A SURVEY ON THE ENERGY CONSUMPTION AND DEMAND IN A SCHOOL

Isaac F. Odesola,
Department of Mechanical Engineering
University of Ibadan, Oyo State, Nigeria

ABSTRACT

Efforts to reduce energy consumption in domestic buildings and commercial areas have been intensified recently in view of the limiting of the growing demand for electricity and the efforts to reduce CO_2. Investigations into energy reduction strategies have been extensive with active and rigorous researches carried out successfully in many countries of the world. A walk-through energy audit was conducted in the School to determine the peak energy demand of the entire School as well as flagged areas for possible energy savings. For the purpose of this study ,the School is broken down into about thirty four offices This paper presents a walk-through energy audit of a School located in Ibadan, Nigeria. A total of about 40.4 kWh of electrical energy per day is required by the School for running all the electrical and mechanical appliances. To reduce the strain on the school's electrical supply systems and hence prevent system outages, the following peak demand reducing strategies have been recommended: Load reducing strategies, High efficiency equipment, Efficient lighting, Efficient air conditioning, Efficient refrigeration, Energy source substitution and on-site heat and electricity generation. It was recommended that this energy audit manual should be used as guide anytime any energy consuming machine is to be installed in the School.

Keywords: Load, energy, energy demand, consumption, electrical energy

INTRODUCTION

Efforts to reduce energy consumption in domestic buildings and commercial areas have been intensified recently in view of the limiting of the growing demand for electricity and the efforts to reduce CO_2 [1]. Investigations into energy reduction strategies have been extensive with active and rigorous researches carried out successfully in many countries of the world.[1-23] Adekunle et al., [1] presented the results of a walkthrough energy audit conducted in a university and recommendations were made as means of tackling the problem from the demand end by focusing on the areas of potential savings flagged by the energy audit. The paper revealed the fact that to tackle the problem of energy demand from the users' end is a big task, but incidentally it may be the only hope of the school in view of inflexibility of supply. Mauro Gambari et al.,[2] gave an innovative technique for modeling multi-zone hydronic heating systems in buildings in an easier and more user friendly manner. An original approach was described in which the thermal and hydronic systems are solved simultaneously by simulating the dynamic behavior of pipe water flow rates, water temperatures, and room air temperatures. The simulation uses mathematical models that apply a Newton-Raphson method(NRM) developed in Matlab and simulink environments. A laboratory heating system ws used to validate the modeling technique. Yi Chen et al.,[3] proposed a new ventilation cooling technology(VCT) for telecommunication base stations(TBSs) in Guangzhou, China. These base stations have high density, a long cooling season and high energy consumption. The results show that the application of VCT to the TBSs in Guangzhou is feasible, the energy saving for VCT is about 49% and the payoff period is less than two years. Rune Vinther et al.,[4] conducted a questionnaire survey to identify the most important factors affecting the occupant's interaction with building control systems(window opening behavior, use of heating, solar shading and electrical lighting). This survey was conducted in Danish dwellings in the late summer of 2006 and again in the winter of 2007.The survey shows that window opening behavior in Danish dwellings was strongly linked to the outdoor temperature.Maria kordjamshidi et al.,[5] used simulation to evaluate the thermal performances of houses, and employ multi-regression analysis to develop the framework. This paper explores methodologies and a framework for assessing a proposed building's projected thermal performances, in both its free running and conditioned operation modes. Free running houses are houses without any mechanical equipment and artificial energy load for space heating and cooling. Xing Su et al., [6] explained that the energy-utilization coefficient is not suitable to the evaluation of natural ventilation. Based on thermal comfort of natural ventilation environment, an evaluation method is then established.Nashib Kafle et al., [7] presented the clean development mechanism(CDM) potential in an academic institution hosting 2500 students through the introduction of renewable energy technologies (Solar

