Employing An Effective Energy Audit Program (EAP) For Household Energy Conservation.

By
ENGR. CALISTER. N. MBA
Department of Computer Engineering,
Caritas University,
Amorji – Nike, Enugu.

Abstract

Effective and efficient energy conservation is a central issue to any developing nation like Nigeria. This is so because the generation, transmission and distribution of such energy is so demanding in terms of economic and technical resources. As a result of this, there is need for proper management of the energy resources. Energy conservation is imperative as the waste of energy do not only have negative impact on our economic standard but also on our environmental features including our housing structures. This paper explored what could be done when energy must have been distributed to the homes in order to use it in the most efficient and prudent ways. The paper exposed the users' pattern of energy consumptions, proposed more prudent measures, as well as major strategies for home energy consumptions.

KEYWORDS: generation, transmission, distribution, environmental features, consumptions.

INTRODUCTION

Energy is the ability to do work, expressed in Joules (J). Different forms of energy include electrical, chemical, mechanical, heat and sound. Energy could be transformed from one form to another, but the total energy still remains the same, this of course summarizes the first law of Thermodynamics. There are a number of energy sources ranging from coal, oil, water, gas, wind, solar, to biomass. Energy is used in our homes for various purposes like heating, air conditioning, lighting, refrigeration, clothes washing, clothes drying, water heating and a whole range of other usages.

Energy is an expensive resource. This exposes the needs for energy conservation in our homes. Home energy conservation refers to efforts made to reduce energy consumption in our homes, thereby trimming off wastages and minimizing cost in our electrical energy consumptions. [2] Home energy conservation saves us from environmental hazards like air or water pollution. These types of pollution occur whenever lights are turned on. This is because turning on lights create little pollution. An average home pollutes more than the average car. A major need for home energy conservation in Nigeria is the cost implication of using such energy like the electrical energy. The Nigeria Electricity Regulatory Commission (NERC) has just released a new electricity billing system - MULTI-YEAR-TARIFF ORDER (MYTO), which has increased the tariff rate by 77%. Due to the economic challenges this new idea will post on the consumers, there is a very high need for optimum efficiency in home energy consumption. Conserving home energy use does not only save money and environment, but also saves our building structures. Minimizing home energy use reduces the effects of energy losses on the building structures. Electromagnetic radiations from home appliances are hazardous to our buildings; this can be avoided by using an effective energy audit program to control such appliances, thereby saving our buildings. There are also various forms of radiations emanating from devices such as incandescent bulbs, computer and television screens, fan controllers and fan switches, these radiations have effects on human health. Energy losses through radiations from such devices should be conserved so as to avoid the health hazards introduced to the human bodies through such radiations.

Al-Tahat and Al-Ali showed the possibilities of improving the efficiency of electricity consumption in Jordanian plastic industry with remarkable energy cost savings. Energy saving estimation should be identified prior to starting an energy program. Most important estimation methods include; simplified engineering method, regression analysis method, dynamic models, and computer simulation model using HAP4.41 software.[1] A real life Jordanian pharmaceutical energy saving program using a computer simulation software (HAP4.41) was simulated and a total annual saving of 6608kwh was achieved by simulating retrofitting actions.

The idea of energy conservation was suggested to be an integral part of the political arena by the environmentally concerned citizens. "However, it was not until energy prices rose, regulations developed on a national level, subsidies for energy conservation emerged, and actions addressing the issue were seen by many local actors as adding value to the unique character the municipality gained by their Renewable Energy Self Sufficiency (RESS) activities, that the actual subject was considered relevant in the municipality".[8] The Demand Side Management (DSM) program by Power Holding Company of Nigeria (PHCN) was introduced as a way of reducing energy consumption among customers with emphasis on energy conservation, energy efficiency and load management. [7] "The potential for energy savings in the Nigerian economy is huge, especially in the three main energy demand sectors namely household, industry, and transportation. In the household sector, there is considerable energy loss due to inefficient traditional three-stone stoves, used for cooking mainly in the rural areas.

