UNITV
Energy Conservation and Management

11 MARKS

Principle of Energy Conservation and also the economics of energy Conservation.
(Nov 2011)(Nov/Dec 2014)(Nov 2012))(Nov 2013))(April 2015)(April 2013)

An economic concept of energy

It is impossible to forecast future economic trends accurately except in one respect: if a non – renewable asset is being used up, its price is bound to go up relative to everything else.

The vast bulk of the energy used in the world today is in the form of non-renewable oil, natural gas and coal. These resources were laid down many millions of years ago and are at present being consumed at the rate of almost 9 billion tonnes of coal equivalent or 0.32 million petajoules (1 petajoule = 10 joules) per annum. This compares with proved recoverable world resources of 20.3 million petajoules of coal and 11.2 million petajoules of oil and natural gas.Theadvanced capitalist industrial countries, which make upto 15.75 percent of the world's population, consume 54.5 percent of these 0.32 million petajoules each year. It is unlikely that the world's under developed countries are going to improve their living standard if they did, the annual world's energy demand would rise to 1.11 million petajoules each year even if the living standards in all western countries remained constant.

So we must conserve energy by all possible means.For example, glass works produce waste heat at between 400 and 500^{0}C. This is quite sufficient to raise intermediate pressure steam for running back pressure turbines to produce electricity and heat in the form of low pressure steam at, say 120^{0}C. This, in its turn could be used to evaporate moisture from agriculture products. The water vapour obtainable from such processes would probably be condensed to provide warm water at about 60^{0}C. This could be employed for space heating or for the supply of heat at fish farms or green houses.

Principles of Energy Conservation and Energy Audit

Energy conservation means reduction in energy consumption but without making any sacrifice of quantity and quality of production in other words, for the same energy consumption, higherproduction. It is therefore impressive that electricity which is in shortage be utilised efficiently and the areas, where the energy is wastefully used are to be identified and corrective measures are searched for adoption. This could be done by "energy audit". Energy Audit is a technical survey of a plant in which the machine wise/ section wise/department wise pattern of energy consumption is studied and attempts to balance the total energy input correlating with production. As a result of study the areas where the energy is wastefully used and the improvements are felt are identified and corrective measures are recommended for adoption on short term/long term basis giving priorities so that the overall plant efficiency could be improved.

Energy conservation can be defined as the substitution of energy with capital, labour, material and time. The two principles governing energy conservation policies are maximum thermodynamic efficiency and maximum cost effectiveness in energy use.

An energy audit helps us to understand more about the ways different energy sources are used in the industry and helps us to identify areas where waste can occur and where scope for improvement may be possible. Energy audit broadly covers the following questions:

(i) How much energy are we consuming?
(ii) Where is the energy consumed?
(iii) How efficiently is the energy consumed?
(iv) Can there be improvements in energy use?

Types of energy audit:

The primary objective of the energy audit is to determine ways to reduce energy consumption per unit of product output to lower operating cost. The energy audit can be two types:

1. Preliminary audit
2. Detailed audit

The action plan towards the achievement of energy conservation through energy audit may be drawn up in to three phases

1. Short term
2. Medium term
3. Long term.

Preliminary audit:

Preliminary audit is carried out in the limited time i.e from 1 to 10 days and it high light the energy cost and wastages in the major equipment and processes. It also gives the major energy supplies and the demanding accounting. The questionnaire containing the industrial details of energy consumption process carried out, energy need to unit product, load dataset must be completed before the pre-audit visit. The financial report regarding the industrial audit will be prepared within two weeks of time.

Detailed audit:

Detailed audit includes engineering recommendations and well defined projects with priorities. It accounts for the total energy utilised in plants. It involves detailed engineering for options to reduce energy cost/consumption. The duration for visit would be 1 to 10 weeks. It requires advance notice to the departmental head arranging for office and secretarial support. The final report would be prepared within the month of audit.

The short term action:

This plan requires no capital investment or least investment to avoid energy wastages and minimizing non-essential energy users and improving the system efficiency through improved maintenance program.

The medium term action:

Plan requires little investment to achieve investment or least investment to achieve efficiency improvement through modifications of existing equipment and other operations.

The long term action:

Plan is aimed to achieve economy through latest energy saving techniques and innovations. The capital investments are required to be studied thoroughly while finalising the long term action plan.

Waste Heat Recovery. **(April/May 2014))(April/May 2012) (Nov 2012)**

Waste heat is heat, which is generated in a process by way of fuel combustion or chemical reaction, and then "dumped" into the environment even though it could still be reused for some useful and economic purpose. The essential quality of heat is not the amount but rather its "value". The strategy of how to recover this heat depends in part on the temperature of the waste heat gases and the economics involved.

Large quantity of hot flue gases is generated from Boilers, Kilns, Ovens and Furnaces. If some of this waste heat could be recovered, a considerable amount of primary fuel could be saved. The energy lost in waste gases cannot be fully recovered. However, much of the heat could be recovered and loss minimized.

Depending upon the type of process, waste heat can be rejected at virtually any temperature from that of chilled cooling water to high temperature waste gases from an industrial furnace or kiln. Usually higher the temperature, higher the quality and more cost effective is the heat recovery. In any study of waste heat recovery, it is absolutely necessary that there should be some use for the recovered heat. Typical examples of use would be preheating of combustion air, space heating, or pre-heating boiler feed water or process water. With high temperature heat recovery, a cascade system of waste heat recovery may be practiced to ensure that the maximum amount of heat is recovered at the highest potential. An example of this technique of waste heat recovery would be where the high temperature stage was used for air pre-heating and the low temperature stage used for process feed water heating or steam raising.

