RENOVATION, MODERNIZATION

AND

UPGRADTION

OF OLD POWER PLANTS – SUSTAINABLE DEVELOPMENT FOR BETTER WORLD

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DECLARATION BY THE GUIDE

This is to certify that the Mr. Anubhav Prabhat Lenka, a student of Power Management, SAP ID 500064739 of UPES has successfully completed this dissertation report on "Renovation Modernization And Up-gradation Of Old Power Plants – Sustainable Development For a Better World" under my supervision.

Further, I certify that the work is based on the investigation made, data collected and analyzed by him and it has not been submitted in any other University or Institution for award of any degree. In my opinion it is fully adequate, in scope and utility, as a dissertation towards partial fulfillment for the award of degree of MBA.

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ABSTRACT

In India, the power sectors a large number of thermal power stations are old and inefficient and have outlived their designed life. They are not able to generate power at their rated capacity or efficiency due to their deteriorated condition. Thus the following study deals with the possibilities of renovation, up-gradation and modernization of coal fired thermal power plants or hydro power plants. The study describes the economy is cost and time, essentially results from the availability of existing infrastructure as only selective critical components can be changed or upgraded that is turbine, generator windings excitation system and many more. Different options with its cost implications have been discussed based on the performance and cost of generation and maintenance. This can lead to increase in efficiency, peak power and energy availability and also increase in life of power plant

CHAPTER 1

INTRODUCTION

As of now total installed capacity of India is 368.79GW, out of which major share is 205GW that is contributed by coal based thermal power plants. This includes old thermal power plants which were commissioned way back in 1970s or even earlier which have outlived their useful life. So, these plants not only their efficiency has reduced also on environmental point of view they are also affecting numerous poisonous gases into the atmosphere. Renovation, Modernization and Upgradation (RM&U) of such units can not only increase the rated capacity but also significant improvement in the plant load factor (PLF), Auxiliary power factor (APC), Specific coal consumption (SCC) and specific oil consumption (SOC).

1.1 OVERVIEW

In India, the Power Sector a large number of thermal power plants as well as hydro power plants are old and have outlived beyond their economical designed life. Renovation, Modernization and Upgradation of old power stations is extremely cost effective, environment friendly and meets sustainability requirements. Further it requires less time for implementation. Many units in such plants are not able to generate power at their rated capacity and efficiency due to their deteriorated conditions. RM&U 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.

1.2 BACKGROUND

The RM&U of thermal power units was first initiated in India way back in 1984 in structured manner and has been recognized 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. This is was a centrally sponsored program and the study was well documented by CEA.

1.3 PURPOSE OF STUDY

The purpose of study of Renovation Modernization & Upgradation (RM&U) of thermal power plants is due to following reasons:

1. To equip the operating units with latest modified & augmented technology equipment/systems with a view to improve their performance in terms of output,

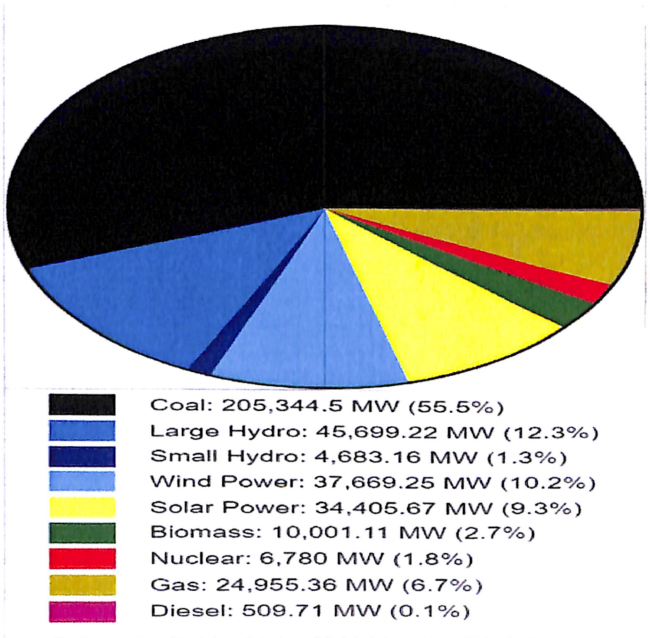
reliability, efficiency and availability, reduction in maintenance requirements, ease of maintenance and minimizing inefficiencies.

