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RESEARCH ARTICLE

ENERGY AUDIT PROCEDURES AND ENERGY SAVINGS OPPORTUNITIES IN EDUCATIONAL INSTITUTIONS AND INDUSTRIAL SECTORS

B. Mythili Gnanamangai[1], S. Rajalakshmi[1], Ashutosh Kumar Srivastava[2], R. Sudhakaran[3], G. Murugananth[4] and P. Thirumoorthi[5]

1. Nature Science Foundation, Coimbatore - 641 004, Tamil Nadu, India.
2. Central Zone, Nature Science Foundation, Gorakhpur - 273001, Uttar Pradesh, India.
3. North Zone, Nature Science Foundation, Faridabad - 101 213, Haryana, India.
4. DepartmentofElectrial and Electronics Engineering, Ahalia School of Engineering and Technology, Palakkad - 678 557, Kerala.
5. Department of Electrial and Electronics Engineering, Kumaraguru College of Technology, Coimbatore - 641 049, Tamil Nadu.

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Abstract

An energy audit is a survey in which the study of energy flows for the purpose of conservation is examined at an Organization. It refers to a system analysis that seeks to reduce the amount of energy used in an Organization without impacting the output. The audit includes suggestions of alternative means and remedial methods for achieving energy savings to a greater extent. Conventionally, electrical energy is generated by means of fossil fuels, hydraulic and wind. Exploitation of fossil fuels and their depletion rate, insist the need for alternate energy source and conservation of electric energy. Primary objective of an energy auditing and management of energy consumption is to offer goods or services at the lowest possible cost and with the least amount of environmental impact. The need for an energy audit is to identify the savings potential and cost reducing methods, understand the ways in which fuel is used, where, the waste occurs and find the scope for improvement.Preparation and completion of a questionnaire, physical examination of the campus, observation and examination of documentation, key person interviews, data analysis, measurements and suggestions are all part of the audit processes.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.

Introduction:-

An energy audit is proposed and conducted to ensure that energy saving practices are implemented and followed by Educational Institutions and Industrial sectors in a sustainable way. Energy audit involves several facts including energy savings potential, energy management and finding alternate source of energy (Cabrera et al., 2010). With these facts in mind, the audit's specific objectives are to assess the competence of the sustainability management and control system, as well as the departments' compliance with applicable rules, policies and standards. It has the

Corresponding Author:- B. Mythili Gnanamangai
Address:- Nature Science Foundation, Coimbatore - 641 004, Tamil Nadu, India.

potential to have a significant influence on the organization's operational cost besides the environmental impact (Singh et al., 2012). Energy Conservation Building Code (ECBC) is established in the year 2017 which provides minimum requirements for the energy-efficient design and construction of buildings across India. It also provides two additional sets of incremental requirements for buildings to achieve enhanced levels of energy efficiency that go beyond the minimum requirements (Gnanamangai et al., 2021). Bureau of Energy Efficiency (BEE) came into force in 2002 towards implementation of energy saving practices in an Organization. Energy-efficiency labels are information affixed to manufactured products and usually communicate the product energy performance (Ingleet al., 2014). BEE has developed a scheme for energy efficiency labelling of buildings coinciding with the star ratings of the building at accelerating energy efficiency activities. BEE Star Rating Scheme is based on actual performance of the building in terms of specific energy usage termed as 'Energy Performance Indicator' by means of star ratings labelled items used (Mishraand Patel, 2016).Energy audit programme provide aid in maintaining a focus on energy price variations, energy supply availability and efficiency, determining an appropriate energy mix, identifying energy-saving technology, retrofitting for energy-saving equipment and so on. In general, an energy audit process dealt with the driving conservation concepts into reality by giving technically possible solutions within a specified time limit while also considering the economic and other organizational issues (Asnani and Bhawana, 2015). It also dealt with the uncover ways to cut operating expenses or reduce energy use per unit of production in terms of savings. It serves as a "benchmark" (reference point) for managing energy in the organization for planning more energy-efficient use across the board (Cabrera et al., 2010).