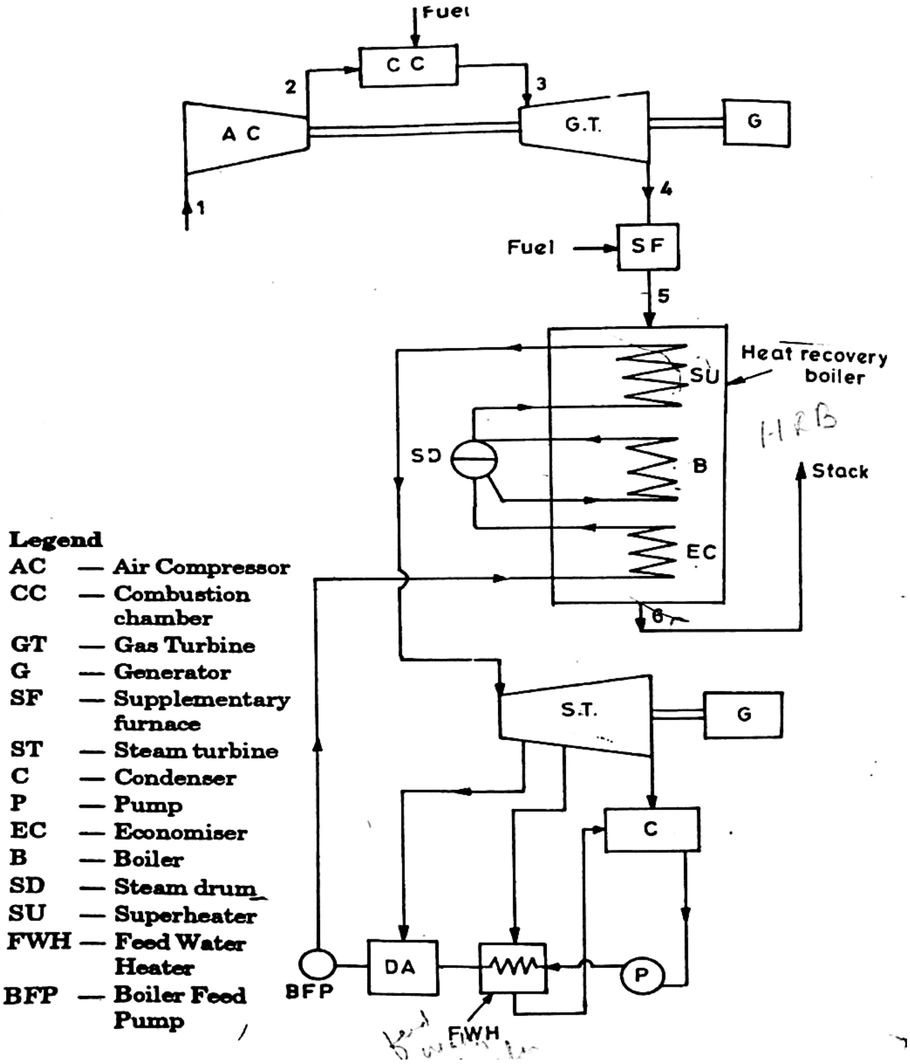


Figure above shows a schematic flow diagram of such a combined cycle. A simple gas turbine cycle, consisting of air compressor, combustion chamber and gas turbine is used with the turbine exhaust gas going to heat a heat recovery boiler to generate superheated steam. That steam is used in a standard steam cycle, which consists of turbine, condenser, pump, closed feed water heaters and deaerating heaters. The heat recovery boiler consists of an economiser, boiler, steam drum and super heater. The gas leaves the heat recovery boiler to the stack. Both gas and steam turbines drive electric generators.

Energy Auditing types and methodologies. (Nov'2015)

Energy Audit:

Types And Methodology Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use, and serves to identify all the energy streams in a facility. It quantifies energy usage according to its discrete functions. Industrial energy audit is an effective tool in defining and pursuing comprehensive energy management programme. As per the Energy Conservation Act, 2001, Energy Audit is defined as "the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption".

Need for Energy Audit

In any industry, the three top operating expenses are often found to be energy (both electrical and thermal), labour and materials. If one were to relate to the manageability of the cost or potential cost savings in each of the above components, energy would invariably emerge as a top ranker, and thus energy management function constitutes a strategic area for cost reduction. Energy Audit will help to understand more about the ways energy and fuel are used in any industry, and help in identifying the areas where waste can occur and where scope for improvement exists. The Energy Audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control programmes which are vital for production and utility activities. Such an audit programme will help to keep focus on variations which occur in the energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment etc. In general, Energy Audit is the translation of conservation ideas into realities, by lending technically feasible solutions with economic and other organizational considerations within a specified time frame. The primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs. Energy Audit provides a " bench-mark" (Reference point) for managing energy in the organization and also provides the basis for planning a more effective use of energy throughout the organization.

Type of Energy Audit

The type of Energy Audit to be performed depends on: - Function and type of industry - Depth to which final audit is needed, and - Potential and magnitude of cost reduction desired Thus Energy Audit can be classified into the following two types.

i) Preliminary Audit
ii) ii) Detailed Audit

Preliminary Energy Audit Methodology

Preliminary energy audit is a relatively quick exercise to:

• Establish energy consumption in the organization
• Estimate the scope for saving
• Identify the most likely (and the easiest areas for attention
• Identify immediate (especially no-/low-cost) improvements/ savings
• Set a 'reference point'
• Identify areas for more detailed study/measurement
• Preliminary energy audit uses existing, or easily obtained data

Detailed Energy Audit Methodology

A comprehensive audit provides a detailed energy project implementation plan for a facility, since it evaluates all major energy using systems. This type of audit offers the most accurate estimate of energy savings and cost. It considers the interactive effects of all projects, accounts for the energy use of all major equipment, and includes detailed energy cost saving calculations and project cost. In a comprehensive audit, one of the key elements is the energy balance. This is based on an inventory of energy using systems, assumptions of current operating conditions and calculations of energy use. This estimated use is then compared to utility bill charges.

Detailed energy auditing is carried out in three phases:

Phase I, II and III.

Phase I - Pre Audit Phase

Phase II - Audit Phase

Phase III - Post Audit Phase

A Guide for Conducting Energy Audit at a Glance Industry-to-industry, the methodology of Energy Audits needs to be flexible. A comprehensive ten-step methodology for conduct of Energy Audit at field level is presented below. Energy Manager and Energy Auditor may follow these steps to start with and add/change as per their needs and industry types

Phase I -Pre Audit Phase Activities

A structured methodology to carry out an energy audit is necessary for efficient working. An initial study of the site should always be carried out, as the planning of the procedures necessary for an audit is most important. Initial Site Visit and Preparation Required for Detailed Auditing An initial site visit may take one day and gives the Energy Auditor/Engineer an opportunity to meet the personnel concerned, to familiarize him with the site and to assess the procedures necessary to carry out the energy audit. During the initial site visit the Energy Auditor/Engineer should carry out the following actions: -

• Discuss with the site's senior management the aims of the energy audit.

• Discuss economic guidelines associated with the recommendations of the audit.

• Analyse the major energy consumption data with the relevant personnel.

• Obtain site drawings where available - building layout, steam distribution, compressed air distribution, electricity distribution etc.

• Tour the site accompanied by engineering/production The main aims of this visit are: -

• To finalise Energy Audit team

• To identify the main energy consuming areas/plant items to be surveyed during the audit.

• To identify any existing instrumentation/ additional metering required.

• To decide whether any meters will have to be installed prior to the audit eg. kWh, steam, oil or gas meters.

• To identify the instrumentation required for carrying out the audit.

• To plan with time frame

• To collect macro data on plant energy resources, major energy consuming centers

• To create awareness through meetings/ programme Phase II- Detailed Energy Audit Activities Depending on the nature and complexity of the site, a comprehensive audit can take from several weeks to several months to complete. Detailed studies to establish, and investigate, energy and material balances for specific plant departments or items of process equipment are carried out. Whenever possible, checks of plant operations are carried out over extended periods of time, at nights and at weekends as well as during normal daytime working hours, to ensure that nothing is overlooked. The audit report will include a description of energy inputs and product outputs by major department or by major processing function, and will evaluate the efficiency of each step of the manufacturing process. Means of improving these efficiencies will be listed, and at least a preliminary assessment of the cost of the improvements will be made to indicate the expected payback on any capital investment needed. The audit report should conclude with specific recommendations for detailed engineering studies and feasibility analyses, which must then be performed to justify the implementation of those conservation measures that require investments.

The information to be collected during the detailed audit includes: -

1. Energy consumption by type of energy, by department, by major items of process equip ment, by end-use
2. Material balance data (raw materials, intermediate and final products, recycled materials, use of scrap or waste products, production of by-products for re-use in other industries, etc.)
3. Energy cost and tariff data
4. Process and material flow diagrams
5. Generation and distribution of site services (eg.compressed air, steam).
6. Sources of energy supply (e.g. electricity from the grid or self-generation)
7. Potential for fuel substitution, process modifications, and the use of co-generation systems (combined heat and power generation).
8. Energy Management procedures and energy awareness training programs within the establishment.

Existing baseline information and reports are useful to get consumption pattern, production cost and productivity levels in terms of product per raw material inputs. The audit team should collect the following baseline data: - Technology, processes used and equipment details - Capacity utilisation - Amount & type of input materials used - Water consumption - Fuel Consumption - Electrical energy consumption - Steam consumption - Other inputs such as compressed air, cooling water etc - Quantity & type of wastes generated - Percentage rejection / reprocessing - Efficiencies / yield

Economics of Energy Conservation.

