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Energy Auditing Application and Household Installation for Optimization of Power Consumption in Bauchi State Metropolises, Nigeria

Yunusa M. A.
Agabi P. I.
Jola G. N.
Onate C. S.
Department of Electrical/Electronic Engineering Technology
The Federal Polytechnic Bauchi, Bauchi, State, Nigeria

Zakka B. E.
Computer Science Department
The Federal Polytechnic Bauchi, Bauchi, State, Nigeria.
**E-mail: benizakka@fptb.edu.ng*

ABSTRACT

The purpose of this paper is to demonstrate how the energy auditing of domestic power consumption for various appliances was used to improve energy efficiency as consumers need to be more aware of their energy consumption/auditing. This will increase the understanding of accurate and economizing methods of energy consumption. The study followed empirical observation to achieve its objectives by using a micro-controller unit that continuously monitors and records the energy consumption. Energy auditing was also conducted on how the public viewed electricity bills were calculated, the cost, consumption, and the ways to moderate the burden of electricity bills. The study was limited to Bauchi State metropolises and it involved only 10 respondents for in-house sampling. The result of this interview was analyzed, and it was revealed that the mode of payment of electricity bills fluctuates with the standard of living, climate, and types of residence reliant on the usage in each household. The Contemporary World today is making a giant stride in the development of all human endeavours due to the development of science and technology, the advance has assuaged most of the manual works that human is doing and replaced them with a machine. This development has caused demand for electrical energy to be increased exponentially over the last decades and so also the bill so also the need for energy auditing. However, the use of the inverter is one of the most helpful methods to reduce electricity consumption.

Key Words: *Energy Auditing, Domestic power, energy efficiency, Electricity consumption, and billing*

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1. INTRODUCTION

With the recent rise in population growth with power demand, the energy efficiency in residential and commercial buildings is becoming a matter of great concern. There is, therefore, a need to know the energy components and how they are utilized. In a residential or commercial building, the major constituents are light sources, heating, ventilation, and air condition. The number of these components to be installed depends upon the technical and environmental standards (Solgi, Hamedani, Sherafat & Fernando, 2019). Energy auditing (EA) allows finding the methods, possibilities, and time for energy management, and it helps the customers to be able to manage their energy consumption wisely to reduce electricity bills. Energy auditing has a lesser cost and is to be precise a more mature option than utilizing advanced and costly means of providing renewable energy since it monitors and often controls energy demand. An energy cost saving of 5–15% is usually achieved swiftly with little to no capital investment or aggressive energy management. Energy audits include energy conservation programs that encompass consumption patterns and the identification of specific energy-saving measures. That is, an energy audit is a systematic procedure to gain adequate knowledge of existing energy consumption profiles and detect operating problems, improve occupant comfort, identify and quantify cost-effective energy savings opportunities, and report the findings.

Electricity consumption in domestic buildings is determined by two main factors: the type and number of electrical appliances in the property; and the use of these appliances by the occupants of the building(Firth, Lomas, Wright, & Wall, 2008). Again, in houses with similar built forms, there can be a wide range of different appliances and have a range of power consumptions. Occupants influence the electricity use of a dwelling both by the purchase of electrical appliances and through their use of these appliances. The variation in the type of electrical appliances present and the occupant's semi-random use of these make domestic electricity consumption difficult to predict with accuracy, particularly at short time steps such as an hour or less(Firth et al., 2008).

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However, a sound understanding of domestic electricity auditing is required for the design and implementation of energy efficiency measures and on-site electricity generation (Swan & Ugursal, 2009). According to Roberts (2013), the energy meter is a device that measures the amount of electrical energy consumed by a residence, business, or an electrically powered device; and these types of electrical meters are typically calibrated in billing units, the most common one being the kilowatt-hour (KWH); they are broadly classified into electromechanical meters and electronic power meters. The electronic power meter sensor module is responsible for measuring energy and instantaneous and average power. Its functionalities allow it to be used for simple domestic electric power measurement applications. Moreover, it can store power consumption profiles and automatically identify and detect malfunctions of home appliances connected to the network at a given moment(Sun et al., 2016).