Currently, the Federal Government of Nigeria has encouraged the importation of energy saving bulbs into the Country as a means of conserving home energy use. Government has also embarked on the prepaid electric meter for every household for a more effective control. [6]

PROCESSES OF ENERGY LOSS

Energy Use Characteristics of Home Devices:

Table 1.0 Energy consumption of Home Appliances

S/N	Device	Range of Energy Consumption (watts)
1	Clothes dryer	1800-5000
2	Fans -Ceiling -Window -Furnace -whole house	 65-175 55-250 750 240-750
3	Heater (portable)	750-1500
4	Clothes iron	1000-1800
5	Microwave oven	759-1100
6	Personal Computer -CPU- Awake/Asleep - Monitor- Awake/Asleep -Laptop	 120/30 or less 159/30 or less 50
7	Refrigerator (frost free 16 cubic feet)	725
8	TV(color) 19″ 27″ 36″ Flat Screen	65-110 113 133 120
9	VCR/DVD	17-21/20-25
10	Water Heater (40 gallon)	4500-5500

Table 1.0 shows a list of home appliances with their respective energy consumptions (in watts).

Estimation of Energy Use:

The energy use of any appliance can be estimated using the formula:

(Wattage x Hours used per day)/1000 = Daily KWH Consumption,

If we multiply the daily KWH consumption by the number of days you use the appliance during the month we obtain the monthly consumption. You can then calculate the monthly cost to run appliance by multiplying the KWH per month by your local utility's rate per KWH consumed. This utility rate depends on the class, which could be residential, commercial tariff code as specified by the NERC's MYTO, which was first implemented in June 2012.

For example, to calculate the energy consumption for a personal computer and monitor for a period of one year;

[(120 watts + 150watts) x 6 hours /day x 365days/year]/1000, if it is on for 6hours in a day.

= [270 watts x 6 hours/day x 365 days/year]/1000

= (591300)/1000

= 591.3 KWH (daily KWH consumption)

Assume utility rate = ₦12.89 (R2 - Enugu - 2012)

Then Energy consumption = 591.3 KWH x 12.89

= ₦7,621.86/year

The wattage of most appliances are usually stamped on the bottom or back of the appliance, or on its name plate. The wattage listed in table 1.0 is the maximum power drawn by the appliance. Since many appliances have a range of settings (for example the volume of a radio), the actual amount of power consumed depends on the setting used at any one time. If the wattage is not listed, you can still estimate by finding the current drawn (in amperes) and multiplying that by the voltage used by the appliance.

ENERGY LOSS IN HOME APPLIANCES

Home electrical appliances consume some energy when they are left on standby mode or even switched off. This loss is so infinitesimal to be noticed by the

consumers, as it ranges between 1w and 30w, but can be significant when put together for all the appliances in a home. The energy consumed by appliances when they are not performing their main functions or when they are switched off is known as standby loss or leaking electricity. [4]. Modern electrical and electronic appliances, even those having on/off switches, consume power for standby functions such as powering off the built in clock or memory, displaying information, responding to remote controls or programming, charging of batteries, etc. [4]

Options to Reduce Standby Power Consumption:

There are basically two options to reduce standby power consumption: behavioral and technical. Behavioral involves better consumer awareness and education on standby energy consumption. Consumers should be properly educated through campaign, advertisement, and should be encouraged to purchase equipments with reduced standby consumption. [4] This is not easy because of the financial and human resources involvement in reaching out to every household, as a result of this; it is not the most cost effective option for public authorities. It may also not be practical to tell people to just unplug their appliances that are not in use. For example, personal computers connected to a network are required to be in standby mode to avoid communication problems with peripheral devices or to the network manager. The second option for reducing standby power consumption in most appliances is the adoption of technological innovations. It is estimated that redesigning appliance circuits can reduce standby power consumption to a high percentage. Some manufacturers already have done this by introducing the standby or sleep mode to certain appliances, in which the products consume much less power. Some devices have programming option for switching off selected components when they are not in use for a stipulated time period. This is the case with portable laptop/notebook computers that go into sleep mode when the keyboard or the mouse is not used for a time period that can be set by the user. Most computers today have two power saving modes incorporated in the product design. This allows the machine to switch off some components after a predefined time period, if the computer remains unused for a longer predefined period; it then enters into a deep sleep mode by switching off several key features. Unfortunately, many users don't use this feature because they are ignorant of it. A research survey by Mohanty (2001) in Thailand in office buildings showed that this feature has not been enabled in 90% of the computers sampled in the offices. One of the areas where substantial energy is consumed when appliances are on standby or switched off is in the power supply system. With recent innovations, it is possible to reduce the no-load losses while providing very high conversion efficiencies. New generation power transformers adopting electronic components are capable of reducing the standby power consumption from 5w to as little as 0.1w. "These transformers are also far more energy efficient, providing 70 to 75% efficiency compared to 40 to 45% of the traditional models they replace". [4]

Concerned with the huge monetary losses, and environmental impacts of standby power consumption at the national level, governments in several countries have initiated programmes to address the issue. For example, the "Energy Star" label of the US Environmental Protection Agency (US EPA) for consumer electronic products takes the standby power use into consideration. The international Energy Agency (IEA) has initiated promoting international action to reduce the standby power consumption of products to 1w in Europe, Australia and Japan.

Effects of Energy Loss:

Energy has been proven to be one of the indispensable needs in our homes, but if not used properly can also expose us to more dangers than the needs. Energy losses in our homes can expose us to some environmental hazards like health hazards, noise pollution and failures of parts of our building structures. There are various forms of radiations emanating from devices like incandescent bulbs, computer and television screens, fan controllers and switches, which are very hazardous to the human body. Some other devices like the fans, refrigerators, TV, kitchen equipments like blender show their loss of energy in form of sound, thereby introducing noise pollution to our homes. Such devices manifest this noise pollution as they are switched either on or off, or even while they operate, or while they experience voltage fluctuations. Energy losses from devices like the electrical wires on the walls, bulbs, switches and wall receptacles directly affect the parts of building structures like the walls, ceiling, etc by introducing tears and wears on such surfaces as a result of installation and re-installation of such devices.

Energy loss in our homes also has some economic implications. It introduces extra cost of maintaining our buildings and the equipments. Loosing energy implies wasting resources, which were used to generate such energy. Unfortunately, we must have paid directly or indirectly for this energy that is been wasted, meanwhile, we have no economic justifications paying for a resource that is not useful

to us, especially in hard times like this, when the energy tariff has been increased by the NERC.

CHALLENGES TO ENERGY CONSERVATION

Energy conservation in Nigeria is faced with a number of challenges, which in this work has been grouped into four main headings viz;

(a) Supply Side Management Challenges:

Epileptic power supply is the hallmark of a developing country like Nigeria. There is no constant power supply in our homes and this posses a great challenge on the energy conservation strategies. For instance, one would rather resort to fuel generated energy supply, rather than paying for some energy efficiency management tools, when the energy supply is not assured. [3] Generally, the Nigeria energy distribution has been monopolized and therefore lacks competition, which is a major key in any business, because of this monopoly, distribution companies like PHCN in Nigeria has not been enthusiastic about introducing some energy conservation management tools and of course encouraging customers to use such tools. As a result of the monopoly that has been in place, there cannot be effective demand side management strategies in place. In the telecommunication industry for example, because of the high level of competition, the service providers are forced to offer some extra services like free calls, bonuses on recharge etc, which are merely business strategies to attract, encourage and retain their customers.

