Energy Conservation and Audit

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Abstract- 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. For reducing cost and increasing efficiency, then use energy conservation, management and audit. The objective of Energy Management is to achieve and maintain optimum energy procurement and utilization, throughout the organization as To minimize energy costs / waste without affecting production and quality. To minimize environmental effects. 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.

I. INTRODUCTION

Energy is the ability to do work and work is the transfer of energy from one form to another. Energy comes in different forms - heat (thermal), light (radiant), mechanical, electrical, chemical, and nuclear energy. 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 non-renewable and fossil sources (coal, oil, etc.). These reserves are continually diminishing with increasing consumption and will not exist for future generations In this paper we study energy conservation and energy efficiency by how to reduce energy demand to reasonable minimum Cost, recover and re-use heat where possible and also study use of energy efficient equipment to supply remaining energy demand, and provide a means to manage use of energy and also study energy and environment and study how to carry out energy audit.

1. Energy Scenario and energy sources:

Energy can be classified into various types based on following criteria..

- Primary and Secondary energy
- Commercial and Noncommercial energy
- Renewable and Non-Renewable 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.

Secondary energy sources like steam, electricity are derived from primary energy sources like coal, oil & gases & are suitable for transportation, distribution and control.

Commercial Energy sources that are available in the market for a definite price are known as commercial sources that are available in the market for a definite price are known as commercial energy. Commercial energy forms the basis of industrial, agricultural, transport and commercial development in the modern world.

Non-commercial energy sources that are not available in the commercial market for a price are classified as Non-commercial energy. Example: Firewood, agro waste in rural areas; solar energy, animal power, wind energy.

Renewable energy sources are those that are essentially inexhaustible, like wind power, solar power, geothermal energy, tidal power and hydroelectric power

Non-renewable energy is the conventional fossil fuels such as coal, oil and gas, which are likely to deplete with time.

II. ENERGY CONSERVATION AND EFFICIENCY

2.1 Energy conservation:

Energy is defined as the ability to do a work and work is transformation of energy from one form to another and also the energy can neither be created nor destroyed. It includes any behavior that results in the use of less energy.

Examples Shut lights off , Don't leave water running, Recycle (bottles, can, papers, glass, etc.) ,Walk or ride a bike ,Open a window in the summer instead of turning on the air conditioning ,use public transportation.

2.2 Energy efficiency:

It involves the use of technology that requires less energy to perform the same function. A compact fluorescent light bulb that uses less energy to produce the same amount of light as an incandescent light bulb is an example of energy efficiency. The decision to replace an incandescent light bulb with a compact fluorescent is an example of energy conservation. Driving the same amount with a higher mileage vehicle is an example of energy efficiency.

2.3. Need of Energy Conservation:

Fossil fuels like coal, oil that has taken years to form is on the verge of depleting soon. In last 200 years we have consumed 60% of all resources. For sustainable development we need to adopt energy efficiency measures. Today 85% of primary energy sources come from non-renewable and fossil sources. These reserves increasing consumption and will exist for future generations.

Energy survey conducted by **Ministry of Power** in 1992 reveled that there is requirement of improvement in energy generation efficiency, improvement in energy transportation (transmission & distribution systems) and enhancing the performance efficiency of use end apparatus. Study of **'Energy strategies for Future'** evolved two things - efficient use of energy, energy conservation and use of Renewable Energy. Energy conservation emerges out to be the first and least cost option.

III. Area of application of Energy Conservation

Electrical system is a network in which power is generated using non-renewable sources by conventional method and then transmitted over longer distances at high voltage levels to load centers where it is used for various energy conversion processes. End user sector are identified as three major areas -Power Generating station, Transmission & Distribution systems, and Energy consumers. Consumers are further classified as Domestic, commercial and Industrial consumers.

3.1.EC in Power generating station:

To generate 1MW power generation cost is Rs 4.5 to 5.25 cores and T& D cost is Rs.2 cores .But cost of saved power is Rs.1Crores/MW important note is time period to set a power plant is 5 years; to set up transmission line 1 year and to plan energy conservation is only 1 month. We have less opportunity for EC in generating area but we can improve the performance efficiency of generators by optimization of load, optimal distribution of load among different units, periodical maintenance and also increasing the capacity by adopting advanced technology using renewable energy sources.

3.2.EC in Transmission & Distribution:

In India the power transmission and distribution (T&D) system is a three tire structure comprising of state grids, regional grids and distribution network. To meet the energy demand power system networks are interconnected through INTRA-REGIONAL LINK. The inter-regional power transmission capacity of India at end of 2007 was 14000 MW. T&D system in India is characterized by heavy losses of about 34.54% according to statistics of 2005-06, as compared to 10-15% in developed countries Power losses in T&D system can be classified as Technical losses and Commercial losses**.**

3.2.1Technical Losses In T&D System:

Power losses occurring in T&D sector due to imperfection in technical aspect which indirectly cause loss of investment in this sector, are technical losses. These technical losses are due to inadequate system planning, improper voltage and also due to poor power factor etc.

