 2012
2.	Draft Report on review of procurement experience (available till the timeline) at Pilot R&M Projects	December 2012
3.	Draft Report on review of Experience (available till the timeline) in Strengthening O&M practices	July 2013
4.	Draft Report on review of R&M Implementation experience (available till the timeline) at Pilot R&M Projects and other R&M projects	December 2013
5.	Draft Report on review of Post - R&M experience in O&M of the thermal power stations	April 2014
6.	Draft Final Report on review of procurement experience available at Pilot R&M Projects [1]	June 2014
7.	Draft Final Report on review of Experience in Strengthening O&M practices[2]	June 2014
8.	Draft Final Report on review of R&M Implementation experience available at Pilot R&M Projects [3]	July 2014

9.	Draft Final Report on review of Post - R&M experience in O&M of listed thermal power stations[4]	July 2014
10.	Conduct Workshop for sharing of experience on Pilot R&M Projects with Stakeholders	September 2014
11.	Final Report on review of procurement experience available at Pilot R&M Projects	October 2014
12.	Final Report on review of Experience in Strengthening O&M practices	October 2014
13.	Final Report on review of R&M Implementation experience available at Pilot R&M Projects	October 2014
14.	Final Report on review of Post R&M experience in O&M of the listed thermal power stations	October 2014

Note:

1 The Draft Report shall include the experience in procurement available at the R&M projects till the indicated timeline. The rest of the experience in procurement at the R&M projects available during the period between submission of the Draft Report and Draft Final Report shall be included in the Draft Final report.

2 The Draft report shall include the experience in strengthening O&M practices available at the R&M projects till the indicated timeline. The rest of the experience in strengthening O&M practices at the R&M projects available during the period between submission of the Draft Report and Draft Final Report shall be included in the Draft Final Report.

3. The Draft report shall include the experience in implementation available at the R&M projects till the indicated timeline. The rest of the experience in implementation at these R&M projects available during the period between submission of the Draft Report and Draft Final Report shall be included in the Draft Final Report.

4 The Draft report shall include the Post- R&M experience in O&M till the indicated timeline. The rest of the experience in the Post- R&M experience in O&M available during the period between submission of the Draft Report and Draft Final Report shall be included in the Draft Final Report.

4.2. The Consultant will be required to submit monthly and quarterly progress reports to CEA.

4.3. The Consultant shall submit 10 copies of Inception Report, 10 copies of all Draft Report, 10 copies of all Draft Final Report and 50 copies of all Final Reports.

4.4. All deliverables/reports shall be prepared in hard form and also in electronic form (Word, Excel, Power Point, pdf files etc.). The reports shall be submitted on A4 Size paper with adequate size of alphabets/symbol & line spacing.

5. Support/Inputs to be provided by CEA

5.1. CEA will be the Employer of the Consultant and will nominate a Project Manager. Project Manager will act as liaison officer to the Consultant's team. He will be the point of contact and initial addressee for all aspects of the works.

5.2. The CEA will provide all existing information, data, reports and maps as available and will assist the Consultant in obtaining relevant information and materials from government institutions and state authorities to the extent possible.

5.3. CEA will not provide any space for office.

5.4. Personal Computers, Laptops, printers, photocopier, stationery items etc. will be arranged by the consultant.

6. Consultant Skill Sets and Team Composition

The Consultant team should have an appropriate mix of experience and expertise in India and abroad in respect of Renovation & Modernisation of thermal power plants and Power Sector Policy /Regulations. The Key Professional Staff in the Consultant team are expected to be from technical background and also having the knowledge of Indian Power Sector, especially with regard to Operation & Maintenance of thermal power stations and R&M/LE programme implementation. The team of the Consultant shall comprise a Team Leader, one R&M Expert, one O&M Expert, one Commercial Expert & one Environment Expert. The Key Professionals would be spending their time depending on requirement of the assignment during the entire duration of the assignment. The Consultant should have an in depth knowledge of the current R&M/LE guidelines/policies and regulatory frameworks for thermal power plants in India. The Consultant should also have expertise in assessing environmental impact/benefits of the R&M/LE projects. The Consultant may propose additional members in their team to provide required expert services in other areas / tasks identified by them. The required qualification & experience is given in the table below:

S. No.	Key Position	Minimum Qualification and Experience	
1.	Team Leader	B.E. / B. Tech	Team Leader shall have minimum fifteen years (15 years) professional experience in Power Sector including ten years' experience in O&M / R&M of coal fired thermal power stations having units of capacity of 110 MW and above.
2.	R&M Expert	B.E. / B. Tech.	R&M specialist should have minimum ten years (10 years) experience in Power sector including two years' experience in R&M of coal fired thermal power stations having units of capacity of 110 MW and above.
3.	O&M Expert	B.E. / B. Tech.	O&M specialist should have minimum ten years (10) years' experience in Power sector including five years' experience in O&M/ R&M of coal fired thermal power stations having units of capacity of 110 MW and above.

