# Assessment of Coping Strategies for Residential Electrical Energy Usage in Ekiti State

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**Abstract**— Electrical energy is a major driver for industrial process, commercial services and residential comforts. The erratic nature of the grid electricity in Ekiti State has constituted hindrances to improved standard of living. The social requirement of the people then required that strategies be developed to make up for the inadequacies. This include the use of generators, inverters, stabilizers, rechargeable lamps, candle and kerosene lamps to meet lighting needs, security and other pressing necessities for residential comfort. There has been a consistent rise in the ownership of generators, inverters and stabilizers to augment for the poor quality and unreliable electric power supply. Data for the work were obtained through the use of structured questionnaires, and physical inspection and patrol of the streets during outage periods especially at peak hour between 7.00 and 9.00 pm. The parameters of these supplement equipment were got from manufacturer's manual while secondary data were obtained to form the basis for the analysis. It was discovered that over one hundred thousand Naira(₦100,000.00) was unknowingly been expended to make up for poor power profile and that the paper recommends that improved grid electricity supply which is clean, cheap and healthy should be provided to alleviate the suffering of the populace and reduce their expenses on electrical energy usage.

**Index Terms**— Cost, coping, strategies, consumers, energy usage, Ekiti State, Nigeria. .

## 1 INTRODUCTION

THE development of sources of energy to accomplish useful work is pivotal to industrial, commercial and residential progress of all nations and it is necessary for improvement in the standard of living. Electrical power system plays a leading role in meeting the challenges of today's development as a converter and transporter of energy for use and convenience of man. Electrical energy is obviously the most used among the other forms of energies and it is a major driver for industrial process, commercial service and residential comforts. In Nigeria, Power Holding company (PHCN) formerly called National Electric Power Authority (NEPA) was saddled with the responsibility of providing efficient, coordinated and economic system of electricity to all nooks and crannies of the nation. PHCN has not been able to meet the onerous assignment required of it and several measures like Emergency Power Programme (EPP), Rehabilitate, Operate and Transfer(ROT), Electric Power System Reform(EPSR) were undertaken to no avail, Okolobah &Ismail (2013). Efforts to unbundle the PHCN to allow independent power producer to participate in revamping the system is not concluded due to bureaucratic bottlenecks, Akinsanya (2012). Presently all efforts were inadequate as all major generating station in Nigeria are in various poor state of disrepair and consequently available capacity is not meeting the desired demand.

Ekiti State is one of the 36 States in Nigeria connected to the National grid and is deeply affected by the low generation profile. Recently, a 132/33kV substation was commissioned to raise the power profile in the State but the associated problems did not allow reasonable result to be felt and as such Akinsanya, Familua & Mogaji (2005) submitted that the distribution sector is ridden with problems of overloading, sub standard conductor, illegal wiring, aged equipment, poor staff attitude, lack of replacement parts among other challenges and therefore the system is fault prone. The low generation profile has led to routine load rescheduling in order to manage available capacity. The erratic nature of the electric power supply in Ekiti State is adversely affecting standard of living as the people now incurred additional expenses to maintain basic needs. Akinsanya & Alake (2012) even observed that the population growth of the nation is not in tandem with the available power capacity which is on the decline. The social requirement of the people then required that strategies be developed to make up for the differences. This include the use of generators, inverters, stabilizers, rechargeable lamps, candle and kerosene lamps to meet lighting needs, security and other pressing necessities especially in the area of using the electronics for residential comfort. There has been a consistent rise in the ownership of generators, inverters and stabilizers to augment for the poor quality and unreliable electric power supply. Unknowingly, during purchase, costumers are mostly unaware of the amount that they would incur while using these supplements. This paper therefore presents the cost analysis of using the appliances in Ekiti State Nigeria In order to determine the additional expenses consumers are paying while using them to deliver services that would have been taken care of by the utility company.

### Methodology

The approaches used in carrying out this work include the use of questionnaires and physical inspection. 100 structured questionnaires were randomly distributed to households/residential electrical energy end users minding their income classes and level of education. Physical inspection and patrol of the streets during outage periods especially at peak hours between 7.00 and 9.00 pm were undertaken to feel the

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importance of the supplement equipment vis-à-vis the impact of generators on the serenity of the built environment considering the generator noise and the pollutants that are associated with its use. Secondary data were obtained to evaluate the cost of coping with the poor and unstable power supply in Ekiti State. The approaches were sufficient to establish the cost of coping strategies for residential energy usage.

