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ENERGY CONSERVATION AND AUDIT-A CASE STUDY

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ABSTRACT: Final energy consumption can be analysed by taking into account the energy demand in each sector like industry,transportation,residential and agriculture.Energy consumption by 2015 year will amount to roughly 70% of the grossworldproduction,because of losses mainly in electric power production plants and in distribution and othertransformations inside energy industries.Energy saving is a social responsibility of every individual.In this paper we have analysed the different methods of energy auditing and we have analysed the energy consumption of our EEE department in K.L.University and provided the paths of less energy consumption.

Keywords: Energy audit, auditing types, instruments, opportunities, pay back periods.

I. INTRODUCTION

An energy audit is an inspection, survey and analysis of energy flows for energy conservation in a building, process or system to reduce the amount of energy input into the system without negatively affecting the output.It shows where the power consumption is more in the given system.It can also be called as controlling of the power to avoid losses for maximize efficiency

A) NEED FOR ENERGY AUDIT:

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

B)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, optimizing 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.

C)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:

Sample Worksheet for Economic Feasibility
Name of Energy Efficiency Measure

1. Investment • Equipment • Civil works • Instrumentation • Auxiliaries
2. Annual operating costs • Cost of capital • Maintenance • Manpower • Energy • Depreciation
3. Annual savings • Thermal Energy • Electrical Energy • Raw material • Waste disposal

Net Savings /Year (Rs./year) = (Annual savings-annual operating costs)
Payback period in months = (Investment/net savings/year) x 12

II. TYPES OF ENERGY AUDITS

The term energy audit is commonly used to describe a broad spectrum of energy studies ranging from a quick walk-through of a facility to identify major problem areas to a comprehensive analysis of the implications of alternative energy efficiency measures sufficient to satisfy the financial criteria of sophisticated investors. Three common audit programs are described in more detail below, although the actual tasks performed and level of effort may vary with the consultant providing services under these broad headings. The only way to insure that a proposed audit will meet your specific needs is to spell out those requirements in a detailed scope of work. Taking the time to prepare a formal solicitation will also assure the building owner of receiving competitive and comparable proposals.

A) PRELIMINARY AUDIT

The preliminary audit alternatively called a simple audit, screening audit or walk-through audit, is the simplest and quickest type of audit. It involves minimal interviews with site operating personnel, a brief review of facility utility bills and other operating data, and a walk-through of the facility to become familiar with the building operation and identify glaring areas of energy waste or inefficiency.

Typically, only major problem areas will be uncovered during this type of audit. Corrective measures are briefly described, and quick estimates of implementation cost, potential operating cost savings, and simple payback periods are provided. This level of detail, while not sufficient for reaching a final decision on implementing a proposed measures, is adequate to prioritize energy efficiency projects and determine the need for a more detailed audit.

B)GENERAL AUDIT

The general audit alternatively called a mini-audit, site energy audit or complete site energy audit expands on the preliminary audit described above by collecting more detailed information about facility operation and performing a more detailed evaluation of energy conservation measures identified. Utility bills are collected for a 12 to 36 month period to allow the auditor to evaluate the facility's energy/demand rate structures, and energy usage profiles. Additional metering of specific energy-consuming systems is often performed to supplement

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utility data. In-depth interviews with facility operating personnel are conducted to provide a better understanding of major energy consuming systems as well as insight into variations in daily and annual energy consumption and demand.This type of audit will be able to identify all energy conservation measures appropriate for the facility given its operating parameters. A detailed financial analysis is performed for each measure based on detailed implementation cost estimates, site-specific operating cost savings, and the customer's investment criteria. Sufficient detail is provided to justify project implementation.

C)INVESTMENT-GRADE AUDIT

In most corporate settings, upgrades to a facility's energy infrastructure must compete with non- energy related investments for capital funding. Both energy and non-energy investments are rated on a single set of financial criteria that generally stress the expected return on investment (ROI). The projected operating savings from the implementation of energy projects must be developed such that they provide a high level of confidence. In fact, investors often demand guaranteed savings. The investment-grader audit alternatively called a comprehensive audit, detailed audit, maxi audit, or technical analysis audit, expands on the general audit described above by providing a dynamic model of energy use characteristics of both the existing facility and all energy conservation measures identified. The building model is calibrated against actual utility data to provide a realistic baseline against which to compute operating savings for proposed measures. Extensive attention is given to understanding not only the operating characteristics of all energy consuming systems, but also situations that cause load profile variations on both an annual and daily basis. Existing utility data is supplemented with submetering of major energy consuming systems and monitoring of system operating characteristics.

