DETERMINANTS, PREVALENCE AND EFFECTS OF ELECTRICITY THEFT AMONG HOUSEHOLDS IN LAGOS STATE

BY

MICHAEL OJO OBAFEMI

MATRIC NO: 193827

B.Sc. Economics (Calabar) M.Sc. Economics (Maiduguri)

A thesis in the Department of Mineral, Petroleum, Energy Economics and Law
Submitted to the Faculty of Multidisciplinary Studies
in partial fulfilment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

of the

UNIVERSITY OF IBADAN

SEPTEMBER, 2021

CERTIFICATION

I certify that this work was carried out by Michael Ojo Obafemi in the Centre for Petroleum, Energy Economics and Law, University of Ibadan, Ibadan, Nigeria.

………………………………………..

Supervisor

Akin Iwayemi

B.Sc. (Ibadan), M.A, PhD (John Hopkins)

Professor, Department of Minerals, Petroleum, Energy Economics

And Law and Department of Economics

University of Ibadan, Nigeria.

…………………………………………..

Co-Supervisor

Musibau Adetunji Babatunde

BSc. MSc. Ph.D. (Ibadan)

Professor, Department of Minerals, Petroleum, Energy Economics

And Law and Department of Economics

University of Ibadan, Nigeria.

DEDICATION

This research is dedicated to my lovely wife and children. Adenike, Bisola, Michael, and Bukola.

ACKNOWLEDGEMENTS

My gratitude goes to my supervisor Professor Akin Phillips Iwayemi for diligently guiding me through the work. He is first and foremost a father. He is ever patient and assiduous. It is a great honour to have passed through his tutelage. I am equally grateful to Professor Musibau Adetunji Babatunde, my co-supervisor, for his supervision of the work and for always making available useful materials of his past students (including his own Thesis) to me as guiding instruments where and when necessary.

The Ph.D. programme would never have taken off were it not for the prompting of the current sub Dean, (Postgraduate), Faculty of Technology, University of Ibadan, Dr Temidayo Emmanuel Omoniyi, (Associate Professor), my bosom friend turned mentor. He was entirely responsible for locating the existence of the programme; guided me through the teething stages and remained a pillar of strength and support to the very end. He sacrificed his meticulous skills, time, abundance goodwill and material resources every inch of the way to see that I progressed seamlessly in the course of running the programme. His contributions have been out of this world. Similarly, I hereby express my appreciation to Dr Dapo Adewole, (Associate Professor), Department of Wood Products Engineering, Faculty of Technology, University of Ibadan for his contributions to preparation for my various presentations at different times.

I would want to offer my gratitude to these special people: My love, Adenike Idayat, Bisola, and Michael, for their perseverance during the program. I also appreciate Mr Peter Olufemi Obafemi; Dr (Mrs) Victoria Iyadunni Oke (Nee Obafemi), Dr Michael Ojo Oke (Lecturer: Ekiti State University) for their support the through the entire length of the programme. I am wishing all of them God’s abundant blessings.

My gratitude also goes to my late father, my mentor extraordinaire, Chief Obafemi Oshadiya, a complete illiterate who did not only hold his children to high moral standards but also chose to put their legs on the path of western education. I shall forever be indebted to him. May his soul continue to rest in perfect peace. Amen.

I thank all the faculty staff, particularly the Director, Centre for Petroleum, Energy Economics and Law, (CPEEL), Professor Adeola Adenikinju, the coordinator, Dr Peter K. Oniemola, Dr Tosin Adeniyi, Professor Olusanya Olubusoye, Professor O. A. Falade, Professor A. O. Adewuyi (Department of Economics), Dr Peter Obute and others for their kind contributions to moulding us to appreciable products capable of projecting the Centre positively to the rest of the world. May God continue to bless them all.

How can I forget the non-Academic staff of CPEEL, the first point of contact of the students? I thank them immensely, from the programme officer, Mr Abayomi Daramola to all the other staff for always being there to assist students even when it was not most convenient.

My special gratitude goes to my two "daughters", Helen Nagberi and Tolulola Tola-Ukabam (Mrs), who are currently both senior staff of the Economic and Financial Crimes Commission (EFCC), Nigeria. They both deployed enthusiasm and copious IT skills to drawing-up my self-constructed structured questionnaire, raising it to a level that made my data gathering seamless and effortless. Their contribution to say the least was most invaluable. I really can't thank them enough, I pray to God almighty to continue to meet them both at their various points of need. Amen.

I am equally indebted to colleagues and friends that I met in the University of Ibadan in the course of running the programme such as Mr Abiodun Ajayi, Head of IT, Postgraduate College, Mr Akin Akintonde of Maths and Statistics Department, Musefiu Adeleke of Economics Department, Ebenezer Oluwole of CPEEL, Kayode Aguda (CPEEL), Emmanuel Onyeuche (CPEEL), Sylvester Egorerua (CPEEL), Bimbo Aremu (CPEEL), Deji Kehinde (CPEEL) and others like Cosmas, Chibuzo, Olayinka Olayiwola, Busayo etc. May they continue to rise in their chosen fields. Amen.

Finally, I wish to appreciate all the staff of both Eko Electricity Distribution Plc and Ikeja Electric Plc who went out of their way to offer valuable support to the research assistants during the data gathering stage. God bless them all. And to the research assistants themselves, I thank them all for the service rendered.

ABSTRACT

Unstable electricity supply has been a major hindrance to economic development in Nigeria. Attainment of stable and reliable electricity supply requires three basic dimensions: technicalities, organisational structures and reduction of Electricity Theft (ET) to the barest minimum. Previous studies focussed more on the technical and organisational requirements with little attention paid to ET and its resultant effects particularly at household level. Therefore, this study was designed to examine the determinants of ET, its prevalence and effects among households in Lagos State, Nigeria.

Becker's Economic Theory of Criminal Behaviour served as the framework, while a survey design was adopted. A self-developed structured questionnaire focusing on determinants, prevalence and effects of ET was randomly administered to 580 household's (area of franchise under Ikeja Electric Plc. (n = 330), and Eko Electricity Distribution Company (n= 250) electricity end-users in Lagos State. Bribery and Corruption (BC), Income Level (IL), Lack of Punishment of Earlier Offenders (LPEO), Running Micro-Business in Residential Apartments (RMBRA), Non-Availability of Taskforce (NAT) to apprehend perpetrators, Frequency of Power Outages (FPO), Electricity Tariff (ELT) and Weak Enforcement of Anti-Electricity Theft laws (WEAET) were factors investigated as potential drivers of ET. Descriptive statistics were used to analyse prevalence and effects of ET, while Probit Regression estimation technique was used to identify its determinants among households at α0.05.

The key drivers of ET were BC (β=0.063), IL (β= 0.060), LPEO (β=0.020), RMBRA (β=0.040), FPO (β=0.101), WEAET (β=0.104) and ELT (β=0.139). All the factors were positive and statistically significant. An important driver of ET, IL (β= 0.060), which was positive and statistically significant indicated that incidence of ET cuts across all income groups in Lagos State. The prevalence of electricity theft was (in two digits) 14.0% indicating excessive involvement of household electricity end-users in ET. The major effects of electricity theft included damage to electric power equipment (64.4%), difficulty in planning for service delivery (68.2%), increased expenses on self-power generation (51.6%), damage to household appliances (61.4%), epileptic electricity supply (72.4%), brown out (73.2%), poor revenue to the electricity distribution companies (82.0%) and further reduction in the quantity of electricity available for household use (72 .4%). The incidence of ET in Lagos State was widespread, cut across all income groups and had varied significant harmful effects on both the households' electricity end-users and the electric power utilities.

Strong determinants of Electricity Theft among households in Lagos State, Nigeria, were corruption, running micro business within residential apartments and weak enforcement of anti-electricity theft laws with severe consequences on the entire electric power value chain. Strengthening institutions for enforcement and application of anti-electricity theft laws is recommended to mitigate the problem.

Keywords: Unstable electricity supply, Electric power utility, Electricity theft in Lagos State

Word count: 470

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANED:	Association of Nigeria Electricity Distributors
A_1:	Special Single Phase and Three (3) Phase
A_2:	Special LV Maximum Demand
A_3:	Special HV Maximum Demand
S1:	Street light Single and Three (3) Phase
AMI:	Advanced Metering Infrastructure
CAPEX:	Capital Expenditure
C1SP:	Commercial Single Phase
C1TP:	Commercial Three (3) Phase
C_2:	Commercial LV Maximum Demand
C_3:	Commercial HV Maximum Demand
CRDs:	Consumer Relationship Officer
CCC:	Customer Care Centre
D_1:	Industrial Single Phase
D_2:	Industrial LV Maximum Demand
D_3:	Industrial HV Maximum Demand
ECOWAS:	Economic Community of West African State
EKEDP:	Eko Electricity Distribution Plc
EPSR:	Electric Power Sector Reform
FGLS:	Feasible Generalised Least Square
GENCOS:	Generating Companies
GDP:	Gross Domestic Product
ICT:	Information and Communication Technology
ECN:	Electricity Commission of Nigeria
IKEDP:	Ikeja Electricity Distribution Plc.
IE:	Ikeja Electric Plc
KEPCO:	Korea Electric Power Corporation
kWh:	Kilowatts hours
LT:	Low Tension
MAP:	Meter Assets Providers
MW:	Megawatts
MDAs:	Ministries, Departments and Agencies
MYTO:	Multi Year Tariff Order
NIPP:	National Integrated Power Projects

NBET:	Nigerian Bulk Electricity Trading Plc
NDA:	Niger Dams Authority
NEDC:	Nigeria Electricity Distribution Company
NEPA:	Nigeria Electric Power Authority
NERC:	Nigeria Electricity Regulatory Commission
NESI:	Nigeria Electricity Supply Industry
NTL:	Non-Technical Losses
OECD:	Organisation of Economic Cooperation and Development
PHCN:	Power Holding Company of Nigeria
PWD:	Public Works Department
R_1:	Residential Life line
R2SP:	Residential Single Phase
R2TP:	Residential Three (3) Phase
R_3:	Residential LV Maximum Demand
R_4:	Residential HV Maximum Demand
SPSS:	Statistical Software for Social Science
TL:	Technical Losses
TCN:	Transmission Company of Nigeria
T & D:	Transmission and Distribution

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Electricity security is essential for modern society and economy to function properly (IEA 2016, Jamail, 2013, Bala, 2013, Schram, 1990). Electricity is required for a variety of applications, including digital technologies, communications infrastructure, and industrial processes (Mutebi, Otim, Okou and Sebitosi 2018, Anumaka, 2012).

Despite Nigeria's vast resource endowment in renewable and non-renewable energy resources (Bala, 2013, Iwayemi, 2011, Oseni, 2011, Tallapragada, 2009), the country has not been able to provide its teeming population stable and reliable electricity due to a lack of adequate and consistent power generation. Nigeria's installed capacity is 12,500MW, but the power sent out as of June 30, 2017 was only 3,419MW. This equates to 200 kWh per capita, which is a fraction of South Africa's 4,229 kWh per capita (MacArthur Foundation 2017). In 2018, the daily generation sent-out averaged an estimated 3,791.6MW (Association of Nigeria Electricity Distributors 2019). Nigerians have only 59.3% access to electricity (USAID 2019, World Bank 2016, Aliyu et al. 2013) and long power outages are experienced by individuals who are linked to the grid (Nigeria Baseline Power Report 2015).

A lack of adequate power generation capacity, sabotage, a dearth of funds for investment, ineffective regulation, insufficient transmission and distribution facilities, old power plants, and pitiable maintenance culture are all regularly identified as key causal factors in Nigeria's on-going power crisis in the majority of existing literature (Bureau of Public Enterprises 2015, Oseni 2011). However, the scale of the economic, social, and environmental implications of unsuccessful efforts to resolve the crisis needs not just a better understanding of the core causes of the issues, but also a reassessment of policy alternatives (Iwayemi 2019).

In view of the foregoing, adequate attention should be paid to the contribution of demand side factors (such as electricity theft) to the country's problem of insufficient electricity supply especially since studies have shown that theft-proofing electric power system is impossible (Smith 2004). It is also worth noting that electricity theft is becoming more common around the world (Sharmaa, Pandey, Punia, and Rao 2016, Winther 2011, Smith 2004), and that the condition in many developing countries, such as India, Ghana, and Tanzania, is particularly worrisome (Sharmaa, Pandey, Punia, and Rao 2016, Winther 2011, Smith 2004; Yakubu, Babu and Adjei 2018; Depuru et al 2011; Winther 2011; Smith 2004).

Pakistan's energy distribution companies lose colossal amount of dollars each year as a result of electricity theft (Jamil, 2012; Bhatia and Gulati 2004; Smith 2004). Theft and other illegal activities account for over 30% of the electricity supplied by utility suppliers in Ghana (Yakubu et al, 2018). Similarly, power theft is an issue in Uganda, costing UMEME Ltd, the country's main electrical distribution company, up to $30 million each year (Ssekika, 2013). In 2008, Turkish inspectors discovered 196,000 electricity customers illegally using electricity out of a total of 4.8 million members (Tasdoven, Fiedler, and Garayev, 2008). The rates of electricity theft in industrialised and developing countries, on the other hand, are substantially different. Theft is relatively uncommon in United States and some countries in Europe, where the rates range from 1-2 %. In the OECD countries, the average is roughly 7%. The loss is even greater in developing countries like Bangladesh, and Turkey. (Bhattacharyya, 2005).

1.2 Statement of the Problem

Given the fact that theft is quite common in electricity distribution systems, the utility firm fails to receive the full price of the power it sells to its customers. However, the high level of electricity theft in Nigeria is a symptom of underlying internal problems in the power industry, which necessitates a more thorough empirical inquiry because the losses to both utilities and end-users can be enormous, with a significant impact on service quality.

More crucially, given the complexities of the factors that lead to electricity theft, Smith (2004) advises that a thorough understanding of the situation is required before any action is taken. What conditions facilitate its persistence and pervasiveness? What is the role of social norms, peer group effect, demography, income classes, religion and spatial location in electricity theft? Why has the effort to control electricity theft based on purely technical and legal solutions such as the use of smart/pre-paid meters been generally ineffective in Nigeria? Given the social and economic settings, what interventions would yield efficient ways of fighting the problem in Nigeria? The need to explore these questions has become imperative given the insights they provide in solving this persistent problem.

As a result, the aim of this study is to examine the factors that encourage residential electricity theft in Lagos, Nigeria. What factors encourage individuals or groups of people to commit acts of energy theft? What is the magnitude of the threat posed by electricity theft? What are the implications of energy theft on Lagos State's domestic electricity end-users? These questions demand inquiry in the quest to grow a robust electricity industry in Nigeria.

1.3 Objectives of the Study

The overarching goal of this study was to investigate the issues surrounding electricity theft in Lagos, Nigeria. The precise objectives were to:

1. Investigate the determinants of electricity theft among households in Lagos state
2. Estimate the prevalence of electricity theft among households in Lagos State.
3. Assess the effects of electricity theft on households in Lagos, Nigeria.

1.4 Justification for the Study

Electricity theft, as a subject, has been given considerable attention in the literature (Yakubu et al 2018; Osigwe and Onyimadu 2018; Saini 2018; Cardenas, Amin Schwartz; Sastry 2016; Min and Golden 2016; Sardar and Ahmad 2015; Lewis 2015; Mira, Hashmi and Saad 2015; Dangar and Joshi 2014; Jamil 2013, Mondero, Biscarri, Biscarri and Millan 2012; Min and Golden 2011; Gaur and Gupta; Yurtseven; Nunoo and Attachie 2011; Jamail and Ahmad; Mimmi and Ecer 2010 and Smith 2004), but only a handful of them have focussed on its determinants.

These studies were also discovered to have focused primarily on Latin America, Asia, Europe, and North America, with the findings indicating that the incidence of electricity theft is determined by temperature, illiteracy, and terrorist attacks (Turkey), electoral cycle and agricultural production rate (India), and the efficiency with which state utilities collect electricity bills (Mexico), electricity price and number of electricity consumers (Pakistan), low income, incorrect usage of electricity and corruption (Brazil) and high deterrence among people due to high chances of detection and penalty (United States).

As may be seen from the foregoing, these determinants of ET are location specific. There is apparent lack of consensus on the factors that influence power theft, prompting further investigation to establish a more adequate explanation for why this problem persists and, more significantly, how to effectively address it. As a result, a good solution to this persistent problem will require considerations beyond traditional technological and legal solutions. It is essential to probe deeper in the search to identify the key causal factors in electricity theft.

It's also worth mentioning that only a handful of the studies have focused on Sub-Saharan Africa. These studies were conducted in Uganda (Mutebi et al, 2015); Tanzania (Winther, 2012), and Ghana (Saini, 2018), and each one used a qualitative approach with a maximum of 50 participants/respondents. These studies cannot be generalised since qualitative studies have a problem with generalisation, Atieno (2009). It is feasible that the outcome of this research would be different if a large enough sample size was combined with a quantitative approach, resulting in a set of various power policy proposals. As a result, this research differs significantly from those undertaken in other African countries.

More importantly, despite the fact that reducing electricity theft is critical to resolving the electric power industry's current financial crisis, thorough research on this topic and the sector in general in Nigeria is still limited, and no known study on the determinants of electricity theft in the country, particularly among households in Lagos State, has yet been conducted, to the best of the researcher's knowledge. This research, therefore, bridges that gap.

This study is unique in that it goes beyond traditional engineering and legal solutions to the theft problem, by including social norms and attitudes, group effects, and psychological variables in the causes of electricity theft and its control. This is critical because the allocation of time and effort between legitimate activities and stealing may be influenced not only by the criminal’s risk aversion, but also by his 'desire for honesty. Individuals who place a high value on 'cost of reputation damage' have a preference for honesty and aversion to risk. Understanding how energy theft affects the overall health of the electricity value chain, holistically, can help formulate policies with the best probability of success.

1.5 Scope of the Study

The study looked at the factors that influence electricity theft in Lagos, Nigeria. In Lagos State, there are two energy distribution companies (DisCos). The scope of this research was limited to the franchise areas under the two DisCos. The choice of Lagos state was influenced by the fact that it is Nigeria's industrial and commercial capital, densely populated and multi-ethnic, with distinct slum and metropolitan characteristics and the state utilises around 24% of the country's total electric power (Lagos state Ministry of Power and Energy 2014).

1.6 Plan of the Study

The research is organised into five sections: An introduction to the work, a statement of the research problem, the study's objective, justification, scope, and plan of the study are all provided in Chapter 1; a literature review and stylized facts on the Nigerian electricity supply industry are supplied in Chapter 2; and the theoretical framework and methodology are given in Chapter 3. Chapter 4 has the data analysis and summary of the findings, while Chapter 5 contains the results, conclusion, policy recommendations, some limitations, and future research opportunities.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter presents a survey of the literature on theoretical, methodological, and empirical issues. It also includes stylised facts on Nigeria's electricity supply industry which comprises: the origin of electricity generation in Nigeria, the changes that led to the unbundling of the electric power business, and the developing issues in the electric power industry. Others include electricity distribution companies in Lagos State, comparison of power distribution tariffs between Eko and Ikeja electricity distribution providers, service reflective tariff, revenue flow in Nigeria’s electricity supply industry and deep insight into the concept of electricity theft.

2.1 Theoretical Literature Review

The focus of this sub-section is the theoretical framework which is energy (electricity) demand theory. Total energy demand (E^d) is further divided into the ideal energy demand (E^{Id}) and the illegal energy demand (E^{IL}). The ideal energy demand theory is not different from theory of demand for any other commodity which indicates what quantities will be purchased at a given price and how price (or income) changes will affect the quantities sought. Illegal energy demand theory on the other hand, has its roots in Becker’s theory of criminal economic behaviour. Energy demand theory is, therefore, presented thus:

$E^d = E^{Id} + E^{IL} = F$ (P, Y, SD factors)

E^d = Total Energy demand by households

E^{Id} = Ideal Energy demand

E^{IL} = Illegal Energy demand

P = Price of electricity

Y = Income of electricity consumers

SD factors = Social economic variables associated with ET

E^d = f (price of electricity, price of its substitutes, real income, type of consumers, degree of urbanization and previous level of electricity consumed and other explanatory variables that capture illegal electricity demand).

2.1.2 Energy demand Theory

The term energy demand can mean different things to different users. Normally it refers to any kind of energy used to satisfy individual energy needs for cooking, heating, travelling, etc., in which case, energy products are used as fuel and therefore generate demand for energy purposes. Energy products are also used as raw materials (i.e. for non-energy purposes) in petrochemical industries or elsewhere and the demand for energy here is to exploit certain chemical properties rather than its heat content. Similarly, the focus may be quite different for different users: a scientist may focus on equipment or process level energy demand (i.e. energy used in a chemical reaction) while planners and policy-makers would view the aggregate demand from a regional or national point of view. Energy demand can correspond to the amount of energy required in a country (i.e. primary energy demand) or to the amount supplied to the consumers (i.e. final energy demand). Often the context would clarify the meaning of the term but to avoid confusion, it is better to define the term clearly whenever used.

A distinction is sometimes made between energy consumption and energy demand. Energy demand describes a relationship between price (or income or some such economic variable) and quantity of energy either for an energy carrier (e.g. electricity) or for final use (such as cooking). It exists before the purchasing decision is made (i.e. it is an ex ante concept—once a good is purchased, consumption starts). Demand indicates what quantities will be purchased at a given price and how price changes will affect the quantities sought. It can include an unsatisfied portion but the demand that would exist in absence of any supply restrictions is not observable. Consumption on the other hand takes place once the decision is made to purchase and consume (i.e. it is an ex post concept). It refers to the manifestation of satisfied demand and can be measured. However, demand and consumption are used interchangeably in this chapter despite their subtle differences.

Electricity, or any energy source whatsoever, does not yield utility itself, but, rather, is desired as an input for other processes or activities that do yield utility. All such processes utilize a capital stock of some durability, and electricity provides the energy input. The demand for electricity is therefore a derived demand, derived from the demand for the output of the processes in question. However, because durable goods are involved, there is need to distinguish between short- and long-run demand for electricity. The short-run is defined by the condition that the electricity-consuming capital stock is fixed, while the long-run takes the capital stock as variable. In essence, the short-run demand for electricity can be seen as arising from the choice of a short-run utilization rate of the existing capital stock, while the long-run demand is tantamount to the demand for the capital stock itself. The derived nature of demand influences energy demands in a number of ways, which in turn has influenced the demand analysis by creating two distinct traditions—one following the neoclassical economic tradition while the other focusing on the engineering principles coupled with economic information Worrel et al. (2004).

From the point of view of economics, the principle for estimating and analysing the demand for energy is not different from that for any other commodity. There are characteristics of energy demand, institutional features of energy markets, and problems of measurement that require particular attention in analysing energy markets. But the microeconomic foundation of energy demand is same as for other commodities. Demand for energy can arise for different reasons. Households consume energy to satisfy certain needs and they do so by allocating their income among various competing needs so as to obtain the greatest degree of satisfaction from total expenditure. Industries and commercial users demand energy as an input of production and their objective is to minimize the total cost of production. Therefore the motivation is not same for the households and the productive users of energy and any analysis of energy demand should treat these categories separately. In effect, the demand for electricity, although a derived demand, depends on the consumers' real income, price of electricity, price of its substitutes, type of consumers, degree of urbanization and previous level of electricity consumed.

From basic microeconomic theory, the demand for a good is represented through a demand function which establishes the relation between various amounts of the good consumed and the determinants of those amounts. The main determinants of demand are: price of the good, prices of related goods (including appliances), prices of other goods, disposable income of the consumer, preferences and tastes, etc. To facilitate the analysis, a convenient assumption also known as ceteris paribus is made which holds other determinants constant or unchanged and the relation between price and the quantity of good consumed is considered.

This simple functional form can be written as follows:

$$q = f(p),$$

where

q is the quantity demanded and p is the price of the good.

The familiar demand curve is the depiction of the above function.

2.1.3 {Ideal} Consumer Demand theory for Energy: Utility Maximization Problem

The microeconomic basis for consumer energy demand relies on consumers' utility maximisation principles. Such an analysis assumes that

- Consumers are utility maximisers
- Consumers prefer more of a good to less of it.
- Facing choices X and Y, a consumer would either prefer X to Y or Y to X, or would be indifferent between them.
- Transitivity: If a consumer prefers X to Y and Y to Z, we conclude he/she prefers X to Z
- Diminishing marginal utility: As more and more of good is consumed by a consumer, ceteris paribus, beyond a certain point the utility of each additional unit starts to fall.

Following consumer theory, it is considered that an incremental rise in consumption of a good, keeping consumption of other goods constant, increases the satisfaction level but this marginal utility decreases as the quantity of consumption increases. Alternatively, it can be said that, over a given consumption period, as more and more of a good is consumed by a consumer, beyond a certain point, the marginal utility of additional units begins to fall.

