

**ESTIMATING HOUSEHOLD WILLINGNESS TO PAY FOR IMPROVED ELECTRICITY
SUPPLY IN LAGOS METROPOLIS.**

Abstract

Nigeria's per capita electricity consumption is one of the lowest in Africa; with the residential sector being the worst hit. The supply from the state owned Power Holding Company of Nigeria (PHCN) is often erratic forcing most households to resort to the use of generators with its attendant noise and air pollution besides other adverse consequences. The study employed non-market valuation techniques (conjoint analysis, contingent method, and multivariate analysis) to assess the Willingness-to-pay for improved electricity supply using two housing estates within Lagos metropolis as case study. The study reveals the attributes of electricity supply services that give the highest utility, and also the Willingness-to-pay bids of the residents of the two estates. These results were combined and tested for sustainability based on the current cost of installing and running the Energy by Motion (EBM) technology; a green technology, considered as one of the most cost-effective options available. Simple 'payback' analysis shows that the very low Willingness-to-pay bids of the residents of the two estates would barely support completely deregulated private sector participation. By implication, electricity supply to the estates under reference (including similar and estates of inferior socio-economic characteristics in the metropolis) would continue to be provided by the state-owned Power Holding Company of Nigeria (PHCN) at the existing subsidized rates.

Keywords: *conjoint analysis, contingent method, power supply, sustainability, Willingness-to-pay.*

1.0 Introduction

Sub-Saharan Africa is in the midst of a power crisis, marked by insufficient generating capacity, unreliable supplies, high prices, and low rates of access to the electricity grid (IMF, 2008). The region's capacity for generating power is lower than that of any other region in the world, and growth has generally stagnated. The average price of power in Sub-Saharan Africa is double that of other developing regions, while supply is unreliable (Eberhard et al., 2008). Because new household connections in many countries are not keeping pace with population growth, the electrification rate, already low, is actually declining (Eberhard et al., 2008). The World Bank

reckons that 500 million sub-Saharan Africans are without what it calls “modern energy” (The Economist, 2012).

Nigeria in particular is facing increasing electricity supply and demand dilemma. In spite of the slow growth in economic activities in recent years, the demand for electricity in Nigeria has continued to increase (Adaramola and Oyewole, 2011; Johnson, Odekoya and Umeh, 2012). Nigeria’s electricity market, dominated on the supply side by the state-owned Power Holding Company of Nigeria (PHCN) has been incapable of providing minimum acceptable international standards of electricity service reliability, accessibility and availability. Current levels of consumption is less than 150kWh per person per year; one of the lowest in the world (Azinge, 2012). Nigeria’s per capita electricity consumption also lags behind other African countries. Indeed, Nigeria’s per capita energy consumption is 4 times less than the African average and about 19 times less than the world average (Sambo, 2009). In Table 1, Okeh (2007) reveals that at cross country comparison of conventional energy output, South Africa with a population of 44.3 million has electricity supply of 30,020 MW which is 12 times what Nigeria with over 160 million has; Egypt with a population of about 77.5 million has 14,250 MW capacities, approximately 6 times higher than Nigeria’s (Olise and Nria-Dappa, 2009). Getting electricity in Nigeria requires eight procedures, takes 260 days and costs 873.9% of income per capita, while the country is ranked 178th out of 185 economies on the ease of getting electricity (World Bank, 2013).

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Table 1: Conventional Energy Supply (2004)

Country	Supply (MW)
South Africa	30,020MW
Egypt	14,250MW
Algeria	6,188MW
Libya	4,710MW
Morocco	3,592 MW
Nigeria	3,500 MW

Source: Okeh (2007)

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In Nigeria, the residential sector accounts for a greater proportion of the country’s electricity consumption with a peak demand of 2,000 GWH per day thereby making it the worst hit sector (Central Bank of Nigeria, 2009).With rising population and consequent increase in household sizes across the country, the demand for electricity continues to grow and more power stations would be required to meet both the existing shortage and the increases. The need for more power stations in the country has long been recognized, but most of the attempts at improving

supply since the 1970s have not yielded the desired results. Sambo (2009) identifies high cost of electricity production as one of the challenges facing the country's power sector.

Given the limited and dwindling resources available to the government at various levels, the ongoing reform in the Nigerian power sector is anchored on deregulation. Past experiences have also shown that direct government involvement in procurement has often been marred by ineptitude and inefficiency. The roadmap for the transformation of the power sector is therefore hinged on private sector participation. However, the sustainability of private sector participation is hinged on appropriate pricing and tariff setting. Presently, there is limited knowledge on how much consumers are willing to pay for improved electricity services in the study area.

One popular means of assessing the sustainability of power/electricity supply has been through Willingness-to-pay studies. If people are willing to pay the full costs of a particular service, then it is a clear indication that the service is valued (and therefore will most probably be used and maintained) and that it will be possible to generate the funds required for sustaining and even replicating the project (Mbata 2006; Devi et al., 2009). If cost is not recovered through tariffs they must be funded through tax system or declining services will lead to higher cost of self-provision (Kerfand and Smith, 1996). History has shown that public subvention cannot be relied upon in times of constrained budgets as this will leave insufficient funds for new investments in operations and maintenance. In the absence of measures of public subsidies, private investment in infrastructure particularly electricity require that the tariffs reflect the full cost of provision including profit margin as an incentive for the investors (Otegbulu, 2011). Sustainable energy planning should be done on the basis of cost-effectiveness, continuous availability, unrestricted supply, and satisfactory regard for the environment (Akinbami & Lawal, 2009). In addition, most environmental goods and services cannot be priced in the market. Hence, resort is made to environmental valuation techniques such as the contingent method and the conjoint analysis. The study is therefore a deviation from the usual supply side management approach to infrastructure provision and management. Electricity consumption is a derived demand and Willingness to pay (WTP) is an expression of the demand for a service, and it is a strong pre-requisite for cost recovery because it is a measure of user satisfaction of a service and of the desire and capability of users to contribute to its functioning (Brikke and Rojas, 2001).