Ways of billing are: By various tariffs and normal energy meters as well as prepaid energy meters; in the billing system, monthly consumption of all equipment is considered for calculation of bills. So, that one can know, how much amount of total electrical energy is used in a month as illustrated below (Sun *et al*., 2016): If 15Watts bulb runs for 1000 hours, it consumes energy of 15 × 1000 = 15,000Wh or 15kWh. If the cost of 1 unit is considered ₦62.33/kWh then the bill for this application will be 15 × 62.33 = ₦ 934.49. While calculating the energy cost of an appliance or electronic device is easy. Most devices have a label that lists how many watts it uses, either on the device or in the owner's manual (Brickfield, Mahling, Noyes, & Weaver, 2011). You will need to find this number to figure out how much the appliance is costing you. You will also need to estimate how many hours a day you use an appliance. If you can't find the wattage label, there are other options to determine how much power your device uses. For example, you can purchase a wattage measuring device, such as the Kill A Watt®. Simply plug your appliance or electronic device into the Kill A Watt® to determine how much power it uses. Or you can contact the manufacturer, with your model number, to find out how many watts a device consumes.

Without auditing your electricity usage when you get your electricity bill each month, you may not think a lot about what goes into it. But, every appliance or electronic device adds a little something to your bill. By figuring out what the biggest energy

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hogs are in your home, you can adjust your usage by unplugging or simply using the devices less. Every change you make should help whittle down your energy expenses (Raj, Sudhakaran, & Raj, 2009).

This work is limited to the domestic power consumption measurement and its appliances that demonstrated the role of monitoring in understanding the trends in electricity consumption of households in Bauchi State Metropolises.

Domestic Power Consumption

Fischer (2008) talked about domestic electricity use and calculation. Brickfield et al. (2011) also discussed automatic energy calculation. They all highlighted general issues that are relevant to the debate on the future of energy in the residential sector and how it is understood and controlled. These previous authors present a high-resolution model of domestic electricity use that is based upon a combination of daily activities, profiles, and how people spend their time performing certain activities with electricity.

In a similar investigation, Rojchaya & Konghirun (2009) have explained microcontroller-based consumption monitoring and warning system that explained how consumers take care of their electrical energy consumption. And how the consumer will protect themselves from extra charges incurred due to minor changes in slab categories; these changes are minimal. They affect the consumer's bill severely.

Additionally, Sugiura, Miwa and Uno (2013) analyzed household energy consumption of lighting and accounted for a large percentage of household energy consumption. It is estimated that the energy consumption of domestic electric appliances decrease by some amount from the older level, mainly due to the energy savings expected for domestic appliances. According to Raj et al. (2009), many consumers could unplug their appliances and go on holidays, assuming the electricity meter would stop. In this paper, standby power consumption of various domestic appliances was determined using an energy cost meter; thus the experimental results

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show that the standby power of various household electrical appliances is consuming more electricity during standby mode (Raj et al., 2009).

Furthermore, Ashiquzzaman, Afroze, and Abdullah (2012) discussed the Design and Implementation of Wireless Digital Energy Meter using a Microcontroller. They present a microcontroller-based wireless digital energy meter to facilitate energy consumption measurement. This project has thus provided simple, accurate, and useful information to the consumer about the real time consumption of appliances.

One of the aims of the present development is to implement a power management system to help the consumer in saving energy and money (Santinato, Arione, & Braghini, 2017). Another purpose of the present development is to make the user aware of potential energy cost savings in selecting different delayed switch-on times for each appliance. A further item of the discovery is to provide a system that comprises a user interface through which the user may also input a predetermined energy cost-saving target referred to a fixed time (week, month). The system being able to select the proper times for switching-on the appliances to get the energy-savings target (Santinato et al., 2017).