Moreover, maximum utility achievable given the prices and income requires marginal rate of substitution to be equal to the economic rate of substitution. This in turn requires that the marginal utility per dollar paid for each good be the same. If the marginal utility per dollar is greater for good A than for good B, then transferring a dollar of expenditure from B to A will increase the total utility for the same expenditure. It follows that reduction in the relative price of good A will tend to increase the demand for good A and vice versa.

Rules

- A rational consumer would buy an additional unit of a good as long as the perceived dollar value of the utility of one additional unit of that good (say, its marginal dollar utility) is greater than its market price.
- The Two-Good Rule

$$\frac{MU_I}{\$P_I} = \frac{MU_H}{\$P_H} \quad \ldots$$

- Consumers’ spending on consumer goods is constrained by their incomes:

  Income = Px Qx + Py Qy + Pw Ow + ….+Pz Qz

- While the consumer tries to equalize

  MUx/Px , MUy/ Py, MUw/Pw,………. and MUz/Pz

  to maximize her utility, her total spending cannot exceed her income.

To maximize utility, a consumer would set:

$$(MUx/Px) = (MUy/Py)$$

If Px increases this equality would be disturbed:

$$(MUx/Px) < (MUy/Py)$$

To return to equality the consumer must adjust his/her consumption having in mind that the consumer cannot change prices, and he/she has an income constraint. In order to make the two sides of the above inequality equal again, given that Px and Py could not be changed, we would have to increase MUx and decrease MUy. Recalling the law of diminishing marginal utility, we can increase MUx by reducing X and decrease MUy by increasing Y.

2.1.4 Illegal Electricity Demand theory

The theft model is developed on the basis of theoretical literature on crimes and in the framework of the economic theory of criminal behaviour and the three-layered principal-agent-client theory of corruption Becker (1968); Becker and Stigler (1974). The choice of studying individual behaviour is methodological and it does not deny the importance of social and economic institutions, of which the individual is a part. In this sub-section, both the “economic theory of criminal behaviour” and “the principal-agent-client theory” are discussed.

This subject falls within the broad category of criminal behaviour, which covers stealing, tax evasion, and corruption, as well as ways to combat them. This literature can be divided into two distinct lineages. The first is the literature on economic analysis of criminal behaviour which can be traced back to Becker's rational choice under uncertainty (Iwayemi 2019; Becker 1968). The underlying message is that a high likelihood of detection combined with harsh punishment will reduce crime by acting as deterrents to illicit behavior.

Becker and his followers highlighted the key significance of incentives in preventing or encouraging illicit action when explaining criminal behaviour and how to control it. The individual decision maker is assumed to weigh the projected benefit and cost of participating in the (criminal) activity. The cost is determined by the likelihood of being arrested and imprisoned, as well as the ruthlessness of the sentence, if caught. The rational choice model of criminal behaviour predicts that when the expected advantage exceeds the expected cost, an individual will be more likely to participate in illicit behaviour (Becker: 1968; Becker and Stigler: 1974).

Given that it is assumed that criminals get caught with some probability (denoted by π), and in the event of getting arrested, they are made to pay a fine equal to *F*. So, the benefit of a law-breaking is *B* (in the event of arrest); *U* and *W*. denote Utility and the level of Wealth of the criminals respectfully.

There are two ways to proceed. First, we can assume that each person commits only one crime (if any)

As such, the decision-maker commits a crime whenever

$$(1-\pi)U(W+B)+\pi U(W-F)>U(W)$$

(Note that it is assumed that you don't get to benefit from the crime if you get caught).

Imagine that there is a distribution of *B* throughout the population considered by an aggregate distribution function *G(B)*, and other than *B* everyone is identical, and assume that there exists some *B* for which

$$(1-\pi)U(W+B)+\pi U(W-F)>U(W)$$

holds:

Furthermore, let *g (B)* >0 (i.e. the density is strictly positive) everywhere.

Claim**:** There exists a value of *B*, denoted *B**, at which all individuals are indifferent between committing crimes and not committing crimes. All characters with *B* > *B** will commit offences and all persons with *B* < *B** will not commit misconducts.

The fact that $(1-\pi)U(W+B)+\pi U(W-F)-U(W)$ starts out bad ends progressive and is monotonic and continuous *B* guarantees this claim.

Thus, *B** is defined so that

$$(1-\pi)U(W+B^*)+\pi U(W-F)=U(W)$$

The share of the population that is criminal equals 1 – *G (B*).*

Claim**:** The value of *B** is increasing with *F* and π.

Totally differentiate $(1-\pi)U(W+B^*)+\pi U(W-F)=U(W)$

To get:

$$\frac{\partial B^*}{\partial \pi}=\frac{U(W+B^*)-U(W-F)}{(1-\pi)U'(W+B^*)}>0$$

$$\frac{\partial B^*}{\partial F}=\frac{\pi U'(W-F)}{(1-\pi)U'(W+B^*)}>0$$

Also

$$\frac{\partial B^*}{\partial W}=\frac{U'(W)-(1-\pi)U'(W+B^*)-\pi U'(W-F)}{(1-\pi)U'(W+B^*)}$$

If *F* = *fW* – i.e. punishment is lost time in the labour force, or a tax that is proportional to labour, then we have:

$$(1-\pi)U(W+B^*)+\pi U(W(1-f))=U(W)$$

and

$$\frac{\partial B^*}{\partial W}=\frac{\begin{bmatrix}U'(W)-(1-\pi)U'(W+B^*)+\\-\pi(1-f)U'(W(1-f))\end{bmatrix}}{(1-\pi)U'(W+B^*)}$$

This is always positive if the coefficient of relative risk aversion satisfies $-x\frac{U''(x)}{U'(x)}\leq 1$ because $\alpha U'(\alpha x)$ is non-decreasing in α , and that implies that

$$U'(W) \geq (1-f)U'(W(1-f))$$

while it is always the case that $U'(W) > U'(W + B^*)$

since marginal utility is decreasing .

Becker Claim N1**:** If catching criminals is expensive but punishing them (say through fines) is free, then, we should drive the punishment probability to zero and increase the punishment to infinity.

This is particularly obvious in the linear case, where *B** solves:

$$(1-\pi)(W + B^*) + \pi(W - F) = W$$

or

$$B^* = \frac{\pi F}{1-\pi}$$

Becker Claim N2: There is no reason to expect that criminals will stop being criminals after they go to jail: if it was optimal to rob before they went to jail it would probably be optimal afterwards as well.

2.1.5 Solving for the optimal punishment

Assume that there is a social cost *C* per crime.

Assume that it is costly to try to catch criminals, and there is just a function $\phi(\pi)$ that captures this cost.

Assume that the social cost per unit of punishment is ϕ times the number of people who are punished times the size of punishment *F*.

Then the social welfare problem (if we exclude the welfare of the criminals) is to find π and *F* that minimize the following:

$$\min_{\pi, F} \phi(\pi) + (1 - G(B^*))(C + \pi\theta F)$$

This yields a first order condition for π:

$$\phi'(\pi) + (1 - G(B^*))\theta F - g(B^*)\frac{\partial B^*}{\partial \pi}(C + \pi\theta F) = 0$$

and a first order condition for *F:*

$$(1 - G(B^*))\pi\theta - g(B^*)\frac{\partial B^*}{\partial \pi}(C + \pi\theta F) = 0$$

which can be rewritten:

$$\pi\theta F = \frac{Fg(B^*)}{1 - G(B^*)\partial F}\frac{\partial B^*}{\partial F}(C + \pi\theta F)$$

Denoting the elasticity of crime to punishment by

$$\varepsilon = \frac{Fg(B^*)}{1 - G(B^*)}\frac{\partial B^*}{\partial F}$$

gives

$$\log F = \log C + \log\left(\frac{\varepsilon}{1 - \varepsilon}\right) - \log \pi - \log \theta$$

Thus the optimal, *F*, fine is a function of:

1. the crime's societal cost, C

2. the crime's elasticity with respect to penalty, $\frac{\varepsilon}{1-\varepsilon}$

3. the likelihood of apprehension, , π

4. the cost of punishing the criminal, Θ

As earlier stated, the basic message is that high probability of detection coupled with severe punishment will reduce crime because they serve as disincentives to illegal behaviour.

2.1.6 Extension of the Basic Model

Becker's article marked the start of a burgeoning and vigorous literature on deterrence theory, with succeeding articles primarily refining the core Becker model (Kaplow & Shavell 2002). The theory has equally attracted critiques by scholars who have not only extended but have introduced different restrictions to enable its wider application. Because the major parts of the basic models do not contain everything there is to say about choices to commit wrongdoing and the impact of penalty, economists have attempted to integrate components that reflect some of the perspectives of other disciplines. Despite the fact that economists have reason to assume that rational people weighing costs and benefits before making decisions are correct, anyone building a formal model will want it to account for the occurrence as completely as possible.

On the other hand, the rational choice model of criminal behaviour has generated criticism at theoretical, methodological and empirical levels. At the theoretical level, two major criticisms have emerged. One is the basic assumption that choice behaviour is in the context of individual person choice framework. Tsebelis (1989; 1990) and others have challenged the single decision-making conceptual framework of the Becker type model and suggest that multi-person decision making framework is more appropriate for a better understanding of the nuances of criminal behaviour. Using a game theoretic framework, they showed that the severity of punishment may not be sufficient to mitigate criminal behaviour as implied in Becker type model (Tsebelis: 1990; Garoupa: 2003). In their contribution to the debate, Hirschleifer and Rasmussen (1992) challenged Tsebelis' two-player, two-strategy simultaneous move game characterization of the inspection problem of Tsebelis and others. Cox (1994) showed that increasing the penalty for an illegal activity may reduce law enforcement probability. Andreozzi (2004) using a game theoretic model with the law enforcement officer as the leader showed that increasing punishment would lessen the likelihood of law application but also reduce crime. He also showed that increasing the officer's compensation (wage incentives) could reduce the likelihood of enforcement and escalate the likelihood of crime. Marjit and Shi (1998) suggest that when the offender can bribe the enforcement officer, crime may not abate. Also an important omission is the absence of strategic interdependence among the consumers in the analysis, a factor that may undermine efficient ways for controlling this problem because strategic behaviour is involved. The game theoretic approach in the search for efficient control mechanism to minimize crime and specifically electricity theft has an advantage because of the strategic interdependence between the key actors in crime

Without doubt, one can say that conventional wisdom in controlling electricity theft based on the rational choice theory of illegal behaviour is apt. However, there are limits to its applicability especially, in low income developing countries, including Nigeria where social norms and attitudes and other factors influence behaviour more profoundly. In some environment, social norms and attitudes influence behaviour more profoundly than purely technical solutions based on the usage of modern technologies (ICT) and smart meters and legal measures to curb electricity crime associated with meter tampering and meter by-passing, may not be sufficient for the effective control of the problem.

2.1.7 The principal-agent-client theory

In the principal-agent-client theory, there exists a principal whose duty is to assign duties to his subordinate, (the agent). The agent’s basic responsibility is to represent the principal’s interest in exchange for some payment either in cash or kind. Ordinarily, since the agent is fully remunerated, the principal should not incur any extra cost to observe the agent’s actions. He should rely on the outcomes of the agent’s actions to assess and reward his behaviour.

In actuality, however, the agent's activities do not necessarily decide the results; they simply affect them since the agent's goals do not always align with the principal's. The model enables the principal to take action that alters the characteristics of the agent's behaviour through the use of incentives (such as persuasion, bonuses, directives, and so on), which is a refinement of the original rewarding system.

However, if the principal chooses to embark on monitoring the actions of the agent in order to control his behaviour, he, the principal, would require a lot of information that would attract costs such as inspection costs, appraisal costs and or prevention costs. More often, he has no access to this critical information.

Another point of contention is that it is vague if the "agency problem" disturbs the principal or the agent. From the perspective of the principal, most of the agency literature concentrated on the normative aspects of the principal-agent relationship. Given the presence of uncertainty and poor monitoring, that literature demonstrated how to arrange the principal-agent relationship so that the agent can make decisions that maximize the principal's welfare. The ensuing positive agency literature has not addressed the initial imbalance, which arises when we try to explain the agent's actions.

The problem of electricity theft and its control is conceptualised as a principal-agent-client theory (Iwayemi, 2019). This framework comes handy in analysing the strategic interactions among the customers of the electricity company, the staff of the distribution company delegated withπ the responsibility to detect theft and the management of the distribution company. The agency theory focuses on corruption and control, the self-interested and opportunistic behaviour of agents, coupled with the information asymmetries which exist between agents and managers which may cause a conflict of interest (Jensen and Meckling, 1976; Fama and Jensen, 1983). In this framework where the players pursue their own strategic interests which are often not mutually consistent, it is well-known that delegation of authority to an agent with inadequate monitoring creates an opportunity for bribery or other forms of corrupt practices between the agent and the client (Mookherjee and Png: 1995). Imperfect observability or unobservability of the effort of the distribution staff in his theft-detection task creates a challenge for the distribution company because effort and outcome of theft-detection may not be well aligned. This conceptual framework is more robust in analysing an environment defined by less sophisticated theft detection and prevention technology, weak legal enforcement, strategic complementarity among those who steal electricity.

2.2 Empirical literature review

Scholarly attention to the determinants of electricity theft has increased noticeably during the last decade and a half (Smith, 2004). This section summarises the main findings of empirical literature regarding the link between electricity theft and the factors that influence it.

The effect of good governance indicators on the propensity to commit electricity theft has been studied extensively in the literature (Gaur and Gupta, 2016 Smith 2004). Countries with low level of accountability have higher propensity to record high incidence of electricity theft because the countries with good corporate governance indicators have more capacity to ensure equitable distribution of resources, earn the trust of the electricity consumers in addition to having stronger institutions Smith (2004). According to Gaur and Gupta (2016), systems characterised by a strong culture of good governance are more likely to succeed in reducing electricity theft and keeping it within sensible boundaries. This is because the mechanisms for reducing theft find an atmosphere that is conducive to their commencement and implementation. According to a research by Smith (2004) that ties electricity theft to bad governance, countries with low corruption perception have lower incidence of electricity theft (less than 6%), while countries with high corruption perception have higher losses (above 30%).

According to studies, areas of the world suffering insecurity have a higher risk of electricity theft (Depuru *et al*., 2011 and Nielsen 2012). The incidence of energy theft rises with the presence of insecurity, anarchy, and illiteracy. According to Mimmi and Ecer (2010), slum inhabitants' expected utility from power theft crime is often modest, while the "costs" are mostly in terms of safety concerns and inadequate quality of the received service, both of which have negative repercussions for general well-being. As for the expected penalty, it cannot be regarded as a determinant in a context of informality with little application of law enforcement, as such; neighbourhoods with high crime rate and low income have higher chances of electricity theft.

The impact of energy costs (electricity tariff) and infrastructure on power theft have also been investigated in diverse situations, with a positive correlation discovered (Jamil and

Ahmad 2013; Katiyar 2013). Gaur and Gupta (2016) advocated for power rates that take into account a region's socioeconomic characteristics and economic structure. Gumusdere (2004) claimed in a model of electricity theft in Turkey that the better the electricity infrastructure, the smaller the loss of power at the time of transmission and distribution.

Privatisation of the entire electricity value chain has been proved in several regions of the world to have a significant positive influence on lowering the level of electricity theft. Beyond individuals' goals of reducing losses by maximizing profits, Gaur and Gaupta (2016) argue that privatisation may have the extra advantage of breaking the link between politicians and exploitation in the power sector, noting that higher collection effectiveness of electricity bills by utilities, as well as greater income, are linked to fewer power thefts.

Furthermore, the likelihood of a consumer stealing power from a distribution feeder is determined by the sector in which the feeder is located. Electricity theft in factories and commercial complexes may not be viable in developed countries due to the transparency of the distribution infrastructure. Whereas, in developing nations like India, agriculture is responsible for a large portion of total electricity utilized, and a significant quantity of electricity is stolen owing to absence of effective metering structure in agricultural and related sectors.

Regarding the prevalence of electricity theft, studies show that attentions of researchers have focused more on determinants, modes and effects or impacts of electricity theft than on its prevalence. Main findings of empirical literature regarding the relationship between electricity theft and its prevalence are presented as follows.

Smith (2004) is one of the few studies that address prevalence of electricity theft in electric power system and the various forms and measures to reduce it. The study finds that lower losses (less than 6%) are most common in countries with low corruption perception and while higher losses are most common in countries with high corruption perception. The same study links electricity theft with mal-governance.

Electricity theft and other illegal activities also account for over 30% of the electricity supplied by utility suppliers in Ghana (Yakubu *et al*., 2018). Similarly, power theft in Uganda is widespread as it accounts for a loss to UMEME Ltd, (the country's main electrical distribution company), of an amount up to $30 million each year (Ssekika 2013). In 2008, Turkish inspectors discovered 196,000 electricity customers illegally using electricity out of a total of 4.8 million customers. This indicates that about 5% of Turkish electricity consumers regularly steal electricity (Tasdoven, Fiedler, and Garayev 2008).

However, it has been properly documented that the rates of electricity theft in industrialized and developing countries, on the other hand, are substantially different. For instance, theft is relatively uncommon in United States of America and some countries in Europe, where the rates range from 1-2 %. In the OECD (Organisation of Economic Cooperation and Development) countries, the average is roughly 7%.

Literature establishes further that ET has a wide range of effects on electricity consumers. Conspicuous among them is the effect on climate change. According to David (2018), ET does not only bring about unnecessary blackouts thereby encouraging users to opt for alternative sources of electricity in the form of diesel and petrol generators which ultimately leads to increase in Green House Gas (GHG) emission, it also denies legal customers of available electricity, returns on investment to the companies, leads to poor quality of power being delivered to the users and compromises security and safety.

Soma et al (2012) in another study confirm that losses from ET affect quality of supply, increases load on the generating station, and affects tariff imposed on genuine customers.. In other words, this paper stresses the effect of ET on quality of supply, burden on the generating station as well as the tariff imposed on genuine customer.

Jamil (2013) and Saini (2018) in separate studies agree that ET Granger causes outages and electricity price change, disruptions to legitimate consumers, overloading/short circuiting of power distribution systems, poor quality of supply, and higher electricity price.

Based on these studies, it is obvious that there is a lack of consensus on the factors that influence power theft and its prevalence, necessitating more research in this area. Furthermore, despite the fact that scholars have conducted studies on electricity theft all over the world, no known study has yet looked into the determinants of electricity theft among households in Lagos state, Nigeria, a region that has continued to suffer from frequent power outages that have harmed the economy. This research, therefore, fills the gap.

Also, from the available literature, it is obvious that high electricity tariff, frequent power outages, poor service delivery, poor returns on investment, high load on generating station and increase in GHG emission are the strong effects of ET. These are probably not exhaustive of the possible effects on consumers, particularly, on residential electricity end-users. Therefore, it is hoped that this study would either validate and or uncover other effects hitherto unknown and unexplained.

2.3. Methodological literature review

This sub-section deals with the review of the various methodologies used by researchers in prior studies. Tabulated details of the methodological review is in Table 2.1 in the Appendix

Studies on issues around ET in the last decade and half used a wide range of methods. While both qualitative and quantitative dominated the approaches used, \majority of the literature reviewed tilted towards the use of quantitative approach (and time series and or panel data). For instance, Gaur and Gaupta (2016), Hashmi and Saad (2015), Jamil (2015), Yurtseven (2015), Jamil (2013), Edson (2013), Montero et al (2011), Mimi and Ecer (2010), Kwakwa (2013), Glden and Min used quantitative approach with nearly all of them using secondary data.

Others like Yakubu et al (2018), Winther (2012) used qualitative approach and both used cross section data from primary source. A few others were different in their approach by using game theory (Cardens et al 2012), Comparative analysis (Lewis, 2015; Smith, 2004).

Among the studies that used quantitative approach, their statistical analysis techniques include fixed effects models, feasible generalised least squares (FGLS) model, bivariate Probit model, Pearson coefficient, Granger causality, three-stages-least-square (3SLS) method, ARDL approach, the Fully Modified Ordinary Least Square, Descriptive statistics and Fixed Effects OLS, Logistic Regression.

From the foregoing, it is obvious that the various methodologies used were determined by data availability and goal(s) of each researcher. In the same vein, this study employed a probit regression model to analyse the factors capable of leading to household end-users stealing electricity. The decision to use this estimation technique was largely guided by the nature of data available (primary data). In addition, the researcher's goal was to identify the probability of an event happening or not; the probit regression model was quite appropriate for our needs (Gujarati 2013). In this study, electricity theft proxy by “meter bypass” was made the response variable to assess end-users' willingness to steal electricity in the face of a variety of incentives and or distinguishing criteria, which served as explanatory variables.

2.4. Nigeria electricity supply industry: Stylized facts

Over the years, Nigeria’s effort to generate adequate and reliable electric power has undergone different transformations. This section presents information about origin of electricity generation in Nigeria, electricity distribution companies in Lagos State, the ownership structure, franchise areas and their mode of operation. A brief comparison of the electricity tariff structures applicable in Lagos state, the performance appraisal of Eko DisCo and Ikeja Electric Plc, revenue flow in Nigeria’s electricity supply industry (NESI) and the anatomy of electricity theft comprising the meaning of electricity theft, the different techniques of electricity theft and types of electricity theft common to different income groups.

2.4.1. Origin of electricity generation in Nigeria

In 1896, the colonial government assembled the first electricity plant in Lagos, with a capacity of 60 KW. This size is comparable to a 75kVA generator often seen in residential apartments and workplaces today. The success of this first plant, on the other hand, led to the establishment of the Nigeria Electricity Supply Company, which was tasked with developing comparable facilities throughout the country. Power plants were soon erected in Port Harcourt, Kaduna, Enugu, Maiduguri, Yola, Zaria, Warri, and Calabar. The public works department (PWD) was in charge of these power plants' operations. The progression was as seen in figure 2.1 in the years that followed.

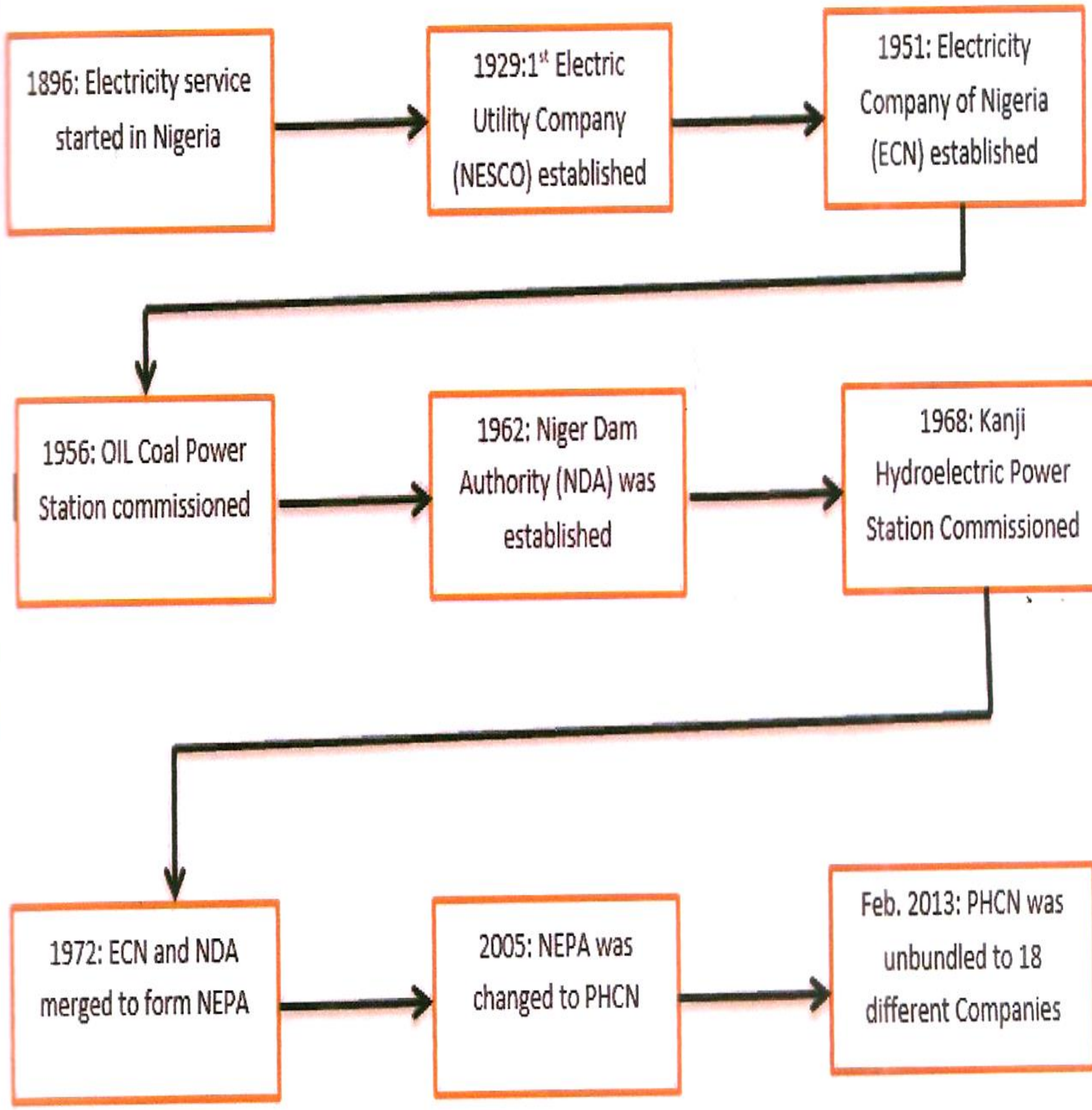


Fig 2.1: Evolution of Nigeria Electricity Supply Industry

Source: Illustrated by Researcher.

