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ENERGY MANAGEMENT AND OPTIMIZING ENERGY IN THERMAL POWER STATION

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Abstract - Energy management can be defined as planning and operation of energy-related production and consumption. The energy management can also be defined as the structured approach designed to manage energy usage, reducing energy cost, raising productivity and creating better work environment. The thermal power plants consume various sources of energy like coal, oil, gas, water and electricity. The principles of energy management applicable to other industries are also applicable to the thermal power plants to save energy. Over the last five years the primary energy consumption of India grew at an average 7 % annually as against global average of 1.6 %. Therefore efficient utilization of available energy resources has assumed significance in the current scenario of energy deficit, fuel security issues, rising prices of conventional energy sources and growing environmental concerns.

Before independence the aggregate power generating capacity of India was 1362 MW. After independence India has achieved significant capacity addition over the last 60 years. At present the installed capacity of power generation is 243,637 MW. But still we are facing shortage of power to the tune of 8% in peak demand and 6% in the installed capacity. The main stake of power generation in India is thermal power and 59 % of the power is generated by coal. The paper depicts the energy management practices recently practiced in thermal power plants to maximize thermal efficiency of the plant. This paper explores energy performance measurement in support of energy management in the thermal power plants. In general, performance measurement is used in management for raising awareness, evaluating performance, management commitment, setting targets and offering decision support. These purposes also apply to energy management, defined here as the management of all activities related to the economic and responsible use of energy in thermal power plant or any energy intensive organization.

Key words- Energy policy and objectives, monitoring performance, energy audit, training and awareness, performance indicators**.**

I.INTRODUCTION

The fundamental goal of energy management is to produce goods and provide services with the least cost and least environmental effect. The judicious and effective use of energy to maximize profits and enhance competitive positions should be the strategy of energy management. the strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems.

In India most of the thermal units are having subcritical technology boilers having efficiency in the range of 34 to 37% with the main steam pressure of 150 to 186 Kg/cm^2 and temperature of 540 to 550^{0}c. As the size of thermal power stations have increased from 500 to 660 and 800 MW, the supercritical technology have adopted to enhance the thermal efficiency up to 40% with main steam pressure and

temperature more than 321 Kg/cm^2 and 560^{0}c. The thermal power plant works on modified Rankine cycle. The complete functioning of the power plant is shown in the figure 1 below.

