BILLING METHODS AND ELECTRICITY CONSUMPTION: A Tale of Two Nigerian Cities

Adeola Adenikinju
Olatokunbo Oluwayemisi
Department of Economics
University of Ibadan, Nigeria

ABSTRACT

Prepaid meters are a relatively new innovation adopted by the Power Holding Company of Nigeria as part of its power supply programme for energy saving. It is a mechanism that changes the attitudes of users towards electricity usage. Studies have shown that a prepaid meter reduces electricity consumption. This study investigates the comparative advantage of the prepaid system over the conventional billing method using a survey technique to find out the preference of the households in Nigeria as a whole. Empirical evidence from the study shows that the adoption of the prepaid meter mechanism will reduce the electricity consumption of users. The study suggests the introduction and acceptance of the prepaid meter as a measure for the conservation of energy.

JEL classification: Q4, Q41, Q55, D1, L68

1. Introduction

ELECTRICITY consumption is one of the most important indices for measuring the standard of living of a country. This is so because almost all aspects of modern living such as education, healthcare delivery, information technology, entertainment, transportation, communication, etc, all depend on electricity to function. Electricity demand has been experiencing growth at a very rapid rate since the early days of power generation. With both population and economic growth, the gap between supply and demand for electricity has been increasing significantly (Krishnan, 2006).

Nigeria, with a population of over 160 million people, is endowed with sufficient energy resources to meet its present and future development requirements. Despite this endowment, about 60-70 per cent of Nigerians do not have access to electricity and modern energy services and those that are connected to the national grid experience power outages that last for hours daily (Etiosa, 2008).The small percentage of Nigerians that have access to the electricity supplied to the public as well as those who generate their own power, are wasting it without considering the implications (Etiosa, 2008). With energy loss close to 40 per cent due to wastage, Nigerians underestimate the importance and gains of energy efficiency to the environment for economic growth. Thus, rather than give some attention to the way energy is used, government has focused almost entirely on power generation and distribution. According to Etiosa (2008), energy wastage is mainly due to the use of inefficient technologies, appalling human behaviour, and low level of infrastructural development (Etiosa, 2008).

Energy efficiency has become one of the main drivers of sustainable development worldwide (UNDP, 2000). The goals of energy efficiency are to:

- reduce the amount of energy used to produce a service or a unit of economic output
- indirectly reduce emissions
- minimize the building of new power stations
- reduce electricity bills
- make more energy available to extend energy supply to other parts of the population
- increase the efficiency and resilience of the economy
- reduce the negative environmental and human health impact from energy production and use (Etiosa, 2008)

A corrective measure that has been adopted by the Power Holding Company of Nigeria as a technological solution is to provide new ways of sustaining energy efficiency through the introduction of prepayment metering, also known as the Pay-As-You-Go system. It is a flexible payment option that requires customers to pay in advance for the electricity, gas or water they use and to enable customers manage their electricity usage efficiently (Aidan, 2003). The mechanism offers information that could help the consumers reduce their household consumption of electricity in addition to other potential benefits.As a relatively new innovation,

prepaid meters are being installed by PHCN as part of its power supply programme. The PHCN started a pilot project of installing prepaid meters in Lagos in 1997 using CONLOG of South Africa in collaboration with ESKOM. Six years later, it still remained largely a pilot project, except that a few more prepaid meters have been installed in Abuja and Kano as an extension of this programme (Nexant, 2003). Before the introduction of the prepaid meter, there was a conventional method adopted by the supplier, which enabled the buyer to pay after the consumption of electricity.

Few studies have focused on the impact of consumer behaviour on residential energy consumption and it has been found that prepaid metering can decrease residential energy consumption. The study carried out by Faruqui et al. () suggested that consumers who actively use an IHD (in-home display) can reduce their consumption of electricity by an average of 7 per cent when the prepayment of electricity is not involved. When consumers both receive an IHD feedback and are on an electricity prepaid system, they are able to reduce their consumption by an average of 14 per cent. With regard to demand response impact, it was found that the impact of prepaid metering and IHD encourage consumers to make more efficient use of energy (Faruqui et al., 2009).

Considering a prepaid service that has improved the day-to-day activities of the consumer, the question that arises is: Does a prepaid billing method reduce the energy consumption of the residents of RCCG, Mowe and Osogbo more than the conventional billing method? Does the prepaid billing method impact the users positively?

Consumption pattern can be controlled and electricity can be saved in two ways: intensity of use and energy service. Intensity of use is the rate at which electricity is used i.e. hours during which consumption occurs, for example, when electricity users turn off electric appliances or meters when they are not at home. Energy service is the method applied to the way appliances are used, for example when one bulb is turned on in a house.

2. Benefits of a Prepaid Meter over the Conventional Meter

There are various reasons why an electricity supplier should consider installing a prepaid metering system. They include improved cash flow, elimination of account posting and inaccurate meter reading, elimination of debts, elimination of disconnection and reconnection fees, ease of installation, elimination of need to

access consumers' property. It also reduces paperwork and the associated costs of postage, paper, printing, and handling.

The prepaid metering system is also advantageous to the customer in terms of budget management, control of energy usage, no disconnection/reconnection fees, no delay in reconnection, no deposits, and the ability to pay back debts. With prepayment, there is no monthly bill (Nexant, 2003).

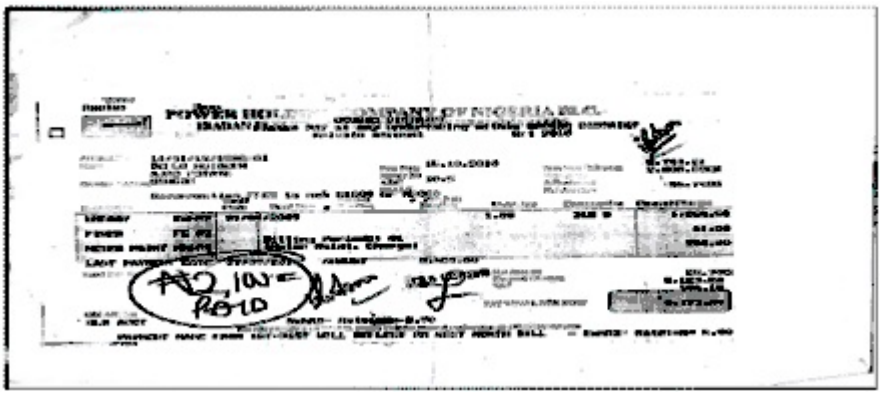

Figure 1. PHCN conventional bill.
Source: Adenikinju & Oluwayemisi, 2011.