ECONOMICS OF ENERGY CONSERVATION

- Reduced dependence on non-renewable sources of energy: Based on current known reserves and consumption of these fuels, the following amount of each fossil fuel remains available as of 2003:
  - Oil: Approximately 1,000 billion barrels, enough to last 38 years
  - Natural Gas: Approximately 5,400 trillion cubic feet, enough to last 59 years
  - Coal: Approximately 1,000 billion metric tons, enough to last 245 years

- Conservation protects national energy security by reducing our dependence on foreign sources of oil.

- Protects the economy and consumers from possible price fluctuations and from energy service disruptions due to natural disasters or other causes.

- The increasing demand for electricity and natural gas requires your utility to find new supplies of energy. Most new supply options require a great deal of money up front, which increases you utility bills.

- Studies show that utility or state investment in energy efficiency helps the local economy. Instead of importing natural gas and electricity supply from outside of your community, energy efficiency relies on domestic and local companies and retailers to provide energy management services and energy-saving products.

- Energy efficiency programs provide customers with home improvements that enhance home comfort and increase property values for homeowners and businesses.

Cogeneration: **(April/May 2014)**

Definition and Need

In conventional power plant, efficiency is only 35% and remaining 65% of energy is lost. Also further losses of around 10-15% are associated with the transmission and distribution of electricity in the electrical grid. These losses are greatest when electricity is delivered to the smallest consumers.A procedure for generating electric power and useful heat in a single installation, the useful heat may be in the form of steam, hot water or hot air. In a heat engine part of the heat taken up from a source at a higher temperature must be discharged to a sink at a higher temperature must be discharged to a sink at a lower temperature. In a cogeneration the mechanical work is converted into electrical energy in an electric generator and the discharged heat which would otherwise be dispersed to the environment is utilized in an industrial process or in other ways. The net result is an overall increase in the efficiency of fuel utilization.

Cogeneration is thus the simultaneous generation of electricity and steam in a single power plant, it has been used by industries and municipalities that need process steam as well as electricity. Examples are chemical industries, paper mills and places that use district heating. From an energy resource point of view, co-generation is beneficial only if it saves primary energy when compared with separate generation of electricity and steam (or heat).

The *co-generation plant efficiency* η_{CO} is given by,

$$\eta_{CO} = \frac{E + \Delta H_s}{Q_A}$$

where, E= electric energy generated

ΔH_s= heat energy or heat energy in process stream

= (enthalpy of steam entering the process) - (enthalpy or process condensate returning to plant)

Q_A= heat added to plant (in coal, nuclear fuel, etc.)

For separate generation of electricity and steam, the heat added per unit *total* energy output is:

$$\frac{e}{\eta_e} + \frac{(1-e)}{\eta_h}$$

where, e= electrical fraction of total energy output

$$= \frac{E}{E + \Delta Hs}$$

η_e= electric plant efficiency

η_h= steam (or heat) generator efficiency

The combined efficiency η_c for separate generation is therefore given by

$$\eta_c = \frac{1}{\left(\frac{e}{\eta_e}\right) + \left[\frac{(1-e)}{\eta_h}\right]}$$

and co-generation is beneficial if the efficiency of the co-generation plant exceeds that of separate generation.

Types of co-generation

There are two broad categories of co-generation:

1. ***The topping cycle***, in which primary heat at the higher temperature end of the Ranking cycle is used to generate high-pressure and temperature steam and electricity in the usual manner. Depending on process requirements, process steam at low pressure and temperature is either (a) extracted from turbine at an intermediate stage, such as for feed water heating, or (b) taken at the turbine exhaust, in which case it is called a *back pressure turbine*. Process steam pressure requirements vary widely, between 0.5 and 40 bar.

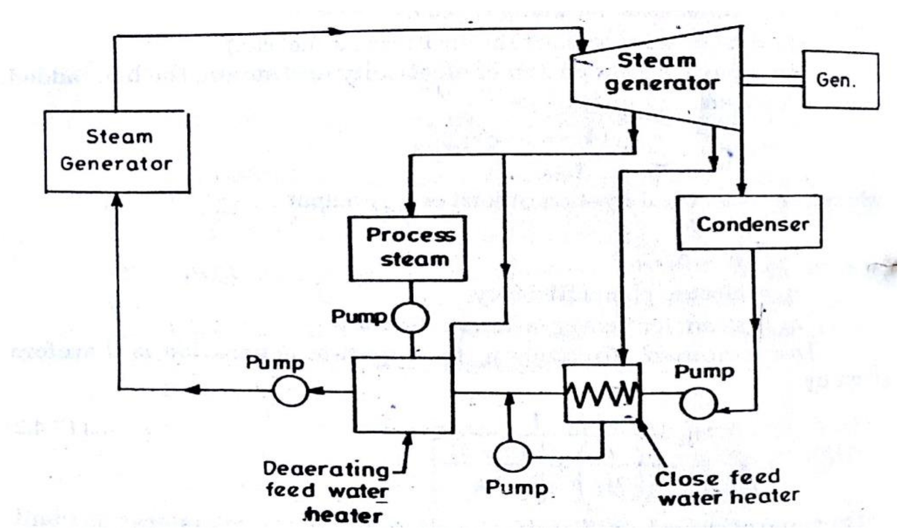
2. ***The bottoming cycle***, in which primary heat is used at high temperature directly for process requirements. An example is the high-temperature cement kiln. The process low grade (low temperature and availability) waste heat is then used to generate electricity, obviously at low efficiency. The bottoming cycle thus has a combined efficiency that most certainty lies below that given by equation

$$\eta_c = \frac{1}{\left(\frac{e}{\eta_e}\right) + \left[\frac{(1-e)}{\eta_h}\right]}$$

and therefore is of little thermodynamic or economic interest.

Only the topping cycle, therefore can provide true savings in primary energy. In addition most process applications require low grade (temperature availability) steam. Such steam is conveniently produced in a topping cycle. Some are:

(a) Steam – electric power plant with a back pressure turbine.
(b) Steam- electric power plant with steam extraction from a condensing turbine.
(c) Gas turbine power plant with a heat recovery boiler (using the gas turbine exhaust to generate steam).
(d) Combined steam- gas turbine power plant.



Cogeneration system

The figure above shows the cogeneration power generation. It consists of steam generator, condenser, deaerating feed water pump, pump and steam generator. The steam generated in the boiler may be wet or dry. It is superheated in the super heater which again takes the heat from the flue gases moving towards the chimney. The superheated steam is supplied to the turbine which generated power. In condenser the latent heat of vaporization of steam is transferred to the circulating waste water supplied from cooling tower.

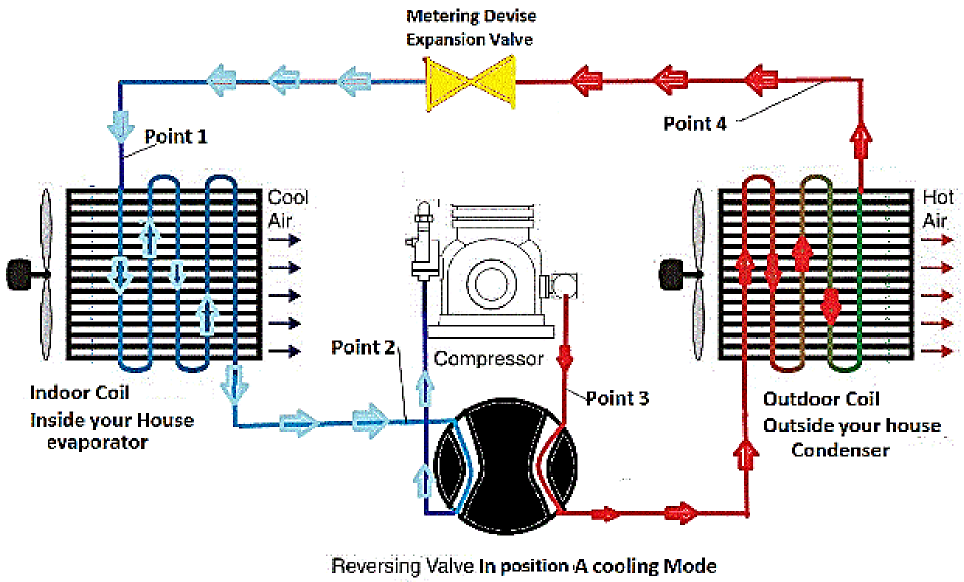
The boiler feed pump raises the feed water pressure and sends water to boiler through high pressure feed water heaters. In steam turbine the steam is expanded and power is generated with the help of generator. But nearly 60 to 70% of the input energy is wasted. This wasted steam is processed and the exhaust steam or gas is utilized for meeting the process heat requirements, the efficiency of utilization of the fuel increases. Here the waste steam is processed and then it goes to the deaerating feed water pump. The oxides like NO_X, SO_X is removedwith the help of deaerating feed water pump. The deaerated steam is pumped to the steam generator.Feed water flowing into the boiler is first preheated in the economiser, which recover the part or heat from the flue gases flowing to the chimney and then going to the atmosphere. This increases the efficiency as less heat must be supplied to the boiler.