2.4.2. Reforms that led to the unbundling of the Industry

Nigeria Electric Power Authority, (NEPA), as it was then known was responsible for generation, transmission and distribution of electricity throughout the federation. It started with only 6,200 MW produced by four thermal power units and two hydro. Invariably, this led to a huge shortfall with respect to quantity demanded. Ultimately, frequent power outages lasting many hours, out of date equipment for power generation, irregular infrastructural maintenance, low revenue inflow, Technical and Non-Technical losses ensued.

The National Power Policy which served as the forerunner to the reform of the electric power industry was publicized in 2001. The objective was to privatise the industry by inviting private participation in all the segments of the industry. The transfer of ownership of the industry to private companies was designed to be gradual. This resulted in formation of critical structures capable of sustaining electricity market in the country.

In line with the government's privatisation policy, the Electric Power Reform Act (EPSRA) was enacted in 2005. It basically made provision for unbundling of the then vertically integrated power authority. This exercise led to the formation of six generation companies, eleven companies in the distribution segment and one transmission company. In addition, government formed a trading company known as Nigerian Bulk Electricity Trading Plc. (NBET) in 2010. NBET was designed as a reliable off-taker of electric power product from the generators. It is worth noting that while the generation and transmission segments were ceded to the private companies, the transmission segment was still controlled by the government. The privatized distribution businesses were now in charge of the customer's energy supply, billing, metering, and maintenance, as well as all other associated services within their business zones.

2.4.3 Emerging Challenges in the Electric Power Industry Post-privatization

2.4.4. Initial Challenges

Many foreign investors were initially hesitant to participate in the privatization because of the electricity sector's perceived history of inefficiency and widespread corruption. Some multinational power businesses with the required expertise and experience were believed to have refused to bid for any of the generation and distribution activities. This led to only a few investors with a thorough understanding of the industry participating in the privatization, and even fewer won control and management of the successor generation and distribution enterprises. Those risk-loving investors who dared to participate were frustrated by dearth of information to enable them do profound and decisive practicability and viability studies.

Another issue was the hefty severance payment the company was reported to owe its thronging workforce. It was expected to cost around N400 billion (around $1.6 billion). Furthermore, the inability of investors to take over successor firms in the generating and distribution segments without the ability to undertake due diligence on the assets proved to be a severe stumbling block in the privatisation process. The assets were allegedly purchased based on government assumptions, numbers, and data.

More crucially, funds expected from outside the country to help improve the process were not obtained since international lenders preferred to back successful bidders or refinance existing facilities rather than participate in the privatisation process. As a result, the winning bidders were given more expensive and shorter-term loans. In addition, due to the failure to undertake due diligence, a number of other concerns developed that could not have been reasonably expected. The demand for a long tax break, a subsidy system, and a periodical review of the Multi-year Tariff Order (MYTO) grew quickly.

2.4.5. Current Challenges

The privatisation process raised a lot of hopes. They include reliable, cost-effective, and efficient electricity supply. These expectations, however, have not been met. After privatisation, electricity supply has been marked by shortages and generally poor service delivery. There are severe stresses across the value chain, from feedstock availability to energy units provided to end-users that not only endanger the sector's financial viability, but also effectively preventing new finance and investment.

Underutilisation of producing capacity, high transmission and distribution losses, and inadequate or low collection rates are among the current concerns. Over 3,000MW of generating capacity is thought to be stranded due to infrastructural issues. Transmission capacity can only wheel 50-60% of installed capacity, and collecting losses at the distribution company (DisCo) level are quite significant.

2.4.6 Electricity Distribution Companies in Lagos State

Lagos State is the only State in the country where two electricity distribution companies are licensed to operate. This electricity distribution companies (DisCos) are Eko Electricity Distribution Company (EKEDP) and Ikeja Electricity Distribution Company (IKEDP).

2.4.7. Ikeja Electricity Distribution Company (Plc.)

2.4.8. Ownership

Ikeja Electricity Distribution Plc. is the largest Nigerian power distribution company with estimated 1,292,113 customers (MYTO 2 2019). It is based in Ikeja, capital of Lagos State. The ownership of the company is made up of the Federal Government of Nigeria (40%) and Korea Electric Power Corporation (KEPCO) - Sahara Group (60%). Prior to privatization, Ikeja Electricity Distribution Company (now known as Ikeja Electric Plc.) was originally a directorate under the defunct utility monopoly called NEPA. Its area of operation covered Lagos North Distribution Directorate. Ultimately, it grew over the years and transformed into IKEDC.

The Sahara Group acquired a 60 percent stake in Ikeja Electricity Distribution Company (IKEDC) (which has since rebranded into Ikeja Electric Plc. (IE) through a Special Purpose Vehicle, New Electricity Distribution Company Limited (NEDC) (with KEPCO as its technical partner) under the privatization scheme. IE is a public limited-liability company that is patnerned by the Bureau of Public Enterprises and the Federal Ministry of Finance, with each holding a 32 % and an 8% share. The former IKEDC had a period of metamorphosis after being handed over to the NEDC/KEPCO Consortium.

2.4.9. Franchise area and mode of operation

The state of Lagos is split into two franchise zones. Each DisCo is in charge of a specific area. IE Plc is responsible for the areas of Alimosho, Ikorodu, Ikeja, Epe, Oshodi, Agege, Shomolu, and Kosofe, as well as sections of Yaba and Mushin Local Governments. It operates through eleven business units: Abule-Egba, Akowonjo, Ikeja, Ikorodu, Ikotun, Ipaja, Oshodi, Ojodu, Odogunyan, Obafemi Awolowo Way, Alausa, Ikeja, Lagos is where IE's corporate headquarters are located.

2.4.10: Meter access

Over half of the company's customers were either unmetered or had antiquated meters when it was taken over. This was a significant difficulty because it complicated energy accountability and encouraged the use of anticipated billing, which resulted in both over and under billing.

The Advanced Metering Infrastructure (AMI) project was launched in collaboration with technical partners KEPCO to address a number of network issues, including metering gaps, revenue assurance, remote monitoring, providing more accurate customer information, improving maintenance culture and thus reducing fault occurrence, load analysis – fault prevention, and prompt escalation. AMI is an integrated system of smart meters that communicate wirelessly with a background IT infrastructure, allowing for efficient energy data monitoring.

Over the next five years following privatisation, the business planned to install 600,000 new meters across its network and connect 592,000 new customers. The goal was to minimise commercial losses to a controllable level in a reasonable amount of time. It started a metering initiative at the top of the distribution network chain in 2015. Over 90% of 11KV feeders, which are the first point of power receipt for distribution within the Company's network, and over 30% of distribution transformers, which are used to manage the supply of energy to consumer residences and outlets, were effectively metered. Additionally, during the year, it began deploying Non Maximum Demand meters. It had successfully installed over 30,000 smart meters to clients inside the network by the end of the year.

2.4.11: Electricity theft challenge

The increasing rate of electricity theft through meter bypass is a key concern for IE. The company's network, according to its website, was plagued by unauthorised connections. It also admits that implementing disconnection orders has been ineffective, with unauthorised reconnections frequently thwarting them. It instructed the Commercial Department's Vigilance, Strategy, and Loss Reduction Unit to monitor, seize, and punish cases of energy theft and unlawful connections and reconnections to deal with these concerns. It recommended the state and federal governments to pass suitable legislation to completely address the challenges connected to energy theft across the distribution network as part of other initiatives to solve the problem. Efforts to reduce electricity theft in the network have been insufficient thus far. Furthermore, no one from the network has ever been charged with offence of electricity theft in any court in the country (Ikeja Electric 2019)

2.4.12 Eko Electricity Distribution Company (Plc.)

2.4.13: Ownership

Eko Electricity Distribution Plc. (Eko DisCo) is in the business of distribution of electricity in its licensed area, covering southern parts of Lagos with a total of estimated 626,294 customers (MYTO 2 2019). Ownership of the company is between the federal government of Nigeria (40%) and others (60%) made up of individuals who are Directors in the company that pulled resources together to set up the company as follows:

Charles Momoh, a director in the company, is the Managing Director of Atlantic Meridian Limited, which is an indigenous enterprise that provides services for the safe extraction, processing and purchase of oil. His management team now provides a huge part of Nigeria with electricity. Tunji Olowolafe, the second director, specializes in private and public infrastructural projects; Dere Otubu, the third director, is the Chairman of Staco Insurance, Senforce Insurance Brokers, SIC Property & Investment and Staco Prime Capital; Ernest Oji, the fourth director, is the Managing Director of Beta Consortium Limited, and Chairman of Alpha Consortium Limited. He has significant working experience in the power sector, and took part in every stage of the division and reformation of PHCN. Next is George Etomi, also a director, is a lawyer in Lagos. Last but not the least is Oladele Amoda (the first Managing Director) who had a career as an electrical engineer in the defunct PHCN. Every single person mentioned on this list has contributed to the development of Eko Electricity Distribution Plc. (EkoDisCo 2019).

2.4.14: Franchise area and mode of operation

The licensed area of Eko Electricity Distribution Company includes the southern portion of Lagos state and Agbara in Ogun state. Badagry, Agbara, Ojo, Festac, Ijora, Mushin, Orile, Apapa, Lekki, Ibeju, and Lagos Island are all part of this. Eko DisCo's licensed area is divided into three circles and ten districts for ease of operation and task division. They are designated West Circle, Central circle and East circle and they comprise three districts, four districts and three districts respectively. The West circle covers Ojo, Agbara and Festac while the Central and the East circles covers Mushin, Orile, Ijora and Apapa and Island, Lekki and Ibeju respectively. The districts offices are each equipped with consumer care service centre for easy resolution of customer complaints. The company also established a minimum of three zonal offices in each district to facilitate faster network breakdown resolution on the low-tension (LT) network of 415 V. The zone team is responsible for the safe operation and maintenance of the LT network.

2.4.15: Meter Access

Regarding meter access under Eko DisCo, the company through its website claims that metering of its registered customers is the company’s priority and it is a continuous exercise. It also indicated that it had metered 65% of its subscribers as far back as 2015 but the company is yet to supply update of the percentage of its customers currently metered. Eko electricity distribution company had earlier informed that the greatest obstacle towards metering the customers at the required pace was the problem of liquidity which slowed it down from raising enough capital to buy meters. Now that the customers are being made to acquire the meter through a newly introduced programme called MAP (Meters Assets Providers), it is expected that more of its customers would be able to have meter access.

2.4.16: Electricity theft challenge

Electricity theft is a major problem facing the operations of Eko DisCo. On its website, the company laments that it loses on the average the sum of N1.2 billion to electricity theft every month. This prompted it to devise a number of measures to tackle the problem. Prominent among the measures taken is its policy to reward whistle-blowers who can bring to the notice of the company valid information regarding the activities of the individuals or groups stealing electricity within its network. Such whistle-blowers are to be rewarded with 20% of whatever amount that is recovered from each report.

A number of high-net-worth clients are said to have been apprehended. One such electricity thief is a hotel in Lagos' Surulere neighbourhood, which was discovered by Eko Electricity Distribution Company personnel engaging in meter bypass. According to an Eko DisCo official, the hotel's complaint over projected billing led to the installation of three pre-paid meters in the hotel, only for the client to short-change the firm using meter by-pass. In all, Eko Electricity Distribution Firm disclosed that 43,000 prepaid meters out of 134,000 placed by the company in the last five years had been tampered with by their owners. This figure represents roughly 32% of the total number of prepaid meters in operation within the power company's service area. However, Eko DisCo acknowledges that its efforts are insufficient to tackle the problem of electricity theft in its network. As a result, it is up to the federal government to put in place a set of policy measures that will minimise the situation.

2.4.17: Distribution Tariff

The costs of the whole value chain for the Nigerian Electricity Supply Industry (NESI), from fuel/feedstock for generation plants to wholesale generation, transmission, distribution, metering and billing, and lastly to the consumer, are reflected in distribution (end-user) tariff. End-user rates are expected to stay regulated until customer choice is established, in order to protect customers' interests and ensure that DisCos get a fair return on their investment. By law, the Nigerian Electricity Regulatory Commission (NERC) is obligated to guarantee that prices are not just cost-reflective, but also that losses are minimized and that as little as feasible of the costs of such losses are passed on to customer. The Commission has set an end-user tariff to cover the costs of electricity (energy and capacity), transmission use of system costs, regulatory and market administration charges, the Discos' distribution charges, and costs associated with metering, billing, marketing, and revenue collection using the Multi Year Tariff Order (MYTO) methodology.

All end-users of electricity in Nigeria are categorised into five main tariff classes, as shown in Table 2.1. Customers are then divided into tariff sub-classes by the particular electricity distribution company (DisCo) depending on their average electricity use. The Commission granted a lifeline rate of N4/kWh ($0.011) for the low-income R1 customer subclass in all eleven Discos, which is the sole uniform tariff among the eleven distribution firms. From one Disco to the next, there is noticeable difference in all other tariff categories or classifications.

2.4.18: Customer Tariff Classification by Categories

The electricity end-user pricing is divided into five (5) groups, as shown in Table 2.1, namely residential, commercial, industrial, special, and street light. Except for the Street light category, each of these categories is further broken into different classes such as lifeline, single phase, three (3) phase, LV maximum demand, and HV maximum demand. Customers who use their premises exclusively for residential purposes are served by the Residential category; customers who use their premises for any purpose other than residential or as factories are served by the Commercial category; customers who use their premises for manufacturing goods such as welding and ironmongery are served by the Industrial category; and customers who use their premises for special purposes are served by the Special category.

Table 2.2 : **Customer Tarrif Classification**

S/N	**RESIDENTIAL**		
1			
2	R1	Life line (50kWh)	Customers who use their premises exclusively for Residential purpose
3	R2SP	Single Phase	
4	R2TP	Three (3) Phase	
5	R3	LV Maximum Demand	
6	R4	HV Maximum Demand	
7	**COMMERCIAL**		
8	C1SP	Single Phase	Customers who use their premises for any purpose other than residential or as factories
9	C1TP	Three (3) Phase	
10	C2	LV Maximum Demand	
11	C3	HV Maximum Demand	
12	**INDUSTRIAL**		
13	D1	Single Phase	Customers who use their premises for manufacturing goods such as welding and ironmongery
14	D2	LV Maximum Demand	
15	D3	HV Maximum Demand	
16	**SPECIAL**		
17	A1	Single Phase and Three (3) Phase	Customers such as Agricultural or Agro-allied industries, water board, religious houses, government and Teaching Hospitals, government research institutes and educational establishment
18	A2	LV Maximum Demand	
19	A3	HV Maximum Demand	
20	**STREET LIGHT**		
21	S1	Single and Three (3) Phase	

Source: NERC (Nigeria Electricity Regulatory Commission)

2.4.19: Comparison of Electricity Tariff for Eko and Ikeja Electricity Distribution Companies Before the Introduction of Service Reflective Tariff (SRT).

Tables 2.2 and 2.3 show that each of the five bands of the end-user tariffs attracts different tariff rates for both DisCos. Indeed, tariff rates differ across the DisCos in the country. In other words, the residential tariff rate under Eko Electricity Distribution Company is different from the residential tariff rate under Ikeja Electric Plc. The same trend is observable in other tariff categories under the different Distribution Companies. The only exemption is sub-class R1 under residential category which is known as “lifeline” class. It is designed for customers that are at the lowest rung of the social economic ladder. This class of customers consumes on the average a maximum of 50kWh of electricity monthly and the tariff rate is N4/kWh ($0.01).

Comparison of the electricity end-user tariff between Eko DisCo and Ikeja Electric in Lagos as seen in tables 2.2 and 2.3 below shows differences between the tariff rates across the two Distribution Companies. For instance, Residential 2 Single Phase (R2SP) is ₦20.06/kWh ($0.057) and ₦18.45/kWh ($0.05) in year 2019 for Eko and Ikeja Disco respectively.. The same pattern may be seen in the tariff structure's other subclasses. The process used to arrive at the tariff paid under each of the licensees is known as the Multi-year Tariff Order (MYTO). Cost recovery/financial viability, signals for investment, certainty and stability, efficient use of the network, risk allocation, simplicity and cost effectiveness, incentives for improving performance, transparency / fairness, flexibility, and exchange rate changes are some of the principles and objectives built into the MYTO pricing.

Table 2.3: Electricity Tariff approved for Eko Electricity Distribution Company N/kWh before Service Reflective Tariff (SRT) 2013-2020.

Class	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
R1	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
R2SP	15.63	24.00	22.34	20.47	20.06	20.07	20.17	19.98	19.90	19.78
R2TP	15.63	25.79	28.39	26.02	25.49	25.51	25.64	25.39	25.29	25.13
R3	28.45	29.00	29.18	26.74	26.19	26.21	26.34	26.09	25.99	25.83
R4	28.45	29.00	29.18	26.74	26.19	26.21	26.34	26.09	25.99	25.83
C1S	19.00	24.00	22.90	20.98	20.55	20.57	20.67	20.47	20.39	20.27
CIT	19.90	30.00	28.60	26.20	25.67	25.69	25.82	25.57	25.47	25.31
C2	26.44	36.00	32.50	29.78	29.17	29.19	29.34	29.06	28.94	28.77
C3	26.44	36.00	32.50	29.78	29.17	29.19	29.34	29.06	28.94	28.77
D1S	21.33	24.00	24.68	22.62	22.16	22.17	22.29	22.07	21.99	21.85
DIT	21.33	30.00	28.74	26.34	25.80	25.82	25.95	25.70	25.60	25.44
D2	27.72	36.00	33.05	30.29	29.67	29.69	29.84	29.55	29.44	29.26
D3	27.72	36.00	33.05	30.29	29.67	29.69	29.84	29.55	29.44	29.26
A1S	20.42	24.00	22.96	21.04	20.61	20.62	20.73	20.53	20.45	20.32
A2	20.42	24.00	22.96	21.04	20.61	20.62	20.73	20.53	20.45	20.32
A3	20.42	24.00	22.96	21.04	20.61	20.62	20.73	20.53	20.45	20.32
LI	15.68	23.52	22.17	20.32	19.90	19.92	20.02	19.82	19.75	19.63

Source: NERC (Nigeria Electricity Regulatory Commission)

Table 2.4: Electricity Tariff approved for Ikeja Distribution Company N/kWh before Service Reflective Tariff (SRT) 2013-2020.

Class	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
R1	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
R2SP	13.21	21.30	21.10	18.94	18.45	18.39	18.51	18.51	18.27	18.15
R2TP	13.21	21.80	21.73	21.15	20.59	20.53	20.67	20.47	20.39	20.26
R3	26.25	36.49	35.68	31.62	30.79	30.70	30.90	30.61	30.49	30.30
R4	26.25	36.92	36.11	32.00	31.16	31.07	31.27	30.98	30.86	30.66
C15P	19.90	27.20	25.56	21.76	21.19	21.13	21.27	21.07	20.99	20.85
CITP	19.90	28.47	27.59	24.45	23.81	23.74	23.90	23.67	23.58	23.43
C2	24.40	37.74	36.91	32.47	31.62	31.53	31.73	31.43	31.31	31.11
C3	24.40	38.14	37.30	32.81	31.95	31.86	32.07	31.77	31.64	31.44
D1	19.68	20.68	27.93	24.56	23.92	23.85	24.01	23.78	23.69	23.54
D2	25.57	38.38	37.54	33.02	32.15	32.06	32.27	31.96	31.84	31.56
D3	25.57	38.85	37.99	33.42	32.54	32.45	32.66	32.35	32.23	32.02
A1	18.84	26.82	26.23	23.24	22.63	22.57	22.71	22.50	22.41	22.27
A2	18.84	30.20	29.53	26.17	25.49	25.41	25.58	25.34	25.24	25.08
A3	18.84	30.36	29.69	26.13	25.62	25.54	25.71	25.47	25.37	25.21
S1	14.47	19.42	18.99	16.83	16.39	16.34	16.45	16.29	16.23	16.13

Source: NERC (Nigeria Electricity Regulatory Commission)

2.4.21: Service Reflective Tariff (SRT)

All power distribution companies in Nigeria began implementing the amended Service Reflective Tariff (SRT) set by the regulator, (NERC), on November 1, 2020. The modification came after the federal government, labour unions, and other stakeholders convened consultative review meetings in response to concerns raised about the basis of the MYTO 2020 SRT pricing, which were set to go into effect on September 1, 2020.

The tariff categorization under the SRT is based on the quality of service and is thus separated into 5 Bands (A-E) depending on the average monthly availability of power supply, interruptions (frequency and length), voltage levels, and other service criteria.

Non-MD customers in band A who use their electricity for at least 20 hours per day would now pay N51.22/kWh under the new rate regime. Consumers in band B would pay N46.93/kWh for a minimum of 16 hours per day, while customers in band C are charged N37.95/kWh for a minimum of 12 hours per day. Customers in bands D and E, who are served at least eight hours per day and four hours per day, respectively, are not affected by the rate change. Their SRT tariffs have been frozen; therefore they will be taxed at the old tariff rate.

Customers with Prepaid Meters in bands A-C who purchased on or after November 1, 2020 have already been charged the new pricing, and Post-paid customers in these bands have also been charged the new tariff during the November 2020 billing cycle.

Despite the introduction of the SRT, the flexibility to allow individual Distribution Company charge appropriate tariff subject to a given band is noticeable. For example, Customers classified under Non-maximum Demand A are charged 51.50/kWh under Eko Electricity Distribution Company while Customers in the same category are charged 51.52/ kWh under Ikeja Electric Plc.

Table 2.5: Revised Customer Tariff Classification and Energy Charges November-December 2020 As Approved by the Nigerian Electricity Regulatory Commission (NERC) for Eko Electricity Distribution Company.

