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Non-Technical Losses, Energy Efficiency and Conservative Methodology in the Electricity Sector of Nigeria: The Case of Calabar, Cross River State[1]

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ABSTRACT: Today's challenge in electricity consumption in Nigeria is on how to use electricity wisely. Nigeria electricity sector is facing abnormal power supply situation, as demand outstrips supply, culminating in electricity supply-cum–demand imbalance. This owes to inefficiency and non technical losses which contributes to incessant power outages resulting in heavy economic losses and poor performance of the economy. This study investigates and identifies non-technical losses in the electricity sector occasioned by illegitimate activities. The methodology is a combination of quantitative and qualitative sample survey. The data set is a simple random sampling of households using electricity, and the number of units chosen was based on statistical power analysis. The result shows that energy wastage is from poor lighting attitudes, and choice of appliances. Implementation of efficient lighting attitudes is encouraged. Findings from the study if replicated will serve as a model for energy efficiency and methodology for the Nigeria Economy.

Keywords: Non-Technical Losses; Energy Efficiency; Conservation
JEL Classifications: Q43; C42; O55

1. Introduction

To this moment, the most unsettled issue in the energy sector of Nigeria is how to use electricity wisely. In Calabar, Cross River State and Nigeria in general, electricity sector is facing an abnormal electricity supply situation, where demand outstrips supply, causing electricity supply-cum – demand imbalance. The outcome of this sorry situation is a result of inefficiency and non –technical losses which have overtime contributed to incessant power outages resulting in heavy economic losses that inflict untold hardship on the population among other malaise. These high losses resulting from non-technical losses have continued to be an issue jeopardizing sustainability of the power sector in Nigeria. The fact that the energy sector have a pervasive impact on other sectors and the economy as a whole, is enough evidence to show that, electricity sector need keen attention in other to pilot the economy on the course of rapid and stable development.

The choice and habit of compliance with quality home appliances on the use of less energy; which is cost saving and protect the environment is lacking in consumers. However, this is because consumer's knowledge about the costs of their consumption decision is generally lacking. The fact that electricity consumers are not able to harness the benefits of energy conservation methodologies; which reduces the consumption of electricity by reducing the total amount of goods and services purchased or consumed that require electricity as an input and the use of energy efficient appliances is a constant electricity supply paradox. Residential buildings, public offices and industrial buildings consume electricity differently depending on the amount and choice of electricity appliance used.

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The use of more efficient air conditioning (AC) units, compact fluorescent lamps (CFLs) also called energy saving light bulbs (ELS) which provide bright light while lasting ten (10) times longer as well as generating and using 75% less heat and energy than the standard incandescent lighting (SID) is alien to the Electricity consumers in Cross River State. Through energy efficiency, the electricity –intensive nature of production process is reduced. By this, there exist a minimal consumption of electricity by reducing the amount of electricity required to produce a given amount of a good/or service thereby conserving the unused energy for further production. The efficiency of an electric appliance be it air conditioner, lighting bulbs, electric iron, Television set etc. is described by its seasonal energy efficiency ratio (SEER) rating.

One fundamental and rational notion by all economic players is the ability to maximize satisfaction with all given knowledge. However, there exist a counter notion to this assertion because most household do not necessarily know fully the cost of each consumption decision they make in real-time within their home and this is known as imperfect information in economics (Croucher, 2010a). While several factors including Lack of proper information may be a factor causing customers to be making "incorrect" consumption decisions, this paper will confine to non- technical losses, energy efficiency and conservative methodology which are proven to be key barriers to attainment of sustainable power supply in Calabar, Cross River State and Nigeria as a whole. The relevance of an efficient and conservative methodology and the stoppage of non- technical losses are second to none in the drive to boost economic growth.

The study investigates and identifies non-technical losses (Vampire losses) in the electricity sector occasioned by illegitimate activities and proffers solutions to the electricity supply crises of Nigeria. The study is significant in that findings from the study if replicated will also serve as a model for energy efficiency and methodology for the Nigeria Economy.