3.2.2Commercial Losses:

Commercial losses are those, which are directly responsible for wastage of money invested in transmission and distribution system. These losses are effects of inefficient management, improper maintenance etc. Corruption is also the main reason contributing to the Commercial losses. Metering losses includes loss due to inadequate billings, faulty metering, overuse, because of meters not working properly and outright theft. Many of the domestic energy meters fail because of poor quality of the equipment.

IV. Energy conservation techniques

4.1.1 EC Techniques in Transformers:

i) Optimization of loading of transformer:

By proper Location of Transformer preferably close to the load center, considering other features like centralized control, operational flexibility etc. This will bring down the distribution loss in cables**.**

Maintaining maximum efficiency to occur at 38% loading (as recommended by REC), the overall efficiency of transformer can be increased and its losses can be reduced

Under fluctuating load condition more than one transformer is used in Parallel Operation of Transformers to share the load & can be operated close to the maximum efficiency range

ii) By Improvisation in Design and Material of Transformer:

To reduce load losses in Transformer, use thicker conductors so that resistance of conductor reduces and load loss also reduces.

To reduce Core losses use superior quality or improved grades of Cold Rolled Grain Oriented (CRGO) laminations.

iii) Replacing By Energy Efficient Transformers:

By using energy efficient transformers efficiency improves to 95 % to 97%.

By using Amorphous transformers efficiency improves to 97 % to 98.5%.

By using Epoxy Resin cast/ Encapsulated Dry type transformer- efficiency improves to 93 % to 97%.

4.1.2Energy Conservation in Transmission Line:

To reduce line resistance-„R‟ solid conductors are replaced by stranded conductors (ACSR or AAC) and by bundled conductors in HT line.

High Voltage Direct Current (HVDC) is used to transmit large amount of power over long distances or for interconnections between asynchronous grids By transmitting energy at high voltage level reduces the fraction of energy lost due to Joule Heating. (V α1/I so I 2 R losses reduces). As load on system increases terminal voltage decreases. Voltage level can be controlled by using voltage controllers and by using voltage stabilizer if required reactive power transmitted through Transmission lines, it causes more voltage drop in the line. To control receiving end voltage, reactive power Controllers or reactive power compensating equipment's such as Static VAR controllers are used.

4.1.3. Energy Conservation In Distribution Line:

a) Optimization of distribution system: The optimum distribution system is the economical combination of primary line (HT), distribution transformer and secondary line (LT), to reduce this loss and improve voltage HT/LT line length ratio should be optimized.

b) Balancing of phase load- As a result of unequal loads on individual phase sequence, components causes over heating of transformers, cables, conductors, motors. Thus, increasing losses

and resulting in the motor malfunctioning under unbalanced voltage conditions.

c) Harmonics: With increase in use of non-linear devices, distortion of the voltage and current waveforms **occurs**, known as Harmonics. Due to presence of harmonic currents excessive voltage and current in transformers terminals, malfunctioning of control equipment's and Energy meter, over effect of power factor correction apparatus, interference with telephone circuits and broad casting occurs. Distribution Static Compensator (DASTACOM) and Harmonic filters can reduce this harmonics.

d) Energy Conservation by using power factor controller:

Low power factor will lead to increased current and hence increase losses and will affect the voltage. We can use Power Factor Controller or Automatic Power.

4.1.4Energy Conservation In Lighting system:

Good lighting is required to improve the quality of work, to reduce human's / worker's fatigue, to reduce accidents, to protect his eyes and nervous system. In industry it improves production, and quality of products / work.

a) Optimum use of natural light: Whenever the orientation of a building permits, day lighting has to be used in combination with electric lighting. The maxim use of sunlight can be get by means of transparent roof sheets, north light roof, etc.

b) Replacing incandescent lamps by Compact Fluorescent Lamps (CFL's): CFL's are highly suitable for places such as Living rooms, Hotel lounges, Bars, Restaurants, Pathways, Building entrances, Corridors, etc.

c) Replacing conventional fluorescent lamp by energy efficient fluorescent lamp: Energy efficient lamps are based on the highly sophisticated technology. They offer excellent color rendering properties in addition to the very high luminous efficacy.

d)Replacement of conventional ballast by Electronic ballast: Installation of high frequency (28 –32Mhz) electronic ballast in place of conventional ballasts helps to reduce power consumption up to 35%.