S. No.	Key Position	Minimum Qualification and Experience	
4.	Commercial Expert	MBA/B.E. / B. Tech.	Commercial expert should having minimum ten years (10 years) experience in contract management in Infrastructure sector including three years (3 years) experience on contract management in R&M/O&M of coal fired thermal power stations.
5.	Environment Expert	Graduation / Post Graduation Degree in Environment.	Environment Expert should have minimum ten years (10 years) experience in assessing the environmental aspects of infrastructure projects.

ANNEXURE-I

List of Units to be considered for review of Procurement Experience for Pilot R&M projects

Sl No	Unit No	Capacity (MW)	Name of Thermal Power Station (TPS)	Name of Utility/State	Executing Agency	Completion of LE Works/Status
1	6	1X210	Koradi TPS	MSPGCL/Maharashtra	Yet to be awarded	DPRs are under finalisation
2	5	1 x 210	Bandel TPS	WBPDCL/West Bengal	Yet to be awarded	DPRs are under finalisation
3	1, 3 & 4	2x110, 1x110	Panipat	HPGCL/ Haryana	BHEL, Yet to be decided	DPRs are under finalisation
4	4 & 5	2x210	*Badarpur	NTPC	Yet to be awarded	DPRs are under finalisation
5	6,7&8	3x110	*Kothagudem	APGENCO, Andhra Pradesh	Yet to be awarded	DPRs are under finalisation
6	3	1x210	Nasik TPS	MSPGCL/Maharashtra	Yet to be awarded	DPRs are under finalisation
7	1 & 2	2x120	*Amarkantak	MPPGCL	Yet to be awarded	DPRs are under finalisation

* As per the meeting held at CEA on November 08, 2012 and Minutes of Meeting communicated by CEA vide their letter no. 2/52/TRM/CEA/2012/1888 dated 21.11.2012, Chandrapur TPS Units 1&2(1x210MW), Parli TPS Units 2&3 (1x 210 MW) and Kolaghat TPS Unit 3 (1x 210MW) have been replaced by Badarpur TPS Units 4&5 (2x210MW), Kothagudem TPS Units 6,7 and 8 (3x110MW) and Amarkantak TPS Units 1,2 (2x120 MW) respectively for Review of Procurement Experience for Pilot R&M projects (completed till May 2014).

ANNEXURE-II

List of Units to be considered for review of R&M Implementation Experience

Sl No	Unit No	Capacity (MW)	Name of Thermal Power Station (TPS)	Name of Utility/State	Executing Agency	Completion of LE Works/Status
1	1& 2	2x120	Ukai TPS	GSECL/Gujarat	BHEL	**Unit 1**- Unit was synchronized on 24 May 2008 after LE works **Unit 2** – Unit was synchronized on 24 February 2010 after LE works
2	9 & 10	1 X210	Obra	UPRUVNL/ Uttar Pradesh	BHEL	**Unit 9**- Synchronized in September 2010. Unit is under stabilization after R&M **Unit 10** –Shut down is expected in October 2011. LE works to be completed in 2012-13
3	3 & 4	2 x 110	Bhatinda TPS	PSPCL/Punjab	Unit 3 - BHEL,	**Unit 3**- Unit is expected to be Synchronized by November 2011 **Unit 4**- LE works to be taken after stabilization of Unit-3
4	1	1x110	Muzaffurpur	KBUNL/Bihar	BHEL	Expected date of Completion November 2011 after LE works
5	5	1 x 210	Bandel TPS	WBPDCL/West Bengal	Yet to be awarded	DPRs are under finalisation
6	1	1X210	**Talcher TPS	Odisha	Yet to be awarded	DPRs are under finalisation
7	1, 3 & 4	2x110, 1x110	Panipat	HPGCL/ Haryana	Unit 1- BHEL, Unit 3&4- Yet to be awarded	**Unit 1**- Unit was synchronized on 4 November 2008 after LE works **Unit 3** – DPRs for LE works is under finalisation **Unit 4** – DPRs for LE works is under finalisation