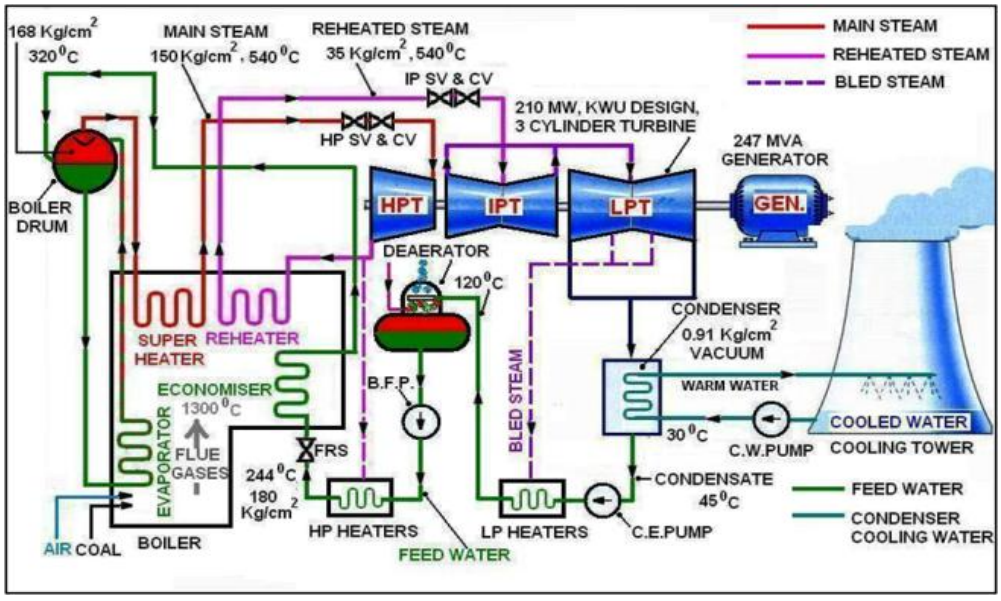

Figure 1 Thermal power generation schematic diagram

The thermal power plant of 1000 MW capacity having pulverized coal fired boiler consumes 12000 tons per day coal and 101 cubic meter of furnace oil per day. In order to run the various power plant auxiliaries it consumes 80MW of power generated from the turbo-generator. The total fuel and electricity consumption is shown in the figure 2.

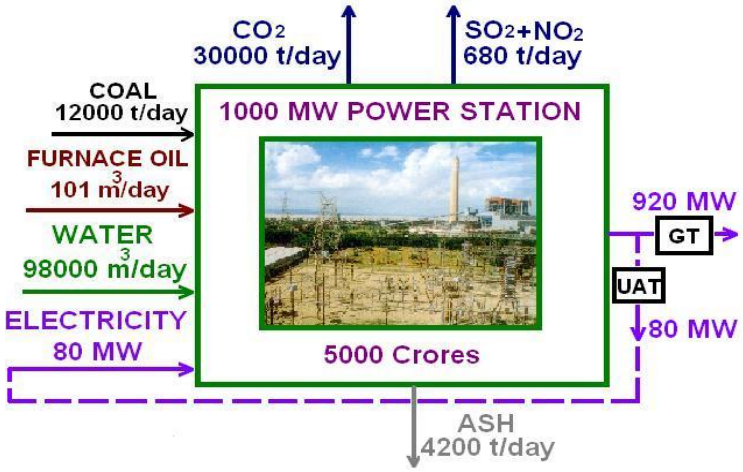

Figure 2 Input output diagram of 1000 MW thermal power plant unit.

The above diagram clearly shows that thermal power plant requires the input of fuel, air, oil, water, ignition energy and electricity to run the power plant auxiliaries. As the power plant consumes various forms of energy in huge quantity it is essential to reduce energy consumption and maximize profit, minimize the cost of electricity by way of energy management techniques.

II.OBJECTIVES OF ENERGY MANAGEMENT

The objective of energy management [1] is to achieve and maintain optimum energy procurement and utilization throughout the organization to minimize energy costs/waste without affecting production and quality and minimize environmental pollution. The various objectives of energy management to achieve required performance of the plant are:-

1. To conserve energy, thereby reducing costs.
2. To cultivate good communications on energy matters.
3. To develop and maintain effective monitoring, reporting and management strategies for wise energy usage.
4. To do research and development to find new and better ways to increase returns from energy investments.
5. To develop interest in and dedication to the energy management programme from all employees.
6. Higher management commitment to achieve the targets and formulation of energy policy.
7. Energy management cell to be established with energy auditors and managers.
8. Documentation of standard operating procedures of thermal power plant. Work instructions for energy saving in major areas.
9. Monitoring energy consumption of various auxiliaries. Display of charts for energy saving.
10. Training and creating awareness of energy conservation amongst the employees to save energy.
11. Achievement of performance indicators to maximize the profit and minimize the cost of power generation.

III.ENERGY MANAGEMENT POLICY

The energy management policy is a statement for commitment to use all energy resources most efficiently and thereby minimizing the impact of our operations on environment and conserving the scarce natural resources [1]. The policy is achieved by following:

- Adopting appropriate energy efficient and clean technologies in process design, procurement, implementation and also continually upgrade the performance.
- Managing efficient use of all forms of energy by adopting industry wide best practices.
- Continually benchmarking our energy performance against the best in the world and improving our competitiveness by training and knowledge sharing.
- Creating awareness about efficient use of energy and conservation methods amongst all our stakeholders.
- Carrying out regular energy audits to identify areas for improvement.
- Complying with all relevant state regulatory and statutory requirements on energy management.
  The energy management policy guidelines are as given below
- Top management commitment.
- Energy management cell
- Capability enhancement & training and motivation
- Monitoring and targeting
- Budget for energy conservation

To quote an example of energy management policy the data was collected from different thermal power plants and policy statement is given below.