e) Installation of separate transformer for lighting: In most of the industries, the net lighting load varies between 2 to 10%. If power load and lighting load fed by same transformer, switching operation and load variation causes voltage fluctuations. This also affects the performance of neighboring power load apparatus; lighting load equipment's and also reduces lamps. Hence, the lighting equipment has to be isolated from the power feeders. This will reduce the voltage related problems, which in turn provides a better voltage regulation for the lighting this also increases the efficiency of the lighting system.

f) Installation of servo stabilizer for lighting feeder: Wherever, installation of separate transformer for lighting is not economically attractive and then servo stabilizer can be installed for the lighting feeders.

g) Control over energy consumption pattern: Occupancy Sensors, Daylight inked Control are commonly used in commercial buildings, malls, offices, where more no. Of lights are to be controlled as per operational hours microprocessor based Light control circuits are used. As a single control unit it can be programmed to switch on /off as per the month wise, year wise and even season wise working schedule.

4.1.5Energy Conservation in Motors:

Considering all industrial applications 70% of total electrical energy consumed by only electric motors driven equipment's.

a. **Improving power supply quality:** Maintaining the voltage level within the BIS standards i.e. with tolerance of +/-6%and frequency with tolerance of +/-3% motor performance improves and also life.

b. Optimum loading: Proper selection of the rating of the motor will reduce the power consumption. If the motor is operating at less than 50% of loading (η<50%) significant power saving can be obtained by replacing with properly sized high efficiency motors. If the motor is operating at loads below 40% of it"s capacity, an inexpensive and effective measure might be to operate in star mode.

c. Improving transmission efficiency: Proper selection of power transmission means (belts, gears) will reduces transmission losses.

d. Stopping idle or redundant running of motors or lights will save 100% power.

e. By use of Soft Starter: Soft starters are essentially stator voltage controllers; helps to overcome above problem. It helps to **restrict** starting current and also provide smooth start and stop operation.

f.By improving power factor: For improving p.f.connect the capacitor bank, which will improve the p.f. of the system from installation to generating station. Maximum improvement in overall system efficiency is achieved, which also reduces Max. Demand of the system and that will reflect in energy bill.

g. Use of high efficiency or Energy efficient motors

The energy efficient motors have reduced losses through improved design, better materials and improved manufacturing techniques. Generally motor life doubles for each 10 0C reduction in operating temperature. While selecting EEM, select with 1.15service factor, design for operation at 85% of rated load.

V. Energy and Environment

The usage of energy resources in industry leads to environmental damages by polluting the atmosphere. Few of examples of air pollution are sulphur dioxide (SO2), nitrous oxide (NOX) and carbon monoxide (CO) emissions from boilers and furnaces, chloro-fluro carbons (CFC) emissions from refrigerants use, etc.

5.1 Evolutionary Trends in Pollution Problems

In both developed and rapidly industrializing countries, the major historic air pollution problem has typically been high levels of smoke and SO2 arising from the combustion of sulphur-containing fossil fuels such as coal for domestic and industrial purposes.

Smog's resulting from the combined effects of black smoke, sulphate / acid aerosol and fog have been seen in European cities until few decades ago and still occur in many cities in developing world. In developed countries, this problem has significantly

reduced over recent decades as a result of changing fuel-use patterns; the increasing use of cleaner fuels such as natural gas, and the implementation of effective smoke and emission control policies. Traffic pollution problems are worsening world-wide. The problem may be particularly severe in developing countries with dramatically increasing vehicle population, infrastructural limitations, and poor engine/emission control technologies and limited provision for maintenance or vehicle regulation.

5.Energy Management:

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

Or "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"

5.1The 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.

VI. Energy Audit

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".

6.1 Aim of Energy audit (need)

- to minimize costs for energy
- to minimize operational costs
- to minimize costs for repairs and reconstruction
- to increase quality of environment that contributes to increased work productivity

6.2 Ten Steps Methodology for Detailed Energy Audit

Phase I –Pre Audit Phase

Step No	Plan of action	Purpose/Results	
Step 1	• Plan and organize •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 • First hand observation & Assessment of current level operation and practices	
Step2	•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 •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, compressors etc. •Boiler/Efficiency trials for (4 – 8 hours)

Step 6	•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 energy audit if any •Use brainstorming and value analysis s •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
Step 9	•Reporting & Presentation to top management	•Documentation, Report Presentation to the top management

Phase III –Post Audit phase

Step 10	•Implementation and Follow-up	Assistant implement ENCON recommendation measures and Monitor the performance •Action plan, Schedule for implementation •Follow-up and periodic review	

VII. Conclusion

Everything what happens in the world is the expression of flow of energy (Electrical) in one of its forms**.** In development process to cope with increasing energy demands, conservation and energy efficiency measures are two parallel paths.

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