**Results and Discussion**

86 percent of the questionnaire distributed were returned and studied to determine the ownership and usage pattern of the equipment. All respondents are connected to the grid electricity by PHCN through either analogue meter or prepaid digital meter. Majority of the consumers are using old analogue meters and readings are not usually taken so they are been billed on monthly estimate of #3,000.00. Table 1 show that all respondents possessed stabilizer and a generator though of varying make and rating while only 21 percent could afford the inverter system. The characteristics of the generators, stabilizer and the inverter are contained in tables 2, 3 and 4. Table 5 showed that the average usage hour of the generator is 2 hours/day while the stabilizer is mostly used with the grid electricity because of its poor quality when available. The 650 VA generators is more popular among the people because of its low initial price, small size, ruggedness, ease of servicing and above all it can comfortably supply the basic daily lighting needs plus the some electronics for evening daily comfort before going to bed. It consumes less fuel, the noise level is low and can be operated easily; however, and it will require that all other loads should be disconnected before use. The 2.4 kVA generator can supply the all the residential load while heating load would be disconnected; higher rating generators are available though only the high salary earners could afford them. The fuel consumption rate was estimated using the data got from respondents while the annual maintenance cost and discount rate were expressed as a factor of initial cost in line with standard practice for robust analysis. Daily availability of grid electricity is epileptic in nature and will be very difficult to estimate but the respondents presented an average of about 4-5 hours daily while the outage period is usually around the peak period of between 7-10 pm daily. The consumers are quite aware of the noise pollution and the poisonous byproducts associated with the use of individual generators, measures are taken to operate the generator in an open place where the effect of the carbon monoxide is reduced. It was discovered that most consumers have never estimated the annual cost of coping with supplement power supply strategies to determine the expenses incurred.

**Cost of Coping Strategy**

Assessment was undertaken to calculate the expenses incurred in using equipment like generators, inverters and stabilizer to cope with the poor quality and unreliable power supply.

**Generator**

Per unit cost of electricity generated using generators is a function of cost of generator, its rating, type of fuel and number of hours used. Two types of generator were common among the consumer group studied; they are the 2.4 kVA and 650 VA types. The cost incurred by a consumer for using generator for an average of two hours per day was chosen as basis for the study. The capital cost is the initial cost incurred on purchase of the equipment while other costs are incurred from time to time on account of maintenance or servicing purchase of fuel (petrol or diesel) used for power generation. To calculate the annual expenses and cost of per unit electricity the following formula has been used (Manisha, Vikas & Leena, 2007).

$C_a = (CRF_g)\ (r, n_g) \times C_g + C_f + FC_g)$ (1)

Where $C_a$ is annual expenditure incurred

$C_g$ is initial capital cost of generator.

r is discount rate

$n_g$ is is the life span of the generator

$CRF_g$ ($r_i$ $n_g$) is the CRF (capital recovery factor) at discount rate, r and life $n_g$

$C_f$ is annual expenditure on fuel.

$FC_g$ is the annual operation and maintenance expenses expressed as a factor of total cost.

A capital recovery factor is the ratio of a constant annuity to the present value of receiving that annuity for a given length of time. Using an interest rate *i*, the capital recovery factor is given by equation (2) as:

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1} \quad (2)$$

Where *n* is the number of annuities received (http://en.wikipedia.org)

Therefore the annual cost of electricity produced using a generator for average of 2 hours/day is approximately #91,940.00

**Inverters**

An inverter is a device that changes direct current (DC) power into alternating current (AC). The inverter transform the DC electricity produced by your battery into the alternating current electricity which is commonly used in most homes for powering lights, appliances and other gadgets. Inverters are rated by their continuous wattage output and the capability of briefly sustaining much lighter loads than they can run continuously (http://wordpress.com//hello-world)

The ownership pattern of inverters is affected by level of income, awareness of importance and other opportunity cost even when it has lower capital and operating cost though they are quite useful mostly as back up option. 21% percent of households were using inverters. There are variety of inverters and batteries available for consumer use in the market. Costs

associated with the use of inverters include the capital cost of inverter and battery, maintenance of battery, cost of electricity consumed on account of charging. The formula used for determining the total cost is given in equation (3) as:

$$C_t = CRF_i\ (r, n) \times C_i + CRF_b(r, n) \times C_b + C_a + E_c \times Tariff \quad (3)$$

Where Ct is the annual expenditure incurred
Ci is the initial cost of inverter
$C_b$ is the initial cost of battery
r is the discount rate
$n_i$ is the life span of inverter
$n_b$ is the life span of battery
$CRF_i$ is the capital recovery factor of inverter at discount rate, r and life span, n )
$CRF_b$ is the capital recovery factor of battery at discount rate, r and life span, n )
$C_a$ is annual maintenance charges of battery (negligible)
$E_c$ is the electricity consumed in charging as it is calculated by
$E_c$ = (Load connected x hours of use)/ inverter efficiency.
Using the formula and the parameters of table 4 below, the annual cost pertaining to use of inverter is eleven thousand, Nine hundred and fifty Naira only (₦11,950.00).

**Stabilizers**

To meet the power requirement, the household is connected to a single phase PHCN line. The grid faces stability issues, fluctuation, under voltage etc due to overload demand. This may cause the frequency of the grid to fluctuate and may result in poor quality power supply cause fluctuation in voltage and frequency.