Thermal Power Station is committed to…

- ***Continually improve its annual generation within the installed capacity through cost effective measures.***
- ***Continually reduce energy resource consumption (Fuels & Power) to generate one unit of electricity through cost effective measures.***
- ***Establish a regular analytical process to identify major areas of generation loss and excessive power & fuel consumption.***
- ***Cultivate a culture of studying and promoting use of latest & cost effective trends and technologies.***
- ***Create greater and greater energy conservation awareness amongst employees by conducting regular training programs, workshops, visits to other power stations.***
- ***Set measurable and time bound objectives & establish & implement their action plans based on energy policy.***

IV.TOP MANAGEMENT COMMITMENT

Energy management programme needs total support of top management for success. Top management should give equal importance to energy efficiency in their corporate objective as manpower, raw materials, production & sales. In order to implement the energy conservation and energy efficiency to reduce the cost of power generation, the top management support at all levels is required. Involvement of the top management of the organization towards the strategy adopted for performance improvement due to energy management practices is essential for energy efficiency of the plant. The top Management also appoints energy consultant to review and advice about energy management practices. The top management also promotes the employees to become energy consultants / auditors/ managers.

V.MONITORING AND TARGETING

The purpose of monitoring and targeting is to enable an understanding energy consumption data.This is to identify the factors which impact upon consumption and set appropriate targets that allow you to review performance. This will subsequently enable to identify avoidable waste or other opportunities to reduce consumption. This particular aspect is related with data collection from the plant either manually or automatic. Now days the power plant is equipped with Data Acquisition System (DAS) and Distributed Digital Control (DDC) to obtain the data of various equipments on line so that the system operating parameters (SOP) of the plant can be monitored, controlled and compared with the designed value so as to achieve desired efficiency of the plant. The plant is also equipped with state of the art technology the Computerized Performance Monitoring software. It gives the performance of the entire plant equipments in fixed time interval and depending on the deviation; the plant can be controlled to achieve required performance indicators [3]. The performance parameters are also recorded with the fixed time interval. The same can be analyzed to achieve the targets set by the top management. The critical parameters are also recorded every hour to monitor and control the performance of the plant. Various Logs like sequence of events, trends, reports are designed to help the management and operators to analyze the data to take decision for improvement of the performance indicators and hence energy savings. Regular monitoring of energy consuming auxiliaries is carried out to find out energy consumption pattern as most of the major auxiliaries are high power consuming auxiliaries in the plant.

VI. ENERGY MANAGEMENT CELL

Under the Energy conservation Act 2001, all thermal power plants falling under Designated Consumers category have to establish energy management cell in the power plant. It is also mandatory to appoint certified energy auditor and manager. As per the guidelines of Ministry of Power, Govt. of India, Bureau of Energy Efficiency (BEE) all designated consumers of thermal power plants have to set up the Energy management cell to monitor the performance of all the major equipments with boiler, turbine and generator in the plant. A typical energy management cell of a thermal power plant is shown below in the figure 3.