Common Wattages for household appliances

Household electrical appliances categories the electricity consumption of a household by the electric power consumed by each appliance and the amount of time each is in use (Setlhaolo, Xia, & Zhang, 2014). The wattage on appliances or electronics varies by device. Typically, older model appliances use more energy, but newer models tend to be more efficient. Table 1 indicates the wattage of household appliances for everyday devices. Your particular device may vary, it should give you a rough estimate of the energy expenses related to the device (Setlhaolo et al., 2014).

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Table 1: List of common wattage on household appliances

Coffeemaker	900-1200watts
Microwave	750-1100 watts
Toaster	800-1400 watts
Dishwasher	1200-2400 watts
Washer	350-500 watts
Dryer	1800-5000 watts
Iron	100-1800 watts
Ceiling fan	65-175 watts
Space heater (40gal)	4500-5500 watts
Hair dryer	1200-1875 watts
Laptop	50 watts
Computer monitor	150 watts
Computer tower	120 watts
Television 19"-36"	65-133 watts
Television 53"-61"	170 watts
Air conditions	1Hp – 2Hp

Type of Tariffs

Daily energy demand is not flat. Peaks of energy are generated during the day which creates varied demand and increases a utility charge to consumers. To avoid dangerous blackouts, utility companies are searching for ways to smooth energy demand by offering advantages to customers who can control their power consumption (Santinato et al., 2017). Consequently, it would be advantageous to design a new generation of appliances that can manage power consumption with different tariffs based on a signed power supply contract (Santinato et al., 2017). A tariff is a way you get charged for your energy. Choosing the right tariff for you can help reduce what you pay for your energy. There are two types of electricity tariffs - electricity and gas.

Also, to help you work out the best, in terms of electricity tariffs, regards should be given to the different tariffs and how they work. However, there are three methods of

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electricity tariffs: single rate, time of use (including flexible pricing), and Controlled load.

a. Single rate tariffs

With a single rate, tariff offers are on peak or off-peak periods. This means that you pay the same rate whatever time of day you use energy. However, the rate is usually lower than the peak rates of a time of use or flexible pricing tariff. This means a single rate offer could be a good choice if You are at home a lot in the evening Monday to Friday and sometimes the consumer may need to use his appliances more often from Monday to Friday, maybe by using a washing machine or dishwasher, etc. Also, single-rate tariffs are sometimes called flat rate, standard rate, anytime rate, or peak rate. Similarly, a single-rate tariff is available to everyone. You do not need a smart meter to get a single-rate tariff offer.

b. Time of use tariffs

The time of use tariff means that electricity costs different prices at different times of the day. Peak electricity costs the most; peak rates usually apply in the evening from Monday to Friday. But some people prepare off-peak electricity is cheapest. Off-peak rates, usually, apply overnight on Saturdays and Sundays. Shoulder electricity costs less than peak because shoulder rates usually apply in between the peak and off-peak periods. Again, a time of use tariff offer could be a good choice if you are out in the evenings from Mondays to Fridays; you are home during the day or on weekends and you use your appliances on the weekend, like your washing machine or dishwasher (Dermentzis et al., 2019).

In a nutshell, some retailers have even more periods than peak, shoulder, and off-peak, for example, a flexible pricing tariff. Flexible pricing tariffs are not available in all areas yet. You will only be able to search for flexible pricing tariff offers on Energy Made Easy if they are available in your area. Retailers will also tell you how to start and end the different periods for their time of use offers in the energy price fact sheet or the retailer's written summary of the offers. To get a time of use

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tariff offer, you need a meter that measures your electricity usage at different times of the day. For example, a smart meter or time of use meter (Kavousian et al., 2013).

c. Controlled load tariffs

For some appliances you can be charged a controlled load tariff when slab is under floor heating, or electric hot water systems. This means that the retailer charges a rate just for that appliance and the energy it uses. Often that appliance has its meter. It is usually only for appliances that run overnight or in off-peak times. So controlled load rates are usually lower and are sometimes called: dedicated circuit consumption, or off-peak.

