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Energy Efficiency in Industrial Utilities

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1. Introduction

The demand for electrical energy has increased tremendously over the last 25 years; its importance is such that it is now a vital component of any nation's economic progress. Increase in population has increased the energy requirements, coupled with the industrialization & socio-economic responsibilities; the energy supply has not kept pace with the demand. This has led to a bleak energy scenario whereby power generation and utilization from alternate energy sources has become very much a necessity. In the industrial context, electrical energy is used to produce a desired output, given the availability of all the relevant raw materials. For a nation to progress economically, the industrial sector has to be constantly encouraged and developed, but as the number of industrial units / sectors increase, energy demand and consumption also increases. The industrial sector is the largest consumer of all the electrical energy that is commercially generated for utilization, and process industries like fertilizer, cement, sugar, textile, aluminum, paper, etc.; are extremely energy intensive in nature. To reduce the increasing demand-supply gap, either more industrial energy has to be generated or the existing consumption of energy has to be brought down without any compromise on either product quality or quantity. The rate of growth in the domestic sector easily outnumbers the industrial sector. In the event of power shortage, industrial sector gains precedence over other sectors, thereby, domestic sector always bears the brunt of long or constant power cuts. The impact of rising energy cost has a disastrous impact on the day-to-day activities of industrial and domestic consumers wherein the prices of commodities, products and even essential services tend to cost more. One option is to improve the working efficiency of the process and systems. This will ensure the reduction in the product cost in addition to efficient energy management. The other option is the use of energy derived from non-conventional energy sources i.e.; ensure a balance between conventional and non-conventional energy sources in the process. With depleting coal reserves, it is very essential to develop the renewable energy technology so as to be an alternative option. Amongst the various renewable energy sources, solar energy is the best possible option and finds application in most of the domestic and industrial processes.

2. Energy audit

With the conventional fuel supplies becoming scarce and more expensive, and the initial investment for harnessing energy from renewable sources being too high; the concept of

energy auditing and energy conservation / efficiency practices have gained significant importance especially in energy intensive industries. Energy audit programmes are inexpensive investments, as compared to the cost of energy utilization, and are an important tool in analyzing and controlling the demand-supply situation. An energy audit serves to identify and quantify all forms of energy usage. The main aim of energy audit is to maintain a proper balance between energy required and the energy actually utilized; while the main objectives of energy audit are to (i) analyze the energy consumed and wasted (ii) develop ways and means to utilize the available energy in the most efficient manner by the use of energy efficient devices (iii) adopt suitable operational strategies, and (iv) time scheduling (e) demand limiting. An industrial energy audit is the most effective tool in bringing out as well as pursuing an effective energy conservation programme. In the industrial context, energy auditing is the process of identifying energy dependent equipment in the system / sub-system processes, quantifying the amount of energy consumed by each of the individual equipment and then, analyzing the data obtained to identify energy conservation opportunities. As processes vary from plant to plant and from sector-to-sector, so do the use and type of equipment; the nature and type of energy audit also varies. Thus there cannot be a standard way of doing an energy audit, but it typically involves analyzing past and present energy consumption data, comparison of actual consumption to the standard consumption data, comparison of present consumption with other firms in the same industrial sector, checking working capacities and overall efficiencies of equipment, review of fuel storage and handling, development of energy use indices for performance comparison, analysis of energy saving incentives and reviewing the need for new energy saving techniques.

All processes and hence energy audit for the process can be divided into three general stages: input side, process side and the output side [1]. The input side energy audit involves an analysis of the fuels used in terms of quantity and quality. The process energy audit involves the analysis of the process in addition to the energy consuming equipment at various stages / sub-stages individually. The output side energy audit deals with the energy that is either rejected or lost out to the surrounding environment. As a number of stages and sub-stages are involved in every process, starting from the input to the final product, the type of the energy audit now becomes very important.

The type of energy audit can be classified into a walk-through audit and a comprehensive audit. A walk-through audit takes the least possible time and generally involves moving around the facility looking for simple possible steps to minimize energy wastage or improving the system process leading to better energy utilisation i.e.; walk-through audit covers only a general notation of the performance. A comprehensive audit involves a longer time frame and generally involves getting into the indepth details of process, i.e.; comprehensive audit covers specific information [2]. A well designed and properly executed extensive energy audit programme will reveal the various areas of energy wastage and process inefficiencies, thereby pin-pointing the areas of immediate improvement.