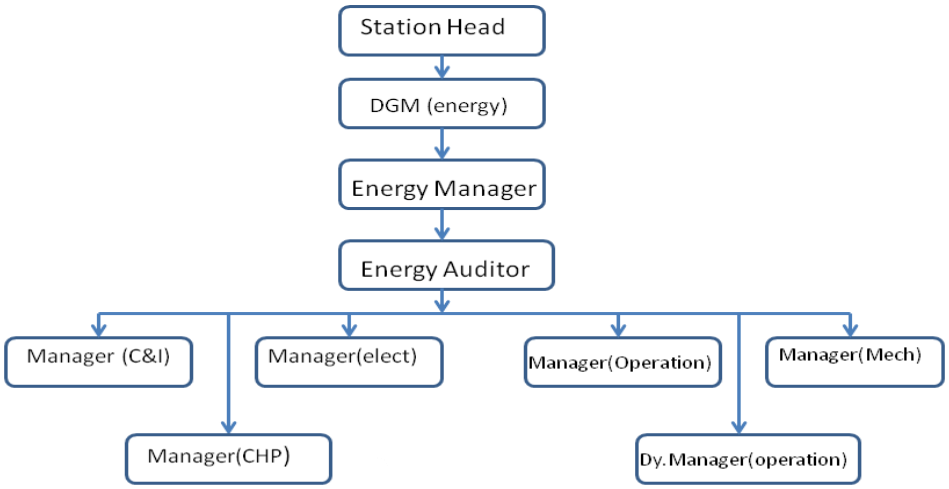

Figure 3 Energy management cell

The function of energy management cell is to monitor the performance of the plant on daily, weekly, monthly and yearly basis. The report is to be submitted to top management for implementation of modifications required for the equipments. The objective is to reduce the forced outages by its analysis and eliminate the root causes. The performance monitoring of critical parameters is essential for the energy efficiency and optimize the cost of power generation. Nowadays the power plants are equipped with the computer based performance monitoring package. The condition monitoring technology system is also implemented for various equipments to monitor the performance and corrective measures are taken to improve reliability and energy efficiency. The major performance indicators to be monitored are as follows to improve the productivity of the plant and financial improvement.

1) Overall heat rate of the plant
2) Auxiliary power consumption of the plant
3) Specific coal consumption
4) Specific oil consumption
5) Thermal efficiency
6) Total outages loss
7) Plant Load Factor (PLF)
8) Availability factor

VII. DOCUMENTATION

The documentation of operation and maintenance practices is prepared based on the instructions manual/ documents provided by the supplier. The standard operating procedures provided by the supplier are to be followed to maximize the plant efficiency. The standard operating procedures are also meant to avoid damages to the equipments. Nowadays the plants are equipped with state of the art controls and instrumentation like Group Sequence for the auxiliaries, DAS, DDC, Programmable logic controllers, Turbine Stress Evaluator (TSE) or Turbine Stress Analyzer (TSA), Automatic turbine run-up system (ATRS), Automatic turbine tester (ATT) and Boiler Fuel Master Controller. The work instructions are also displayed at various operating places in the plant so as to follow standard operating procedures for energy saving.

VIII. PLANT MAINTENANCE PRACTICES FOR ENHANCEMENT OF PERFORMANCE

Every power plant has separate maintenance section for general, preventive, break down maintenance and annual overhaul of main equipments and its auxiliaries. Every section is headed by the In- charge and maintenance crew is functioning under his guidance and control. The In - charge normally reports to Maintenance head of the power plant. The various maintenance sections are Boiler maintenance, Turbine maintenance, Electrical maintenance and testing, Coal Handling Plant maintenance, Ash Handling plant maintenance, D M Water treatment plant maintenance. Proper and appropriate maintenance planning leads to increased availability and Plant Load Factor.

Pro-Active Maintenance is one of the hallmarks of top performing generating companies worldwide in their successful efforts to establish a Pro-active O&M program, that uses equipment reliability, cost and efficiency data to supplement the recommendations of the equipment manufacturers and the utility's firsthand experience. The modern proactive maintenance management system is shown in figure 4.