III. ENERGY AUDIT METHODOLOGY

Step 1 - Interview with Key Facility Personnel

During the initial audit, a meeting is scheduled between the auditor and all key operating personnel to kick off the project. The meeting agenda focuses on: audit objectives and scope of work, facility rules and regulations, roles and responsibilities of project team members, and description of scheduled project activities. In addition to these administrative issues, the discussion during this meeting seeks to establish: operating characteristics of the facility, energy system specifications, operating and maintenance procedures, preliminary areas of investigation, unusual operating constraints, anticipated future plant expansions or changes in product mix, and other concerns related to facility operations.

Step 2 - Facility Tour

After the initial meeting, a tour of the facility is arranged to observe the various operations first hand, focusing on the major energy consuming systems identified during the interview, including the architectural, lighting and power, mechanical, and process energy systems.

Step 3 - Document Review

During the initial visit and subsequent kick-off meeting, available facility documentation are reviewed with facility representatives. This documentation should include all available architectural and engineering plans, facility operation and maintenance procedures and logs, and utility bills for the previous three years. It should be noted that the available plans should represent "as-built" rather than "design" conditions. Otherwise, there may be some minor discrepancies between the systems evaluated as part of the audit and those actually installed at the facility.

Step 4 - Facility Inspection

After a thorough review of the construction and operating documentation, the major energy consuming processes in the facility are further investigated. Where appropriate, field measurements are collected to substantiate operating parameters.

Step 5 - Staff Interviews

Subsequent to the facility inspection, the audit team meets again with the facility staff to review preliminary findings and the recommendations being considered. Given that the objective of the audit is to identify projects that have high value to the customer, management input at this juncture helps establish the priorities that form the foundation of the energy audit. In addition, interviews were scheduled with key representatives designated

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by the facility as having information relevant to the energy audit. These representatives may include major energy consuming system service and maintenance contractors and utility representatives.

Step 6 - Utility Analysis

The utility analysis is a detailed review of energy bills from the previous 12 to 36 months. This should include all purchased energy, including electricity, natural gas, fuel oil, liquefied petroleum gas (LPG) and purchased steam, as well as any energy generated on site. If possible, energy data is obtained and reviewed prior to visiting the facility to insure that the site visit focuses on the most critical areas. Billing data reviewed includes energy usage, energy demand and utility rate structure. The utility data is normalized for changes in climate and facility operation and used as a baseline to compute projected energy savings for evaluated ECM's.Utilities generally offer a comprehensive portfolio of rate tariffs and riders that can be tailored to the energy consumption and demand of the end-user. In addition, with the advent of deregulation, energy can be purchased on contract from a number of third party marketers. Using energy consumption/demand characteristics revealed by a detailed analysis of recent utility bills, the optimum energy supply options is identified.In addition, given the high cost of purchased energy it may be cost-effective to produce some of the facility's energy requirements on-site. Options may include: power generators for emergency power and peak-shaving, solar panels, wind power and cogeneration.

Step 7 - Identify/Evaluate Feasible ECMs

Typically, an energy audit will uncover both major facility modifications requiring detailed economic analysis and minor operation modifications offering simple and/or quick paybacks. A list of major ECMs is developed for each of the major energy consuming systems (i.e., envelope, HVAC, lighting, power, and process). Based upon a final review of all information and data gathered about the facility, and based on the reactions obtained from the facility personnel at the conclusion of the field survey review, a finalized list of ECMs (energy conservation measures) is developed and reviewed with the facility manager.

Step 8 - Economic Analysis

Data collected during the audit is processed and analyzed back in our offices. We build models and simulations with software to reproduce our field observations and develop a baseline against which to measure the energy savings potential of ECMs identified. We then calculate the implementation cost, energy savings and simple payback for each of the ECMs being investigated.