Energy Conservation Acts (ECA)

These acts are aiming to provide information about the efficient use of energyand its conservation and for the matters connected therewith or incidental thereto. These are implemented by the Bureau of Energy Efficiency (BEE) came into force from March 2002 which extends to the whole of India exceptthe state of Jammu and Kashmir. BEE introduced the Standards and Labelling (S&L) programme in 2006.Energy efficiency standards are procedures and regulationsthat prescribe limits on the energy consumption (or minimum levels of the energy efficiency) of manufactured products in the buildings.Energy-efficiency labels are information affixed to manufactured products and usually communicate the product energy performance.The star rating of the building is aimed at accelerating energy efficiency activities in commercial buildings across the country. BEE Star Rating Scheme is based on actual performance of the buildingin terms of specific energy usagetermed as Energy Performance Indicator (EPI).BEE is generally offering the guidelines to conserve energy consumption and how energy efficiency methodology is not followed in the buildings.

Functions of Bureau of Energy Efficiency (BEE)

Energy intensive industries and other establishments specified as designated consumers are Aluminium, Fertilizer, Iron and Steel, Cement, Pulp and paper, ChlorAkali, Sugar, Textile, Chemicals, Railways, Port Trust, Transport sectors (Industries and services), Petrochemicals, Gas crackers, Naptha Crackers and Petroleum Refineries, Thermal Power Stations, Hydel power stations, Electricity transmission companies and distribution companies and commercial buildings or establishments. The BEE is applicable to all these designated consumers.As per the Energy Conservation Act 2001, any consumer with connected load of more than 100 kWor 120 kVA, is termed as designated consumer.

Energy Conservation Building Code (ECBC)

It was established in the year 2017 which provides minimum requirements for the energy-efficient design and construction of buildings across India. It also provides two additional sets of incremental requirements for buildings to achieve enhanced levels of energy efficiency that go beyond the minimum requirements (Mishraand and Patel, 2016). The ECBC is applicable to buildings or building complexes (are intended to be used for commercial purposes) that have a connected load of 100 kW or greater or contract demand of 120 KVA or greater. The National Building Code of India 2016 (NBC) is the reference standard for lighting levels, heating, ventilating, and air conditioning (HVAC), thermal comfort conditions, natural ventilation, and any other building materials and system design criteria addressed in this code. The following codes, programmes, and policies will take precedence over the code in case of conflict: 1) Any policy notified as taking precedence over this code, or any other rules on safety, security, health, or environment by Central, State, or Local Government and 2) Bureau of Energy Efficiency's Standards and Labelling for appliances and Star Rating for buildings, provided both or either are more stringent than the requirements of this code.

Need for Energy Audit

In any Organization, 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(Backlund and Thollander, 2015). Energy Audit will help to understand more about the ways energy and fuel are used and help in identifying the areas where waste can occur and where scope for improvement exists. Energy Audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control programmes which are vital for production and utility activities (Wang et al., 2013). 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.

Aims and Objectives of an Energy audit:-

The aims and objectives of an energy audit as per the checklist of the Nature Science Foundation, Coimbatore, Tamil Nadu, India are to identify the energy efficiency, energy conservation and savings opportunities at the premises of the audit sites in a systematic manner (Gnanamangaiet al., 2021). The study will be carried to review of energy saving opportunities and measures implemented in the audit sites which in turn to identify the various energy conservation measures and saving opportunities.Implementation of alternative energy resources for energy saving opportunities and decision making in the field of energy management are being monitored. Creating awareness among the stakeholders on energy conservation and utilization along with providing a technical information on how to build an energy balance as well as guidance to be sought for particular applications are also recorded. The technical information (for example, how to build an energy balance) as well as guidance to be sought for particular applications with respect to identify the potential energy-saving opportunities are also observed.

