UNIT – I
GENERAL ASPECTS

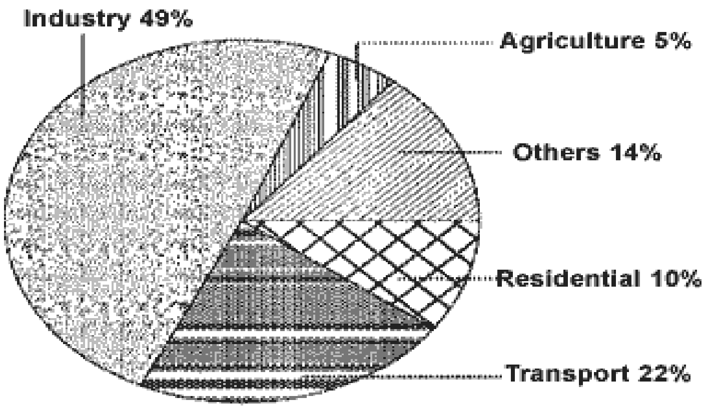
ENERGY MANAGEMENT AND AUDIT

ENERGY MANAGEMENT: AN OVERVIEW

Energy is an integral part of today's modern life. It has become the blood of our day to day life. But it is not free. It comes at a monetary price but more than that it comes at environment cost too.

It is very difficult to think about our modern life without energy. But the generation of energy requires natural resources which are depleting day by day. On the other side, use of energy is increasing exponentially. In developing nation like India, about 49% of total commercial energy is consumed in industries and utilities like Compressed Air, Air Conditioning, Steam, Hot water, Electrical systems, fuel, water system consumes substantial part of total energy in these industries.. Figure Number 1.1 shows, sector wise energy consumption for the year 1999-2000.

Figure No 1.1: Sector wise Energy Consumption (1999-2000)



Source: Bureau of Energy Efficiency, India.

Thus the need to improve and maintain energy efficiency in industrial utilities is strongly felt to survive in present scenario of rising energy costs and volatile energy markets and to gain competitive advantage. On the other side, consumption of energy resources in industries leads to atmospheric pollution and damages environment. Application of energy efficient technologies to improve energy efficiency (i.e., reductions in energy per unit of output) in industries are often suggested as a means of reducing carbon emissions. In many cases where climate change is not a concern; improvements in energy efficiency will pay for themselves through reductions in energy costs.

In India, per capita Energy Consumption is very low. Being a developing country, it needs to achieve Economic Growth by increasing its pace of development through industrialization. There are two options to match the pace of industrial development. First one is to produce more and more industrial energy which is quite difficult considering depleting natural resources and second one is to reduce the consumption of energy by improving energy efficiency in industries especially in utilities. The research focuses on reducing energy consumption of industrial utilities through energy efficient technologies. It also focuses on barriers to energy efficiency in industries and training needs of the employees for the effective energy management in industries.

Pune is a hub of automobile industries in India and one of the most polluted city in the state. This study deals with the energy management in utilities of automobile industries in Pune manufacturing passenger cars. The researcher studied the status of energy management in these industries with respect to energy efficient technologies adopted and barriers in their adoption, performance assessment of utility equipment, utility costing, and training needs of employees on energy management.

We have limited fuels available on earth. Our demand for energy is increasing day-by- day. It is possible that someday, most of fuels will be exhausted, and we will have to switch over to alternate energy. At present consumption levels (world) are - Crude oil will last only for 45 years. Gas will last for 65 years. Coal will be finished in nearly 2001.

It is estimated that Industrial energy use in developing countries constitutes about 45-50 % of the total commercial energy consumption. Much of this energy is converted from imported oil, the price of which has increased tremendously so much so that most of developing countries spent more than 50 % of their foreign exchange earnings. Not with standing these fiscal constraints, developing countries need to expand its industrial base like us if it has to generate the resources to improve the quality of life of its people. The expansion of industrial base does require additional energy inputs which become more & more difficult in the present scenario.