Heat Pump/ Heat Exchanger.

HEAT PUMP

The Heat Pump is very simple which transfers or *pumps* heat from one place to another, (notice the use of the word “pump”- heat is not generated but rather is moved).

The real Heat Pump in action
Cooling Mode (regular Air Conditioning)

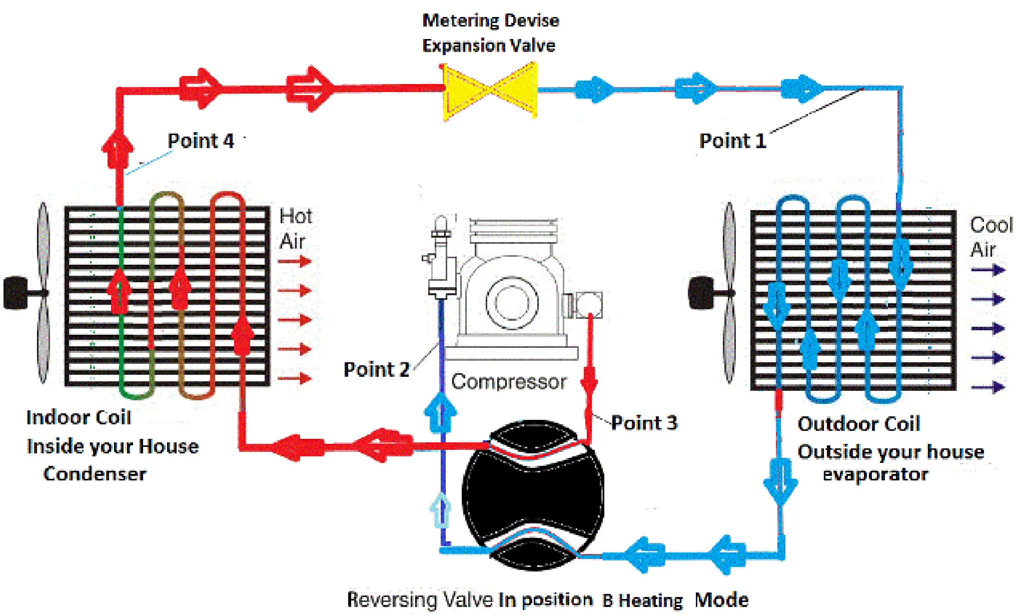


- **At Point 1** At the beginning of the cycle the refrigerant (such as Freon) is in a liquid form (gas contained under pressure becomes a liquid just like the propane in the tank that you use to BBQ that juicy steak). This liquid refrigerant is very cold. It enters the evaporator coil located inside your house. The hot air in your house moves over the coil and the air starts to lose its heat and cool down.
- **At Point 2** After the refrigerant leaves the indoor evaporator coil it has absorbed heat and become gas. Just like when you heat water on the stove and it becomes steam the refrigerant

gas evaporated when it absorbed all that heat in the house (that's why we call this coil the evaporator). The refrigerant enters the compressor which mechanically pressurizes the gas. That process will increase its temperature so the refrigerant will leave the compressor as hot gas.

- **At Point 3** The refrigerant next moves to the condenser coil located outside the house. Because the temperature outside is lower than the temperature of the hot gas the heat is transferred or "rejected" from the refrigerant in the coil to the outside air. As the temperature of the refrigerant gas cools it will form liquid condensate- just like the water droplets that form on a cold glass of soda (that's why we call this coil the condenser).
- **At Point 4** The refrigerant leaves the outdoor condenser coil as warm liquid. Now we need to make the warm liquid refrigerant cold so that it can absorb more heat. So it goes to the metering device which drops the pressure on the warm liquid and thus drops its temperature. The refrigerant leaves the metering device as a cold liquid, ready to repeat the cycle again.

Working of heat pump in heating mode:



By reversing valve, i.e. it Rotates 90° , that changes the direction of the flow of the refrigerant (Freon). It goes in the opposite direction and this is the reverse of the cooling cycle. Instead of absorbing heat from inside the house it absorbs heat from the air outside the house and "rejects" (or transfers) that heat to the indoor air. Now the indoor coil has become Condenser and the outdoor coil has become Evaporator.Notice that the heat isn't generated by an oil burner or a gas furnace. It is just moved (or pumped) from the outside air to inside the house. This is why the Heat Pump is so popular in moderate climates. You don't need to have a furnace or get oil or gas delivered when the weather cools off.Because of the reversing valve you can use the same electric system as both an air conditioner and a heater!

Energy Management and the role of energy engineers.

(Nov 2013)(Nov/Dec 2014)(April/May 2012)(Nov 2013)

Definition 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"

The objective of Energy Management is to achieve and maintain optimum energy procurement and utilization, throughout the organization and:

- To minimize energy costs / waste without affecting production & quality
- To minimize environmental effects.

Principles of Energy Management

The principles of Energy Management involve the following:

i. Procure all the energy needed at the lowest possible price (Example: buy from original sources, review the purchase terms)

ii. Manage energy use at the highest energy efficiency (Example: improving energy use efficiency at every stage of energy transport, distribution and use)

iii. Reusing and recycling energy by cascading (Example: waste heat recovery)

iv. Use the most appropriate technology (select low investment technology to meet the present requirement and environment condition)

v. Reduce the avoidable losses. (Make use of wastes generated within the plant as sources of energy and reducing the component of purchased fuels and bills)

Energy Management Skills

Energy Management involves a combination of both managerial and technical skills / knowledge.

Managerial skills, which includeis bringing about awareness, motivating people at all levels, changing the structure & procedure, monitoring the energy consumption, norms target setting, etc. Both the organizational and people changes are required. For example, a mere awareness campaign in an industry on switching off lights, fans and air conditioners brought about a significant reduction in energy consumption.

Technical skills are a pre-requisite in improving the energy efficiency of a process or equipment such as boilers, furnaces etc. For example, to improve the boiler efficiency one need to know the principles of combustion, heat transfer and steam generation.

Energy Manager should be technically well versed with manufacturing process, energy utilization technologies, in addition to awareness of statistical techniques of data processing, applied economics and cost accountancy.

Energy Management Strategy

Energy management should be seen as a continuous process. Strategies should be reviewed annually and revised as necessary. The key activities (see Figure 3.1) are outlined below:

1. Identify a Strategic Corporate Approach

The starting point in energy management is to identify a strategic corporate approach to energy management. Clear accountability for energy management needs to be established, appropriate financial and staffing resources must be allocated, and reporting procedures initiated. An energy management program requires commitment from the whole organisation in order to be successful.