The literature survey suggests the saving of energy consumption. The second literature survey gives an idea about the energy consumption of daily activities. The third literature survey suggests consumers shall be aware of energy consumption and extra charges. The last paper suggests the real-time consumption with cost using a microcontroller.

Methodological direction

How power consumption is calculated (for this we use the Naira (₦) for example)
This auditing system of energy consumption provides the real-time consumption detail of every load and about the consumer's bill. Auditing electricity consumption has 4 Easy Steps.

STEP 01 watts per day

To calculate energy consumption costs, multiply the unit's wattage by the number of hours you use to find the number of watt-hours consumed each day. For example, let us say you use a 125-watt television for three hours per day. By multiplying the wattage by the number of hours used per day, we find that you are using 375 watt-hours per day.

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125 watts X 3 hours = 375 watt-hours per day

STEPS 02 convert to kilowatts

But electricity is measured in kilowatt-hours on your electricity bill. Since we know that 1 kilowatt equals 1,000 watts, calculating how many kWh a device uses is as easy as dividing by 1,000.

375 watt-hours per day / 1000 = 0.375 kWh per day

STEP 03 usages over a month period

Now, to find out how much it costs you on your electric bill, you will have to make the equation a bit further. First, you'll need to figure out how many kWh the TV uses per month:

375 watt-hours per day X 30 day = 11.25 kWh per month

STEP 04 figuring out the cost

Next, pull out your last electric bill and see how much you pay per kWh. For this example, let us say you pay 10 cents per kilowatt-hour. To find how much the TV costs you in a month, multiply your electricity rate by the kWh per month that you calculated above.

11.25 kWh per month X ₦0.10 per kW = ₦1.13 per month

Another example

Here is another costlier example: Your refrigerator runs 24 hours a day. Most refrigerators consume 300-780 watts of electricity. Let us assume you bought a model that uses only 300 watts.

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300 watts X 24 hours = 7,200 watt-hours per day

7,200 watt-hours per day / 1000 = 7.2 kWh per day

7.2 kWh per day X 30 days = 216 kWh per month

216 kWh per month x ₦0.10 per kWh = ₦21.60 per month

Findings and Discussion

The process of obtaining data on electricity tariffs was conducted by interviewing 10 respondents from Bauchi metropolitan area. Because of the interview session, we got some information on the following:

Wiring Type

a. Single phase

The type of load available at the user's home using single phase wiring is 45 lamps, one (1) air conditioning (2h/p), six (6) ceiling fans, and four (4) portable fans. The amounts to be paid by consumers on average are ₦6,000 - ₦6,500.

b. Three phase

The type of load available at the user's home using three-phase wiring is 50 lamps, four (4) air conditioning (2h/p), and seven (7) ceiling fans. The amounts to be paid by consumers on average are ₦5,800 - ₦6,000. From these two types of electrical wiring systems, three-phase wiring has low charging rates compared to single-phase wiring. The use of load in three-phase wiring is more than single phase wiring (Yan *et al* 2015). This shows that the three-phase wiring is better than single phase wiring which can reduce the electricity bill.

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a. Savings

Consumers should save on electricity usage by auditing to reduce electricity bills. Users should be minimizing the use of electrical appliances. For example, switch off the lights before going to bed and the other part of the house when they are in the living room.

b. Reduce the power value

Each electrical equipment; has a different wattage value (Setlhaolo et al., 2014). When the electrical equipment has a high voltage value then the electricity consumption tariff will increase. For example, a fluorescent lamp has a value of 40 watts while LED light has a value of 20 watts. This LED light has a low wattage value compared to fluorescent lamps. In addition, this LED light is brighter, better, and more effective. So reducing the use of electrical equipment can reduce electricity consumption (Setlhaolo et al., 2014).

c. Use the timer

Use of timer in electrical appliances such as air conditioning: when using the timer, we can control the duration of use of electrical equipment. For example, using individual air conditioning before sleep can set a timer for two or three hours of use. Then, the air conditioner will switch off after time automatically.

