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Optimizing the Use of Electrical Power in a Deregulated Power System

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Abstract: There is no doubt that the present power crisis afflicting Nigeria will persist unless the government diversifies her energy sources and adopt new technologies available to reduce energy wastages and save cost. This study identified the use of renewable energy sources, such as solar panels for street lights, employing new distribution automation technologies, adoption of demand side management and energy conservation measures and finally building environmental-friendly energy efficient houses. The study will be of benefit to the public power utilities and the general public to forestall future power generation shortages and reduction in costumer's energy bills

Key words: Electrical power, deregulated, optimizing, renewable energy, wastages

INTRODUCTION

Nigeria is faced with rising demand for electricity and dwindling generating capacity from absolute generating plants. Incessant power outages are the order of the day. This has forced many hospitals, banks, telecommunications outfits, industries, commercial enterprises and residential homes to depend on generating sets for electricity supply.

In a study conducted by one of the Manufacturer Association of Nigeria (MAN) branch in Lagos, about 85% of the members depend on standby generators, 50% of them have more than four generating plants, 20% do not use NEPA at all (Ekeh *et al*., 2007). Covenant University, Ota Nigeria has total installed electric power generating plant of about 5.85MVA from 13 diesel generating sets provided as backups. Enormous amount of money is spent to buy diesel to fuel generating sets for electricity supply during periods of power outage. A particular study revealed that about N 38.78 million was spent in a month to fuel these generating sets. This value excludes the cost of purchase of spares, oils and maintenance (Azuwike, 2007). The lingering spate of epileptic power supply has caused MTN a Nigeria telecommunication company to spend over N12 billion on generator acquisitions alone. It has also necessitated the spending of N500 million monthly or a staggering N6 billion yearly on diesel. Worse still, more than N5 billion go into replacing items damaged by erratic power supply (Anaro, 2007).

According to the International Monetary Fund (IMF), manufacturers in Nigeria lose between N26.50 and N28.50 per kWh to power outages. Also, power generated by manufacturers is at the cost of N35 per kWh, against the normal tariff of N8.50 per kWh. This leaves a shortfall of between N26.50 and N28.50 as added cost of production to manufacturers (Ekeh and James, 2007).

A recent survey by MAN on power supply by the Power Holding Company of Nigeria (PHCN) to industries in the first quarter of 2006 indicates that the average power outages increased from 13.3hours daily in January to 14.5 h in March 2006. According to the International Monetary Fund (IMF), owing to the frequent power outages, manufacturers in the country now use oil-based generation to meet 70% of their power needs. As reported by Wentzel (2005), Nigeria has remained top importing country of diesel generating sets (range 1 kVA to over 2 MVA) in Africa amounting to US$86.60, 94.47 and 122.36 million dollars in 2002, 2003 and 2004, respectively.

There is no doubt that the country is in an energy crisis and the need to manage the existing capacity is imperative. The study therefore, examines the possibility of employing existing and new technologies to reduce energy wastages and save cost. It is a follow up of the study on management of the existing capacity of electric

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power with energy saving devices (Verderber, 1989). Other benefits of the study include the following (Azuwike, 2007):

- Provide cost-effective energy and capacity resources to help defer the need for new sources of power, including generating facilities, power purchases and transmission and distribution additions.
- Reduce the cost on the purchase of diesel to run the generating plants.
- Low maintenance cost.
- Maximum operation of available generating plants.
- Postpone investments in new generating plants.
- Forestall future power generation shortages.
- Reduction in air pollution such as noise and emission of greenhouse gases.
- Reduction in consumer energy bills.
- Reduction in energy bill payable to Power Holding Company of Nigeria (PHCN).

STRATEGIES TOWARDS EFFICIENT ENERGY USAGE AND COST REDUCTION

In order to meet up with the energy need of consumers especially at homes aggressive energy management strategies should be pursued. The aim of energy management is to reduce the amount of energy that a building consumes. Good energy management starts with building energy efficient houses. The next stage is to identify inefficiencies and agree on actions to improve efficiency. These actions need associated targets and ongoing monitoring to measure their performance (Somolu, 2007).