2. The primary objective is aimed at generation sustenance and overcoming problems such as rise in plant heat rate, specific coal consumption & auxiliary consumption and reduce the gross generation & PLF etc.
3. Reduction is APC(auxiliary power consumption), SOC(specific oil consumption) and SCC(specific coal consumption)
4. The Residual Life Assessment (RLA) and Life Extension (LE) program are generally taken up by most utilities company whose operation of the plant is beyond their original designed life or the technology of the existing has been obsolete to such an extent that it may not be easy to arrange the spares or it may hamper the environment.

1.4 RESEARCH HYPOTHESES

The study of such type of program is required in India because India is the third largest producer and also third largest consumer of electricity. The total installed capacity is 368.79 GW.

Following image shows the power contribution from different sources.



Thus, it is seen that power is mostly contributed by thermal power plants which are getting old day by day.

As per CEA, the following table shows the region wise power supply position for the year 2019 where there is depict of power supply in some regions.

State / Region	Energy				Peak			
	Requirement	Availability	Surplus (+)/ Deficit (-)		Demand	Availability	Surplus (+)/ Deficit (-)	
	(MU)	(MU)	(MU)	(%)	(MW)	(MW)	(MW)	(%)
Northern	398,020	456,855	58,835	14.8	63,300	62,525	-775	-1.2
Western	418,323	426,401	8,078	1.9	53,837	58,817	4,980	9.3
Southern	348,077	345,708	-2,369	-0.7	49,600	47,384	-2,216	-4.5
Eastern	156,703	150,192	-6,511	-4.2	22,884	24,014	1,130	4.9
North-Eastern	15,914	19,550	3,636	22.9	2,708	3,049	342	12.6
All India	1,337,036	1,398,706	61,670	4.6	180,682	185,122	4,440	2.5

So the efforts are made to convince the private firms for upgradation and renovation as well as public firms to take such initiative to fulfill the gap of power supply in our country.

CHAPTER 2

LITERATURE REVIEW

2.1 REVIEW AREA BROAD

Considering the present scenario of gap between demand and supply of power, RM&U is a beneficial option to increase the energy availability from old thermal and hydro power plants. The enhancement in energy availability does not ask for damages to environment & ecology and benefit are carried over to the people without compromising on the future needs of the next coming generations. It is the way forward for increasing generation by utilizing the same resources in reasonable and adequate manner.

2.2 REVIEW AREA NARROW

The following disadvantages if renovation modernization and up-gradation of old thermal power plant is not done:

- The running cost of thermal power station will gradually increase with comparison when the new plant was erected.
- From environment point of view it will pollute the atmosphere due to production of large amount of smoke and fumes.
- Maintenance cost gradually increased day by day.
- Non availability of spares if plant technology gets downgraded.
- Consumption of coal, water and other necessities will gradually increase as the life span of the plant increases.
- Gradual increase of SCC(specific coal consumption), SOC(specific oil consumption) and APC(auxiliary power consumption)

2.3 FACTORS CRITICAL TO SUCCESS OF STUDY

The following are the important factors that can lead to developments were RM&U study can be undertaken by public or private utilities,

1. Improvement in fuel preparation /handling and firing systems for uniform temperature distribution.
2. Introduction of Furnace Safeguard and Supervisory System (FSSS).
3. Introduction of Burner Management system (BMS).
4. Introduction of discrete control system (DCS).

5. Implementation of techniques for low NOx burners and stage combustion for low emission of NOx.
6. Modification of Mill system for grinding. Proper grinding of coal as per desired size and appropriate air fuel mixing can contribute complete combustion of and reduction of unburnt which leads to reduction in bottom ash.
7. Enhance the safety features and environmental improvements using addition of Effluent treatment plant, online pollution monitoring system and dry ash utilization.
8. Energy efficient auxiliaries like microprocessor based ESP controllers and vapor absorption system for HVAC system.
9. Steam turbine blades retrofitting with latest improvement and technology.
10. Improvement in Boiler pressure parts metallurgy system.

Thus the above technical changes in a power plant can lead to improvement of SOC, APC, SCC and PLF. Due to which the efficiency of a plant can be increased in a cost effective manner.