Studies in Willingness to pay for improved electricity supply have been carried out in a number country, developing and developed (Virgee 2005; Cameron 1988, 1986; Cameron et al 1996; Choynowski 2002; Kessides 1993, 1995, 2001, 2004; Morrison and Nalder 2009; Whittington 2003; Brook and Irwing 2003; Kateregga 2009). Similar studies have also been carried out across Nigeria (Lee and Anas 1991; World Bank 1996; Otegbulu 2010, 2011; Shomolu; 2006). However, none of these previous Nigerian studies has considered the areas covered by this study, and none has used the approach adopted for this study.

The study is in four sections. This introductory section is followed by the history and current state of energy crisis in Nigeria. The third section concentrates on the study methodology and the

statistical tools employed for data analysis. The fourth section includes data analysis and discussion of the results as well as the concluding remarks.

2.0 Review of literature

2.1 Infrastructure and economic growth

Cities have played a key role in the evolution of the global economy. Cities are generators of enormous wealth and act as the powerhouse of the national economy. The strength of a nation's economy, the contact point of international economies, the health of our democracy and the vitality of the humanistic endeavors, all are dependent on whether or not the city works (Ciceros cited in Otegbulu, 2012). It is also axiomatic that infrastructure is the engine driving the modern cities. The contribution of infrastructure to economic development in general, and to residential properties in particular, is enormous since it provides good neighborhood quality, encourages investment, enhances accessibility, facilitates information flows and helps in achieving highest and best use (World Bank, 1994). For instance, manufacturing, petro-chemical, iron and steel industries; breweries, petroleum refineries, hospitals, schools, barbing saloon, tailoring and welding workshops, to mention but a few, require regular supply of electricity for effective performance of their activities. Besides their direct value as an item in the "consumption basket" of households, infrastructural services are also a means to acquiring other goods and services. The direct and indirect consumption benefits from electricity, for example, include extra hours of study time due to electric lighting, the availability of new forms of entertainment (e.g. cinema, television) and access to labor saving appliances, among others (Otegbulu, 2011).

Unfortunately, the level of deficiencies and the degree of deterioration of infrastructure in Nigerian cities is alarming and worrisome due to inability of government to meet up its social responsibilities to the people (Ajilowo, 2010). Of the constraints to infrastructural development, funding is pivotal and universal. The depression of the late 80s and 90s which has not abated, has led to substantial reduction in local, state and federal government revenue resulting in abandoned projects, decay and total neglect of infrastructure. At an estimated average cost of US\$1.5 million needed to add a Mega Watt of electricity, Nigeria would need a whopping US\$150 billion (N18 trillion) to generate additional 100,000MW required for full industrialization of the economy by 2020 based on a growth rate of 13% as projected by the Energy Commission of Nigeria (Sambo et al., 2010). Previous attempts at improving funding of infrastructure including electricity supply in Nigeria such as the establishment of Urban Development Bank have made but insignificant change as the bank itself faced funding problem. In the prevailing circumstances of dwindling funds and increasing demand, creative and innovative solutions are required to address the power supply problem in Nigeria.

2.2 History and current state of electricity supply in Nigeria.

Electricity generation in Nigeria began in 1896. The Nigeria Electricity Supply Company (NESCO) commenced operations as an electric utility company in Nigeria in 1929 with the construction of a hydroelectric power station at Kurra near Jos. By an Act of Parliament in 1951, the Electricity Corporation of Nigeria (ECN) was established, while the Niger Dams Authority (NDA) was established in 1962 with a mandate to develop the hydropower potentials of the country. The ECN and NDA were merged in 1972 to form the National Electric Power Authority (NEPA), which, as a result of unbundling and reform in the power sector, was renamed the Power Holding Company of Nigeria (PHCN) in 2005 (Sambo et al., 2010). PHCN is the primary source of electricity supply to nine out of every household in Lagos; while secondary sources are made up of generator (60), local lamp (37%), solar energy (2%) and battery (1%) (COS, 2010). Nigeria's primary energy resources are in excess if its domestic energy requirement such that Nigerians should not experience supply inadequacy on account of quantum of deposit (Adegbulugbe and Seriki, 1991). Nigerian energy resources include gas, crude oil, coal, solar, nuclear, and hydro (Ubi et al., 2012). However, only four of these resources namely: coal, crude oil, natural gas and hydro, are presently been utilized. Nigeria's power sector currently has less than 8,000 MW of installed capacity, and less than 6,000 MW of available capacity, with only about 4,000 MW of regular powers going through the grid. The country currently has 14 generating plants, which supply electric energy to the National Grid. Of the 14 generating plants, 3 are hydro and 11 are thermal (gas/steam). Seven of the fourteen generation stations are over 20 years old. The national grid is made up of 4,889.2km of 330kV lines, 6,319.33km of 132kV lines, 6,098MVA transformer capacity at 330/132kV and 8,090MVA transformer capacity at 132/33kV. The double-digit transmission and distribution losses are extremely large by international standards and are among the highest in the world. The system losses are five to six times what obtain in well-run power systems (Sambo et al., 2010). Nigeria has made efforts to increase foreign participation in the electric power sector by commissioning independent power projects (IPPs) to generate electricity and sell it to PHCN. Thus, in April 2005, Agip's 450-MW plant came online in Kwale in Delta State. Other IPPs at various stages of completion include the 276-MW Siemens station in Afam, Exxon Mobils 388-MW plant in Bonny, ABBs 450-MW plant in Abuja, and Eskoms 388-MW plant in Enugu, among others. The government has also approved the construction of four thermal power plants at Geregu, Alaoja, Papalanto, and Omotosho, with a combined capacity of 1,234 MW. In the 1970s, the industrial sector was the leading consumer of electricity, accounting for over 50 percent of the total, followed by residential consumers. However, since the 1980s, the residential sector has taken over the lead accounting, on the average for over 50 percent of the total (see Fig. 1).