Building energy efficient houses: A house or a building can be thought as being an envelope, which shelters an indoor space from the weather outside. The objective of the envelope is to maintain a comfortable environment inside regardless of how hot or cold or windy it is outside. One way is to build the house and then force the inside temperature to be comfortable by using fans, heaters, air conditioners, window louvers or computerized control schemes. A better way is to design the building with more consideration for its environment so that the need for active space heating or cooling by mechanical or electrical means is substantially reduced, if not totally eliminated.

The energy efficient housing design principles are based on the idea of using natural conditions to the best advantage and they encompass all the available techniques of creating a “healthy” interaction between indoor and outdoor climatic conditions in buildings (Doyle *et al*., 2005). Therefore, energy efficient houses should recognize the following (Liu *et al*., 2005):

- Proper building orientation and symmetry. Building design should permit most of the spaces to be day lighted. Using day lighting reduces energy consumption by replacing electric lights with natural light. Buildings designed for day lighting typically use 40-60% less electricity for lighting needs than do conventional buildings.
- Provision of enough windows for cross ventilation. In very hot climates ventilation is very important. This will go a long way in reducing the use of air conditioners at homes and offices. Although sunlight and daylights are free and readily accessible, however, their use without causing glare and overheating can be difficult. Glare can be avoided by using window sills, louvers, reflective blinds and other devices to reflect light deep into the buildings. Thus windows with selective glazing that transmit the most visible light while reducing solar heat should be favoured.
- Selection of suitable building materials. The walls and floor act as thermal mass to store the heat gained. Therefore hollow blocks and bricks should be used as much as possible. The shape of a building is also important from an energy point of view. A tall, slender building has a high surface area to volume ratio. Ideally a building should be compact, with a low surface area to volume ratio, since the building’s surface is the element through which the heat transfer occurs.

Demand Side Management (DSM) and Energy Conservation Measures (ECM): Demand side management and energy conservation measures are processes of managing the consumption of energy. These processes are designed to optimize the available and planned generation resources (Momoh *et al*., 2006). It has been reported that a lot of energy is lost at the consumers’ side of the grid. According to Somolu (Aderibigbe and Olukoya, 2007) Nigerians waste a lot of electricity (with each household wasting at least 100W at a time (total nation-wide = 200-300 MW). Demand side management and energy conservation measures therefore refer to actions taken on the customer’s side of the meter to change the amount or timing of energy consumption. They offer solutions to problems such as: load management, energy efficiency, strategic conservation and related activities. Consumers should be educated on the need and incentive to reduce their demand at peak times. Methods that the consumers can use to reduce energy consumption and wastages include the following:

Retrofitting ballasts and lighting for lower costs and higher efficiency. Fluorescent lights need ballasts (that is, devices that control the electricity used by the unit) for starting and circuit protection. Ballasts consume energy. Existing fluorescent ballasts can be replaced with improved electromagnetic ballasts and electronic ballasts. This could raise the efficiency of the fixture by 12-30%.

The new improved electromagnetic ballasts reduce ballast losses, fixture temperature and system wattage. Since they operate at cooler temperatures, they last longer than standard electromagnetic ballasts.

Electronic ballasts operate at a very high frequency that eliminates flickering and noise. They are even more efficient than improved electromagnetic ballasts. Electronic ballasts have the following advantages over the traditional magnetic ballasts: Energy saving up to 35%, light instantly, improved power factor, operates on low voltage load, less in weight and increases the lifespan of the lamps. These advantages outweigh the initial investment (higher costs when compared with conventional ballasts). The lifespan is high especially when used in a lighting circuit fitted with an automatic voltage stabilizer.

Relamping: Relamping means substituting one lamp for another to save energy. New fixtures are available which produces superior energy savings, reliability and longevity compared with incandescent lamps. Compact Fluorescent Lamps (CFLs) are generally considered best for replacement of lower incandescent lamps at homes, offices, commercial and industrial outfits. These lamps have efficacy ranging from 55-65 lumens $Watt^{-1}$. The average rated lamp life is 10,000 h, which is 10 times longer than that of a normal incandescent. They offer excellent colour rendering properties in addition to the very high luminous efficiency. Typical energy efficient replacement options, along with the per cent energy saving, are given in Table 1.

