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Management of Existing Capacity of Electric Power with Energy Saving Devices

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Abstract: The strategy of management of the existing capacity by proper illumination design and the use of energy saving devices in the residential sector is reported. Improper installation design and the use of all sorts of devices at homes has led to a lot of electrical energy wastages resulting in the need to increase the generation capacity. The study revealed that annual energy of 551.88kWh could be saved for a three – bedroom flat when energy saving fluorescent lamps were used. The corresponding naira savings was 2,207.52 per annum. In addition, the sizes of cable, fuses/circuit breakers required are reduced and hence reduction in the cost of installation. The paper advocates the need for proper design and installation of energy saving devices in homes. The paper will be of relevance to lighting installation designers, power systems engineers, power utility managers, and the general public.

Introduction

The Power Holding Company of Nigeria (PHCN) is rapidly moving towards full privatization of its component parts: generation, transmission, and distribution. Already a number of independent power producers (IPPs) has commenced generation, which has led to considerable improvement in generation capacity. This Herculean task of meeting with the energy needs of the nation cannot be realized if we do not manage our existing capacity with energy saving devices. Although it is believed/ agreed that privatization would lead to improvement of generation capacity, system security and achievement of improved overall efficiencies, however, the poor use of domestic devices will not help matters. The concept of energy as one of the resources subject to management processes has led to the widespread use of the term energy management. Although energy management has a broader concept, it is synonymous with energy conservation. It is defined as the strategy of adjusting and optimizing energy- using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of providing the output from these systems [1].

It is to be stated that the reason why energy management has not received widespread recognition in Nigeria has been the relatively low cost of energy in the past. Also, there is the absence of information and understanding of the potential benefits to be derived from energy management programmes. However, with the power system reform in Nigeria, the era of cheap energy delivery to the consumers or non payment of electricity bills is a thing of the past.

The residential sector is one of the major energy-consuming sectors in many developing countries (more than 50 per cent in Nigeria) [2,3]. The energy in this sector is used primarily to provide comfortable and convenient living conditions for the population [2] .In a typical home, the energy use pattern includes energy for space heating/ air conditioning (32%), refrigeration (8%), water heating (13%), appliances and lighting (32%) and electric ironing (15%) [4].

A number of literatures has reported the energy use and management in industries [1, 5, 6] and increasing generation capacity [7, 8, 9]. However, few have addressed managing existing capacity through the use of energy saving devices [10]. This paper addressed the problem of managing the existing capacity.

The rational use of energy is also associated with efforts to curtail energy wastages and is concerned exclusively with energy conservation as a means of increasing economic benefits (improved production capacity). It begins with good housekeeping practices, with little or no investment involved [5].

The purpose of this paper is therefore to create the necessary awareness of the electrical energy conservation measures through the use of energy saving devices. It will also help to identify areas with high-energy prospects for energy conservation resources. In addition, it will evaluate the economic and technical practicalities of implementing effective use of energy and hence reduces energy waste. It is equally hoped that the results obtained from the study will assist in future projections of energy use in the residential sector as well as policy decisions on price structure, tariff and billing issues in a deregulated utility environment, like Nigeria. Other benefits include: assisting the power utility company to manage the existing capacity and hence the marginal cost of generating capacity, quantifying the cost benefit accruing from the use of energy saving devices in homes, and finally, reduce the cost of installation by reducing the size of cables, fuses/circuit breakers used in residential houses.

2.0 CHOICE OF LAMPS AND LUMINARIES

A good lighting scheme is desirable as it can raise the quality of life, not only by improving the environment in terms of comfort and pleasure but also by increasing productivity, reducing accidents, improving security and reducing maintenance costs [11]. The different lamps and their characteristics are briefly discussed.

The incandescent lamps (GLS lamps) mostly emit infra – red radiation in the form of heat. The lamps are the least energy efficient type of lighting and inexpensive to buy. However, their running costs are high. They are most suitable for areas where lighting is used infrequently and for short periods, such as laundries and toilets. Standard incandescent bulbs last about a thousand hours and must be regularly replaced [4].