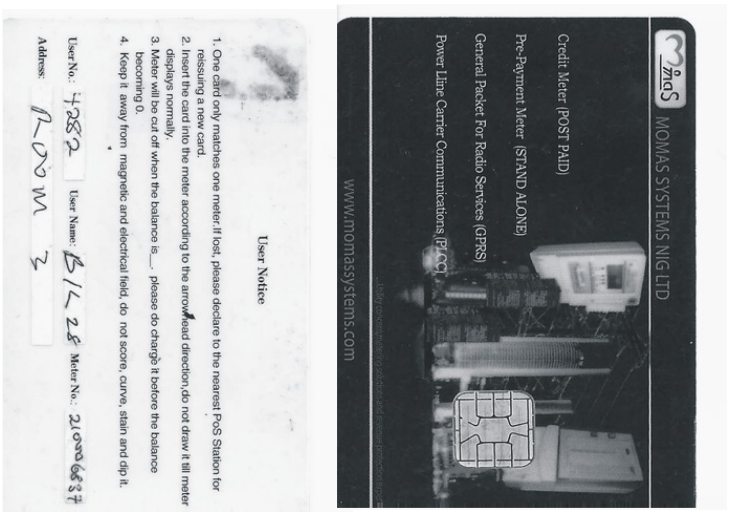

Figure 2. User card.
Source: Adenikinju & Oluwayemisi, 2011.

3. Types of Electronic Meters used at RCCG Redemption Camp

The single-phase smart card digital energy meter (fig. 3) is found mainly in small residential or commercial installations. It has an installed capacity below 12KVA and is mostly rated 5–25 amps (Abiodun, 2010).

Figure 3. A single-phase smart card digital energy meter.
Source: Adenikinju & Oluwayemisi, 2011.

The three-phase meter (fig. 4) is found mainly in medium or fairly large residential or commercial installations with an installed capacity between 12KVA and 18KVA. It is above 25 amps and commonly rated 50 – 100 amps. This type of meter can accommodate a fuller load than a single-phase meter. It provides accessibility to three phases, that is, if one phase goes off, one can easily switch to the another phase (Abiodun, 2010).

Figure 4. A three-phase smart card prepayment digital energy meter.
Source: Adenikinju & Oluwayemisi, 2011.

The maximum demand (MD) meter (fig. 5) is used in large residential or commercial installations with or without transformers. Such installations include: industries, factories, offices, and establishments with an installed capacity above 18KVA. Maximum demand meters are in two groups: whole-current and current transformer (CT) operated. The whole-current MD meter is like the three-phase meter, whereby the supply cable is connected directly to the meter, thus allowing the whole current to flow through the meter. It is rated 50–100 amps.

The CT-operated MD meter is used in low tension metering where the supply cable is too large, or the supply current is too dangerous for both the meter and personnel to handle. It allows a proportionate amount of current flowing in the primary circuit to flow through the meter. It is rated between 100/5A – 800/5A, that is, a load demand not exceeding 500KVA.

Figure 5. A maximum demand meter.
Source: Adenikinju & Oluwayemisi, 2011.

The various kinds of meters in this category are Transva, Trivector, Indigo and Electronic & Micro-processor meters. High tension metering or panel meters are desirable on a load demand exceeding 500KVA. In such cases, both the current transformer (CT) and the voltage transformer (VT) are employed.

4. Objectives of the Study

The central purpose of this study is to describe the effects of a prepaid method of billing on the electricity consumption pattern of users in Nigeria, using the Redeemed Christian Church of God's Redemption Camp at Mowe, Ogun State and selected areas in Osogbo, Osun State. Specifically the study:

- compares prepaid billing payment on electricity consumption to conventional payment in Nigeria and shows the relationship between consumer's behaviour and their energy consumption.
- assesses the preferences of consumers between the conventional and the prepaid method of billing
- compares the effect of variation in tariff between Redemption Camp, Ogun State, and Osogbo in Osun State.

5. Overview of the Theoretical and Empirical Literature

Research into feedback on energy consumption, given by way of written communication, displays or personal contact, began in the wake of the first oil crisis in the late 1970s. It was carried out largely by psychologists. These early studies established that feedback can have measurable effects on behaviour, and that it works to encourage energy conservation. They were, however, experimental in nature, not suitable for replication on a large scale, and the feedback was typically given over a short period of time (up to three months) (Frankish and Darby, 2009).

Since that time, the research literature has become more diverse, reflecting the differing aims behind a given piece of research, along with differing theoretical perspectives. For example, electricity feedback can be used to reduce demand, or to encourage people to use less electricity at peak times; the goal will affect the outcome in terms of overall usage and its timing (Frankish and Darby, 2009). The underlying theory of consumer demand is based on the behaviour of individual agents and the microeconomic basis for consumer energy demand relies on consumers' utility maximization principles. Such an analysis assumes that consumers know their preference sets and ordering of preferences. It also assumes that preference ordering can be represented by some utility function and that the consumer is a rational one, in that he/she will always choose a most preferred bundle from the set of feasible alternatives (Subhes & Govinda, 2009). Behavioural economics research shows that individuals do not make consistently rational decisions, as defined by utility of outcomes. There is no guarantee therefore that providing users with the information needed to make a rational choice will actually increase the likelihood of that choice being made. Therefore, the general implication to support consumer decision making is that the ideal formulation of classical utility theory must be combined with psychological insights of behavioural economics (Frankish and Darby, 2009).

Darby (2010) studied four theoretical approaches in assessing the behavioural change of consumers either in the short or long run. According to him, the examination of human behaviour towards the usage of electricity is managed sociologically, economically, psychologically and educationally. However, only the economic, psychological and educational aspects are applicable to the management of the prepayment metering programme.

Economic theories assume that energy is a commodity and that consumers will adapt their usage in response to price signals. According to this theory, financial incentives have some impact on energy-using behaviour and energy-related investments, with the size of incentive affecting the scale of response. In the literature, residential electricity demand-shifting in response to time-varying tariffs demonstrates this. Although, customers react in quite different ways to price levels and price changes, and even if significant opportunities to save energy and money are present, only those with certain rationalistic styles may be able to appreciate that fact (Lutzenhiser, 2002). In the overall consumption and electrical demand-shift in the UK, Owen and Ward (2010) noted that household gas customers reduced their use by 12 per cent overall from 2005 to 2007 in response to higher prices. Real price increases for electricity between 2005 and 2007 suggested a modest demand reduction in 2007. Despite real price increases, demand for domestic electricity rose by 2.4 per cent in 2008 when the winter was colder. Irrespective of prices rising, consumers will rather choose extra heat than save money if the weather is very cold (Owen and Ward, 2010).

Psychological theory assumes that energy use can be affected by stimulus – response mechanisms and by engaging attention. Fischer (2008), in her review of energy feedback from a psychological standpoint, identified the following 'likely' features for a successful feedback, i.e. effective in stimulating conservation and satisfying to households: actual consumption (i.e. accurate and trustworthy), frequent (ideally daily or more often), interaction and choice for households, appliance-specific breakdown (the review relates to electricity), a prolonged period and historical or normative comparisons (although the effects of the latter are less clear) presented in an understandable and appealing way. As Fischer pointed out, the more clearly someone can link consumption to specific appliances and activities, the more clearly behaviour patterns become relevant to the size of the energy bill (Fischer, 2008). Abrahamse et al. (2005) pointed out that information may increase knowledge, but does not necessarily affect behaviour. Feedback is effective to the extent that it provides highly specific, relevant, actionable

information, and a means of checking the effectiveness of actions (Abrahamse et al., 2005).