An energy audit should include a lot of information needed to move forward with an energy management plan. A table of suggested metrics, a description of major energy usage and cost indices, and a breakdown of how energy is used should all be included. An energy audit can also aid in the development of an action plan at an organization. The energy audit component of the energy management process comprises determining the amount of detail (high, mid-range and detailed) that an energy auditor will review during the audit, as well as the scope of any audit related suggestions (Rajalakshmiet al., 2021).

Benefits of Energy Audit

Reduced Energy Expenses:

The most obvious benefit is that the less energy the Organization uses, the less money that the Organization will have to spend on energy costs.

Identify Problems:

An energy audit can also help to identify any issues that the equipment might have. The auditor could find small leaks in the compressed air system. These leaks would cost a significant amount of money if it is not noticed. Auditors can also detect dangerous health risks like the carbon monoxide that's emitted from equipment that hasn't been vented properly. With a regular energy audit, the organization will be able to address these kinds of issues promptly to help ensure the health and safety of the staff members.

Increased Employee Comfort:

During the audit, the Organization might learn about changes that have been made regarding insulation and air sealing. Completing these enhancements will help create a more reliable and more efficiently cooled or heated space for the employees. In turn, more comfortable employees tend to be more productive, so not only will the Organization save on energy costs, but may also improve overall well-being.

Personalized Recommendations:

Working with an energy expert can help learn about new energy-efficient technologies. The professional will customize a plan, recommending which upgrades will give the most return on investment. These might include updated lighting systems, a new HVAC system, weatherization measures like insulation and air sealing, and more. While some of the recommendations might have a substantial up-front cost that many of them will pay for themselves in a short period of time with significantly reduced energy expenses.

Show Environmental Concern:
By taking steps to be more energy efficient, the Organization will be showing the employees and clients that the organization cares about the impact on the environment.

Increased Property Value:
Using the recommendations of an energy auditor to make facility more energy efficient could also help to increase its overall worth. Things like solar panels, high-efficiency LED lighting, and weatherization procedures are all things that contribute to a higher property value.

Longer Equipment Lifespan:
An energy auditor might recommend to update some of the equipment for maximum energy savings. If the Organization decide to upgrade, it will not only save on energy costs, but also expect the equipment to last a long time. This is because newer, more energy-efficient equipment doesn't have to work as hard as older, outdated units to provide the same level of performance.

Energy audits will evaluate the Organization "as a whole", the goal is not to evaluate single measures but to consider a wide range of available alternatives (Electrical, Mechanical, Envelope and Water).The audit will not only inform about the opportunities but also provide information with financial analysis. This will enable prioritization based on financial benefit and return on investment.It provides technical information regarding the proposed energy conservation measures.A good quality audit will analyse the historical energy use and find potential issues using statistical methods.Provide information with emissions analysis to help understand the benefits of the decisions from an environmental standpoint.Understand where energy is used and which areas are worth focusing on the most.Provide benchmark information to help understand the energy use performance compared to others.

Energy Auditing Procedure
In order to conduct an energy audit, several methods are adopted in the audit sites in which walk-through and detailed auditsmay be conducted. The balance of total energy inputs with total energy outputs and identification of all energy streams in a facility are taken into account. Amount of energy used by each of its energy streams are calculated as per the methodology mentioned in this Manual of Gnanamangai et al. (2021). The top three operating expenses of the Organization are typically observed to be energy (both electrical and thermal), labour and materials. During the audit, physical verification of Lighting, Ceiling-, Table- and Exhaust- Fans, A/C machines, Solar panels, Heaters, Generators, Uninterrupted power supply machines and ventilators load fixtures and verification of installed energy efficient system's capacities are carried out. Inspection of when the cost or prospective cost savings in each of the above components are considered, energy always wins, and the energy management task becomes a key cost reduction area. Location of the electrical machines, conditions of them and their accessories are inspected through physical verification as per the regulation of World Green Building Council (WGBC, 2021). The energy bill from the supply utility company (Example: Tamil Nadu Electric Generation and Distribution Corporation Limited, Chennai) is audited and assessed for the load demand requirement and efficient consumption of energy. Stakeholders are interacted with the scope for improvement and energy and environment management during the audit (Choy and Karudan, 2016).