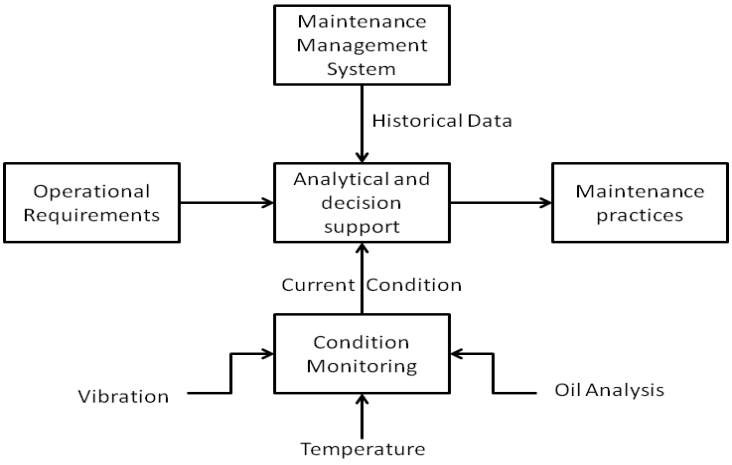

Figure 4 Maintenance management systems for thermal power plant

The key performance indicators (KPI) for maintenance are as follows

1) Refine maintenance guidelines
2) Maintenance practices
3) Failure effect analysis
4) Root cause analysis
5) Pareto analysis of failure causes
6) Establish equipment Operating and performance standards

The standard maintenance practices are followed for all equipments so that the energy consumption would be less or as per the specifications. The display of various charts for energy consumption, and stopping procedures for auxiliaries are made at operating places so as to follow standard guidelines for operation as well as maintenance.

IX. AUXILIARY POWER CONSUMPTION (APC) REDUCTION

As mentioned above in this paper the thermal power plant requires various auxiliaries of boiler, turbine and turbo-generator to run the plant continuously. Any failure of these auxiliaries will lead to tripping of the plant and the power generation stops. Therefore these auxiliaries play very important role in running the power plant. As a thumb rule in a thermal power plant 10% of the total power produced is consumed to run the auxiliaries like pulvarisers, fans, pumps, blowers, coal crushers, conveyer coal belts etc. The 210 MW thermal power plants consume 20 to 22 MW and 500 MW Thermal power plant unit consumes about 50 to 55 MW of power to run the auxiliaries.

If steps could be taken to reduce this APC to only 8 %, it will help in avoiding fresh capacity addition of a unit of 120 MW size. Auxiliary power consumption reduced from 10% to 9%, and then total saving in the installed thermal generation capacity of 134389 MW would be 32,254 X 10^3 kwh/day. If cost of power generation is Rs. 2.50, then total saving comes to 32,254 X 1000 X 2.5 = 806.34 Million Rs. Per day. Additional power available for consumers per day 32254 X 10^3 kwh/day or 322.54 million units per day Thus APC reduction initiatives not only reduce energy consumption but also ensures more revenue because of increase in energy export and hence enhancement in Plant Load Factor (PLF). The steps to be adopted for reduction of Auxiliary power consumption in the thermal power plant

The thrust Areas for Energy Conservation are:

- On line monitoring of power consumption of various auxiliaries through Online Energy Monitoring System (OLEMS)
- Monitoring the power consumption of each equipment before and after overhaul
- Introduction of latest state of the art technologies on specific systems without waiting for R&M of the whole power plant
- Better O&M practices
- Introduction of VFDs
- Energy efficient coating of the pumps
- Standby auxiliary is to be started after achieving the full load on running auxiliary
- Trial run of the auxiliaries after maintenance work is to be taken for specific time period
- Idle running of the auxiliaries should be avoided

In the CEA Report on operation norms for 2009-14, the reduction in Auxiliary Energy Consumption (AEC) on account of turbine driven BFP was increased from 1.5% to 2.5% thus lowering the AEC for 500 MW units with TBFP to 6.0 % from the prevailing 7.0 %. However, no changes were made in the allowable AEC as such and thus the prevailing norms for AEC have been continuing for the last 20 years. Improvements in equipment/systems design have occurred over the years like introduction of axial fans having lower power consumption, introduction of variable frequency drives, overall design optimization etc. Further, the auxiliary consumption may not increase proportionately with unit size and higher sized units are expected to have lower auxiliary consumption in terms of percentage of unit size.