(b) Economic challenges

The population of Nigeria has been proven by research to be increasing on daily basis, and greater percentage of this population has also been proven to be in abject poverty. The consistent high rate of inflation in Nigeria also places the cost of living on the high side making the economic status of the populace to be very low. This makes it difficult for them to afford some standard materials or items of their choices. Those two factors; poverty and inflation, make the consumers settle for sub standard and inexpensive materials for their residential buildings leading to low quality structures. This exposes the buildings to greater number of air leak sources, which reduces drastically the efficiency of energy use. Many energy consumers as well cannot afford some low energy consuming appliances because of their high prices due to their low economic and financial standards.

(c) Technological challenges

Technological advances in home energy efficiency have not been explored to a satisfactory level. Nigeria has not adopted some technologies like the wireless sensor networks or remote monitoring systems, which could allow a consumer to remotely manipulate his/her home appliances for the purpose of conserving energy. There is also explicit lack of infrastructure needed to create, deliver and maintain new forms of energy efficiency. New technologies need to be in place to catch up with the growing needs of the society.

(d) Social Challenges

On the supply side, there is no uniform and standard billing method that is adopted for all the energy consumers, rather various methods exist. Popularly, the estimation method is used, which mostly do not favor the consumers; this makes the consumers reluctant to conserve energy in their homes. On the consumer's side, a great number is completely ignorant of the relevance and implications of conserving energy, many are not aware of the scarce resources used to even generate the energy, and so they embark on wasting these resources by not regulating their own personal energy use. The attitude of some energy consumers is unprogressive. Many leave their appliances like bulbs, computers, security lights etc on, when they are not using them. Some users have formed the habit of using electricity to do most of their cooking, heating etc, even when they have other cheaper means; this implies wasting the energy resources. Some other users are simply lazy to switch off equipments that are not in use. These are the social challenges to energy conservation in our homes.

STRATEGIES FOR ENERGY CONSERVATION

Home Energy assessment (Home Energy Audit (HEA)):

A home energy assessment strategy called home energy audit (HEA) shows how much energy your home consumes and suggests what measures you can take to make your home more energy efficient. An assessment will show you problems that may, when corrected, save you significant amounts of money for a period of time. Home energy assessment can be conducted by using strategies like:

(a) (i) The Do –It- Yourself Strategy (DIY)

(ii) A Professional Energy Auditor Strategy (PEA)

(b) Smart Meters and a Smarter Grid Strategy (SMSGS)

(c)Time Based Electricity Rates Strategy (TBERS)

(d) Demand Side Management Strategy (DSMS)

(a) (i) Do-It-Yourself Strategy (DIY):
This energy saving strategy suggests an application of a self effort and management skills by the energy consumers to attain the most energy efficiency level in their homes. It implies the consumers applying the personal efforts on minimizing the usage and wastage of the home appliances as well as using such appliances where and when there is actually a need. In this strategy, the consumer takes adequate precautions and does a personal analysis to make a smart choice of the appliance to use for a particular purpose at any given time. Here, the consumer applies common sense to switch off and unplug those equipments not in use, to block air leaks and insulate some parts of the building. The consumer applies the energy assessment tips in the last section below to reduce his/her energy costs. However, for a more detailed assessment, a professional energy auditor can be consulted.

(a) (ii) Professional Energy Auditing Strategy (PEAS):

A professional auditor uses a variety of techniques and equipment to determine the energy efficiency of a structure. He uses special test equipment to find air leaks, areas lacking insulation, and malfunctioning equipments. Thorough assessments often use equipment such as blower doors, which measure the extent of leaks in the building envelope, and infrared cameras, which reveal hard-to-detect areas of air infiltration and missing insulation. The auditor analyses how well your home's energy systems work together, and compares the analysis to your utility bills. After gathering information about your home, the auditor will recommend cost effective energy improvements that enhances comfort and safety. Some will also estimate how soon your investment in efficiency upgrades will pay off. There are also possible alternatives to the DIY strategy as discussed below.