** As per the meeting held at CEA on November 08, 2012 and Minutes of Meeting communicated by CEA vide their letter no. 2/52/TRM/CEA/2012/1888 dated 21.11.2012, Koradi TPS Unit 6 (1x 210 MW) has been replaced by Talcher TPS Unit 1 (1x 210 MW) for review of R&M Implementation Experience.

ANNEXURE-III

List of Units to be considered for Review of Post-R&M Experience in O&M

Sl No	Unit No	Capacity (MW)	Name of Thermal Power Station (TPS)	Name of Utility/State	Executing Agency	Completion of LE Works/Status
1	1& 2	2x120	Ukai TPS	GSECL/Gujarat	BHEL	**Unit 1**- Unit was synchronized on 24 May 2008 after LE works **Unit 2** – Unit was synchronized on 24 February 2010 after LE works
2	1 & 2	2x120	Amarkantak Exten TPS	MPPGCL/Madhya Pradesh	BHEL	**Unit 1**- Expected date of Completion by October 2011 **Unit 2** – Unit was synchronized on 26 October 2010
3	9 & 10	1 X210	Obra	UPRUVNL/ Uttar Pradesh	BHEL	**Unit 9**- Synchronized in September 2010. Unit is under stabilization after R&M **Unit 10** –Shut down is expected in October 2011. LE works to be completed in 2012-13
4	3 & 4	2 x 110	Bhatinda TPS	PSPCL/Punjab	Unit 3 -BHEL,	**Unit 3**- Unit is expected to be Synchronized by November 2011 **Unit 4**- LE works to be taken after stabilization of Unit-3
5	1	1x110	Muzaffarpur	KBUNL/Bihar	BHEL	Expected date of Completion is November 2011 after LE works
6	7	1x110	Barauni TPS	BESB/Bihar	BHEL	Completion of LE works is expected in 2012-13
7	5	1 x 210	Bandel TPS	WBPDCL/West Bengal	Yet to be awarded	DPRs are under finalization
8	6	1X210	Koradi TPS	MSPGCL/Maharashtra	Yet to be awarded	DPRs are under finalization

APPENDIX-II

Fax: 011-2618 6904

Government of India
Central Electricity Authority
Thermal Renovation & Modernisation Division
Sewa Bhawan, 9th Floor, North Wing
R. K. Puram, New Delhi -11 00 66

No. 2/52/TRM/CEA/2012/ 1888

Dated: 21.11.2012

Subject: Minutes of the meeting held at CEA on November 08, 2012 to discuss the progress of various consultancy assignments awarded under the Project "Technical Assistance to CEA for Addressing the Barriers to Energy Efficient R&M of Coal Fired Generating Units in India" funded by World Bank. reg.

Enclosed please find herewith the Minutes of the Meeting held at CEA on November 08, 2012 to discuss the progress of various consultancy assignments awarded under the Project "Technical Assistance to CEA for Addressing the Barriers to Energy Efficient R&M of Coal Fired Generating Units in India" funded by World Bank.

(T.P Singh)
Chief Engineer (TRM) Div.

To

S/Shri

- C. Subramaniam, Senior Power Engineer, South Asia Sustainable Development-Energy, The World Bank, Hindustan Times House, 18-20, Kasturba Gandhi Marg, New Delhi-110001, Fax NO. 49247639
- Mr. Suresh Gehani, Director, ABPS Infrastructure Advisory Pvt. Ltd., 309, A-Wing, Kohinnor City, Kirol Road, OFF LBS Marg, Kurla (West), Mumbai - 400 070. (Fax-022 - 61240499)

- Mr. Vivek Srivastava, Technical Director, KPMG Advisory Services Pvt. Ltd., Building No 10, 8th Floor, Tower-B, DLF Cyber City, Phase-II, Gurgaon – 122002(India). (Fax: 0124-2549101)
- Mr. Anish De, Chief Executive Officer, AF - MERCADOS EMI, 1202, Millennium Plaza, Tower B, Sector - 27, Gurgaon(Haryana) – 122 002. (Fax : 0124-424-1751)
- Ms. M. Vanisree, Dy. Chief Engineer (Elect-I), WAPCOS Limited, 76-C, Sector - 18,Gurgaon (India), Pincode –122 015. (Fax: 0124-2349449)