X.OPERATING PRACTICES IN THERMAL POWER PLANT

The operating procedures for main plant and auxiliaries play important role in saving energy. Therefore it is essential to follow standard operating procedures for starting and stopping the plant. The instruction manuals must be made available to the operating staff and written guidelines are also given to operate the plant on higher efficiency. There is an every opportunity to optimize the thermal efficiency [5] of the plant by monitoring and controlling the critical parameters which are responsible for energy saving. Standard operating procedures and written work instructions are practiced and documented for energy management. It is also essential to follow proper scheduling of various operations to reduce start up time of the plant so as to bring the machine on bar quickly.

XI.ENERGY AUDIT AND CORRECTIVE & PREVENTIVE ACTIONS

Energy audit [3] is the analysis of input and output parameters to evaluate the discrepancy in the process of power generation. Energy audit is the analysis of energy in the plant which signifies that when the designed input energy is given to the process, whether you get the desired output or not. Energy audit system has to find out the potential areas where energy saving opportunities are available. Energy audit also aims at identifying, evaluating and analyzing various forms of energy input and output. The steps involved in carrying out the energy audit in the power plant are

- Plan and organize the procedure of energy audit
- Walk through Audit
- Informal Interview with Energy Manager, Production / Plant Manager / operators / Engineers
- Conduct brief meeting /awareness programme with all divisional heads and persons concerned
- Primary data gathering, Process Flow Diagram, & Energy Utility Diagram
- Conduct survey and monitoring
- Conduct detailed trials /experiments for selected energy guzzlers
- Analysis of Energy Use
- Identification and development of Energy Conservation (ENCON) opportunities
- Cost benefit analysis
- Reporting & Presentation to top management
- Implementation and Follow-up plan for energy saving

After carrying out the audit, as per the recommendations the corrective and preventive action has to be taken for continual improvement of energy efficiency, energy conservation, quality, environment and safety performance.

- CA/PA actions helps to find the root cause of the problem
- It helps to prepare implementation plan to make the solutions irreversible.
- Reduce repeatability of the root causes.
- Improve the reliability of the equipments and process.
- Reduce man hours.
- Reduce auxiliary power consumption.
- Reduce cost and hence burden on customers.

It is therefore recommended to carry out internal audit [4] regularly in the plant and external audit at least every year to find out the potential areas of energy saving.

XII.TRAINING AND AWARENESS RELATED TO ENERGY SAVINGS

The training programs are arranged in the plant for creating the awareness for energy saving by way of energy management amongst the engineers and operators. The Performance Monitoring/ Energy cell normally arrange two / three training programs in a year. Some times Engineers are deputed outside the

organization to attend the training programs on Energy efficiency, Thermal power plant performance monitoring, and Energy conservation potential in the plant. The other programs on Energy Audit [6] are also organized by the reputed organizations in India like Bureau of Energy Efficiency (BEE), National Power Training Institute (NPTI), Central Power Research Institute (CPRI) and National Productivity Council (NPC). On the same lines worth mentioning that NPTI in association with Evonik had organized 20 such programs all over India on Energy Efficiency and Audit to create awareness in the top and middle level Managers / Engineers from various Thermal Power Plants. The training need analysis for the employees is carried out every year for indentifying training needs related to energy management. At least one training program for employees on energy management and energy audit is organized to cover 20% of the employees.

Based on the energy management practices followed in the plant for energy efficiency optimization the following model between energy management approaches and performance indicators for thermal power plant have been thought. The model would benefit the plants in India to improve productivity, enhance the generation, reduction in cost of generation and maximize profit [7]. The model is shown in figure 5.