2.4 SUMMARY

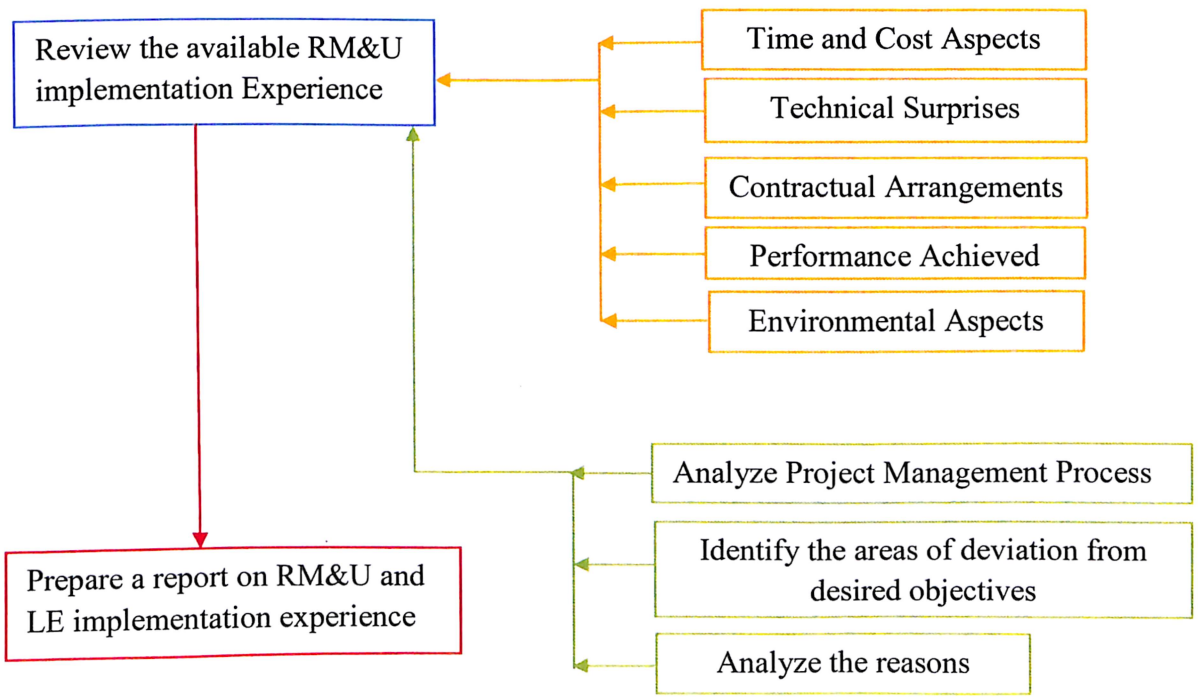


Figure 2 Literature Review Table

For the need of RM&U of such old power plants, The World Bank financed the projects i.e "Coal fired generation rehabilitation projects" after which CEA took such steps and assigned many consultants for the detailed study of "Energy Efficiency R&M"

Following are the plants where such projects (Renovation & Up-gradation) have been implemented in small manner,

1. Unit#1 NTPC, Talcher - Odisha
2. Unit#1 & 2 of UKAI TPS - Gujarat
3. Unit#9 & 10 of OBRA, TPS - UP
4. Unit#3 & 4 of GDNTP, Bhatinda - Punjab
5. U#1 of Muzaffarpur, TPS - Bihar
6. U#5 of Bandel, TPS, WB
7. Unit#1 & 2 of Panipat, TPS – Haryana

Apart of thermal power plants some significant data has also been collected from Hydro plants which are undergoing RM&U at present,

1. Baira Siul – Himachal Pradesh
2. Loktak - Manipur

CHAPTER 3

RESEARCH, METHODOLOGY & PLAN

3.1 DATA SOURCES

Central Electricity Authority (CEA) has prepared a National Perspective Plan for execution of Renovation Modernization & Up-gradation (RM&U) and Life Extension (L.E.) works at various state owned Thermal Power Stations in the country. Apart from that it has hired many consultants for implementation related to Renovation, Up-gradation and modernizations. Based on the condition and age of a plant, it is necessary to study the renovation possibilities if the unit is to be continued in service.