Water Heater. Solar Steam Cooking) and adoption of energy efficient technologies(Compact Fluorescent Lighting. Energy Efficient Air Conditioners). Out of the four cases analyzed, the solar water heater generating 48.13 tCO_2/year was identified as the candidate CDM project. The total amount of CO_2 that can be saved from emitting to the atmosphere by employing the renewable and energy efficient technologies is 311.34 tCO_2/year. John Are Myhren and Sture Holmberg[8] reported four cases investigating how much thermal efficiency may be improved and how thermal comfort in the room can be affected by simply changing the position of the ventilation air inlet in relation to the radiator. The purpose of this paper is to provide guidance for manufacturers of heating and ventilation systems. A secondary objective is to demonstrate how CFD simulations may be used to illustrate indoor climate in a nuanced way. Avgelis and Papadopoulos [9] presented a method for choosing and managing in the best possible way heating, ventilating and air conditioning (HVAC) systems in new and existing buildings. The method utilizes a combination of two analysis' tools, the multicriteria decision-making and the building simulation towards the direction of a holistic assessment of HVAC systems. The results show that the proposed model allows the classification of alternative technical solutions concerning the HVACs design, taking into consideration economic, energy and environment criteria as well as criteria of users' satisfaction. Papaefthimiou et al. [10] reported a combined methodology for the rating of advanced glazing that is aimed to add the economical and the environmental aspect to the existing evaluation systems. Apart from the special characteristics of the advanced glazing, alife cycle analysis (LCA) study and an eco-efficiency analysis have been combined to provide an alternative rating scheme, which has been applied to an elecrochromic window as a case study. Isaac Moradi [11] developed a new and automatic method for controlling the quality of daily global solar radiation using sunshine duration hours. The method developed is capable of identifying systematic and non-systematic errors and its ability has been shown in three different climates including semi-arid, coastal humid and very arid climates. Ursula Eicker and Dirk Pietruschka [12] in their contribution to the system design of solar thermal absorption chillers, a simulation model was developed for absorption cooling systems, combined with a stratified storage tank, steady state or dynamic collector model and hourly resolved building loads. The model was validated with experimental data from various solar cooling plants. The work showed that dynamic system simulations are necessary to determine the correct solar thermal system size and to reach a given solar fraction of the total energy requirement. Ibrahim Dincer [13] investigated the precooling process parameters of the individual fruits (tomatoes, cucumbers, squashes, and eggplants) in the batches of 5, 10, 15, and 20 kg subjected to hydrocooling. In the analysis, the precooling process parameters in terms of the cooling coefficient, lag factor, and half cooling time were found to be dependent upon the batch weight of the product. Antonopoulos and Democritou [14] developed a new 'wall-heat gain function' which provides the heat entering a space through a wall under periodic outdoor conditions and constant indoor temperatures. The main advantage of the proposed wall-heat gain function over the well-known conduction transfer function is that the former is directly applicable without iterations and so simple that it may be used without a computer. An impressive feature of the proposed wall-heat-gain function is that it may be applied to existing wall constructions of unknown materials and properties. Choudhury et al., [15] presented a detailed theoretical performance and economic analysis of conventional solar air heaters with bare plate, single cover and double cover. Evaluation of the annual cost (AC) and the annual energy gain (AEG) of the collectors has been performed and the ratio AC/AEG is displayed for different parameters. It was discovered that, except for very high flowrates and very small duct depths the cost of solar energy decreases with increase in collector length. The optimum value of duct depth which corresponds to the minimum cost for energy gain is different for different lengths and flowrates. Domenico Coiante and Luciano Barra [16] proposed a practical alternative method for evaluating the real cost of electrical Energy based on the philosophy of avoiding the damage rather than paying for it. This method was applied to estimate roughly the increasing factor in a grid of central power stations typical of industrialized countries with the prevalent dependence on fossil fuels. Under the hypothesis of reducing the pollutant emissions(including carbon dioxide) by a factor of 10 and accounting for social costs related to the fuel cycle and the waste disposal, a factor larger than 3 between real and internal costs was found. Jinlong Ouyang et al.. [17] presented economic analysis of energy-saving renovation measures for urban existing residential buildings in China based on thermal simulation and site investigation. The paper used one urban existing residential building in Hangzhou city in China as the subject building and analysed the economic benefits from the energy-saving renovation measures through the life cycle cost approach. The study demonstrated the fact that a significant reduction potential of energy savings can be made from high-performance building envelopes of the existing residential buildings in Hangzhou city. Azadeh and Ghaderi et al.. [18] proposed a deterministic approach for performance assessment and optimization of power distribution units in Iran. Deterministic approach composed of data envelopment analysis (DEA). principal component analysis (PCA) and correlation techniques. Seventeen electricity distribution units were considered for the purpose of the study. It happened to be the first study to present an integrated deterministic approach for assessment and optimization of power distribution in Iran. Soteris Kalogirou invstigated [19] the thermal performance, economic and environmental life cycle analysis of thermosiphon solar water heaters. The results presented showed that considerable percentage of the hot water needs of the family are covered with solar energy. This is expressed as the solar contribution and its annual value is 79%. The system investigated gave very positive and very promising financial characteristics with payback time of 2.7 years and life cycle savings of 2240 Euro with electricity backup and payback time of 4.5 years and life cycle savings of 1056 Euro with diesel backup. The saving, compared to a conventional system, is about 70% for electricity or diesel backup. Valentinas Klevas et al., [20] discussed the methodological problems related with integration of sustainable energy projects into regional development procedures and provide guidelines, ensuring that energy elements may compile integral uniformity in terms of regional goals. They concluded that the economic development should be shifted away from energy and resource intensive industries, clean-up technologies towards the development clean technologies and knowledge intensive industries which are environmentally efficient in the long-term and provide for sustainable development. The power outages in Universities is common in recent times, particularly in developing countries where these outages are closely linked to peak times since electricity is a non-storable commodity and must be supplied at the same time that is being used, Adekunle et al.,[1]. End users have very important part to play considering the issue of effective energy management. Actions taken by them to reduce wastages in energy usage go a long way in managing energy crisis in a particular community. There must be incentive for efficient energy use as obtained in developed countries to discourage wastages and inefficient use of energy. Having gone through recent efforts made by researchers in this direction, it is very obvious that more studies are still needed in the area of energy demand and consumption. The need to address this current issue in developing countries has provided the impetus for this exercise. This paper presents a walk-through energy audit of a postgraduate school located within a university community in Ibadan whose goals among other things is to excel in teaching , research and community service.