In educational theory, effective energy use is a skill that is learned through experience in specific situations. Energy users are not a uniform category of learners but a mixed ability and a mixed age class. They have differing levels of skill and understanding, and different motives for learning. For example, they may be looking for understanding and 'right action' in relation to the environment; looking for what is 'wrong' with their consumption (and bills) with a view to saving money; trying to keep in tune with social norms; trying to work with new types of gadgets; or some combination of these and other factors (Aune, 2001; 2007). According to educational theory, feedback has a role in teaching energy management skills, and in giving people a sense of their ability to control usage better. If people can experiment with energy in their homes or workplaces and see the consequences of their usage, the literature shows that they typically increase control over consumption and may form new habits. Feedback is seen as a necessary element in energy education or the building of 'energy literacy', which has to take into account the mixed abilities and motivations of users – including lack of motivation (Valocchi et al., 2009). Kempton and Layne (1994) stated that selling energy is very different from selling 'solid' commodities such as groceries. The kWh is easy to meter, for the utility, but 'irrelevant' to the buyer. It cannot be assumed that people will know how to act in order to reduce demand if they have little or no idea how much each end use contributes to that demand, and how it might be altered. In educational terms, they need to be able to add accurate, trustworthy information (information that they cannot easily get hold of themselves) to what they already know about the way they consume energy (Kempton and Layne, 1994).

Study has shown that energy consumption may be curbed if consumers have more information regarding their consumption of energy. Many empirical studies that examined the information feedback on energy consumption to residential households have been conducted. The type of information measures that are examined differ from study to study. Some focus on in-home displays while others use the Internet to provide information or feedback. Others depend on more frequent mailings. These studies have shown that information measures can decrease subsequent consumption by as much as 5-10 per cent (Matsukawa, 2004). Fewer studies have focused on the impact of consumer behaviour on residential energy consumption and it has been found that smart metering can decrease

residential energy consumption. The study carried out by Faruqui et al. (2009), suggested that consumers who actively use an IHD can reduce their consumption of electricity by an average of 7 per cent when prepayment for electricity is not involved.

When consumers both receive IHD feedback and are on an electricity prepaid system, they are able to reduce their consumption by an average of 14 per cent. It was also found that the impact of time varying rates is augmented by a direct feedback from IHDs and that IHDs encourage consumers to make more efficient use of energy (Faruqui et al., 2009).

6. Research Methodology

The cross-sectional survey and in-depth interview methods were employed to generate data for this study. The main reason for the adoption of these methods was to generate both quantitative and qualitative data on the billing methods. In the cross-sectional survey, questionnaires were administered to a total of 600 respondents, using a stratified random sampling method, out of which 565 were returned. For the in-depth interview, a total of 71 participants were interviewed, each participant was the head of the family and the representative of the household.

Redemption Camp, Mowe, Ogun State and selected areas in Osogbo, Osun State were used for the study between March and December 2011. These areas were used for the purpose of comparing consumers with prepaid and conventional meters in Nigeria. The RCCG generating plant is privately owned by the mission and there is constant electricity supply while the area studied in Osun State is managed by PHCN. This can be used to analyse the variation in price tariff between the two. In Osogbo, focus was on areas with constant electricity and ones with irregular supply of electricity and the areas that are inhabited by the rich as well as ones inhabited by the poor. Estate and Ata-Oja are the rich areas while Igbonan, Isale-Osun and Alekuwodo are the poor areas. The study population comprised consumers that use prepaid and conventional billing electricity methods among the households in RCCG, Mowe and Osogbo. Six hundred questionnaires were administered in all to households in RCCG, Mowe and Osogbo: 200 from RCCG, Mowe and 400 from selected areas in Osogbo. Income level was taken into consideration.

The study involved both male and female working groups with a salary scale of ₦10,000 and above, and who were aged 20 and above. For the purpose of this

study, these groups are categorized into single, married, divorced/separated and widow/widower and are represented by the head of each household. The sampling technique employed in this study was stratified random sampling. Both the purposive and systematic random sampling methods were adopted in selecting the houses with prepaid meters and the ones without prepaid meters. A stratified sampling method was systematically used in selecting the houses based on the difference in prices, areas with constant electricity supply, areas with power failure, rich and poor areas, streets that use prepaid meters and ones without prepaid meters, and the usage of electricity.

From all the selected areas, a total of 71 households were randomly selected and the head of the selected households were interviewed. The in-depth interview respondents were selected using a purposive sampling method and the selection depended on relevance, availability and convenience. Of the total number of questionnaires that were administered, 565 usable questionnaires were recovered; 196 from RCCG, Mowe, 174 from Osogbo (prepaid) and 195 from Osogbo (billing).

A structured questionnaire and a semi-structured in-depth interview guide were the research instruments used in the study. The interview was randomly conducted (qualitative and open-ended) to extract information on the opinion of the participants towards the adoption of the prepaid method of payment and their attitudes towards electricity usage. The interview guide comprised the questions extracted from the questionnaire in the cross-sectional survey. These questions provided detailed information on the objective of the study.

The structured questionnaire used in the cross-sectional survey which contained 29 questions was administered to the 565 respondents. The questionnaire had two sections. Section A was designed to obtain the biodata of the respondents and measure the impact of the prepaid billing system while section B focused on the appliances owned by the consumers and the energy usage pattern. The items in section A were measured on a 3-point Likert scale. Data analysis was both quantitative and qualitative. The data were subjected to quantitative analysis while the information from the interview was thoroughly interpreted.

The questionnaire was designed by the researcher. A pilot survey was conducted to detect ambiguities, i.e. questions that were not easily understood or poorly structured and those that were irrelevant. From the respondents' responses in the pilot survey, the entire questionnaire was restructured to eliminate

shortcomings. Cronbach's alpha was used to determine the consistency and reliability of the items.

6.1 Method of analysis

The study employed a survey approach to generate data from respondents in Redemption Camp, and selected areas in Osogbo. The data obtained from the survey were analysed using basically two approaches: descriptive and econometric. The descriptive approach involved the use of tables while the econometric estimate was obtained using the ordinary least squares multiple regression method to analyse the energy consumption patterns of consumers.