This paper is organized as follows. Section two looks at the relevant literature in non technical losses and energy efficiency methodology. Section three presents the overview of electricity sector in Nigeria. In section four, the different shapes and forms of non-technical losses are discussed. Section five and six present strategies for achieving minimum electricity losses and the barriers to energy efficiency in Calabar, respectively. While section seven looks at energy efficiency in Calabar. Finally sections eight and nine, presents the methodology and data set for the study and our conclusions and relevant policy recommendations respectively.

2. Review of Literature

Studies like Ayodele (2003), MEFL (2011), Croucher (2010b) and Chevron (2011) have x-rayed the importance of an efficient energy sector to a developing economy like Nigeria, and how to improve on this efficiency by adopting different methodologies to conserve and curb vampire losses. According to Ayodele (1998), the electricity crisis in Nigeria makes many inhabitants especially the poor miserable.

Subair and Oke (2008) also pointed out that the existing of great stress, tension, suspicion and conflict between electricity users and provider officials have encouraged illegitimate activities such as illegal electricity connection either to the national grid or the existing residential/industrial electricity outfit, over/under billing and payment via unscrupulous business collusion and vandalization of equipment resold in most cases to provide electricity institutions. The situation mentioned above is the major causes of non-technical losses in the electricity, which is a great minus on the revenue generation to the utility.

To avoid these non-technical losses, Odumosu (2005) stress that the way forward is to strengthen the capacity to recover debts through honest marketing strategies. To achieve energy efficiency in Nigeria, various studies have been carried out and policy recommendations made by earlier scholars in these area. Amongst these are; Owan (2007) who in a paper presented in the world energy council African Forum state the objective and benefits of energy efficiency to include the introduction of efficiency lighting such as compact fluorescent lights (CFL) and T8 lamps, use of LED fixtures, reactive power Kvar improvements, use of intelligent/ smart metering, improvement in energy efficiency and standards, industrial process improvements. He further identified certain approaches to energy efficiency to include; setting industry standards for building and specifications, incentives for new technological adoption, energy audit and accounting, cost benefit analysis and new and retrofit projects, project costing, cash flow, IRR/payback.

In a related development, Sambo (2007) in his paper on energy efficiency programmes recommended an enabling environment around capacity building, energy audit /assessment, energy codes and standards- energy labeling, research development and demonstration, energy pricing/efficiency policy etc. to solve the losses in the energy sector. Esan (2007) also presented the gaps to bridge in the electricity efficiency to include; raising general awareness, advocating a holistic and innovative approach towards achieving energy efficiency in Nigeria.

While, Cappers et.al (2010) in a study on the impact of aggressive energy efficiency savings occurring in Massachusetts relative to a business as usual case of moderate energy efficiency savings. In their findings they discovered that aggressive energy efficiency savings would cause retail prices to increase at a more rapid rate, because the reduction in sales exceeds the utility cost savings from energy efficiency. From literatures so far x-rayed, none has used primary data in the form of questionnaires to test energy efficiency and non technical losses in Calabar. The study therefore stands distinct in this area.

3. Electricity Sector in Nigeria

Electricity supply as an economic infrastructural facility is indispensable to a nation's economic development. The efficiency of the supply of electricity will not only influence returns on investment in existing enterprises, it also plays a major role in the creation of an economic environment which influences decisions on potential investments.

Given the different historical antecedents of the power sector, both in structure, transformation, unbundling and tariff; the Nigeria electricity sector is characterized as having a cost structure where significant amount of its overall cost are fixed costs. It is as a result of this huge/substantial fixed cost that makes the sector to have only one transmission and distribution network (national grid) provider. This practice is called "natural" monopolies, because it makes no sense to have more than one "wire" from a home/business to electricity generation source. To protect the consumers therefore, these has been redefined to regulated monopolies.

However, other earlier studies such as Subair and Oke (2008), Babatunde and Shuaibu (2009), Udah (2010), Tallapragada (2009) have described the basic characteristics of Nigeria electricity sector. Nigeria currently has about 7,500 megawatts of installed capacity and 3,500 megawatts of available generation supplied through its national grid against an estimated total of 10,000 megawatts (AIR 2011). From the foregoing, only 40% of Nigeria population has access to electricity with an average annual per capita power consumption of only 155 kilowatts this brings Nigeria to one of the lowest in the world, (AIR, 2011). Most of the available public-sector capacity is underperforming and dilapidated due to their old nature. A great number of the thermal plants which ordinarily would have boost power generation are losing up to one-third of their generation capacity due to gas supply shortages to them. The unmet demand by public owned national utility Power Holding Company of Nigeria, (PHCN) is one major reason for making the public to resort to self generation at high cost to themselves and the economy. This also can be accountable to the non-technical losses in the system as a great number of consumers bypass wire all to getting electricity at all cost. The dysfunctional state of the existing power infrastructure in Nigeria has caused a grim situation warranting to the declaration of a state of emergency in the power sector of Nigeria. Resulting reforms in the power sector from 2005.