According to the 2001 Energy Conservation Act, 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'. This act is giving a clear picture stating that energy management and environmental effects should be taken into action for energy savings in a sustainable manner (Rajalakshmi et al., 2021). Stakeholders are to be interacted with the scope for improvement about the audit will be discussed. Potential areas in which the scope of energy conservation and saving opportunities available in the current context have to be identified and suggested for implementation.

Conduct of an Energy Audit
There are seven steps in the energy audit processes such as 1) Opening meeting among the audit team and auditees, 2) Planning and organizing the energy audit, 3) Conduct a walk-through audit at different sites, 4) Macro data collection and observation, 5) Analysis of data collected from the Organization, 6) Best practices followed in the Organization towards energy savings, 7) Recommendations for further improvement, 8) Exit meeting after the audit to discuss about the audit findings and 9) Follow-up of the implementation of recommendations and suggestions.

For efficient working, a standardized approach for conducting an energy audit is required. An initial audit site assessment is always recommended, as the planning of the procedures required for an audit is crucial.

Planning and organizing the audit:
Planning and organizing are the integral part of the energy audit. An initial visit to the audit sites is to be organized and the areas to be inspected are listed

Walk-Through audit:
Simple audit, screening audit or visual audit are the other names, by which walk-through audits are addressed. The main purpose of the walk-through audit is to obtain general information about the sites in which electrical energy is being used at the maximum.

Macro Data collection and observation:
Current level operation and practices within the campus are to be assessed and then the data regarding the number of electrical loads connected in each section are to be collected.

Instruments used for an Energy Audit
An energy audit requires measurements, such as the energy identification and quantification, and these quantities necessitate the instruments to be used in a consistent way. The following are some of the criteria that are commonly monitored during an energy audit: Voltage (V), Current (I), Power factor, active power (kW), apparent power (demand in kVA), reactive power (kVAR), energy consumption (kWH), frequency (Hz), harmonics, illumination level, etc. are the basic electrical parameters that are to be studied in an energy audit. Temperature and heat flow, radiation, air and gas flow, liquid flow, speed, air velocity, noise and vibration, dust concentration, TDS, pH, moisture content, relative humidity, flue gas analysis - CO_2, O_2, CO, SO_x, NO_x, combustion efficiency are the mechanical, thermal and other parameters that are to be analyzed during the audit.

Energy Audit Process and Determination
The site inspection will take place at the agreed-upon time during the initial meeting. In order to evaluate the site's pattern of energy usage and check tariffs, the energy auditor will examine at least 24 months of energy payment bills.Following the completion of energy audits, the energy audit report will include a list of energy-saving options along with a detailed recommendation. Although the majority of the proposals will require some financial investment, the report should assist in determining which are most cost-effective and realistic. Obtaining estimates from vendors as well as implanting ideas and instructions to save energy are the next and last phase of audit.

Targeted Energy Audit
Target audits are more focused on a certain sector, piece of equipment or procedure. During the audit, detailed data will be collected and analysed. It entails conducting in-depth interviews with the target participants, as well as analysing the energy flow and associated costs. The outcome is to recommend activities to be engaged for improvement.

Detailed Energy Audit
A comprehensive energy audit generates a detailed facility implantation plan by accounting for all important equipment's energy consumption. The most precise calculation of energy savings and costs is provided by this audit (Bae and Seol, 2006). It considers how all projects interact, accounts for the energy consumption of all important equipment and delivers full energy cost efficiency estimates as well as project prices. The energy balance is one of the most important parts of a thorough audit. This focuses on a list of energy-consuming systems, current operating circumstances assumptions, and energy use calculations. Detailed energy auditing is being carried out in three phases such as Phase I (Pre-audit Phase), II (Audit Phase) and III (Post-audit Phase).

