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PRACTICAL-1

AIM: OVERVIEW OF ENERGY SCENARIO AND INTRODUCTION TO ENERGY CONSERVATION

Introduction

Energy is one of the major inputs for the economic development of any country. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever increasing energy needs requiring huge investments to meet them.

Energy can be classified into several types based on the following criteria:

- Primary and Secondary energy
- Commercial and Non commercial energy
- Renewable and Non-Renewable energy

Primary and Secondary Energy

- Primary energy sources are those that are either found or stored in nature. Common primary energy sources are coal, oil, natural gas, and biomass (such as wood). Other primary energy sources available include nuclear energy from radioactive substances, thermal energy stored in earth's interior, and potential energy due to earth's gravity.
- Primary energy sources are mostly converted in industrial utilities into secondary energy sources; for example coal, oil or gas converted into steam and electricity. Primary energy can also be used directly. Some energy sources have non-energy uses, for example coal or natural gas can be used as a feedstock in fertilizer plants.

Commercial Energy and Non Commercial Energy

Commercial Energy

The energy sources that are available in the market for a definite price are known as commercial energy. By far the most important forms of commercial energy are electricity, coal and refined petroleum products.

Non-Commercial Energy

The energy sources that are not available in the commercial market for a price are classified as non-commercial energy. Non-commercial energy sources include fuels such as firewood, cattle dung and agricultural wastes, which are traditionally gathered, and not bought at a price used especially in rural households.

Renewable and Non-Renewable Energy

- Renewable energy is energy obtained from sources that are essentially inexhaustible. Examples of renewable resources include wind power, solar power, geothermal energy, tidal power and hydroelectric power. The most important feature of renewable energy is that it can be harnessed without the release of harmful pollutants.
- Non-renewable energy is the conventional fossil fuels such as coal, oil and gas, which are likely to deplete with time.

Global Primary Energy Reserves

Coal

The proven global coal reserve was estimated to be 9,84,453 million tonnes by end of 2003. The USA had the largest share of the global reserve (25.4%) followed by Russia (15.9%), China (11.6%). India was 4th in the list with 8.6%.

Oil

The global proven oil reserve was estimated to be 1147 billion barrels by the end of 2003. Saudi Arabia had the largest share of the reserve with almost 23%. (One barrel of oil is approximately 160 litres)

Gas

The global proven gas reserve was estimated to be 176 trillion cubic metres by the end of 2003. The Russian Federation had the largest share of the reserve with almost 27%.

Indian Energy Scenario

Coal dominates the energy mix in India, contributing to 55% of the total primary energy production. Over the years, there has been a marked increase in the share of natural gas in primary energy production from 10% in 1994 to 13% in 1999. There has been a decline in the share of oil in primary energy production from 20% to 17% during the same period.

Energy Supply

Coal Supply

India has huge coal reserves, at least 84,396 million tonnes of proven recoverable reserves (at the end of 2003).

This amounts to almost 8.6% of the world reserves and it may last for about 230 years at the current Reserve to Production (R/P) ratio. In contrast, the world's proven coal reserves are expected to last only for 192 years at the current R/P ratio.

Reserves/Production (R/P) ratio- If the reserves remaining at the end of the year are divided by the production in that year, the result is the length of time that the remaining reserves would last if production were to continue at that level. India is the fourth largest producer of coal and lignite in the world. Coal production is concentrated in these states (Andhra Pradesh, Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra, Orissa, Jharkhand, West Bengal).

Oil Supply

Oil accounts for about 36 % of India's total energy consumption. India today is one of the top ten oil-guzzling nations in the world and will soon overtake Korea as the third largest consumer of oil in Asia after China and Japan.

The country's annual crude oil production is peaked at about 32 million tonne as against the current peak demand of about 110 million tonne. In the current scenario, India's oil consumption by end of 2007 is expected to reach 136 million tonne (MT), of which domestic production will be only 34 MT. India will have to pay an oil bill of roughly $50 billion, assuming a weighted average price of $50 per barrel of crude. In 2003-04, against total export of $64 billion, oil imports accounted for $21 billion.

India imports 70% of its crude needs mainly from gulf nations. The majority of India's roughly 5.4 billion barrels in oil reserves are located in the Bombay High, upper Assam, Cambay, Krishna-Godavari. In terms of sector wise petroleum product consumption, transport accounts for 42% followed by domestic and industry with 24% and 24% respectively. India spent more than Rs.1, 10,000 crore on oil imports at the end of 2004.

Natural Gas Supply

Natural gas accounts for about 8.9 per cent of energy consumption in the country. The current demand for natural gas is about 96 million cubic metres per day (mcmd) as against availability of 67 mcmd. By 2007, the demand is expected to be around 200 mcmd. Natural gas reserves are estimated at 660 billion cubic meters.

Electrical Energy Supply

The all India installed capacity of electric power generating stations under utilities was 1,12,581 MW as on 31st May 2004, consisting of 28,860 MW- hydro, 77,931 MW - thermal and 2,720 MW- nuclear and 1,869 MW- wind (Ministry of Power). The gross generation of power in the year 2002-2003 stood at 531 billion units (kWh).

Nuclear Power Supply

Nuclear Power contributes to about 2.4 per cent of electricity generated in India. India has ten nuclear power reactors at five nuclear power stations producing electricity. More nuclear reactors have also been approved for construction.

Hydro Power Supply

India is endowed with a vast and viable hydro potential for power generation of which only 15% has been harnessed so far. The share of hydropower in the country's total generated units has steadily decreased and it presently stands at 25% as on 31st May 2004. It is assessed that exploitable potential at 60% load factor is 84,000 MW.

Final Energy Consumption

Final energy consumption is the actual energy demand at the user end. This is the difference between primary energy consumption and the losses that takes place in transport, transmission & distribution and refinement.

The actual final energy consumption (past and projected) is given in Table 1.1

TABLE 1.1 DEMAND FOR COMMERCIAL ENERGY FOR FINAL CONSUMPTION (BAU SCENARIO)

Source	Units	1994-95	2001-02	2006-07	2006-07
Electricity	Billion Units	289.36	480.08	712.67	1067.88
Coal	Million Tonnes	76.67	109.01	134.99	173.47
Lignite	Million Tonnes	4.85	11.69	16.02	19.70
Natural Gas	Million Cubic Meters	9880	15730	18291	20853
Oil Products	Million Tonnes	63.55	99.89	139.95	196.47

Energy Intensity

Energy intensity is energy consumption per unit of GDP. Energy intensity indicates the development stage of the country. India's energy intensity is 3.7 times of Japan, 1.55 times of USA, 1.47 times of Asia and 1.5 times of World average.

Long Term Energy Scenario for India

□ Coal

Coal is the predominant energy source for power production in India, generating approximately 70% of total domestic electricity. Energy demand in India is expected to increase over the next 10-15 years; although new oil and gas plants are planned, coal is expected to remain the dominant fuel for power generation.

Despite significant increases in total installed capacity during the last decade, the gap between electricity supply and demand continues to increase. The resulting shortfall has had a negative impact on industrial output and economic growth. However, to meet expected future demand, indigenous coal production will have to be greatly expanded.

Production currently stands at around 290 Million tonnes per year, but coal demand is expected to more than double by 2010. Indian coal is typically of poor quality and as such requires to be beneficiated to improve the quality; Coal imports will also need to increase dramatically to satisfy industrial and power generation requirements.

□ Oil

India's demand for petroleum products is likely to rise from 97.7 million tonnes in 2001-02 to around 139.95 million tonnes in 2006-07, according to projections of the Tenth Five-Year Plan. The plan document puts compound annual growth rate (CAGR) at 3.6 % during the plan period.

Domestic crude oil production is likely to rise marginally from 32.03 million tonnes in 200102 to 33.97 million tonnes by the end of the 10th plan period (2006-07). India's self sufficiency in oil has consistently declined from 60% in the 50s to 30% currently. Same is expected to go down to 8% by 2020. As shown in the figure 1, around 92% of India's total oil demand by 2020 has to be met by imports.

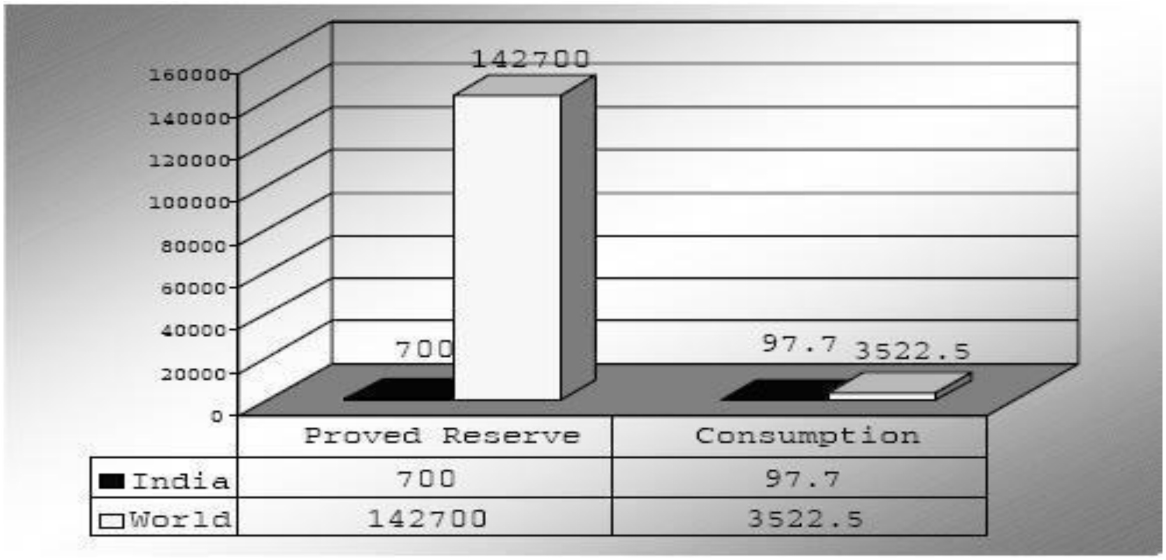


Figure 1: Proven Oil Reserve/Consumption (in Million Tonnes)

Natural Gas

India's natural gas production is likely to rise from 86.56 million cmpd in 2002-03 to 103.08 million cmpd in 2006-07. It is mainly based on the strength of a more than doubling of production by private operators to 38.25 mm cmpd.