3.2 RESEARCH METHODOLOGY

The RM&U measures suggested in the study are based on hot and cold walk down survey of the plant and energy audit measure taken during the course of the study. Need for the RM&U of the unit to be discussed and various options for improvement in energy efficiency and replacement of existing obsolete technology were to be identified. The results of the analysis can be verified or compared using different simulation models like "The Ebsilon Professional" simulation model.

RM&U of old plants is a very difficult, complex and challenging task. A systematic approach is required to check each and every part. So the systematic way of checking is done through studies like Residual life assessment (RLA) and Life Extension (LE) Studies.

The above study is basically the comparison between the design parameters and parameters collected from the present through which an SOC (Specific Oil Consumption), APC (Auxiliary Power Consumption) and SCC(Specific Coal Consumption) can be compared.

Details of the methodology are well explained in the next segment.

3.3 DATA ANALYSIS PROCEDURE

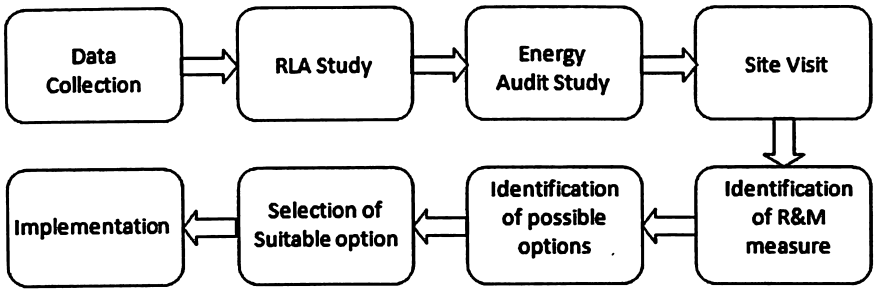


FIGURE 3.Step Wise Methodology for taking RM&U measures

- **Data Collection:**

  Data collection is process of gathering and measuring information on variables of requirement in a systematic manner that enables for research, hypothesis or evaluate outcome.

- **RLA Study:**

  Residual life assessment studies basically on fitness characteristics of a component and to assess their remnant life. Thermal power plants approximate life span is about 25years, so identification of failure prone areas and their treatment covers under RLA study For a power plant RLA study includes the boiler, piping, pressure parts, pumps, turbine, compressor and etc. For power plants basically RLA study is carried out for boiler and turbines.

  Thus RLA and LE studies are helpful in determining which component of the plant is to be retained and which one is to be replaced or discarded.

  Following is the ways for essential study that is need to be carried out for assessing the feasibility of the machines:

  - General Guidelines
  - Assessment of the existing condition of the machine
  - Studies on the generator and its parts
  - Studies on the turbine and its parts

- **General Guidelines:** Here general guidelines are set for what type of equipment we required RLA or LE study. In general if equipment has reached its end life and it can cause irreparable loss then renovation for the sake of modernization is required. Or else to upgrade the capacity of the unit, both the generator and turbine capacity is governed and thus a final decision is taken for after checking each and every component.
- **Assessment of existing condition of machine:** Here the first step is to assess the condition of the machine and its components. For this a detailed and thorough study is required like temperature, vibrations and metallurgical and stress analysis study of each component is required. All this study is to be done by the OEM or manufactures or designers. The experts should carry the above step in systematic way as per following ways:

    - History of the machine
    - System parameters of the machine
    - Diagnostic test on machines

- **Study on generator and its parts:** Here some technical things are to be studied for upgrading the capacity of the generator. Different tests are carried on generators like ELCID, TAN DELTA, RSO, IR.

  It can be classified as follows,

    - Improve the insulation system
    - Improve the ventilation system and cooling system
    - Improve the metallurgical properties

- **Study on turbine and its parts:** Here various components of the turbine and its accessories are taken for study. Non destructive techniques are used for pressure parts study and final output is compared between the operational parameters and non destructive test.

- **Energy audit study:**

  This portion contains the details of the energy evaluation of the project is done. An energy auditor conducts this study and brings up the ideas or suggestions for different ways to consume power in an efficient manner or what equipments are consuming more power than its design parameters. Here the operation parameters or data is to be taken from beginning of the plant and the data is evaluated with the availability of the machines. The final data will give us the power potential and after considering the overall efficiency of the generating equipment, it is here possible to arrive the true power potential of the power plant.

  It is an inspection, survey and analysis of energy flows for energy conservation in a power plant.