Execution of an Energy Audit
Phase I: Pre-Audit activities
The major action is to visit and examine the audit site, followed by the audit process plan. During the visit, the auditor should discuss the goals of the energy audit with the site's senior management people, as well as the guidelines associated with the audit's recommendations, analyze the major energy consumption data with the relevant personnel and obtain site drawings like building layout, steam distribution layout, compressed air distribution and electricity distribution. The main objectives of this visit are to finalize the energy audit team and to determine which of the major energy-consuming areas which in turn to identify any existing instrumentation or the need for new metering. Determination of whether any meters, such as kWh, steam, oil, or gas metres, need to be installed prior to the audit, planning according to the time frame to gather macro data on plant energy resources and main energy consumers.

Phase II: Detailed Energy Audit activities
Depending on the extent and complexity of the system, a full audit might take anywhere from a few weeks to several months to complete. Detailed studies are used to create and investigate energy and material balances for specific plant, department or pieces of process equipment. To guarantee that nothing is missed, plant activities are watched for lengthy periods to time whenever possible, including at night, on weekends, and during ordinary working hours. The audit report will include a breakdown of energy inputs and outputs by the main department of feature, as well as an evaluation of the performance of each phase of the manufacturing process.The audit report should conclude with specific suggestions for conducting detailed technical studies and feasibility assessments in order to assist the implementation of conservation programmes that require expenditure. During the detailed audit phase, the following information will be collected:

1. Energy consumption by kind of energy, sector, major process equipment and end-use
2. Data on the material balance (raw materials, intermediate and final products, etc.)
3. Data about energy prices and tariffs
4. Diagrams of process and material flow
5. Site service creation and distribution (ex: compressed air, steam)
6. Energy supply sources (ex: electricity from the grid or self-generation)
7. Fuel substitution, process adjustments, and the utilization of cogeneration systems (combined heat and power generation)

Phase III: Post-Audit activities
During this phase, the organization's energy management ensures that all of the audit team's recommendations on Energy Conservation (ENCON) approaches are correctly implemented in the system. It tracks the system's performance once its' been implemented and keeps track of the results. It also plans and manages future audits, as well as preparing an action plan for implementation. Periodic evaluations will be done, and the team will identify any additional areas for improvement during the post-audit phase.

Steps to be followed in an Energy Audit
The process for conducting an energy audit must be adaptive from one industry to the other. An energy manager / representative or an auditor can start with these steps and add to or adjust them based on their needs and industry / educational institutions types.

Lighting systems

Lighting is a crucial service that keeps people out of the dark in all sectors. Industrial lighting consumes between 2 and 10% of total electricity, depending on the type of industry. In the realm of lighting, technological advancements and increased efficiency have resulted in significant energy savings. To reduce energy consumption in buildings, natural lighting can save a significant amount of energy compared to artificial lighting. Improve the light control system, by grouping the lighting systems such that it provides greater flexibility in control. For this microprocessor or microcontroller can be installed. It's better to use natural day lights always, wherever possible and available.

Evolution of energy efficient lamp systems

Electrical systems

In most buildings, electricity is the most frequent source of energy. Most of the industrial activities use four types of opportunities to reduce the cost of it. The opportunities include reduction of peak demand, or the maximum power in kW/kVA needed by the facility, reduction of overall energy (measured in kWh) consumed, increasing the facility's power factor and transfer of energy usage at the time when energy costs are found to be lower.