Step 9 - Prepare a Report Summarizing Audit Findings

The results of our findings and recommendations are summarized in a final report. The report includes a description of the facilities and their operation, a discussion of all major energy consuming systems, a description of all recommended ECMs with their specific energy impact, implementation costs, benefits and payback. The report incorporates a summary of all the activities and effort performed throughout the project with specific conclusions and recommendations.

Step 10 - Review Recommendations with Facility Management

A formal presentation of the final recommendations is presented to facility management to supply them with sufficient data on benefits and costs to make a decision on which ECMs to be implemented.

IV. ENERGY AUDIT INSTRUMENTS

The requirement for an energy audit such as identification and quantification of energy necessitates measurements; these measurements require the use of instruments. These instruments must be portable, durable, easy to operate and relatively inexpensive. The parameters generally monitored during energy audit may include the following: Basic Electrical Parameters in AC &DC systems – Voltage (V), Current (I), Power factor, Active power (kW), apparent power (demand) (kVA), Reactive power (kVAr), Energy consumption (kWh), Frequency (Hz), Harmonics, etc.Parameters of importance other than electrical such as temperature & heat flow, radiation, air and gas flow, liquid flow, revolutions per minute (RPM), air velocity, noise and vibration, dust concentration, Total Dissolved Solids (TDS), pH, moisture content, relative humidity, flue gas analysis – CO_2, O_2, CO, SO_x, NO_x, combustion efficiency etc.

Key instruments for energy audit are listed below.

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The operating instructions for all instruments must be understood and staff should familiarize themselves with the instruments and their operation prior to actual audit use.

ELECTRICAL MEASURING INSTRUMENTS:

These are instruments for measuring major electrical parameters such as kVA, kW, PF, Hertz, kVAr, Amps and Volts. In addition some of these instruments also measure harmonics.

These instruments are applied on-line i.e on running motors without any need to stop the motor. Instant measurements can be taken with hand-held meters, while more advanced ones facilitates cumulative readings with print outs at specified intervals.

1)CombustionAnalyzer: This instrument has in-built chemical cells which measure various gases such as O2, CO, NOX and SOX.

2)Fuel Efficiency Monitor: This measures oxygen and temperature of the flue gas. Calorific values of common fuels are fed into the microprocessor which calculates the combustion efficiency.

3)Fyrite: A hand bellow pump draws the flue gas sample into the solution inside the fyrite. A chemical reaction changes the liquid volume revealing the amount of gas. A separate fyrite can be used for O2 and CO2 measurement.

4)Contact Thermometer: These are thermocouples which measures for example flue gas, hot air, hot water temperatures by insertion of probe into the stream. For surface temperature, a leaf type probe is used with the same instrument.

5)InfraredThermometer: This is a non-contact type measurement which when directed at a heat source directly gives the temperature read out. This instrument is useful for measuring hot spots in furnaces, surface temperatures etc.

6)Pitot Tube and Manometer:Air velocity in ducts can be measured using a pitot tube and inclined manometer for further calculation of flows.

7)Water Flow Meter: This is a non-contact flow measuring device using Doppler Effect / Ultra sonic principle. There is a transmitter and receiver which are positioned on opposite sides of the pipe. The meter directly gives the flow. Water and other fluid flows can be easily measured with this meter.

8)Tachometer, Stroboscope, Speed Measurements: In any audit exercise speed measurements are critical as they may change with frequency, belt slip and loading. A simple tachometer is a contact type instrument which can be used where direct access is possible. More sophisticated and safer ones are non contact instruments such as stroboscopes.

9)Leak Detectors: Ultrasonic instruments are available which can be used to detect leaks of compressed air and other gases which are normally not possible to detect with human abilities.

10)Lux meters: Illumination levels are measured with a lux meter. It consists of a photo cell which senses the light output, converts to electrical impulses which are calibrated as lux.