Electricity

India currently has a peak demand shortage of around 14% and an energy deficit of 8.4%. Keeping this in view and to maintain a GDP (gross domestic product) growth of 8% to 10%, the Government of India has very prudently set a target of 215,804 MW power generation capacity by March 2012 from the level of 100,010 MW as on March 2001, that is a capacity addition of 115,794 MW in the next 11 years

.

In the area of nuclear power the objective is to achieve 20,000 MW of nuclear generation capacity by the year 2020.

Energy Sector Reforms

Since the initiation of economic reforms in India in 1991, there has been a growing acceptance of the need for deepening these reforms in several sectors of the economy, which were essentially in the hands of the government for several decades. It is now been realized that if substance has to be provided to macroeconomic policy reform, then it must be based on reforms that concern the functioning of several critical sectors of the economy, among which the infrastructure sectors in general and the energy sector in particular, are paramount.

Coal

The government has recognized the need for new coal policy initiatives and for rationalization of the legal and regulatory framework that would govern the future development of this industry. One of the key reforms is that the government has allowed importing of coal to meet our requirements. Private sector has been allowed to extract coal for captive use only. Further reforms are contemplated for which the Coal Mines Nationalization Act needs to be amended for which the Bill is awaiting approval of the Parliament. The ultimate objective of some of the ongoing measures and others under consideration is to see that a competitive environment is created for the functioning of various entities in this industry. This would not only bring about gains in efficiency but also effect cost reduction, which would consequently ensure supply of coal on a larger scale at lower prices. Competition would also have the desirable effect of bringing in new technology, for which there is an urgent and overdue need since the coal industry has suffered a prolonged period of stagnation in technological innovation.

Oil and Natural Gas

Since 1993, private investors have been allowed to import and market liquefied petroleum gas (LPG) and kerosene freely; private investment is also been allowed in lubricants, which are not subject to price controls. Prices for naphtha and some other fuels have been liberalized. In 1997 the government introduced the New Exploration Licensing Policy (NELP) in an effort to promote investment in the exploration and production of domestic oil and gas. In addition, the refining sector has been opened to private and foreign investors in order to reduce imports of refined products and to encourage investment in downstream pipelines. Attractive terms are being offered to investors for the construction of liquefied natural gas (LNG) import facilities.

Electricity

Following the enactment of the Electricity Regulatory Commission Legislation, the Central Electricity Regulatory Commission (CERC) was set up, with the main objective of regulating the Central power generation utilities. State level regulatory bodies have also been set up to set tariffs and promote competition. Private investments in power generation were also allowed. The State SEBs were asked to switch over to separate Generation, Transmission and Distribution corporations. There are plans to link all SEB grids and form a unified national power grid.

Energy Conservation and its Importance

Coal and other fossil fuels, which have taken three million years to form, are likely to deplete soon . In the last two hundred years, we have consumed 60% of all resources. For sustainable development, we need to adopt energy efficiency measures. Today, 85% of primary energy comes from nonrenewable, and fossil sources (coal, oil, etc.). These reserves are continually diminishing with increasing consumption and will not exist for future generations.

What is Energy Conservation?

Energy Conservation and Energy Efficiency are separate, but related concepts. Energy conservation is achieved when growth of energy consumption is reduced, measured in physical terms. Energy Conservation can, therefore, be the result of several processes or developments, such as productivity increase or technological progress. On the other hand Energy efficiency is achieved when energy intensity in a specific product, process or area of production or consumption is reduced without affecting output, consumption or comfort levels. Promotion of energy efficiency will contribute to energy conservation and is therefore an integral part of energy conservation promotional policies.

Energy efficiency is often viewed as a resource option like coal, oil or natural gas. It provides additional economic value by preserving the resource base and reducing pollution. For example, replacing traditional light bulbs with Compact Fluorescent Lamps (CFLs) means you will use only 1/4th of the energy to light a room. Pollution levels also reduce by the same amount.
Nature sets some basic limits on how efficiently energy can be used, but in most cases our products and manufacturing processes are still a long way from operating at this theoretical limit. Very simply, energy efficiency means using less energy to perform the same function. Although, energy efficiency has been in practice ever since the first oil crisis in 1973, it has today assumed even more importance because of being the most cost-effective and reliable means of mitigating the global climatic change. Recognition of that potential has led to high expectations for the control of future CO_2 emissions through even more energy efficiency improvements than have occurred in the past. The industrial sector accounts for some 41 per cent of global primary energy demand and approximately the same share of CO_2 emissions.

PRACTICAL: 2

AIM: Energy management concept, principles, benefits and its significant.

- The fundamental goal of energy management is to produce goods and provide services with the least cost and least environmental effect. The term energy management means many things to many people. One definition of energy management is:

"The judicious and effective use of energy to maximize profits (minimize costs) and enhance competitive positions"

- Another comprehensive definition is:

"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

- Minimizing energy wastage
- Modifying operation, where possible, to make the best use of energy
- Training and motivation to staff for energy reduction practices
- Optimizing energy efficiency with suitable technology

Managing and reducing energy consumption not only saves money but also helps in mitigating climate change and enhancing corporate reputation. The primary objective of energy management is to achieve and maintain optimum energy procurement and utilization, throughout the organization which may help in minimizing energy costs and mitigating environmental effects.

Importance of Energy Management

Energy should be regarded as a business cost, like raw material or labor. Companies can achieve substantial reduction in energy bills by implementing simple housekeeping measures. Reduction and control of energy usage is vital for an organization as it:

- ***Reduces costs*:** Reducing cost is the most compelling reason for saving energy. Most organizations can save up to 20% on their fuel cost by managing their energy use;
- ***Reduces carbon emissions***: Reducing energy consumption also reduces carbon emissions and adverse environmental effects. Reducing your organization‟s carbon footprint helps build a „green‟ image thereby generating good business opportunities; and

- ***Reduce risk***: Reducing energy use helps reduce risk of energy price fluctuations and supply shortages.

Regulatory requirements aiming to reduce carbon emissions and energy use require accurate energy data collection and effective management systems. Good energy management practices are compliant with these requirements and help fulfill regulatory obligations. Businesses worldwide are showing interest in appointment of a formal/informal energy manager to coordinate energy management activities. The main task of an energy manager is to set up a system to collect, analyze and report on energy consumption and costs which may involve reading electricity meters regularly and analysis of utility bills.

Carbon emissions from energy use dominate the total greenhouse gas emissions of most organizations. Sound energy management is rapidly emerging as an integral part of carbon management which in turn helps organizations in effective overall environmental management. In addition to financial benefits, energy management has other significant advantages for an organization such as:

- Organizations achieve stronger market position by demonstrating „green" credentials. Energy management improves competitive advantage as most consumers prefer to source from socially responsible businesses;

- Organizations adopting energy management systems can influence supply chains by preferring suppliers who adopt environment management practices; and

- Energy management creates a better workplace environment for employees by improving working conditions.

The five important activities

- Reporting energy results to multiple internal stakeholders

- Benchmarking facility energy performance
- Making the case for capital expenditure

- Getting a commitment by line staff to reduce energy impact through operating procedure

• Preventive maintenance

Benefits of energy management (EM)

To Industry:

• Overall electricity bill of industry is reduced

• Competitiveness of the organization will increase in the competitors

• Productivity of the organization will increase

• Ultimately it will increase the profit

To Nation:

• EM can save energy resource of the nation

• EM helps in enhancing energy security **To global:**

• EM will reduce environmental effects

• Maintains a sustainable environment • Reduce Global warming effect.

PRACTICAL-3

AIM: DETAILED REVIEW OF ENERGY CONSERVATION ACT-2001 WITH ITS FEATURES

Policy Framework – Energy Conservation Act – 2001

With the background of high energy saving potential and its benefits, bridging the gap between demand and supply, reducing environmental emissions through energy saving, and to effectively overcome the barrier, the Government of India has enacted the Energy Conservation Act – 2001. The Act provides the much-needed legal framework and institutional arrangement for embarking on an energy efficiency drive.

Under the provisions of the Act, Bureau of Energy Efficiency has been established with effect from 1st March 2002 by merging erstwhile Energy Management Centre of Ministry of Power. The Bureau would be responsible for implementation of policy programs and coordination of implementation of energy conservation activities.