The energy audit whether walk-through or comprehensive should be carried out by an energy auditor specifically designated for the purpose. The energy auditor may be from within the organization or an expert / consultant not connected with the organization, but must be well versed with the process involved. The main responsibilities of the energy auditor are:

- Plan, direct and execute an extensive energy audit process wise and system wise
- Quantify the process and system energy needs
- Quantify the process and system efficiencies

- Compare the present data with historical data
- Identify the various energy saving measures, analyze their technical / financial feasibility
- Organize the energy saving measures into low / medium / high priority and also into proposals requiring small / large investments
- Documentation regarding the energy saving proposals
- Appraise / convince the management regarding the need for implementation of energy saving measures
- Follow up on the implementation with periodic monitoring / appraisal

Investment related energy saving proposals require the consent of the management. In such cases, the decision making does not rest with energy auditor. It therefore becomes important that the energy auditor must prepare a detailed report listing out the various options available, their technical feasibility, financial requirements, time frame needed and possible gains that can be achieved. Thus the role of the energy auditor becomes very important. An energy audit report for a work area within the plant facility should essentially cover the following and the same can be extended to other units with relevant changes so as to form an energy audit report for the plant.

- Company details: name, location, power, fuel & water demand, products manufactured
- Work area details: name, dimensions, working hours, power, fuel, water & process requirements, process description, work output
- Device details: devices used, nameplate details, accessories, metering, control parameters, age, assumptions, maintenance details
- Observations: input, process & output, loading pattern, inefficiencies, wastages, comparison with historical data, possible reasons for deviations, potential opportunities
- Operational difficulties: feedback from personnel, maintenance, housekeeping, maintenance records
- Recommendations: input, process & output changes, replacements, retrofits, investments, training
- Benefits: process & product improvements, power, material & monetary savings, economic analysis, payback periods, forecasting
- Options available: tariff, efficient devices, systems, vendors, rebates, subsidies
- Probable implementation plan: time period, priorities, training requirements, investments
- References list: technical reports, handbooks, manuals
- Team details: plant work area, energy audit

The energy audit report must be simple in presentation as it should be understood by all concerned be it the president of the company or the maintenance personnel. It is also essential that the report be written in a manner that even a non-technical person should be in a position to understand the underlying message. The report should be a blend of text, figures, tables, etc. so that it is not monotonous in nature. The assumptions made during the energy audit must be easily justifiable. All standard formulas and measuring units can be a part of the annexure for reference. There must be consistency in information flow, i.e.; same variables or notations must be not be used a second time that may lead to confusion. The energy audit report can be in two parts: first part being the overall summary that highlights the important details and second part being the indepth report. This will enable the top management to concentrate only on the first part and in case of need of discussions, second part will be handy. In addition, the report

should be sensible from the technical & financial point of view, i.e.; it should be encouraging enough for the management to realize that implementation will lead to better prospects. Thus a reader friendly energy audit report is an important step in initiating the implementation of audit recommendations.

Successful completion of an energy audit identifies the areas for improvement, which leads to listing out a number of energy conservation proposals. In depth discussion with the relevant people leads to an energy management strategy which is quite significant in bridging the gap between availability and requirement of electrical power.

3. Energy management

Energy management embodies engineering, design, applications, utilization, and to some extent the operation and maintenance of electric power systems to provide the optimal use of electrical energy [2]. The most important step in the energy management process is the identification and analysis of energy conservation opportunities, thus making it a technical and management function, the focus being to monitor, record, analyze, critically examine, alter and control energy flows through systems so that energy is utilized with maximum efficiency [1]. Every industrial facility in a particular location is unique in itself; hence a systematic approach is extremely necessary for reducing the power consumption, without adversely affecting the productivity, quality of work and working conditions. Thus, for any process, energy conservation methodologies can be categorized into (i) housekeeping measures (ii) equipment and process modifications (iii) better equipment utilization and (iv) reduction of losses in building shell [3]. Thus energy management involves consumption and optimization of energy usage at various stages in the plant process in the most efficient way.

