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STUDY ON WALK-THROUGH ENERGY AUDIT OF A FACULTY BUILDING

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ABSTRACT

Nigeria has been facing energy crisis for several years to meet the growing energy needs. Therefore, for sustainable environment and to contribute towards carbon neutrality, it is very much crucial to introduce energy audit in every sector in order to cut the growing demand. As such, this paper focuses on walk-through energy audit of Faculty of Engineering building in Federal University Dutsin-Ma. Data was collated manually and "Microsoft Excel" tool was used to analyze the building's energy consumption. Electrical systems in the building were partitioned in to 68% for Surface panel light, 19% for Fan, 8% for AC, 3% for Fridge, 1% for Computer, 0.2% for projector, and 0.4% for printer and TV respectively. The result obtained shows total connected electric load as 131254-watt, with 10480-watt for lighting, 3380-watt for electrical equipment and 117394-watt for cooling and ventilation systems. Moreover, average individual energy consumption per day was found to be 463-kWh for AC, 151-kWh for Fan, 73-kWh for lighting, 23-kWh for fridge, 0.3-kWh for printer, 0.4-kWh for projector, 0.7-kWh for TV, and 10-kWh for Computer. The result also revealed that lighting systems have the highest percentage on number of appliances, whilst cooling and ventilation parameters have the highest power consumption amongst other parameters. Therefore, energy conservation measures discussed for AC being the highest energy consuming appliance may result to optimistic energy saving. Furthermore, reliable environmental-friendly alternative energy source that is up to 131-kW can be use to power lighting, cooling & ventilation and electrical appliances of the Faculty building.

Keywords: Energy Audit, Walk-Through, Microsoft Excel, FUDMA, HVAC

INTRODUCTION

Energy is one of most essential operating parameter in residential, industrial and commercial sector of any country for economic and social development. Hence, energy consumption keeps on increasing globally. This consumption in 2017 has reached 13,730 Mtoe which is 2.33% greater than that of the year 2016 (Li, 2008). The prominent source of this energy is fossil fuels, which are non-renewable and harmful to mankind and his environment. Despite the emergence of renewable energy sources such as solar, wind, and biomass; a sustainable option that would reduce dependence on these fossil source has not been fully developed yet. One of the techniques that would facilitate bridging this world energy demand and supply gap apart from enhancing alternative sources of energy generation is efficient energy utilization.

The process of analyzing a facility, showing how and where that facility can limit its energy consumption as well as lower its cost is known as energy audit. In existing buildings, factors such as aging of the device, aging of the wires used, dust factor, humidity, and various other factors perverts the performance and the efficiency of loads system. These result in loss of electrical energy in form of heat energy which increases power consumption and lowers the system efficiency. The losses could be reduces through energy auditing (Marika, 2017).

Faculty of Engineering building in Federal University Dutsin-ma came on board in 2021. The building as depicted in plate 1 is 2 storied, with 4 wings. It consists of administrative offices, computer laboratories, lecture rooms, security section, faculty library, Departmental libraries, Drawing studio, professional laboratories, faculty workshop and Conference rooms well occupied by 6 Departments namely: Mechanical, Agricultural, Civil, Mechatronics, Chemical and Electrical & Electronics Engineering Department.

Plate 1: Faculty of Engineering Building, FUDMA

The reason behind this energy audit was as a result of the need to power the building with alternative energy source. Ultimate loads such as heating, ventilation, and air conditioning (HVAC) system, pump, computers, blowers, fans, compressor, lightening system, and many other light and heavy machines proposed in the electrical engineering drawing of the new-to-construct building are not achieved in the actual building after completion. Hence, carrying out energy audit is the effective tool to determine the overall energy consumption of the building and helps to obtain the best solution for its conservation.

Energy audit

A survey, inspection and analysis of energy flow in order to gives a better picture of the overall energy consumption and identify energy efficiency and conservation opportunities in a building, this process or system is known as energy audit. Energy audit according to Seai (2015) should be conducted after 3 consecutive years with effect from date the last report was submitted. This auditing process remain the main factor to a systematic approach for decision making in the field of energy management, as it quantifies the energy usage according to its discrete function. The process is also recognized as a tool for tackling carbon emission level as well as improving energy efficiency in buildings (Dimitrios *et al.*, 2017).