Important features of the Energy Conservation Act are:

Standards and Labeling

Standards and Labeling (S & L) has been identified as a key activity for energy efficiency improvement. The S & L program, when in place would ensure that only energy efficient equipment and appliance would be made available to the consumers.

The main provision of EC act on Standards and Labeling are:

- Evolve minimum energy consumption and performance standards for notified equipment and appliances.
- Prohibit manufacture, sale and import of such equipment, which does not conform to the standards.
- Introduce a mandatory labeling scheme for notified equipment appliances to enable consumers to make informed choices
- Disseminate information on the benefits to consumers

Designated Consumers

The main provisions of the EC Act on designated consumers are:

- The government would notify energy intensive industries and other establishments as designated consumers;
- Schedule to the Act provides list of designated consumers which covered basically energy intensive industries, Railways, Port Trust, Transport Sector,
- Power Stations, Transmission & Distribution Companies and Commercial buildings or establishments;
- The designated consumer to get an energy audit conducted by an accredited energy auditor;
- Energy managers with prescribed qualification are required to be appointed or designated by the designated consumers;
- Designated consumers would comply with norms and standards of energy consumption as prescribed by the central government.

Certification of Energy Managers and Accreditation of Energy Auditing Firms

The main activities in this regard as envisaged in the Act are:

A cadre of professionally qualified energy managers and auditors with expertise in policy analysis, project management, financing and implementation of energy efficiency projects would be developed through Certification and Accreditation programme. BEE to design training modules, and conduct a National level examination for certification of energy managers and energy auditors.

○ Energy Conservation Building Codes:

The main provisions of the EC Act on Energy Conservation Building Codes are:

- The BEE would prepare guidelines for Energy Conservation Building Codes (ECBC);

- These would be notified to suit local climate conditions or other compelling factors by the respective states for commercial buildings erected after the rules relating to energy conservation building codes have been notified. In addition, these buildings should have a connected load of 500 kW or contract demand of 600 kVA and above and are intended to be used for commercial purposes;

- Energy audit of specific designated commercial building consumers would also be prescribed.

○ Central Energy Conservation Fund:

The EC Act provisions in this case are:

- The fund would be set up at the centre to develop the delivery mechanism for large-scale adoption of energy efficiency services such as performance contracting and promotion of energy service companies. The fund is expected to give a thrust to R & D and demonstration in order to boost market penetration of efficient equipment and appliances. It would support the creation of facilities for testing and development and to promote consumer awareness.

○ Bureau of Energy Efficiency (BEE):

- The mission of Bureau of Energy Efficiency is to institutionalize energy efficiency services, enable delivery mechanisms in the country and provide leadership to energy efficiency in all sectors of economy. The primary objective would be to reduce energy intensity in the Indian Economy.

- The general superintendence, directions and management of the affairs of the Bureau is vested in the Governing Council with 26 members. The Council is headed by Union Minister of Power and consists of members represented by Secretaries of various line Ministries, the CEOs of technical agencies under the Ministries, members representing equipment and appliance manufacturers, industry, architects, consumers and five power regions representing the states. The Director General of the Bureau shall be the ex-officio member-secretary of the Council.

- The BEE will be initially supported by the Central Government by way of grants through budget, it will, however, in a period of 5-7 years become self-sufficient. It would be authorized to collect appropriate fee in discharge of its functions assigned to it. The BEE will also use the Central Energy Conservation Fund and other funds raised from various sources for innovative financing of energy efficiency projects in order to promote energy efficient investment.

Role of Bureau of Energy Efficiency

The role of BEE would be to prepare standards and labels of appliances and equipment, develop a list of designated consumers, specify certification and accreditation procedure, prepare building codes, maintain Central EC fund and undertake promotional activities in coordination with center and state level agencies. The role would include development of Energy service companies (ESCOs), transforming the market for energy efficiency and create awareness through measures including clearing house.

Role of Central and State Governments:

The following role of Central and State Government is envisaged in the Act

- Central - to notify rules and regulations under various provisions of the Act, provide initial financial assistance to BEE and EC fund, Coordinate with various State Governments for notification, enforcement, penalties and adjudication.

- State - to amend energy conservation building codes to suit the regional and local climatic condition, to designate state level agency to coordinate, regulate andenforce provisions of the Act and constitute a State Energy Conservation Fund for promotion of energy efficiency.

Enforcement through Self-Regulation:

E.C. Act would require inspection of only two items. The following procedure of selfregulation is proposed to be adopted for verifying areas that require inspection of only two items that require inspection.

- The certification of energy consumption norms and standards of production process by the Accredited Energy Auditors is a way to enforce effective energy efficiency in Designated Consumers.

- For energy performance and standards, manufacturer‟s declared values would be checked in Accredited Laboratories by drawing sample from market. Any manufacturer or consumer or consumer association can challenge the values of the other manufacturer and bring to the notice of BEE. BEE can recognize for challenge testing in disputed cases as a measure for self-regulation.

○ Penalties and Adjudication:

- Penalty for each offence under the Act would be in monetary terms i.e. Rs.10,000 for each offence and Rs.1,000 for each day for continued non Compliance.
- The initial phase of 5 years would be promotional and creating infrastructure for implementation of Act. No penalties would be effective during this phase.
- The power to adjudicate has been vested with state Electricity Regulatory Commission which shall appoint any one of its member to be an adjudicating officer for holding an enquiry in connection with the penalty imposed.

PRACTICAL-4

AIM: ENERGY CONSERVATION SYSTEM- A CASE STUDY

Overview of Energy Conservation Projects

JICA's Action towards the Energy Conservation Sector:

- JICA provides support for the stable supply of electric power, use of renewable energy and energy conservation in the energy sector, a part of energy and mining, which forms one of the development issues.
- Total global energy consumption is climbing rapidly, which is a reflection of economic growth in developing countries. If fossil fuel consumption continues to grow at the current pace, resource shortages, global warming and other issues are likely to become more serious. With growing awareness of these global environmental issues and a recent rise in energy prices, developing nations increasingly realize the importance of efficient consumption of energy or energy conservation. Meanwhile, after experiencing two oil shocks, Japan is now a leader in energy conservation. Japan"s use of its own experience to provide assistance is invaluable to developing countries.
- Broadly speaking, there are two different forms of assistance in energy conservation. The first is a technical cooperation project approach and the second is a group training approach. In the technical cooperation project approach, a center facility responsible for training, assessment and public relations activities in energy saving is set up in the recipient country and assistance is provided until the country becomes capable of operating it by themselves.

- For example, the energy conservation project in Turkey included the following activities and inputs:

(i) Training:

The project offered practical energy conservation techniques to factory personnel responsible for energy management. It also provided training for training instructors and introduced a mini plant for hands-on training on energy conservation to the National Energy Conservation Center (NECC).

(ii) Examination:

The project identified the status of energy consumption in factories and buildings, and gave them advice to encourage efficiency. Measuring instruments that were essential to the assessment were provided, together with technical guidance.

(iii) Public relations:

The project helped construct a website of the NECC and held seminars and workshops on a number of different topics.

- In the group training approach, personnel working in the area of energy conservation from different countries are invited to Japan so that they can learn the Japanese legal system and the practice of energy conservation in factories and other facilities. The training runs for a period of about one month.

Case study 1: Energy Conservation Project in Turkey

Project Overview:

(1) Background:

Turkey is heavily dependent on energy imports. Its energy self-sufficiency ratio failed to reach 50 percent in 1997 and continues to fall each year in line with recent rapid growth in energy consumption in the industrial sector. Specifically, consumption has increased 20 percent in the past five years. The Turkish government has been working to achieve energy conservation to address the issue of global warming and boost the international competitiveness of Turkish businesses in the European market.

The National Energy Conservation Center (NECC) has launched an energy administrator scheme that encompasses more than 500 factories with large plants consuming 2,000 TOE20 or more of energy to encourage energy conservation efforts. In accordance with the regulation issued in 1995 on “the measures to be taken to increase energy efficiency in industrial establishments,” the scheme obliges major plant businesses to assign energy administrators for energy saving. The NECC additionally engages in activities for energy conservation assessment and proposals to factories and other facilities, and in propagation of energy saving technologies. However, it has fallen short of the targeted energy saving level, because of inadequacy in the systems of the NECC and the business sector to carry out energy conservation activities and the lack of technical capabilities.

In response, the Turkish government asked Japan for project-type technical cooperation aimed at improving energy conservation by fostering the capacity of the NECC under the General Directorate of Electrical Power Resources Survey and Development Administration (EIE).

(2) Descriptions of the Cooperation:

1) Targets

(i) Overall goal:

Specific energy consumption at the factories and other facilities, where energy assessment is conducted, will be reduced.

(ii) Project Purpose:

The capacity of NECC in training, energy conservation assessment, policymaking, public relations and propagation will be developed.

2) Activities

(i) An operation and management structure was set up in the NECC for energy conservation activities
.

(ii) The C/P became better skilled at using and managing the training materials and measuring instruments provided.

(iii) The C/P acquired overall skills and knowledge necessary for the energy administrator training.

(iv) The C/P acquired skills and knowledge requisite to energy conservation assessment of factories and other facilities in different industrial sectors.

(v) The NECC became equipped with enhanced capabilities to offer information to different industries, to raise public awareness of energy conservation and to prepare policy suggestions.