6.2 Model specification

In theory, consumption of electricity is considered a dependent variable of other related independent variables. In this paper, the relationships will be examined and an attempt will be made to relate them to the literature through an econometric model that will show the results of RCCG, Mowe and Osogbo as the case study using data for the period of March and December 2011. The study has a dependent variable and four independent variables as well as the econometric model to measure income, price tariff, size of the family and behaviour as the explanatory variables and monthly residential electricity consumption per household in kWh as explained variable. The behaviour of the users was computed and obtained by adding consciousness and pattern of use of electricity. The core explanatory variables that influence household electricity consumption are thus described in the model below. The income of the household is the most important economic variable that is assumed to determine household electricity consumption. The variables included in the model are to test the hypothesis of the consumer's preference. The model to be used can be explicitly specified as follows:

$$ELEC = f\,(INCO,\ TARI,\ SOFA,\ BEHA) \tag{1}$$

6.3 Statistical or econometric model

$$ELEC = \beta_0 + \beta_1 INCO + \beta_2 TARI + \beta_3 SOFA + \beta_4 BEHA + ei \tag{2}$$

where:

$ELEC$ = monthly residential electricity consumption per household in kWh

INCO = disposable income of the household
TARI = tariff price of the electricity
SOFA = size of the family
BEHA = behaviour of the electricity users
βs = unknown parameters which will be estimated
ei = stochastic or random disturbance (with usual properties of zero mean and non-serial correlation)

Since electricity consumption per household and the regressors are in a linear form, the coefficients are directly related. In other words, a linear regression model involves measuring the electricity consumption with respect to disposable income, tariff price, size of the family and behaviour.

6.4 Theoretical expectations

The theoretical expectations about the coefficients of the explanatory variables are: $\beta_1 > 0$, $\beta_2 < 0$, $\beta_3 > 0$, $\beta_4 < 0$. Incidentally, the estimated model will also be used to study the effect of tariff structure for consumer electricity consumption. The result generated from the data will be presented in tables. The coefficients of income and size of the family should have positive signs, which means that as income and size of the family increase, electricity consumption increases. Similarly, the coefficients of tariff price and behaviour are also expected to have negative signs, which show that the impact of a prepaid meter will reduce electricity consumption.

6.5 Hypotheses

6.5.1 *Hypothesis I*

H_0: The income of prepaid users has shown no significant impact on electricity consumption in RCCG, Mowe and Osogbo.

H_1: The income of prepaid users has shown significant impact on electricity consumption in RCCG, Mowe and Osogbo.

6.5.2 *Hypothesis II*

H_0: The tariff price of electricity has shown no significant impact on electricity consumption in RCCG, Mowe and Osogbo.

H_1: The tariff price of electricity has shown significant impact on electricity consumption in RCCG, Mowe and Osogbo.

6.6 Analysis of distribution and characteristics of the respondents

The results are presented in table 1. Overall, it was observed in the survey that 56 per cent of the respondents who bought electricity vouchers at vending machines were men, while 44 per cent were women. This indicates that more men are seen purchasing vouchers at the vending point but the study showed that women consume more energy than men. About 68 per cent of the respondents were married. Incomes were recorded as low, medium and high. Approximately 66 per cent of households with low income were reported to have the highest percentage of electricity consumption.

Table 1. Distribution and characteristics of the respondents

		RCCG		Osogbo Prepaid		Osogbo Conventional		Overall	
		Total	%	Total	%	Total	%	Total	%
Gender	Female	84	42.9	78	44.8	88	42.1	250	44.2
	Male	112	57.1	96	55.2	107	54.9	315	55.8
Age	20 – 30	38	19.4	22	12.6	32	16.4	92	16.3
	31 – 40	92	46.9	77	44.3	76	39	245	43.4
	41 – 50	36	18.4	53	30.5	56	28.7	145	25.7
	51 & above	30	15.3	22	12.6	31	15.9	83	14.7
Marital Status	Single	64	32.7	31	17.8	53	27.2	148	26.2
	Married	124	63.3	132	75.9	127	65.1	383	67.8
	Divorced/Separated	3	1.5	3	1.7	1	0.5	7	1.2
	Widow/Widower	5	2.6	8	4.6	14	7.2	27	4.8
Size of the Family	1	28	14.3	10	5.7	6	3.1	44	7.8
	2	61	31.1	29	16.7	31	15.9	121	21.4
	3 – 5	85	43.4	109	62.6	99	50.8	293	51.9
	6 – 8	21	10.7	25	14.4	56	28.7	102	18.1
	9 & above	1	0.5	1	0.6	3	1.5	5	0.9
Monthly Salary	₦10,000 – ₦50,000	53	27	81	46.6	63	32.3	197	34.9
	₦51,000 – ₦100,000	49	25	72	41.4	53	27.2	174	30.8
	₦101,000 – ₦150,000	46	23.5	18	10.3	32	16.4	96	17
	₦151,000 – ₦200,000	18	9.2	3	1.7	21	10.8	42	7.4
	₦201,000 – ₦500,000	18	9.2	-	-	20	10.3	38	6.7
	₦500,000 & above	12	6.1	-	-	6	3.1	18	3.2

Source: Adenikinju & Oluwayemisi, 2011.

7. Suggestions by Electricity Consumers

The structured questionnaire highlights the suggestions of the consumers based on the billing method and prepaid meter used in their various residences. In Osogbo, 16 out of 195 users of the conventional billing meter responded that government should eradicate the conventional billing method and replace it with the prepaid meter method. According to them, the conventional billing method is a means of exploitation of the users by PHCN; they are billed for what they did not consume thus the billing is not commensurate with the level of consumption. Also, 12 out of 174 users of the prepaid meter system in Osogbo suggested that the installation of the new meter should be at government expense, i.e., installation should not attract any fee.

Maintenance of transformers and prepaid meters should be carried out regularly and the practice of by-passing the meter should be curbed by PHCN staff. This will result in constant electricity supply.

In RCCG, 56 out of 196 users of the prepaid meter suggested ways that government can improve the use of prepaid meters. The percentage of users of the prepaid meter in RCCG is extremely high compared to Osogbo and the impact of the prepaid meter is felt by them in that there is constant electricity supply, but the tariff is very high. They suggested that the prepaid meter should be introduced to the rest of the country, and the practice of by-passing the meter should be curbed by PHCN officials. This can be realized by activating GPRS to track those who default on their payment and their activities should be investigated. Tariffs should be reduced to prevent the by-passing of meters. Currently, the tariff is high because the turbines use diesel. In order to lower the tariff, the diesel turbines should be converted to gas turbines. If there is a reduction in tariff, consumers will buy more credit which will result into the generation of more revenue. Another way of reducing tariff is that subsidy should be introduced.

Other suggestions include:

- creation of awareness on how to maximize the use of the prepaid meter, convenient use of the prepaid meter
- availability of credit 24 hours a day
- introduction of database for monitoring a customer's consumption of electricity and proper management of the electricity supply department.

Collectively, the percentage of electricity users that preferred the privatization of PHCN was extremely high. This can be attributed to the power outages around the

nation and it is believed that the generation and distribution of electricity can be properly handled by private firms who would ensure that there is constant electricity supply.