SERVICE BAND	TARIFF RATE	AMOUNT	TARIFFS
	NMD-A	NGN 51.50	R2SRSTA1SA1TD1SD1TC1SC1TE1E2
SERVICE BAND A (20 hrs)	MD1-A	NGN 54.07	R3C2D2A1S1
	MD2-A	NGN 54.07	R4C3D3A3E3
SERVICE BAND B (16 hrs)	MD1-8	NGN 50.23	R3C2D2A1S1
	MD2-8	NGN 50.23	R4C3D3A3E3
SERVICE BAND C (12hrs)	NMD-C	NGN 38.44	R2SRSTA1SA1TD1SD1TC1SC1TE1E2
	MD1-C	NGN 45.12	R3C2D2A1S1
	MD2-C	NGN 45.12	R4C3D3A3E3
	NMD-E	NGN 36.15	R2SRSTA1SA1TD1SD1TC1SC1TE1E2
SERVICE BAND E (4hrs)	MD1-E	NGN 39.63	R3C2D2A1S1
	MD2-E	NGN 39.63	R4

Source: Eko Electricity Distribution Company

Table 2.6: Revised Customer Tariff Classification and Energy Charges November-December 2020 As Approved by the Nigerian Electricity Regulatory Commission (NERC) for Ikeja Electric Plc

Service Bands	**New Tariff Class**	**Old Tariff Class**	**New Tariff (Naira)**
Lifeline (customers consuming less than 50 kWh/month)	**R1**	**R1**	**4**
A (minimum of 20hrs/day)	A – Non-MD	R2, CI, DI, AI (single and three phase)	51.22
	A–MD 1	R3, C2, D2, A2 Street Light	53.66
	A–MD 2	R4, C3, D3, A3	54.12
	A Bilateral	Customers on Bilateral Contract	56.70
B	B-Non-MD	R2 C1, D1, A1 (single and three phase)	46.93
(minimum of 16hrs/day)	B-MD1	R3, C2, D2, A2 Street Light	47.71
	B-MD 2	R4, C3, D3, A3	53.61
C (minimum of 12hrsday)	C-Non-MD	R2, C1, D1, A1 (single and three phase)	37.95
	C-MD 1	R3, C2, D2, A2 Street Light	42.80
	C-MD 2	R4, C3, D3, A3	52.59
D (minimum of 8hrs/day)	D-Non-MD	R2, CI, DI, A1 (single and three phase)	FROZEN
	D-MD 1	R3, C2, O2, A2 Street Light	FROZEN
	D-MD 2	R4, C3, 03, A3	FROZEN
E (minimum of 4hrs/day)	E-Non-MD	R2, CI, DI, AI (single and three phase)	FROZEN
	E-MD 1	R3, c2, d2, a2 Street Light	FROZEN
	E-MD 2	R4, C3, D3, A3	FROZEN

Source: Ikeja Electric Plc

2.4.22: Revenue Flow in Nigeria's Electricity Supply Industry

Figure 2.2 presents the revenue flow in Nigeria's Electricity Supply Industry. The figure indicates that the distribution segment is the revenue collecting agency for the industry's entire value chain. The electricity end users (at the extreme right) pay bills for units of electricity consumed directly to the DisCos. Subsequently, the revenue is shared as follows: Twenty four per cent (24%) of the revenue collected is retained by the collecting DisCo; Four per cent (4%) goes to the Central Bank of Nigeria, CBN; Four per cent (4%) goes to the regulator, Nigeria Electricity Regulatory Commission, NERC; Eleven per cent (11%) goes to the Transmission Company of Nigeria, TCN and the balance of fifty seven per cent (57%) goes to the Power Generating Companies, (GenCos) and the Feed Stock Suppliers. Without doubt, the survival of the industry depends directly on the capacity of the Distribution Companies to collect revenue optimally. Anything that threatens the revenue collection capacity of the DisCos (such as electricity theft) practically threatens the wellbeing of the entire industry

Revenue Flow in Nigeria's Electricity Supply Industry

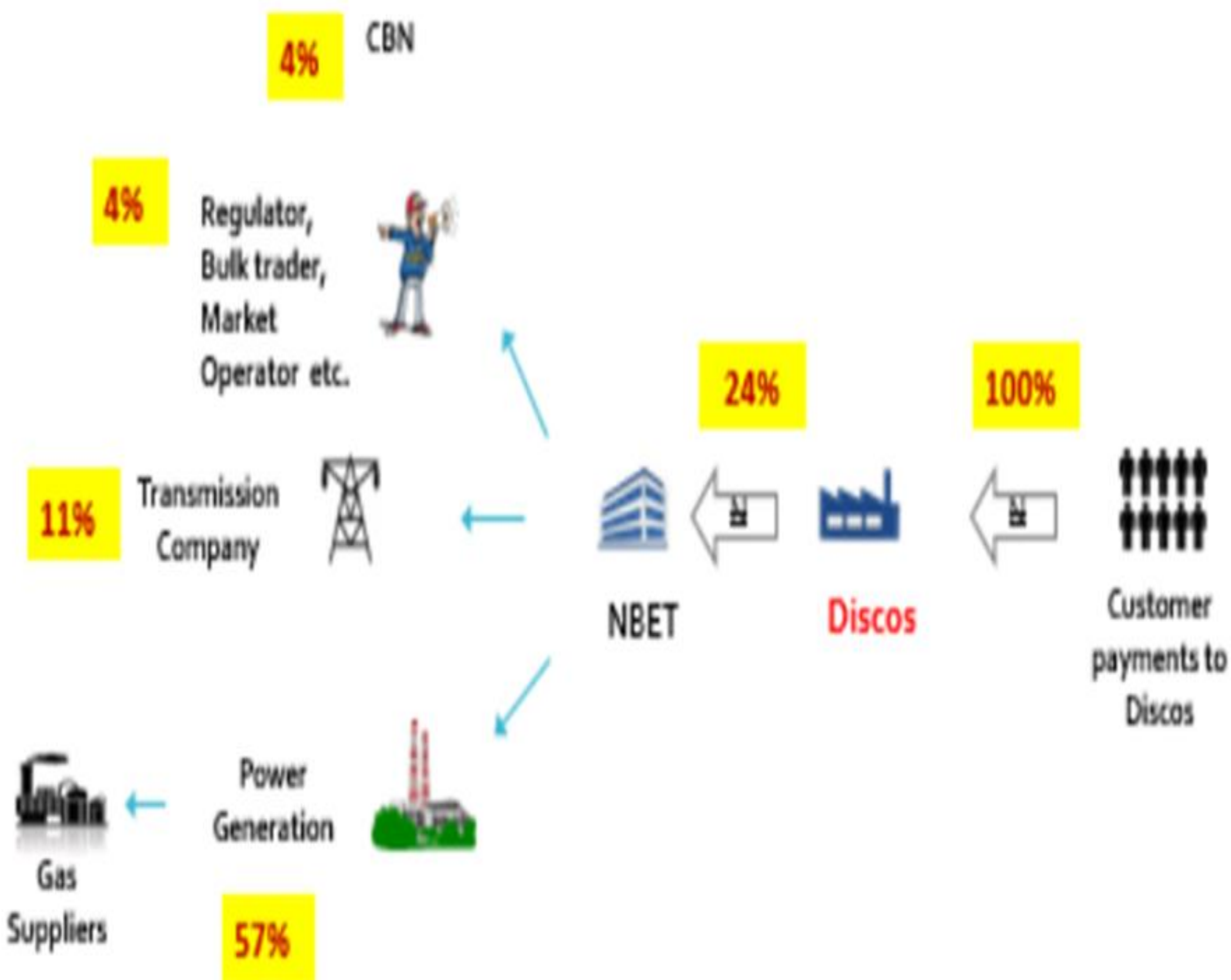


Figure. 2.2: Nigeria Electricity Supply Industry (NESI) Revenue Flow.

Source: Association of Nigeria Electricity Distributors

2.4.23: Comparison of Revenue Flow between Eko Disco and Ikeja Electric Plc 2013 – 2017

EkoDisCo and Ikeja Electric Plc, the two companies licensed to operate in Lagos commenced full operations in 2013 as successor companies to power holding company of Nigeria, (PHCN). As mandated by the regulator, Nigerian Electricity Regulatory Commission, (NERC), audited annual financial reports of these companies are regularly published and pasted on the companies' websites with links on the website of the regulator, NERC, for easy access.

Fig. 2.4 presents the gross revenue for both companies for the period of 2013 to 2017, a period of 5 early years following take off of business. This revenue profile contains only gross revenue (before tax and other operation costs were deducted). In the electric power industry, revenue profile is a performance indicator alongside other indicators like collection efficiency, metering progress, NBET (Nigerian Bulk Electricity Trading Company) remittances and technical/commercial loss reduction among others. It is also important to note that each company's revenue profile is a function of energy received and energy billed for the period under review. The DisCos usually receive different amounts of energy from Transmission Company of Nigeria (TCN) based on certain considerations such as availability of the product, size of the subscribers of the DisCo, willingness and capacity of each DisCo to take on products. For example, Eko DisCo states on its website that it is never able to get enough energy from the grid to meet its demands of about 2,000MW as the quantity of electricity regularly sent to it hovers around 300-400MW which is just 15-20% of its requirement.

Table 2.4 indicates that from 2013 to 2016, Ikeja Electric Plc. received more revenue than Eko DisCo on year to year basis. As a matter of fact, in year 2013, Eko DisCo received only 69.4% of Ikeja Electric Plc' revenue. Similarly, in year 2014, Eko DisCo's total revenue was 89.6% of Ikeja Electric Plc. Same trend continued in 2015 and 2016 when Eko DisCo's total receipt was only 84.4% and 87.7% of Ikeja Electric Plc' receipt respectively. However, the trend changed in 2017 when Eko DisCo's total revenue exceeded that of Ikeja Electric Plc by 0.72%. Neither NERC nor any of the two companies offered explanations for this development. Each year's revenue is in billions of Nigeria naira.

Table 2.7: Revenue Profile of EkoDisCo and Ikeja Electric Plc.

		N'000			
	2013	**2014**	**2015**	**2016**	**2017**
EKO DISCO	35,288,213	48,764,738	51,007,001	56,536,377	69,065,249
IKEJA ELECTRIC Plc.	50,685,937	54,436,806	62,636,220	64,497,695	68,568,675
Share of Eko in IE	69.4%	89.6%	81.4%	87.7%	100.72

Source: Nigerian Electricity Regulatory Commission (NERC)

Figure. 2.3 presents the comparison of the revenue profile between Eko DisCo and Ikeja Electric Plc for a period of 2013 to 2017. The blue block stands for Eko DisCo's revenue while the light brown colour stands for Ikeja Electric Plc' revenue.

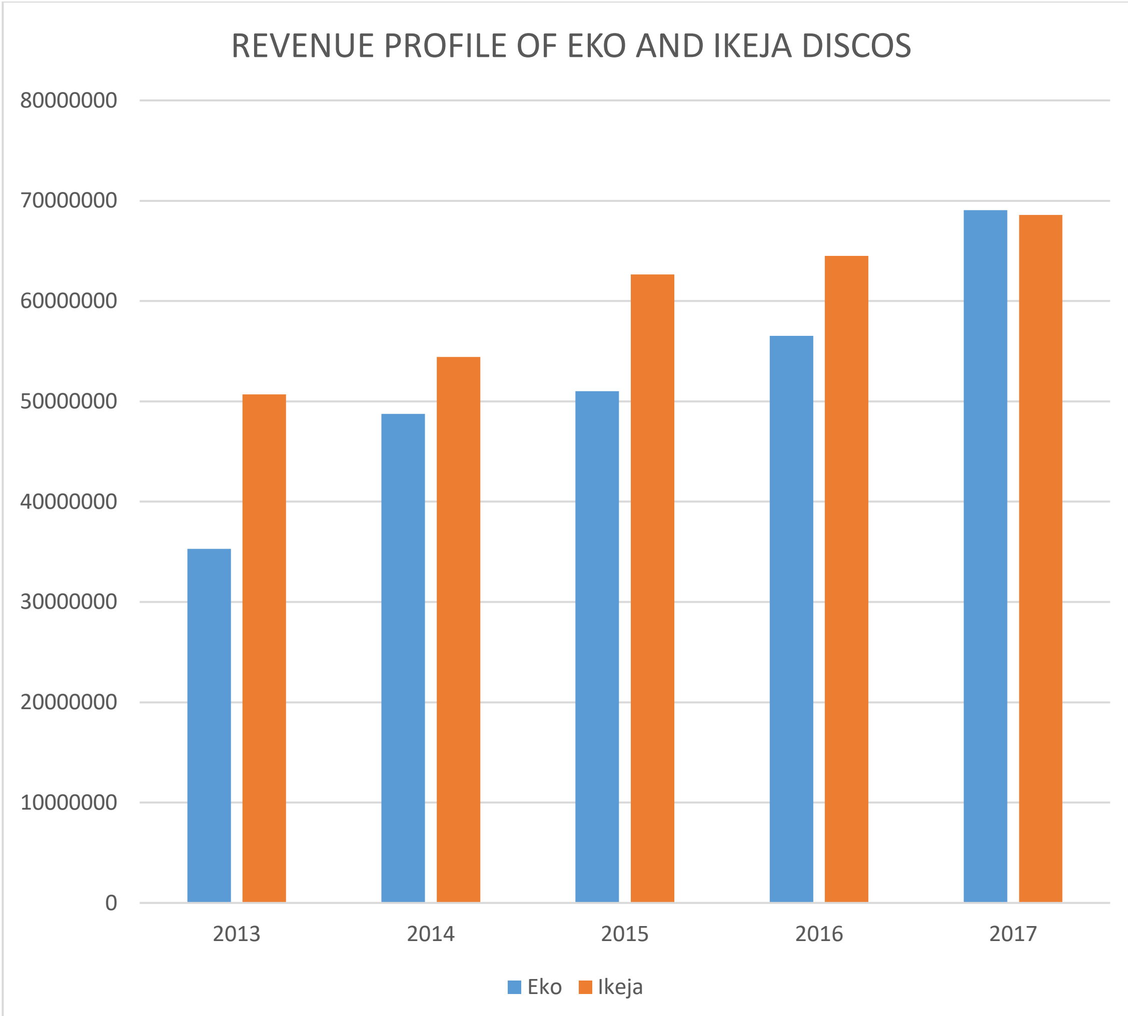


Figure. 2.3: Revenue profile of Eko DisCo and Ikeja DisCo

Source: Nigerian Electricity Regulation Commission (NERC)

2.4.24: Energy Billed by Eko DisCo and Ikeja Electric Plc between 2018/Q2 to 2019/Q3

Table 2.5 presents the quantity of energy billed by both Eko electricity Distribution Company and Ikeja Electric Plc between the second quarter of 2018 and the third quarter of 2019. Energy billed refers to the quantity of energy distributed by the DisCos to their customers for which payment was expected. Many times the gap between energy distributed or energy billed and revenue received is often big due to many reasons like collection efficiency of the DisCo, electricity theft, estimated billing and refusal of certain customers to pay (e.g. the military, police and MDAs).

Comparison of energy distributed between Eko DisCo and Ikeja Electric Plc in the period under review shows that Ikeja Electric Plc distributed more energy in each and every quarter than Eko DisCo. The reasons for this are not far-fetched. According to Multi-Year Tariff (2019), Ikeja Electric Plc has more registered customers than Eko DisCo among others. The statistics is also captured in figure. 2.4

Table 2.8: Energy Billed by Eko DisCo and Ikeja Electric Plc: 2018/Q2 to 2019/Q3

	2018/Q2	2018/Q3	2018/Q4	2019Q1	2019/Q2	2019/Q3
Eko	766	679	707	762	742	731
IE	863	801	850	893	915	943

Source: Association of Nigerian Electricity Distributors (2019)

Fig 2.4: Energy billed by Eko DisCo

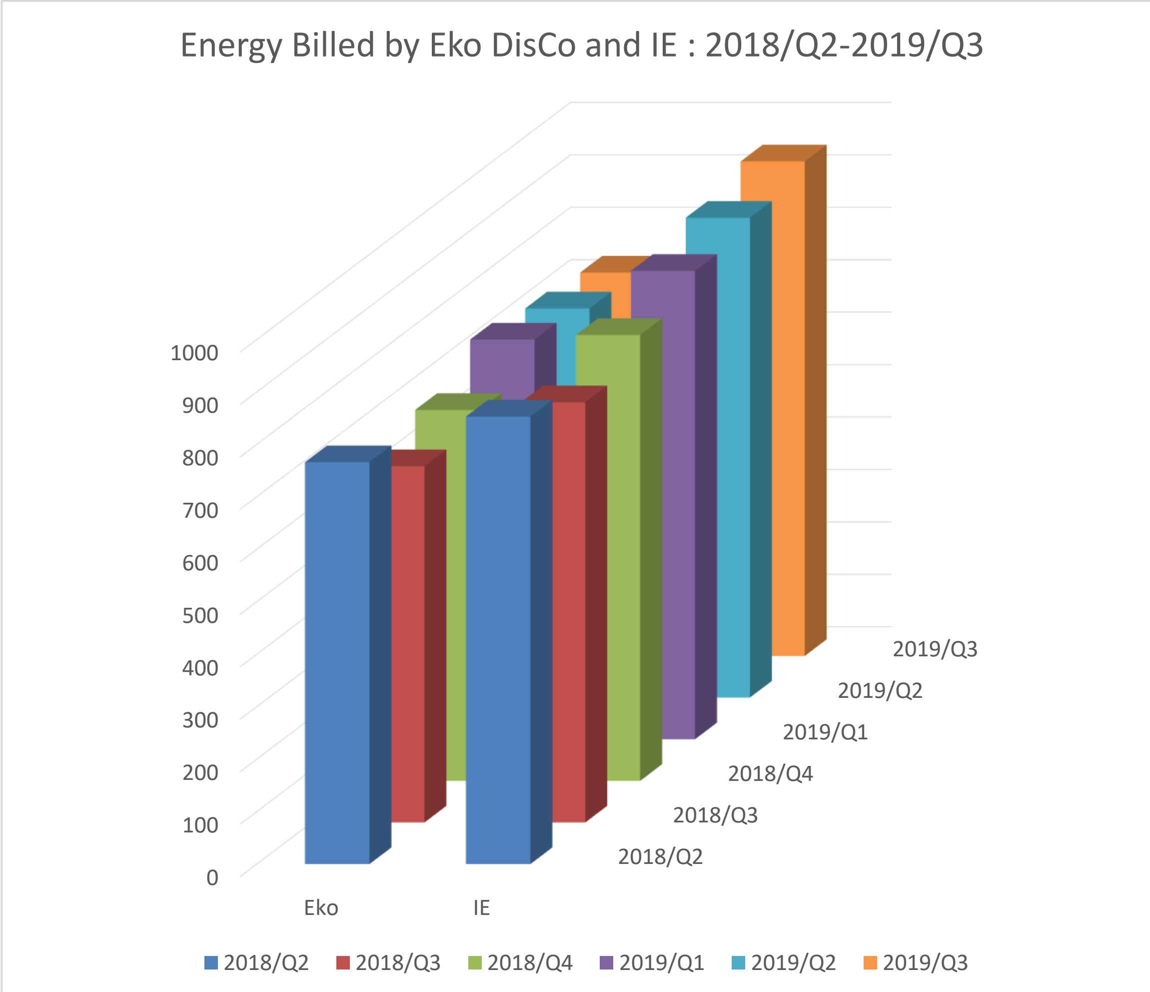


Figure 2.4 Energy billed by Eko DisCo and Ikeja Electric Plc: 200018/Q2-2019/Q3

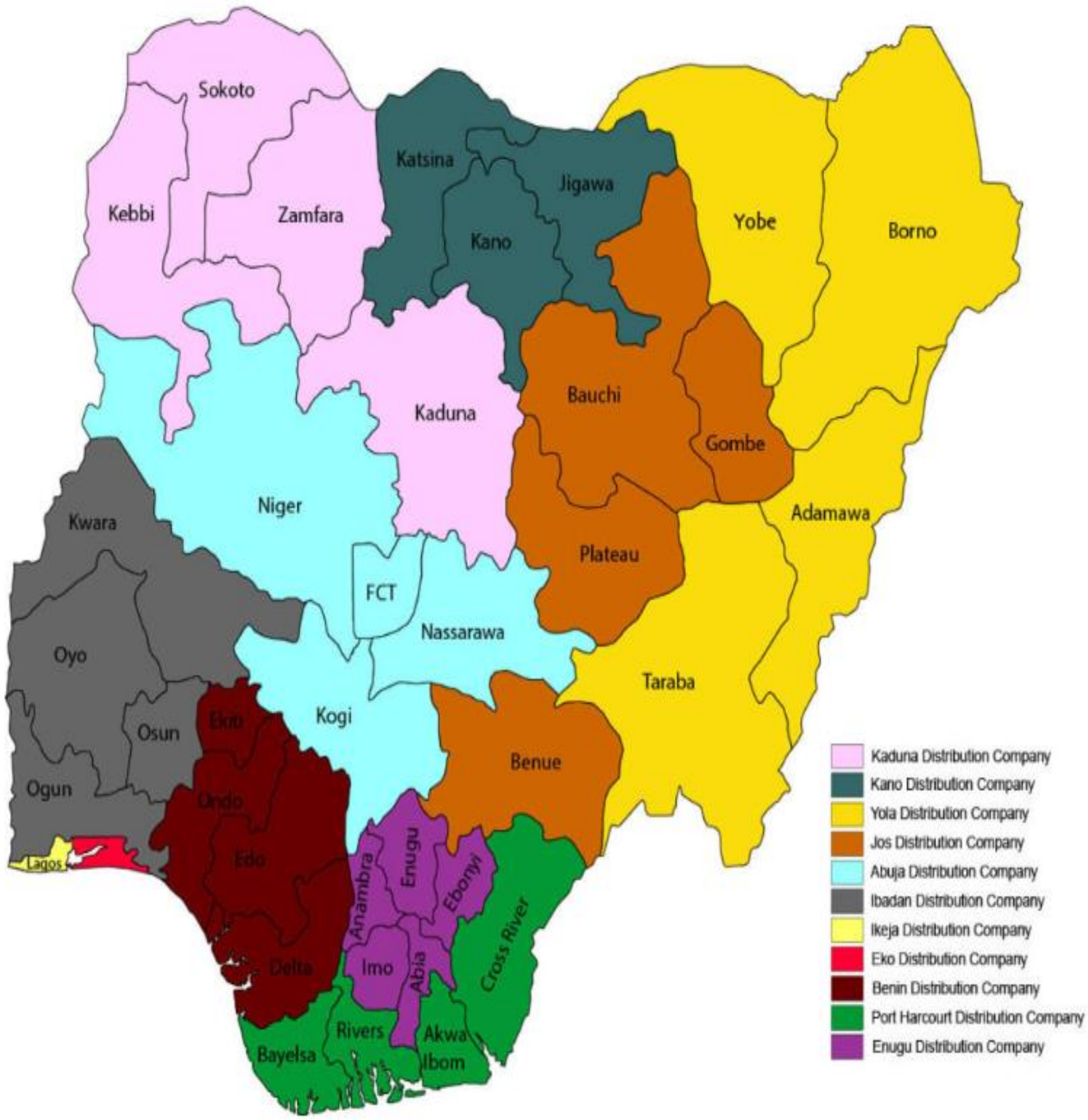
Source: Association of Nigerian Electricity Distributors (2019)

2.4.25: Electricity Distribution Companies in Nigeria and Their Locations

Figure 2.5 shows that Kaduna Electricity Distribution Company in pink color covers four (4) states namely: Kaduna, Kebbi, Sokoto and Zamfara. Kano Electricity Distribution Company covers three states namely: Katsina, Jigawa and Kano. Yola Electricity Distribution Company in bright yellow colour has four States under its area of operation as follows: Taraba, Adamawa, Yobe and Borno. Jos Electricity Distribution Company is brown colour operates in Fourstates as follows: Benue, Plateau, Bauchi and Gombe. Abuja Electricity Distribution Company in light blue colour has three States and the Federal Capital territory under its jurisdiction as follows:

Niger, Nassarawa, Kogi and Abuja (the Federal Capital). Next is Ibadan Electricity Distribution Company in ash colour operating in four States as follows: Kwara, Oyo, Osun and Ogun. Ikeja Electricity Distribution Company in light yellow colour and Eko Electricity Distribution Company in red colour both operate in one state which is Lagos state. Benin Electricity Distribution Company covers four States namely: Ekiti, Ondo, Edo and Delta. Port Harcourt Electricity Distribution Company in green colour operates in Four states which are: Cross-River, Rivers, Akwa Ibom and Bayelsa. Last but not the least is Enugu Electricity Distribution Company in purple colour. It covers five states namely: Anambra, Enugu, Ebonyi, Imo and Abia.

Nigeria's map showing the Eleven Electricity Distribution Companies and areas of Coverage



Source: ANED (Association of Nigerian Electricity Distributors 2019)

Figure 2.5: All Eleven Electricity Distribution Companies and Areas of Operation

2.4.26: Insight into Electricity Theft

Electricity is generated at a number of power plants, most of which are located far from load centres or end-users. Wires, transformers, and conductors are then used to transport it to end-users. A portion of the energy is wasted during transmission and distribution. In the electricity system, this is referred to as transmission and distribution (T&D) losses can be subdivided further into Technical losses (TL) and non-technical losses (NTL). Power dissipation in transmission lines, transformers, and other power system components causes technical losses, which are unavoidable. It is possible to calculate technical losses (TL) in transmission and distribution (T&D) using data on total load on the grid and total energy billed (Soma et al 2010).Non-technical losses (NTL) are caused by actions outside of the power system or by loads and conditions that the technical losses computation often overlooks. They are more difficult to measure because these losses are frequently unaccounted for by the electricity system operators and thus have no recorded data. Theft of electricity accounts for a significant portion of NTL. It's worth noting that utilities bill for power based on readings displayed on meters at the consumer's interface, unless electric meters have yet to be placed and electricity consumption is approximated. It's worth noting that electricity theft can only be investigated in areas where either prepaid or post-paid meters are available.