- **Site Visit:**

  After completing the RLA & LE study and plant/energy audit, the next phase is preparation of Detailed Project Report (DPR). Detail evaluation report is to be prepared for the above studies and to be presented for further proceedings.

- **Identification of RM&U measure:**

  For implementation of RM&U works we need to focus on plant performance parameters. Key parameters for a power plant are heat rate, SOC, APC, PLF, SCC and environmental emissions. Here the details of the present equipment and remedial actions to be taken for improving the deteriorated components and replacement plan can be shown with details of change in facilities.

  So identification at this stage is primarily on historical data collected and its comparison with the standard operation parameters.

- **Identification of possible options:**

  At this stage, the scope is to analyzed the available data's and coordinate the specialized testing that are conducted earlier and come up with options that can be implemented for further processing.

  So, it contains the options which are available for RM&U of the power plant or unit under consideration and what to do for the options suggested.

- **Selection of Suitable Options:**

  After defining the scope of RM&U work, design specifications and different packages are decided. The details of the cost of the construction or cost to be incurred for the project schedule for implementation of proposed or approved options for RM&U.

  The tendering process begins with pre bidding, techno commercial discussion, negotiations and final bidder is decided.

- **Implementation:**

  Following activities are involved for implementation of RM&U projects

  - Ordering of the material
  - Inspection of material
  - Receipt of material at site
  - Planning for unit shutdown
  - Implementation and monitoring work

3.4 SOURCES OF ERROR

Analysis and review of various aspects for implementation of RM&U projects differ for different area of work. The RM&U projects don't go as per plan and there is some serious obstacles that can delay the project.

RM&U implementation experience as a whole including the analysis of the project management process, areas where the actual project implementation can deviate from schedule and probable reasons for deviations.

Broadly it deals with the following aspects,

- Time and cost aspect
- Technical surprises
- Contractual agreements
- Plant/unit performance

1. **Time and cost aspect:**

There are some plants whose RLA study and Energy auditor study would be completed and identification phase may also get completed but implementation phase won't be started/ can get delayed.

Reason for over time:

- Cost forecasting won't be acceptable for the plant/ final negotiation was getting delayed.
- Delay in supply of materials from OEM (either due to non due payments/ heavy demand)
- Performance of sub contractors was not up to the mark.
- Delay in preparing and finalizing of various sub-contractors.
- Running units may get abruptive shutdown due to some problem.
- Lack of coordination within contractors of between various units

2. **Technical surprises:**

Technical surprises can be encountered during implementation phase in boiler, turbine and generators. Design problem or erection problem can be observed during implementation phase. Different types of technical problem can be encountered which need to be addressed with the Original Equipment Manufacturers (OEMs).

3. **Contractual agreements:**

Different utilities can make various contractual provisions to ensure achievement of plant performance parameters and adhere to the project schedule.

Contract breach/ contract disputes between contractor and vendor can be one of the main reasons for the delay.

So for that credentials of the sub vendors need to be verified thoroughly and proper penalty clause to be mentioned in the agreement while issuing the tender. Different task team to be established to check the progress of the work that is to be carried out by the contractors.

4. Plant Unit Performance:

Different provisions can be made for liquidated damage by different utility companies. Liquidated damages are depended on performance and delay by the contractors for RM&U works.

After RM&U works, the performance of that unit with respect to parameters such as PLF, SOC, SCC, APC, heat rate, reduction in numbers of tripping, environmental aspects and DM water consumption to be checked and if guarantee performance not achieved then that utility has the liability to impose penalty on the contractors.

CHAPTER 4

ANALYSIS

The Government of India's policies & priorities are enunciated under national electricity policy and the tariff rate policies are notified under the electricity act of 2003, technical & cost details, financial and cost details, financial and cost benefit analysis have been considered to ascertain the economic aspects for the proposed investment as per criteria involved for RM&U projects.

4.1 Techno economical analysis

The technical & financial inputs and assumptions are basically based on the norms of that are specified by Central electricity Authority (CEA) and Central electricity regulatory commission (CERC) under government of India. Here no norms have been specified rather the prevailing industry practice have been considered.