4. Non-Technical Losses

Generally, losses in electricity supply to the final consumers are the amount of electricity injected into the transmission and distribution grid that are not paid for by users, World Bank (2009). Usually these losses come in two different components; Technical and Non-Technical losses. Although, they are avoidable financial losses if properly handled, but they can also present great economic loss for the utility if not handled on time and treated seriously.

However, while technical losses occur naturally in the form of power dissipation in electricity system components like transformers, transmission and distribution lines; the non-technical or Vampire loss which is our focus in this paper are exogenously caused. They are often caused by certain actions that are external to the power system. Non –technical losses are man induced losses and they include; electricity theft through illegal connection to the grid or tampering of a consumption meter, errors as a result of inadequate accounting and record keeping as well as non-payment by

customers after a billing period. Metering and billing are the least efficiently executed tasks by PHCN which amount to non-technical losses. Some of the perverse effects of non-technical losses are that those customers who are accurately billed and regularly paying their bills are subsidizing those users who do not pay for electricity consumption, World Bank (2009). Within the sub-Saharan Africa, since utilities do not cover its cost due to non-technical losses, this posses financial burden on government budget. For instance Nigeria has the highest inefficiencies in the electric sector where the utility is capturing only 25% of revenue owed and all other cost is borne by the state, therefore putting a heavy financial load on the state budget.

Currently, PHCN uses two methods of metering system; the post-paid (analog) billing system and digital pre-paid meter. The labour-intensive post-paid system which involves reading meters physically by the PHCN employees and paying for already consumed electricity. Often times, this is the method that accounts for major non-technical or vampire losses due to corrupt practices such as bribing of officials who waive bills for customers and bypassing of wires by customers themselves. Consumers who claim they are overcharged due to estimation of bills would often want to pay back by passing or not paying bills at all. The pre-paid meters reduce the issue of non-technical losses as it helps to prevent overcharging on the consumers. Although, only a small percentage of consumers have pre-paid meters and this can be said to be one of the contributing factor to non-technical losses incurred by PHCN. Non -technical losses come in different forms and shapes such as;

-Giving exorbitant estimated bills not in line with meter reading.

Exorbitant monthly electricity bills which occur as a result of meter estimation rather than correct meter reading and calculation based on uninterrupted electricity use thereby charging for power not used can cause consumers not to comply with monthly meter bills and avoid paying electricity bills.

-Commercial losses and cancellation of bills by PHCN officials

Illegal cancellation of bills by PHCN officials who collect money directly from consumers is a rampant and major cause of losses incurred in PHCN. Illegal tapping and bypassing of electricity and buying off the meter-readers are another avenue for non-technical losses.

5. Strategic Methodology and Modeling in Achieving Minimum Electricity Losses

The least efficiently executed task by PHCN is metering and billing. From our empirical analysis, colossal revenue is lost to illegal consumers through this channel. This can be reduced to the barest minimum through a more proactive approach

To achieve sustained and less non-technical losses in the Nigeria electricity sector, there must be market discipline and consumers awareness.

Market discipline encompasses training and management of staff and external contractors, community engagement, IT training, commercial and technical management as well as punitive actions for defaulters.

a). Achieving efficiency through Commercial and Technical measures.