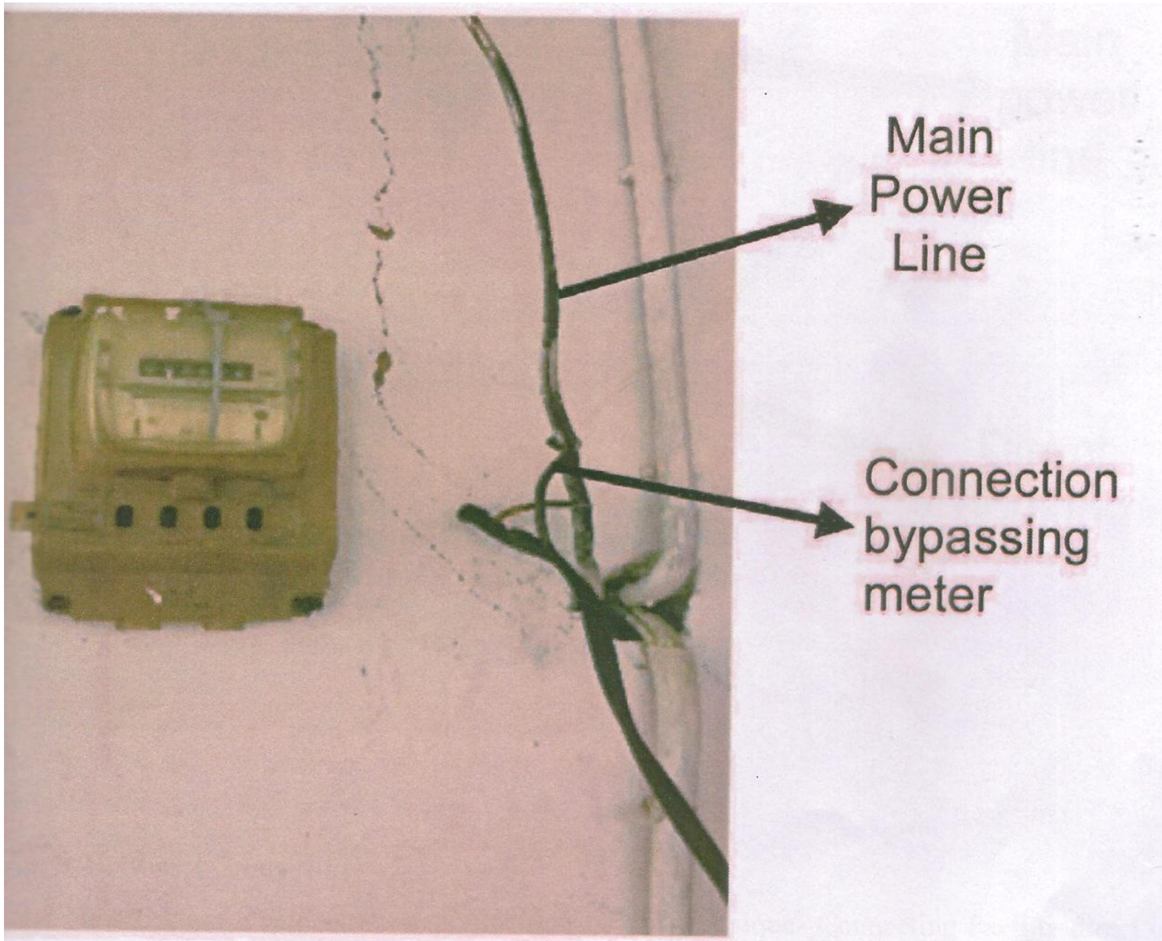
Utilities designate their personnel to various duties, such as maintenance, power retailing, and theft detection, among others, in order to provide electricity to their customers. Customers are directly interacted with by a utility staff functioning as an agent, who may cooperate with some of them. By receiving bribes from customers, the agent may be able to assist them in concealing their true electricity consumption. This illegal arrangement may benefit both the corruptible staff and the clients.

Electricity theft can be defined as an issue involving faulty recording, less than real reporting (workers collude with users to conceal actual consumption in order to generate illicit private money), and low recovery (non-payment from consumers).

In summary, there are four basic ways to unlawfully obtain electricity (Smith, 2004). Illegal hook-ups, meter manipulation or bypass, billing inconsistencies, and unpaid payments are among ways that electricity can be fraudulently obtained. When electrical lines are directly connected to the grid system from a person's home, this is known as an illegal hook-up. It's also quite simple to spot. Because meter tampering is technically complex and usually necessitates some electrical wiring knowledge, it is assumed to be less common among poor houses. By placing a device into the meter, meter tampering can be accomplished, resulting in an incorrectly reduced reading on the meter. Only an audit of the premises or anomalies in the electricity bill might reveal this tampering. Meter bypass happens when some of the premises' wiring is designed to avoid passing through the meter. This is far easier to detect than meter tampering (Steadman 2009). Meter bypass is a popular practice used by electricity thieves in both Ikeja Electric and Eko DisCo's networks, according to both companies.

2.4.27: Practical Demonstration of Electricity Theft Techniques

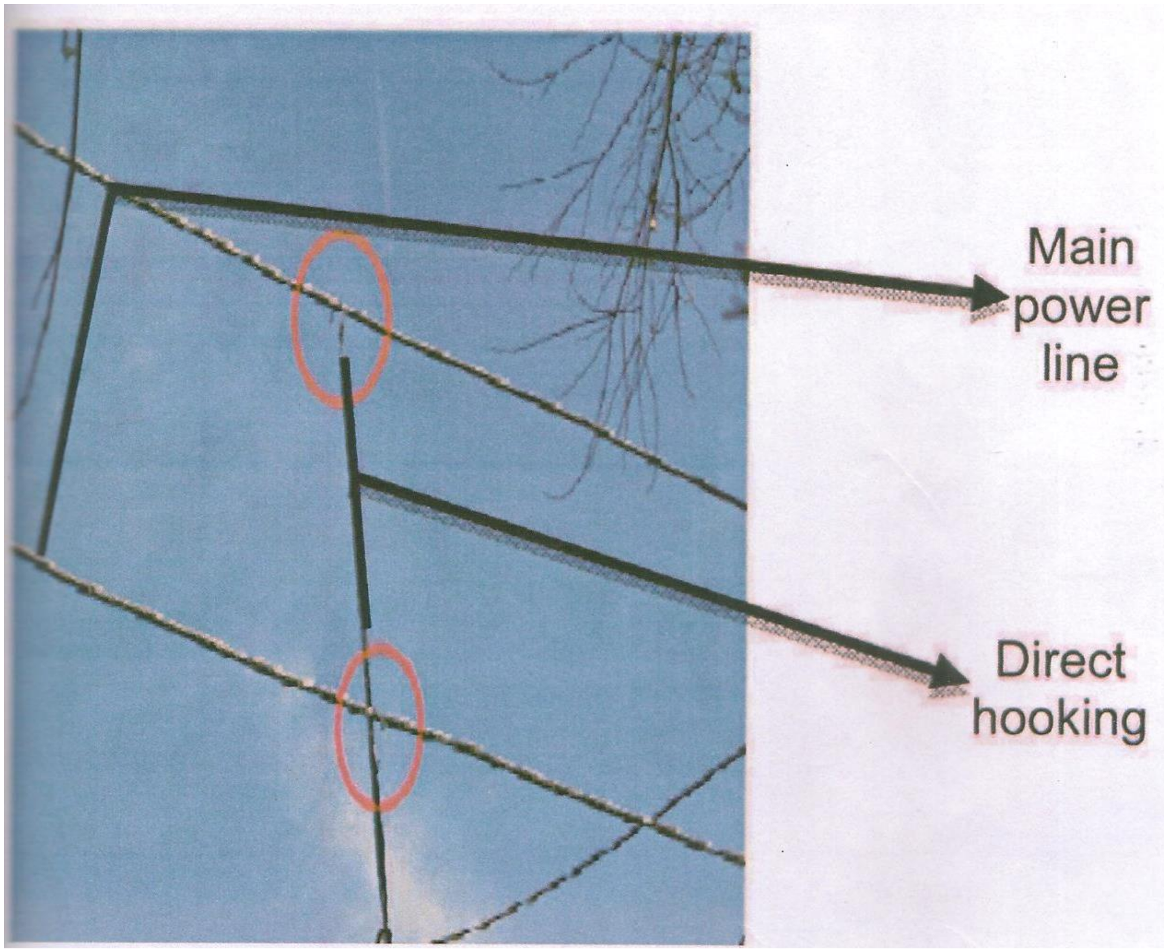
In figure 2.6, the wire from the overhead cable (Main Power Line) meant for the meter to record units of electricity consumed has been connected directly to the Customer’s facility without passing through the meter. Electricity consumed is therefore unrecorded and unpaid for. This method is called Meter Bypassing.



Source: Hussain, Z.et al (2017)

Figure 2.6: Demonstration of Electricity theft technique – Bypassing Meter

Figure. 2.7 shows a different variant of electricity theft technique. The Customer connects his facility directly to the overhead cable (Main Power Line). No meter is used and as such, units of electricity consumed cannot be recorded or paid for. This method is called Hooking.



Source: Hussain, Z. et al (2017)

Figure. 2.7: Further Demonstration of Electricity Theft technique – Connecting Facility direct to the overhead Cable.

CHAPTER THREE

THEORETICAL FRAMEWORK AND METHODOLOGY

3.0. Overview

The theoretical framework and methodology are discussed in this chapter. There are two main sections in the chapter. The theoretical framework is discussed in Section 3.1, while the methodology containing model specification, sampling strategies, data analysis and estimation techniques are discussed in section 3.2.

3.1 Theoretical framework

The theoretical framework of this study is rooted in energy (electricity) demand theory. However, the energy demand theory is made up of ideal energy demand and illegal energy demand.

$E^{dd} = E^{Id} + E^{IL} = f(P,Y,SD \text{ factors})$ …….. …….. ………… (1)

E^{Id} = Ideal electricity demand ……….. ………… ….. (2)

E^{IL} = Illegal electricity demand ………. ………… ………… (3)

E^{dd} = Total electricity demand by households

P = Price of electricity (Electricity tariff)

Y = Income of electricity end-users

$E^{IL} =$ ET: Illegal electricity demand = Electricity Theft (ET)

SD factors = Socio-economic and or demographic factors associated with E^{IL}

Apart from the normal factors, there are peculiar factors that determine illegal electricity demand. They are captured by the SD factors to include gender of respondents, frequency of power outage, lack of punishment of earlier offenders, bribery and corruption, weak legal enforcement, non-availability of task force and presence of micro business using electricity to function among residential apartments.

The principle for calculating and analysing energy consumption is no different than that for any other commodity from an economic standpoint. In analysing energy markets, there are certain characteristics of energy demand, institutional elements of energy markets, and measurement issues that require special consideration. Energy demand, however, has the same microeconomic underpinning as other commodities. Energy demand can arise for a variety of reasons. Households spend energy to meet specific requirements, and they do so by allocating their income among competing wants in order to maximize satisfaction from total expenditure. Industries and commercial users need energy as a manufacturing input, with the goal of lowering total production costs. Demand for energy can arise for different reasons. Households consume energy to satisfy certain needs and they do so by allocating their income among various competing needs so as to obtain the greatest degree of satisfaction from total expenditure.. In effect, while being a derived need, the demand for electricity is determined by the consumers' real income, the price of electricity, the price of its replacements, the kind of consumers, the degree of urbanization, and the prior level of power consumption.

However, the focus of this research is on unlawful electricity usage, which Becker's economic theory of criminal behaviour can explain. The most common method for modelling household consumer behaviour in terms of electricity theft is to employ risky decision-making economics and assume that the household is an expected-utility maximiser.. Domestic electricity customers are thought to be risk averse and connected to the grid. He or she can, however, illegally steal electricity from the grid by interfering with or circumventing the utility's electric meter, or by any other methods.

The individual's decision is based on a comparison of the anticipated benefits with the associated risk and costs. Power theft is comparable to obtaining a risky item, whereas completely paying for electricity usage is comparable to gaining a secure asset. As a result, stealing electricity becomes a portfolio decision that follows the Von Neumann-Morgenstern axioms for uncertain behaviour.. One potential issue in this approach is its emphasis on the fact that people should not enjoy taking risks in the first place. In this situation, they should not enjoy committing crime for the sake of it.

3.2.3.1 Electricity Theft: Dishonest Consumers

The standard approach to model the behaviour of electricity stealing consumer is based on the economics of decision-making under risk with the presumption that the individual involved is an expected-utility-maximiser. We assume that the electricity consumer is risk averse and is connected to electricity grid. However, he/she can extract electric power from grid illegally either through meter-tampering or by-passing the electricity meter of the utility if he/she chooses. The decision of the individual is based on comparing the associated expected benefits with the risk involved and expected costs. In particular, paying fully for electricity consumption can be viewed as purchasing a safe asset, while electricity theft is analogous to purchasing a risky asset. Therefore, electricity theft decision facing an individual essentially becomes a portfolio selection that conforms to the Von Neumann-Morgenstern axioms for behaviour under uncertainty.

A consumer faces the choice of whether or not to commit electricity theft. What he/she will gain from engaging in electricity theft depends on a number of random factors, some of which are assumed to be known to him/her before he/she makes the decision. Assume that the average electricity price is α and individual consumes C units of electricity that has the value $R = \alpha.C$, measured at a particular point in time when he is assumed to pay. The electricity stealing consumer conceals an amount $T= (C - X)$ units and pays only for X units whereas T units become a part of distribution losses of utility. Hence, utility charges an amount $r = \alpha.X$, and his/her pecuniary gain equals $G = \alpha.T$ which is only a fraction of the total due payment. Since the amount of electricity stolen T is endogenous it is difficult to interpret the actual gain for the electricity stealing consumer.

Therefore, to make the relationship interpretable, we use a constant amount of theft i.e. $\check{T}$ such that $\check{T}$ is the maximum amount of electricity that could be stolen by a client. Let us assume the electricity tariff rate α to be fixed for simplicity and ignore the implications on electricity theft of prevailing multiple block pricing where tariff rate rises for each higher block consumed. The choice for the consumer lies in two alternative options, either to pay in full for the electricity consumed or steal electricity. One of the two outcomes is expected if he/she chooses the latter option. The consumer may be able to conceal electricity theft or be detected with probability p. The probability of detection is assumed to depend on the surveillance expenditures. As a general rule, the fines or sanctions imposed on the offender depends on the harm to society due to the offence [Becker (1968)].

In case of detection the consumer has to pay a fine f, where fine is assumed to exceed the value of electricity theft that is, $f > \alpha \check{T} > 0$. If a consumer engaging in electricity theft succeeds in hiding his/her crime, the value of illegally consumed electricity is his/her pecuniary benefit. We ignore the cost of other risks and focus mainly on the risk of detection and lost reputation and money due to fine. The non-pecuniary reputation cost in case of detection depends on the society's behaviour towards the crime. Although the moral psychological cost is also involved, yet it may be insignificant. Since the individuals notice how others behave, the pilferage decision fundamentally becomes interdependent.

In general, if a household engages in electricity theft and is caught and prosecuted, the fine imposed on them will be equal to the financial loss. Given that the expected utility without bribing is:

$$E(U) = (1-p).U(Y+G-\rho) + p.U(Y+G-f-d-\rho)\ldots.\ \ldots..\ \ \ldots\ldots \quad (4)$$

where:

U = Utility function of riches including monetary benefit of electricity theft. The function is assumed to reflect risk aversion, that is, $U' > 0$ and $U'' < 0$;

Y = Riches of the customer;

G = Monetary advantage in the form of dishonest saving through electricity theft that equals electricity price '$\boldsymbol{\alpha}$' multiplied by the amount of electricity stolen ***'T';***

p = The likelihood that the household that engages in electricity theft will be identified and convicted. It is expected that the prospect of being caught is independent of the amount of theft, although in practice, the utility surveillance expenditures may be based on the amount of electricity consumption or losses;

f = Fine received from the household representative who is convicted for electricity theft. The fine or penalty can be monetary or non-monetary in nature, but this variable measures the financial cost in case of detection. It is assumed that the fine or penalty is influenced by the assessed illegal private benefit to the consumer. It may also include the cost of obtaining new connection in case of power cut as a penalty for theft;

d = Money equivalent to non-financial value of reputation cost, and

ρ = Money equivalent to non- financial value of moral satisfaction loss.

In summary, an individual will engage in electricity theft if and only if,

$$(1-p).U(Y + G - \rho) + p.U(Y + G - f - d - \rho) > U(Y) \quad \ldots\ldots\ \ldots.\ \ldots\ldots \quad \ldots\ldots \quad (5)$$

3.2.3.2 Electricity Theft: Involving Corruption among Consumers and Utility Employees

The consumer (client), utility employee (agent), and utility/government are the major participants in our three-layered (principal-agent-client) model of power theft with corruption. Because the utility employee has direct contact with the customer, he or she functions as the principal's agent. Essentially, we're interested in the interaction between the agent and the client. The agent's discretionary powers contribute to corruption in the electricity retailing industry. In this study, corruption is defined as an illegal transaction between an agent and a client, as well as the misuse of office or discretionary power for personal gain. Electricity is a big source of rent-seeking for bureaucrats. The principal's ability to impose strict rules and keep a tight eye on the agent limits the agent's behaviour. Because complete monitoring is too expensive, employees are frequently given considerable flexibility under the standards.. The level of corruption at a utility may be determined by the degree of imprecision in the application of rules and the cost of monitoring the personnel.

The principal may be fully informed about its revenue loss and the amount of electricity stolen by customers, but it will not be able to discriminate between honest and corruptible consumers until the agent tasked with monitoring detects electricity theft. To decrease the risk of conviction, the corruptible agent may collude with consumers and divide payoffs with supervisors and co-workers. As a result, the net compensation for him is only a portion of the entire bribe received.

Assume a utility employee, say a meter-reader, is tasked with reporting the amount of power consumed by customers. A customer must decide whether to steal electricity by paying a little bribe to the meter reader. He/she will decide whether or not to engage in corruption based on the cost and value of doing so. Allow the individual's financial benefit to be G minus the bribe payment b. The bribe payment dilutes the deterrent effect by lowering the likelihood of detection. If the consumer is caught, he or she must pay a fine f,

where

$$f > (G - b) > 0.$$

The pecuniary benefit may lead the agent to accept bribe in exchange for favouring the client in reducing its electricity charges. As a result, the agent will report X units of electricity. Since electricity is charged on the basis of meter reading and the meter reader reports electricity consumption to the principal hence petty corruption prevails in the sector and is of recurrent nature. With a probability of p, the principal can detect electricity theft. If an agent is charged with accepting a bribe from a customer and is found guilty, he may be fired and fined $\eta > 0$. Likewise, the condemned client must pay a fine of $f > 0$. The penalty for corrupt agents η and fines for convicted consumers' f must be smaller than their individual wealth for deterrence to be practical. The consumer's gain from electricity theft is equal to $(G - b)$, while that of agent equals b, the bribery receipt. The financial loss of the principal equals G, which consequently results in the social cost of theft to other consumers. The client faces the choice whether or not to steal electricity consumed at some given probability of being caught. Below, we model separately the behaviour of the client towards electricity theft with corruption as well as the agent towards accepting bribe.

(i) Given the client's affluence, he or she will provide a bribe if the predicted profit exceeds the honest payment for the electricity spent. I.e. if G – pf is positive.

$$(1 - p)\ U(Y + G - b - \rho) + p.U(Y + G - b - f - d - \rho) > U(Y - \alpha.C) \ \dots \ (6)$$

Keeping all parameters the same as described in Equation (1) and,

b = the bribery paid to get the favours of the agent.

Presumably, a higher fraction of total electricity stealing risk-averse clients opt bribe payment to conceal actual electricity consumption with reduced probability of detection. The incidence of theft in this case, essentially depends on policy variables including; tariff rate (r), amount of fine or penalty (f), probability of detection (p), and reputation cost associated with electricity theft. Presumably, a greater proportion of overall electricity theft risk-averse clients choose bribe payment to disguise actual electricity usage with a lower chance of discovery. In this scenario, policy variables such as tariff rate (r), amount of fine or penalty (f), probability of detection (p), and reputation cost associated with power theft all influence the incidence of theft.

(ii) The behaviour of the utility employee or agent towards corruption can be explained. We compare the agent's predicted advantage in terms of wage, bribes, and cost in the event of conviction, as well as the penalty and termination from the position. Let w 0 be the salary rate in a different employment, which is estimated to be lower than w in the electricity company. Let us assume that if he/she is caught, he/she will be fined ŋ> 0 and fired from their job.

$$E(U) = 1 - p\ .U(w + b) + p.U(w\ 0 - ŋ) \ \dots \ \dots \ \dots \ \dots \ (7)$$

Only if the predicted return is greater than his or her legitimate income would an agent take a bribe for facilitating electricity theft. If the agent is risk averse, he or she will accept a bribe if and only if,

$$(1 - p).\ u(w + b) + p.u(\ w\ 0 - ŋ) > u(w) \ \dots \ \dots \ \dots \ (8)$$

Because we assume the agent's utility function is linear, expected utility maximisation is the same as expected income maximisation. The principal can control the following policy variables to reduce the agent's corruption with electricity theft: utility wage rate (w), penalty rate (ŋ), probability of detection (p), and reputation (d). These policy variables include economic, social, legal and governance issues, all of which can be carefully managed to obtain the desired outcomes for a long-term power business

3.3 Methodology

3.3.1 Model Specification

Based on the theoretical framework, the following analytical framework and model were developed to capture issue of prevalence and effects as well as the determinants

Analytical framework for prevalence and effects: Prior studies on prevalence and effects of electricity theft are scanty. Methodologies used in the literature include comparative analysis (Smith 2004) and simple descriptive statistics such as pie chart, bar chart and percentages (Mbanjwa 2017). In this study, Mbanjwa's (2017) methodology has been adopted to capture the prevalence and effects of electricity theft due to the nature of data available (primary data).

Analytical specification for determinants: Also, in the literature, studies such as Jamil and Ahmad, (2013), Katiyar, (2013), Depuru, *et al*. (2011) and Nielsen, (2012) identified a number of factors that could influence electricity theft around the world as including: price of electricity (electricity tariff), income of end-users, delay in supply of electricity connections, frequently interrupted power supply, collusion with utility employees and socio-economic characteristics such as poverty, literacy, urbanization, number of transformers and households electrified, among others. One peculiarity of these studies is their use of a quantitative method to measure incidence of electricity theft. Given the number of factors capable of causing electricity theft as identified earlier, it has also been properly documented that the consequences of electricity theft included power outage resulting from illegal connections which in turn leads to transformer damage, and the external cost imposed on honest end-users in terms of high electricity tariff.

This study used probit regression to identify the factors that could prompt end-users to want to steal electricity. The dependent variable, which in this case is electricity theft proxy by meter bypass, was made a response variable so as to measure the propensity of end-users to steal electricity given a number of incentives and or disincentive factors which constituted the explanatory variables. Building on the findings of previous studies and extending them, the electricity theft model to estimate was specified as follows:

$$E^{IL}ti = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \beta_9 X_{9i} + \beta_{10} X_{10i} + \beta_{11} X_{11\mathrm{i}} + \beta_{12} X_{12i} + \beta_{13} X_{13i} + \beta_{14} X_{14i} + \beta_{15} X_{15i} + \mu_i \quad (3.1)$$

X_{1i} = *Age group*$_i$

X_{2i} = *Gender*$_\mathrm{i}$

X_{3i} = *Level of education*$_i$

X_{4i} = *Occupation*$_i$

X_{5i} = *Accommodation*$_i$

X_{6i} = *Use of electric meter*$_i$

X_{7i} = *Status on property*$_i$

X_{8i} = *Price of electricity*$_i$

X_{9i} = *Briber and Corruption*$_i$

X_{10i} = *Lack of punishment*$_i$

X_{11i} = *Non-availability of task forceto check E-theft*$_i$

X_{12i} = *Presence of micro-business in the household*$_i$

X_{13i} = *Weak legal enforcement*$_i$

X_{14i} = *High level of poverty*$_i$

X_{15i} = *Unemployment*$_i$

ETt_i = *Electricity theft*

μ_i = *Stochatic error term*$_i$

All the variables and coding frame are defined in the questionnaire (see Appendix 1) β, β_1, β_2, β_6, β_8, β_9, β_{10}, β_{12}, β_{13}, β_{14}, β_{15} are the parameter estimates from the probit regression while μ_i is the stochastic error term.

3.3.2. A priori Expectation

$\beta_1 > 0$, $\beta_2 < 0$, $\beta_3 < 0$, $\beta_4 > 0$, $\beta_5 > 0$ or < 0, $\beta_6 < 0$, $\beta_7 > 0$ or < 0, $\beta_8 < 0$, $\beta_9 < 0$ $\beta_{10} < 0$, $\beta_{11} < 0$ $\beta_{12} < 0$, $\beta_{13} < 0$, $\beta_{14} < 0$, $\beta_{15} < 0$.

3.3.4. Data type and sources

This study adopted the use of survey technique to obtain the required data on determinants of electricity theft among households in Lagos, Nigeria. The electricity consumers focused upon were those that were classifiable under the residential category. It was assumed that the factors that motivated individuals using pre-paid meter to steal electricity might be different from that of a post-paid meter user. In low income communities in the suburb of Lagos state, Nigeria, there was mostly one meter for a household, even though there were many rooms in some of the houses. The population of such households often ranged from five to twenty. In the middle income neighbourhoods, there were flats in each house with each person using one meter; there were often as many as ten flats in a house. It was assumed that, if ten people decided to steal electricity, their reasons might be different from that of one person stealing electricity.

Electric meter users were categorised into prepaid meter users and post-paid meter users. It was assumed that the two groups of consumers might be motivated by different reasons to steal electricity. Where meters were not provided, provision was made for respondents on estimated billing system. Survey methodology was used. To gather the required data, a self- structured questionnaire was developed. The questionnaire shown in Appendix 1 had five closed-ended questions and one open-ended question where respondents were asked to give a comment, bordering on their choice of reasons they believed would make customers engage in electricity theft.