Table 2. Suggestions of the electricity users

	Osogbo Conventional	Osogbo Prepaid	RCCG Prepaid	Total
Number of respondents	16	12	56	84
Availability of credit 24hours a day			11	11
Convenient usage of the prepaid meter			3	3
Conversion of diesel turbine to gas turbine			10	10
Constant electricity supply	16	12		28
Creation of awareness on maximizing the usage of the prepaid meter			2	2
Curbing of the bye-passing		8	4	12
Electricity should not be privatized		1	3	4
Eradication of conventional billing method	13			13
Installation of the new meter by the government		8		8
Introduction of the prepaid meter to the rest of the country		5	12	17
Maintenance of the transformer and prepaid meter		4	7	11
Moderation in price tariff			43	43
Privatization of PHCN	15	8	18	41
Tariff price subsidy			18	18

Source: Adenikinju & Oluwayemisi, 2011.

8. Analysis of Findings

In order to analyse the effects of prepaid metering on the electricity consumption pattern of users in Nigeria, a descriptive test was conducted. The result is shown in the tables 3a and 3b.

8.1 Differences in billing methods and users' behaviour

As can be seen in table 3a, 322 out of 565 respondents switch off all their electrical appliances when they are not at home, while the remaining 243 leave their electric appliances on. In RCCG, approximately 66 per cent of the population put off their electricity before leaving for work, while the other 34 per cent leave

their electricity on irrespective of the time. In Osogbo, 52 per cent of the users put off their electrical appliances. From table 3b and figure 6, about 89 per cent of the respondents that use prepaid meters and 11 per cent of conventional meter users put off their electrical appliances.

Table 3a. Electricity usage (town of residence)

	Do you switch off all appliances when you are not at home?		
	Yes	No	Total
RCCG	130	66	196
Osogbo	192	177	369
Total	322	243	565

Table 3b. Electricity usage (method of electricity payment in the home)

	Do you switch off all appliances when you are not at home?		
	Yes	No	Total
Conventional	34	161	195
Prepaid	288	82	370
Total	322	243	565

Source: Adenikinju & Oluwayemisi, 2011.

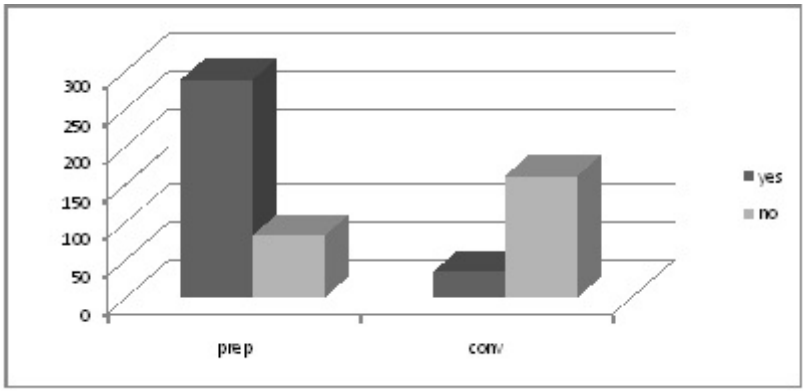

Figure 6. Electricity usage (switching off all the appliances when not at home).
Source: Adenikinju & Oluwayemisi, 2011.

Approximately, 34 per cent of prepaid users and 66 per cent of conventional users leave their electrical appliances working. One of the reasons why electrical appliances are turned off in Osogbo is the irregularity of electricity supply. Also, most of these areas experience low voltage which can cause damage to electrical gadgets. In addition to this, prepaid users are mindful of how they consume electricity and irrespective of power failure, the meter is switched off before leaving for work.

Table 4a shows that 58 per cent of prepaid users in RCCG spend between ₦2,000 and ₦5,000 on electricity monthly. Only 6 per cent spend higher amounts on electricity. This is as a result of PHCN's high tariff. It also depends on the electrical gadgets owned by the users. In Osogbo, 48 per cent of the population pay between ₦500 and ₦1,000, while 52 per cent pay between ₦2,000 and ₦5,000. Figure 7 reveals that 72 per cent of conventional users in Osogbo are billed between ₦2,000 and ₦5,000, while the remaining 28 per cent are billed between ₦500 and ₦1,000. The result indicates that those who subscribe to the conventional method are billed for what they do not consume. The table clearly reflects that PHCN has stipulated amounts that the consumers are billed. Only 174 users of prepaid meters in Osogbo and 196 users in RCCG are billed based on their consumption.

Table 4a. Monthly billing (state of residence)

	Currently, how much do you spend on electricity per month on the average?				
	₦500 - ₦1,000	₦2,000 - ₦5,000	₦6,000 -₦9,000	₦10,000 and above	Total
RCCG	60	114	9	13	196
Osogbo	177	191	1	0	369
Total	237	305	10	13	565

Table 4b. Monthly billing (method of electricity payment in the home)

	Currently, how much do you spend on electricity per month on the average?				
	₦500 - ₦1,000	₦2,000 - ₦5,000	₦6,000 - ₦9,000	₦10,000 and above	Total
Conventional	55	140	0	0	195
Prepaid	182	165	10	13	370
Total	237	305	10	13	565

Source: Adenikinju & Oluwayemisi, 2011.

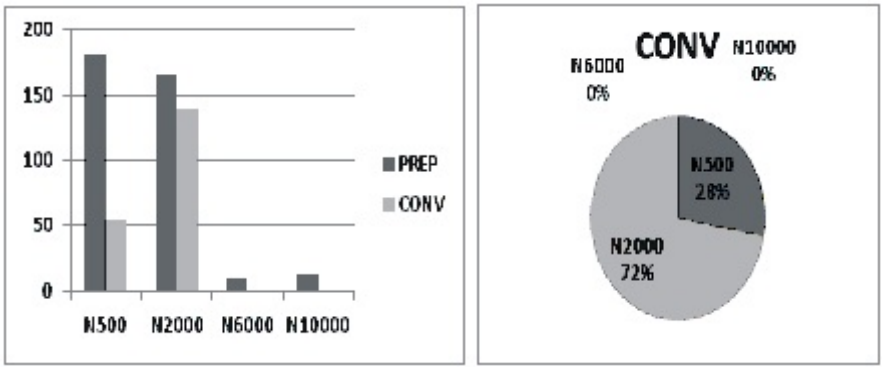

Figure 7. Monthly billing (electricity consumption per month on the average).
Source: Adenikinju & Oluwayemisi, 2011.

The results show that with a prepaid meter, 97 per cent of the users are conscious of their electricity usage in RCCG, while in Osogbo only 46 per cent properly manage their electricity consumption as shown in table 5a. In table 5b and figure 8 it is shown that 97 per cent of the prepaid method users are conscious of how electricity is used, while 100 per cent of those who use the conventional method mismanage electricity. In other words, all those who use the conventional method waste energy without considering the implications.