In response to the wave of challenges related to energy use, some industries around the world have reduced energy intensities by adopting and developing energy efficient technologies and management strategies. This is a justification for their high energy end-use and high contribution to energy related environmental problems. By doing so, industries have not only gained improvement in environmental protection, but also gained economic and social dividends. Numerous studies have highlighted the tremendous gains of implementing industrial energy efficiency and management measures. Notably, some of these studies reveal that greater savings can be realized in developing countries.

Considerable untapped potential exists for curbing wasteful use of energy estimated to be of the order nearly 30 per cent of the total consumption of commercial energy. The size of energy efficiency markets growing @ 10% annually in India is estimated to be in the range of Rs. 200 to Rs. 300 billion. In spite of many efforts and benefits of energy efficiency, several technical, financial market and policy barriers have constrained the implementation of energy efficiency projects.

Indian industry uses energy more intensively than is the norm in industrialized countries. While selected modern Indian units often display very high efficiency that approaches world best practice levels, the average intensity lags world best levels. Indian industry has undergone a transformation since 1991, the year the economy was opened to foreign investment and competition. Energy per unit of valued added in the industrial sector has declined since then. However, there still remains considerable scope for continued improvement of energy efficiency in Indian industry, and for learning from both worldwide and Indian best practices.

Considering potential for energy savings especially in industries, fastly depleting energy resources and the harmful effects of energy consumption on environment, researcher has taken this study to understand the energy efficient measures adopted by the industries and barriers in their adoption. This study incorporates the investigation of barriers for the implementation of energy efficient technologies in Industrial utilities to shed light on the rationale for non-adoption of cost effective industrial energy efficient technologies.

India is one of the fastest growing modern economies of the world today. With economic growth rates ranging between 8% and 9% in the last 6 years and a double digit growth rate target for next decade, the Indian economy has become an energy guzzler. As per the global environment facility (GEF), industry remains the largest consumer of energy in the Indian economy; accounting for over 50% of total primary energy consumption in the country. There are estimated 13 million Micro, Small, and Medium-sized Enterprises (MSME) contributing to around 45% of manufacturing output, and employing more than 40 million people. Most of energy intensive MSMEs depend on inefficient equipment, technology and operating practices, leading to high energy consumption and significant CO_2 emissions.[5]

Indian industries are lagging in application of Energy Efficient technologies for improving energy efficiency because of the various reasons. Specific energy consumption is very high in

Indian industries.

The main reasons for higher specific energy consumption in Indian industries are:

1) Obsolete technology
2) Lower capacity utilization
3) Causal metering and monitoring of energy consumption
4) Lower automation
5) Raw material quality and poor handling
6) Operating and maintenance practices
7) Lack of knowledge/awareness among the employees

So, the technology upgrades, Re-engineering and continuous evaluation, Self- knowledge & Awareness among the masses is basic step towards energy conservation program in any industry. It is strongly required to monitor energy utilization on continuous basis and relate it to specific energy consumption. This research analyses the status of training programs on energy management conducted in the organization and needs of the employees to improve their technical capabilities and awareness about energy management in passenger car manufacturing automobile industries in Pune. It provides comprehensive information about the industrial energy culture of these industries derived from both primary and secondary data sources.

Since, the substantial share of energy resources is consumed in generation, distribution and utilization of electrical and thermal utilities, improving energy efficiency in industrial utilities is the very first step in Energy Management. Hence it calls "Management of Energy in industrial utilities".

These electrical and thermal utilities are not only energy intensive utilities but the least energy efficient systems too. Over a period of time, both performance of these utility equipment and utility system reduces drastically. The causes are many such as poor maintenance, wear and tear etc. All these lead to additional utility Equipment installations leading to more inefficiency. Therefore, a periodic performance assessment of these utility Equipment with a standard procedure is essential to minimize the cost of energy. This doctoral study also deals with the status of performance assessment of major utility equipment at a periodic intervals with standard procedure.