In terms of sampling technique, a multi-stage sampling technique was used to obtain a sample of 500 households in the study area. In the first stage, the area was purposively divided according to electricity business districts. In all, there are thirteen electricity distribution districts under the area of franchise of both DisCos; seven districts under Eko DisCo (Agbara, Apapa, Festac, Ijora, Lagos Island, Lekki and Mushin) and six districts under Ikeja Electric Plc (Abule Egba, Ikeja, Ikorodu, Oshodi, Shomolu and Akowonjo). All the electricity distribution districts were covered by the survey. The second stage involved a selection of neighbourhoods of similar residential density characteristics such as: high, medium and low residential areas. In the third and final stage, the study areas were randomly selected. The choice of the technique was made in order to give equal representation to all the households in the areas of franchise under the two electricity Distribution Companies in Lagos State. The questionnaires were designed to collect data on basic information relating to their socio-economic characteristics, factors contributing to electricity theft, determinants of electricity theft, its prevalence and effects in their respective places of abode. One questionnaire was administered to each household's head/representative that had adequate information about the household's electricity consumption pattern.

The researcher and the trained research assistants carried out the field survey in a manner designed to achieve high level of accuracy. Given proximity between households under Ikeja and Eko electricity Distribution Companies license areas and the need to collect accurate information, the questionnaires were given and collected instantly. For proper completion of the questionnaire, the team was instructed to interview the households' heads so as to ascertain the correctness of the information submitted. Where the households' heads were not available, the households' representative was the next to be interviewed A total of 580 households were sampled. However, out of the 580 questionnaires administered, only 500 were returned (86.2%) for analysis.

3.3.5 Data analysis and estimation technique

The information from the questionnaires administered was collated, scored and computed using statistical software called SPSS, (version 25) before being moved to STATA 15 software for further analysis. For all the questions raised in the questionnaire, the respondent's options were analysed in accordance with various descriptive statistical tests such as frequency counts, simple percentages and probit regression.

3.3.6 Sample Design and Related Issues

In determining the sample size for the survey, the following procedures were followed:

- ❖ Population of residential electricity end users under each DisCo used for the study was based on the figures received from MYTO,
- ❖ Residential electricity end users under each DisCo were purposively selected taking into consideration ownership of smart meters or absence of smart meters. At the time of survey, 40% of Ikeja Electric Plc customers and 60% of Eko electricity distribution customers did not own smart meters.
- ❖ Sample size determination formula was then applied
- ❖ Structured questionnaire was randomly administered to the electricity end users

The magnitude of the variables imputed in the sample size formula is as follows:

i. Population size (N): The number of electricity customers (R2 subclass); Ikeja Electric DisCo) = 700,000; .Eko DisCo = 494,000

ii. Confidence Interval (e): No sample is perfect; a confidence interval of ±5% was used by the researcher.

iii. Confidence level (Z): A 95% confidence level was used. The corresponding value of the 95% confidence level in the Z-table is 1.96 from the Z-score table.

iv. Percentage (P): A percentage of 50% was used. This is often the worst case percentage in determining the sample size needed for a given level of accuracy and to ensure that the sample size will be large enough in representing the total population.

The sample size adopted from Taro-Yamane (1967) determination formula is given as:

$$\text{Sample size} = \frac{Z^2 * P(1 - P)/e^2}{1 + (Z^2 * P(1 - P)/e^2N)}$$

Where $Z = 95\% = 1.96$, $P = 50\% = 0.5$, $e = \pm 5\% = 0.05$,

N = {Ikeja DisCo = 700,000, Eko DisCo – 494,000}

Substituting the above values into the sample size equation to determine the number of respondents required, thus:

Sample size = 330 for IE Plc and 250 for Eko DisCo.

The selected areas used were Abule Egba, Apapa, Festac, Ijora, Ikeja, Ikorodu, Lagos Island, Lekki, Mushin, Ojo and Oshodi under both areas of franchise of both Eko DisCo and Ikeja Electric. 580 households were administered questionnaires (a minimum of 250 for Eko DisCo and 330 for Ikeja DisCo), only 500 responses (representing86.2 per cent of the sampled households were retrieved and used for the analysis.

3.3.7 Validity and reliability of the instrument

To ensure the validity of this study instruments, a pre-test of the instruments was carried out among a population of 5o participants in Agbowo area in Ibadan a location deemed to have similar attributes to ensure that they met their actual purpose. Moreover, the study instruments were subjected to face validity assessments by the project supervisor and other experts in the field of this study. To ensure the reliability of the study instruments, Nunnally (1978) acceptable reliability coefficient of 0.7 and above was considered. Reliability coefficient was calculated using the formula for calculating Alpha (α).

Alpha is calculated using the following formula:

$$\alpha = K / (K - 1) [1 - (\sum\sigma^2{}_k / \sigma_{total}{}^2)],$$

where K is the number of items,

(∑σ2 k is the sum of the k item score variances, and

/σtotal2 is the variance of scores on the total measurement.

This calculation of the reliability coefficient has helped to examine the degree to which multiple measured variables of the same thing agreed with one another.

3.4 Ethical Considerations

The study was guided by the Generally Accepted Scientific Principles of Human Research Ethics. Ethical consideration of Confidentiality of data (ii) Beneficence of participants and (iii) Voluntariness were adhered to in the research. Thus, anonymity, confidentiality, beneficence and right of refusal and discontinuation were given and explained to research subjects. All subjects participated voluntarily without coercion. Respect for ethical considerations also informed the nature of confidential data analysis used as names of interviewees were not included in the data narratives.

CHAPTER FOUR

EMPIRICAL RESULTS AND ANALYSIS

4.0. Overview

This chapter presents the result of the study. The chapter is divided into sections starting with the socio-economic characteristics of the respondents. This is followed by analysis of determinants of electricity theft in Lagos state, effects of electricity theft in the city, summary of problem statement, summary of findings, some policy recommendations and conclusion. Some limitations and possible areas of further research are also discussed.

4.1. Analysis of Socio-economic and demographic characteristics of respondents

This subsection presents the descriptive statistics used in this study. In particular, it provides socio-economic characteristics of the respondents such as; their location by age; sex; educational level; occupational level; marital status, among others. This helps to understand the sampled location and features of households among these electricity distribution companies' end-users. The location distribution of sample questionnaire within areas in Lagos state is presented in Table 4.1. Thirteen electricity distribution business districts under both Ikeja and Eko electricity companies were sampled using random sampling technique. A total of 580 households were sampled. However, out of the 580 questionnaires administered, only 500 were returned (86.2%) for analysis. The breakdown of the returned questionnaire is presented in Table 5.1 shows that (6.0%) was returned from Abule Egba, (4.4%) from Apapa, (3.8%) from Festac town and (3.7%) from Ijora area of Lagos state.

Table 4.1: Location Distribution of Study Sample Area

Location	Frequency	Percent
Agbara	40	8.0
AbuleEgba	30	6.0
Apapa	22	4.4
Festac	19	3.8
Ijora	18	3.7
Ikeja	51	10.2
Ikorodu	21	4.2
Lagos Island	30	6.0
Lekki	16	3.2
Mushin	56	11.2
Ojo	37	7.4
Oshodi	23	4.6
Shomolu	39	7.8
Akowonjo	30	6.0
Total	500	100.0

Source: Field Survey, 2019

The other areas covered within Lagos state include Ikeja (10.2%), Ikorodu (4.2%), Lagos Island (6%), Lekki (3.2%), and Mushin (11.2%), Ojo (7.4%), Oshodi (4.6%) and Shomolu (7.8%) area of Lagos State. Thus, it can be deduced that more questionnaires were returned from Mushin area of Lagos state, under which the Eko electricity distribution company operates.

The age distribution of the respondents is presented in Figure 4.1. From the analysis, most of the respondents' sampled in the thirteen business districts of the Ikeja and Eko electricity distribution companies ranged between 21 and 40 years of age. As shown, 47.6% of the respondents were within the age bracket of 21 and 40 while 22.0% were within the age bracket of 16 and 20 years. The result also revealed that 25.6% of the sampled respondents fell within the age bracket of 41 and 64 years, while those aged 65 and above represented only 4.2% of the total sampled respondents. From the results, it can be deduced that most of the household sampled respondents were within their prime age (21-40 years).

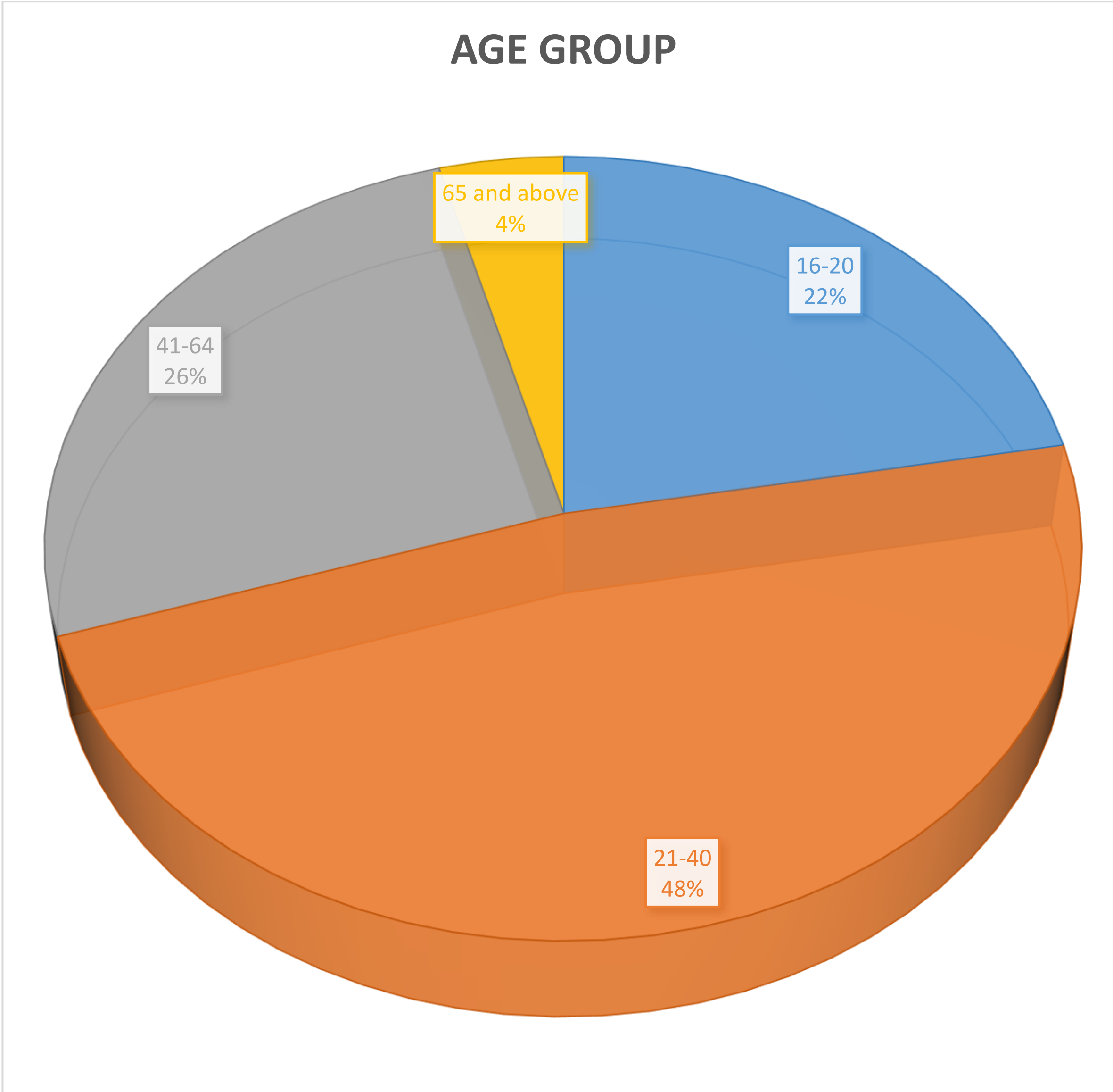


Figure 4.1: Age distribution of respondents
Source: Field Survey, 2019

The distribution of the respondents according to age is presented in Figure 4.1a to 4.1c. From the aggregate household analysis, most of the respondents' sampled in the twelve operating areas under both Ikeja and Eko electricity distribution companies ranged between 21 and 40 years of age. As shown in Figure 5.1a, 47.6% of the respondents were within the age bracket of 21 and 40 while 22.0% were within the age bracket of 16 and 20 years. The result also revealed that 25.6% of the sampled respondents fell within the age bracket of 41 to 64 years, while those aged 65 and above represented only 4.2% of the total sampled respondents. From the results, it can be deduced that most of the household sample respondents were within their prime age (21-40 years). For households under Ikeja DisCo only, 45.0% of the respondents were within the age bracket of 41 to 64 while 25.0% and 30.0% of the respondents were within the age bracket of 21-40 years and those aged 65years and above respectively.

Similarly, the distribution of respondents according to age under Eko DisCo showed that respondents aged 21 to 40 constituted 22.0%, while 52.0% and 26.0% of the respondents were within the age bracket of 41-64 years and those aged 65 years and above respectively.

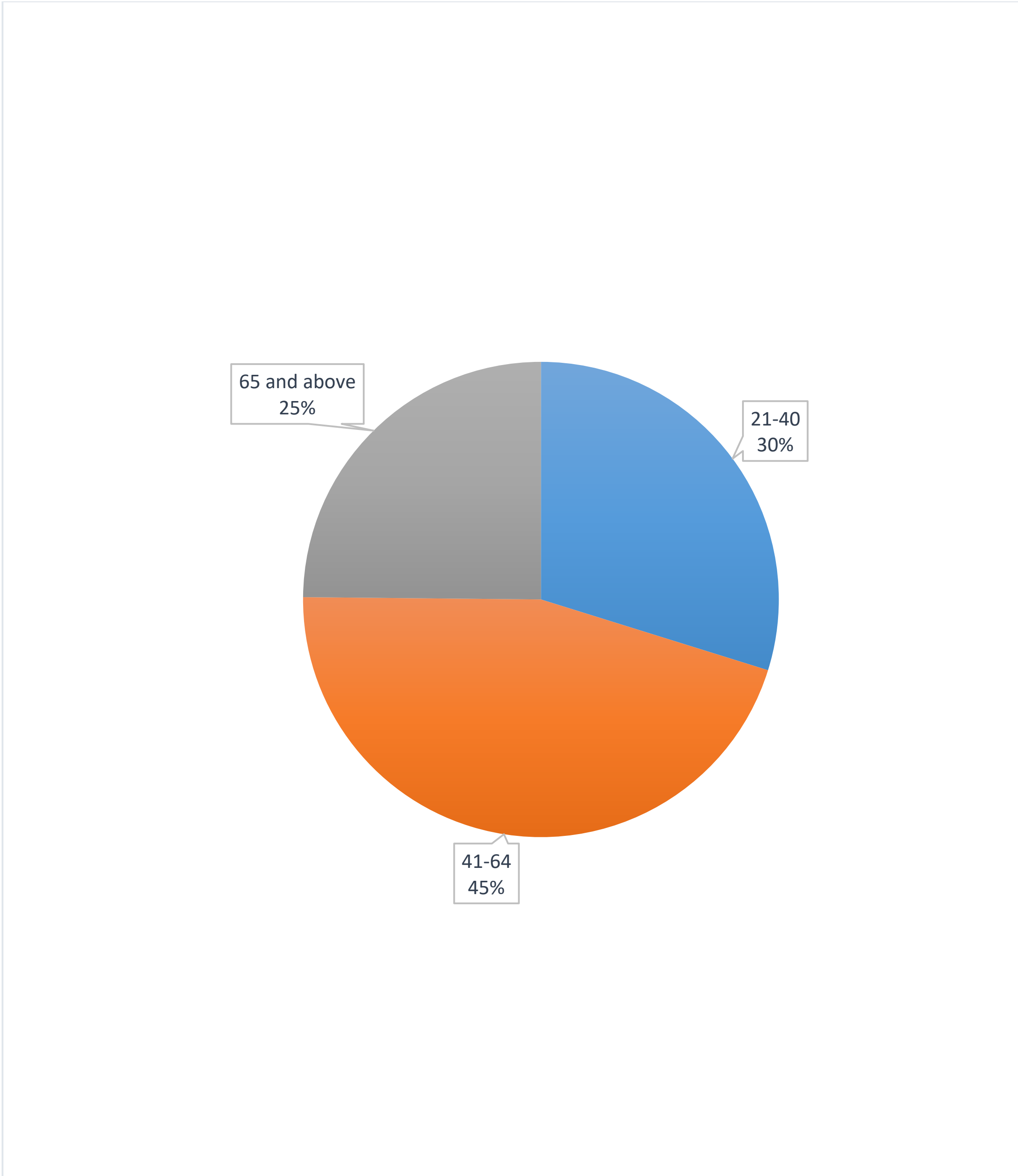


Figure 4.1b: Age distribution of respondents (Ikeja Electricity Distribution Company)
Source: Field Survey, 2019

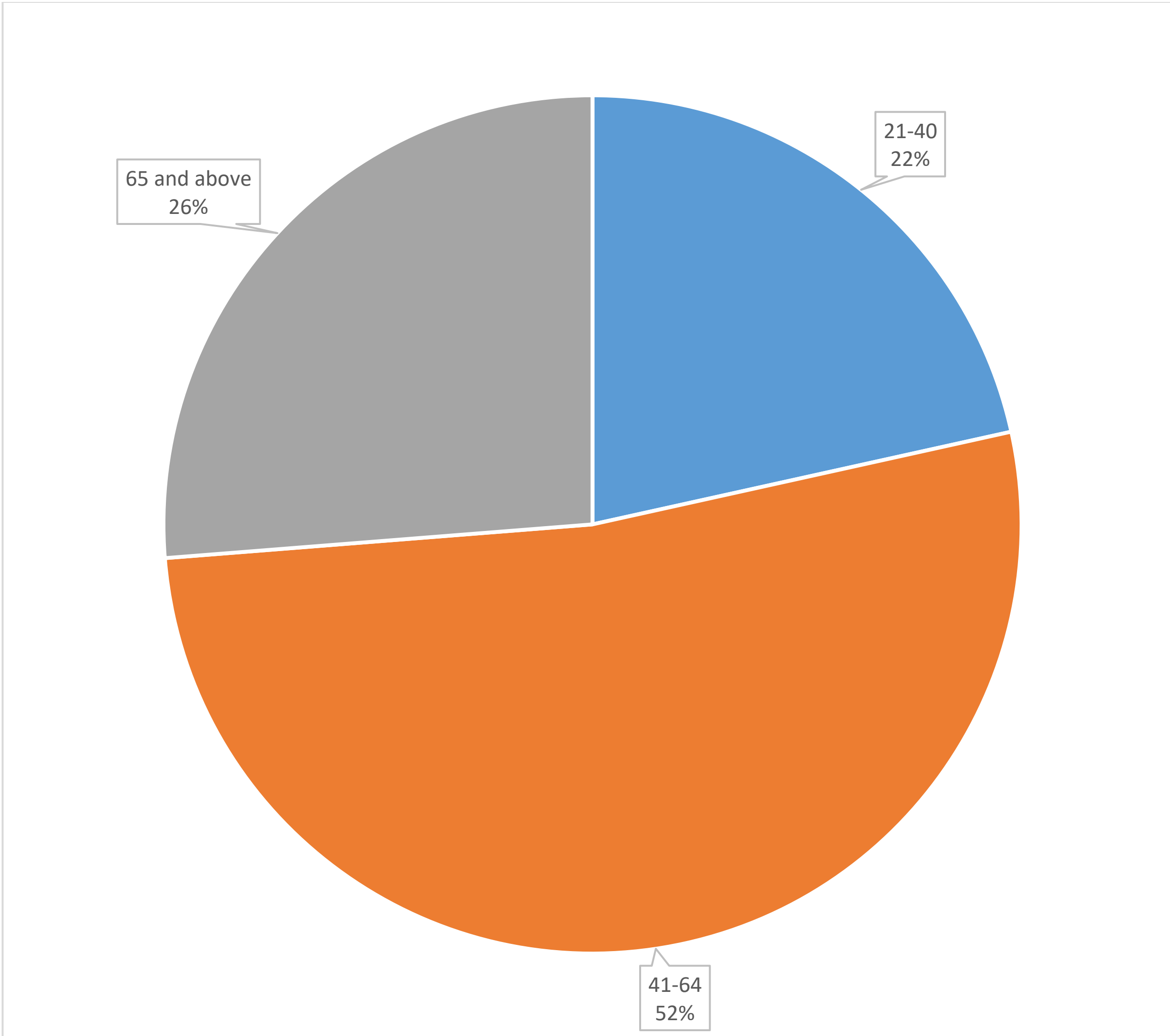


Figure 4.1c: Age distribution of respondents (Eko Electricity Distribution Company)
Source: Field Survey, 201

The distribution of the sampled household respondents according to gender is presented in Figure 4.2a through 4.2c. Figure 4.2a shows that most of the household respondents sampled were males. As highlighted in the diagram; out of a total of 500 respondents, 51.4% were males and 48.6% were females. This implies that majority of the household respondents sampled in the twelve areas of study covered by Ikeja and Eko electricity distribution companies were males. Figure 4.2b represents Ikeja electricity household representatives sampled. From the Figure, 51.0% were males and 49.0% were females, while Figure 4.2c shows that there were more female respondents (53.0%) under Eko electricity distribution company area than males (47.0%).

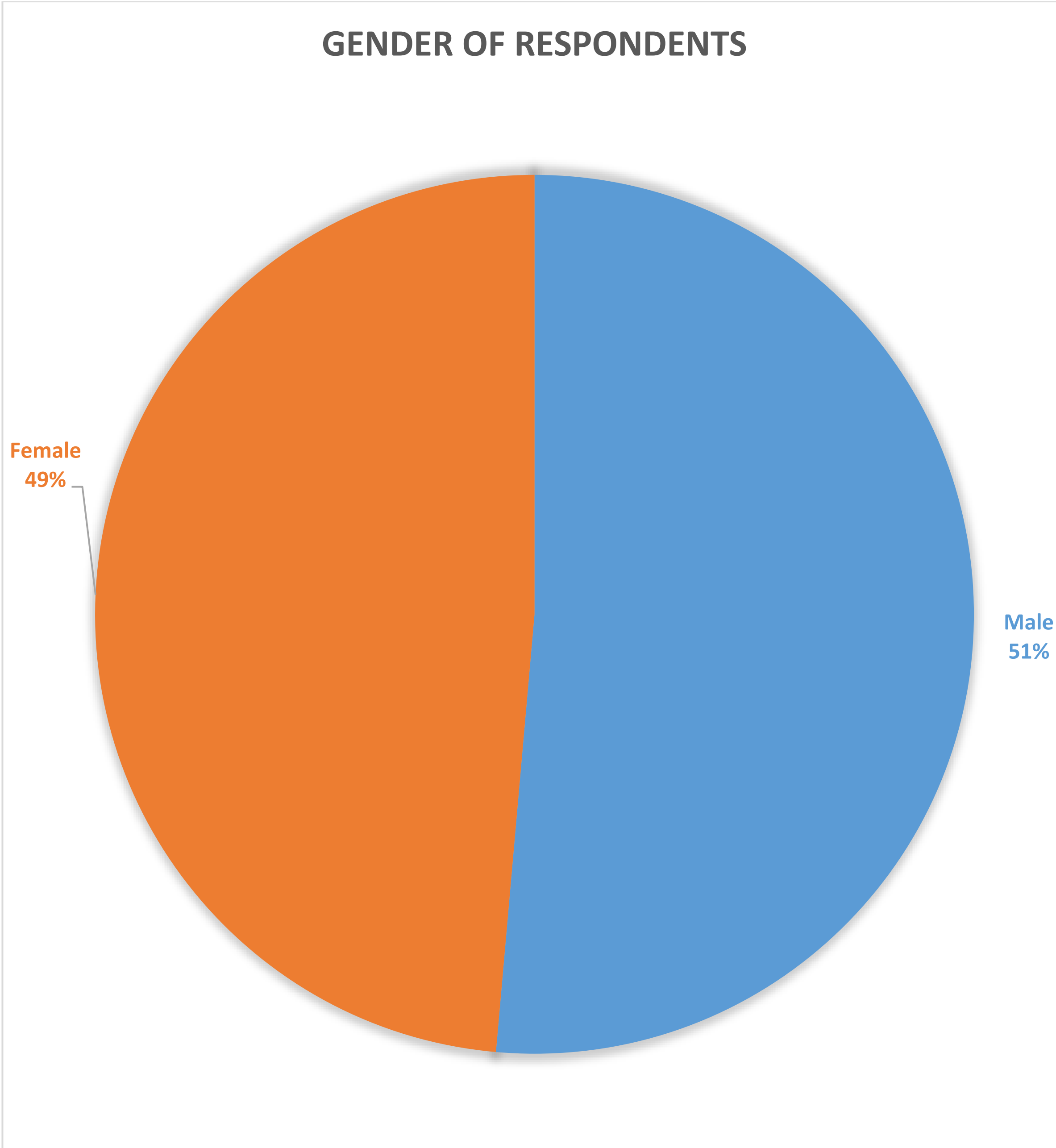


Figure 4.2a: Gender distribution of all respondents
Source: Field Survey, 2019

The distribution of sampled household respondents according to gender is presented in Figure 4.2. It can be inferred that most of the household representatives sampled were males. As highlighted in fig 4.2, out of a total of 500 respondents, 51.4% were males and 48.6% were females. This implies that most of the household respondents sampled in the twelve areas covered by Ikeja and Eko electricity distribution companies were males.