In a fluorescent lamp (MCF lamp), by contrast, the emission is mostly ultra – violet radiation which is converted into visible light by the introduction of various fluorescent phosphors which are coated on the inside of the tube. The lamps are the most energy saving form of lighting for households and use only about a quarter of the energy used by incandescent bulbs to provide the same light level. They are more expensive to buy but are much cheaper to run and can last up to ten thousand hours. There are two main types of fluorescent lamps: tubular and compact. The tubular lamps, also known as fluorescent tubes, are available in a straight or circular shape. They are cheaper to buy than the compact fluorescent lamps (CFLs), but unlike CFLs require special fittings. The tubes are ideal for kitchens, garages and workshops. Compact fluorescent lamps (CFLs), also known as long life bulbs, are usually designed to fit into conventional bayonets or screw fitting light sockets. They come in a range of shapes [4].

A third lamp worth mentioning is the low pressure sodium discharge lamp (SOX lamp). Its spectral distribution concentrates around 589nm giving a distinct yellow appearance, making all the surrounding colours look yellow.

The choice of these lamps is an important consideration and a source of reducing energy wastages. Table 1 shows the lifecycle costs for lighting systems using different globes to produce the same amount of light. The lifecycle costs include purchase, running and replacement costs [4]. Table 2 reveals the efficacies of some selected flames and lamps [12].

Table 1: Lifecycle costs for different lighting systems [4]

/No.	Parameters	Different lighting globes		
		100W Incandescent	18W CFL	65W Halogen
	Running cost over 10,000 hours*	$90	$17	$68**
	Average life	1000 hours	6000 hours	2000 hours
	Purchase cost	$3, 6 bulbs@ 50c	$7, 1 lamp	$6, 3 lamps @ $2
	Total cost	$93	$24	$74

* Based on 15 cents per unit of electricity.

** Includes magnetic transformer losses

Table 2 Efficacies of selected flames and lamps [12]

S/No.	Light source	Efficacy (Lm/W)	
		Lamp alone	Lamp plus ballast
1	Sunlight	92	-
2	Open gas lamp	0.2	-
3	Gas mantle	1 to 2	-
4	Incandescent lamp: 40 W	12	-
	100 W	18	-
5	Fluorescent lamps, plus ballast:		
	20W, 24 in, T12, plus 13 W	65	39
	40W, 48 – in, T12, plus 13.5W	79	59
	75W, 96 – in, T12, plus 11W	84	73
6	Metal halide. 400W, plus 26W	80	75
7	Sodium:		
	400W high pressure, plus 39W	120	109
	180W low pressure, plus 30W	180	154
8	Mercury, 400W, plus 26W	57	53.5

A lighting designer will almost consider the following points when deciding a type of lamp for a particular lighting scheme.

1. the lamp's colour quality.
2. the lamp's colour appearance, that is, the lamp's apparent colour based on its correlated colour temperature – warm, intermediate, cool or cold.
3. knowledge of the run – up time to full brightness and also its re –strike time.
4. suitability, efficacy, life, and need for starting control gear.
5. protection from substances in the environment (internal or external).
6. energy cost and lamp maintenance/replacement costs.

Electrical Energy Consumption Profile And Energy Cost

A study on the electrical energy consumption for different categories of residential consumers in some selected areas in Edo State has been reported [13]. The study revealed that the electrical energy consumed depends on the class of consumers and locations. It indicated that more electrical energy is consumed in the residential urban areas of Benin City, followed by semi urban areas of Ekpoma and Uromi.

Electricity tariffs are desirable in order to recoup the cost associated with the purchase, installation, operations and maintenance of generating plants and the salaries of personnel. The utility costs are of three types: energy cost (or fuel costs), capital costs and customer – related costs. Therefore, a customer's bill may be any combination of the three basic costs [3]: demand charge or kW charge (which accounts for this contribution to the utility incurring capacity cost), energy charge or kWh charge (which relates to his kWh consumption over the billing period), and fixed charge or minimum charge or customer charge (which is a recurrent flat rate charged to recover costs associated with metering and billing).