Energy Conservation and Efficiency

It was reported in the last 200 years that 60% Fossil fuels reservoirs are being used up. Yet, 85% of energy sources come from this non-renewable and fossil source. Hence, fossil fuels are on the verge of depleting soon. Energy conservation and improvement of efficiency can stand to reduce all the energy demands for sustainable development (Israfil & Mirza, 2020).

Energy conservation involves any attribute that results in the use of less energy. An example is opening window instead of turning on the air conditioning system in summer. Energy efficiency includes less energy technology usage to perform constant function. An example is the use of compact fluorescent light bulb (less energy technology) to produce the same amount of light as an incandescent light bulb. Therefore, Energy efficiency means less energy for the same output, while Energy conservation is all about minimizing energy usage by less energy service. The notion that combined these two different concepts together is Energy Audit.

Sharma *et al.* (2021) classified Energy audits in to targeted, walk through, and detailed energy audit.

The target energy audit is an advance of the walk-through energy audit. It provides more detailed information of the targeted project. This expanded preliminary audit technique is also called Standard energy audit. It involves an intensive analysis of energy cost and usage, equipment, systems and building characteristics in commercial, residential and industrial structures.

Walk-through also known as a preliminary audit is the quickest and simplest type of audit in which the auditor only explores the energy consumption of the structure. In this first step energy auditing process, the auditor using physical observation will identify the energy consumption area and developed typical energy saving opportunities. Walk-through energy audit can be completed within short period of time. As such, details require further detailed energy audit for sufficient for energy-saving solution.

Detailed energy is also known as comprehensive energy audit. From the name detailed energy audit, it provide detailed report on energy consumption, energy saving opportunities, installation cost, as well as their payback period in order guide the project contractor on actual measure to install in the structure. This investment-grade energy audit involves the use of modeling and simulation tools and requires thorough data collection over long period of time.

Cann (2012) in his study recommend the inclusion of utility cost analysis as fourth type of energy audit. The main purpose of this analysis is to carefully analyze the operating cost of a given structure. Auditor in utility cost energy audit has to firstly carryout walk through audit of the structure in order to collect data and make observation before checking the utility rates. Upon completion of this audit, the auditing team should conclude whether or not a given structure can benefit from using existing tariffs to reduce operating costs.

Need for Energy Audit

Fossil fuel emits greenhouse gases, which are harmful to mankind, in the process of generating energy. Energy audit being a concept for managing energy consumption will directly or indirectly reduce this environmental effect. Paucar *et al.* (2017) highlighted the reasons for undertaking an energy audit to include, but are not limited to the following: It identifies opportunities that will facilitate reduction in energy consumption and lower operating cost, enhances energy conservation and improves energy efficiency, gives clear understanding of structures' energy utilization patterns, identifies prospects for using alternative source of energy, identifies areas where waste and scope for improvement exist, reduces energy consumption, reduces the energy bill as well as expenditure, enhances energy conservation and improves energy efficiency, results to reduction of carbon footprint, leads to the prospects of using alternative source of energy, and minimizes waste and pollution.

Energy Audit Process

Flow of activities in auditing process has been categorized in to three distinct stages, which are pre - site work, site visit and post - site work (Survey, 2002).

The aim of pre - site work stage is to understand the structure of the building. At this preparatory level the auditor is required to develop the general profile of the building and draft list of question which shall be discussed at on - site visit stage of the process.

The auditor having generated better idea of the building from previous stage is at the on-site work stage of the process. Auditor at this stage is expected to inspects and observes the actual facilities in the building and provide answers to the question that were raised at Pre - Site Work stage of the audit process.

Auditor at post - site work stage is to evaluate and analyze all the data collected from the previous stage of the process, so as to suggest energy saving opportunities and finally draft energy audit report.

