Journal of Energy Research and Environmental Technology (JERET)
p-ISSN: 2394-1561; e-ISSN: 2394-157X; Volume 5, Issue 3; July-September, 2018; pp. 76-78

http://www.krishisanskriti.org/Publication.html

A Review on the Energy Audit of the Building Sector

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Abstract—*Energy consumption in the building is an important issue for the government as well as the private organization. The building sector (residential, commercial and industrial) have become the worldwide energy consumer with 40% of overall energy consumption. More than half of the total energy consumed by the industrial sector worldwide for various industrial processes. The most of the energy consumption comes from the heating, cooling and lighting load. Thus, the energy audit of the building is an essential exercise to promote energy retrofitting measure. The aim of the energy audits to reduce energy consumption in the building, reducing energy cost and provides better indoor thermal comfort. Energy audit to the building includes building construction materials, heating, cooling and lighting load. The aim of the paper is to review the techniques of energy auditing which include building simulation software, construction material used by considering energy conservation in the form of electrical energy that helps to fill the gap in energy efficiency improvement, policy development, and environmental analysis.*

Keywords: *Energy Consumption, Energy Auditing, Energy saving techniques.*

1. INTRODUCTION

Energy is essential for social and economic development of the country. In the industrialised countries more than a billion of people (about 20% of the world's population) consume about 60% of the total energy whereas 40% of the total energy is consumed by the developing countries [1]. The environment and economic are affected due to energy consumption in the building sector. The building sectors consume 40% of the total energy Worldwide [2]. The most of the consumption in buildings came from the heating and Air- condition system which ensure indoor thermal comfort of the occupants. Literature[3-5] shows that the public non residential building i.e. school buildings consumes a large amount of thermal energy and reduce indoor air quality as its health hazardous, because there is no energy saving measure were applied in the buildings. Therefore, it is important to do the energy audit of the building for reduces the energy consumption and improve indoor air quality for the occupants.

Energy audit is a process to identify the problem in the building sector, reduce the energy consumption and improve indoor thermal comfort. Energy audit analysis was performed in a school building of Italy. Umberto and Stefania [6] studied both electric and thermal energy consumption in the 13 school buildings by energy audit techniques. Their analysis shows thermal consumption is up to 80% of the total energy consumption. They found that the electric energy can be reduced up to 46% and thermal energy can be save up to 38%. From the last 20 years, the environment is polluted due to poor building performance; where the building releases 50% of carbon dioxide emission and 70 % sulfide oxide into the atmosphere. Industrial building consumed 16% of World fresh water, 25% of timer and 40% of World energy annually [7]. 50% of electricity is consumed by domestic sector in Saudi Arabia [8]. In the Europe the energy consumption of building rises up to 40% of its total energy [9]. Sustainable material and construction, sustainable energy use and waste management are the three pillars of sustainability in the building environment and the three aspects that affect the building environment are thermal comfort, indoor air quality and energy efficiency. Many authors have implemented the three levels of energy auditing for the existing buildings and found that the buildings performance could be improved. Various governmental offices in Hong Kong studied for energy performance and improving energy management practice. Its reveals that the energy saving could be achieved through the energy management practice which can minimize the electric energy bill [10].

The aim of the paper is to review the energy consumption in the building, heating, cooling and lighting loads, energy audit techniques and energy saving techniques.

2. ENERGY AUDIT TECHNIQUES

Energy audit technique can be conducted into three different level of auditing. Depend on the building complexity, budget limit and time. The 3 level of audit defined by the ASHRAE 100- 2006 standard are as follow: level 1, "walk through assessment", level 2, "energy survey and analysis" and level 3, "detailed analysis of capital intensive modification". A flow chart representing the audit process is shown in Figure 1. The level of energy audit is explained briefly as below:

Level 1 Walk through assessment

The level 1 is the simplest and basic requirement of the audit. This level needs to take several inspection of the building by

the energy audit team. A proper checklist of the building envelopes (door, window, roof, floor etc.) can prepare by the audit team and also necessary to bring the instruments i.e., millimeters, thermometers, lux meters etc. during the inspection. This level includes the general inspection of building envelopes, HVAC equipment, lighting and other equipments in the building. The level 1 provide brief information about the heat, cooling lighting uses in the building and insulated non- insulated part of the building.