3) Period

Five years from August 2000 to July 2005

(3) Parties and Factors Concerned in CD Analysis:

Table 4 demonstrates different parties and factors concerned with the project in CD analysis.

Table 4: Parties and Factors Concerned in CD Analysis – Project in Turkey

Level	Parties and factors concerned	Elements to be considered for the project
Individuals	Personnel of the C/P	- NECC staff
Organization	C/P (governmental body responsible for the project)	- National Energy Conservation Center (NECC) of the General Directorate of Electrical Power Resources Survey and Development Administration (EIE)
Society and systems	Other governmental bodies	
	Factories and other facilities	- Energy administrators - Factories and other facilities owning large plants consuming at least 2,000 TOE - Other factories and facilities
	ESCO companies	
	Equipment manufacturers	
	Electric power suppliers	
	Statutory system	- Energy regulations (1995) - Energy conservation laws (to be enacted in Dec. 2005)
	Public funds	
	Incentives	- Training and assessment fee revenues to EIE/NECC - A sense of leadership in Central Asia - EU accession developed into a political issue
	ESCO market	
	Awareness of energy conservation	- Boosting of international competitiveness of businesses in Europe
	Partnership	
	Donors	- World Bank
	Preconditions	

(4) Results and Evaluation:

1) Results:

The purpose of this project was to increase NECC‟s capacity to provide training, to conduct energy conservation assessment, to make policies and to carry out public relations and promotion activities.

This objective was successfully achieved, as the results below show. Moreover, the project succeeded in bolstering the functions of the NECC and eventually reduced the total energy consumption of the industrial sector in Turkey by an estimated maximum of five percent.

(i) Training activities:

Eighteen sessions of energy administrator training were conducted. Among 345 trainees participating in the training, 168 obtained qualification certificates. (Including those with conventional qualification certificates, 78 percent of the factories and facilities subject to the energy regulations have the certificates.) Three sessions of international training joined by neighboring countries were conducted.

(ii) Energy conservation assessment:

A total of 118 energy conservation assessments were carried out, including 19 detailed assessments.

(iii) Public relations:

The project saw 136 seminars and other events held.

2) Conclusion of the Evaluation at the Time of Completion:

The project was successfully carried out and can be deemed to have produced substantial outcomes. It was confirmed that the predetermined goals would be met prior to the termination of the project period. Among the numerous achievements attained within the project targets, what was particularly remarkable was that the personnel of the NECC reached the necessary level of operational capabilities defined in the project. While the technical cooperation was provided, they acquired new skills and knowledge and learned to use them in NECC operations. The improved capacity of individual personnel of the partner institution is organically integrated into the organizational capacity.

(5) Major Issues Influencing the Project Implementation:

There was no major issue that affected the project implementation.

PRACTICAL-5

AIM: HEAT RECOVERY SYSTEM AND ITS POTENTIAL OPPORTUNITIES

- 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.

- 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 by adopting following measures as outlined in this chapter.

- Typical examples of use would be preheating of combustion air, space heating, or preheating 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.

Types of Heat Recovery Systems:

High Temperature Heat Recovery

The following Table 5.1 gives temperatures of waste gases from industrial process equipment in the high temperature range. All of these results from direct fuel fired processes.

Medium Temperature Heat Recovery

The following Table 5.2 gives the temperatures of waste gases from process equipment in the medium temperature range. Most of the waste heat in this temperature range comes from the exhaust of directly fired process units.

TABLE 5.1:- TYPICAL WASTE HEAT TEMPERATURE AT HIGH TEMPERATURE RANGE FROM VARIOUS SOURCES

Types of Device	Temperature, °C
Nickel refining furnace	1370 –1650
Aluminium refining furnace	650–760
Zinc refining furnace	760–1100
Copper refining furnace	760– 815
Steel heating furnaces	925–1050
Copper reverberatory furnace	900–1100
Open hearth furnace	650–700
Cement kiln (Dry process)	620– 730
Glass melting furnace	1000–1550
Hydrogen plants	650–1000
Solid waste incinerators	650–1000
Fume incinerators	650–1450

TABLE 5.2:- TYPICAL WASTE HEAT TEMPERATURE AT LOW TEMPERATURE RANGE FROM VARIOUS SOURCES

Source	Temperature, °C
Process steam condensate	55–88
Cooling water from:	
Furnace doors	32–55
Bearings	32–88
Welding machines	32–88
Injection molding machines	32–88
Annealing furnaces	66–230
Forming dies	27–88
Air compressors	27–50
Pumps	27–88
Internal combustion engines	66–120
Air conditioning and refrigeration condensers	32–43
Liquid still condensers	32–88
Drying, baking and curing ovens	93–230
Hot processed liquids	32–232
Hot processed solids	93–232

Low Temperature Heat Recovery

The following Table 5.3 lists some heat sources in the low temperature range. In this range it is usually not practical to ext ract work from the source, though steam production may not be completely excluded if there is a need for low -pressure steam. Low temperature waste heat may be useful in a supplementary way for preheating purposes.

TABLE 5.3:- TYPICAL WASTE HEAT TEMPERATURE AT LOW TEMPERATURE RANGE FROM VARIOUS SOURCES

Source	Temperature, °C
Process steam condensate	55–88
Cooling water from: Furnace doors	32–55
Bearings	32–88
Welding machines	32–88
Injection molding machines	32–88
Annealing furnaces	66–230
Forming dies	27–88
Air compressors	27–50
Pumps	27–88
Internal combustion engines	66–120
Air conditioning and refrigeration condensers	32–43
Liquid still condensers	32–88
Drying, baking and curing ovens	93–230
Hot processed liquids	32–232
Hot processed solids	93–232

Benefits of Waste Heat Recovery

Benefits of 'waste heat recovery' can be broadly classified in two categories:

Direct Benefits:

Recovery of waste heat has a direct effect on the efficiency of the process. This is reflected by reduction in the utility consumption & costs, and process cost.

Indirect Benefits:

a) **Reduction in pollution**: A number of toxic combustible wastes such as carbon monoxide gas, sour gas, carbon black off gases, oil sludge, Acrylonitrile and other plastic chemicals etc, releasing to atmosphere if/when burnt in the incinerators serves dual purpose i.e. recovers heat and reduces the environmental pollution levels.

b) **Reduction in equipment sizes:** Waste heat recovery reduces the fuel consumption, which leads to reduction in the flue gas produced. This results in reduction in equipment sizes of all flue gas handling equipments such as fans, stacks, ducts, burners, etc.

c) **Reduction in auxiliary energy consumption:** Reduction in equipment sizes gives additional benefits in the form of reduction in auxiliary energy consumption like electricity for fans, pumps etc.

Development of a Waste Heat Recovery System

Understanding the process Understanding the process is essential for development of Waste Heat Recovery system. This can be accomplished by reviewing the process flow sheets, layout diagrams, piping isometrics, electrical and instrumentation cable ducting etc. Detail review of these documents will help in identifying:

a) Sources and uses of waste heat

b) Upset conditions occurring in the plant due to heat recovery

c) Availability of space

d) Any other constraint, such as dew point occurring in an equipments etc.

After identifying source of waste heat and the possible use of it, the next step is to select suitable heat recovery system and equipments to recover and utilize the same.

Economic Evaluation of Waste Heat Recovery System

- It is necessary to evaluate the selected waste heat recovery system on the basis of financial analysis such as investment, depreciation, payback period, rate of return etc. In addition the advice of experienced consultants and suppliers must be obtained for rational decision.
- Next section gives a brief description of common heat recovery devices available commercially and its typical industrial applications.

PRACTICAL-6

AIM: ENERGY EFFICIENCY IN THERMAL UTILITIES AND SYSTEMS

BOILERS

- A boiler is an enclosed vessel that provides a means for combustion heat to be transferred into water until it becomes heated water or steam. The hot water or steam under pressure is then usable for transferring the heat to a process. Water is a useful and cheap medium for transferring heat to a process.

- When water is boiled into steam its volume increases about 1,600 times, producing a force that is almost as explosive as gunpowder. This causes the boiler to be extremely dangerous equipment that must be treated with utmost care.

- The process of heating a liquid until it reaches its gaseous state is called evaporation. Heat is transferred from one body to another by means of (1) **radiation**, which is the transfer of heat from a hot body to a cold body without a conveying medium, (2) **convection**, the transfer of heat by a conveying medium, such as air or water and (3) **conduction**, transfer of heat by actual physical contact, molecule to molecule.

- The performance parameters of boiler, like efficiency and evaporation ratio reduces with time due to poor combustion, heat transfer surface fouling and poor operation and maintenance. Even for a new boiler, reasons such as deteriorating fuel quality, water quality etc. can result in poor boiler performance. Boiler efficiency tests help us to find out the deviation of boiler efficiency from the best efficiency and target problem area for corrective action.

$$Boiler\ Efficiency\ (\eta) = \frac{Q\,x(h_g - h_f)}{q \times GCV} \times 100$$

Where, hg – Enthalpy of saturated steam in kCal/kg of steam hf – Enthalpy of feed water in kCal/kg of water

Boiler Efficiency

There are two methods of assessing boiler efficiency.

1) **The Direct Method**:
Where the energy gain of the working fluid (water and steam) is compared with the energy content of the boiler fuel.

2) **The Indirect Method:**

Where the efficiency is the difference between the losses and the energy input.