Copy for information to :

1. SA to Chairman, CEA
2. SA to Member (Thermal), CEA
3. SA to Member (E&C),CEA

Minutes of the Review meeting held at CEA on November 08, 2012 to discuss the progress of various consultancy assignments awarded under the Project "Technical Assistance to CEA for Addressing the Barriers to Energy Efficient R&M of Coal Fired Generating Units in India" funded by World Bank.

A meeting was held on November 08, 2012 at CEA to discuss the progress of various consultancy assignments awarded under the Project "Technical Assistance to CEA for addressing the barriers to Energy Efficient R&M of Coal Fired Generating Units in India" funded by World Bank.

At the outset, Chief Engineer (TRM), CEA, Shri T.P Singh welcomed the representatives of World Bank and representatives from Consultancy Organisations.

Present:

The following representatives attended the meeting:

CEA:

- Sh. T.P Singh Chief Engineer (TRM) Div.
- Sh. Bhai Lal, Director, (E and R&M) Div.
- Sh. J. N. Prasad, Dy. Director, TRM Div.
- Sh. Anis Ahmad, Dy. Director, TRM Div.

World Bank:

- Sh. B. John Hamso, Senior Energy Economist
- Sh. C. Subramaniam, Senior Power Engineer
- Smt. Mani Khurana, Energy Economist

ISC (ABPS Infra):

- Sh. Suresh Gehani, Director
- Sh. Himanshu Agarwal, Deputy Manager

Mercados Energy Markets (India) Pvt. Ltd

- Sh. Anish De, Chief Executive Officer
- Sh. Vikas Gaba, Senior Manager
- Sh. Saurabh Gupta, Senior Consultant
- Sh. Rajarishi Goswami, Consultant

KPMG Advisory Services Pvt. Ltd. :

- Sh. Ashutosh Kumar, Manager
- Sh. Gaurav Goyal, Consultant

WAPCOS

- Smt. M. Vanisree, Addl. Chief Engineer, Power
- Sh. N.S Chauhan, Consultant

The summary of the discussions held during the meeting are as follows:

1. **Progress Review of Study on "Review of Institutional Capacity and Implementation of Capacity Strengthening Interventions at CEA"**

a. The representatives of M/s KPMG Advisory Services Pvt. Ltd. briefed about the status of Study on "Review of Institutional Capacity and Implementation of Capacity Strengthening Interventions at CEA" and submitted that Focussed Group Discussions with the Wing Nodal Officers and Special Assistants to the Members of 29 divisions of CEA have been undertaken as required for submission of report on Assessment of Institutional Capacity of CEA. Further, the Draft Questionnaire for undertaking the customer expectation surveys has been prepared and circulated to the Wing Nodal Officers and Special Assistants to the Members for comments. In this regard, World Bank representatives suggested KPMG to circulate Questionnaire to World Bank once it is finalised after incorporating the comments on the questionnaire.

b. M/s KPMG also discussed the list of stakeholders for undertaking customer expectation survey. With regard to the list of stakeholders, World Bank suggested to include SJVNL (Satluj Jal Vidyut Nigam Limited), Torrent Power and CESC (Calcutta Electric Supply Corporation) as a backup, in case consent for survey from any of the listed stakeholders is not obtained.

c. World Bank representatives further suggested that the CEA shall provide the letter addressed to Ministry of Power, Planning Commission, Ministry of Coal, Ministry of Environment & Forest etc. either of Member/Chairman of CEA to M/s KPMG Advisory Services Pvt. Ltd. to obtain the good response from customers.