2. Appoint Energy Manager

The energy manager, who should be a senior staff member, will be responsible for the overall coordination of the program and will report directly to top management. Energy managers need to have a technical background, need to be familiar with the organisation's activities and have appropriate technical support.

3. Set up an Energy Monitoring and Reporting System

Successful energy management requires the establishment of a system to collect,analyze and report on the organisation's energy costs and consumption. This will enable an overview of energy use and its related costs, as well as facilitating the identification of savings that might otherwise not be detected. The system needs to record both historical and ongoing energy use, as well as cost information from billing data, and be capable of producing summary reports on a regular basis. This information will provide the means by which trends can be analyzed and tariffs reviewed.

4. Conduct Energy Audit

An energy audit establishes both where and how energy is being used, and the potential for energy savings. It includes a walk-through survey, a review of energy using systems, analysis of energy use and the preparation of an energy budget, and provides a baseline from which energy consumption can be compared over time. An audit can be conducted by an employee of the organization who has appropriate expertise, or by a specialist energy-auditing firm. An energy audit report also includes recommendations for actions, which will result in energy and cost savings. It should also indicate the costs and savings for each recommended action, and a priority order for implementation.

5. Formalize an Energy Management Policy Statement

A written energy management policy will guide efforts to improve energy efficiency, and represents a commitment to saving energy. It will also help to ensure that the success of the program is not dependent on particular individuals in the organization. An energy management policy statement includes a declaration of commitment from senior management, as well as general aims and specific targets relating to:

- Energy consumption reduction (electricity, fuel oil, gas, petrol etc.)
- Energy cost reduction (by lowering consumption and negotiating lower unit rates)
- Timetables
- Budgetary limits
- Energy cost centers
- Organisation of management resources.

6. Prepare and Undertake a Detailed Project Implementation Plan

A project implementation plan should be developed as part of the energy audit and be endorsed by management. The plan should include an implementation time table and state any funding and budgetary requirements. Projects may range from establishing or changing operational procedures to ensure that plant and equipment use minimum energy, renegotiating electricity supply arrangements etc. to adopting asset acquisition programs that will reduce energy consumption. An overall strategy could be to introduce energy management projects, which will achieve maximum financial benefits at least cost to the organization.

7. Implement a Staff Awareness and Training Program

A key ingredient to the success of an energy management program is maintaining a high level of awareness among staff. This can be achieved in a number of ways, including formal training, newsletters, posters and publications, and by incorporating energy management into existing training programs. It is important to communicate program plans and case studies that demonstrate savings, and to report results at least at 12-month intervals. Staff may need training from specialists on energy saving practices and equipment.

8. Annual Review

An energy management program will be more effective if its results are reviewed annually. Review of energy management policy and strategies will form the basis for developing an implementation plan for the next 12 months.

TOP MANAGEMENT SUPPORT:

TOP MANAGEMENT COMMITMENT AND SUPPORT

Top management shall make a commitment to allocate manpower and funds to achieve continuous improvement. To establish the energy management programme, leading organizations appoint energy manager, forma dedicated energy team and institute an energy policy.

(i). APPOINT AN ENERGY MANAGER

The tasks of energy manger are setting goals, tracking progress, and promoting the energy management program. An Energy Manager helps an organization achieve its goals by establishing energy performance as a core value. The Energy Manager is not always an expert in energy and technical systems. Successful Energy Manager understands how energy management helps the organization achieve its financial and environmental goals and objectives. Depending on the size of the organization, the Energy Manager role can be a full-time position or an addition to other responsibilities.

Location of Energy Manager

The energy management function, whether vested in one “energy manager or coordinator” or distributed among a number of middle managers, usually resides somewhere in the organization between senior management and those who control the end-use of energy.

Exactly how and where that function is placed is a decision that needs to be made in view of the existing organizational structure.

Energy Manager: Responsibilities and Duties to be assignedunder the Energy Conservation Act, 2001.

Responsibilities

- Prepare an annual activity plan and present to management concerning financially attractive investments to reduce energy costs

- Establish an energy conservation cell within the firm with management's consent about the mandate and task of the cell.
- Initiate activities to improve monitoring and process control to reduce energy costs.
- Analyze equipment performance with respect to energy efficiency
- Ensure proper functioning and calibration of instrumentation required to assess level of energy consumption directly or indirectly.
- Prepare information material and conduct internal workshops about the topic for other staff.
- Improve disaggregating of energy consumption data down to shop level or profit center of a firm.
- Establish a methodology how to accurately calculate the specific energy consumption of various products/services or activity of the firm.
- Develop and manage training programme for energy efficiency at operating levels.
- Co-ordinate nomination of management personnel to external programs.
- Create knowledge bank on sectoral, national and inter-national development on energy efficiency technology and management system and information denomination
- Develop integrated system of energy efficiency and environmental up gradation.
- Co-ordinate implementation of energy audit/efficiency improvement projects through external agencies.
- Establish and/or participate in information exchange with other energy managers of the same sector through association

Duties

- Report to BEE and State level Designated Agency once a year the information with regard to the energy consumed and action taken on the recommendation of the accredited energy auditor, as per BEE Format.
- Establish an improved data recording, collection and analysis system to keep track of energy consumption.
- Provide support to Accredited Energy Audit Firm retained by the company for the conduct of energy audit
- Provide information to BEE as demanded in the Act, and with respect to the tasks given by a mandate, and the job description.
- Prepare a scheme for efficient use of energy and its conservation and implement such scheme keeping in view of the economic stability of the investment in such form and manner as may be provided in the regulations of the Energy Conservation Act.

(ii). FORM A DEDICATED ENERGY TEAM

The tasks of energy team are executing energy management activities across different parts of the organization and ensuring integration of best practices.

Decisions affecting energy use are made every day by employees at all levels in an organization. Creating an energy team helps to integrate energy management activities in an organization.

In addition to planning and implementing specific improvements, the energy team measures and tracks energy performance and communicates with management, employees and other stakeholders.

The size of the energy team will vary depending on the size of the organization. In addition to the Energy Manager who leads the team and dedicated energy staff, the team can include a representative from each operational area that significantly affects energy use, such as:

- Engineering
- Purchasing
- Operations and Maintenance
- Building/Facilities Management
- Environmental Health and Safety
- Contractors and Suppliers
- Utilities

Energy team can encourage communications and the sharing of ideas between various departments in an organization. It can serve to obtain agreements on energy conservation projects, which affect more than one department. It can provide a stronger voice to the top management than a single energy manager normally could. The composition of the energy team will vary from one organization to another, depending on the existing management structure, the type and quantity of energy used and other company-specific factors.

The frequency of team meetings depend on the importance of energy costs in the overall cost structure of the company and what projects are in progress at any time. Normally a monthly meeting is usual, so that monthly production and energy consumptions may be reviewed together by the committee. This review would include a comparison of actual performance against previously set targets and budget figures, as well as against previous months. Other items for the agenda should be a review of the status of energy conservation investments in progress or planned.

(iii). INSTITUTE AN ENERGY POLICY

Energy policy provides the foundation for setting performance goals and integrating energy management into an organization's culture and operations.

Energy Policy provides the foundation for successful energy management. It formalizes top management's support and articulates the organization's commitment to energy efficiency for employees, shareholders, the community and other stakeholders.

A formal written energy policy acts both as:

- A public expression of the organization’s commitment to energy conservation and environmental protection
- A working document to guide the energy management practices and provides continuity.

It is in the company's best interest that support for energy management is expressed in a formal written declaration of commitment accompanied by a set of stated objectives, an action plan for achieving them, and a clear specification of responsibilities.

Typical Format of an Energy Policy

- Declaration of top management's commitment to, and senior and middle management's involvement in, energy management.
- Statement of policy.
- Statement of objectives, separated into short and long-term goals.