FURNACES

- Furnace is by definition a device for heating materials and therefore a user of energy.
- Heating furnaces can be divided into batch-type (Job at stationary position) and continuous type (large volume of work output at regular intervals).

Purpose of the Performance Test

- To find out the efficiency of the furnace
- To find out the Specific energy consumption

1. Furnace Efficiency, η $= \dfrac{\text{Heat output}}{\text{Heat Input}} \times 100$

$$= \frac{\text{Heat in stock (material)} \quad \text{(kCals)}}{\text{Heat in Fuel /electricity} \quad \text{(kCals)}} \times 100$$

2. Specific Energy Consumption $= \dfrac{\text{Quantity of fuel or energy consumed}}{\text{Quantity of material processed.}}$

Furnace Efficiency

The efficiency of a furnace is the ratio of useful output to heat input. The furnace efficiency can be determined by both,

- Direct Method
- Indirect Method

Factors Affecting Furnace Performance

The important factors, which affect the efficiency, are listed below for critical analysis.

- Under loading due to poor hearth loading and improper production scheduling
- Improper Design
- Use of inefficient burner
- Insufficient draft/chimney

- Absence of Waste heat recovery
- Absence of Instruments/Controls
- Improper operation/Maintenance
- High stack loss
- Improper insulation /Refractories

PUMPS

- Pumps come in a variety of sizes for a wide range of applications. They can be classified according to their basic operating principle as dynamic or displacement pumps. Dynamic pumps can be sub-classified as centrifugal and special effect pumps. Displacement pumps can be sub-classified as rotary or reciprocating pumps.

- In principle, any liquid can be handled by any of the pump designs. Where different pump designs could be used, the centrifugal pump is generally the most economical followed by rotary and reciprocating pumps. Although, positive displacement pumps are generally more efficient than centrifugal pumps, the benefit of higher efficiency tends to be offset by increased maintenance costs.

HEAT EXCHANGERS

- Heat exchangers are equipment that transfer heat from one medium to another.

- The proper design, operation and maintenance of heat exchangers will make the process energy efficient and minimize energy losses.

- Heat exchanger performance can deteriorate with time, off design operations and other interferences such as fouling, scaling etc.

Purpose of the Performance Test

To determine the overall heat transfer coefficient for assessing the performance of the heat exchanger. Any deviation from the design heat transfer coefficient will indicate occurrence of fouling.

CHECKLISTS & TIPS FOR ENERGY EFFICIENCY IN THERMAL UTILITIES

Boilers

- Preheat combustion air with waste heat. (22°C reduction in flue gas temperature increases boiler efficiency by 1%)
- Use variable speed drives on large boiler combustion air fans with variable flows.
- Burn wastes if permitted.
- Insulate exposed heated oil tanks.
- Clean burners, nozzles, strainers, etc.
- Inspect oil heaters for proper oil temperature.
- Close burner air and/or stack dampers when the burner is off to minimize heat loss up the stack.
- Improve oxygen trim control (e.g. -- limit excess air to less than 10% on clean fuels). (5% reduction in excess air increases boiler efficiency by 1% or: 1% reduction of residual oxygen in stack gas increases boiler efficiency by 1%) • Automate/optimize boiler blow down. Recover boiler blow down heat.
- Use boiler blow down to help warm the back-up boiler.
- Optimize deaerator venting.
- Inspect door gaskets.
- Inspect for scale and sediment on the water side. (A 1 mm thick scale (deposit) on the water side could increase fuel consumption by 5 to 8%.)
- Inspect for soot, fly ash, and slag on the fire side. (A 3 mm thick soot deposition on the heat transfer surface can cause an increase in fuel consumption to the tune of 2.5%)
- Optimize boiler water treatment.
- Add an economizer to preheat boiler feed water using exhaust heat.
- Recycle steam condensate.
- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple boilers.
- Consider multiple or modular boiler units instead of one or two large boilers.
- Establish a boiler efficiency-maintenance program. Start with an energy audit and follow up, then make a boiler efficiency-maintenance program a part of your continuous energy management program.

Steam System

- Fix steam leaks and condensate leaks. (A 3 mm diameter hole on a pipe line carrying 7 Kg/cm2 steam would waste 33 Kilo litres of fuel oil per year)
- Accumulate work orders for repair of steam leaks that can't be fixed during the heating season due to system shutdown requirements. Tag each such leak with a durable tag with a good description.
- Use back pressure steam turbines to produce lower steam pressures.
- Use more-efficient steam desuperheating methods.
- Ensure process temperatures are correctly controlled.

- Maintain lowest acceptable process steam pressures.
- Reduce hot water wastage to drain.
- Remove or blank off all redundant steam piping.
- Ensure condensate is returned or re-used in the process. (6°C raise in feed water temperature by economizer/condensate recovery corresponds to a 1% saving in fuel consumption, in boiler)
- Preheat boiler feed-water.
- Recover boiler blow down.
- Check operation of steam traps.
- Remove air from indirect steam using equipment (0.25 mm thick air film offers the same resistance to heat transfer as a 330 mm thick copper wall) • Inspect steam traps regularly and repair malfunctioning traps promptly.
- Consider recovery of vent steam (e.g. -- on large flash tanks).
- Use waste steam for water heating.
- Use an absorption chiller to condense exhaust steam before returning the condensate to the boiler.
- Use electric pumps instead of steam ejectors when cost benefits permit
- Establish a steam efficiency-maintenance program. Start with an energy audit and follow up, then make a steam efficiency-maintenance program a part of your continuous energy management program.

Furnaces

- Check against infiltration of air: Use doors or air curtains • Monitor O_2 /CO_2/CO and control excess air to the optimum level
- Improve burner design, combustion control and instrumentation.
- Ensure that the furnace combustion chamber is under slight positive pressure
- Use ceramic fibres in the case of batch operations
- Match the load to the furnace capacity
- Retrofit with heat recovery device
- Investigate cycle times and reduce
- Provide temperature controllers
- Ensure that flame does not touch the stock

Insulation

- Repair damaged insulation. (A bare steam pipe of 150 mm diameter and 100 m length, carrying saturated steam at 8 kg/cm2 would waste 25,000 litres furnace oil in a year)
- Insulate any hot or cold metal or insulation.
- Replace wet insulation.
- Use an infrared gun to check for cold wall areas during cold weather or hot wall areas during hot weather.

- Ensure that all insulated surfaces are cladded with aluminum
- Insulate all flanges, valves and couplings
- Insulate open tanks (70% heat losses can be reduced by floating a layer of 45 mm diameter polypropylene (plastic) balls on the surface of 90°C hot liquid/condensate)

Waste heat recovery

- Recover heat from flue gas, engine cooling water, engine exhaust, low pressure waste steam, drying oven exhaust, boiler blow down, etc.
- Recover heat from incinerator off-gas.
- Use waste heat for fuel oil heating, boiler feed water heating, outside air heating, etc.
- Use chiller waste heat to preheat hot water.
- Use heat pumps.
- Use absorption refrigeration.s
- Use thermal wheels, run-around systems, heat pipe systems, and air-to-air exchangers.

PRACTICAL-7

AIM:SPECIAL FEATURES OF CO-GENERATION PLANTS AND THEIR TYPES

Need for Cogeneration

 Thermal power plants are a major source of electricity supply in India. The conventional method of power generation and supply to the customer is wasteful in the sense that only about a third of the primary energy fed into the power plant is actually made available to the user in the form of electricity (Figure 7.1). In conventional power plant, efficiency is only 35% and remaining 65% of energy is lost. The major source of loss in the conversion process is the heat rejected to the surrounding water or air due to the inherent constraints of the different thermodynamic cycles employed in power generation. Also further losses of around 10–15% are associated with the transmission and distribution of electricity in the electrical grid.