2. **Progress Review of Study on "Reduction of barriers to R&M interventions in thermal power plants in India"**

a. The representatives of M/s Mercados Energy Markets (India) Pvt. Ltd. briefed about the status of Study on "Reduction of barriers to R&M interventions in thermal power plants in India" and submitted that the following Draft guidelines have already been submitted to CEA:

- Draft Guidelines for Risk Identification and Mitigation in R&M Projects
- Draft Guidelines for Early Identification of Potential Technical Surprises in R&M Projects and ways of addressing them.

b. M/s Mercados submitted that the next deliverable of "Draft Report on study for identifying the potential reduction in Green House Gas (GHG) emissions on account of R&M and suggesting possible framework for monetizing the GHG reduction" will be submitted during the week starting November 19, 2012.

c. M/s Mercados further requested CEA to extend the date of submission of "Draft Report on study of International best practices in R&M projects" as they are planning to visit some of the R&M projects implemented in other countries to obtain the first-hand international experience of Pilot R&M projects. M/s Mercados suggested to submit the Draft report on the same by first week of January. World Bank and CEA both agreed for the request and suggested M/s Mercados to submit report by first week of January.

d. World Bank suggested that the Draft Guidelines prepared by M/s Mercados should be sent to major Suppliers/Consultants/Utilities/Funding Agencies, which are playing vital role in R&M of thermal power stations for their comments, before these are discussed in the Task Force Meeting.

3. **Progress Review of "Study for Developing Markets for Implementation of R&M scheme in thermal power stations in India"**

a. The representatives of M/s Mercados Energy Markets (India) Pvt. Ltd. briefed about the status of "Study for Developing Markets for Implementation of R&M scheme in thermal power stations in India" and submitted that the Draft Excel based model for estimating the R&M Potential Assessment of coal based thermal power stations in India is almost prepared. M/s Mercados further informed that their team would like to have a discussion with CEA on the Model during the week starting November 19,

2012. Accordingly, based on discussions the Draft Report for the **"Study with the aim of developing markets to meet the impending demand of R&M in India"** will be submitted to CEA.

b. M/s Mercados further informed that they are planning to have Workshops/Road Shows on the draft report during the month of January 2013. Thereafter, the final Report for **"Study with the aim of developing markets to meet the impending demand of R&M in India"** will be submitted to CEA.

4. **Progress Review of Study on "Review of Experience from Pilot R&M Interventions in Thermal Power Stations in India"**

a. M/s WAPCOS Ltd. briefed that the revised Inception Report has been submitted to CEA and it will be finalised after incorporating CEA's comments on the same. Further M/s WAPCOS informed that site visit to Panipat Thermal Power Plant has been conducted.

b. During the meeting, the list of Plants selected for reviewing the various experience of R&M was discussed and it was decided to make the following replacements in the list of Power Plants selected for review of the "Procurement Experience for Pilot R&M Projects (completed till May 2014)" and "R&M Implementation Experience" considering the fact that desired experience may not be available at the power plant during the course of the study.

Table: List of the Power Plants to be replaced

S.No.	Existing Power Plants in the List	Replaced New Power Plants in the list
Procurement Experience for Pilot R&M Projects (completed till May 2014)		
1.	Chandrapur TPS, Units 1&2 (1x210 MW), Maharashtra	Badarpur TPS, Units 4 & 5 (2 x 210 MW), NTPC
2.	Parli TPS, Units 2&3 (1x210 MW) Maharashtra	Kothagudem TPS, Units 6, 7 & 8 (3 x 110 MW), APGENCO
3.	Kolaghat TPS, Unit 3 (1x210 MW), West Bengal	Amarkantak TPS, Units 1,2 (2 x 120 MW), MPPGCL
R&M Implementation Experience		
1.	Koradi TPS, Unit 6 (1X210 MW) Maharashtra	Talcher TPS, Units 1 (1x210 MW)

5. Task Force Meeting

It was discussed to schedule the next meeting of Task Force for Promoting Renovation & Modernisation(R&M) of Thermal Power Stations in India to December 17, 2012. Further it was discussed that during the next Task Force meeting, major Utilities/Suppliers/Consultants those are active in the field of R&M of thermal power stations, should also be invited to discuss the Guidelines prepared under the study Reduction of Barriers, i.e., "Draft Report and Guidelines for Risk Identification and Mitigation in R&M Projects" and "Draft Guidelines for Early Identification of Potential Technical Surprises in R&M Projects and ways of addressing them".

6. Hosting on Draft Guidelines on CEA Website

It was discussed that CEA may host "Draft Guidelines for Risk Identification and Mitigation in R&M Projects" and "Draft Guidelines for Early Identification of Potential Technical Surprises in R&M Projects and ways of addressing them" on its website for obtaining the comments of various stakeholders.

The meeting ended with a vote of thanks to the Chair.