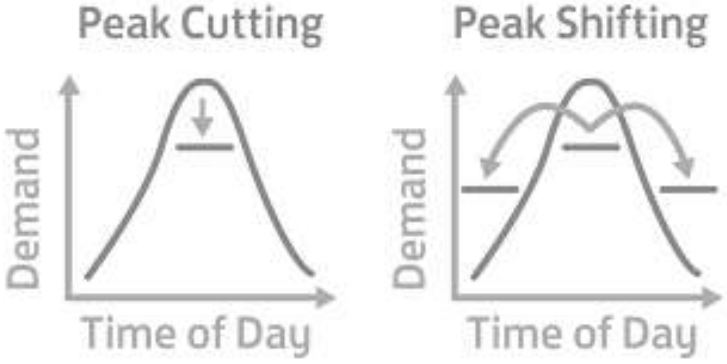
Energy Saving opportunities in Electrical Systems

a. Create a public awareness:

An awareness among the workers about the expense of electricity and services as well as the amount spent in the plant to be created. A good contact mechanism should be established such that the communication of energy conservation efforts and its outcome reaches all the stakeholder. Create awareness such that any electrical appliances when not in use have to be switched off. In particular, switching off the TVs, laptops, desktops and other electronic gadgets in sleeping mode for more than an hour is not advisable. Also continuous charging of mobile phones should be avoided. This will improve the life of the gadget and also reduce the electricity consumption.

b. Reduce the peak demand

Peak demand can be reduced by shutting off non-essential loads termed as load shedding during peak hour, rescheduling the operation of certain loads such that some of them are operated during off-peak period and improving the process to reduce electrical power requirement.



Reducing of Peak Demand in energy efficiency

c. Reducing energy consumption

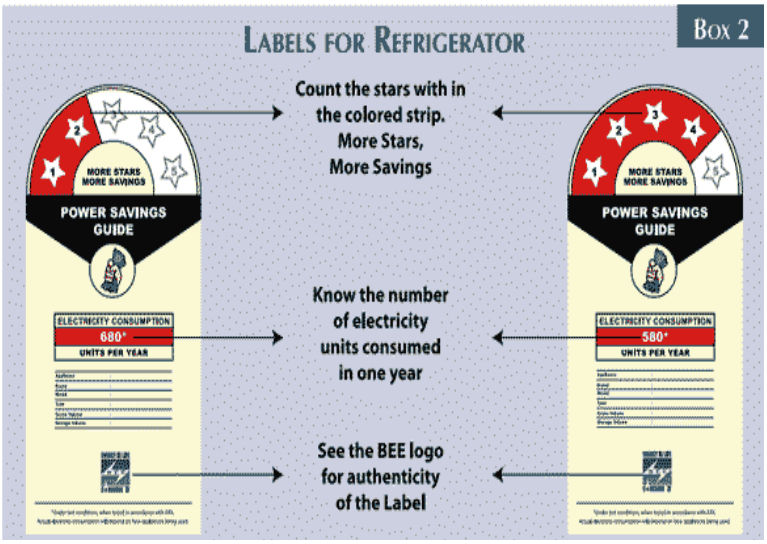
Energy consumption can be reduced by switching off excessive lights, fans, AC machines and replacing inefficient lighting fixtures with more energy-efficient fixtures. Shut down the unneeded equipment whenever it is necessary. Replace motor and driven equipment drives with energy-efficient variable speed drives, look into hydraulic drives and switch to soft-start technology. Replace old electric motors with energy efficient electric motors once the efficiency showed poor in performance which will be used for energy consumptions and savings.

d. Power factor improvement

Slight improvement in power factor, can reduce the energy consumption to a greater extent. At a main switchboard or central distribution site, utilize the appropriate capacitors as a bank.The capacitors can be installed in a smaller group at the motor control centre. Large capacitor banks can be individually installed on large power users for effective power improvement.

e. Use of high star rated equipment

Appliances viz. refrigerators, air conditioners, geysers, heaters, televisions, etc. might have star rating stickers, which are called Bureau of Energy Efficiency (BEE) star labels. These labels indicated how much electricity that appliance consumes in a year. The ratings may be from one star to five stars. When the equipment is with five stars, it means that it's extremely efficient and consumes less energy with standard operating conditions. The star label is authenticated only when it possesses the BEE logo on the label. The following Figure depicts the sample star label and the details provided by it.