Terms and conditions for CERC under regulation act 2009 is that, tariff states that any expenditure admitted by commission for determination of tariff on renovation modernization and Upgradation and life extension should be serviced on normative debt-equity ratio, after writing off the original amount of the replaced assets from the original project cost. Based on the technical examination and assessment, we can derive some ways. The cost estimates that can be covered under each option include equipment cost, erection charges, commissioning charges, taxes and duties and interest during the period of construction. The proposed items of equipment and works take into account the effects of investment costs , increased outage period , reduced capacity, change in heat rate, other variable costs, fixed costs, works power consumption, unit capacity and availability. Economic assumptions for financial analysis can be described below

- Rate of interest
- Discount for levelising
- Service tax
- Oil cost
- Short term cost of power purchase
- Return equity
- Debt-equity ratio

4.2 Economic Analysis

This portion of detailed project report contains the details of the appraisal of the financial viability of the project. It shows all the calculations of net present value, internal rate of return, benefit cost ratio. These calculations are carried out on the incremental benefit philosophy. This section contains the sensitivity analysis for the project.

4.3 Environmental Analysis

This integrated environmental control model can be used to provide a systematic techno-economic analysis of the cost of emission control equipment, the reduction in greenhouse gas emissions and other key parameters.

4.4 Option based Analysis

This analysis is used to determine the optimal capital investment for owners of an existing pulverized coal power plant to make money today, given their beliefs about the future values of key variables that affect the investment outcomes.

4.5 NEED FOR THE RESEARCH

The main benefits of RM&U are:

- To increase unit availability and reliability.
- Restoration / up-rating of generation capacity.
- Achieving rated or better efficiency of the unit, with minimal use of SCC, APC and SOC.
- To achieve an extended competitive plant-life for another 15 to 20 years.
- To meet current environmental norms.

CHAPTER 5

INTERPRETATION OF RESULTS

The RM&U measures suggestions are based on cold and hot walk down surveys of a plant. The test and energy audit measurements taken during the course of the study and the availability of the documents from the plant site and subsequent discussions with the plant engineers. Need of RM&U of the plant need to be discussed and various options including cost implication for the improvement in the energy efficiency and replacement of existing & obsolete technology can be formulated. Improved operation, enhancement of efficiency and environmental aspects are the main objectives of the RM&U study. The measures for RM&U were first considered for a base case in which the recommendations were restricted to bare minimum to extend the life of a unit for an at least 15-20 years without restoring the design capacity. Also further measures were not only to extend the plant life but also improve the efficiency and to reduce auxiliary consumption and to enhance the maximum output. The benefits to the utility that can be included are as follows:

- Low capital investment / MW (Mega Watt) for equivalent additional capacity to that of a new project.
- Shutdown period will be shorter.
- Impact to environment will be beneficial without any additional plant or water or etc.
- Cost of generation will be considerably low.
- Rehabilitation and resettlement of nearby villages is not required.

The benefits anticipated as a result of implementation of the preferred option for this project can be briefly described as the following,

- Life of a unit can be extended to 15 – 20 years.
- Designed capacity / the rated capacity can be restored with the further improvement after some additional measures if taken.
- Forced outages will be reduced.
- Improvement in environmental measures as per the norms of Pollution Control Board.
- Higher safety will be ensured for operational personnel and equipments.

- There will be huge cost reduction in maintenance expenditure, fuel and oil consumption and auxiliary power consumption.

Improvement in performance of pulverized coal fired thermal power plant (210MW):

A study was carried out for RM&U of 210MW coal fired thermal power plant by a renowned company. The RLA study and LE study along with energy audit study carried and found three ways for RM&U of an old and aging power plant of capacity 210MW. So, on basis of analysis, it was found that there is percentage reduction in auxiliary consumption, increase in PLF, reduction in heat rate of the station/unit and reduction in oil and coal consumption.