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"

(Cape Hart, Turner and Kennedy, Guide to Energy Management Fairmont press inc. 1997)

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.

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 program..

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), labor 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 program which are vital for production and utility activities. Such an audit program 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.

Principles of Energy Audit :

. Eliminate un necessary energy usage.

. Improve efficiency of energy usage.

. Buying energy at low cost.

. Adjusting operations to allow purchasing energy at low prices.

. Control the cost of energy not the BTU.

. Control energy as a product cost.
. For same energy higher production.
. Energy saved is the money earned which can be used in the other productive means.

2 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

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 pre- sented below.

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/ program.

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 pay- back on any capital investment needed.

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

1.Energy consumption by type of energy, by department, by major items of process equipment, 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 (e.g. 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 utilization
- 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

Draw process flow diagram and list process steps; identify waste streams and obvious energy wastage

An overview of unit operations, important process steps, areas of material and energy use and sources of waste generation should be gathered and should be represented in a flowchart as shown in the figure below. Existing drawings, records and shop floor walk through will help in making this flow chart. Simultaneously the team should identify the various inputs & output streams at each process step.

Example: A flowchart of Penicillin-G manufacturing is given in the figure3.1 below. Note that waste stream (Mycelium) and obvious energy wastes such as condensate drained and steam leakages have been identified in this flow chart

The audit focus area depends on several issues like consumption of input resources, energy efficiency potential, impact of process step on entire process or intensity of waste generation / energy consumption. In the above process, the unit operations such as germinator, pre-fermentor, fermentor, and extraction are the major conservation potential areas identified.

Identification of Energy Conservation Opportunities

Fuel substitution: Identifying the appropriate fuel for efficient energy conversion

Energy generation : Identifying Efficiency opportunities in energy conversion equipment/utility such as captive power generation, steam generation in boilers, thermic fluid heating, optimal loading of DG sets, minimum excess air combustion with boilers/thermic fluid heating, optimissing existing efficiencies, efficient energy conversion equipment, biomass gasifiers, Cogeneration, high efficiency DG sets, etc.

Energy distribution: Identifying Efficiency opportunities network such as transformers, cables, switchgears and power factor improvement in electrical systems and chilled water, cooling water, hot water, compressed air, Etc.

Energy usage by processes: This is where the major opportunity for improvement and many of them are hidden. Process analysis is useful tool for process integration measures.

Technical and Economic feasibility

The technical feasibility should address the following issues

- Technology availability, space, skilled manpower, reliability, service etc
- The impact of energy efficiency measure on safety, quality, production or process.
- The maintenance requirements and spares availability

The Economic viability often becomes the key parameter for the management acceptance. The economic analysis can be conducted by using a variety of methods. Example: Pay back method, Internal Rate of Return method, Net Present Value method etc. For low investment short duration measures, which have attractive economic viability, simplest of the methods, payback is usually sufficient. A sample worksheet for assessing economic feasibility is provided below:

Classification Of Energy Conservation Methods

1. Low cost – High return.
2. Medium cost- medium return.
3. High cost –high return.

Energy Audit Reporting Format

After successfully carried out energy audit energy manager/energy auditor should report to the top management for effective communication and implementation. A typical energy audit reporting contents and format are given below. The following format is applicable for most of the industries.

Understanding Energy Costs

Understanding energy cost is vital factor for awareness creation and saving calculation. In many industries sufficient meters may not be available to measure all the energy used. In such cases, invoices for fuels and electricity will be useful. The annual company balance sheet is the other sources where fuel cost and power are given with production related information.

Energy invoices can be used for the following purposes:

•They provide a record of energy purchased in a given year, which gives a base-line for future reference

•Energy invoices may indicate the potential for savings when related to production requirements or to air conditioning requirements/space heating etc.