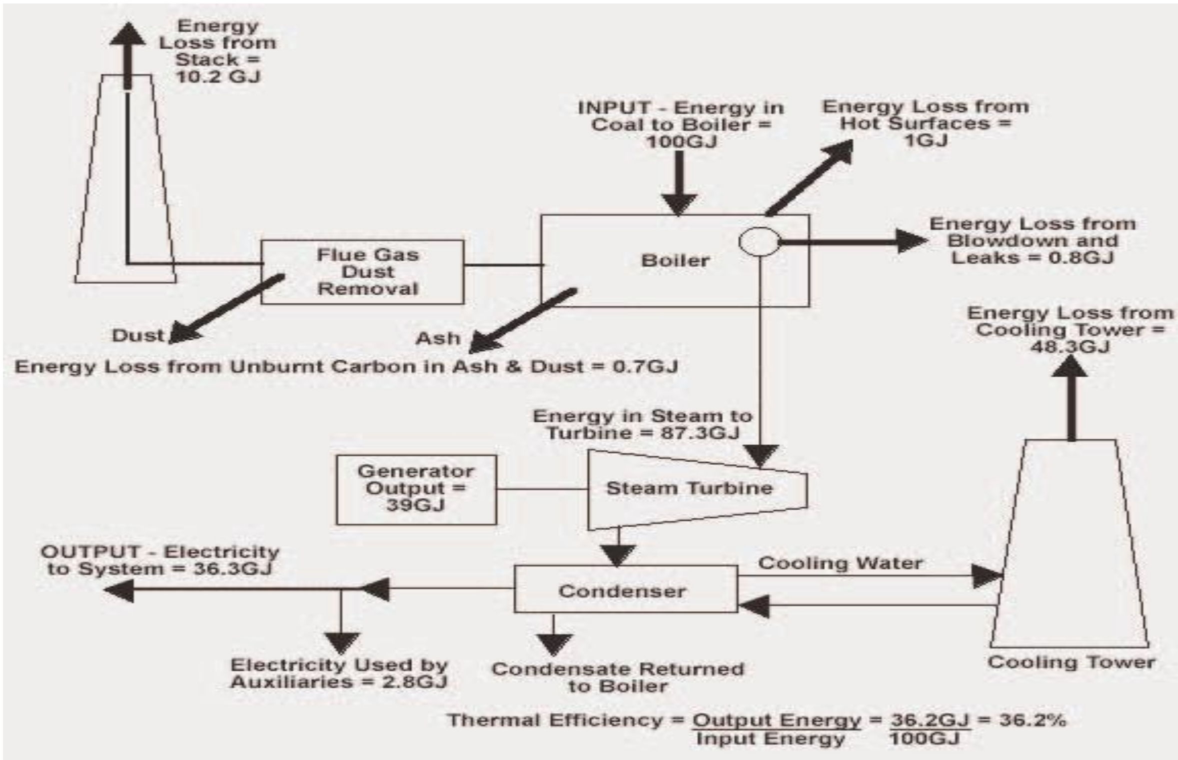


Figure 7.1 BALANCE IN A TYPICAL COAL FIRED POWER STATION
For an Input Energy of 100 Giga Joules (GJ)

Principle of Cogeneration

- Cogeneration or Combined Heat and Power (CHP) is defined as the sequential generation of two different forms of useful energy from a single primary energy source, typically mechanical energy and thermal energy.

- Mechanical energy may be used to drive an alternator for producing electricity, or rotating equipment such as motor, compressor, pump or fan for delivering various services. Thermal energy can be used either for direct process applications or for indirectly producing steam, hot water, hot air for dryer or chilled water for process cooling.

- Cogeneration provides a wide range of technologies for application in various domains of economic activities. The overall efficiency of energy use in cogeneration mode can be up to 85 per cent and above in some cases.

Classification of Cogeneration Systems

- Cogeneration systems are normally classified according to the sequence of energy use and the operating schemes adopted.

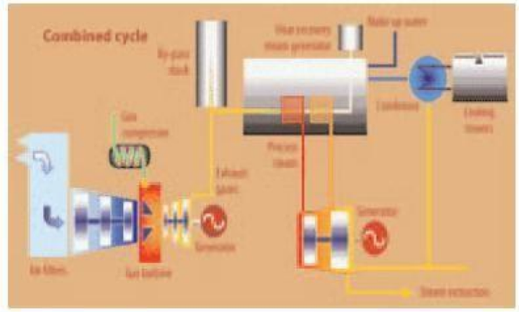
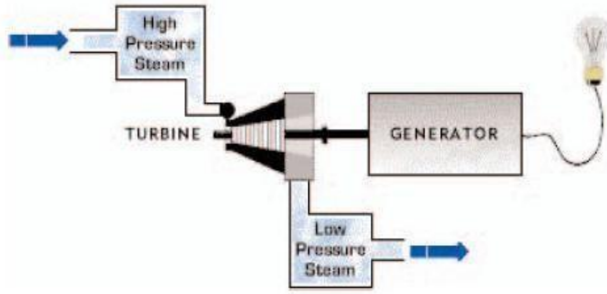
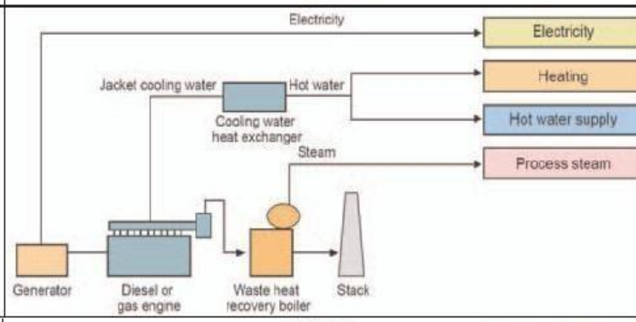
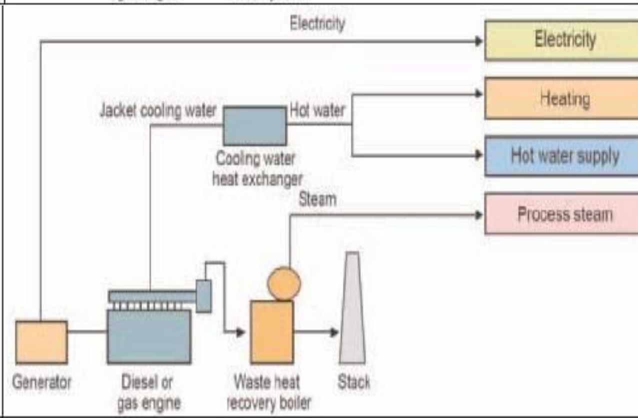
- A cogeneration system can be classified as either a topping or a bottoming cycle on the basis of the sequence of energy use.

- In a topping cycle, the fuel supplied is used to first produce power and then thermal energy, which is the by-product of the cycle and is used to satisfy process heat or other thermal requirements.

- Topping cycle cogeneration is widely used and is the most popular method of cogeneration.

Topping Cycle

The four types of topping cycle cogeneration systems are briefly explained in Table 7.1.

TABLE 7.1 TYPES OF TOPPING CYCLES	
A gas turbine or diesel engine producing electrical or mechanical power followed by a heat recovery boiler to create steam to drive a secondary steam turbine. This is called a combined-cycle topping system.	
The second type of system burns fuel (any type) to produce high-pressure steam that then passes through a steam turbine to produce power with the exhaust provides low-pressure process steam. This is a steam-turbine topping system.	
A third type employs heat recovery from an engine exhaust and/or jacket cooling system flowing to a heat recovery boiler, where it is converted to process steam / hot water for further use.	
The fourth type is a gas-turbine topping system. A natural gas turbine drives a generator. The exhaust gas goes to a heat recovery boiler that makes process steam and process heat	

Bottoming Cycle

In a bottoming cycle, the primary fuel produces high temperature thermal energy and the heat rejected from the process is used to generate power through a recovery boiler and a turbine generator. Bottoming cycles are suitable for manufacturing processes that require heat at high temperature in furnaces and kilns, and reject heat at significantly high temperatures. Typical areas of application include cement, steel, ceramic, gas and petrochemical industries. Bottoming cycle plants are much less common than topping cycle plants. The Figure 7.2 illustrates the bottoming cycle where fuel is burnt in a furnace to produce synthetic rutile.
The waste gases coming out of the furnace is utilized in a boiler to generate steam, which drives the turbine to produce electricity.

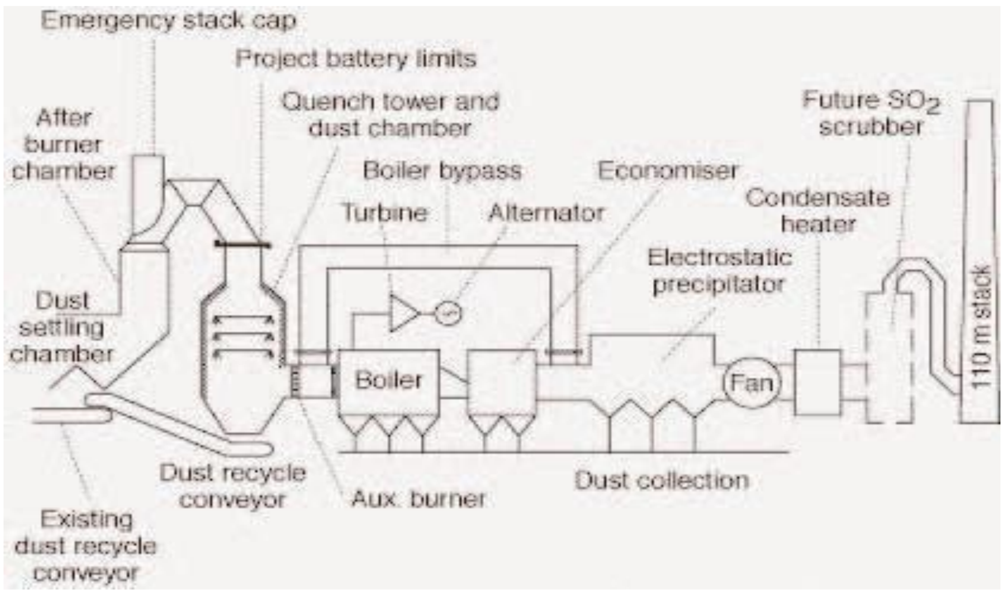


Figure 7.2 Bottoming Cycle

Factors Influencing Cogeneration Choice

The selection and operating scheme of a cogeneration system is very much site-specific and depends on several factors, as described below:

- **Base electrical load matching**

  In this configuration, the cogeneration plant is sized to meet the minimum electricity demand of the site based on the historical demand curve. The rest of the needed power is purchased from the utility grid. The thermal energy requirement of the site could be met by the cogeneration system alone or by additional boilers. If the thermal energy generated with the base electrical load exceeds the plant‟s demand and if the situation permits, excess thermal energy can be exported to neighbouring customers.