OPTION	SCOPE	STATUS AFTER RM&U			LEVELISED HEAT RATE	Cost (in Millions)	Shutdown
		Capacity	Life Extension	Heat Rate (GROSS)			
A	Restore capacity of unit to its design i.e 210MW & modification for higher GCV coal	210	20	2400	2597	6864.05	6
B	Increase capacity to 215MW, LP retrofit	215	20	2370	2565	7120.25	6
C	Increase capacity to 215MW by retrofit of turbine , ESP & Mill modification without generator replacement	215	20	2350	2544	7446.48	6

TABLE 2: Options for Renovation, Modernization and Upgradation

Above table shows three options were analyzed for RM&U study for 210MW plant. With different options to choose the cost of the project varies. Depending upon the above options, the economic benefits for first year after implementation of RM&U project is shown below in a summarized manner,

DESCRIPTION	WITHOUT RM&U	AFTER RM&U		
		Option A	Option B	Option C
Revenue	5745	6600.3	6981.4	6996.7
Coal Cost	4619	4626.2	4790.7	4751.4
Savings in Coal Cost		-7.6	-172.1	-132.9
Oil Cost	83	91.6	64	64
Savings in Oil Cost		-8.8	18.8	18.8
O&M Cost	613	504.9	516.9	601.0
O&M Cost Savings		107.8	95.8	95.8
Annual Overall Additional Revenue		946.4	1178.6	1233.1

TABLE 3: Economic Benefits for 1st year after RM&U project

Above table shows, under each option we see there is improvement in operational performance of the plant with respect to what it was before the implementation of RM&U. So, on basis of interpretation, operational benefits include reduction in auxiliary consumption, increase in PLF, heat rate reduction and savings in oil and coal consumption which ultimately leads to increase in revenue.

So the table 3 shows the economic benefits accruing for the first year after implementation of RM&U project, under each option whatever the RLA and LE study done for each option. Thus the result is improved operational performance of the plant with comparison to before.

CHAPTER 6

CONCLUSION

Considering the present scenario of gap between demand and supply of power, RM&U is a beneficial option to increase the energy availability from old hydropower projects. The enhancement in energy availability does not ask for damages to environment and ecology and benefits are carried over to the people without compromising on the future needs of the next generation. It is way forward for increasing generation by utilizing the same resource with reasonable investment and adequate return.

EXPECTED OUTCOME OF THE STUDY

Benefits to the utility include the following:

- Low capital investment per MW of equivalent additional capacity as compared to that for a new project.
- Shorter shutdown period
- Beneficial environment impact with no additional requirement of plant or water.
- Lower cost of generation
- No requirement of rehabilitation and resettlement of people.

The benefits anticipated as a result of implementation of the preferred option for this project, as noted in the report, could briefly be the following:

- Life of the unit will be extended for 15-20 years.
- Rated capacity/ designed capacity will be restored and will be improved further with additional measures.
- Forced outages will be reduced.
- Environmental improvement measures taken will enable plant to meet Pollution Control Board norms.
- Higher safety will be ensured for operational personnel and equipment.
- Savings in maintenance expenditure, SOC, APC and SCC.

BIBLIOGRAPHY

- CEA, "National Perspective Plan for Renovation & Modernization and Life Extension of Thermal Power Stations (up to 2016-17)"
- Various data from official website of CEA.
- N. AYODHI and M. PAL, "Renovation, Up-gradation and Modernization of Durgapur Projects Power Station: Life Extension Program First of its kind in INDIA," in PowerGen, Delhi, 2000.
- CERC,"http://www.npti.in/Download/Distribution/CERC(Terms%20&%20Conditions%20of%20Tariff)%20FY%202009-14.pdf," CERC, 2009. [Online].
- CERC, "http://www.cercind.gov.in/," 2009. [Online]. Available: http://cercind.gov.in/2009/February09/SOR-regulations-on-T&Cof-tariff-05022009.com.
- CERC, "http://www.cercind.gov.in/," 2009. [Online]. Available: http://cercind.gov.in/2009/February09/SOR-regulations-on-T&C-of-tariff-05022009.pdf.

ABBRIVIATIONS

RM&U : Renovation Modernization and Up-gradation

SCC : Specific Coal Consumption

APC : Auxiliary Power Consumption

CEA : Central Electricity Authority

CERC : Central electricity regulatory commission

DPR : Detailed Project Report

DM : De-Mineralized

ESP : Electro Static Precipitator

GW : Giga Watt

HVAC : Heating Ventilation and Air Conditioning

IR : Insulation Resistance

LE : Life Extension

MW : Mega Watt

NOx : Nitrogen Oxide

OEM : Original Equipment Manufacturer

PLF : Plant Load Factor

RLA : Residual Life Assessment

RSO : Recurrent Surge Oscillography

SOC : Specific Oil Consumption