Findings from quite numbers of studies have shown that, substantial amount of energy and money could be conserved if rigorous energy audit is practiced. They include study on energy audit in Malta by Cann (2012), who finally highlighted that lowering of operating costs and utility bills reduction remain the general idea behind energy auditing process. Another research paper on energy audit by Mhaske *et al* .(2019) has recommended the technique as a continuous process that further clarify the potentials of renewable energy technologies. Paucar *et al.* (2017) in their article developed a standard methodology to perform an energy audit. To verify its viability, the method was used to carry out energy audit in an engineering laboratory and was recommended to be use as guide to quantify energy efficiency. Evaluation of energy efficiency for University building was conducted by Kiriaki (2011). Economic and environmental factors such as depreciated payback period, savings to investment ratio and net present value were determined. It was concluded from their study that energy performance evaluation is the first area of concern to improve the energy efficiency for buildings.

Study on energy audit and management by (Israfil & Mirza, 2020) uses MS Excel to categorize and calculate energy losses, consumption and savings. Finding from their study revealed that reasonable amount of energy and funds could be conserved if proper energy audit process is executed. In Poland and Finland a study to examine the electricity consumption of larger and smaller wastewater treatment plants were conducted by Seai (2011). It was disclosed from his result that the biological stage consumed more energy than other stages in the treatment process. Simon *et al.* (2019) performed an energy audit to observe the entire production and process system at RR industry, Makarpura Vadodara. Findings from the study assisted them to reduce the overall energy loss as well as energy bill without affecting the production and quality of the service. The use of software package for energy auditing is an area that is gaining more attention. In accordance with that, Awanish *et al.* (2015) recommended the use of ETAP software for energy audit in residential buildings. Sharma *et al.* (2021) in their study also presented other various types of software that are use to aid energy audit.

MATERIALS AND METHODS

The methodology adopted for this audit was a two step process comprising of:

i. Data Collection – Exhaustive data collection was achieved using information gathering, interviews and discussion with various operating personnel in the Faculty. Key operating data for electricity consumption parameters which include lighting, cooling & ventilation and electrical appliance were obtained from control panels and via random on-site measurements.
ii. Data Analysis - Detailed analysis of data collected was done manually. The database generated manually was used for producing graphical representations using MS Excel to point the highest energy consumed parameter and appliance. Some typical energy saving opportunities that will help in focusing on energy conservation were discussed.

RESULTS AND DISCUSSION

The total number of appliances used in the Faculty building is 1538 which was partitioned in to 68% for Surface panel light, 19% for Fan, 8% for AC, 3% for Fridge, 1% for Computer, 0.2% for projector, and 0.4% for printer and TV respectively as depicted in figure 1.

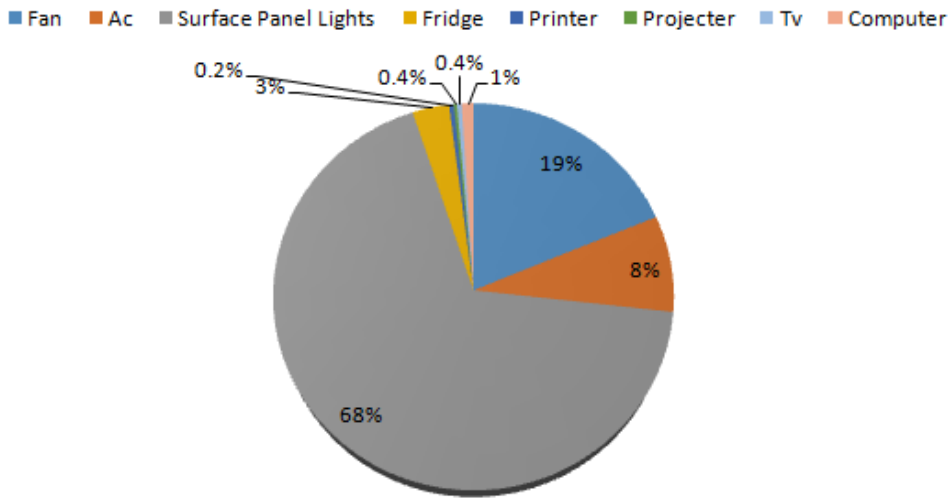

Figure 1: Percentage Number of Appliances

The total connected electric load in the faculty building as depicted in figure 2 is 131254-watt, with 21600-watt AC load, 21600-watt Fan load, 10480-watt lighting load, 3290-watt fridge load, 300-watt printer load, 200-watt projector load, 330-watt TV load, 2550-watt Computer load.