- Electricity bills should be properly read, and meters regularly inspected
- Market programmes should be regularly organized to create awareness to the consumers that electricity is a commercial good with price.
- Customers should be properly informed on their rights and obligations.
- A check against irregular connections and tampered or damaged consumption meters should be conducted regularly.
- All consumption meters and customers connection points should be properly scaled to avoid being tampered with.
- Provision of digital meters to all customers
- Monitoring operations conditions of installed seals and lighting service.

b). Achieving efficiency through IT

- Checking consistency in field activities through IT
- Detection of irregular service conditions through commercial MIS
- Regular and reliable data for all activities in the sector

c). Achieving efficiency and less –losses through punitive actions

- Enacting a strong legislation to ensure effective action against electricity theft
- Ensure recovery of old debts, especially in industrial cases through judicial actions

- Punishing and prosecuting both staff and consumers in cases involving meter adjustment, electricity theft, estimation and writing off debts by PHCN staff
- Enacting legislation against keeping of security lights on during the day time.

6. Barriers to Energy Efficiency in Calabar, Cross River State- Nigeria

Targeting the behavior of electricity consumers has been touted as the most effective way to achieving energy efficiency in Calabar, Cross River State. Interestingly, research has proven that behavioral programs are more cost effective than other energy efficient programs. Energy efficiency as a resource is confronted with a number of market barriers which often prevent consumers from making least-cost purchasing choices. There are several reasons and factors that have been identified to be responsible for creating energy efficiency gap in the Nigeria electricity sector. Some may be corrected through interventions by the policy makers or the utilities/agencies (e.g PHCN) themselves. However, some barriers may remain insurmountable and would continue to affect energy efficiency measures throughout the economy. These barriers to energy efficiency gap in Nigeria can be identified as follows,

i). Lack or Imperfect information

Lack of sufficient information by customers about the choice and type of energy efficient options is one major reason why there is under-investment in cost-effective energy efficient options. Usually customers remain relatively ignorant to the type and choice of appliance that is energy efficient. In Cross River state, statistics show that Business and government offices, hospitality industry, and residential buildings uses incandescent bulbs and less energy efficient appliances that consume more energy than the ESLB or that with SEER. Most of the appliances are old fashioned with no consideration for energy efficiency by the producers. Majority of households and energy users in Cross River State are adamant and ignorant about energy efficiency and conservation. To the locals, turning on lights is a solution to his electricity problems, while the workings and conservation is not given thought to.

ii). Liquidity constraints

Credit worthiness or liquidity constraints by electricity customers are one major barrier that militates against relatively expensive energy efficiency measures. Electricity appliances such as energy saving light bulbs (ESLB), Ac units with high SEER are more expensive than the conventional types. From statistics one unit of ESLB (18watts) in Calabar go for as much as N500, while in contrast a normal standard incandescent bulb (40-60 watts) goes for between N50 to N100. This is also applicable to other appliances that have high energy efficiency. Lack of credit or liquidity by electricity consumers may prevent a reasonable percentage of electricity customers from using the profitable energy efficiency measures. Therefore, this liquidity factor may cause majority of customers to go for the less energy efficient products. In Cross River State, majority of energy consumers are in the rural areas; even those in the cities are civil servants with very meager salaries to purchase expensive energy saving appliances all in the name of conservation. Therefore, based on their credit capacity, they go for cheap but less energy –efficient products with lower up-front cost.

iii). The principal-agent problem

The principal- agent problem is usually found in the case of landlords and tenants. According to Croucher (2010a), this occurs when one group makes the investment decision but another group receives the benefits of the investment decision. The scenario of principal-agent can be found when for example; the Landlord (who is the agent) decides to invest in energy efficiency measures, while the tenant (the principal) is generally responsible for paying the energy bills. Therefore, if the agent cannot recoup through changing higher rent, at least the costs of the energy efficiency investment then they would not install the measure.

7. Energy Efficiency and Conservation in Calabar, Cross River State- Nigeria

In economic science, derived demands are commodities not demanded for its own sake, but as input for further production. Therefore, electricity usage/consumption is a derived demand because it is used as an input for the production of goods and services for economic savings/production. The desire by Household, business and commercial buildings like hotels, Banks and government offices to light up, cool homes and carry out economic activity and services, determined the demand for electricity (input). With the provision of these needed services (output) in the economy, using

electricity (inputs) the only way to achieve optimally is to reduce electricity usage/consumption by adopting energy efficiency and/or energy conservation methods. By this, Energy efficiency attempts to achieve reduced electricity consumption by reading the amount of electricity required to produce a given amount of a good/service. In effect energy efficiency reduces the electricity-intensive nature of the production process (Croucher, 2010a).