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Appendix-III
Questionnaire

Additional Data/Information Regarding Implementation of R&M Works

1. Project

Name of the Project :
Name of the State Utility :
Unit No. & Capacity :
Date of start of R&M Works :
Date of completion of R&M Works :
Expected Date of completion :
Original Date of Commissioning :

2. Project Schedule Milestones

Milestones	Target Date	Actual Date
Date of RLA Study [Give brief details of RLA studies]		
Zero date of R&M Project		
Date of Shutdown for R&M		
Original Target Date for completion of R&M works		
Hydro Test		
Boiler Light Up		
Synchronization (oil)		
Synchronization (coal)		
P.G. Test		

3. a) Type of Procurement Process (OEM /ICB/ Competitive)

i. BTG Package :
ii. BOP Package :

b) Packages for R&M works& their executing Agencies

i. BTG Package :
ii. BOP Package :

4. Scope of Renovation & Modernization Works

a.) The major scope of R&M works under various packages:-

A. Boiler:

B. Turbine:

C. Generator:

D. Balance of Plant:

E. Electrical:

F. Control &Instrumentation:

b.) Any deviations (additions/deletions) in the original scope of work, if any, and reasons thereof:

c.) Performance Parameters of Unit:

Performance Parameters	Before R&M / LE	Target Value of R&M/LE	Actual After R&M / LE
Generation per year (MU)			
Max Load attained (MW)			
PLF (%)			
Availability (PAF) %			
Auxiliary Power Consumption (%)			
Specific Coal Consumption (kg/kWh)			
Specific Oil Consumption (ml/kWh)			
Heat Rate (kCal/kWh)			
GCV of Coal (kCal/kg)			
Boiler Efficiency (%)			
Turbine Efficiency (%)			
SPM Level (mg/Nm^3)			
SOx			
NOx			

5. Execution of Project

i. Target date for Completion of dismantling work :
ii. Actual date for Completion of dismantling work :
iii. Major Problems faced during dismantling Process :

Sl. No.	Area	Target Date for Dismantling	Actual Date for Dismantling
i.	Boiler		
ii.	Turbine:		
iii.	Generator		
iv.	Balance of Plant:		
v.	Electrical		
vi.	Control & Instrumentation:		

6. Current status of the Project (For Works in Progress)

a.) Package-wise Progress [%age]

i. Boiler :

ii. Turbine :
iii. Generator :
iv. Balance of Plant :
v. Electrical :
vi. Control & Instrumentation :

b.) Pending Works, if any

7. Time Aspect of the Project

Scheduled completion time (in Months) :
Time actually taken (in Months) :
Time Over run (in Months), with reasons :
Reasons:

8. Cost Aspect of the Project

a. Name of Funding Agency :
b. Package wise Estimated cost of the Project:
c. Expenditure details
d. Reasons for Cost Over run
e. Moratorium period:

9. Technical surprises encountered [Area-wise]:

Sl. No.	Area	Technical Surprise in Detail	Delay due to Technical Surprise	Additional Cost, if any
1	Boiler			
2	Turbine:			
3	Generator			
4	Balance of Plant: [AHP, CHP etc.]			
5	Electrical			
6	Control & Instrumentation:			

10. Steps taken to address the Technical Surprises.

11. Contractual Arrangements and Procedure

Detail of Provision of Liquidated Damages (LD):
For Contract completion: **For short fall in guaranteed parameters**:

i. Performance Guarantees (PG) provided in the contract:

ii. Payment Schedule:

12. Project Management Process

I. General Information

R&M Team for implementation of R&M Project
R&M Team of Contractor

Project Monitoring Process being followed
Issues related to Decision making, if any:
Whether all Contractors executed the work as per conditions laid in Work Orders or there was any breach of contracts:

II. Pre-shutdown activities

Design Aspect-delays:
No of Drawings approved before shutdown:
Submission of L1, L2 and L3 Schedules

L1	:
L2	:
L3	:

Supply Management

Supply of critical items

The sequence of supply whether venders supplied materials in time:
Please give reasons for delay, if any

13. **Front available for major works. How much delays were caused due to this?**

14. **Key milestones for commissioning of Unit**

15. **Coordination**

16. **Issues& Problems faced**

17. **Overall remark / suggestion on execution of R&M works?**

18. **Overall Suggestion:**