MATERIALS and METHODS

Energy Demand in the School

The form of energy consumed in the School is mainly electricity. A walk-through energy audit was conducted in the School to determine the peak energy demand of the entire School as well as flagged areas for possible energy savings. For the purpose of making this study as simple as possible, the School is broken down into about thirty four offices.

The electrical energy end use in the School is categorized as follows:

- Space cooling - All the energy used for ventilation and air conditioning equipment such as room fans, air conditioners and extractor fans.
- Refrigeration – This comprises energy used by food and drink cooling equipment such as water dispensers, fridges and freezers.
- Water heating – This includes energy used by water heaters of all kinds.
- Cooking – This includes energy utilized by cooking equipment such as electric cookers, gas cookers, electric toasters and microwave ovens.
- Personal computers – This includes all computer systems, printers and servers
- Office machines – These include all the office equipment that are in offices, e.g. typewriters, fax machines, photocopy machines and scanners.
- Lighting – All forms of lighting appliances ranging from incandescent lamps to fluorescent lamps, halogen lamps, rechargeable lamps, street lights and others.
- Electronics – All electronics appliances such as television sets, radio sets, video cassette players, video compact disc players and decoders.
- Others – This include pumping machines, pressing iron and blender

The data obtained during the energy audit are presented in tables and charts. The total energy demand for the School is shown in table 1.0 . A total amount of 40.44kWh electrical energy is needed by the School per day for smooth operation. Figs. 1-5 give the proportion of this energy demand for different end uses. Since energy demand is a choice, we therefore pursue means of reducing demand.[1]. Figs.1-5 will assist in pointing out areas on which these strategies will be focused.

Table 1: Energy audit data

S/N	ROOM	POWER CONSUMED(Watts)
1	A1	67253.60
2	A4	853350.40
3	A3	194729.60
4	A5-A7	115992
5	A9	31609.60
6	A10	4019080.8
7	A12	106548
8	A13	8052382.4
9	B1	486948.8
10	B2	107369.60
11	B4	103688.60
12	B3	96720.80
13	B6	85392
14	C3	47208.8
15	C4	52841.6
16	D2 &D3	93190.4
17	D6	45769.60
18	Admission(1)	52752
19	A16 & A17	4028900
20	Store(Account)	4038808.8
21	Account	47549.60
22	Account(1,2,3)	4066502.4
23	Board Room	293168.8
24	Store(2)	38048
25	Store(1)	12044541
26	D13	56638.4
27	D10	41008.4
28	D11	41974
29	D12	41030.4
30	D15	822120.8
31	C3	66232.8
32	D8 & D9	147410.8
33	D4	44208.8
34	D5	50830.4