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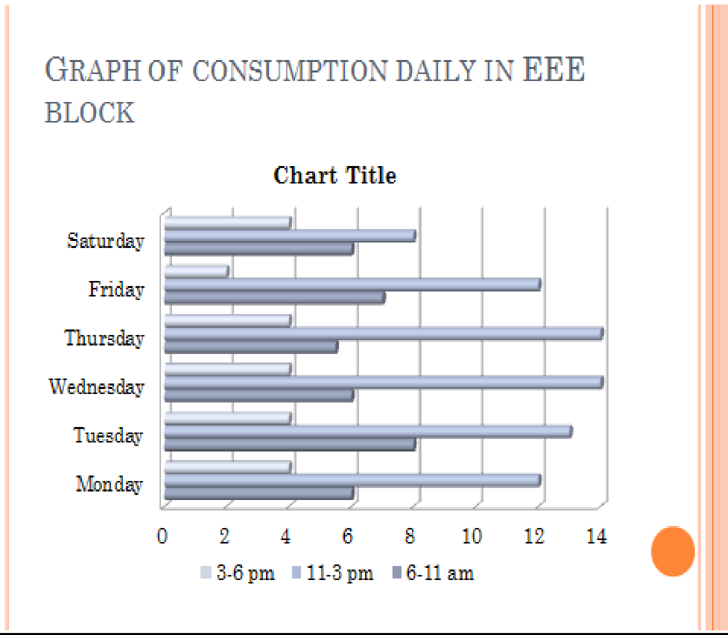

Fig1: Energy Consumption in EEE Block

Different equipment power consumption

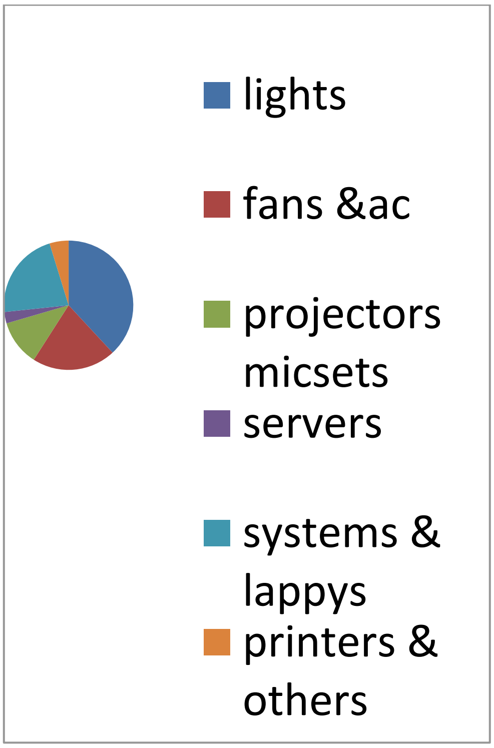

Fig2: Power Consumption of Different Equipment in EEE Dept.

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V. RECOMMENDATIONS FOR LOW POWER CONSUMPTION IN EEE DEPARTMENT

1) LIGHTING SYSTEM

1. One of the best energy-saving devices is the light switch. Turn off lights when not required.
2. Many automatic devices can help in saving energy used in lighting. Consider employing infrared sensors, motion sensors, automatic timers, dimmers and solar cells wherever applicable, to switch on/off lighting circuits.
3. As for as possible use task lighting, which focuses light where it's needed. A reading lamp, for example, lights only reading material rather than the whole room.
4. Dirty tube lights and bulbs reflect less light and can absorb 50 percent of the light; dust your tube lights and lamps regularly.
5. Fluorescent tube lights and CFLs convert electricity to visible light up to 5 times more efficiently than ordinary bulbs and thus save about 70% of electricity for the same lighting levels.
6. Ninety percent of the energy consumed by an ordinary bulb (incandescent lamp) is given off as heat rather than visible light.
7. Replace your electricity-guzzling ordinary bulbs (incandescent lamps) with more efficient types. Compact fluorescent lamps (CFLs) use up to 75 percent less electricity than incandescent lamps.
8. A 15-watt compact fluorescent bulb produces the same amount of light as a 60-watt incandescent bulb.