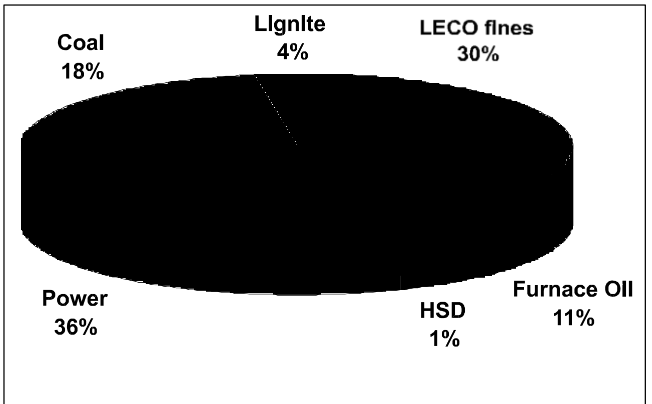
•When electricity is purchased on the basis of maximum demand tariff

•They can suggest where savings are most likely to be made.

•In later years invoices can be used to quantify the energy and cost savings made through energy conservation measures

A wide variety of fuels are available for thermal energy supply. Few are listed below:

- Fuel oil
- Low Sulphur Heavy Stock (LSHS)
- Light Diesel Oil (LDO)
- Liquefied Petroleum Gas (LPG)
- COAL
- LIGNITE
- WOOD ETC.



Total Energy Bill - Rs. 6 Crores/annum

Understanding fuel cost is fairly simple and it is purchased in Tons or Kiloliters. Availability, cost and quality are the main three factors that should be considered.

The following factors should be taken into account during procurement of fuels for energy efficiency and economics.

- Price at source, transport charge, type of transport
- Quality of fuel (contaminations, moisture etc)
- Energy content (calorific value)

Electricity price in India not only varies from State to State, but also city to city and consumer to consumer though it does the same work everywhere. Many factors are involved in deciding final cost of purchased electricity such as:

- Maximum demand charges, kVA
- Energy Charges, kWh

(i.e., How much electricity is consumed?)

- TOD Charges, Peak/Non-peak period

(i.e. When electricity is utilized ?)

- Power factor Charge, P.F

(i.e., Real power use versus Apparent power use factor)

- Other incentives and penalties applied from time to time
- High tension tariff and low tension tariff rate changes
- Slab rate cost and its variation
- Type of tariff clause and rate for various categories such as commercial, residential, industrial, Government, agricultural, etc.
- Tariff rate for developed and underdeveloped area/States
- Tax holiday for new projects

Benchmarking and Energy Performance

Benchmarking of energy consumption internally (historical / trend analysis) and externally (across similar industries) are two powerful tools for performance assessment and logical evo- lution of avenues for improvement. Historical data well documented helps to bring out energy consumption and cost trends month-wise / day-wise. Trend analysis of energy consumption, cost, relevant production features, specific energy consumption, help to understand effects of capacity utilization on energy use efficiency and costs on a broader scale.

External benchmarking relates to inter-unit comparison across a group of similar units. However, it would be important to ascertain misleading. Few comparative factors, which need to be looked into while benchmarking exter- nally are:

- Scale of operation
- Vintage of technology
- Raw material specifications and quality
- Product specifications and quality

Benchmarking energy performance permits

- Quantification of fixed and variable energy consumption trends vis-à-vis production levels
- Comparison of the industry energy performance with respect to various production levels (capacity utilization)
- Identification of best practices (based on the external benchmarking data)
- Scope and margin available for energy consumption and cost reduction
- Basis for monitoring and target setting exercises. The benchmark parameters can be:
- Gross production related

e.g. kWh/MT clinker or cement produced (cement plant)

e.g. kWh/kg yarn produced (Textile unit)

e.g. kWh/MT, kCal/kg, paper produced (Paper plant)
e.g. kCal/kWh Power produced (Heat rate of a power plant) e.g. Million kilocals/MT Urea or Ammonia (Fertilizer plant) e.g. kWh/MT of liquid metal output (in a foundry)