The basic approach is to make each customer category pay for the costs it imposes on the power utility. At present, the electricity tariff on the residential customer can be represented as:

Customer bill (Naira) = Energy costs + VAT (1)

and Energy costs (Naira) = Fixed charge + meter maintenance charge + kWh charge (2)

In Nigeria, the following costs are currently charged to residential consumers:

Fixed charge = N 30.00
Meter maintenance charge = N 100.00
KWh charge = N 4.00 x kWh consumed.
VAT = Value Added Tax = 5% of the energy costs.

Using this information, the Naira cost of average monthly tariff accruing from electrical energy consumption for the different residential categories in Benin City, Ekpoma, and Uromi in Edo State were computed. A typical Nigerian family living in 3 – bedroom flat spends more than 2, 500 naira per month on home utility bills. The situation is worse for those in duplex and bungalow type of residential building.[13].

Load Calculations

An analysis of the specific benefit accruing from the use of energy saving devices in a well – designed apartment/household was carried out. The purpose was to obtain a reliable predictive tool, which would enable calculation of baseline electrical energy requirement, which is necessary for implementation of energy conservation measures. The consumer loads are usually classified under the following headings [14]: lighting, heating, and electronics (entertainments). As a case study, the load calculations for a typical three bedroom flat was carried out. Note that the use of energy saving fluorescent lamps in place of incandescent lamps in lighting was employed in all cases with the exception of security lighting.

Table 3 shows the energy usage patterns of two 3 – bedroom flats using incandescent lamps and energy saving fluorescent lamps.

Table 3 Comparison of Annual Estimate of Engergy Usage Patterns of two 3 – bedroom flats using incandescent lamps and energy saving fluorescent lamps

S/No.	Appliance	Use of incandescent lamps (kWh)	Use of energy saving fluorescent lamps (where applicable) (kWh)
1	Lighting loads	5431.20	3591.6
2	Heating loads	4362	4362
3	Ceiling fans	258	258
4	Air conditioners	2580	2580
5	Refrigerators	1923	1923
6	Electronics (Home appliances)	1586	1586
7	Total	16140.20	14300.60
8	Total x 0.3	4842.06	4290.18

A consumer may not be using all loads at the same time, hence we need to use diversity factor based on the ratio of maximum demands for each load and the sum of the maximum demand for the total load. In forecasting a residential consumer load, we need to know the load factor: that is, the ratio of average load for a given period of time to the maximum demand during the same period. Thus, the main parameters for forecasting the load requirements in a residential building are based on the following [14]:

1. average load factor of 0.3.
2. average diversity factor of 1.0.
3. average power factor of 0.85.
4. number of hours (8760) per year.

Discussion

The use of energy saving devices has been identified as an important element of a successful energy management strategy. It provides the starting point and direction of progress for management of existing capacity of electric power. Energy waste through poor installation design and the use of inefficient energy devices in homes will give rise to extra generating capacity, and hence extra investment resulting to additional cost.

The relatively low electrical energy consumption per household in the rural area may be justified/ attributed to the use of alternative sources such as firewood, kerosene, gas for water heating, and cooking. Also the use of air conditioners is a luxury.

The load demands for a typical three bedroom flat when incandescent lamps and energy saving fluorescent lamp fittings are used is shown in Table 3. As can be seen from the table more than 551.88 kWh of the energy consumption can be saved when energy saving lamp fittings are used. The naira equivalent of the energy savings is 2,207.52 per annum, an equivalent of 183.96 Naira per month per housing unit. This will translate to considerable savings if the number of building types and the population is put into consideration.

In addition to the cost benefit, the fluorescent fittings have been adjudged to exhibit the best electrical and photometric characteristics [10]. The result of the study revealed that for the available locally 20W ballast/lamp system, the Newclime/ Lamptan fixture recorded the best starting characteristic, while the Philip/ Maspion energy saving fitting showed a remarkable characteristic in the 40W category [10].