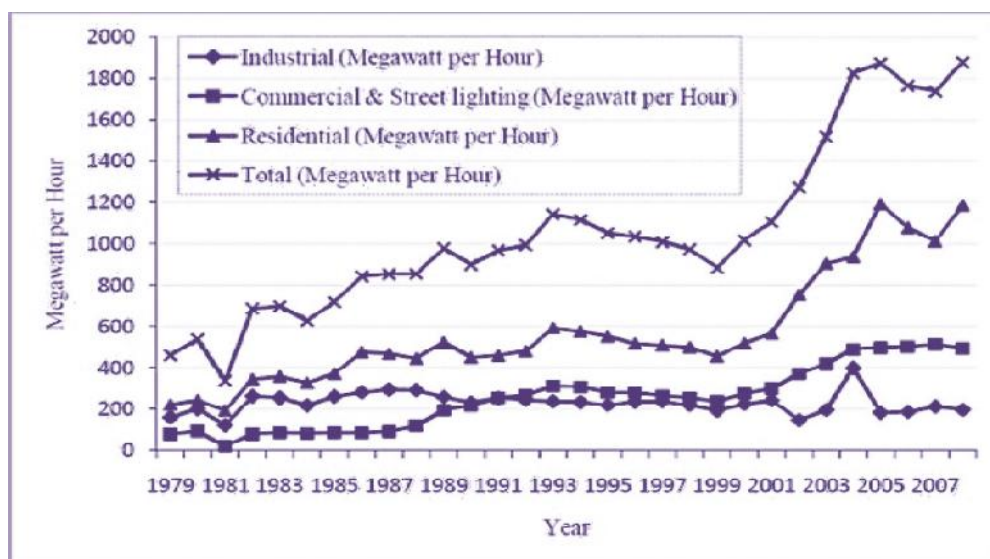


Figure 1: Electricity Consumption Pattern in Nigeria (1979-2007)

Source: CBN, 2009

The Nigerian energy industry is probably one of the most inefficient in the world in terms of meeting customers' needs. Currently, the average daily power generation is below 2,700MW, which is far below the peak load forecast of 8,900MW for the currently existing infrastructure (Ubi et al., 2012). Nigerian energy crisis is in generation, transmission and distribution. These include insufficient funding of power station, obsolete equipment, inadequate generation availability, overloaded transformers, bad feeder pillars, substandard distribution lines, poor/obsolete communication equipments, poor billing system, unwholesome practices/poor customer relations by staff, low staff morale and lack of regular training (Sambo et al., 2010). The energy crisis is manifested in blackouts and brownouts. Getting a faulty transformer fixed in most cases is a nightmare, not to talk about replacing one that has been declared 'dead'. More often than not, residents are forced to contribute money to buy transformers, when as a matter of fact, transformers should be provided by the respective PHCN companies. Consumers are confronted with 'crazy' monthly electricity bills irrespective of whether there was power supply or not.

According to a household survey conducted by the Lagos State Central Office of Statistics (COS, 2010), 85% of sampled households experience power interruption daily; 10% experience it few times a week; 3% experience it few times a month; while 2% do not experience interruption at all. It was also revealed that 48% of the households enjoy between 1-5 hours of electricity supply per day; 30% enjoy supply less than 1 hour per day; 15% are supplied for between 6-10 hours per day and only 2% claimed that to have electricity between 21-24 hours per day. The analysis of the results showed that 90% of the household connected to PHCN supply are dissatisfied with the performance of the authority (PHCN). Given the epileptic supply, households have to incur extra cost in fueling and maintaining their private generators to augment supply. The use of generators comes with negative externalities such as noise and fumes, beside the running costs

and the very hazardous practice of storing petrol meant for the generators in small containers in the homes.

3.0 Study Area

This first leg in a series of study in different parts of the metropolis covers two residential housing estates - the LSDPC known as Ojokoro Estate and Millennium Estate, within the same neighborhood in Ifako Ijaiye Local Government area of Lagos. These estates are located at the peri-urban area, North-west of Lagos metropolis. The building characteristics in each of the estate are similar except in the number of accommodation provided. Millennium Estate comprised of 480 one-, two-, and three-bedroom flats while, Ojokoro Estate is made up of 1080 two-, and three-bedroom flats. Lagos metropolitan forms a larger part of Lagos state, one of the 36 states making up the Federal Republic of Nigeria.

4.0 Method of Research

The primary focus of this study is to estimate Willingness-to-pay for improved electricity services in Lagos metropolis using two medium-income housing estates developed by the Lagos State Development and Property Corporation (LSDPC). The study also assesses the viability of the EBM as a technology to drive the needed improvement.

4.1 Data collection

Primary data was collected through self-administered questionnaires. Systematic random sampling technique was adapted whereby a flat or household in every three blocks is sampled in the Millennium Estate; and a flat in every four blocks in Ojokoro Estate, in proportion to the number of blocks in each estate. The choice of households as the study population is based on the fact that households are the major consumers of urban services; and the state of the infrastructure therefore impacts more on households than any other group.

The questionnaire has three sections. The first section deals with household socio-economic characteristics. The second section addresses households' current use of electricity and their Willingness-to-pay bids; while the third section presents profiles of electricity service attributes that the respondents are expected to rank. The questionnaires were administered to the heads of households or their spouses because these are the members of a household adjudged to be in a position to give credible response to questions relating to provision of electricity for the household. However, in few situations where neither the household head nor the spouse could be reached, questionnaires were administered to any adult member of the household considered sufficiently informed to provide reliable information.