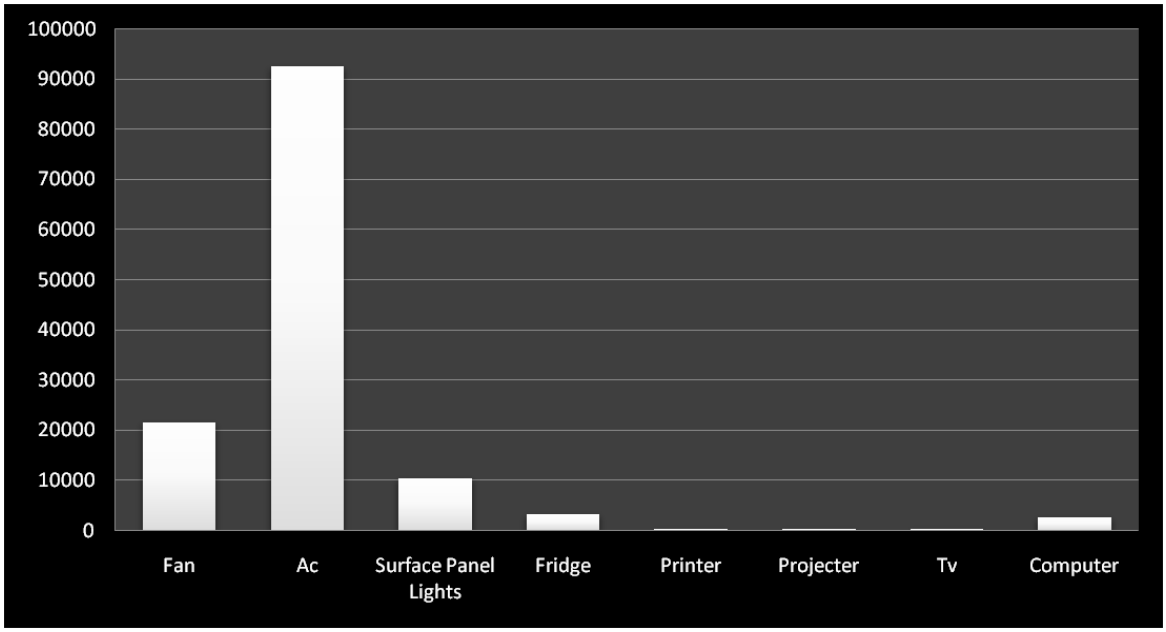

Figure 2: Connected Electric Load in the Faculty Building

The total average energy consumption per day in the Faculty building as depicted in figure 3 is 722-kWh, with 463-kWh for AC, 151-kWh for Fan, 73-kWhfor lighting, 23-kWhfor fridge, 0.3-kWhfor printer, 0.4-kWh for projector, 0.7-kWhfor TV, and 10-kWh for Computer.