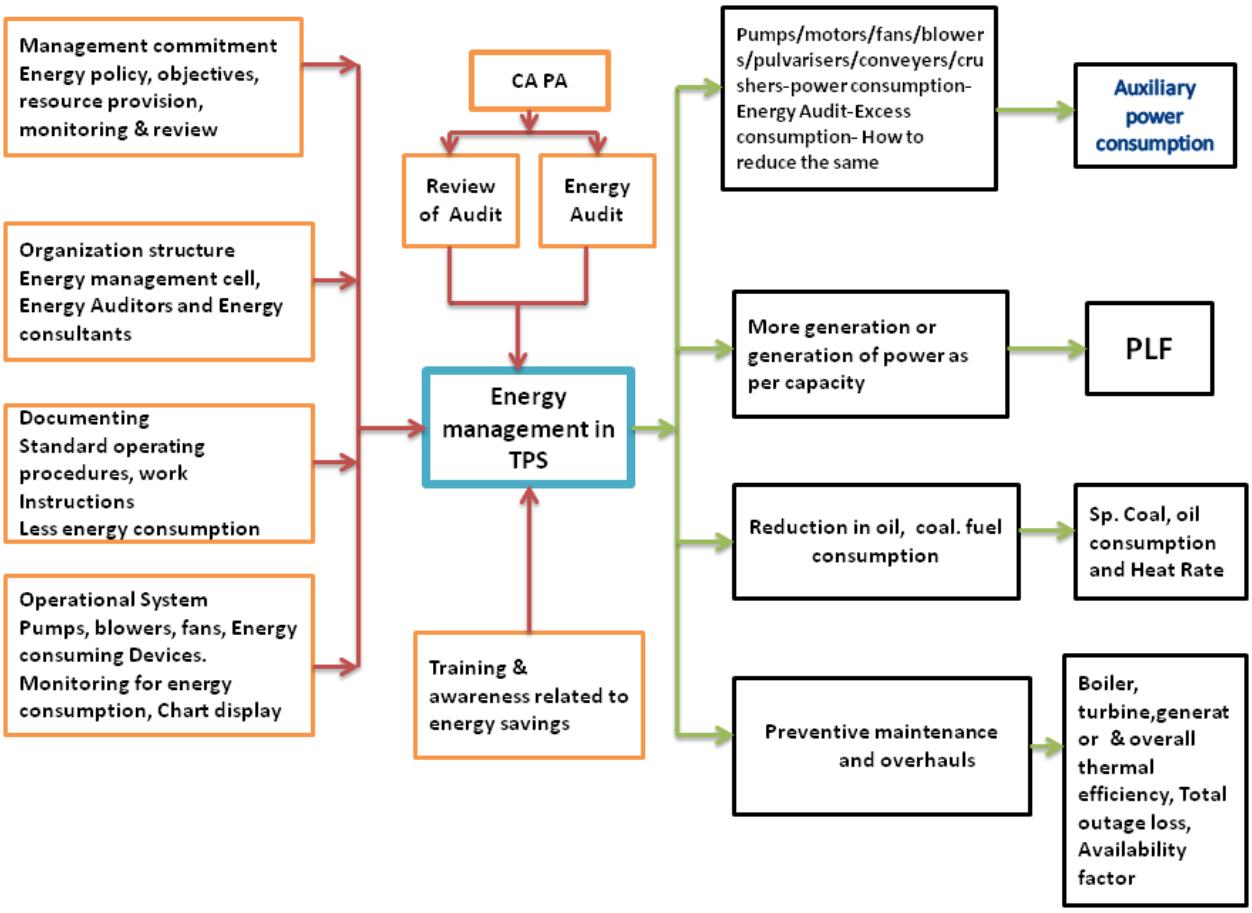

Figure 5 Model of energy management approaches and performance parameters for TPS

XIII.CONCLUSION

We have taken this research paper study on the Energy management approaches which have positive impact on the power plant performance parameters to improve productivity of the plant and financial measures thereby evolving a model which suits the modern Thermal Power plants in the country. The paper aims to explore the concept and philosophy of energy management approaches to improve the performance parameters thereby achieving the energy savings and minimize the cost of power generation, process improvement, financial performance, customer satisfaction and employee satisfaction. Energy saving objectives is prepared with specific goals and targets. We feel important to address this issue through an academic and business research.

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