256 4.2 Data analysis

257 The study employed the contingent method, conjoint analysis, multivariate analysis and the
 258 'payback period' analysis. Contingent valuation model is based on a hypothetical market
 259 situation, which elicits the prices of goods and services which cannot be priced in the market
 260 place. It is referred to as contingent because the results are dependent or contingent upon a
 261 devised hypothetical market. It is based on the assumption that a properly designed survey can
 262 elicit responses comparable to those arising under actual situations. Contingent method entails
 263 asking people of either their maximum Willingness-to-pay (WTP) for an increase in
 264 environmental quality, or their Willingness-to-accept compensation to forgo such an increase.
 265 The binomial logistic regression is one of the various forms of the discrete choice models. The
 266 model statistically relates the choice made by an individual to the attributes of that person and
 267 the attributes of the alternatives available to the choice maker.
 268 Conjoint analysis is a survey procedure that is used to derive the values of particular attributes of
 269 goods and services. Information is collected about individual's choices between different goods
 270 that vary in terms of their attributes or service levels. With this information, it is possible to derive
 271 values for each particular attribute or service. If price is included as an attribute in the choice
 272 scenarios, value can be defined in terms of dollar (or any other currency), which can be used
 273 with the valuation approach (Bond and Hopkins, 2000). There are three different conjoint
 274 approaches: conjoint rating, conjoint ranking, and paired comparison.
 275 The payback period decision rule focuses on how long it takes an investor to recover his initial
 276 capital outlay; the longer the time, the riskier the investment is considered to be, and vice versa.

277
 278 **Table 2: Variables Employed in the Model to Estimate Willingness-to-pay**

S/No	Variable definition	Variable code	Variable measurement	Expected sign
	Willingness to pay: Dependent variable	WTP	Dummy: 1 indicating willingness to pay; otherwise.0.	
2.	Monthly Household Income	HHINCOM	Measured in Naira(N)*	+
3.	Household size	HHSZ	Number of persons in the household	?
4.	Education level of household head	EDN	The number of years spent in school by household head	+
5.	Age of household	AGE	Age of household head in number of years	?
6.	Employment status of	EMPLOY	Dummy: 1 if household head	+

	household head		is employed; otherwise 0.	
7.	Type of dwelling unit	Dwelling	Categorical variable of either a 2-bedroom flat or 3-bedroom flat.	?
8.	Electricity bill per month	BILL	Measured in Naira*	?
9.	Number of days using private electricity generator	GENDAYS	Days in number	?
10.	Number of hours using generator/ week	GENCOST	Measured in Naira (N)*	+
11.	Number of hours electricity supplied/day.	ELECTHOUR	Number of hours	-

*1US\$ = N165

4.3 Preference for electricity service attributes

In this section, the conjoint analysis is used to explain the preference for electricity service attributes among the sampled households in the two estates. The rational consumer who seeks to maximize the amount of utility from products to be consumed evaluates the value or utility of such products or services by considering the separate amount of utility provided by each attribute. In determining the preference for energy services, attributes such as price, capacity, bill category, frequency of outages and payment vehicles will be regarded as attributes of the service provisions. These attributes are composed into different profiles of electricity services which were presented to respondents to rank in the order they would prefer them.

Table 3: Electricity Service Attributes

S/No	Attributes	Description	Levels
1.	Consumption	Monthly electricity consumption	500 kwh 100 kwh
2.	Hours	Hours of supply per day	16 hours 24 hours
3.	Metering	Preferred type of meter	Prepaid metering

			post-paid meeting
4.	Billing	Expected monthly bill	N2,000 N4,000

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296 In different conjoint studies, it has been found that the tolerance level of a respondent is between
 297 12–30 concept cards and 6–8 product attributes, depending on the motivation and product
 298 awareness of the respondents (Oppewal and Vriens, 2000). This study examined the choice of
 299 the households in the two estates for the different service profiles. To minimize the tendency for
 300 respondents to get confused while evaluating too many profiles, only four important attributes of
 301 electricity services have been selected, namely: preferred consumption level per month, hours of
 302 supply, payment vehicle and price (see Table 3). Each of the attributes has two levels. Thus, the
 303 total number of possible combination with these four attributes at the chosen levels is 16 (2 X 2 X
 304 2 X 2). The SPSS algorithm generated eleven profiles in this case. Given the number of
 305 attributes under consideration and the levels, the minimum number of profiles that is needed is 5
 306 according to Tripathi and Siddiqui (2010). That is, the total number of levels minus total number
 307 of attributes plus 1. The 11 profiles generated for this study therefore appear to be sufficient in
 308 determining the marginal contribution of each attribute to the utility. The respondents were
 309 required to rank 11 concept cards of different electricity service attributes.

310

311 **Table 4: Orthogonal Arrays of Attributes and Levels**

Profile	Consumption	Hours of supply	Metering option	Expected bill
	1,000Kwh	24 hours	Post-paid metering	N2,000
B.	1,000 Kwh	16 hours	Pre- paid metering	N4,000
C.	500 Kwh	16 hours	Pre- paid metering	N4,000
D.	1,000 Kwh	16 hours	Post- paid metering	N4,000
E.	1,000 Kwh	24 hours	Pre- paid metering	N2,000
F.	1,000 Kwh	24 hours	Pre- paid metering	N4,000
G.	500 Kwh	24 hours	Post- paid metering	N2,000
H.	1,000 Kwh	24 hours	Post- paid metering	N4,000
I.	500 Kwh	16 hours	Post- paid metering	N2,000
J.	1,000 Kwh	16 hours	Pre- paid metering	N2,000
K.	500 Kwh	16hours	Post- paid	N4,000

			metering	
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314 Considering the attributes selected in this study, overall preference or total utility of a
315 combination (R) of a profile can be expressed by the following mathematical expression:

316 *Preference (p) = Utility of consumption level + Utility of hourly supply + Utility of metering option*
317 *+ Utility of level of electricity prices + constant*

318 This model is used in determining the attribute of the electricity services that has greater
319 preference to the households and the profile of services that they consider to be of greatest
320 utility.