Table 5a. Electricity management (town of residence)

	Are you conscious of how you use your electricity (do you manage your electricity now)?			
	Yes	No	I can't tell	Total
RCCG	190	3	3	196
Osogbo	170	199	0	369
Total	360	202	3	565

Table 5b. Electricity management (method of electricity payment in the home)

	Are you conscious of how you use your electricity (do you manage your electricity now)?			
	Yes	No	I can't tell	Total
Conventional	0	195	0	195
Prepaid	360	7	3	370

Table 5a. Electricity management (town of residence)

	Are you conscious of how you use your electricity (do you manage your electricity now)?			
	Yes	No	I can't tell	Total
RCCG	190	3	3	196
Osogbo	170	199	0	369
Total	360	202	3	565

Table 5b. Electricity management (method of electricity payment in the home)

	Are you conscious of how you use your electricity (do you manage your electricity now)?			
	Yes	No	I can't tell	Total
Conventional	0	195	0	195

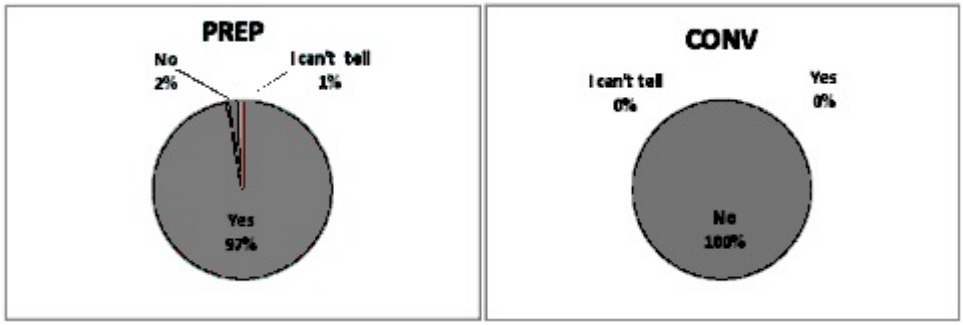

Figure 8. Electricity management (consciousness of electricity usage).
Source: Adenikinju & Oluwayemisi, 2011.

Total	360	202	3	565

Source: Adenikinju & Oluwayemisi, 2011.

Table 6a shows that in RCCG, 171 respondents had a preference for the prepaid meter over the conventional meter, while 25 were faced with indecision. In Osogbo, 126 respondents liked their billing method, 185 detested their billing system and the remaining 58 could not decide if their billing method was appropriate for their consumption profile. The results in table 6b show that 79 per cent of prepaid users liked their billing method while 21 per cent were indecisive. About 95 per cent of the users of the conventional method did not like their billing system, 2 per cent liked it, while the remaining 3 per cent could not precisely understand if their billing method was appropriate.

Table 6a. Billing method (town of residence)

	Do you think the billing system you use appropriately record your consumption profile?			
	Yes	No	I can't tell	Total
RCCG	171	0	25	196
Osogbo	126	185	58	369
Total	297	185	83	565

Table 6b. Billing method (method of electricity payment in the home)

	Do you think the billing system you use appropriately records your consumption profile?			
	Yes	No	I can't tell	Total
Conventional	4	185	6	195
Prepaid	293	0	77	370
Total	297	185	83	565

Source: Adenikinju & Oluwayemisi, 2011.

Figure 9 shows that 99 per cent of the users of the prepaid billing method were satisfied with their electricity consumption, while 1 per cent preferred the conventional billing to the prepaid billing.

Figure 9. Billing method (appropriate record of consumption profile).

8.2 Consumer preferences between the prepaid and the conventional billing method

The assessment of consumer preference between the conventional and the prepaid method of billing is shown in table 7.

Table 7. Billing method preference (town of residence)

	If you have a choice, which billing system would you have preferred?		
	Conventional billing method	Prepaid billing method	Total
RCCG	15	181	196
Osogbo	42	327	369
Total	57	508	565

Source: Adenikinju & Oluwayemisi, 2011.

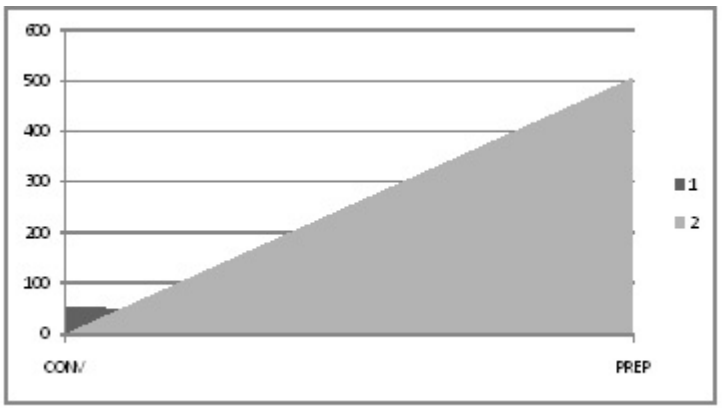

Figure 10. Billing method preference.
Source: Adenikinju & Oluwayemisi, 2011.

Table 7 shows that 92 per cent of RCCG residents and 87 per cent of the residents of Osogbo prefer the prepaid to the conventional method of billing. Collectively, 90 per cent of the respondents prefer the prepaid method to the conventional method, while the remaining 10 per cent of the users of the conventional method like their method of billing. These results show that a majority of the respondents prefer the prepaid method of billing to the conventional method of billing. This is because it displays the kWh worth of electricity that is consumed. One of the possible reasons why the remaining 10 per cent prefer the conventional method of billing is that there is no restriction with regard to electricity usage.

8.3 The effect of variation in tariff pricing

The effect of variation in tariff between RCCG and Osogbo is shown in table 8. The table shows that 47 per cent of the residents in RCCG wanted constant electricity supply irrespective of the tariff, 34 per cent of the respondents were not interested in an increment in tariff, while the remaining 19 per cent were indecisive. In Osogbo, 97 per cent wanted an increment in tariff, while 3 per cent did not. However, the majority of the users of the prepaid and the conventional meters wanted constant electricity irrespective of increment in tariff (figure 11).

Table 8. Tariff price (town of residence)

	If tariff/price is to be increased and there is constant electricity supply, would you be willing to pay more?			
	Yes	No	I can't tell	Total
RCCG	92	66	38	196
Osogbo	359	10	0	369
Total	451	76	38	565

Source: Adenikinju & Oluwayemisi, 2011.

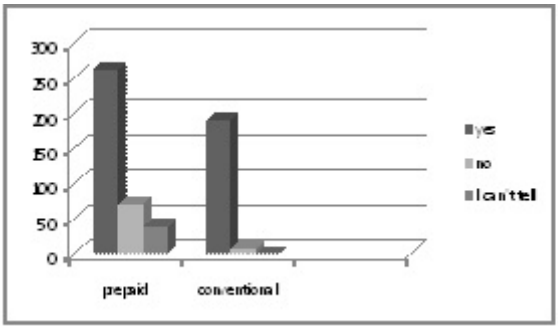

Figure 11. High tariff.
Source: Adenikinju & Oluwayemisi, 2011.

8.4 Interview results

Seventy-one participants were randomly selected and were grouped into households with prepaid meters and households without prepaid meters.

8.4.1 Households with prepaid meters

Users of prepaid meters in Osogbo were in support of the adoption of the billing method. They opined that installation of the new meter should be done by government and should not attract any fee. They stressed that transformers and the prepaid meters should be properly maintained and bypassing the meter should be curbed by PHCN staff. These, they believe will result in constant electricity supply.