Energy management is responsibility of all involved in the industrial process but there must be person(s) specifically designated to oversee the implementation of energy efficiency proposals. Thus the role of energy manager is equally important as that of the energy auditor. The energy manager should have upto date technical skills to understand intricate technicalities of the process and excellent managerial skills in order to plan, organize, direct and control the various energy requirements. This will ensure that competency of the energy manager will not be questioned at any point in time and also, the top management can rest assured that targets set will be easily achieved. The main responsibilities of the energy manager are:

- Setting up of an energy management cell with well-defined objectives
- Generate ideas for energy management to create / promote awareness
- Initiate regular training programmes for constant knowledge updation
- Initiate steps for appropriate monitoring and recording practices
- Set targets that are realistically achievable by all concerned in the process
- Proper implementation of the energy audit findings
- Ensure that all data related to unit / plant are maintained centrally and easily accessible
- Ensure coordination between top, middle and lower management personnel
- Associate with energy managers of related industries for information exchange
- Ensure easy information flow through proper communication

An energy manager's report for a work area within the plant facility should concentrate on the findings of the energy audit report, take into account the historical data and set realistic benchmarks / targets that contribute significantly towards energy efficiency. The reports

prepared must be shared with all concerned especially with energy auditors. This will reassure the energy auditors that their reports are taken seriously and due importance / credit are attached to the work done. In short, the energy manager should be the bridge between the top management and unit personnel.

Demand side management (DSM) is an important policy issue in recent years in the context of energy management. DSM aims to (i) minimize energy consumption (ii) reduce maximum demand (iii) promote use of electricity to reduce green house gas emissions (iv) replacement of bio fuel by commercial energy to stop deforestation. The demand reduction management can be practiced by (i) efficient utilization of existing capacity (ii) reduction in transmission and distribution losses, and (iii) effective peak demand management. These methods are most appropriate for reducing the power bills and to meet the requirements of high quality of power. Implementation of DSM projects encourages introduction of energy efficient technology and equipment in all sectors.

4. Energy Management Strategies (EMS)

An energy management programme will be effective when the concerned persons are taken into confidence; awareness is created regarding the need / importance of the process and responsibility assigned so as to ensure team work. It is also important to understand that the EMS will not be same across the plant; rather it will be device specific. The first step in the development of an EMS is by forming a committee comprising of energy manager as the head, energy auditor, plant / unit manager, plant / unit personnel and maintenance personnel. The first meeting should basically discuss (a) energy auditor's findings (b) best operational procedures with unit and maintenance personnel (c) allotment of responsibilities (d) setting realistic benchmarks and targets (e) plan the work schedule. Subsequent meetings should discuss energy audit observations, targets set and targets achieved for energy management. A critical analysis of deviations in the targets set / achieved must be carried out and EMS reworked if necessary. The committee should meet on a regular basis perhaps every 10 days so as to ensure close monitoring. In addition to the above, it is very important to develop and motivate the concerned persons by upgrading their knowledge through regular workshops / training programmes. It is also important that competitions be conducted amongst the various units in the plant and incentives / awards be instituted for units / employees for best results achieved. In addition the EMS should be the basis for a comprehensive energy policy that will be implemented across the plant irrespective of the process involved.

Some of the commonly used equipment used in energy intensive processes are boiler systems, steam systems, refractories, furnaces, motor driven systems, compressed air systems, heating, ventilation and air conditioning systems, fans, blowers, pumping systems, cooling towers, illumination systems, diesel generators, etc. The energy management strategy should basically concentrate on:

- Boiler Systems: fuel, steam pressure, temperature, fans, blow down, ash handling, efficiency, heat loss, leaks, handling systems, dust collection, waste heat recovery, maintenance schedules, heat recovery, insulation requirements, feed water, piping, ventilation, economizers, air-preheaters, etc.
- Diesel Generators: fuel, quality, heat, exhaust, load, maintenance, etc.
- Electricity: magnitudes, frequency, quality, tariff, metering, power factor, load curve
- Energy Storage Systems: insulation, temperature, control, maintenance, etc.
- Furnaces: losses, conveyor, fixtures, storage, insulation, temperature, heaters, lining, ducts, coils, cover, temperature, slag, water, heat recovery, burners, etc.