(b) Smart Meter and Smart Grid Strategy (SMSGS):
Smart meters provide two-way communication between the utility and the consumer, helping the utility to know about blackouts for example. This helps utilities to maintain more reliable electrical service. Smart meters can be used with home energy management systems such as web-based tools that the utility provides, or devices that can be installed in the home. Smart meters can display your home energy use; help you find ways to save energy and money, and even allow you to remotely adjust your thermostat or turn appliances off. Smart meters and home energy management systems allows customers to program how and when their home uses energy. A typical example here is a system where a group of home equipments is being remotely monitored and controlled using a mobile GSM phone.

(c) Time Based Electricity Rates Strategy (TBERS):
Smart meters and home energy management systems allow customers to program how and when their home uses energy. Such programs might charge you the actual cost of power at any one time, ranging from high prices during times of peak demand to low prices during off-peak hours. If customers are able to shift their power usage to off peak times such as boiling water late in the night, these programs can save money as well as the equipments. To help reduce their peak power demands and save energy/money, many utilities are introducing programs that encourage their customers to use electricity during off peak hours. Time-based rates are very attractive to plug-in hybrid owners and electric vehicle owners where it applies, since typically these vehicles are recharged at nights i.e. off peak periods when the rate is low.

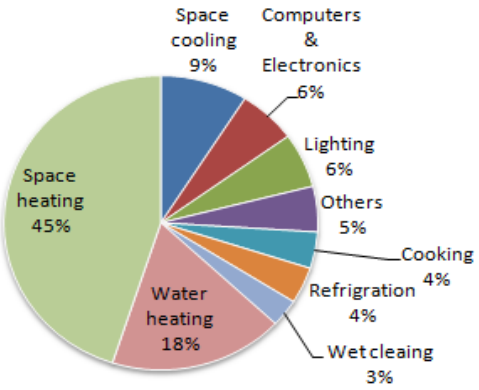
(d) Demand Side Management Rates Strategy (DSMRS):
"Demand side management programs usually consist of the planning, implementation and monitoring activities of electric utilities that are designed to encourage customers to modify their level and pattern of electricity usage. Instead of building new power plants to respond to increasing customer demand, electricity producers can also endeavour to minimize their customer's demand for power by offering special programs for homeowners, business, institutions and industries". [7] Demand side management strategy like educating the consumers on how to actually use the energy assessment tips as discussed in this paper will go a long way minimizing the energy usage efficiency in our homes.

ENERGY SAVING STRATEGIES

According to the 2010 Buildings Energy Data Book, heating accounts for the biggest portion of our utility bills as shown in the pie chart (figure 1).

Figure 1: Pie Chart Showing Energy Consumption

However, there is also a large room of improving the efficiency of electricity consumption in the homes. Improving home's insulation and sealing air leaks are the fastest and most cost-effective ways to reduce home energy waste. One of the quickest efficiency



measures that can be taken is to caulk, seal and weather strip all seams, cracks and openings to the outside of a building structure. Some home energy saving tips include:

1. Planning smart purchases – look for the ENERGY STAR Label ® on the equipments. Energy star products meet strict efficiency guidelines set by the US Environmental Protection Agency and the US Department of Energy.[9]
2. Use renewable energy at home such as solar and wind to save electrical energy and reduce environmental impact. For example air dry cloths instead of using electric drying.
3. Study your family's lighting needs and look for ways to use controls like-sensors, dimmers, or timer to reduce lighting use.
4. Turn appliances off when they are not in use.
5. Plug home electronics into power strips, turn the power strips off when the equipment is not in use – some electronics like TV, DVD, and Computers in standby mode still take several watts of power.
6. Wash only full loads of dishes and clothes
7. Air dry dishes instead of using your dishwasher's drying cycle.
8. Ensure that windows and doors are closed when heating or cooling your home.
9. Lower the thermostat on your heater to 120^{o}F.
10. Install a programmable thermostat to lower utility bills and manage your heating and cooling systems efficiently.
11. Check the insulation in your attic, exterior and basement walls, ceilings, floors and crawl spaces.
12. Check for air leaks around walls, windows, ceilings, doors, light and plumbing fixtures, switches and electrical outlets.
13. Ensure that your appliances and heating systems are properly and regularly maintained. Check your owner's manual for the recommended maintenance.