GRAND TOTAL = 40.4440246 kWh

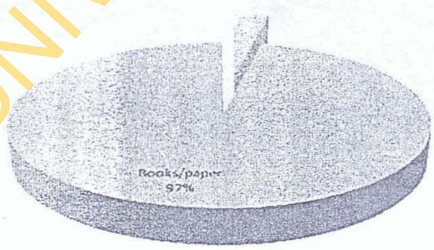

Figure1: Percentage number of equipment in the schools

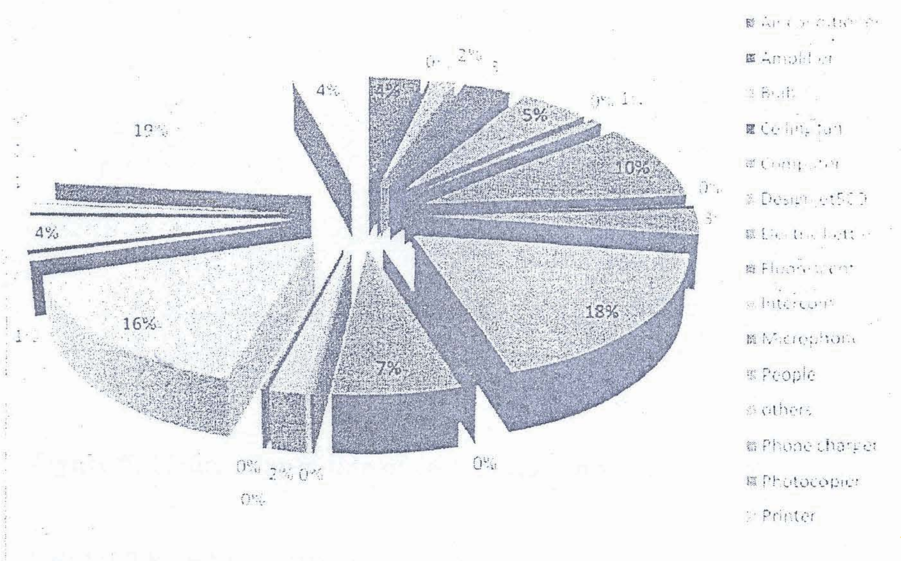

Figure 2: Electrical energy demand for different end uses in the School

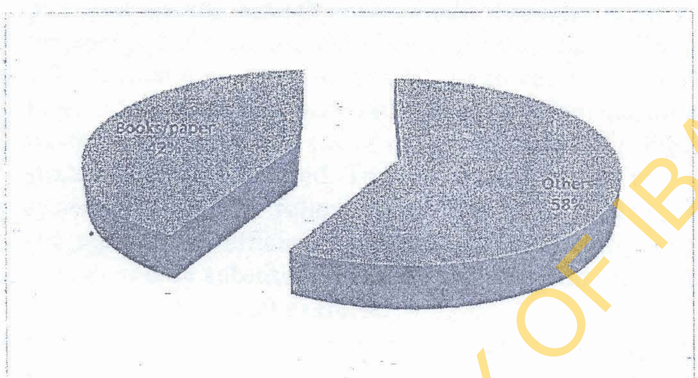

Figure 3: Power consumed by books/paper relative to other equipment in the school