321

322 **5.0 Data analysis and discussions**

323 **5.1 Household socio-economic characteristics**

324 Table 5 summarizes the socio-economic characteristics of sampled household heads in the two
325 estates under study. From the table, majority of the sampled household heads, 83% in
326 Millennium Estate and 77% in Ojokoro Estate, are male. Household heads are also well
327 educated with 54% and 47% having a minimum of HND/B.Sc. degree in Millennium and Ojokoro,
328 respectively; and none without any form of education. Household size of between 5 to 10
329 members is predominant in the two estates, 91% in Millennium and 87% in Ojokoro.
330 Approximately 64% of the households are employed in Ojokoro Estate and 49% in Millennium
331 Estate. Others are self-employed.

332

333 **Table 5: Household Socio-Economic Characteristics**

	Millennium Estate		Ojokoro Estate	
	Frequency	%	Frequency	%
<i>Gender of household head</i>				
Male	173	83.17	212	77.09
Female	35	16.83	63	22.91
Total	208	100.00	275	100.00
<i>Level of education of household head</i>				
Primary	2	0.01	14	5.09
Secondary	31	14.90	76	27.63
ND/NCE	47	22.60	44	0.16
HND/Degree	113	54.33	130	47.27
Masters degree	15	7.21	10	3.64
PhD	-	-	1	0.003

Total	208	100.00	275	100.00
<i>Household size</i>				
Less than 5	14	6.73	27	9.82
Between 5 and 10	189	90.87	240	87.28
Above 10	5	24.4	8	2.9
Total	208	100.00	275	100.00
<i>Employment status of household head</i>				
Employed	101	48.56	177	64.36
Unemployed	62	29.81	51	18.55
Self employed	45	21.63	47	17.9
Total	208	100.00	275	100.00
<i>Household head's monthly income</i>				
Less than N18,000	21	10.10	13	4.73
Between N18,000 and N35,000	17	8.17	79	28.73
Between N35,000 and N50,000	31	14.90	23	8.36
Between N50,000 and N100,000	40	19.23	110	40.40
Over N100,000	99	47.60	49	17.82
Total	208	100.00	275	100.00

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335 Approximately 48% of the respondents in Millennium Estate earn over N100, 000 per month.

336 Millennium Estate is a relatively new, modern estate which only middle or higher income earners

337 can afford. For Ojokoro Estate, majority of respondents (40%) earn between N50, 000 and N100,

338 000 per month. Ojokoro Estate is an older estate. At the time it was built and allocated, it was

339 meant for the low-income earners. Thus, it is often referred to as Ojokoro Low-income Estate.

340 However, given the present economic realities, low-income earners can no longer afford to take

341 a lease or purchase any of the units in the estate.

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344 **Table 6: Respondents' Dwelling Characteristics**

	Millennium Estate		Ojokoro Estate	
<i>Type of dwelling</i>	Frequency	%	Frequency	%
1-Bedroom flat	18	8.65	-	-
2-Bedroom flat	99	47.60	157	57.09
3-Bedroom flat	91	43.75	118	42.91
Total	208	100.00	275	100.00

<i>Tenure type</i>				
Home Owner	91	43.75	159	
Renter	117	56.25	116	42.18
Total	208	100.00	275	100.00

Source: Field Study

Table 6 shows that 9% of the sampled households in Millennium Estate resides in one- bedroom flat, 48% in 2 bedroom flat, and 44% in 3-bedroom flat. In Ojokoro Estate, it is 57% in 2-bedroom flat, and 43% in 3-bedroom flat. The study sample therefore cut across all categories of available accommodation in the two estates. Majority of households in the Millennium Estate are tenants; while in Ojokoro Estate, majority are owner-occupiers.

Table 7: Regularity of Electricity Supply

<i>Regularity of electricity supply</i>				
	Frequency	%	Frequency	%
Very regular	-	-	-	-
Regular	-	-	-	-
Irregular	176	84.62	168	61.09
Very irregular/unreliable	32	15.38	107	38.91
Total	208	100.00	275	100.00
<i>Causes of irregular electricity supply</i>				
	Frequency	%	Frequency	%
Bad Transformer	69	33.17	118	42.90
Load shedding	123	59.13	77	28.00
Problem from power station	-	-	48	17.45
Uncertain	16	7.69	32	11.64
Total	208	100.00	275	00.00
<i>Most frequently encountered problem with electricity supply</i>				
	Frequency	%	Frequency	%
Frequency blackout	208	100	275	100
Power fluctuation	-	-	-	-
Low current	-	-	-	-
Excess current	-	-	-	-
Total	208	100.00	275	100.00

Source: Study Field, 2012

According to the statistics in Table 7, electricity supply on the two estates is highly irregular. On Millennium Estate power supply is perceived by majority (59%) as characterized by load shedding and malfunctioning or lack of transformers (33%). For Ojokoro Estate supply is characterized by broken down transformers (43%), load shedding (28%), and faults from the power station (18%). As a result of all these, the two estates suffer frequent blackouts.