Actions

- Have the CEO or head of the organization officially issue the policy
- Involve key people in policy development to ensure cooperation
- Tailor the policy to the organization's culture
- Make it understandable to employees and public alike
- Consider the skills and abilities of management and employees
- Include detail that covers day-to-day operations
- Communicate the policy to all employees, and encourage them to get involved

Role and Responsibilities of Energy manager. **(April 2013)(April/May 2012)**

Energy manager occupies an important position and is a focal point of all the activities pertaining to energy management in the organization. The energy manager provides leadership in the development of policy on energy management action plan and plays a key role in the formulation of corporate energy policy. Energy managers also perform the activities related with plant energy management, project management, personnel management and financial management at the plant level. He also prepares the information to be submitted to the designated agency with regard to the energy consumed and action taken on the recommendation of the accredited energy auditor.

Bureau of Energy Efficiency (BEE) has taken up the challenge of creating a cadre of professionally qualified energy managers with expertise in energy management, project management, financing and implementation of energy efficiency projects, and policy analysis. BEE has been empowered by the law for directing designated consumers (power intensive industries) to designate or appoint certified energy managers in charge of activities for efficient use of energy and its conservation.

According to Mr. K. K. Chakarvarti, Energy Economist, Bureau of Energy Efficiency, the responsibilities and duties of an energy manager are as follows:

Responsibilities:

- Prepare an annual activity plan and present to management concerning financially attractive investments to reduce energy costs.
- Establish an energy conservation cell within the firm with management's consent about the mandate and task of the cell.
- Initiate activities to improve monitoring and process control to reduce energy costs.
- Analyze equipment performance with respect to energy efficiency.
- Ensure proper functioning and calibration of instrumentation required to assess level of energy consumption directly or indirectly.
- Prepare information material and conduct internal workshops about the topic for other staff.

- Improve disaggregating of energy consumption data down to shop level or profit center of a firm.
- Establish a methodology how to accurately calculate the specific energy consumption of various products/services or activity of the firm.
- Develop and manage training programme for energy efficiency at operating levels.
- Co-ordinate nomination of management personnel to external programmes.
- Create knowledge bank on sectoral, national and international development on energy efficiency technology and management system and information dissemination.
- Develop integrated system of energy efficiency and environmental upgradation.
- Co-ordinate implementation of energy audit/efficiency improvement projects through external agencies.
- Establish and/or participate in information exchange with other energy managers of the same sector through association.
- Report to BEE and State level designated agency once a year the information with regard to the energy consumed and action taken on the recommendation of the accredited energy auditor, as per BEE format.
- Establish an improved data recording, collection and analysis system to keep track of energy consumption.
- Provide support to accredited energy audit firm retained by the company for the conduct of energy audit.
- Provide information to BEE as demanded in the Act, and with respect to the tasks given by a mandate, and the job description.
- Prepare a scheme for efficient use of energy and its conservation and implement such scheme keeping in view the economic stability of the investment in such form and manner as may be provided in the regulations of the Energy Conservation Act.

Layout of combined cycle plant with super changed boiler. (April 2015)

Combined cycle is a characteristics' of a power producing engine or plant that employs more than one thermodynamic cycle. Heat engine are only able to use a portion of the energy of their generation usually less than 50%. The remaining heat from combustion is generally wasted. Combining two or more cycle such as Brayton cycle and Rankine cycle results in improved overall efficiency. In a combined cycle power plant (CCPP) or combined cycle gas turbine (CCGT) plant, as gas turbine generator generates electricity and waste heat is used to make steam to generate additional electricity via a steam turbine, this last step enhances the efficiency of electricity generation. As a rule, in order to achieve high efficiency, the temperature difference between the input and output heat levels be as high as possible. This is achieved by combined the Brayton (gas) and Rankine (steam) thermodynamics cycle. The schematic diagram of combined cycle is shown in fig

A general over view of combined cycle power plant:

Energy distribution in CCPP: Energy flow diagram (Fig.1.2) shows the distribution of the entering energy in to its useful component and the energy losses which are associated with the condenser and stack losses. This distribution will vary some with different cycle as the stack losses decreased with more efficient multi level pressure heat recovery steam generating (HRSG) units.

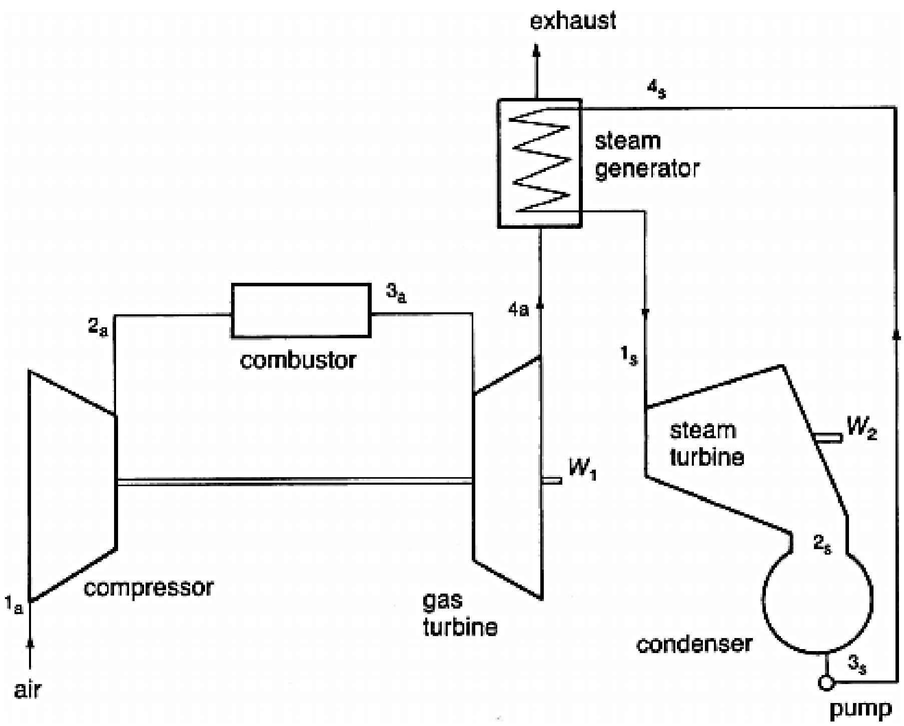


Fig.1.1 A schematic diagram of combined cycle power plant.

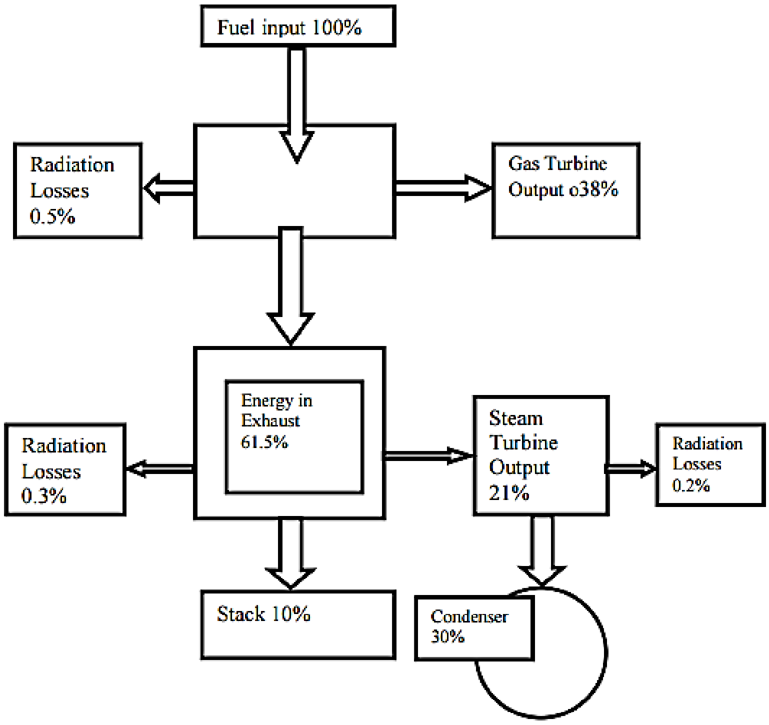


Fig.1-2.Energy distribution in a combined cycle power plant.