Base Thermal Load Matching

Here, the cogeneration system is sized to supply the minimum thermal energy requirement of the site. Stand-by boilers or burners are operated during periods when the demand for heat is higher. The prime mover installed operates at full load at all times. If the electricity demand of the site exceeds that which can be provided by the prime mover, then the remaining amount can be purchased from the grid. Likewise, if local laws permit, the excess electricity can be sold to the power utility.

Electrical Load Matching

In this operating scheme, the facility is totally independent of the power utility grid. All the power requirements of the site, including the reserves needed during scheduled and unscheduled maintenance, are to be taken into account while sizing the system. This is also referred to as a “stand-alone” system. If the thermal energy demand of the site is higher than that generated by the cogeneration system, auxiliary boilers are used. On the other hand, when the thermal energy demand is low, some thermal energy is wasted. If there is a possibility, excess thermal energy can be exported to neighbouring facilities.

Thermal Load Matching

The cogeneration system is designed to meet the thermal energy requirement of the site at any time. The prime movers are operated following the thermal demand. During the period when the electricity demand exceeds the generation capacity, the deficit can be compensated by power purchased from the grid. Similarly, if the local legislation permits, electricity produced in excess at any time may be sold to the utility.

PRACTICAL-8

AIM-AN APPROACH TO STUDY ENERGY AUDIT, ENERGY MONITORING AND TARGETING

Definition & Objectives of Energy Management

The fundamental goal of energy management is to produce goods and provide services with the least cost and least environmental effect.

The term energy management means many things to many people. One definition of energy management is:

"The judicious and effective use of energy to maximize profits (minimize costs) and enhance competitive positions"

Objective of Energy Audit

- To reduce energy cost which affect the company profitability
- To manage national energy supply and demand balance
- To effect national trade and financial balance
- To reduce global and local enviromental pollution
- To prevant loss and waste disposal
- To achieve occuptional safety and health

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) 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**

Ten Steps Methodology for Detailed Energy Audit

Step No	PLAN OF ACTION	PURPOSE / RESULTS
	Phase I –Pre Audit Phase	
Step 1	• Plan and organise • Walk through Audit • Informal Interview with Energy Manager, Production / Plant Manager	• Resource planning, Establish/organize a Energy audit team • Organize Instruments & time frame • Macro Data collection (suitable to type of industry.) • Familiarization of process/plant activities • First hand observation & Assessment of current level operation and practices
Step 2	• Conduct of brief meeting / awareness programme with all divisional heads and persons concerned (2-3 hrs.)	• Building up cooperation • Issue questionnaire for each department • Orientation, awareness creation
	Phase II –Audit Phase	
Step 3	• Primary data gathering, Process Flow Diagram, & Energy Utility Diagram	• Historic data analysis, Baseline data collection • Prepare process flow charts • All service utilities system diagram (Example: Single line power distribution diagram, water, compressed air & steam distribution. • Design, operating data and schedule of operation • Annual Energy Bill and energy consumption pattern (Refer manual, log sheet, name plate, interview)
Step 4	• Conduct survey and monitoring	• Measurements : Motor survey, Insulation, and Lighting survey with portable instruments for collection of more and accurate data. Confirm and compare operating data with design data.
Step 5	• Conduct of detailed trials /experiments for selected energy guzzlers	• Trials/Experiments: - 24 hours power monitoring (MD, PF, kWh etc.). - Load variations trends in pumps, fan compressors etc.

		- Boiler/Efficiency trials for (4 – 8 hours) - Furnace Efficiency trials Equipments Performance experiments etc
Step6	• Analysis of energy use	• Energy and Material balance & energy loss/waste analysis
Step 7	• Identification and development of Energy Conservation (ENCON) opportunities	• Identification & Consolidation ENCON measures • Conceive, develop, and refine ideas • Review the previous ideas suggested by unit personal • Review the previous ideas suggested by energy audit if any • Use brainstorming and value analysis techniques • Contact vendors for new/efficient technology
Step 8	• Cost benefit analysis	• Assess technical feasibility, economic viability and prioritization of ENCON options for implementation • Select the most promising projects • Prioritise by low, medium, long term measures
Step9	• Reporting & Presentation to the Top Management	• Documentation, Report Presentation to the top Management.
	<u>Phase III –Post Audit phase</u>	
Step10	• Implementation and Follow-up	Assist and Implement ENCON recommendation measures and Monitor the performance • Action plan, Schedule for implementation • Follow-up and periodic review

<u>ENERGY MONITORING AND TARGETING</u>

- Energy monitoring and targeting is primarily a management technique that uses energy information as a basis to eliminate waste, reduce and control current level of energy use and improve the existing operating procedures. It builds on the principle **"you can't manage what you don't measure"**. It essentially combines the principles of energy use and statistics.

- While, monitoring is essentially aimed at establishing the existing pattern of energy consumption, targeting is the identification of energy consumption level which is desirable as a management goal to work towards energy conservation. Monitoring and Targeting is a management technique in which all plant and building utilities such as fuel, steam, refrigeration, compressed air, water, effluent, and electricity are managed as controllable resources in the same way that raw materials, finished product inventory, building occupancy, personnel and capital are managed. It involves a systematic, disciplined division of the facility into Energy Cost Centers. The utilities used in each centre are closely monitored, and the energy used is compared with production volume or any other suitable measure of operation. Once this information is available on a regular basis, targets can be set, variances can be spotted and interpreted, and remedial actions can be taken and implemented.

- The Monitoring and Targeting programs have been so effective that they show typical reductions in annual energy costs in various industrial sectors between 5 and 20%.

Elements of Monitoring & Targeting System

The essential elements of M&T system are:

- **Recording** -Measuring and recording energy consumption

- **Analysing** -Correlating energy consumption to a measured output, such as production quantity

- **Comparing** -Comparing energy consumption to an appropriate standard or benchmark
- **Setting Targets** -Setting targets to reduce or control energy consumption

- **Monitoring** -Comparing energy consumption to the set target on a regular basis

- **Reporting** -Reporting the results including any variances from the targets which have been set

- **Controlling** -Implementing management measures to correct any variances, which may have occurred. Particularly M&T system will involve the following:
- **Checking** the accuracy of energy invoices

- **Allocating** energy costs to specific departments (Energy Accounting Centres)
- **Determining** energy performance/efficiency

- **Recording** energy use, so that projects intended to improve energy efficiency can be checked

- **Highlighting** performance problems in equipment or systems

PRACTICAL-9

AIM: FINANCING OPTIONS OF ENERGY CONSERVATION PROJECTS

Financing Options

There are various options for financing in-house energy management

- From a central budget
- From a specific departmental or section budget such as engineering
- By obtaining a bank loan
- By raising money from stock market
- By awarding the project to Energy Service Company (ESCO) By retaining a proportion of the savings achieved.

Self-Financing Energy Management

- One way to make energy management self-financing is to split savings to provide identifiable returns to each interested party. This has the following benefits:

  - Assigning a proportion of energy savings to your energy management budget means you have a direct financial incentive to identify and quantify savings arising from your own activities
.
  - Separately identified returns will help the constituent parts of your organization understanding whether they are each getting good value for money through their support for energy management.

  - If operated successfully, splitting the savings will improve motivation and commitment to energy management throughout the organization since staff at all levels will see a financial return for their effort or support.

  - But the main benefit is on the independence and longevity of the energy management function.

Ensuring Continuity

- After implementation of energy savings, your organization ought to be able to make considerable savings at little cost (except for the funding needed for energy management staff). The important question is what should happen to these savings?

- If part of these easily achieved savings is not returned to your budget as energy manager, then your access to self-generated investments funds to support future activities will be lost. And later in the program, it is likely to be much harder for you to make savings.

- However, if, an energy manager, has access to a proportion of the revenue savings arising from staff's activities, then these can be reinvested in:

- Further energy efficiency measures

- Activities necessary to create the right climate for successful energy management which do not, of themselves, directly generate savings

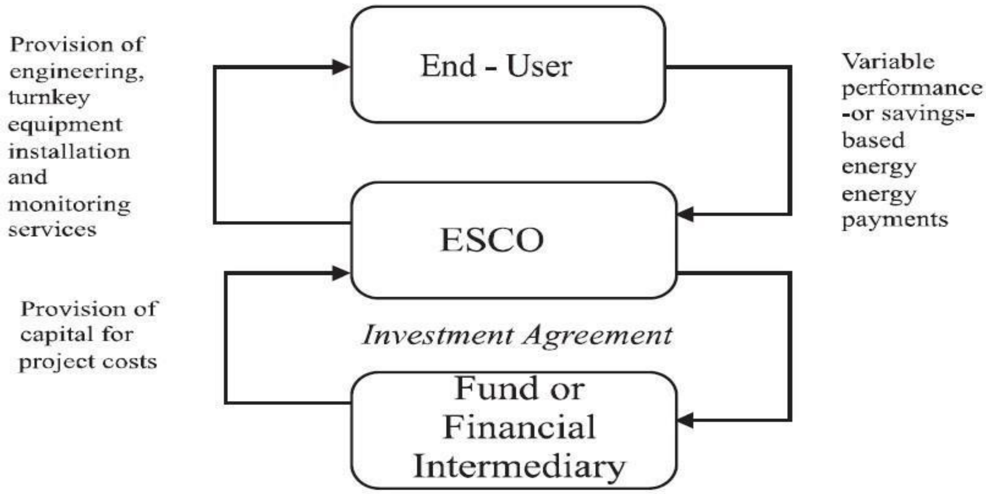
- Maintaining or up-grading the management information system.