Table 8: Electricity Supply and Costs

<i>No. of hours electricity is supplied/day</i>				
	Frequency	%	Frequency	%
1-5 hours	164	78.85	13	4.73
6-10 hours	-	-	114	41.45
7-15 hours	-	-	148	53.81
16-20 hours	-	-	-	-
17-24 hours	-	-	-	-
Total	208	100.00	275	100.00
<i>Average electricity bill/month</i>				
	Frequency	%	Frequency	%
N100 – N500	-	-	-	-
N 501 - N 1,000	-	-	-	-
N 1,001 - N 2,000	-	-	157	57.09
N2,001 – N3000	-	-	117	42.55
N3,001 - -N5000	208	100	-	-
Above N5,000	-	-	-	-
Total	208	100.00	275	100.00

The use of alternative source of power, that is, private generator is common to both estates. On Millennium Estate, 37% of the households uses generator for between 1 and 3 days in a week. In Ojokoro Estate, 32% uses electricity generators in 1 to 3 days in a week. About 54% of the respondents in Millennium Estate claims to spend between N2, 001 and N5, 000 weekly; while 36% spends between 500 and N2, 000 to run their generators. For Ojokoro Estate, 50% spends between N2, 001 and N5, 000 a week and 12% spends between N5, 00 and N2, 000 weekly.

Table 9: Frequency of Use and Cost of Private Generator

Millennium Estate	Ojokoro Estate
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Frequency of use of private generator				
	Frequency	%	Frequency	%
Daily	77	37.02	53	19.27
1-3 days a week	92	44.23	87	31.64
4-6 days a week	21	10.10	53	19.27
Once in a long while	9	4.33	72	26.18
Not at all	9	4.33	10	3.64
Total	208	100.00	275	100.00
Cost of running private generator/week				
	Frequency	%	Frequency	%
N500 – N2,000	74	35.58	33	12
N 2,001 - N 5,000	112	53.85	137	49.82
N 5,001 - N 10,000	13	6.25	42	15.27
Above N10,000	9	4.33	63	22.91
Total	208	100.00	275	100.00

Source: Field Study

5.2 Contingent valuation

It is important to determine average household expenditure on electricity per month so as to form a basis for the comparison of the Willingness-to-pay bids. Average payment for electricity in a month for Millennium Estate is between N3, 000 and N5, 000 because each flat on this estate receives uniform electricity bills of N4, 600 per month. The situation varies for Ojokoro Estate where the pre-paid metering system is installed. The average electricity bill per month is lower as the respondents claim to pay between N1, 000 and N3, 000. Payment per Kilowatt-hour of electricity used combined with frequent outages is responsible for the lower figure. The households complement the low amount spent on electricity from public supply with extra expenditure on private generator.

Table 9 shows the Willingness-to-pay for improved electricity services among the residents of the two estates. Out of the 208 households sampled on Millennium Estate, only 38% are willing to pay for improved supply while the remaining 62% believed that they are already paying too much for electricity supply that is erratic and sparing. They are therefore less willing to pay for any proposed improvement. For Ojokoro Estate, 64% of the sampled households are willing to pay more for improved supply. Though this estate also receives poor supply; however, the estate is served with prepaid meters which guarantee relatively efficient billing. The residents are therefore more willing to pay for improved power supply.

Table 10: Willingness to Pay for Improvement in Electricity Services

	Millennium Estate		Ojokoro Estate	
<i>Willingness to Pay</i>				
	Frequency	%	Frequency	%
Yes	79	37.98	176	64.00
No	129	62.02	99	36.00
Total	208	100.00	275	100.00
<i>WTP (Bid) Amount</i>				
	Frequency	%	Frequency	%
N500 – N1,500	-	-	-	-
N1, 501 - N 2,500	-	-	-	-
N 2,501 - N 4,000	-	-	24	13.64
N4,001 - N6,000	79	-	152	86.36
N6,000+	0	-	0	0
Total	79	100.00	176	100.00

Source: Field Study

In terms of Willingness to pay bid, all respondents on Millennium Estate are willing to pay between N4, 000 and N6, 000 (see Table 10). Majority of Ojokoro Estate residents are also willing to pay the same range of between N4, 000 and N6, 000. The mean Willingness-to-pay for households in Millennium Estate is N4, 936, with a standard deviation of N611.676; giving the coefficient of variation of 12%, a moderate dispersal of the bids around the mean. The mean Willingness-to-pay for Ojokoro Estate residents is N5, 057.47 with a standard deviation of N612.61, while the coefficient of variation is also moderate at 12%.

5.3 Determinants of Willingness-to-pay for improved electricity supply

It is common in Contingent valuation studies to use multivariate techniques in determining how the socio-economic characteristics of the respondents and other variables affect the WTP bids. The purpose of this kind of analysis is two folds. First, if the WTP bids are correlated with the variables suggested by economic theory; this increases the reliability that the bids are indeed reflections of the respondents' preferences and not just random occurrence. Second, models of the determinants of the respondents' WTP bids can be used to predict how changes in socio-economic and other variables can affect the demand for the good.

The estimated Binomial logistic regression model for the two estates is presented on Table 12. Cox and Snell R^2 of 0.735 and 0.702 for Millennium Estate and Ojokoro Estate, respectively; suggesting that no less than 70% of the Willingness-to-pay decision is explained by the selected explanatory variables.

Table 11: Regression Analysis Results: Determinants of Willingness-to-pay

WTP bid	Millennium Estate			Ojokoro Estate		
	B	Wald	exp(B)	B	Wald exp	(B)
Intercept	2.006	3.824		4.810	6.101	
HHINCOM	0.142	3.443	1.153	0.033	2.290	1.034
HHSZ	0.744	4.926	2.104	0.120	3.158	1.128
EDN	0.115	2.788	3.050	0.111	4.009	0.895
AGE	0.005	1.801	1.005	0.021	2.210	1.021
EMPLOY	0.018	2.224	1.114	0.029	3.989	1.029
GENDAYS	0.073	3.257	2.924	0.120	2.117	1.127
GENCOST	0.019	1.649	1.019	0.217	1.091	0.805
ELECTHOUR	-0.012	2.019	0.988	-0.019	3.661	0.981

Source: Field Study

From the regression analysis results in Table 11, households in Millennium Estate an increase in household income (HHINCOM) by N1, 000 increases Willingness-to-pay by 14.2%; every addition of one income earner to the household (HHSZ) increases Willingness-to-pay by 74.4%; the employment status of household heads makes a difference of 10.8% to Willingness-to-pay. For each addition to the number of days private generator is used in a week (GENDAYS) Willingness-to-pay increases by 7.3%. The cost of running generators (GENCOST) also increases the probability of Willingness-to-pay for improved electricity. Every additional hour that electricity is supplied, Willingness-to-pay is reduced by 1.2%.