To combat the situation, consumers are forced to use voltage stabilizer for some of their appliances like refrigerator, ACs and Television personal computer and in some case for the entire house. Costs associated with stabilizer include capital cost, and the cost of electricity consumed by it. To arrive at total costs, the approach used is similar to that used for inverter given by equation(4) as:

$$C_a = CRF_s(r, n) \times C_i + E \times (1 - \eta) \times Tariff \quad (4)$$

Where $C_a$ is annual expenditure incurred
$C_i$ is initial capital cost of stabilizer
r is discount rate
n is life of stabilizer
η is efficiency
$CRF_s(r, n)$ is the CRF at discount rate r and life ns of stabilizer
$E_{ca}$ is electricity consumed by appliance connected to stabilizer

Using the deductions and the formula, the annual associated cost of using stabilizer for the chest freezer for average of 5 hours daily is found to be Two thousand, two hundred and eighty Naira only (₦2,280.00).

**Weighted Price of Electricity**

The weighted price of electricity for an average consumer who uses generator for 2 hours daily, stabilizer for five hours daily and inverters for 2 hours can be calculated by taking the weighted average of the cost incurred for generating electricity through generator and that incurred for using grid electricity at a monthly estimated bill of ₦3,000.00. This is found to be One hundred and forty thousand, one hundred and seventy Naira only (₦142,170.00)

**Conclusion and Recommendation**

In this paper, attempt has been made to show that erratic nation of grid electricity in Ekiti State has caused the consumers to device alternative strategies to cope with the standard of living. This cost of coping is found to be substantial considering the level of economy of the Nigerian nation more so that the per capita income is very low. Households were however not aware of the magnitude of the expenses incurred to sustain the strategies. It was discovered that over One hundred thousand Naira (₦100,000.00) was unknowingly been expended to make up for poor power profile and that the paper recommends that improved grid electricity supply which is clean, cheap, healthy and environmentally friendly should be provided to alleviate the suffering of the populace and reduce their expenses on electrical energy usage. The government should intensify all efforts to privatize the power system because private investors are better known for efficient service delivery.

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TABLE1
OWNERSHIP OF COPING EQUIPMENT

| Appliances | Ownership | Percentage |
|---|---|---|
| Generator A | 30 | 35% |
| Generator B | 56 | 65% |
| Stabilizer | 86 | 100% |
| Inverters | 18 | 21% |

TABLE 2
PARAMETERS OF GENERATORS

| Parameter | Generator TypeA | Generator Type B |
|---|---|---|
| CC | ₦35,000.00 | ₦12,000.00 |
| R | 2.4 kVA | 650 VA |
| LS | 15 Years | 10 Years |
| AMC | 10% of capital cost | 20 % of capital cost |
| ADU | 2 Hours/day | 2 Hours/day |
| PF | 0.85 lagging | 0.85 lagging |
| CP | ₦97.00/litre | ₦97.00/litre |
| DR | 5% | 5% |
| AFC | 1.2 litre/hour | 0.6 litre/hour |

*CC- capital cost, R=Rating AMC= Annual maintenance Cost ADU= Average Duration of Use, PF= Assumed power Factor, CP =cost of Petrol, DR= Discount Rate. , LS=Life Span, AVF =Average rate of fuel consumption*

TABLE 3
PARAMETERS OF INVERTER

| Parameters | Responses |
|---|---|
| Initial cost of inverter | #35,000.00 |
| Life span of inverter | 10 years |
| Duration of use | 2 hours/day |
| Rating | 1000 W |
| Total connected load | 380 W |
| Overall efficiency | 80% |
| Discount rate | 5% |
| Battery specification | MF DIN 100Ah, 12V |
| Life span of battery | 3 years |
| Cost of battery | #20,000.00 |
| Charging expenses | #4,780.00 |

TABLE 4
PARAMETERS OF STABILIZER

| Parameter | Value |
|---|---|
| Cost of stabilizer | ₦5,000 |
| Rating | 1 kVA |
| Total connected load | 320W |
| Life cycle | 10 Years |
| Discount rate | 5% |
| Efficiency | 80% |
| Operating cost/Tariff | 14.00/kWh unit |

TABLE 5
QUESTIONNAIRE RESPONSES

| Issues | Responses |
|---|---|
| Sources of electrical power | PHCN and generator |
| Availability of grid electricity | About 4-5 hours daily, |
| Quality of service | Poor and erratic |
| Average monthly Bill | #3,000.00 |
| Type of meter | Analogue/ Prepaid |
| Peak time | 7-9pm |
| % Possession of generator | 100% |
| Rating of generator | 650 VA and 2.4 kVA |
| Daily usage of generator | 2 Hours (Average) |
| Average fuel consumption | 60-90 Litres/month |
| Time of use of generator | 7-9pm Daily |
| Average rate of maintenance | 6 times/year |
| Cost per service | #600.00/ service |
| Pollution and noise | Yes |
| % possession of stabilizer | 100% |
| No of stabilizer /consumer | One |
| Rating of stabilizer | 1kVA |
| % possession of inverter | 21% |
| Rating of inverter | 1 kVA |
| Excess cost incurred | Not aware |