Installing lighting control systems, in bathrooms, stores and bedrooms: Lighting controls are devices for turning lights on and off or for dimming them. The simplest type is a standard snap switch or on-off switch. Presently majority of our lights are controlled by snap switches. This is the simplest and the most widely used form of controlling a lighting installation. Its initial investment is extremely low, but the resulting operational cost may be high. It does not provide the flexibility to control the lighting, where it is not required. There is the need to install lighting control systems such as are photocells, timers, occupancy sensors and dimmers in bathrooms, stores, bedrooms and other not frequently used areas.

Street light control: Street lighting accounts for more than 50% of all electricity consumed. Of this value about 50% or more of the energy is wasted by absolute equipment, inadequate maintenance, or inefficient use. Saving lighting energy requires either reducing electricity consumed by the light source or reducing the length of time. The following light control systems can be adopted at the design stage and also in Table 2:

- Grouping of lighting system, to provide greater flexibility in lighting control. This could be achieved by mechanical or electronic time clocks.
- Installation of microprocessor based controllers. In this method the use of microprocessor/infrared controlled dimming or switching circuits is employed. The lighting control can be obtained by using logic units located in the ceiling, which can take pre-programme commands and activate specified lighting circuits. Advanced lighting control system uses movement detectors or lighting sensors, to feed signals to the controllers.

Table 1: Energy savings by the use of high efficacy lamps

	Lamp types		Power saving	
Sector	Existing	Proposed	Watts	(%)
Domestic/Commercial	GLS 100W	*CFL 25W	75	75
Industrial	GLS 13W	*CFL 9W	4	31
GLS 200W	Blended 160W	40	20	
TL 40W	TLD 36W	4	10	
Industrial/Commercial	HPMV 250W	HPSV 150W	100	37
HPMV 400W	HPSV 250W	150	35	

* Wattages of CFL includes energy consumption in ballasts

Table 2: Energy saving potential by the use of high efficiency lamps for street lighting

Existing lamps			Replaced units			Saving	
Type	Watts	Life	Type	Watts	Life	Watts	(%)
GLS	200	1000	ML	160	5000	40	7
GLS	300	1000	ML	250	5000	50	17
TL	2×40	5000	TL	2×36	5000	8	6
HPMV	125	5000	HPSV	70	12000	25	44
HPMV	250	5000	HPSV	150	12000	100	40
HPMV	400	5000	HPSV	250	12000	150	38

- Installation of "exclusive" transformer for lighting. Most of the problems faced by the street and open court lighting equipment and gears is due to voltage fluctuations. Hence, the lighting equipment has to be isolated from the power feeders. This provides a better voltage regulation for lighting. This will reduce the voltage related problems, which in turn increases the efficiency of the lighting system.
- Installation of servo stabilizer for lighting feeder. Whenever, installation of exclusive transformer for lighting is not economically attractive, servo stabilizer can be installed for the lighting feeders. This will provide stabilized voltage for the lighting equipment. The performance of gears such as chokes, ballasts, will also be improved due to the stabilized voltage. This set up also provides the option to optimize the voltage level fed to the lighting feeder. In many plants, during the non-peak hours, the voltage levels are on the higher side. During this period, voltage can be optimized, without any significant drop in the illumination level.

Installing Hot Water Control (HWC): A typical HWC is rated at 3 KW. Without control it will operate in a continuous cycle based on upper and lower thermostat settings, adding significantly to the household load. The hot water in cylinders can be made to operate by defined algorithm. The algorithm design dictates how and when the HWC will function and in turn how the load profile will be affected. i.e. peak clipping, load shifting or strategic conservation. This type of control allows the heating of water cylinders to be directly controlled by the distribution system operator. The magnitude of the MW saving can be quite considerable given the size of the water cylinder load and the number of consumers that have a HWC.

Voltage reduction: Voltage reduction is a technique of intervention that is mainly used when there is a severe power shortage. Although voltage reduction is mainly used in emergency situations, some utilities use it as a method of reducing the demand on the system during normal operation. If used only at peak times, voltage reduction falls into the category of peak clipping. If it is used for an extended period, it falls into category of strategic conservation. Investigations revealed that reducing the nominal voltage by 10% can result in 7-18% decrease in the consumer load. This magnitude of saving would allow for the deferral of capital expenditure on new generation and network upgrades. Another advantage of this method of emergency conservation is that if the load is reduced, the distribution line losses will also be reduced. The distributor would not need to buy as much energy to meet its consumers' needs. The main disadvantage of using the voltage reduction method is that consumers, especially at the end of the distribution line, may experience low quality of supply due to under voltage. Installing capacitors for use in conjunction with voltage can improve this.