- Heating Systems: temperature, ventilation, piping, controls, insulation, maintenance, load profiles, storage, etc.
- Illumination Systems: adequacy, luminaire, glare, sensors, standards, day lighting, control, maintenance, lamps, ballasts, etc.
- Instrumentation: analog, digital, calibration, panels, CTs, PTs, etc.
- Motor Systems: pumps, air compressors, fans, piping, volume, pressure, temperature, dust, control, ducts, leakage, nozzles, efficiency, loading, drive systems, class, instrumentation, etc.
- Refrigeration and Air Conditioning Systems: heat, load, windows, temperature, thermostats, air, illumination, insulation, ducts, piping, evaporators, condensers, heat exchangers, vapour, control, maintenance, etc.
- Steam Systems: pressure, temperature, superheating, piping, condensate recovery, leaks, steam traps, venting, maintenance, insulation, valves, etc.
- Ventilation Systems: air handling, thermal insulations, distribution, blockages, leakages, maintenance, control, heat recovery, etc.

All data have to be recorded and maintained for future reference. These facts and figures do give a fair idea about the pattern of energy consumption and its cost per unit of the finished product. As energy consumption is directly related to production rate, the energy consumed for every finished product can be used as a reference index. When sufficient amount of data has been built up over a period, the records then have to be converted into meaningful forms. Pictorial representations in the form of bar charts, pie charts and Sankey diagrams showing energy use and energy lost, process flow diagrams showing energy consumption at every stages of the operational process, etc. will go a long way in identifying the areas of high energy consumption, high costs of operation and in turn, the energy saving potential.

5. Renewable energy

In the previous century, the industrial revolution was powered by coal leading to setting up of large power plants as it was the only reliable source of energy available in abundance. Over the years, oil replaced coal as it was the cleaner form of fuel leading to increased industrialization. Due to increased usage of coal and oil in the name of economic development, environmental problem has started to put a lid on economic progress. The environmental concerns of fossil fuel power plants are due to sulfur oxides, nitrogen oxides, ozone depletion, acid rain, carbon dioxide and ash. The environmental concerns of hydroelectric power plants are flooding, quality, silt, oxygen depletion, nitrogen, etc. The environmental concerns of nuclear power plants are radioactive release, loss of coolant, reactor damage, radioactive waste disposal, etc. The environmental concerns of diesel power plants are noise, heat, vibrations, exhaust gases, etc. Finding and developing energy sources that are clean and sustainable is the challenge in the coming days.

Considering the depleting coal reserves, increasing power demand, cost of fuels and power generation, the power generating capacity can only be increased by involving renewable energy sources. The renewable energy source produce less pollution and are constantly replenished which is quite an advantage. Due to the future need of increasing power requirements, research has led to development of technology for efficient and reliable renewable energy systems. The various forms of renewable energy sources are solar, wind, biomass, tidal, fuel cells, geothermal, etc. The main advantages of renewable energy sources are sustainability, availability and pollution free. The disadvantages of renewable energy are

variability, low density and higher cost of conversion. In order to sustain the present sources, the future energy will be mix of available energy sources utilised from multiple sources. This will ensure that the environment will be a lot less polluted. Renewable energy is the future from here on.

Among the various renewable energy sources, solar energy is the best usable source as the sun is the primary source of energy and the earth receives almost 90 % of its total energy from the sun. In one hour, the earth receives enough energy from the sun to meet its energy needs for almost a year. Solar energy can be converted through chemical, electrical or thermal processes. Solar radiation can be converted into heat and electricity using thermal and photovoltaic (PV) technologies. The thermal systems are used for hot water requirements, cooking, heating etc., while PV are used to generate electricity for standalone systems or fed into the grid. Solar energy has a lot economic, energy security and environmental benefits when compared to conventional energy for certain applications. Solar power is a cost effective solution to generate and supply power for a variety of applications, from small stand alone systems to large utility grid-tied installations. The conversion of solar energy requires certain equipment that have a relatively high initial cost but considering the lifetime of the solar equipment, these systems can be cost competitive as there are no major recurring cost and minimal maintenance cost. Even though solar energy systems have a reasonably high initial cost; they do not have fuel requirements and often require little maintenance. Hence the life cycle costs of a solar energy system should be understood for economic viability of the PV system. The important factors to be considered for a renewable energy system are power requirements, source availability, system type, system size, initial cost, operation cost, maintenance cost, depreciation, subsidies etc.