Users of prepaid meters in RCCG responded that the prepaid meter should be introduced to the rest of the country and in order to curb those who bypass the meter, it should be designed in a way that it cannot be tampered with or GPRS should be activated to track defaulters. The Power Holding Company of Nigeria should also set up a body to investigate the activities of those who bypass their meters. According to them, moderation in price tariff could also be a means of curbing the bypassing of meters. Other contributions include: creation of awareness on how to maximize the usage of the prepaid meter, convenient usage of the prepaid meter, and availability of sale of credit 24 hours a day.

8.4.2 Households without prepaid meters

Users of the conventional billing meter responded that government should eradicate the use of the conventional billing method and replace it with the prepaid meter. According to them, the billing method is a means by PHCN of exploiting users because they are billed for what they do not consume.

Collectively, the percentage of electricity users that want the privatization of PHCN is extremely high. The main reason for this is the power outages around the nation, and it is believed that the generation and distribution of electricity can be effectively handled by private firms. According to all the users of electricity in the study area, there should be constant electricity supply irrespective of the price.

8.5 Analysis of regression results

Table 9 shows the correlation matrix among the variables used in the study. It reveals that electricity consumption and behaviour are negatively related while income and electricity consumption are positively related. This correlates with the energy income ladder, that is, the higher the income, the higher the demand for more efficient energy and vice-versa. The electricity tariff (i.e. price) is weak and negatively related with electricity consumption. Family size, however, is positively related to income, electricity consumption and tariff.

Table 9. Correlation matrix of electricity consumption

	BEHA	ELEC	INCO	SOFA	TARI
BEHA	1.000000	-0.514797	-0.425860	-0.136728	0.269044
ELEC	-0.514797	1.000000	0.567781	0.260143	-0.399325
INCO	-0.425860	0.567781	1.000000	0.115039	-0.383641
SOFA	-0.136728	0.260143	0.115039	1.000000	0.210420
TARI	0.269044	-0.399325	-0.383641	0.210420	1.000000

Source: Adenikinju & Oluwayemisi, 2011.

Table 10 provides the regression results of the impact of the prepaid meter on electricity consumption. The econometric relationships were as follows: it was found that income and family size have a significant positive effect on electricity consumption. This implies that an increase in income and the size of the family will result in an increase in electricity consumption. Alternatively, price tariff and individual behaviour have significant impact on electricity consumption, which indicates that an increase in price tariff and individual behaviour cause a decrease in electricity consumption. All the relationship results were consistent in terms of theory on the ground of 'a priori expectation' as all the coefficients have the expected signs.

Table 10. Determinants of electricity consumption

	Coefficient	t-Statistic	Prob	R^2 = 0.489187
	1.924772	10.65632	0.0000	AdjR^2 = 0.483589
INCO	Variable	7.437138	0.0000	D.W stat = 1.692037
TARI	C	-5.839573	0.0000	F-stat = 87.38687
SOFA	0.201032	5.993841	0.0000	Prob(F-stat) = 0.000000
BEHA	-0.418131	-6.553711	0.0000	

Source: Adenikinju & Oluwayemisi, 2011.

If income and family size increase by 1 unit, on average, electricity consumption will increase by 0.18 and 0.20 units respectively. Similarly, if tariff price and behaviour increase by 1 unit, on average, electricity consumption will decrease by 0.36 and 0.42 units respectively. It was found that a Durbin-Watson value of 1.70, which is greater than the DW table value upper limit, means that there is no evidence of serial correlation. The R^2 value of 0.49 means that about 49 per cent of the variations in electricity consumption is explained by the variation in income, tariff price, size of the family and behaviour. Thus, 51 per cent variation in electricity consumption is explained by other factors not captured in the model.

Actually, the R^2 is very low. Researchers sometimes play the game of maximizing R^2, that is, choosing the model that gives the highest R^2.This may be dangerous, for in regression analysis the objective is not to obtain a high R^2 but rather to obtain dependable estimates of the true population regression coefficients and draw statistical inferences about them. In empirical analysis it is not unusual to obtain a very high R^2 but find that some of the regression coefficients either are statistically insignificant or have signs that are contrary to a priori expectations. Therefore, the researcher should be more concerned about the logical or theoretical relevance of the explanatory variables to the dependent variable and their statistical significance. If, in this process, a high R^2 is obtained, well and good; on the other hand, if the R^2 is low, it does not mean the model is necessarily bad (Gujarati, 2003). The adjusted R^2 indicates that after taking into account the number of regressors, the model explains only about 48 per cent of the variation in electricity consumption.

F-statistic 87.4 and Prob (F-statistic) 0.0000 are statistically significant. The estimated intercept and the entire estimated coefficient for income, size of the family, behaviour and tariff price were found statistically significant as the t-statistic value was found to be greater than the absolute value of 2 for all variables and using the p-value. Thus the null hypotheses that income, size of the family, behaviour and tariff price have no statistically significant effect on electricity consumption at 5 percent levels of significance is rejected. By implication, income, size of the family, behaviour and tariff price have an impact on the consumption of electricity.

In the analysis, two hypotheses were tested with a least squares regression and the results are presented in table 10. These hypotheses state that the income of prepaid users and the tariff price of electricity have shown no significant impact

on electricity consumption in RCCG, Mowe and Osogbo in Osun State for null hypothesis, and have shown significant impact on the electricity consumption in RCCG at Mowe and Osogbo in Osun State for alternative hypothesis. From the regression results, both income of prepaid users and tariff price of electricity for RCCG, Mowe and Osogbo, Osun State satisfied the 'a priori expectation' of the electricity theory and are statistically significant. Since P-value < 0.05 level of significance, the null hypothesis that income and tariff price have no effect on electricity consumption at a 5 per cent level of significance is rejected. The income of prepaid users and tariff price of electricity have significant impact on electricity consumption in RCCG, Mowe and Osogbo in Osun State.

The results of the study clearly show that the prepaid metering method of payment has had a positive effect on electricity consumption. Figure 12 shows that 79 per cent of the prepaid method subscribers are satisfied with the billing method while 95 per cent of the users of the conventional method want the conventional method to be eradicated. Also, electricity consumption and the behaviour of the users of the prepaid billing method are inversely related (figure 13). This is because early studies on prepayment metering established that the prepaid billing method can have a noticeable effect on behaviour, which encourages energy conservation and enables customers to manage their electricity usage efficiently. It is also a mechanism which offers information that could help the consumers to reduce their household consumption of electricity.