CONCLUSION

The research revealed that there are possibilities and strategies for reducing drastically or at least minimizing our home energy consumptions. A home energy assessment program known as energy audit program (EAP) was exploited. It revealed the application areas of energy in our homes, alternatives to such application areas, precautions to take in order to avoid or reduce energy waste, and the strategies for conserving home energy. The most efficient ways to use our home energy resources were given.

However, these strategies that could promote our home energy efficiency still face some challenges, making 100% efficiency not guaranteed. The epileptic power supply and the unavailability of a uniform and structured billing system still pose some challenges to the customer's attitudes towards the energy audit/assessment strategies. Greater percentage of the energy consumers is not educated on the implications of energy waste. Energy waste has both economic and environmental negative implications on human beings and our buildings as well. Education and sensitization programme/awareness that will make the consumers accept and adopt the new technologies are not in place. This makes them unfriendly to the new idea/technology. They should be properly exposed to the fact that improving energy efficiency utilization in our homes not only saves the resources but also saves our environment, including the houses that we live in. These services should also be extended to the localities as well. Government is therefore called upon for more information on specific energy saving practices. A functional and structured billing system (for example the prepaid meter) should be made available to all the electrical energy users as this will encourage them to adopt the new technology (EAP) and actually apply them. Consumers should also change their negative formed habits on energy waste; established habits need to be replaced with new energy saving habits and attitudes. Energy consumers should also come to terms with the fact that things have changed in that respect. For example, the NERC MYTO 2012, effective from May 31st 2012, charges ₦12.89K for R2 class (i.e. residential level 2) per kilowatt hour in Enugu for instance, which was formerly ₦ 7.30K. The consumers must be ready to pay

for the amount of energy they use since the prepaid meter will be installed for every user as proposed by NERC.

REFERENCES

1. Al-Tahat, M; Al-Ali, A. (2012) Energy saving opportunities in Jordanian Pharmaceutical Industries. *Perspective of Innovations, Economics and Business.* Vol. 10, Issue 1, 2012 PP 35-50.
2. Hirota A. (2008) Energy Saving Technologies in Home Appliances.
3. Iyayemi A. (2008) Nigeria's Dual Energy Problems: Policy issues and challenges. *The Energy Journal*, Fourth Quarter 2008, pp17-21 International Association for Energy Economics.
4. Mohanty B. (2001) Standby Power losses in Household Electrical Appliances and Office Equipment. A Paper presented at the Regional Symposium on Energy Efficiency Standards and Labeling. 29-31 May 2001. Accessed on 20th July 2012 at http://www.un.org/esa/sustdevr/sdissues/energy/op/clasp-mohanty.
5. National Energy Policy (2003) Energy Planning and Policy Implementation. *Energy Issues.* Accessed on 20th July, 2012.
6. Nigerian Electricity Regulatory Commission (NERC). (2012) Multi-Year Tariff Order (MYTO) for the Determination of the Cost of Electricity sold to Distribution /Retail Companies for the Period 1 June 2012 to 31st May 2017.
7. Okoro O. I, Govender P., Chikuni E. (2007) Power Sector Reforms in Nigeria; Opportunities and Challenges. *Journal of Energy in Southern Africa* Vol. 18 N0 3 August 2007.
8. Stablo J, Ruppert W. C. (2012). The Integration of Energy Conservation into the Political Goal of Renewable Energy Self-Sufficiency – A German Case Study, based on a Longitudinal Reconstruction. *Sustainability* Vol. 4 pp 888-916 May (2012).
9. US Department of Energy (2011) Energy savers: Tips on saving Money and Energy at Home. Accessed on 10th August, 2012 at http://www.energysavers.gov/your_home/appliances/index.cfn