Various Star labels on energy conservation by the Bureau of Energy Efficiency (BEE)

f. Refrigerator systems

Refrigerators are an important appliance in domestic and industrial sectors. It plays a vital role in the healthcare industry in large scale usage. The energy saving opportunities that could be attempted in refrigeration systems are replacing the old refrigerator with a new one, such that the new one is of high star rated and so energy efficient. Location of the refrigerator is crucial and should be located with proper ventilation on the back side of the refrigerator. Setting an optimal temperature will improve the life of the appliance. The other ways to improve the energy efficiency of the refrigerator includes, closing the door without any delay, defrosting it and checking for door seas frequently and only placing cold food stuff inside.

g. Air-conditioners

Air-conditioners are quite common and wide usage now-a-days. Following certain procedures will improve the performance of the air-conditioners effectively and thereby reduce the energy consumption. The procedures to be adopted are routine cleaning of AC filters and evaporator coils, straightening of the bent coil fins, inspecting the window seals such that no cool air escapes from the conditioned space and regular cleaning of the debris from fan, compressor and condenser in case of split ACs.

h. Optimal water usage

Setting of optimal temperature and water usage also improves energy efficiency of an establishment. There are some practices would result in reduced energy consumption like a) Take short showers instead of baths, as it reduces the time in showers, b) Reduce the water heater's temperature and turn-off the faucet, c) Laundry loads should be washed with cold water, d) Use the dishwasher effectively, e) Fix the leaks and cracks in the piping systems in the buildings, f) On the water heater tank, instal low-flow fittings and heat traps, g) Hot-water storage tanks should be insulated properly, h) Timers can be installed for geysers and i) Old clothes washers and geysers can be replaced.

i. Alternate energy sources

Use of alternate energy sources will reduce the electricity consumption. Geysers can be replaced with solar water heaters. In spite of higher capital cost, the solar water heaters aid in reduced consumption of electrical energy to a greater extent.

Solar Water Heaters

Carbon Footprint by measuring Carbon dioxide level in the Campus

The level of carbon dioxide is measured in different places across the Organization campus using a portable CO_2 Analyzer (Non dispersive infra-red meter). In addition, CO_2 meter is also displayed the readings of atmospheric temperature, relative humidity and dew point in the places, where the level CO_2 is measured. All the reading are taken simultaneously.Carbon footprint per year is calculated (www.carbonfootprint.com) based on electricity usage per year in which CO_2 emission from electricity and the sum of transportation per year in terms of number of the shuttle buses service operated by the Organization and number of cars, motorcycles and trucks entering in the Organization campus (Peters and Romi, 2014). These factors are multiplied with total number of trips in each day and approximate travel distance of vehicles covered in each day with a coefficient (0.01) to calculate the emission of CO_2 in metric tons/year. There are some ways to reduce the carbon footprint in the organizations effectively. Understanding the carbon footprint can help limit the impact of the consumption on the environment. Small changes can make a big difference in the long run, for example when it comes to transportation, food, clothing, waste, etc. in energy conservation strategies (Pramanik, 2013).

Conclusion:-

The energy conservation initiatives taken up by every organization are substantial. Energy efficient lighting schemes, awareness created among stakeholders and necessary power backups should be practiced by the organization effectively. There are some best practices should be followed on energy audit in the Organization like use of efficient Transformers, Generators and UPS that should be protected properly with fencing and kept awareness boards on 'Dangers' and 'Warnings'. Electrical wires, switch boxes and stabilizers should be properly covered without any damage which will cause any problems to the stakeholders. Adaptation of drip and sprinkler irrigation and solar street-lights in the campus to minimize the energy potential should be well appreciated. This may lead to the prosperous future in context of 'Energy Efficiency Campus' and thus sustainable environment and community development to the stakeholders in coming years to come.Energy management programmes include energy audits, wherein, the savings potential and cost reducing methods are identified and operated.

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