From the above, the amount of current required to supply the required load is reduced. In terms of the cable, the size is reduced and hence a reduction in cost. It should be stated that the quantity will be same but cost of materials needed to manufacture the cable will greatly reduce.

Again, since the current required is reduced, this will go a long way in reducing the size of fuse/circuit breaker. Thus the cost per fuse/circuit breaker rating is reduced. This is additional Naira saving. As a rule of thumb, the higher the rating of the fuse/circuit breaker, the higher the price.

With tariffs likely to go up at the next review period, it is apparent that unless wastages are reduced to the barest minimum, residential customers are likely to default[15]. Such a situation will definitely throw the sustainability of the reform process in doubt and private investors would not be attracted to the sector. It is therefore important that the issue of customers' ability to pay economic tariffs through the use of energy saving devices be addressed as part of the whole reform process.

From the foregoing, it can be seen that the existing capacity can be put to maximum use. In terms of cost, the extra generating capacity and hence marginal cost of generating capacity will be greatly reduced.

Recommendations

In view of the above discussions, the following energy auditing tips are suggested:

1. Review of existing information on the patterns of electricity end – use in the residential sector and conduct additional surveys to determine how electricity is currently being used in the country.
2. Develop minimum installation design standards for different classes of residential quarters before connection is done.
3. Promote the use of energy saving devices in residential homes. This can be achieved by reducing taxes and duties on energy saving devices so that they are more attractive to purchase than the inefficient ones.
4. Develop manuals, consumer guides and other educational materials on energy conservation through proper design and the use of energy saving devices.
5. Bring to the notice of the consumers the cost benefits accruing from the proper installation design and the use of energy saving devices.
6. Monitor compliance and enforce regulatory requirements.
7. Turn off the lights in any room not in use, or consider installing timers, photocells, or occupancy sensors to reduce the amount or time your lights are on.
8. Take advantage of daylight by using light – coloured, loose – weave curtains on your windows to allow daylight to penetrate the rooms and parlour while preserving privacy. Also, decorate with lighter colours that reflect daylight.
9. Use fluorescent fixtures with reflective backing and electronic ballasts for your workroom, garage, and laundry areas. Also, use tube fluorescent and energy efficient compact fluorescent lights ((CFLs) in fixtures through out your home to provide high – quality and high – efficiency lighting. Fluorescent lamps are much more efficient than incandescent bulbs and last much longer. Although fluorescent lamps cost a bit more than incandescent bulbs, they pay for themselves by saving energy over their life time.

10. Use outdoor lights with a photocell unit or a motion sensor so that they will turn on only at night or when some one is present. A combined photocell and motion sensor will increase your energy savings even more. Exterior lighting is one of the best places to use compact fluorescent lamps.
11. Make sure your heating and cooling systems are properly maintained. Check your owner's manuals for the recommended maintenance. Also, consider installing programmable thermostat that is compatible with your heating and cooling system. Heating and cooling systems account for a considerable household's energy consumption.
12. Always turn off your home appliances such as computer and monitor, TVs and DVD players, when not in use. These appliances in standby mode still use several watts of power.
13. Improved architectural design for buildings

and the development and use of new building materials with reasonable specific heats for thermal stability might offer new options. Architects should recognize the need to design individual houses to take maximum advantage of the natural conditions of harmattan, dry and rainy seasons, day, and night.

Conclusion

The paper covers the technical opportunities for end – use electricity conservation in the residential sector. It is seen that proper design

and the use of the energy saving devices can save substantial energy and hence assist in the management of existing capacity of electric power.

Energy efficient improvements not only make your home more comfortable, they can yield long term financial rewards. Reduced utility bills more than make up for the higher price of energy efficient appliances and improvements over their lifetimes.

The result of the study has confirmed that there is a huge energy saving potential to be derived if minimum installation design standards are adopted and the use of energy saving devices employed. A saving up to 2,207.52 Naira per annum for consumers living in a three bedroom flat is anticipated.

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