2) ROOM AIR CONDITIONERS

1. Use ceiling or table fan as first line of defense against summer heat. Ceiling fans, for instance, cost about 30 paise an hour to operate - much less than air conditioners (Rs.10.00 per hour).
2. You can reduce air-conditioning energy use by as much as 40 percent by shading your home's windows and walls. Plant trees and shrubs to keep the day's hottest sun off your house.
3. One will use 3 to 5 percent less energy for each degree air conditioner is set above22°C (71.5°F), so set the thermostat of room air conditioner at 25°C (77°F) to provide the most comfort at the least cost.
4. Using ceiling or room fans allows you to set the thermostat higher because the air movement will cool the room.
5. A good air conditioner will cool and dehumidify a room in about 30 minutes, so use a timer and leave the unit off for some time.
6. Keep doors to air-conditioned rooms closed as often as possible.
7. Clean the air-conditioner filter every month. A dirty air filter reduces airflow and may damage the unit. Clean filters enable the unit to cool down quickly and use less energy.
8. If room air conditioner is older and needs repair, it's likely to be very inefficient. It may work out cheaper on life cycle costing to buy a new energy-efficient air conditioner.

3)REFRIGERATORS

1. Make sure that refrigerator is kept away from all sources of heat, including direct sunlight, radiators and appliances such as the oven, and cooking range. When it's dark, place a lit flashlight inside the refrigerator and close the door. If light around the door is seen, the seals need to be replaced.
2. Refrigerator motors and compressors generate heat, so allow enough space for continuous airflow around refrigerator. If the heat can't escape, the refrigerator's cooling system will work harder and use more energy.
3. A full refrigerator is a fine thing, but be sure to allow adequate air circulation inside.
4. Think about what you need before opening refrigerator door. You'll reduce the amount of time the door remains open.
5. Allow hot and warm foods to cool and cover them well before putting them in refrigerator. Refrigerator will use less energy and condensation will reduced.
6. Make sure that refrigerator's rubber door seals are clean and tight. They should hold a slip of paper snugly. If paper slips out easily, replace the door seals.
7. When dust builds up on refrigerator's condenser coils, the motor works harder and uses more electricity. Clean the coils regularly to make sure that air can circulate freely.

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8. For manual defrost refrigerator, accumulation of ice reduces the cooling power by acting as unwanted insulation. Defrost freezer compartment regularly for a manual defrost refrigerator.

4)WATER HEATER

1. To help reduce heat loss, always insulate hot water pipes, especially where they run through unheated areas. Never insulate plastic pipes.
2. By reducing the temperature setting of water heater from 60 degrees to 50 degrees C, one could save over 18 percent of the energy used at the higher setting.

5)**COMPUTERS**

1. Turn off your home office equipment when not in use. A computer that runs 24 hours a day, for instance, uses - more power than an energy-efficient refrigerator.
2. If your computer must be left on, turn off the monitor; this device alone uses more than half the system's energy.
3. Setting computers, monitors, and copiers to use sleep-mode when not in use helps cut energy costs by approximately 40%.
4. Battery chargers, such as those for laptops, cell phones and digital cameras, draw power whenever they are plugged in and are very inefficient. Pull the plug and save.
5. Screen savers save computer screens, not energy. Start-ups and shutdowns do not use any extra energy, nor are they hard on your computer components. In fact, shutting computers down when you are finished using them actually reduces system wear - and saves energy

6)MOTORS

1. Properly size to the load for optimum efficiency. (High efficiency motors offer of 4 - 5% higher efficiency than standard motors)
2. Use energy-efficient motors where economical.
3. Use synchronous motors to improve power factor.
4. Check alignment.
5. Provide proper ventilation (For every 10 oC increase in motor operating temperature over recommended peak, the motor life is estimated to be halved)
6. Check for under-voltage and over-voltage conditions.
7. Balance the three-phase power supply. (An imbalanced voltage can reduce 3 - 5% in motor input power)
8. Demand efficiency restoration after motor rewinding. (If rewinding is not done properly, the efficiency can be reduced by 5 - 8%)

7) DRIVES

1. Use variable-speed drives for large variable loads.
2. Use high-efficiency gear sets.
3. Use precision alignment.
4. Check belt tension regularly.
5. Eliminate variable-pitch pulleys.
6. Use flat belts as alternatives to v-belts.
7. Use synthetic lubricants for large gearboxes.
8. Eliminate eddy current couplings.
9. Shut them off when not needed.