d. Home design

One of the feebleness of homes in Malaysia is inappropriate design (Romli *et al*., 2017). Most homes have made designs that cause poor lighting. There are not many numbers of windows and doors available. For example, in every part of the room, a wall that causes the light cannot enter the space provided in the room. According to Romli *et al.* (2017), to make the design good with lighting, a door or rooftop that is transparent could be used to ease the light entering the house. In addition, users can install a solar roof bracket mounting system. This system uses renewable energy that can save electricity users.

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e. Awareness and knowledge

Every individual needs to have awareness and knowledge about energy auditing. Usually, the individual who is responsible for paying the bill is aware of the need to reduce electricity usage. Supposedly, every individual in the home should play a role in this electricity consumption. Otherwise, it will not happen. For example, when the number of occupants in a house increases and the use of electrical equipment will increase the tariff, they are not aware of the use of electricity, which will cause them to.

f. Use the inverter

The use of the inverter is one of the most helpful methods to reduce electricity consumption. This inverter will use the same current when using this electrical equipment. It only uses once high energy to get started. Typically, electrical appliances that do not use the inverter will use a cut-off when it reaches a maximum value and repeatedly use high energy to restart the equipment. Examples of equipment that use inverters are washing machines, air-conditioners, and refrigerators. Usually, this equipment has a star symbol that shows the level of electricity savings.

The Factors affecting the use of high electricity

a. The frequency of use of electrical equipment

The use of electrical equipment value and the beginning of great power often increases electricity consumption. For example, women in Bauchi State often use an automatic dry iron. Whenever they washed and wanted to wear their clothes, they may use an automatic dry iron. The use of this equipment requires a high-power start-up. So, to save electricity, this should set its use like using this iron once for a week wears.

b. Number of people in household

The number of individuals in a house also affects the use of this electricity. When many residents in a house will increase electricity consumption; for example, the respondents will only pay their electricity bill of ₦6,000 for the regular month but on

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school holidays the total electricity bill will be ₦ 6,500 as their children return home and increase the number of users.

c. Individual awareness

Every individual must have awareness of electricity consumption. If these individuals are unaware they will use this electrical equipment at will, though they do not need it. For example, individuals who do not have the awareness will let the lights open when they sleep and turning on the lights in another room while not using the room.

d. Home design

Home design is also a source of high electricity consumption. For example, a house that has several windows and doors that less will cause poor lighting. This causes the use of lamps even during the day.

The benefits of reducing electricity consumption

When we reduce this electricity consumption we can reduce electricity bill payments. It would be beneficial if it can save you money and used elsewhere. For example, when the value of the payment can be reduced from ₦ 5,800 to ₦ 6,000, we can reduce by ₦ 700 It is a great value and very useful. If we save energy and use it, we can save money.

Individuals involved in reducing electricity consumption

Usually responsible individuals who pay attention to reducing energy consumption are parents and people who pay bills. Individuals who do not pay their bills are usually not involved and aware of this problem because not using their money. Parents will usually give awareness and knowledge about this and usually it is only temporary. Individuals involved in these savings are individuals who find it difficult to pay electricity bills.

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CONCLUSION

The purpose of this paper was to demonstrate how the energy auditing of domestic power consumption for various appliances improves energy efficiency as consumers need to be more aware of their energy consumption/auditing. Energy auditing on how the public viewed electricity bills, the cost of consumption, and the ways to moderate the burden of electricity bills were calculated. The study was limited to Bauchi State metropolises and it involved respondents for in-house sampling. The results were analyzed. It was revealed that the mode of payment of electricity bills fluctuates with the standard of living, climate, and types of residence reliant on the usage in each household. This study adopts the use of domestic power consumption measurement and its appliances. A sample on house electric power consumption measurements has been carried out in Gwallameji domestic buildings where the result shows that there is a great variation in the electricity consumption as a result of different standards of living, climate, and types of residence, depending on the usage of appliances in each house. The contributing factors to these variations were consumption from continuous, standby, and active appliances.