For Ojokoro Estate residents, an increase in household income by N1, 000 increases Willingness-to-pay by 3.3%. An increase in household size by an addition of an income earner increases Willingness-to-pay by 12.0%; while the employment status of the household head makes a difference of 2.9% to Willingness-to-pay. Number of days private generator is used within a week makes a difference of 7.3% in Willingness-to-pay. The cost of running generators and the number of hours of electricity is supplied to households make a difference of 21.9% and 1.9% in Willingness-to-pay, respectively.

5.4 Conjoint analysis

In this section the conjoint analysis is used to determine the preference for electricity service attributes among the sampled households. Electricity service was decomposed into four attributes with two levels each. These attributes and levels are used to compose profiles that are presented to respondents to rank (11 profiles in all) for the different attributes extracted from the ensuing regression model.

Table 12: Selected Attributes of Electricity Service

S/No	Attributes	Description	Levels
1.	Consumption	Monthly electricity consumption	500 kwh 100kwh
2	Hours	Hours of supply per day	16 hours 24 hours
3	Metering	Preferred type of meter	Prepaid metering Post-paid metering
4	Billing	Expected monthly bill	N2,000 N4,000

Regression analysis was used to determine the utility of each of the selected attributes among the combined 483 sampled residents of the two estates. The rank for each of the profiles was taken as the dependent variable; while the independent variables were dummy variables - availability of the attribute at certain level =1, otherwise 0. The result of the regression is as in Table 12. The model has an adjusted R^2 of 0.472 with an F-value of 44.61 providing enough ground to reject the null hypothesis that the variables jointly lack explanatory power.

Table 13: The Regression Analysis Results

Variable	Coefficient	t-value
Constant	4.337	2.321
1,000 Kilowatt hour	1.863	5.116
16 hour Supply	1.220	3.425
24 hour Supply	1.538	2.423
Prepaid metering	0.081	2.308

N2,000 Bill per month	0.720	3.721
Adjusted R ²	0.472	
F- value	44.610	

463

464 Each of the regression coefficients in Table 13 represents the marginal utility derivable from each
 465 attribute. For instance, provision of 1,000-kilowatt hour in a bundle added 1.863 to the total utility.
 466 16 hour and 24 hour supply of electricity adds utility of 1.220 and 1.538, respectively. From this
 467 regression, it can be observed that the incorporation of prepaid metering to service bundle
 468 increases total utility by 0.081. Setting utility bill at N2, 000 also increases total utility by 0.720. It
 469 is evident from this analysis that the attribute of electricity supply services that gives the highest
 470 utility is the availability of 1,000-kilowatt hour to households. 24 and 16 hours of supply are in
 471 second and third position, respectively. From Table 14, the first three profiles have 24-hour
 472 connection in their mix to reassert the significance of this attribute.

473

474 **Table 14: Total Utility and Order of Preference**

Profile	Consumption	Hours of supply	Metering option	Expected bill	Total utility	Rank
	1,000Kwh	24 hours	Post-paid metering	N2,000	4.121	2 nd
B.	1,000 Kwh	16 hours	Pre- paid metering	N4,000	3.164	4 th
C.	500 Kwh	16 hours	Pre- paid metering	N4,000	1.301	11 th
D.	1,000 Kwh	16 hours	Post- paid metering	N4,000	3.083	6 th
E.	1,000 Kwh	24 hours	Pre- paid metering	N2,000	4.202	1 st
F.	1,000 Kwh	24 hours	Pre- paid metering	N4,000	3.482	3 rd
G.	500 Kwh	24 hours	Post- paid metering	N2,000	1.538	9 th
H.	1,000 Kwh	24 hours	Post- paid metering	N4,000	1.944	7 th
I.	500 Kwh	16 hours	Post- paid metering	N2,000	1.9440	8 th

J.	1,000 Kwh	16 hours	Pre- paid metering	N2,000	3.157	5 th
K.	500 Kwh	16hours	Post- paid metering	N4,000	1.220	10 th

Source: Field Study, 2012.

5.5 Viability appraisal of EBM technology

The EBM technology is a green energy solution that marks a breakthrough in the provision of sustainable, clean, and green energy. It is non-nuclear and is 100% environment-friendly. The technology produces zero carbon emission; provides a stable energy and heat source at competitive prices and is a superior plant to any coal- or gas-driven electricity generating plant. Furthermore, the technology generates lower noise pollution and has the capacity to run for approximately 40 years before a major maintenance is carried out. Average electric power costs per Kw-hour is about 5cents (about N8); which can be sold in pre-paid, pay-as-you go, or in contractual units. Maintenance (preventive) downtime per unit is estimated at less than 5% of total operating time per annum. The plants are designed to suit requirements ranging from 750KW to 300MW. It is said that 750KW can power an average of 22 homes/households while the custom proposed modular development starts with the first 20MW which takes between 6 to 10 months to integrate with an associative cost of about \$3.5M per Megawatt. There are evidences of EBM usage and working prototypes in Europe, North America and Asian countries including Hungary, Canada, and China etc.