Although both attempt to achieve the same outcome; In the case of energy efficiency, the focus is on adjusting input requirement while energy conservation concentrates on output requirement which indirectly affect the demand for the input component. Cross River State is a tourism hub in Nigeria with great natural/human resources. It is bounded in the south by the Atlantic Ocean, Cameroun Republic etc. Due to the tourism nature of the state hospitality industry flourishes/strives well and these allows for high electricity consumption. The presence of Banks and growth in residential and commercial construction driven by population growth has added emphasis on the usage of electricity consumption in Calabar.

Government offices are the most hit as almost major ACs are as old as the buildings without conservation and efficiency in electricity. The light/appliances are often not turned off in Hotels, Offices and Residential and public buildings after close of work and all other devices unplugged when not in use, but always kept on standby. Residential buildings have poor culture and habits of using energy saving lighting bulbs/ appliances than public offices like Banks. All these are avenues for wasteful electricity consumption in Calabar.

8. Methodology and Data Set

The study adopts a- descriptive cum discussion approach in analyzing non-technical losses and energy efficiency in Calabar. Electricity consumers in Nigeria are divided into six (6) categories, namely residential, commercial, industrial, street lighting, customers on special tariff , and international customers, Tallapragada (2009). The paper examines electricity conservation and efficiency by using primary data from questionnaires administered to residential and commercial customers such as in residential, Banks and government buildings. While data for non- technical losses from which both technical and non-technical losses were extracted was from PHCN Calabar business district (energy distribution and commercial data base).

The study focuses on determining whether there exist energy efficiency and conservation by consumers due to the use of electric appliances and attitude to energy use and also if actually there are losses in electricity as a result of illegal activities and corrupt practices by PHCN staff and consumers.

9. Empirical Results

Table 1 reports the monthly electricity distribution in the Calabar Business district from January to December 2011. From the data, it can be deduced that the difference between actual energy generated from the two main feeder transformers (T1 and T2) with the energy distributed to the consumers gives the technical losses in each month totaling 16,0345 megawatts for the year 2011. This figure is quite colossal if expressed in monetary term, as such a huge loss in the course of transmission will affect available energy for distribution.

For the non-technical losses, (which is our focus in this paper) data from table.i, also show that except for the month of January, 2011 all other months registered large sum of revenue on non-technical losses ranging between N8million to N40million in the month of August. However, a total of all non-technical losses incurred in the Calabar Business unit for 2011 summed up to about N490, 184.05Million. This whooping sum is enough to collapse any going business concern. Replicating this in all the PHCN business units across Nigeria means a lot of loss. Based on the data from Calabar Business unit, the estimate for non-technical losses for thirty seven PHCN business Units representing state capitals and Abuja, is N18,136,809.85billion, while average monthly non-technical losses stood at N1,51,400.82 billion.

On the aspect of energy efficiency and conservation, data from questionnaires were administered to two hundred respondents within Calabar business unit (Southern Senatorial district of Cross River State). From the result, majority (98.5%) of respondents use electricity from PHCN, this is because there is wide spread rural electrification in the state. On the type of electric bulbs used, 24% of total respondents use CFLs, while 60% of respondents use standard Incandescent Bulbs (SIB) only 16%of respondents use both the CFLs and SIB.

Table 1. Monthly electricity distribution and Non- Technical Losses in Calabar Business District (Jan- Dec. 2011)