Grid connected PV system gives us the option to reduce the electricity consumption from the electricity grid and in some instances, to feed the surplus energy back into the electrical grid. The grid connected PV systems distinguish themselves through the lack of a need for energy storage device such as a battery. The basic building block of PV technology is the solar cell. Many solar cells can be wired together to form a PV module and many PV modules are linked together to form a PV array. A PV system usually consists of one or more PV modules connected to an inverter that changes the PV's DC to AC, not only to power our electrical devices that use alternating current (AC) but also to be compatible with the electrical grid.

Cogeneration is the conversion of energy into multiple usable forms. The cogeneration plant may be within the industrial facility and may serve one or more users. The advantages of cogeneration are fuel economy, lower capital costs, lower operational costs and better quality of supply.

6. Power quality

To overcome power shortage in addition to increasing power demand, industrial sectors are encouraged to adopt energy efficiency measures. Process automation involves extensive use of computer systems and adjustable speed drives (ASDs), power quality (PQ) has become a serious issue especially for industrial consumers. Power quality disturbances are a result of various events that are internal and external to industrial utilities. Because of interconnection of grid network, internal PQ problems of one utility become external PQ problems for the other.

The term power quality has been defined and interpreted in a number of ways: As per IEEE Std 1159, PQ refers to a wide variety of electromagnetic phenomena that characterize the voltage and current at a given time and at a given location on the power system [4]. As per

IEC 61000-1-1, electromagnetic compatibility is the ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment [5]. In simple terms, power quality is considered to be a combination of voltage quality and current quality, and is mainly attributed to the deviation of these quantities from the ideal. Such a deviation is termed as power quality phenomena or power quality disturbance, which can be further divided into phenomenon: variations and events. Variations are small deviations away from the nominal or desired value involving voltage and current magnitude variations, voltage frequency variations, voltage and current unbalance, voltage fluctuations, harmonic voltage and current distortions, periodic voltage notching, etc. Events are phenomena that happen every once in a while involving interruption, under voltages, overvoltage, transients, phase angle jumps and three-phase unbalance [6].

The PQ problems can originate from the source side or the end user side. The source side of PQ disturbances involves events such as circuit breaker switching, reclosures, pf improvement capacitors, lightning strike, faults, etc., while the end user side of PQ disturbances involves non-linear loads, pf improvement capacitors, poor wiring & grounding techniques, electromagnetic interference, static electricity, etc. The effects of PQ disturbance depend upon the type of load and are of varied nature. Computers hang up leading to data loss, illumination systems often dim or flicker, measuring instruments give erroneous readings, communication systems experience noise, industrial process making use of adjustable speed drives inject harmonics as well as experience frequent shutdowns [7].

Industrial utilities need good PQ at all times as it vital to economic viability. The end users need standards that mainly set the limits for electrical disturbances and generated harmonics. The various organizations that publish power quality standards are ANSI (Steady State Voltage ratings), CENELEC (Regional Standards), CISPR (International Standards), EPRI (Signature newsletter on power quality standards), IEC (International Standards), IEEE (International and United States standards color book series).

There are generally two methods towards correction of PQ problems. The first method is load conditioning, wherein the balancing is done in such a manner that the equipments are made less sensitive to power disturbances and the other method is to install conditioning systems that either suppresses or opposes the disturbances. Active power filters offer an excellent solution towards voltage quality problem mitigation and can be classified into series active power filters and shunt active power filters. The selection of the type of active power filter to improve power quality depends on the type of the problem.

7. Economic analysis

With limited capacity addition taking place over the years, industrial utilities are forced to go for various energy management strategies. This may require additional financial commitment to achieve significant savings. The Life Cycle Cost (LCC) method is the most commonly accepted method for assessment of the economic benefits over their lifetime. The method is used to evaluate at least two alternatives for a given project of which only one alternative is selected for implementation based on the result of the economic analysis. In other words, LCC is the evaluation of a proposal over a reasonable time period considering all possible costs in addition to the time value of money. The initial investment made is called the capital cost while the equipment has a salvage value when it is sold. The additional investments exist in the form of recurring costs such as maintenance and energy

usage. These costs are grouped as annual costs and expressed in a form that can be added directly to the capital cost. The capital cost can be segregated into two components: direct costs and indirect costs. Direct costs are monetary expenditures that can be directly assigned to the project such as material, labor for design and construction, start-up costs while indirect costs or overheads are expenditures that cannot be directly assigned to a project such as taxes, rent, employee benefits, management, corporate offices, etc. The capital cost now represents the total expenditure.