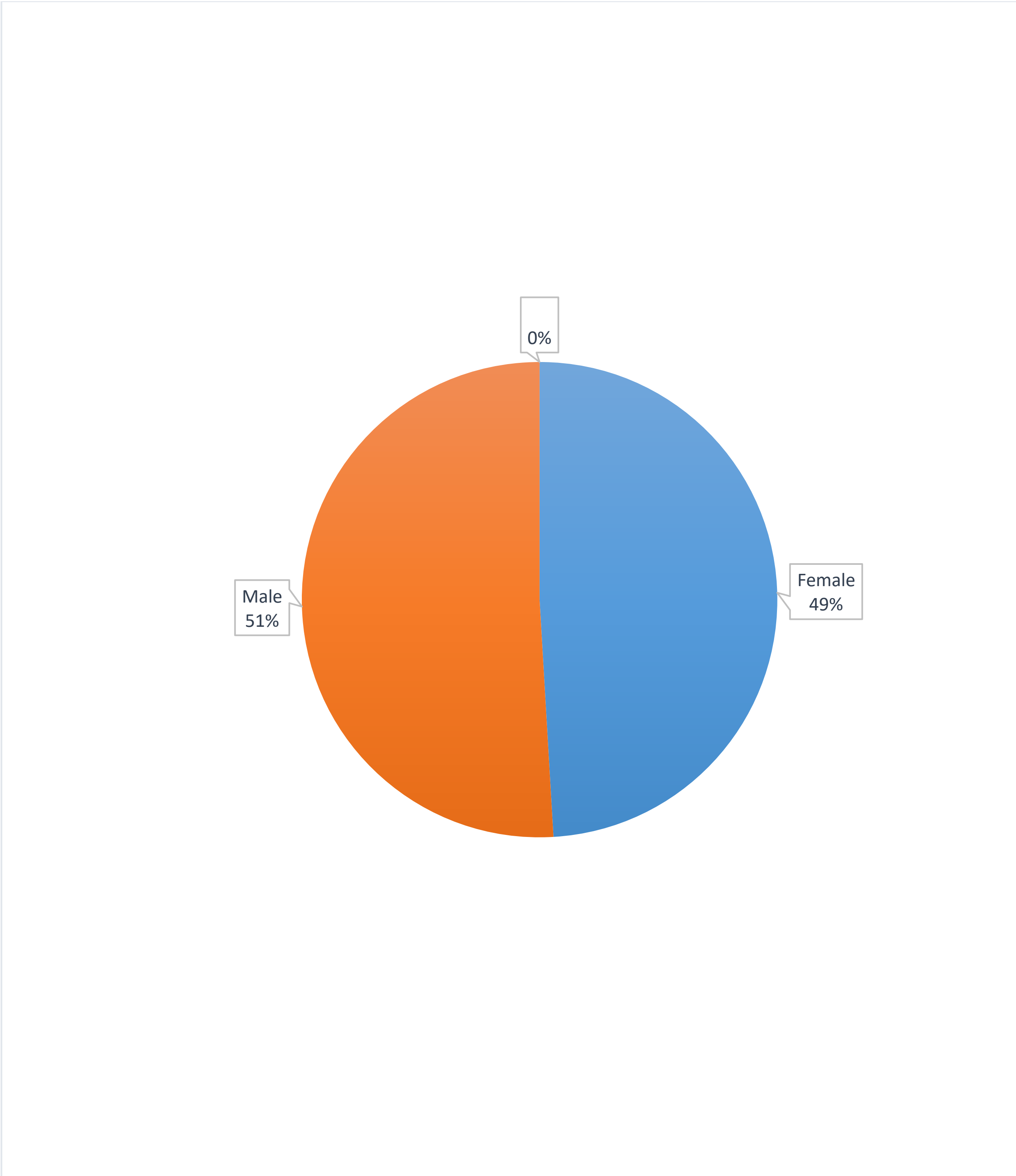


Figure 4.2b: Gender distribution of respondents (Ikeja)
Source: Field Survey, 2019

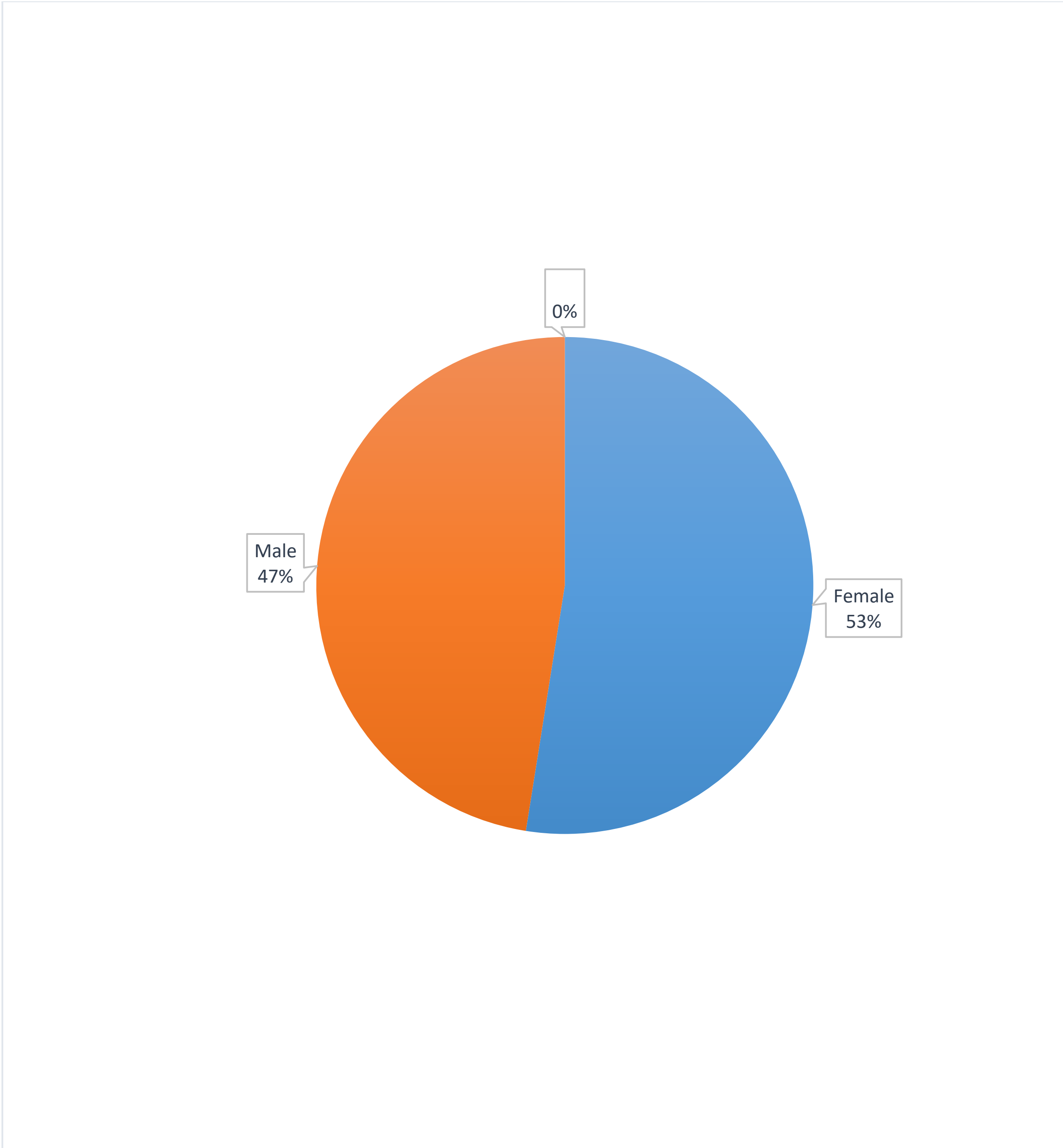


Figure 4.2c: Gender distribution of respondents (Eko)
Source: Field Survey, 2019

Figure 4.3a through 4.3c present the religion affiliation of respondents. From Figure 4.3a, it is evident that most of the respondents were of the Christian faith which was 59.4% of the total sampled respondents under areas of license of both Eko and Ikeja DisCo. This is followed by 33.4% of those who professed Islamic faith, while 5.6% and 1.6% represented those that believed in tradition and other religions.

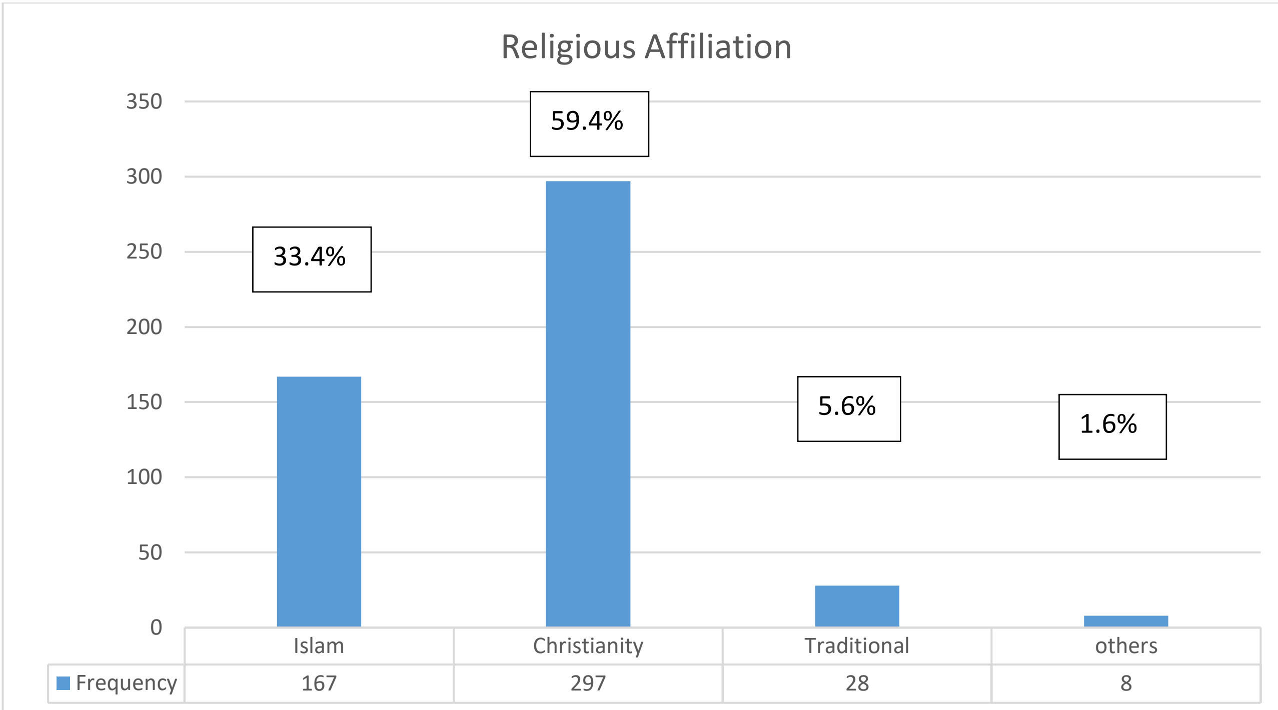


Figure 4.3a: Type of religion of all respondents

Source: Field Survey, 2019

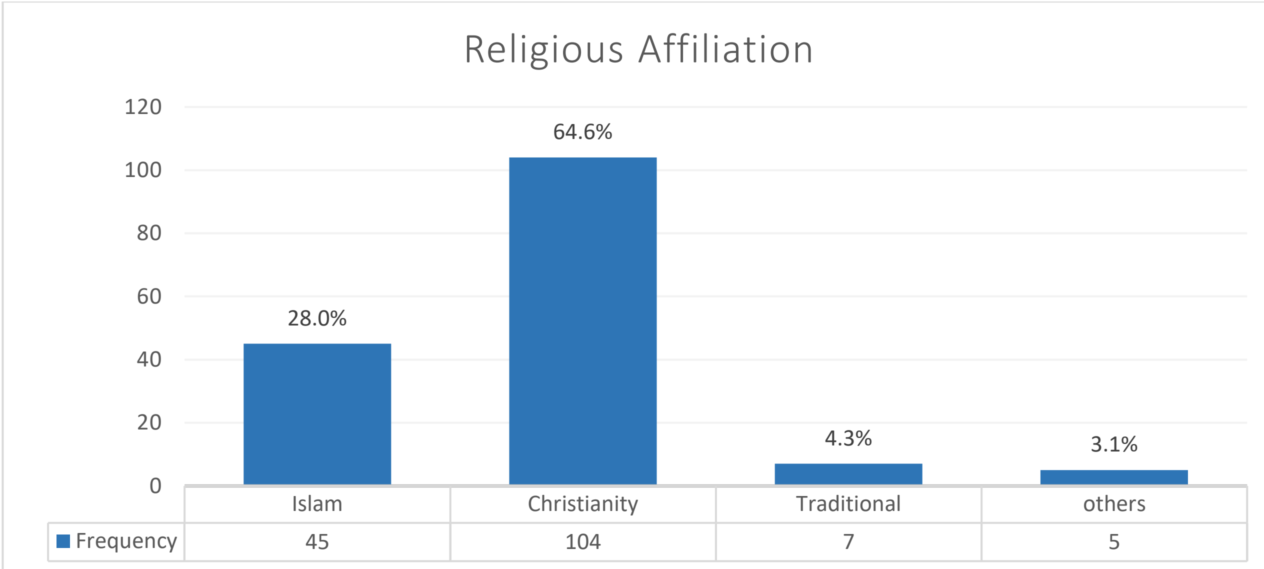


Figure 4.3b: Type of religion of respondents (Ikeja)

Source: Field Survey, 2019

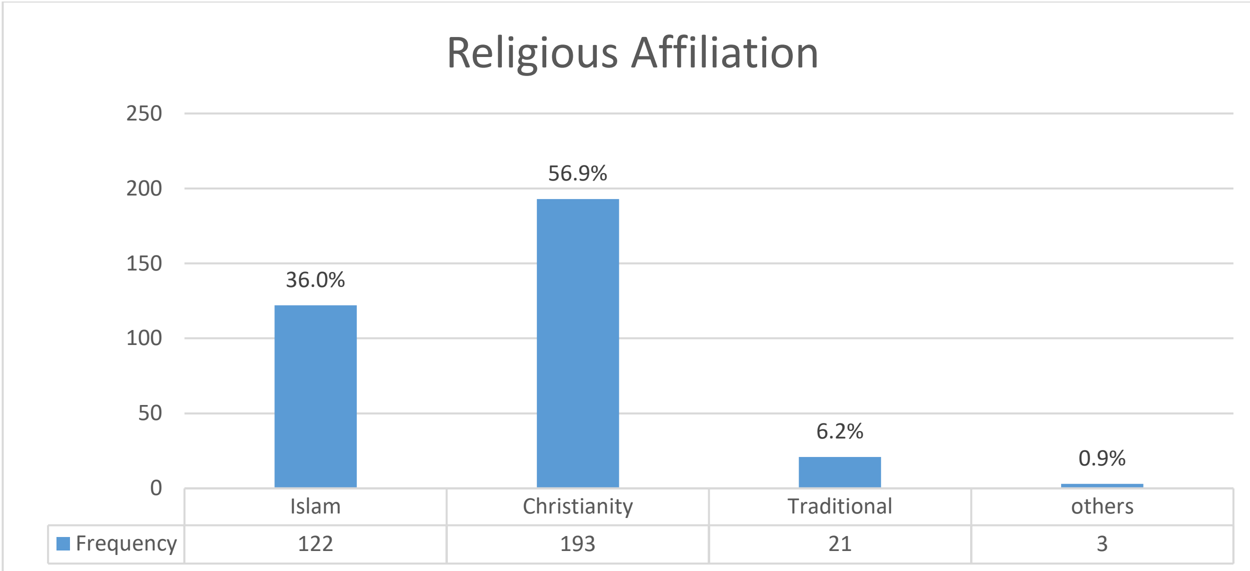


Figure 4.3c: Type of religion of respondents (Eko)

Source: Field Survey, 2019

Figure 4.3c shows that respondents under Eko DisCo exhibited similar characteristics as the respondents under Ikeja DisCo with Christian faith representing 56.9% of the sampled respondents. This is followed by 36.0% of the followers of Islamic faith, while 6.2% and 0.9% represented to that believed in tradition and others religions respectively.

The distribution of the sampled respondents according to marital status is presented in Figure 4.4. As shown in the diagram, 39.4% of the respondents sampled were single and had never been married. 46.6% were married, 4.2% were separated while 5.4% and 4.4% were divorcees and widowers respectively. This indicates that almost half of the household representatives sampled were married.

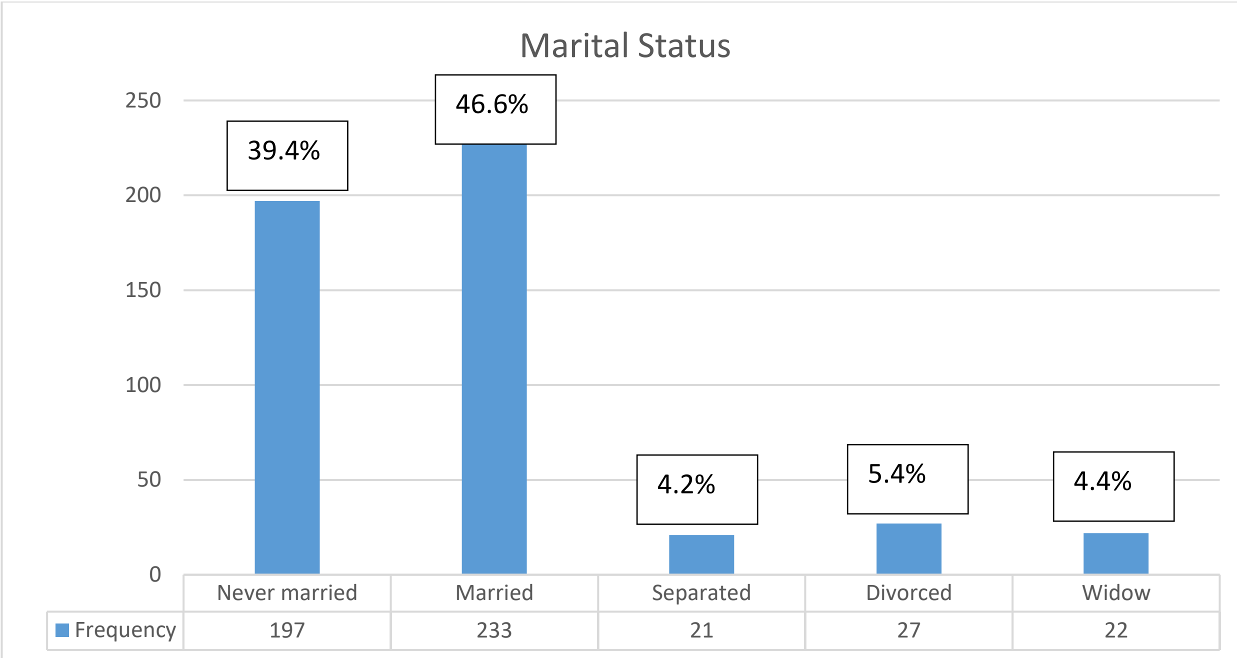


Figure 4.4: Marital Status of all respondents
Source: Field Survey, 2019

Furthermore, the marital status of the sampled respondents under Ikeja DisCo is presented in Figure 4.4b, while the analysis of the respondents under Eko DisCo is shown in Figure 4.4c. As shown in these diagrams, there were more married household respondents than those that were separated, divorced and widowed in the areas of franchise under the two electricity distribution companies in Lagos.

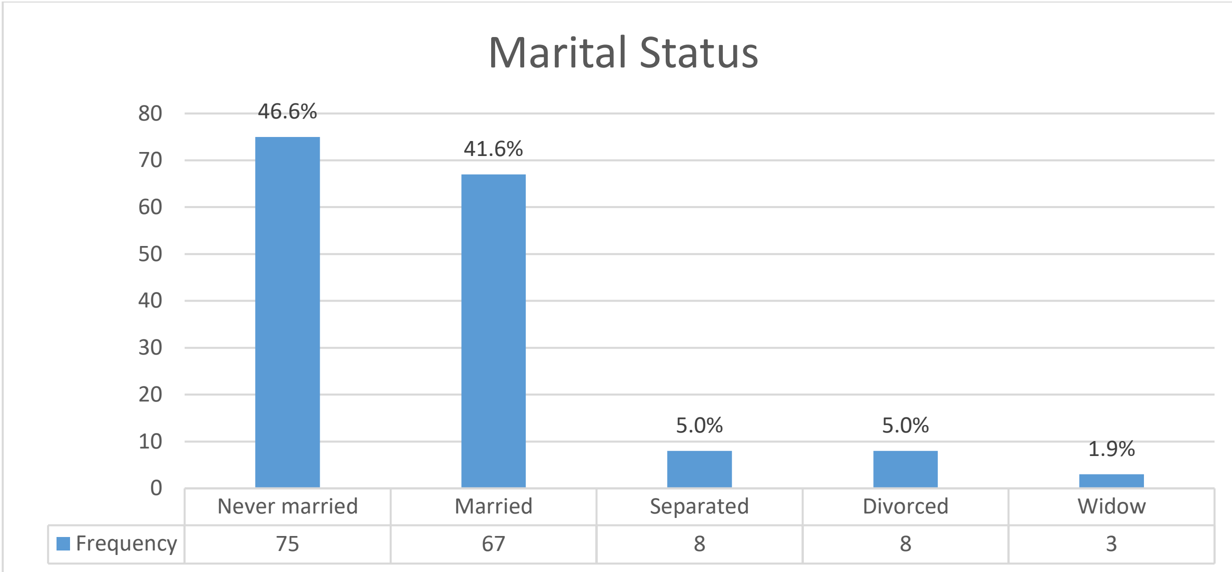


Figure 4.4b: Marital Status of respondents (Ikeja)
Source: Field Survey, 2019

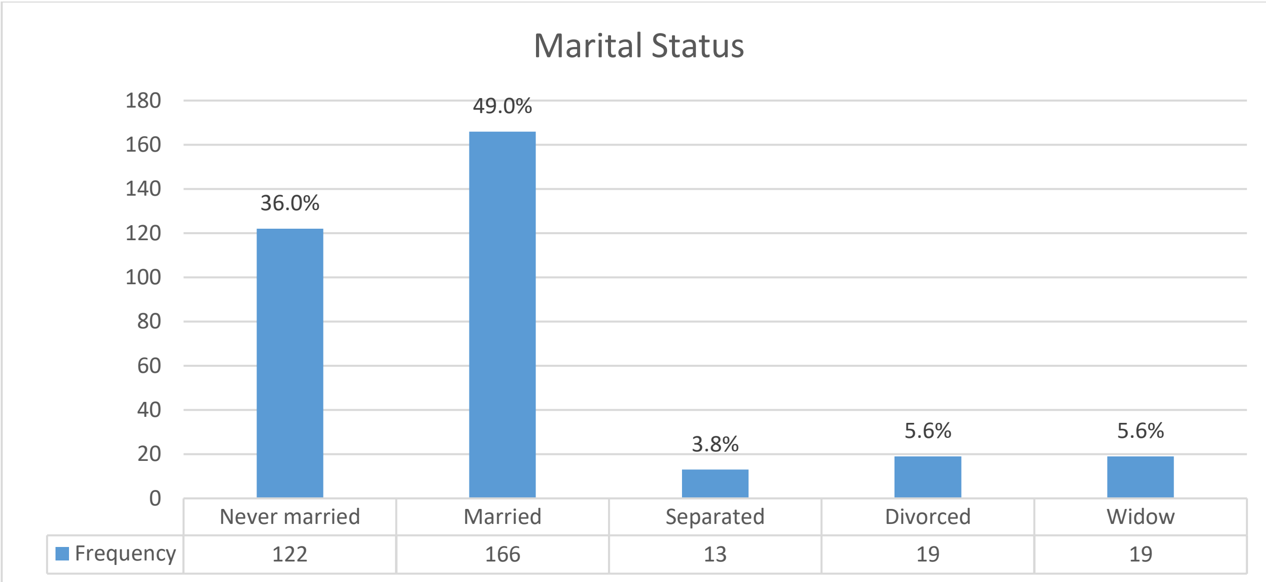
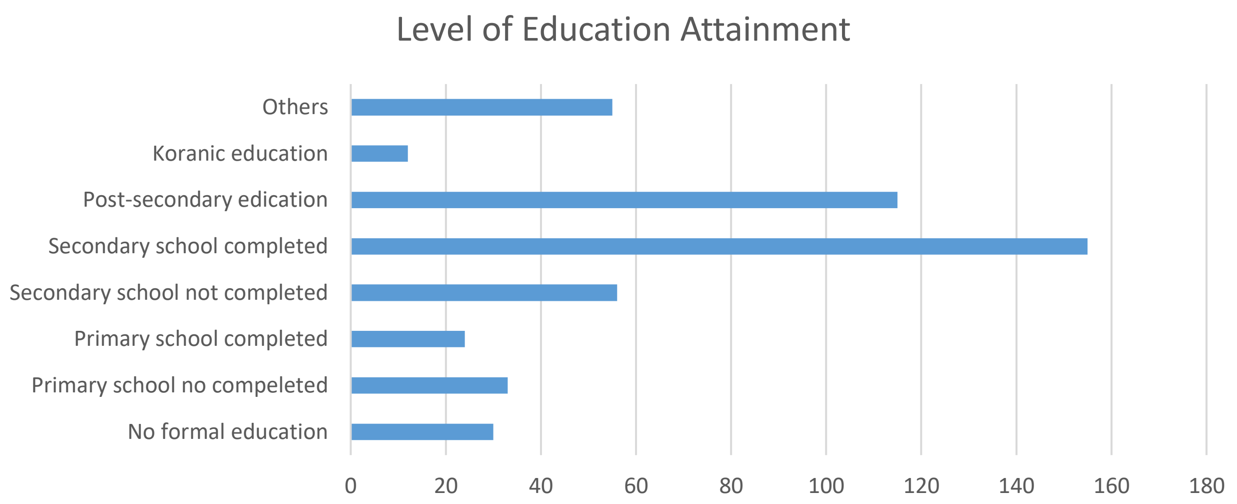