Circuit breaker tariff: The capacity of a residential consumer to contribute to the system maximum demand is limited by installing a low circuit breaker rating. A consumer can choose from a range of circuit breaker ratings e.g. 20, 30 or 60. The monthly basic charge increases with the circuit breaker rating. The kWh cost can also be set at different levels depending on the circuit breaker size. Consumers can then choose the best option for themselves based on their own financial situation. If they choose a low value circuit breaker, they must plan their use of electricity in such a way that they do not trip the circuit breaker. If they decide at some stage that they need a higher value circuit breaker, they can apply to the distributor for an upgrade. Circuit breaker tariffs fall into the category of strategic conservation. The main advantage of this method is that it trains the consumer to use energy efficiently.

Lighting maintenance: Maintenance is vital to lighting efficiency. Light levels decrease over time because of ageing lamps and dirt on fixtures, lamps and room surfaces. Together, these factors can reduce the total illumination by 50% or more, while lights continue drawing full power. The following basic maintenance suggestions can help prevent this:

- Clean fixtures, lamps and lenses every 6-24 months by wiping off the dust. However, never clean an incandescent bulb while it is turned on. The water's cooling effect will shatter the hot bulb.
- Replace lenses if they appear yellow.
- Clean or repaint small rooms every year and larger rooms every 2-3 years. Dirt collects on surfaces, which reduces the amount of light they reflect.
- Consider group relamping. Common lamps, especially incandescent and fluorescent lamps lose 20-30% of their light output over their service life. Many lighting experts recommend replacing all the lamps in a lighting system at once. This saves labour, keeps illumination high and avoids stressing any ballast with dying lamps.

Employing new Distribution Automation Technologies (DATs): A number of distribution automation technologies are in place and could be used to reduce energy wastages. A distribution automation technology or Distribution Management System (DMS) as it sometimes called is a system of computer-aided tools used by operators of electric distribution network to monitor, control and optimize the performance of the distribution system. The deployment of DATs will provide the following benefits (Somolu, 2007):

- Enables management to take full control of their energy management operations, thus reducing costs.
- Shift loads to off-peak periods.
- Scheduling large loads to start at different times. By delaying the start of a large load for as little as 15 min, peak values will be reduced.
- Peak shaving, involves reducing the entire energy load.

The use of DATs will maximize use of efficient base load generation and reduce the need for spinning reserve.

Use of renewable energy source: Renewable energy is a technology that makes use of the naturally occurring substances such as wind, water, sun and biomass to generate electricity. They are renewable by virtue of their limitless nature. Wind, for instance, will always blow. There will always be sunlight. Therefore, there is the need to incorporate renewable energy sources, especially solar panels into the distribution networks. The use of solar cell technology will go a long way to save energy from public utility supply. A solar powered street lighting system that is totally independent of the utility power supply should be incorporated in our distribution system. Solar panels are connected in such a manner to charge maintenance-free battery with sufficient capacity to light the streets and/or traffic signals. Solar water heaters should be encouraged. Solar generated electricity is environmentally friendly as it is devoid of the following:

- Emission of greenhouse gases-global warming.
- Emission of ozone depletion gases.
- Noise, smoke and general nuisance from domestic diesel generators right into our ears, faces and lungs.

CONCLUSION

The study x-rayed the available choices in technologies that could be employed to reduce energy consumption and hence save cost. It identified the use of renewable energy sources, such as solar panels for street lights, employing new distribution automation technologies, adoption of demand side management and energy conservation measures and building environmental-friendly energy efficient houses.

Energy efficient improvements not only reduce energy wastages and save cost, but forestall future power generation shortages, reduce air pollution from the use of generating sets.

The result of the study will go a long way in reducing the energy bill payable to power utility company, postpone investments in new generating plants and hence manage the existing generating plants.

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