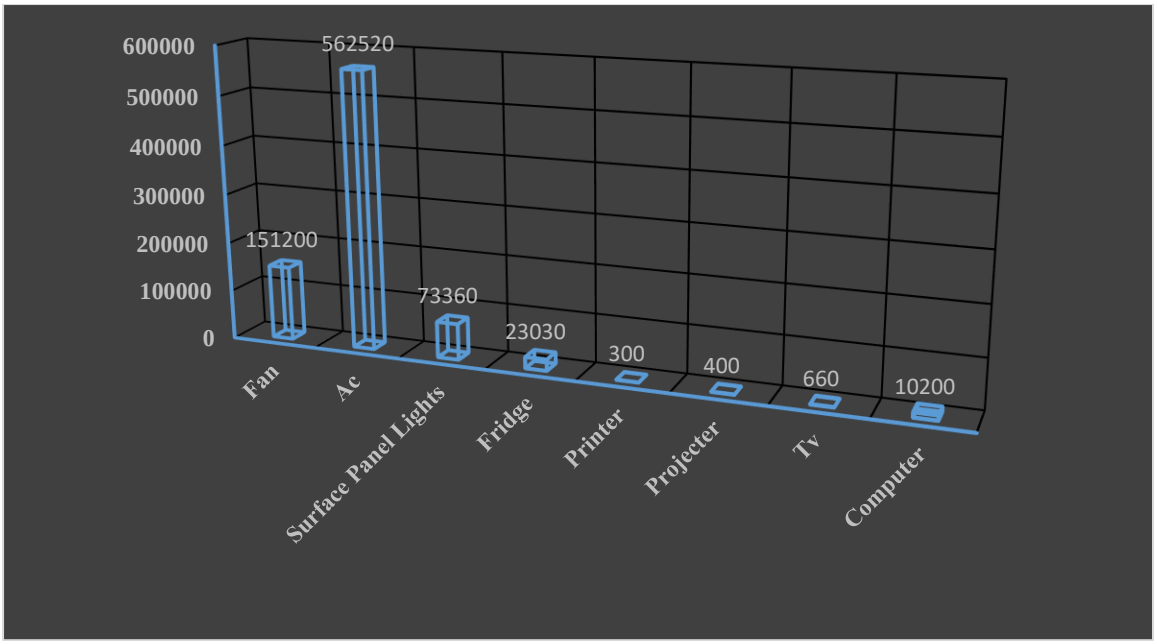

Figure 3: Average daily energy consumption of the Faculty Building

Lighting system has the highest percentage number of appliances that is 38% greater than cooling and ventilation systems (Fan, Fridge, AC) and 66% greater than electrical equipment (TV, Printer, Computer Projector) in the whole Faculty. The cooling and ventilation systems consumed highest energy that is 81% greater than that of lighting system and 86% higher than the energy consumed by electrical equipment in the entire building. It was also found that cooling and ventilation systems consumed the highest amount of energy per day that is about 637-kWh, followed by lighting and electrical system with 73-kWh and 11.4-kWh respectively. AC is observed to be the highest energy consumed appliance and fall within cooling and conditioning parameters. Thus, energy saving opportunities measures such as the use of 5-star rating AC as recommended by Arpit *et al.* (2021) may lead to a good proportion of saving of energy as well as utility bill. Switching off electrical appliances that are not in use as suggested by Vaishnavi *et al.* (2021), remain amongst the simplest and efficient changes in energy usage that can lead to more sustainable energy consumption. Measures such as the use of AC with local control only when deem necessary and the use of natural ventilation overnight especially in areas with no security threat as reported by Aedah and Mahdi (2018) can aid in reducing energy consumption. Other typical energy saving opportunities such as Using the absorption chillers, Using 'free-cooling' during low ambient conditions, lowering air changes, as well as matching variable speed control on fans, refrigerant compressors and circulation pumps to demand as reported by Marika (2017) can improve air conditioners usage and reduce energy loss.

CONCLUSION

The current energy situation of the Faculty building after evaluation revealed that the total energy consumption for lighting, cooling & ventilation and electrical appliances of the Faculty is 131254-watt, with air conditioning loads having the highest percentage of power consumption (89%), while electrical appliances are having the least (3%). Lighting systems despite their highest percentage in terms of number of appliances, consume less power in comparison with the cooling and ventilation parameters. Therefore it is recommended that any alternative energy source that is at most 132-kW can be use to power lighting, cooling & ventilation and electrical appliances of the Faculty. Furthermore, the energy conservation measures discussed can help in reducing early operating cost as well as saving of some kilowatt hours (kWh) of energy, which may lead to reduction in significant amount of carbon emission and carbon footprint.

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