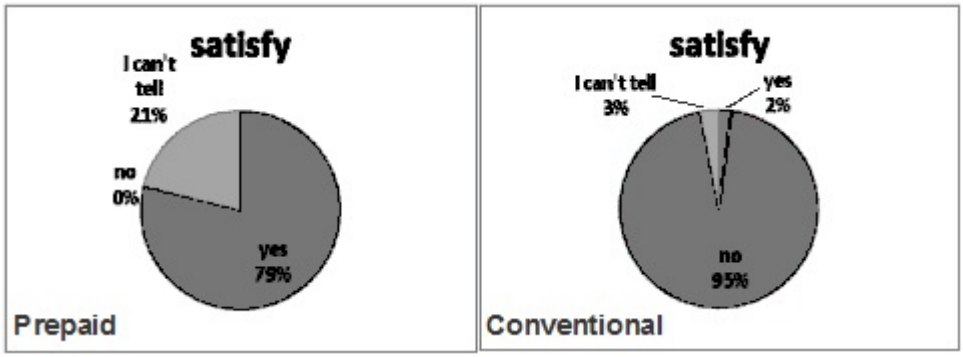

Figure 12. Prepaid versus conventional.
Source: Adenikinju & Oluwayemisi, 2011.

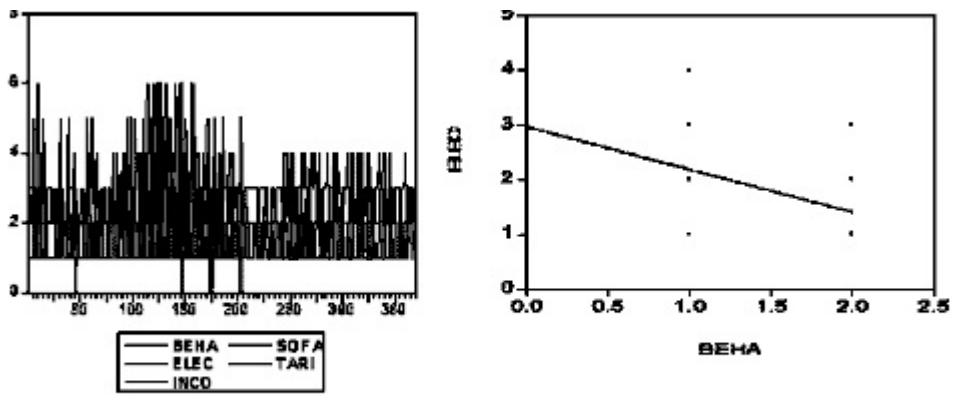

Figure 13. Effect of prepaid billing method on behaviour.
Source: Adenikinju & Oluwayemisi, 2011.

9. Conclusion

This study has empirically verified the effect of the prepaid method of billing metering on electricity consumption in the Redemption Camp at Mowe, Ogun State and at Osogbo in Osun State. The study describes the effect of prepayment on electricity consumption, assesses the preference of consumers between the conventional/billing meter and the prepaid meter, and analyses the variation in the price of electricity in Nigeria. Generally, it is observed that the prepaid method of billing in Nigeria has had a positive impact on electricity consumption.

The null hypothesis (H_0) which states that the income of prepaid users and the tariff price of electricity have shown no significant impact on electricity consumption in RCCG and Osogbo was rejected. The outcome of the study is that the income of users of the prepaid method and the tariff price of electricity have impact on electricity consumption in RCCG and Osogbo. Thus, it can be said that the prepaid service has significantly reduced the electricity consumption of the users thereby sustaining energy efficiency.

10. Policy Implications for Findings

Preliminary results suggest that significant energy savings result only when prepaid metering programmes are coupled with high energy prices (Wang, 2011). A better understanding of the impact of prepaid metering programmes and their effects

could lead to improved policy development, efforts that can significantly reduce the nation's residential energy consumption, increase its energy security, and generate positive health benefits for citizens.

Further studies need to be conducted in the area of energy policy decisions regarding change to the prepaid meter. This should be preceded by high quality research based on detailed analysis of prevailing energy use and behaviours as well as systems that affect energy use such as tariff. Therefore, appropriate electricity tariff rate accompany by enlightenment and education should accompany installation of prepayment meters. The combination of both will increase realized energy savings. In addition, importation or manufacture of energy saving electricity equipment or gadgets should be encouraged by the government while curbing of bypassing of meters should be seriously discouraged.

References

Abiodun, A.F. 2010. Metering and MD Meter Installation. PHCN, Ojoo, Ibadan.

Abrahamse, W., L. Steg, C. Vlek, and T. Rothengatter. 2005. A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology* 25 (3): 273 - 291.

Aidan, K. 2003. 'Prepayment Meters.' *Commission for Energy Regulation*. A Consultation Paper CER 03/291.

Aune, M. 2001. Energy technology and everyday life – The domestication of Ebox in Norwegian households. http://www.eceee.org/conference_proceedings/eceee/2001/Panel_4/p4_1/paper.

Aune, M. 2007. Energy comes home. *Energy Policy* 35: 5457-5465.

Darby, S. 2010. Smart metering: What potential for householder engagement? *Building Research and Information* 38(5): 442 - 457.

Etiosa, U. 2008. *Report of a National Dialogue to Promote Renewable Energy and Energy Efficiency in Nigeria*. Benin City: Community Research and Development Centre.

Faruqui, A., S. Sanem, and S. Ahmed. 2009. The impact of informational feedback on energy consumption: A survey of the experimental evidence. *Energy* 35 (2010).

Fischer, C. 2008. Feedback on household electricity consumption: A tool for saving energy? *Energy Efficiency* 1(1): 79-104.

Frankish, C. and S. Darby. 2009. Literature reviews. In: Will Anderson W. and V. White. *Exploring Consumer Preferences for Home Energy Display Functionality*. Centre for Sustainable Energy, Bristol.

Gujarati, D. 2003. *Basic Econometrics*. New York: The McGraw-Hill Companies, Inc.

Kempton, W. and L.L. Layne. 1994.The consumer's energy analysis environment. *Energy Policy* 22(10), 857 - 866.

Krishnan, R. 2006. Remote disconnect and prepayment metering. *Metering International* 3.

Lutzenhiser, L. 2002. Marketing household energy conservation: the message and the reality. In: Dietz, Thomas and Paul C. Stern, eds. Chapter 3, *New tools for Environmental Protection: Education, Information And Voluntary Measures*. Washington, D. C.: National Academy Press.

Matsukawa, I. 2004. The effects of information on residential demand for electricity. *Energy Journal* 25(1).

Nexant, 2003. Metering Strategies for NEPA. http://pdf.usaid.gov/pdf_docs/Pnacy989.pdf.

Owen, G. and J. Ward. 2010. *Smart Pre-payment in Great Britain*. Sustainability First, London.

Subhes, C. and R. Govinda. 2009. Energy Demand Models for Policy Formulation: A Comparative Study of Energy Demand Models. *The World Bank Policy Research Working Paper* 4866.

Valocchi, M., J. Juliano, and A. Schurr. 2009. Lighting the way. Understanding the smart energy consumer. Ohio: IBM Institute for Business Value.

Wang, Joy H. 2011. Behavioral Policy Modeling: Consumer Behavior Impacts on Residential Energy Consumption. School of Public Policy, Georgia Institute of Technology, Atlanta, http://www.spp.gatech.edu/faculty/WOPRpapers/Wang. WOPR11.pdf, 20.07.2012