Load shearing between prime mover over the entire operating range of combined cycle power plant: The distribution of the energy produced by gas turbine and steam turbine as a function of total energy produced is shown in Fig (1.3). This diagram shows that the load sharing characteristics of each of the prime mover changes drastically with off design operation. The gas turbine at design supplies 60% of the

total energy delivered and steam turbine delivers 40% of energy while at off design conditions (below 50% of design energy), the gas turbine delivers 40% of the energy while the steam turbine delivers 60% of energy

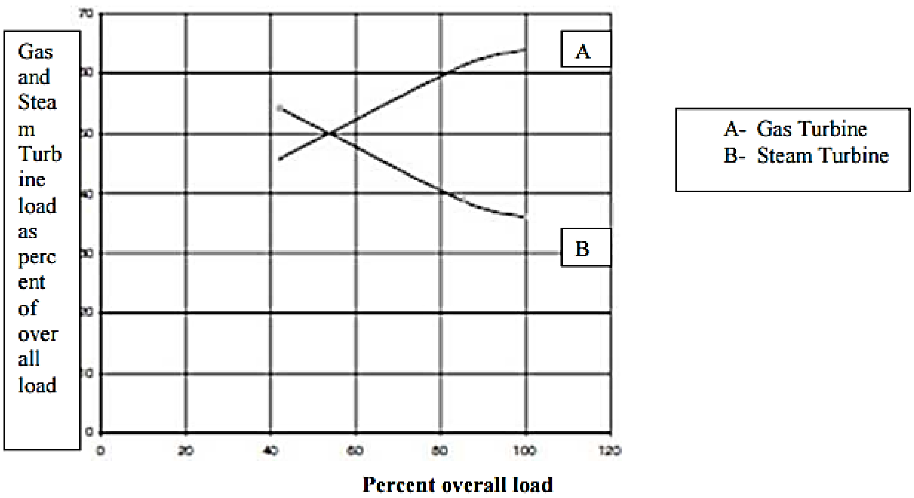


Fig.1-3. Load shearing between prime mover over the entire operating range of combined cycle power plant.

Main components of combined cycle power plants:

The major components that make up a combined cycle are compressor, gas turbine, HRSG, and steam turbine as shown in Fig.1.1.

1. Compressor:

A compressor is a device, which pressurizes a working fluid. There are three types of compressors. The positive displacement compressors are used for low flow and high head, centrifugal compressor are medium flow and medium head, and axial flow compressor for high flow and low head. Nearly all gas turbine plants producing over 5 MW have axial flow compressors.

Combustor All gas turbine combustors perform the same function; they increase the temperature of the high-pressure gas. The gas turbine combustor uses very little of its air (10%) in the combustion process. The rest of the air is used for cooling and mixing. The new combustors are also used circulating steam for cooling purposes. The air from the compressor must be diffused before it enters the combustor. The velocity of the air leaving the compressor is about 122 to 183 (m/sec) and the velocity in the combustor must be maintained below 15.2 (m/sec). Even at these low velocities care must be taken to avoid the flame to be carried on downstream. The combustor is a direct-fired air heater in which fuel is burned almost stoichiometrically with onethird or less of the compressor discharge air. Combustion products are then mixed with the remaining air to arrive at a suitable turbine inlet temperature.

Combustor performance is measured by efficiency, the pressure decrease encountered in the combustor, and the evenness of the outlet temperature profile. The combustion efficiency is a measure of combustion completeness. The combustion completeness affects fuel consumption directly, since the heating value of any unburned fuel is not used to increase the turbine inlet temperature. Normal combustion temperatures range from 1871 0C to 1927 0C. At this temperature, the volume of nitric oxide in the combustion gas is about 0.01%. If the combustion temperature is lowered, the amount of nitric oxide is substantially reduced.

2 Gas turbine

There are two types of turbine used in gas turbine I. Axial flow turbine II. Radial flow turbine The axial flow turbine, like its counter parts the axial flow compressor, has flow which inter and leaves in the axial direction. Most axial flow turbine consist of more than one stage: the front stages are usually impulses (zero reaction) and the later stages have about 50% reaction. The impulses stages produces about twice output of a comparable 50% reaction stage, while the efficiency of an impulses stage is less than that of 50% reaction stages.

3.**Coatings**

There are three basic types of coatings: thermal barrier coatings, diffusion coatings, and plasma sprayed coatings. The advancements in coating have also been essential in ensuring that the blade base metal is protected at these high temperatures. Coatings ensure that the life of the blades is extended and in many cases are used as sacrificial layers, which can be stripped and recoated. The life of a coating depends on composition, thickness, and the standard of evenness to which it has been deposited. The general type of coatings is little different from the coatings used 10-15 years ago. These include various types of diffusion coatings such as aluminide coatings originally developed nearly 40 years ago. The thickness required is between 25–75 µm thick. The new aluminide coatings with platinum increase the oxidation resistance, and also the corrosion resistance. The thermal barrier coatings have an insulation layer of 100–300 µm thick, are based on ZrO2-Y2O3, and can reduce metal temperatures by 50–150 0C. This type of coating is used in combustion cans, transition pieces, nozzle guide vanes, and also blade platforms.

4. Heat recovery steam generator (HRSG)

The gas turbine exhaust gases enter the Heat Recovery Steam Generator (HRSG), where the energy is transferred to the water to produce steam. There are many different configurations of the HRSG units. Most HRSG units are divided into the same amount of sections as the steam turbine. In most cases, each section of the HRSG has a Pre-heater, an Economizer and Feed-water, and then a Super heater. The steam entering in the steam turbine is superheated. The most common type of an HRSG in a large Combined Cycle Power plant is the drum type HRSG with forced circulation. These types of HRSGs are vertical; the exhaust gas flow is vertical with horizontal tube bundles suspended in the steel structure. The steel structure of the HRSG supports the drums. In a forced circulation

HRSG, then the steam water mixture is circulated through evaporator tubes using a pump. These pumps increase the parasitic load and thus detract from the cycle efficiency. In this type of HRSG the heat transfer tubes are horizontal, suspended from un-cooled tube supports located in the hot gas path. Some vertical HRSGs are designed with evaporators, which operate without the use of circulation pumps.

5. Multipressure Steam Generators—These are becoming increasingly popular. With a single pressure boiler, there is a limit to the heat recovery because the exhaust gas temperature cannot be reduced below the steam saturation temperature. This problem is avoided by the use of multipressure levels.

6. Pinch Point—This is defined as the difference between the exhaust gas temperature leaving the evaporator section and the saturation temperature of the steam. Ideally, the lower the pinch point, the more heat recovered, but this calls for more surface area and, consequently, increases the backpressure and cost. Also, excessively low pinch points can mean inadequate steam production if the exhaust gas is low in energy (low mass flow or low exhaust gas temperature). General guidelines call for a pinch point of 8–22 0C. The final choice is obviously based on economic considerations.

7. Approach Temperature—This is defined as the difference between the saturation temperatures of the steam and the inlet water. Lowering the approach temperature can result in increased steam production, but at increased cost. Conservatively high-approach temperatures ensure that no steam generation takes place in the economizer. Typically, approach temperatures are in the 5.5–11 0C range. Fig. 1.5 is the temperature energy diagram for a system and also indicates the approach and pinch points in the system.