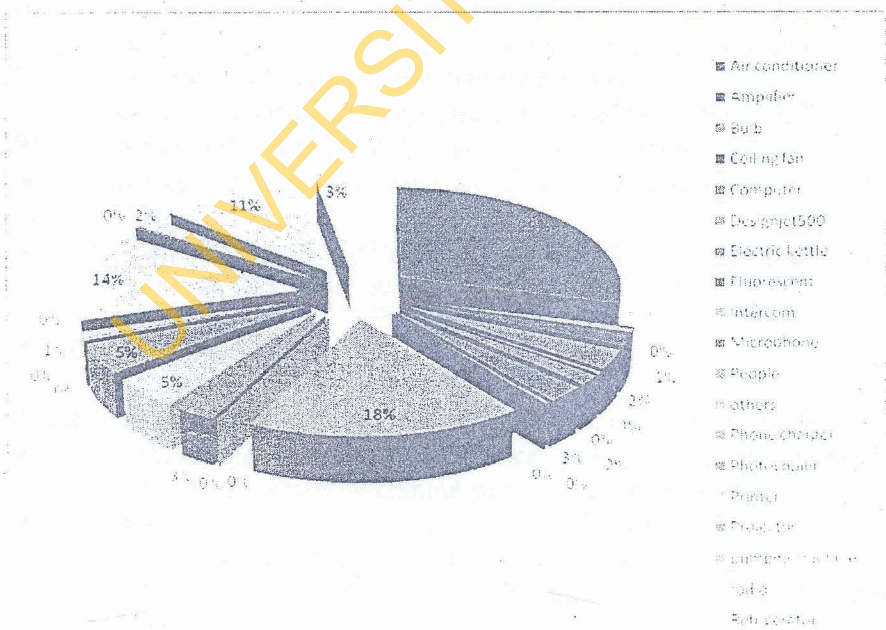

Figure 4: Percentage total power rating contribution of all equipment to 'others'

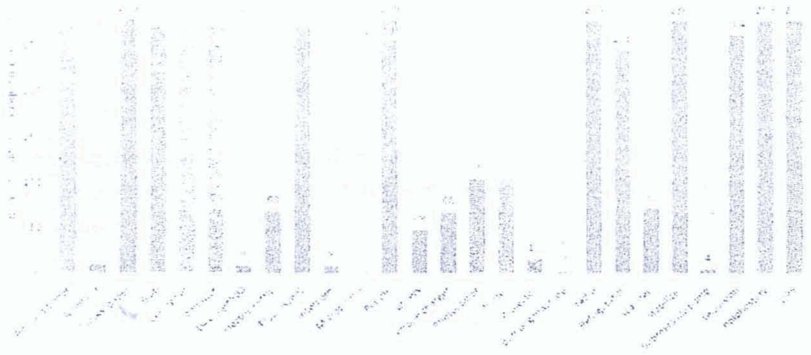

Figure 5: Hours of operation of each equipments in the school

RESULTS and DISCUSSIONS

The need to know the total electrical energy required by the School for running all the equipment and machines and proper control of energy consumption has motivated this study. This study has successfully provided a walk-through energy audit through a survey conducted in the School. The data obtained during the energy audit are presented in tables and charts. The total energy demand for the School is shown in table 1.0 . A total amount of 40.44kWh electrical energy is needed by the School per day for smooth operation. Figs. 1-5 give the proportion of this energy demand for different end uses. Since energy demand is a choice, we therefore pursue means of reducing demand[1]. Figs.1-5 will assist in pointing out areas on which these strategies will be focused. To reduce the strain on the school's electrical supply systems and hence prevent system outages, the following peak demand reducing strategies have been recommended: Load reducing strategies, High efficiency equipment, Efficient lighting, Efficient air conditioning, Efficient refrigeration, Energy source substitution and on-site heat and electricity generation[1] The following have been identified from the energy audit exercise:

- A total of about 40.4kWh of electrical energy per day is required by the School
- The electrical energy available from the 'university grid' is not sufficient to power all the electrical and mechanical gadgets installed in the School
- A total of sixty units of both split and windows air-conditioners have been installed in the School
- About sixty percent of the installed air-conditioners had blocked air filters indicating that they have not been serviced for more than six months
- Occasional electrical surges have damaged ten of the installed A/Cs over time
- None of the installed A/Cs had automatic voltage regulator to control the electrical surge.
- Air conditioners were installed in the offices without having the knowledge of the energy load of each of the offices.
- There is no dedicated maintenance crew to carry out preventive maintenance exercises for all the installed A/Cs in the School.

CONCLUSION

In the light of the above, the following recommendations were made:

- Considering the amount of electrical energy requires to run the School facilities, there is need for a standby generator of commensurate capacity to be put in place.
- A dedicated maintenance crew should be put in place urgently to carry out day to day preventive maintenance of the electrical and mechanical appliances in the School.
- Those air conditioners that are due for servicing should be removed and serviced so as to reduce energy consumption per day in the School
- To prevent damage as a result of electrical surges, all the A/Cs should be installed with automatic voltage regulator(AVR).
- Henceforth, this energy audit should be used as guide when next air conditioner is to be installed in any of the rooms.