Year/Month	Actual Amount of Energy From T1&T2 *(Megawatts)* **(1)**	**Energy Distributed (*Megawatts)* (2)**	Technical losses *(Megawatts)* **(1-2)=(3)**	Monthly Bills Distributed to consumers (NM) **(4)**	Amount Collected from consumers (NM) (5)	Loss from Non-technical losses (**NM) (4-5)= (6)**
			2011			
January	16,501.4	16,250.3	243.100	95,643.875	97,770.150	-2,126.27
February	17,318.0	17056.6	261.4	108,548.150	95,341.76	13,513.974
March	13,863.4	13,511.2	352.2	104,299.270	95,413.839	8,885.431
April	14,493.4	13,879.8	614.6	98,798.014	97,477.235	1,320.779
May	10,730.9	8928.6	1,802.3	106,083.462	97,379.359	8,704.103
June	15,739.0	15,080.8	658.2	86,482.820	97,023.546	10,540.726
July	18,010.7	16,909.2	1,101.5	112,589.979	89,222.581	23,367.398
August	19,795.1	17,332.3	2,462.8	142,401.646	102,229.007	40,172.639
September	20,861.2	17,804.1	3,057.1	150,864.780	114,034.418	36,830.362
October	15,879.2	14,523.1	1,356.1	118,891.526	107,728.563	11,162.963
November	13,874.1	12,501.4	1,37207	121,395.796	121,732.390	336,594.7
December	22,423.4	19,670.8	2,752.6	108,891.553	107,664.311	1,227.242
Total	**199, 489.8**	**183,455.2**	**16,034.6**	**1,354,890.87**	**1,223,017.159**	**490,184.05**

Source: PHCN Calabar Business District (2012) Computation by authors.
**(T1 and T2 = Feeder Transformer 1and 2)

On whether the people are aware of different electricity appliance and bulbs that are energy efficient and do not consume much current and make one pay less or more; 45% of respondents are well informed of the cost attached to using Energy efficient appliances, while the remaining 55% are not aware of energy efficient appliances. Concerning wastage non conservation of energy by keeping security lights on and use of high wattage bulbs, 62% of respondents keep their security lights on throughout the day while 30% respondents say they put off security light during the day 8% are indifferent to it, saying they sometimes turn the lights off when they remember to do so. In the same vein, majority of respondents of about 60% use electric bulbs of 60-200 watts, while 24% of respondents use below 60watts.

Lastly a greater proportion of respondents, about 70% are of the opinion that they are over billed by PHCN meter readers and so may be forced not to pay their bills if such abnormally continues. On this note, 85% of respondents urgently need digital pre-paid meters to enable them pay as they use electricity, while 25% are not aware of digital pre-paid meters and so are indifferent.

10. Conclusions

This paper investigates the degree of non-technical losses and energy efficiency and conservation in Calabar, Cross River State; using primary data from well structured questionnaires and secondary data on technical and non technical losses occasioned by different variables within the Calabar Business district.

Nigeria public electricity sector is in comatose. To fulfill improved electricity supply to meet up the demand, therefore, a plausible conservative and efficient methodology is essential and also a check against vampire losses to guard against unnecessary losses that may negatively affect the sector.

Achieving the objectives of this paper needs two approaches. The first is tackling non-technical losses and second is proffering solutions and methodology for energy conservation and efficiency. Tackling non-technical losses in the electricity sector of Nigeria would be a very great fit for economic growth and development. To promote energy efficiency therefore, local manufacturing of energy efficient appliances/ electric items like compact fluorescent lamps (CFLs) should be encouraged. Nigeria Electricity and Regulatory Commission (NERC) should partner with and identify a manufacturer of CFLs by making sure that quality and long lasting CFLs are produced. Standard organization of Nigeria (SON) should be up to their task in checking against the influx of substandard CFLs and other electric appliances into Nigeria.

Retrofitting measures should be supported by NERC, PHCN, as such; incandescent lamps should be replaced in public and residential buildings as much as possible. Sometimes as a way of

encouraging residential consumers, CFLs should be offered to them at much reduced prices equivalent or smaller than that of the standard incandescent lamps. NERC should establish an energy efficiency and conservation department (EECD) responsible to sensitizing, training and following up to ensures energy efficiency and conservation in large government, commercial as well as residential buildings. Legislators/Policy makers should also be sensitized on the need for energy efficiency and conservation.

The empirical result has established the existence of gaps both on the part of the consumers and staff of PHCN. This justifies earlier studies which stressed that Nigeria electricity is in a sorry state. To achieve sustained and near Zero non-technical losses in the Nigeria electricity sector, there must be market discipline and consumers awareness. Market discipline encompasses training and management of staff and external contractors, community engagement, IT training, commercial and technical management as well as punitive actions for defaulters. For sustainable economic growth in Nigeria electricity efficiency and conservation methodology as well as zero non-technical losses should be pursued to make electricity available for productive uses. The crux of the matter is attitudinal change by all economic players and understanding that electricity is a commercial commodity that must be paid for by all consumers.

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