8)FANS

1. Use smooth, well-rounded air inlet cones for fan air intakes. • Avoid poor flow distribution at the fan inlet.
2. Minimize fan inlet and outlet obstructions.
3. Clean screens, filters, and fan blades regularly.
4. Use aerofoil-shaped fan blades.
5. Minimize fan speed.
6. Use low-slip or flat belts.
7. Check belt tension regularly.

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8. Eliminate variable pitch pulleys.
9. Use variable speed drives for large variable fan loads.
10. Use energy-efficient motors for continuous or near-continuous operation
11. Eliminate leaks in ductwork.
12. Minimize bends in ductwork
13. Turn fans off when not needed.

VI. PAY BACK PERIOD AND ANALYSIS OF THE POWER CONSUMPTION

As in this department the more power consuming applications are

1. Computers
2. Low Pf Motors
3. Tube Lights
4. Fans
5. Air Conditioners

Total number of computer to be changed to LED and energy efficient are -35x65w=2275
Total number of tube light to slim tubes is - 188x28=5264
Low Pf motors are replaced with high Pf motor - 6
Air conditioners with 3 star rating should be changed to 5 star - 3
Fridge with pf .6 are to be replaced with .85 - 2

Total power conserved if these applications are replaced with the energy efficient applications

1. 35x80=2800, 35x65=2275 net 525 w
2. 188x 40=7520, 188x28=5264 net 2256w
3. 188x 65=12220, 188x 55=10340 net 1880w
4. AC require 5900 w but 5 star require only 4950 w

Net =2850
Total watts conserved
7511 = 7.5 units per hr
7.5 x 24 = 180 units per day
180 x 365 = 65700 units per year
65700 x 5 = Rs. 3,28,500 per year are saved

Initial costs are:

1. Fan cost about Rs. 1800
2. LED monitor is Rs. 6500
3. AC 5 star is Rs. 66000
4. Slim tube light is Rs. 400

Payback period

Total cost of all applications to be changed are =856960
Cost saved on electricity bill every year is =328500
In 2 years and 8 months we can pay back our initial cost

VII. SCOPE

Energy audit includes following actions, steps and processes:

i. Conducting in depth energy audit by systematic process of accounting and reconciliation between the following:
   - Actual energy consumption.
   - Calculated energy consumption taking into account rated efficiency and power losses in all energy utilizing equipment and power transmission system i.e.
   - Conductor, cable, panels etc.

ii. Conducting performance test of pumps and electrical equipment if the difference between actual energy consumption and calculated energy consumption is significant and taking follow up action on conclusions drawn from the tests.

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iii. Taking up discharge test at rated head if test at Sr. No. (ii) is not being taken.
iv. Identifying the equipment, operational aspects and characteristic of power supply causing inefficient functioning, wastage of energy, increase in hydraulic or power losses etc. and evaluating increase in energy cost or wastage of energy.
v. Identifying solutions and actions necessary to correct the shortcomings and lacunas in (iv) and evaluating cost of the solutions.
vi. Carrying out economic analysis of costs involved in (iv) and (v) above and drawing conclusions whether rectification is economical or otherwise.
vii. Checking whether operating point is near best efficiency point and whether any improvement is possible.
viii. Verification of penalties if any, levied by power supply authorities e.g. penalty for poor power factor, penalty for exceeding contract demand.
ix. Broad review of following points for future guidance or long term measure:
   - C-value or f-value of transmission main
   - Diameter of transmission main provided
   - Specified duty point for pump and operating range
   - Suitability of pump for the duty conditions and situation in general and specifically from efficiency aspects
   - Suitability of ratings and sizes of motor, cable, transformer and other electrical appliances for the load

VIII. CONCLUSION

The energy audit which deals with inspection, survey and analysis of energy flows for energy conservation in a building, process or system to reduce the energy consumption by the system without negatively affecting the output .We showed where the power consumption is more in the given system.It also included the reduction losses and improvement of power quality .we suggested the new models in place of old existing models and found the cost benefits for new installed application over the old application.

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