REFERENCES

Adekunle O. A, Olatunde Damisa, Sunday A.Oke, Akinwale B. Ayoola and Allen O.A.(2008). A survey on the energy consumption and demand in a tertiary institution. Maejo International Journal of Science and Technology. 2(02):331-344

Mauro Gambari, Riccardo Manzini and Alberto Regattieri. (2009). Simulink simulator for building hydronic heating systems using the Newton-Raphson algorithm. Energy and Buildings. 41: 848-855

Yi Chen, Yufeng Zhang and Qinglin Meng. (2009). Study of ventilation cooling technology for telecommunication base stations in Guangzhou. Energy and Buildings. 41: 738-744

Rune Vinther Anderson, Jorn Tofturn, Klaus Kaae Anderson and Bjarne W. Olesen.(2009). Survey of occupant behaviour and control of indoor environment in Danish dwellings. Energy and Buildings. 41:11-16

Maria K. and Steve King (2009). Overcoming problems in house energy ratings in temperate climates: A proposed new rating framework. Energy and buildings. 41:125-132

Xing Su, Xu Zhang and Jun Gao.(2009). Evaluation method of natural ventilation system based on thermal comfort in China. Energy and Buildings. 41:67-70.

7. Nashib Kafle and Jyotirmay Mathur (2009). Feasibility study of capturing carbon credit benefits in an academic institution: A case study. Energy and Buildings. 41:133-137.

John Are Myhren and Sture Holmberg (2009). Design considerations with ventilation- radiators: Comparisons to traditional two-panel radiators. Energy and Buildings. 41:92-100.

A. Avgelis and A.M. Papadopoulos (2009). Application of multicriteria analysis in designing HVAC systems. Energy and Buildings. 41:774-780.

S. Papaefthimiou, E. Syrrakou and P.Yianoulis (2009). An alternative approach for the energy and environmental rating of advanced glazing: An electrochromic widow case study. Energy and Buildings. 41: 17-26.

Isaac Moradi (2009). Quality control of global solar radiation using sunshine duration hours. Energy. 34:1-6.

Ursula Eicker and Dirk Pietruschka (2009). Design and performance of solar powered absorption cooling systems in office buildings. Energy and Buildings. 41: 81-91 Ibrahim Dincer. 2009. An effective method for analyzing precooling process parameters

Ibrahim Dincer (1995). An effective method for analyzing pre-cooling process parameters. International journal of Energy Research. 19:95-102.

K.A.Antonopoulos and F. Democritou (1995). Experimental and numerical determination of a new wall-heat-gain function. International journal of Energy Research.19:103-116.

C. Choudhury, P.M.Chauhan and H.P.Garg (1995). On the cost-effectiveness of solar air heaters. International journal of Energy Research. 19:133-144.

N.D. Uri and Mohinder Gill (1995). The agricultural demand for electricity in the United States. International journal of Energy Research. 19:145-157.

Domenico Coiante and Luciano Barra (1995). A practical method for evaluating the real costof electrical Energy. International journal of Energy Research.19:159-168.

A.Alicilar, M. Dougan and M.Guru (1995). Optimization of a double stage flash system. International journal of Energy Research.19:169-179.

Jiniong Ouyang, Jian Ge and Kazunori Hokao (2009). Economic analysis of energy-saving renovation measures for urban existing residential buildings in China based on thermal simulation and site investigation. Energy Policy. 37:140-149.

A. Azadeh, S.F. Ghaderi and H. Omrani (2009). A deterministic approach for performance assessment and optimization of power distribution units in Iran. Energy Policy.37:274-280.

Soteris Kalogirou (2009). Thermal performance, economic and environmental life cycle analysis of thermosiphon solar water heaters. Solar Energy.83:39-48.

N.N.Ezhova and S.V. Sudareva (2009). Modern methods for removing carbon dioxide from flue gases emitted by thermal power stations. Thermal Engineering.56(1):15-21.

Valentinas Klevas, Dalia Streimekiene and Androne Kleviene (2009). Susainability assessment of the energy projects implementation in regional scale. Renewable and sustainable Energy Reviews.13:155-166.