Energy Performance Contracting and Role of ESCOS

- If the project is to be financed externally, one of the attractive options for many organizations is the use of energy performance contracts delivered by energy service companies, or ESCOs.

- ESCOs are usually companies that provide a complete energy project service, from assessment to design to construction or installation, along with engineering and project management services, and financing. In one way or another, the contract involves the capitalization of all of the services and goods purchased, and repayment out of the energy savings that result from the project.

- In performance contracting, an end-user (such as an industry, institution, or utility), seeking to improve its energy efficiency, contracts with ESCO for energy efficiency services and financing.



ESCO ROLE

- In some contracts, the ESCOs provide a guarantee for the savings that will be realized, and absorbs the cost if real savings fall short of this level. Typically, there will be a risk management cost involved in the contract in these situations. Insurance is sometimes attached, at a cost, to protect the ESCO in the event of a savings shortfall.

- Energy efficiency projects generate incremental cost savings as opposed to incremental revenues from the sale of outputs. The energy cost savings can be turned into incremental cash flows to the lender or ESCO based on the commitment of the energy user (and in some cases, a utility) to pay for the savings.

PRACTICAL-10

AIM-SEMINAR REPORT ON "ENERGY PERFORMANCE ASSESSMENT OF BOILERS"

Performance Evaluation of Boilers

- The performance parameters of boiler, like efficiency and evaporation ratio reduces with time due to poor combustion, heat transfer surface fouling and poor operation and maintenance.

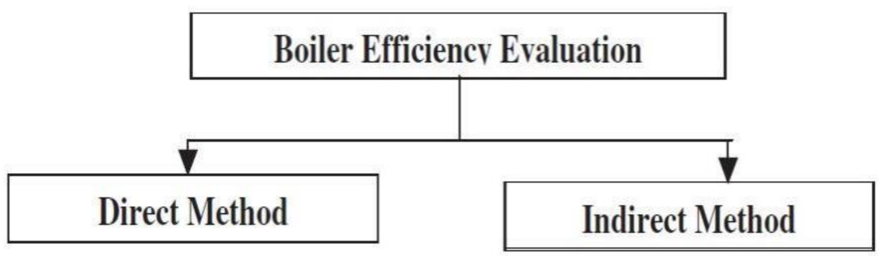
- Even for a new boiler, reasons such as deteriorating fuel quality, water quality etc. can result in poor boiler performance. Boiler efficiency tests help us to find out the deviation of boiler efficiency from the best efficiency and target problem area for corrective action.

Boiler Efficiency

Thermal efficiency of boiler is defined as the percentage of heat input that is effectively utilised to generate steam. There are two methods of assessing boiler efficiency.

- **The Direct Method:** Where the energy gain of the working fluid (water and steam) is compared with the energy content of the boiler fuel.

- **The Indirect Method:** Where the efficiency is the difference between the losses and the energy input.



A. Direct Method

This is also known as „input-output method" due to the fact that it needs only the useful output (steam) and the heat input (i.e. fuel) for evaluating the efficiency. This efficiency can be evaluated using the formula

$$Boiler\ Efficiency = \frac{Heat\ Output}{Heat\ Input} \times 100$$

- Parameters to be monitored for the calculation of boiler efficiency by direct method are :

- Quantity of steam generated per hour (Q) in kg/hr.
- Quantity of fuel used per hour (q) in kg/hr.
- The working pressure (in kg/cm2(g)) and superheat temperature (°C), if any
- The temperature of feed water (°C)
- Type of fuel and gross calorific value of the fuel (GCV) in kCal/kg of fuel
  -

$$Boiler\ Efficiency\ (\eta) = \frac{Q\,x\,(h_g - h_f)}{q \times GCV} \times 100$$

Where, hg – Enthalpy of saturated steam in kCal/kg of steam hf – Enthalpy of feed water in kCal/kg of water

Example

- Find out the efficiency of the boiler by direct method with the data given below:
  - Type of boiler : Coal fired
  - Quantity of steam (dry) generated : 8 TPH
  - Steam pressure (gauge) / temp : 10 kg/cm2(g)/ 180°C
  - Quantity of coal consumed : 1.8 TPH
  - Feed water temperature : 85°C
  - GCV of coal : 3200 kCal/kg
  - Enthalpy of steam at 10 kg/cm2 pressure : 665 kCal/kg (saturated) – Enthalpy of feed water : 85 kCal/kg

$$Boiler\ Efficiency\ (\eta) = \frac{8 \times (665 - 85) \times 1000}{1.8 \times 3200 \times 1000} \times 100 = 80\%$$

- It should be noted that boiler may not generate 100% saturated dry steam, and there may be some amount of wetness in the steam.

Advantages of direct method:

- Plant people can evaluate quickly the efficiency of boilers
- Requires few parameters for computation Needs few instruments for monitoring

Disadvantages of direct method:

- Does not give clues to the operator as to why efficiency of system is lower
- Does not calculate various losses accountable for various efficiency levels

B. Indirect Method

- There are reference standards for Boiler Testing at Site using indirect method namely British
- Standard, BS 845: 1987 and USA Standard is ASME PTC-4-1 Power Test Code Steam Generating Units‟.
- Indirect method is also called as heat loss method.

- The efficiency can be arrived at, by subtracting the heat loss fractions from 100. The standards do not include blow down loss in the efficiency determination process.

- A detailed procedure for calculating boiler efficiency by indirect method is given below. However, it may be noted that the practicing energy mangers in industries prefer simpler calculation procedures. The principle losses that occur in a boiler are:

    - Loss of heat due to dry flue gas
    - Loss of heat due to moisture in fuel and combustion air
    - Loss of heat due to combustion of hydrogen
    - Loss of heat due to radiation
    - Loss of heat due to un burnt

- In the above, loss due to moisture in fuel and the loss due to combustion of hydrogen are dependent on the fuel, and cannot be controlled by design.

- The data required for calculation of boiler efficiency using indirect method are:
  - Ultimate analysis of fuel (H_2, O_2, S, C, moisture content, ash content)
  - Percentage of Oxygen or CO_2 in the flue gas
  - Flue gas temperature in °C (Tf)
  - Ambient temperature in °C (Ta) & humidity of air in kg/kg of dry air • GCV of fuel in kCal/kg
  - Percentage combustible in ash (in case of solid fuels)
  - GCV of ash in kCal/kg (in case of solid fuels)

Solution :

Theoretical air requirement

$$=[(11.6 \times C) + \{34.8 \times (H_2 - O_2/8)\} + (4.35 \times S)]/100 \text{ kg/kg of fuel}$$

Excess Air supplied (EA) = $\frac{O_2\%}{21 - O_2\%} \times 100$

Actual mass of air supplied/ kg of fuel (AAS) = {1 + EA/100} × theoretical air

i. Percentage heat loss due to dry flue gas $= \frac{m \times C_p \times (T_f - T_a) \times 100}{GCV\ of\ fuel}$

   m = mass of dry flue gas in kg/kg of fuel

   m = Combustion products from fuel: CO_2 + SO_2 + Nitrogen in fuel + Nitrogen in the actual mass of air supplied + O_2 in flue gas. (H_2O/Water vapour in the flue gas should not be considered)

   C_p = Specific heat of flue gas (0.23 kCal/kg °C)

ii. Percentage heat loss due to evaporation of water formed due to H_2 in fuel

$$= \frac{9 \times H_2 \times \{584 + C_p (T_f - T_a)\}}{\text{GCV of fuel}} \times 100$$

Where, H_2 - kg of H_2 in 1 kg of fuel
C_p - Specific heat of superheated steam (0.45 kCal/kg °C)

iii. Percentage heat loss due to evaporation of moisture present in fuel

$$= \frac{M \times \{584 + C_p (T_f - T_a)\}}{GCV \text{ of fuel}} \times 100$$

Where, M – kg of moisture in 1kg of fuel
C_p – Specific heat of superheated steam (0.45 kCal/kg)°C
584 is the latent heat corresponding to the partial pressure of water vapour.

iv. Percentage heat loss due to moisture present in air

$$= \frac{AAS \times humidity\ factor \times C_p \times (T_f - T_a)}{GCV \text{ of fuel}} \times 100$$

C_p – Specific heat of superheated steam (0.45 kCal/kg °C)

v. Percentage heat loss due to unburnt in fly ash

$$= \frac{\text{Total ash collected / kg of fuel burnt} \times \text{G.C.V of fly ash}}{\text{GCV of fuel}} \times 100$$

vi. Percentage heat loss due to unburnt in bottom ash

$$= \frac{\text{Total ash collected / kg of fuel burnt} \times \text{G.C.V of bottom ash}}{\text{GCV of fuel}} \times 100$$

vii. Percentage heat loss due to radiation and other unaccounted loss

The actual radiation and convection losses are difficult to assess because of particular emissivity of various surfaces, its inclination, air flow pattern etc. In a relatively small boiler, with a capacity of 10 MW, the radiation and unaccounted losses could amount to between 1% and 2% of the gross calorific value of the fuel, while in a 500 MW boiler, values between 0.2% to 1% are typical. The loss may be assumed appropriately depending on the surface condition.

Efficiency of boiler (η) = 100 - (i + ii + iii + iv + v + vi + vii)