Economic analysis is an important step in the energy management process as they greatly influence decisions with regard to plant operations [2]. Though there are a number of economic models available for investment justification, LCC analysis is more advisable to be used as it takes into consideration the useful period of the equipment taking into account all costs and also the time value of money, and converting them to current costs. LCC is the evaluation of a proposal over a reasonable time period considering all pertinent costs and the time value of money, and is usually tailor made to suit specific requirement.

$$\text{As in [2], Total LCC} = PW_{CL} + PW_{OC} \quad (1)$$

PW_{CL} is the present worth of capital and installation cost given by

$$PW_{CL} = IC + (IC \times FWF \times PWF) \quad (2)$$

IC is the initial cost; FWF is the future worth factor; PWF is the present worth factor.

$$FWF = \text{future worth factor} = (1 + \text{Inf})^N \quad (3)$$

Inf is the rate of inflation; N is the operating life in years.

$$PWF = \text{present worth factor} = 1 / (1 + DR) \quad (4)$$

DR is the discount rate

As in [8], LCC can be represented in general mathematical form as

$$LCC (P_1, P_2, \dots) = IC (P_1, P_2, \dots) + ECC (P_1, P_2, \dots) \quad (5)$$

IC is the initial cost of investment; ECC is the energy consumption cost; P_1, P_2, \dots are a set of design parameters.

As in [9], LCC can be mathematically expressed as for a specific case for motor options is

$$LCC = PP + [C \times N \times PWF] \times P_{LOSS} \quad (6)$$

PP is the purchase price; C is the power cost; N is the annual operating time; PWF is the cumulative present worth factor; P_{LOSS} is the evaluated loss

As in [10], LCC can also be expressed as

$$LCC = C_{IC} + C_{IN} + C_E + C_O + C_M + C_S + C_{ENV} + C_D \quad (7)$$

C_{IC} is the initial cost; C_{IN} is the installation and commissioning cost; C_E is the energy cost; C_O is the operating cost; C_M is the maintenance and repair cost; C_S is the down time cost; C_{ENV} is the environmental cost and C_D is the disposal cost.

LCC is the total discounted cost of owning, operating, maintaining, and disposing of equipment over a period of time. Thus the various components of LCC are:

- a. Initial & Future Expenses: Initial expenses are all costs incurred prior to occupation of the facility while future expenses are all costs incurred after occupation of the facility.

- b. Residual Value: Residual value is the net worth of a building at the end of the study period.
- c. Study Period: The study period is the period of time over which ownership and operations expenses are to be evaluated.
- d. Real Discount Rate: The discount rate is the rate of interest reflecting the investor's time value of money. Discount rates can be further separated into two types: real discount rates and nominal discount rates. The difference between the two is that the real discount rate excludes the rate of inflation and the nominal discount rate includes the rate of inflation.
- e. Present Value: Present value is the time-equivalent value of past, present or future cash flows as of the beginning of the base year. The present value calculation uses the discount rate and the time a cost was or will be incurred to establish the present value of the cost in the base year of the study period.
- f. Capital Investment: The amount of money invested in a project or a piece of equipment (this includes labor, material, design, etc.)

The LCC process involves the following steps:

1. Define cost analysis goals: This involves analysis objectives, identification of critical parameters and the various problems in analysis.
2. Identify guidelines and constraints: This involves evaluation of the available resources, determination of schedule constraints, management policy and technical constraints involved.
3. Identify feasible alternatives: This involves identification of all available options, practical and non-practical options.
4. Develop cost breakdown structure: This involves identification of all LCC elements, cost categories and their break downs.
5. Select / develop cost models: This involves identification of available cost models and construction of new models if necessary.
6. Developing cost estimating relationships: This involves identification of the input and supporting data.
7. Develop Life Cycle Cost profile: This involves identification of all present and future based cost related activities taking into consideration the inflationary effects.
8. Perform sensitivity analysis: This involves analysis of important parameters and its impact on overall cost and LCC.
9. Select best value alternatives: This involves choosing the best alternative that maximizes reliability with minimal cost.