Level 2 energy survey and analysis

The information collected by energy audit team from level 1 is not sufficient to understand the building performance. Thus a survey measuring is necessary. The purpose of the survey to identify how energy are being used in the building, how much for heating, how much for cooling, how much for lighting etc. Energy audit team identify which part of the building or component is needed to improvement for ensure the thermal comfort of the occupant. In this level of auditing, it is necessary to identify the energy losses. There at various instrument that help in energy audit survey e.g. light level meter, data logger, temperature and humidity meter, infrared thermometer, indoor air quality meter etc. The inspection of this level gives the information of heat losses from wall, roof, floor, door, and window.

Level 3 detailed analysis of capital intensive modification

A comprehensive audit provides opportunities to most accurate estimate of energy and cost saving. It provides information of energy saving of all the major equipment uses in the building or industries. The detailed audit is one of the key components of the energy balance. A detailed audit may be able to take several weeks or months to complete. The detailed analysis of audit provide a detailed of energy input and product output by major processing function in the industries and evaluate the efficiency of all the process in the industry.

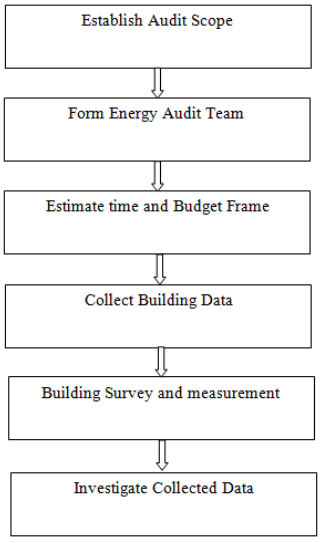

Figure 1: The Energy audit flow chart [18]

3. THERMAL LOAD CALCULATION

3.1. Thermal performance of the building

Thermal performance of entire building is very essential to save energy. Thermal investigation of building includes, construction material, insulation material, the building consumed up to 55% of the total energy after the working hour, so, there is a good opportunity to save the energy in the building.

3.2. Lighting Load and Plug-in equipment

Lighting is the second largest component of electricity consumption in the building. The energy uses and consumption load could vary, it depend on the type of lamps uses and operating hours. After working hours, the light and plug-in equipment were left on and it consumes lots of energy. Sait [11] carriers a computer tool Hourly Analysis Program (HAP) to simulate energy use, calculation of energy cost and used to estimate loads and designing system [12].NETWORK ANALYZER MPR-53S uses for measure the daily consumption [13].

4. RECOMMENDATION TO IMPROVE THE EFFICIENCY OF THE BUILDING PERFORMANCE

Many authors [14-16] suggested that the 10% of energy can be save by insulating the exterior wall and 20 % of space cooling load can be reduce by applying the glass wool [17]. Install occupancy sensors to interact with the occupancy load in the room/ office, which can be reduce energy consumption in the building. Eliminate unnecessary energy uses by lighting and plug-in equipment.

If the indoor air temperature could be maintained at 24^{o}C, the energy can be save up to 23.2 %. The 5.7% of energy can be saving if the temperature is set to 28^{o}C after working hours. 13.7 % of energy can be saved if HVAC system is turned off during the weekend. 2.3% of the total energy can be saved, if T-8 fluorescent replaced with T-5 fluorescent light [18].

5. CONCLUSION

The levels of the energy audit identify many opportunities to save energy and very less payback period. If the recommendation by the energy audit team is being implemented, the 52% of total energy can be saved [18]. 45% of electricity consumed during the working hour and 55% of electricity was consumed during the non-working hour. So, it is recommended that timer sensors should be installed on the A/C units to turn off the units after the working hours and during the weekends. The electrical load in the commercial buildings due to air conditioning is between 50% and 70% [11]. Insulation provides the building warmer in winter and cooler in summer. 60% of heat loss occurs through single pane

window, thus installing double glass window can reduces the heat loss through the window.

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