At current market prices, the cost of generating 1 megawatt of electricity required to serve 100 homes through EBM technology is \$3,500,000. Four (4) of such plant is required to serve the households in Millennium Estate bringing the total cost to \$14,000,000, equivalent of N2, 240,000,000, at the current exchange rate of 1US\$=N165. Combining this with the revenue projected in Table 15, and using the payback period appraisal technique, it will take approximately 170 years for the investment to break even for the Millennium Estate given the Willingness-to-pay bid of the residents ($N2,240,000,000/13,107,744 = 170.89$). Ojokoro Estate with 1,080 accommodation units/households requires 11 Nos. EBM plant at a cost of N6, 160,000,000 ($11 \times 3,500,000 \times 160$), and a payback of approximately 117 years for the same reason ($N6, 160,000,000/52430976 = 117.49$).

Table 15: Expected Receipt Based on Households' WTP Bids

	Mean WTP	Nos. of households	Expected revenue/month (gross)	Maintenance/ transmission cost @20%	Expected revenue/ month(net)	Expected revenue/ year (net)
Millennium	4,936,71	480	2,369,621	473,924.2	1,895,696	13,107,744

estate						
Ojokoro estate	5055,40	1,080	5,461,560	1,092,312	4,369,248	52,430,976

504

505 From the scenarios displayed in Table 16, a WTP of N100, 000.00 is required to guarantee a
 506 payback period of 6 years which may be considered the minimum required in a situation of
 507 uncertain political atmosphere and unstable economic policies, both of which tend to exacerbate
 508 the downside risks of investments. A monthly expenditure of N100, 000.00 on electricity for
 509 home use is certainly beyond the financial capability of most Nigerians, except perhaps, the very
 510 affluent, which are but an insignificant proportion of the population. Since the cost of providing
 511 the EBM technology increases in proportion to the number of households (size of the estate),
 512 larger estate would not reduce the average cost of the technology or the appropriate WTP bid.

513

514 **Table 16: Projection of Costs and Revenue Based on Hypothetical WTP bids**

No of House holds	Cost of EBM technology	Mean WTP/ month	Expected gross revenue/ month	Maintenance & transmission cost @ 20%	Expected revenue (net)/ month	Expected revenue (net)/ year	Payback Period
1,080	11 units @ N560,000,000= N6,160,000,000	15,000	15,000,000	3,000,000	12,000,000	144,000,000	43 yrs
		20,000	20,000,000	4,000,000	16,000,000	192,000,000	32 yrs
		25,000	25,000,000	5,000,000	20,000,000	240,000,000	26 yrs
		30,000	30,000,000	6,000,000	24,000,000	288,000,000	21 yrs
		40,000	40,000,000	8,000,000	32,000,000	384,000,000	16 yrs
		50,000	50,000,000	10,000,000	40,000,000	480,000,000	13 yrs
		60,000	60,000,000	12,000,000	48,000,000	576,000,000	11 yrs
		75,000	75,000,000	15,000,000	60,000,000	720,000,000	9 yrs
		100,000	100,000,000	20,000,000	80,000,000	960,000,000	6 yrs
2,500	25 units @ N560,000,000= N14,000,000,000	15,000	37,500,000	7,500,000	30,000,000	360,000,000	39yrs
		20,000	50,000,000	10,000,000	40,000,000	480,000,000	29 yrs
		25,000	62,500,000	12,500,000	50,000,000	600,000,000	23yrs
		30,000	75,000,000	15,000,000	60,000,000	720,000,000	19yrs
		40,000	100,000,000	20,000,000	80,000,000	960,000,000	15 yrs
		50,000	125,000,000	25,000,000	100,000,000	1,200,000,000	12 yrs
		60,000	150,000,000	30,000,000	120,000,000	1,440,000,000	11 yrs
		75,000	187,500,000	37,500,000	150,000,000	1,800,000,000	10 yrs
		100,000	250,000,000	50,000,000	200,000,000	2,400,000,000	6 yrs

515

516 6.0 Conclusion and recommendations

This study investigates Willingness-to-pay for improved electricity supply and also assessed the viability of the EBM technology to drive the improvement using two medium-income public residential estates as a starting point in a series of similar studies intended to cover different types and composition of residential estates/neighborhoods in Lagos Metropolis.

The results showed that Willingness-to-pay for improved electricity services in Millennium Estate is affected by household income, household size, number of days households use their generators within a week, and the cost of running generator. For Ojokoro Estate, Willingness-to-pay is affected by increase in household income, household size, employment status of household head, number of days generator is used within a week, and the cost of running generator. The Willingness-to-pay bid for Millennium Estate is N4, 936, and N5, 057.47 for Ojokoro Estate. The results of conjoint analysis showed that the attribute of electricity supply service that gives the highest utility to the residents of the two estates is the availability of 1,000-kilowatt hour to each household. Viability appraisal based on simple Payback analysis and using the current cost of installation and operating the Energy by Motion (EBM), one of the acclaimed cost-effective green technologies available revealed that it will take approximately 170 years and 117 years to recoup initial capital for Millennium Estate and Ojokoro Estate, respectively. Cost and revenue projections revealed that a minimum electricity charge of N100, 000.00 monthly is required to acquire and sustain the EBM technology.

One obvious inference from the study is that sustainable electricity supply to the housing estates under reference through private sector participation is presently not feasible. It implies that electricity supply to the estates and other estates of similar (or lower standards) socio-economic characteristics in the metropolis would continue to be provided by the state-owned Power Holding Company of Nigeria (PHCN) at the existing subsidized rates.

The study throws light on cost recovery in electricity supply. The results therefore provide useful inputs into government policy formulation when choosing and designing alternative source of power supply for residential areas of different socio-economic characteristics in the metropolis particularly in the light of the ongoing private-public partnership arrangement. The results also provide private investors in the energy sector the basis for realistic pricing and tariff design for sustainable power projects, especially when considering the EBM technology option.

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