2- MARKS

1. **What do you mean by Economics of power generation?**

   The art of determining the per unit i.e. one KWh cost ofproduction of electrical energy is known as Economics of power generation.

2. **Write the Objectives of Supply management.** **(April/May 2012)**

   a. Increase the output of the system without spending huge capital.
   b. Operate the plant at most economical power factor.
   c. Replace the old technology machine with new one to improve quality and production.

3. **What is the difference between base load and peak load?**

   The unvarying load which occurs almost the whole day is known as base load. The various demands of load over and above the base load arethe peak load.

4. **Define the term waste heat recovery?**

   Waste heat is the heat which is not at all used and exhausted out as a waste product. Waste heat is normally available from the industry in the form of process steam and water at high temperature. Also, the waste heat is discharged with the exhaust gases in so many industries. This heat can be recovered for useful purpose. This process is known-as waste heat recovery.

5. **What are the waste materials, which can be used for fuel for power generation?**

   - Municipal waste
   - Industrial waste
   - Paper waste
   - Rubber waste.

6. **What is heat Exchanger?**

   A **heat exchanger** is a piece of equipment built for efficient heat transfer from one medium to another. The media may be separated by a solid wall to prevent mixing or they may be in direct contact.

7. **Write about waste heat boilers?**

   The waste heat boilers use the waste heat in gases coming out of diesel engines and gas turbines at high temperature (or) use the waste as a fuel in the incineration.Some boilers use the industrial dirty gases for power generation.

8. **Definition cogeneration**:

   A production of electricity and useful thermal energy simultaneously from a common fuel source. The rejected heat from industrial processes can be used to power an electric generator. Surplus heat from an electric generator can be used for industrial processes, or for heating purposes.

9. **Write down the application of co-generation.**

   - Increased efficiency of energy conversion and use.

- Lower emission to the environment in particular of co_2, the main greenhouse gas.
- Biomass fuels and some waste materials such as refinery gases, agricultural wastes are used. They serve as fuels for cogeneration schemes increases the cost effectiveness and reduce the need for waste disposal.

10. Define energy conservation? **(April 2015)(April/May 2014)**

Energy Conservation means reduction in energy consumption but without making any sacrifice in the quality or quantity of production. In other words, it means increasing the production from a given amount of energy input by reducing losses/wastage and maximizing the efficiency.

11. What are the principles of energy conservation? **(Nov 2013)(Nov/Dec 2014)**

The general principles of Energy Conservation are:

- Recycling of waste
- Modernization of technology
- Waste heat utilization
- Proper house keeping
- Judicial use of proper types of energy
- Judicial use of proper type of fuel
- Training of manpower
- Adopting daylight saving time
- Proper operation and maintenance
- Cogeneration

12. What are the steps to be followed for energy conservation? **(April 2013)**

The two principles of governing energy conservation policies are maximum thermodynamic efficiency and maximum cost effectiveness in energy use.

13. What are the types of co-generation?

- The topping cycle
- The bottoming cycle

14. What are the steps towards energy conservation?

Formulation of administrative and information programme relatively easy and in expensive to implement like tune ups, light turn offs, small adjustment in production process etc., effective in reducing current energy consumption to the extent of 3 to 7%. The responsibility for implementation of this programme falls on the operators and low level managers.Re-equipping,Retrofitting and Re-cycling through small incremental investments for gaining 5 to 10% savings. Middle level managers will make these decisions.

Major production process changes through large scale capital expenditure for obtaining savings from 20 to 90% gain, depending on the nature of operations and facilities involved.

15. What are the classifications of electrical energy conversion? **(Nov 2012)**

Energy from charged particles called electricalenergy.

The process of fission (splitting atoms) and fusion (combining atoms) gives us another type of energy called nuclearenergy.

16. What are the types of cogeneration plants? **(Nov 2011)**

i. Combined cycle of gas turbine and steam power plant.
ii. Combined cycle of gas turbine and diesel power plant.

17. What is the necessity of demand forecasting? **(Nov 2011)**

Demand forecasting is the activity of estimating the quantity of a product or service that consumers will purchase. Demand forecasting involves techniques including both informal methods, such as educated guesses, and quantitative methods, such as the use of historical sales data or current data from test markets. Demand forecasting may be used in making pricing decisions, in assessing future capacity requirements, or in making decisions on whether to enter a new market.

18. Define energy audit. April 2015

An energy audit is an inspection, survey and analysis of energy flows, for energy conservation in a building, process or system to reduce the amount of energy input into the system without negatively affecting the output(s)

19. State the objectives of energy management Nov 2015

Energy management includes planning and operation of energy production and energy consumption units. Objectives are resource conservation, climate protection and cost savings, while the users have permanent access to the energy they need

20. Clearly state the factors to be considered for number and size of generator units section. April 2016

Many people believe smaller generators can be used for standby electric power because they are not running all the time. This is not only a myth but can actually be very detrimental. Unfortunately, generator under sizing is one of the most common mistakes committed by buyers. Not only does it involve the risks of damaging your new asset (the generator), but it can also damage other assets connected to it, create hazardous situations, and even limit overall productivity of the unit and/or the business relying on it. If nothing else, the key thing to remember here is that more is always better than less.

How to Determine the Right Size Engine or Generator: While there is no substitute for having a certified electrician perform an inspection and calculate everything for you, the guidelines below do offer some great starting points and should at least get you started in the right direction:

21. State the vital role of energy manager April 2016

The responsibilities of an Energy Manager are:

- Prepare an annual activity plan and present to management concerning financially attractive investments to reduce energy costs
- Establish an energy conservation cell within the firm with management's consent about the mandate and task of the cell.
- Initiate activities to improve monitoring and process control to reduce energy costs.

PONDICHERRY UNIVERSITY QUESTIONS

2 MARKS

1. Write the Objectives of Supply management. **(April/May 2012)**
2. Define energy conservation? **(April 2015)(April/May 2014)**
3. What are the principles of energy conservation? Nov'2015 **(Nov 2013)(Nov/Dec 2014)**
4. What are the steps to be followed for energy conservation? **(April 2013)**
5. Define Energy Conversion. **(April 2014)**
6. What are the classifications of electrical energy conversion? **(Nov 2012)**
7. What is Deaeration? **(Apr 2013)**
8. What are the types of cogeneration plants? **(Nov 2011)**
9. What is the necessity of demand forecasting? **(Nov 2011)**
10. Define energy audit. April 2015
11. State the objectives of energy management Nov 2015
12. Clearly state the factors to be considered for number and size of generator units section. April 2016
13. State the vital role of energy manager April 2016

11 MARKS

1. Explain about principle of energy conservation and also the economics of energy Conservation. (Nov 2011)(Nov/Dec 2014)(Nov 2012))(Nov 2013))(April 2015)(April 2013)
2. Explain in detail about energy conservation opportunities. (Nov' 2015)
3. Explain about waste heat recovery. (April/May 2014))(April/May 2012) (Nov 2012)
4. Explain cogeneration in detail. (April/May 2014)
5. Explain about energy Management in detail and the role of energy engineers. (Nov 2013)(Nov/Dec 2014)(April/May 2012)(Nov 2013)
6. Explain the energy management practices employed in India. (May 2016)
7. Discuss the role and responsibilities of energy manager. (April 2013)(April/May 2012)
8. Explain the concept of energy conservation based on (a) Maximum energy efficiency (b) Maximum cost effectiveness in energy use. (May 2016)
9. Explain the various types of energy audit. (April 2015)
10. Enumerate different energy auditing types and methodologies in detail. (Nov'2015)
11. Explain the layout of combined cycle plant with super changed boiler. (April 2015)