REFERENCES

Ashiquzzaman, M., Afroze, N., & Abdullah, T. M. (2012). Design and Implementation of Wireless Digital Energy Meter using Microcontroller. *Global Journal of Research In Engineering*, *12*(2-A).

Brickfield, P. J., Mahling, D., Noyes, M., & Weaver, D. (2011). Automatic energy management and energy consumption reduction, especially in commercial and multi-building systems: Google Patents.

Dermentzis, G., Ochs, F., Gustafsson, M., Calabrese, T., Siegele, D., Feist, W., … Bales, C. (2019). Energy & Buildings A comprehensive evaluation of a monthly-based energy auditing tool through dynamic simulations , and monitoring in a renovation case study. *Energy & Buildings*, *183*, 713–726. https://doi.org/10.1016/j.enbuild.2018.11.046

Firth, S., Lomas, K., Wright, A., & Wall, R. (2008). Identifying trends in the use of domestic appliances from household electricity consumption measurements. *Energy and Buildings, 40*(5), 926-936.

Fischer, C. (2008). Feedback on household electricity consumption: a tool for saving energy? *Energy efficiency*, *1*(1), 79-104.

Kavousian, A., Rajagopal, R., & Fischer, M. (2013). Determinants of residential electricity consumption: Using smart meter data to examine the effect of climate, building characteristics, appliance stock, and occupants' behavior. *Energy*, *55*, 184-194.

Pawan K., Gagandeep S., Surjit S., Srete N., Hamid R., Zoran B(2019.). Perspectives and Intensification of Energy E ffi ciency in commercial residential buildings using stretegic auditing and demand side management.

Raj, P. A.-D.-V., Sudhakaran, M., & Raj, P. P.-D.-A. (2009). Estimation of standby power consumption for typical appliances. *Journal of Engineering Science and Technology Review*, *2*(1), 71-75.

Roberts, T. (2013). Customer billing in a communications network: Google Patents.

Rojchaya, S., & Konghirun, M. (2009). *Development of energy management and warning system for resident: An energy saving solution.* Paper presented at the Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology, 2009. ECTI-CON 2009. 6th International Conference on.

Romli, M. H., Tan, M. P., Mackenzie, L., Lovarini, M., Kamaruzzaman, S. B., & Clemson, L. (2017). Factors associated with home hazards: findings from the Malaysian Elders Longitudinal Research study. *Geriatrics & gerontology international*.

Santinato, M., Arione, E., & Braghini, G. (2017). Electronic system for power consumption management of appliances: Google Patents.

Setlhaolo, D., Xia, X., & Zhang, J. (2014). Optimal scheduling of household appliances for demand response. *Electric Power Systems Research*, *116*, 24-28.

Solgi, E., Hamedani, Z., Sherafat, S., & Fernando, R. (2019). The Viability of Energy Auditing in Countries with Low Energy Cost : A Case Study of a Residential Building in Cold Climates.

Sugiura, S., Miwa, A., & Uno, T. (2013). Analysis of household energy consumption of lighting and electric appliances and predictions for 2020.

Sun, Q., Li, H., Ma, Z., Wang, C., Campillo, J., Zhang, Q., . . . Guo, J. (2016). A comprehensive review of smart energy meters in intelligent energy networks. *IEEE Internet of Things Journal*, *3*(4), 464-479.

Swan, L. G., & Ugursal, V. I. (2009). Modeling of end-use energy consumption in the residential sector: A review of modeling techniques. *Renewable and Sustainable Energy Reviews*, 13(8), 1819-1835.

Yan, S., Tan, S.-C., Lee, C.-K., Chaudhuri, B., & Hui, S. R. (2015). Electric springs for reducing power imbalance in three-phase power systems. *IEEE Transactions on Power Electronics*, 30(7), 3601-3609.