Thus the life cycle cost is now written for specific situations taking into consideration all possible relevant parameters that need to support economic decisions regarding the various possible energy management options.

8. Energy Management Information Systems (EMIS)

EMIS is an IT based specialized software application solution that enables regular energy data gathering and analysis, used as a tool for continuous energy management. The main advantage of an EMIS application is the possibility of data collection, processing, maintenance, analysis and display on a continuous basis. A modern EMIS is integrated into an organization's systems for online process monitoring and control. An EMIS provides sensitive information to manage energy use in all aspects and is therefore an important element of an

energy management programme. The nature of the EMIS will depend on company, inputs, process, products, cost incurred, instrumentation, control systems, historical data, reporting systems, etc. The EMIS should provide a breakdown of energy use and cost by product / process at various levels to improve process, systems and achieve cost control. The information generated by an EMIS enables actions that create financial value through proper energy management and control. An EMIS can be effectively used for benchmarking energy usage to achieve cost control. Benchmarking can be defined as a systematic approach for comparing the performance of processes in the present state with the best possible results without reduction in quality or quantity. It is a positive step in achieving targets that would ensure process improvement. The various steps involved in benchmarking are:

1. For the similar process, obtain the best possible result from various sources and set as reference
2. Compare the working result with the reference result and analyze them for deviations
3. Present the findings to the personnel involved and discuss the options for sustained improvement
4. Develop action plans and assign responsibilities
5. Implement plans with regular monitoring

The success of EMIS depends upon management, policies, systems, project, investment, etc. Implementation of an EMIS should lead to early detection of deviations from historical energy usages thereby identification of energy management proposals, budgeting, implementation schedules, etc. It is important to recognize that the EMIS brings process and system benefits in addition to financial benefits.

9. Energy policy

An organization should show its commitment to energy management by having a well-defined energy policy. The energy policy should of some purpose and should be motivating enough for all employees to contribute towards achieving the organizational goals. The energy policy should essentially contain the following:

- Energy policy statement of purpose
- Objectives of the energy policy
- Commitment and involvement of employees
- Action plan with targets for every process and systems
- Budget allocation for various activities
- Responsibility and accountability at all levels

The policy should take into account the nature of the work, process, systems in use in addition to the work culture of the organization. The draft policy should be circulated amongst the employees for their inputs. Having taken all the employees into the process of energy policy formulation, the final version of the document should be approved by the top management and circulated within the organization for implementation. The above energy policy may be a summarized version and a detailed version. The summarized version should be displayed at various important locations while the detailed version should be filed as a hard copy in the various departments / units and sent as a email to all employees.

It is important to understand that the goals and objectives defined in the energy policy must be achievable. The energy policy implementation must be periodically reviewed and the expected outcomes compared with the results achieved. Wide deviations in the results should lead to a review of the process and systems in place in addition to the energy policy.

10. Conclusions

With increasing energy prices directly impacting the product prices in addition to widening energy demand-supply gap, industries are encouraged to go in for energy saving in addition to use of multiple energy sources. This can be accurately gauged by having an appropriate energy audit. A good and comprehensive energy audit will lead to a list of energy saving options that can be adopted. A detailed discussion on the audit findings leads to an energy management program. Some of the energy saving options requires additional investment. For major investments, life cycle cost (LCC) analysis is a useful tool as it evaluates a proposal over a reasonable time period considering all pertinent costs and the time value of money. It is also important to remember that introducing renewable energy sources into the process needs additional systems that concerns power quality issues. Energy management information system (EMIS) is an IT based specialized software application solution that enables regular energy data gathering and analysis used as a tool for continuous energy management. An EMIS provides sensitive information to manage energy use in all aspects and is therefore an important element of an energy management programme. All organization should show its commitment to energy management by having a well-defined energy policy. The energy policy should be definitive, straightforward and motivating enough for all employees to contribute towards achieving the organizational goals. Thus energy management in industrial utilities is the identification and implementation of energy conservation opportunities, making it a technical and management function, thus requiring the involvement of all employees so that energy is utilized with maximum efficiency

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