- Equipment / utility related

e.g. kW/ton of refrigeration (on Air conditioning plant)
e.g. % thermal efficiency of a boiler plant
e.g. % cooling tower effectiveness in a cooling tower e.g. kWh/NM^3 of compressed air generated
e.g. kWh /litre in a diesel power generation plant.
While such benchmarks are referred to, related crucial process parameters need mentioning for meaningful comparison among peers. For instance, in the above case:

•For a cement plant - type of cement, blaine number (fineness) i.e. Portland and process used (wet/dry) are to be reported alongside kWh/MT figure.
•For a textile unit - average count, type of yarn i.e. polyester/cotton, is to be reported along side kWh/square meter.
•For a paper plant - paper type, raw material (recycling extent), GSM quality is some important factors to be reported along with kWh/MT, kCal/Kg figures.
•For a power plant / cogeneration plant - plant % loading, condenser vacuum, inlet cool ing water temperature, would be important factors to be mentioned alongside heat rate (kCal/kWh).
•For a fertilizer plant - capacity utilization(%) and on-stream factor are two inputs worth comparing while mentioning specific energy consumption
similarities, as otherwise findings can be grossly misleading. Few comparative factors, which need to be looked into while benchmarking extern- nally are:

- Scale of operation
- Vintage of technology
- Raw material specifications and quality
- Product specifications and quality

Benchmarking energy performance permits
•Quantification of fixed and variable energy consumption trends vis-à-vis production levels

- Comparison of the industry energy performance with respect to various production levels (capacity utilization)
- Identification of best practices (based on the external benchmarking data)
- Scope and margin available for energy consumption and cost reduction
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- For a fertilizer plant - capacity utilization(%) and on-stream factor are two inputs worth comparing while mentioning specific energy consumption ating parameters to be reported while mentioning specific energy consumption data.
- For an Air conditioning (A/c) plant - Chilled water temperature level and refrigeration load (TR) are crucial for comparing kW/TR.
- For a boiler plant - fuel quality, type, steam pressure, temperature, flow, are useful com parators alongside thermal efficiency and more importantly, whether thermal efficiency is on gross calorific value basis or net calorific value basis or whether the computation is by direct method or indirect heat loss method, may mean a lot in benchmarking exer cise for meaningful comparison.
- Cooling tower effectiveness - ambient air wet/dry bulb temperature, relative humidity, air and circulating water flows are required to be reported to make meaningful sense.
- Compressed air specific power consumption - is to be compared at similar inlet air temperature and pressure of generation.
- Diesel power plant performance - is to be compared at similar loading %, steady run condition etc.

Plant Energy Performance

Plant energy performance (PEP) is the measure of whether a plant is now using more or less energy to manufacture its products than it did in the past: a measure of how well the energy management programme is doing. It compares the change in energy consumption from one year to the other considering production output. Plant energy performance monitoring compares plant energy use at a reference year with the subsequent years to determine the improvement that has been made.

However, a plant production output may vary from year to year and the output has a significant bearing on plant energy use. For a meaningful comparison, it is necessary to determine the energy that would have been required to produce this year production output, if the plant had operated in the same way as it did during the reference year. This calculated value can then be compared with the actual value to determine the improvement or deterioration that has taken place since the reference year.

Production factor

Production factor is used to determine the energy that would have been required to produce this year's production output if the plant had operated in the same way as it did in the reference year. It is the ratio of production in the current year to that in the reference year.

Reference Year Equivalent Energy Use

The reference year's energy use that would have been used to produce the current year's production output may be called the "reference year energy use equivalent" or "reference year equivalent" for short. The reference year equivalent is obtained by multiplying the reference year energy use by the production factor (obtained above)

Reference year equivalent = Reference year energy use x Production factor.

Matching Energy Usage to Requirement

Mismatch between equipment capacity and user requirement often leads to inefficiencies due to part load operations, wastages etc. Worst case design, is a designer's characteristic, while optimization is the energy manager's mandate and many situations present themselves towards an exercise involving graceful matching of energy equipment capacity to end-use needs. Some examples being:

- Eliminate throttling of a pump by impeller trimming, resizing pump, installing variable speed drives
- Eliminate damper operations in fans by impeller trimming, installing variable speed drives, pulley diameter modification for belt drives, fan resizing for better efficiency.
- Moderation of chilled water temperature for process chilling needs
- Recovery of energy lost in control valve pressure drops by back pressure/turbine adoption
- Adoption of task lighting in place of less effective area lighting.

Maximising System Efficiency

Once the energy usage and sources are matched properly, the next step is to operate the equipment efficiently through best practices in operation and maintenance as well as judicious technology adoption. Some illustrations in this context are:

- Eliminate steam leakages by trap improvements
- Maximize condensate recovery
- Adopt combustion controls for maximizing combustion efficiency
- Replace pumps, fans, air compressors, refrigeration compressors, boilers, furnaces, heaters and other energy consuming equipment, wherever significant energy efficiency margins exist.

Optimizing the Input Energy Requirements

Consequent upon fine-tuning the energy use practices, attention is accorded to considerations for minimizing energy input requirements. The range of measures could include:

- Shuffling of compressors to match needs.
- Periodic review of insulation thickness
- Identify potential for heat exchanger networking and process integration.
- Optimization of transformer operation with respect to load.

Fuel and Energy Substitution

Fuel substitution: Substituting existing fossil fuel with more efficient and less cost/less polluting fuel such as natural gas, biogas and locally available agro-residues.
Energy is an important input in the production. There are two ways to reduce energy dependency; energy conservation and substitution.
Fuel substitution has taken place in all the major sectors of the Indian economy. Kerosene and Liquefied Petroleum Gas (LPG) have substituted soft coke in residential use.
Few examples of fuel substitution

- Natural gas is increasingly the fuel of choice as fuel and feedstock in the fertilizer, petro chemicals, power and sponge iron industries.
- Replacement of coal by coconut shells, rice husk etc.
- Replacement of LDO by LSHS Few examples of energy substitution

Replacement of electric heaters by steam heaters
Replacement of steam based hot water by solar systems

Case Study: Example on Fuel Substitution

A textile process industry replaced old fuel oil fired thermic fluid heater with agro fuel fired heater. The economics of the project are given below:

A: Title of Recommendation : Use of Agro Fuel (coconut chips) in place of Furnace oil in a Boiler
B: Description of Existing System and its operation : A thermic fluid heater with furnace oil currently.
In the same plant a coconut chip fired boiler is operating continuously with good performance.

C: Description of Proposed system and its operation : It was suggested to replace the oil fired thermic fluid heater with coconut chip fired boiler as the company has the facilities for handling coconut chip fired system.

D: Energy Saving Calculations
<u>Old System</u>
Type of fuel Firing : Furnace Oil fired heater
GCV : 10,200 kCal/kg
Avg. Thermal Efficiency : 82%
Heat Duty : 15 lakh kCal / hour
Operating Hours : 25 days x 12 month x 24 hours = 7,200 hrs.
Annual Fuel Cost : Rs.130 lakh (7200 x 1800 Rs./hr.)

Modified System

Type of fuel saving = Coconut chips fired Heater
GCV = 4200 kCal/kg
Average Thermal Efficiency = 72 %
Heat Duty = 15 lakh kCal / hour
Annual Operating Cost = 7200 x 700 Rs./hr = 50 lakh
Annual Savings = 130 - 50 = Rs.80 lakh .
Additional Auxiliary Power +
Manpower Cost = Rs. 10 lakh
Net Annual Saving = Rs. 70 lakh Investment for New Coconut Fired heater = Rs. 35 lakh

Simple pay back period = 6 months