Figure 4.4c: Marital Status of respondents (Eko)
Source: Field Survey, 2019

\\

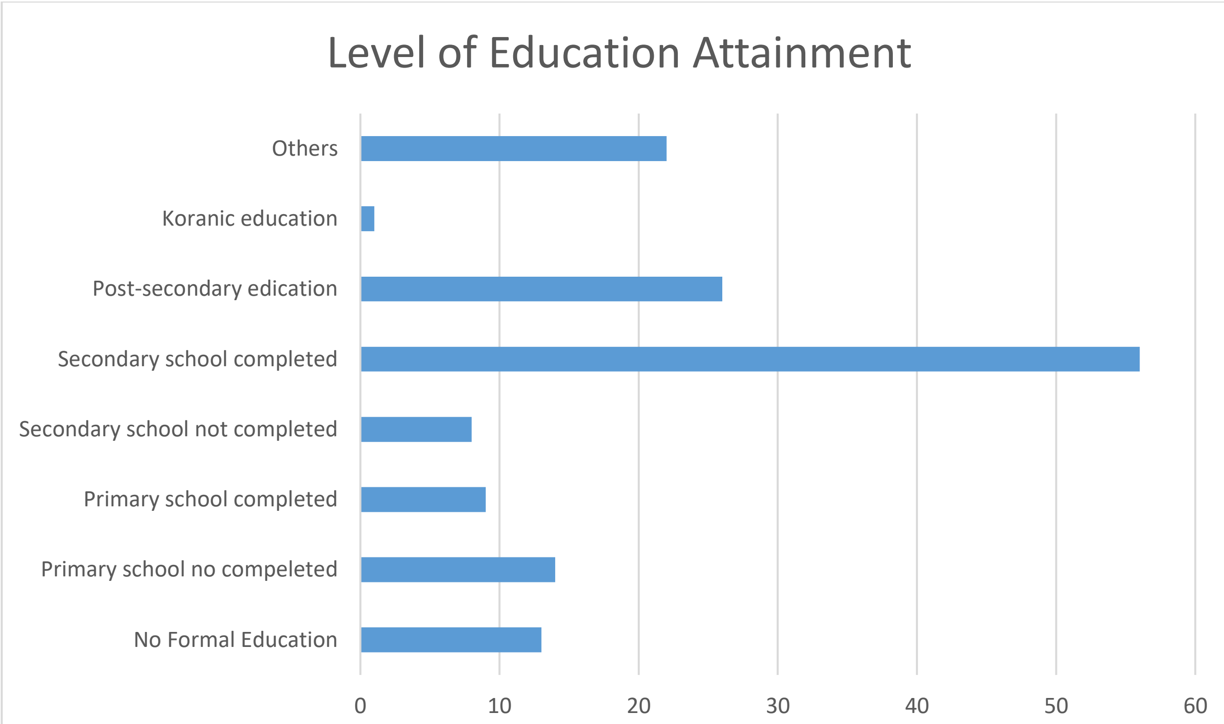
To capture the level of education, Figure 4.5 presents the distribution of respondents according to their educational attainment. From Fig 4.5, it is evident that most of the respondents completed at least secondary school education while 6.0% did not have any form of education. The statistics shows that 4.8% of the respondents completed primary school; 31.0% post-secondary school; 2.4% Quantic school; 6.6%did not complete primary school; and 11.0%belonged to others. The summary is that most of the respondents had at least primary education



	No formal education	Primary school no compeleted	Primary school completed	Secondary school not completed	Secondary school completed	Post-secondary edication	Koranic education	Others
Frequency	30	33	24	56	155	115	12	55

Figure 4.5: Highest Level of Education Attainment of all Respondents
Source: Field Survey, 2019

Figure 4.5b presents the distribution of respondents according to their educational attainment under Ikeja DisCo. From the Figure, most of the respondents completed at least secondary school education while only 13 did not have any form of education.



	No Formal Education	Primary school no compeleted	Primary school completed	Secondary school not completed	Secondary school completed	Post-secondary edication	Koranic education	Others
Frequency	13	14	9	8	56	26	1	22

Figure 4.5b: Highest Level of Education Attainment of Respondents (Ikeja)
Source: Field Survey, 2019

Figure 4.5c depicted that 29.2% of the respondents in franchise area under Eko electricity Distribution Company completed at least secondary school education while, another 26.3% had post-secondary education. From the total sampled respondents of 339, only 5.0% did not have any formal education. The summary is that most of the respondents had at least primary education

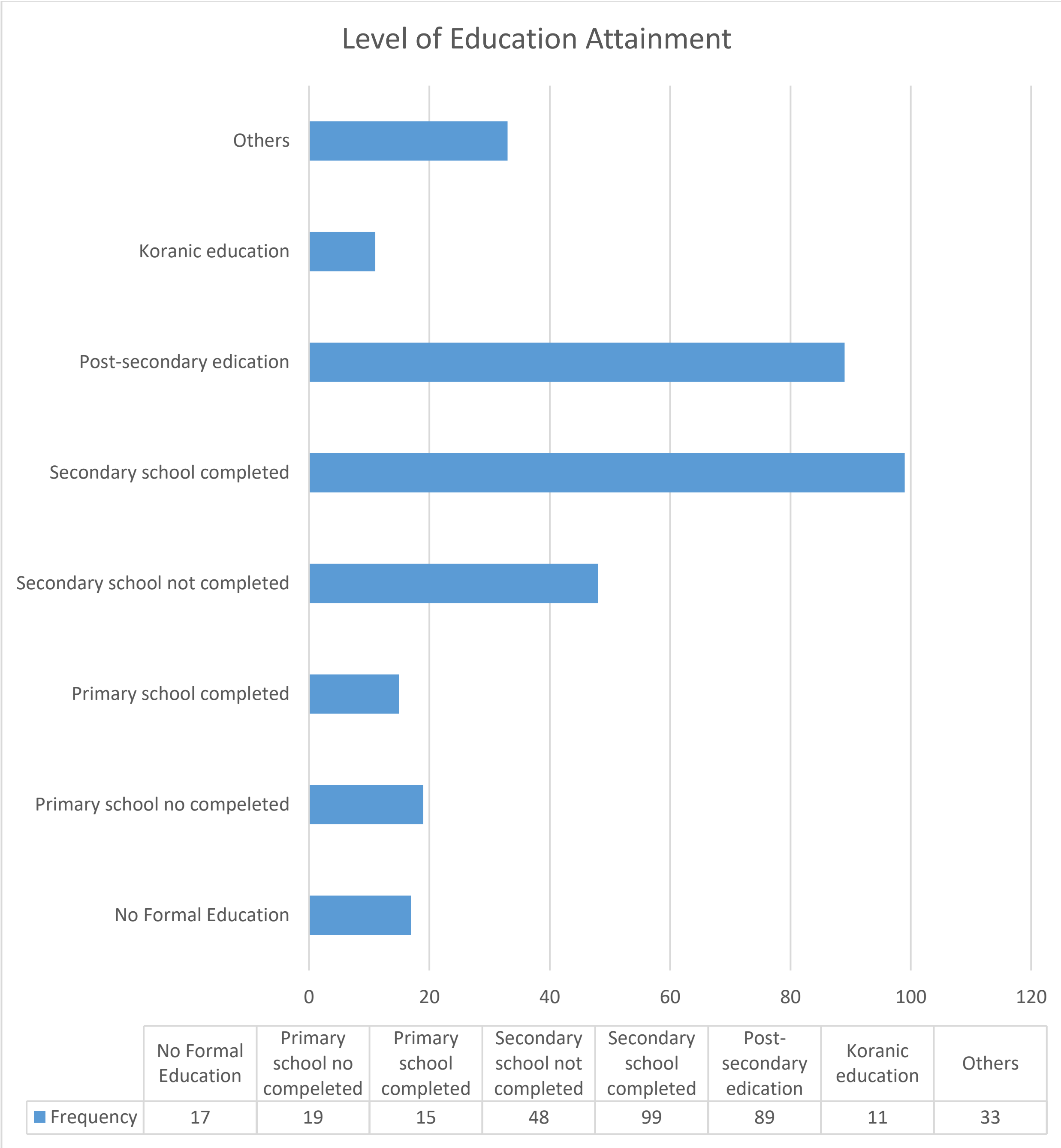


Figure 4.5c: Highest Level of Education Attainment of Respondents (Eko)
Source: Field Survey, 2019

The occupational statistics of the respondents is presented in Figure 4.6. The chart revealed that most of the respondents were into trading or business 25.8%. This was followed by the number of respondents who were into lower white collar jobs/business 20.6%. The number of respondents who were into farm related activities was 14.8%; while those into skilled related works like plumbing, electrical, mechanical and carpentry related activities among others constituted 19.6% of the total sampled respondents Figure 4.6 showed that most of the respondents were from households that were into trading or business.

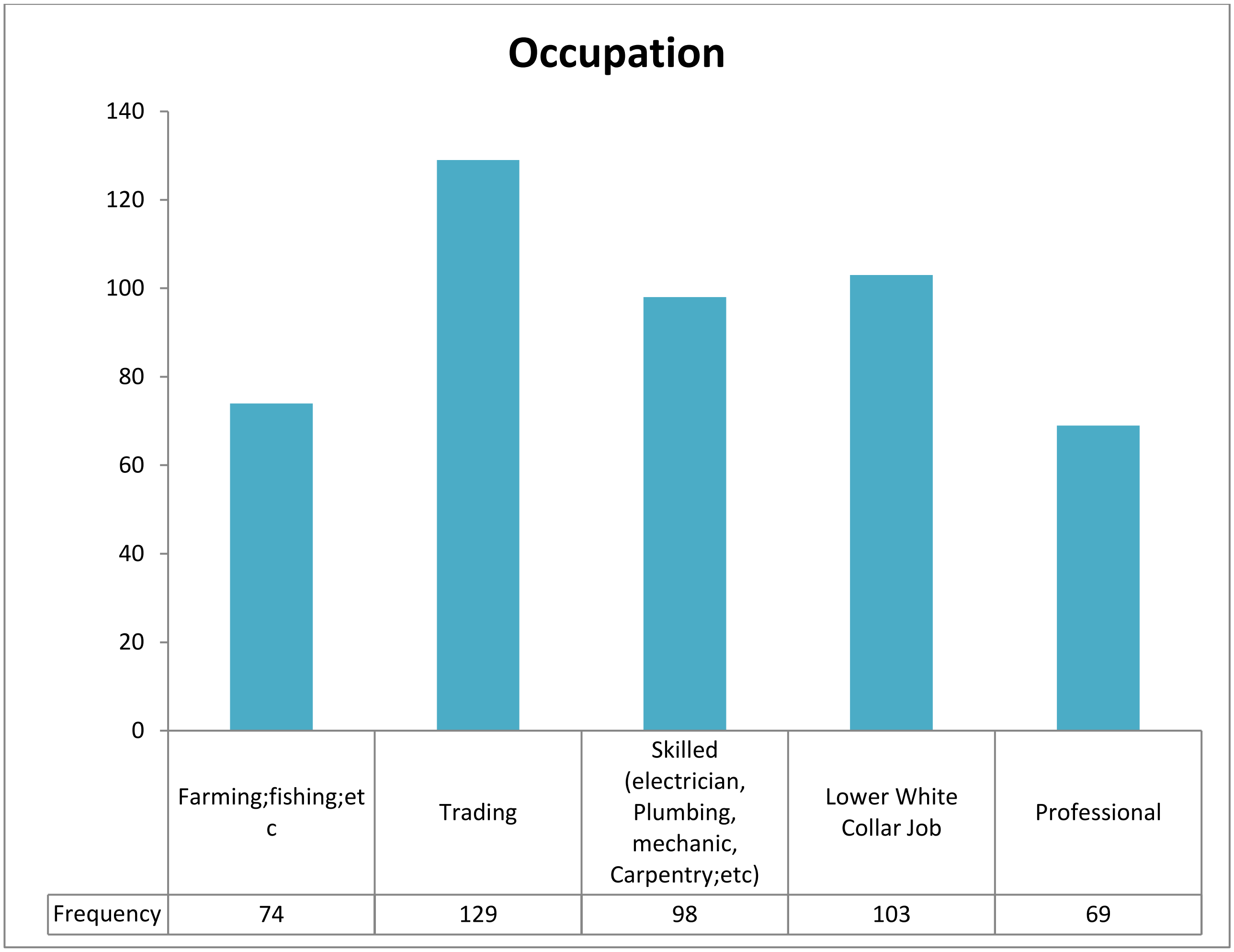


Figure 4.6: Occupational distribution of all Respondents
Source: Field Survey, 2019

The distribution of the respondents according to occupation under Ikeja electricity Distribution Company is presented in Figure 4.6b. The figure shows that most of the respondents were skilled labourers by occupation. They constituted 23.0% of the respondents. This was followed by 22.4% of respondents who were into lower white collar jobs/business. The proportion of respondents who were into farming activities was 13.7%; while those that were into hand-work related occupation was 22.4% of the total sampled respondents.

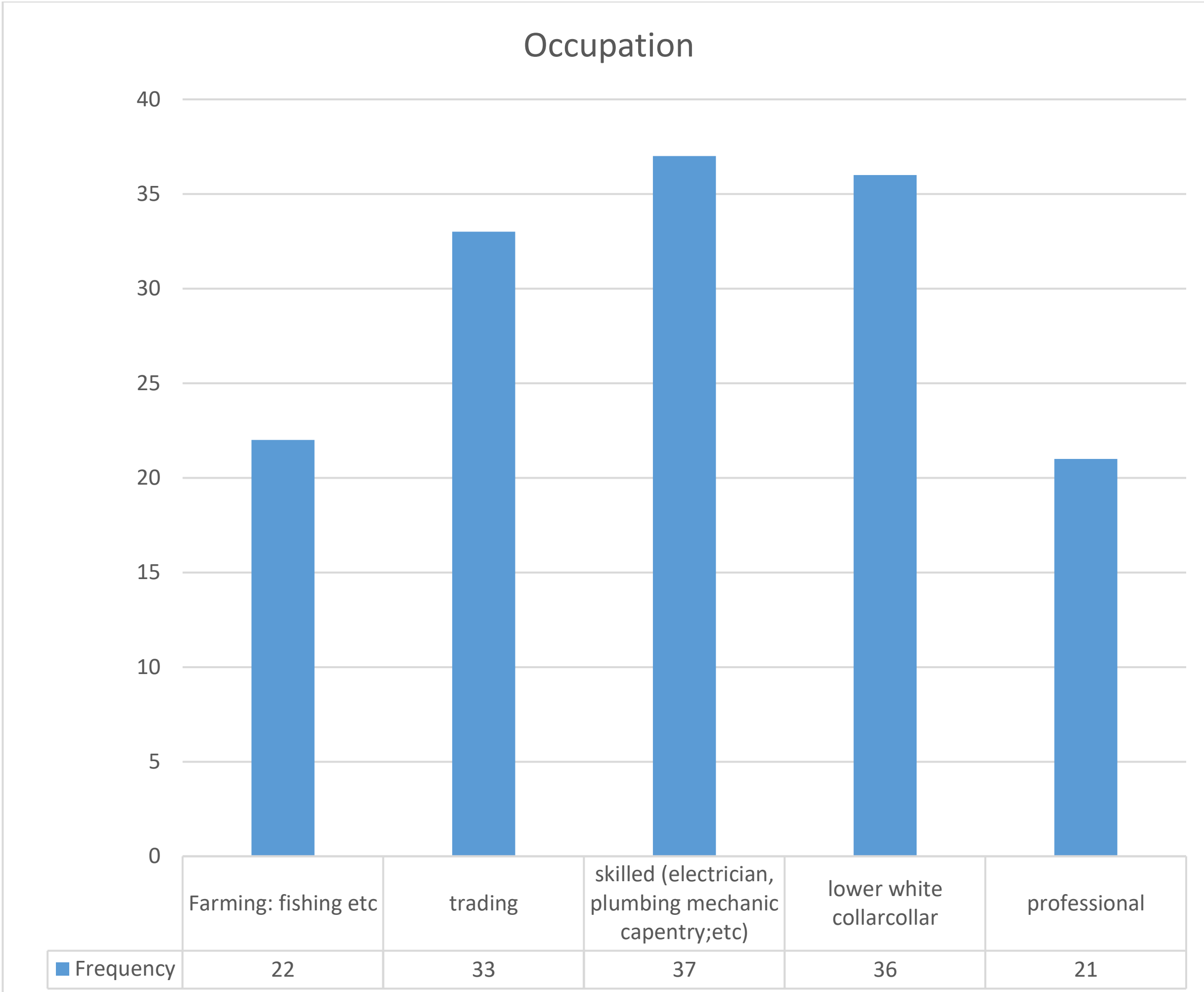


Figure 4.6b: Occupational distribution of Respondents (Ikeja)

Source: Field Survey, 2019

Similarly, distribution of respondents according to occupation under Eko electricity Distribution Company is presented in Figure 4.6c with traders having more respondents, 28.3%, than any other form of occupation in the area.

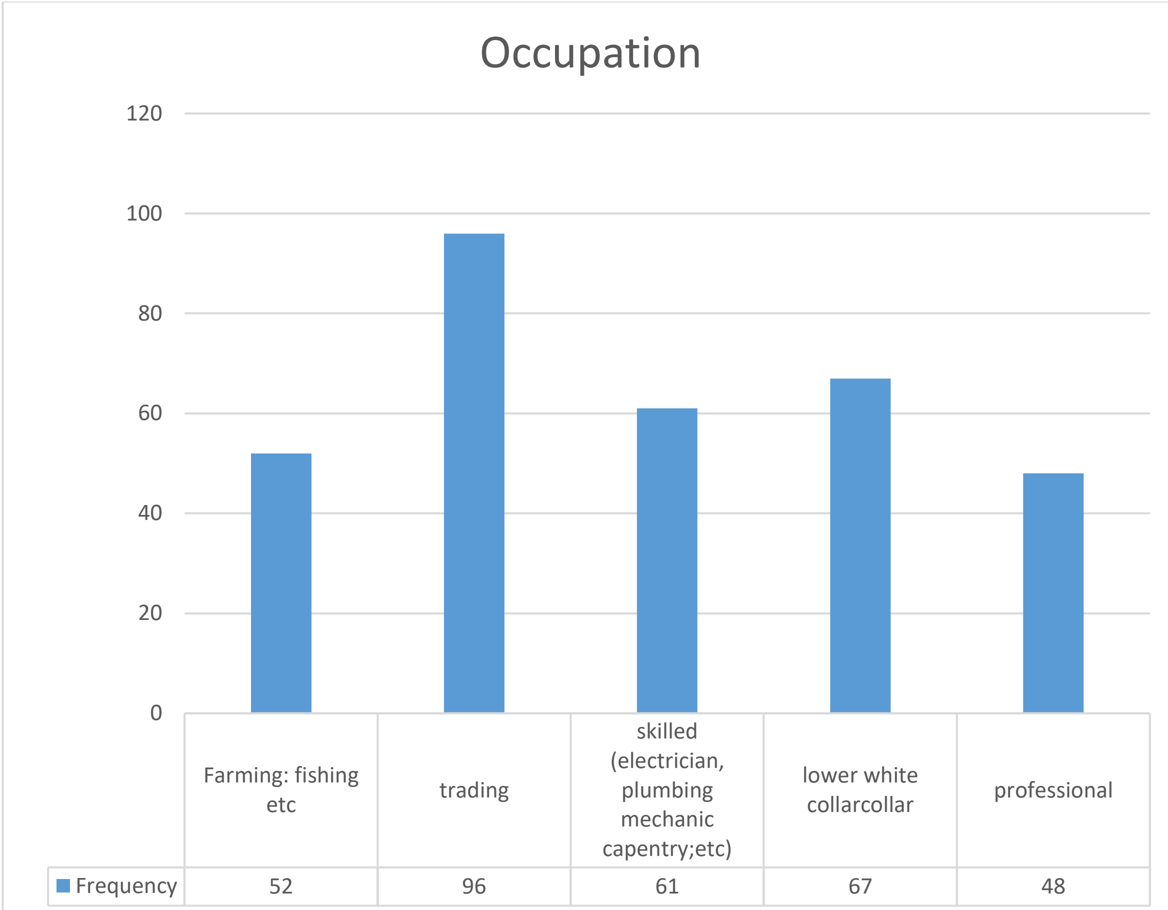


Figure 4.6c: Occupational distribution of Respondents (Eko)
Source: Field Survey, 2019

The distribution of respondents according to income is presented in Table 4.2. 40.6% of the respondents sampled earned between 1000 and 30,000, 27.4% earned between 31,000 and 50,000, 20.4% earned between 51,000 and 200,000 while only 5.0% and 1.8% earned between 201,000-500,000 and 501,000 and above respectively. Among the sampled respondents, 4.8% failed to provide answer to the question. The summary here is that most of the household respondents' income ranged between 1000 and 200,000.

Table 4.2: Income Group of all Respondents per month

Income group	Frequency	Percent
1000-30,000	203	40.6
31,000-50,000	137	27.4
51,000-200,000	102	20.4
201,000-500,000	25	5
501000 and above	9	1.8
No Response	24	4.8
Total	500	100

Source: Field Survey, 2019

Table 4.2b and 4.2c show that lower income group dominated the respondents sampled. In the license area under Ikeja Electric Plc, 47.2% of the sampled respondents earned between 1000 and 30,000, 24.8% earned between 31,000 and 50,000, 14.9% earned between 51,000 and 200,000 while only 6.8% and 1.2% earned between 201,000-500000 and 501000 and above respectively. In areas under Eko DisCo, 37.5% of the respondents sampled earned between 1000 and 30,000, 28.6% earned between 31,000 and 50,000, 23.0% earned between 51,000 and 200,000, while only 4.1% and 2.1% earned between 201000-500,000 and 501,000 and above respectively.

Table 4.2b: Income Group of Respondents per month (Ikeja)

Income group (₦)	Frequency	Per cent
1000 – 30,000	76	47.2
31,000-50,000	40	24.8
51,000-200,000	24	14.9
201,000-500,000	11	6.8
501,000 and above	2	1.2
No Response	8	5
Total	153	95

Source: Field Survey, 2019

Table 4.2c: Income Group of Respondents per month (Eko)

Income group (₦)	Frequency	Per cent
1000 – 30,000	127	37.5
31000-50,000	97	28.6
51,000-200,000	78	23
201,000-500,000	14	4.1
501,000 and above	7	2.1
No Response	16	4.7
Total	323	95.3

Source: Field Survey, 2019

Figure 4.7 presents the distribution of respondents' according to electricity billing system. In Nigeria, three main forms of electricity billing exist. They include prepaid metering, post-paid and estimated billing systems. Both prepaid metering and postpaid metering systems involve the use of electric meters. The difference between the two is that prepaid meters are configured to accept payment prior to consumption of electricity (pay before service) while postpaid meters are configured to accept payment post consumption of electricity (or pay after service). Only the estimated billing system does not involve the use of electric meters either due to the fact that meters are being processed or the DisCo concerned has no meter to supply to the customer at the point in time. Estimated billing system is a temporary solution pending availability of electric meter. Many times, the system leads to a lot of disagreement between electric utility and the customer. According to NERC, dispute arising from estimated billing system accounts for over 80% of all complaints received from customers in every quarter under all the DisCos nationwide. From the survey conducted, analysis revealed that 39.6% of the households used prepaid metering system, 30.2% used post-paid, while 29.6% used the old estimated billing system. Although, about 0.6% of the total sampled respondents did not provide information about their billing system, the study observed the dominance for pre and post-paid billing systems.

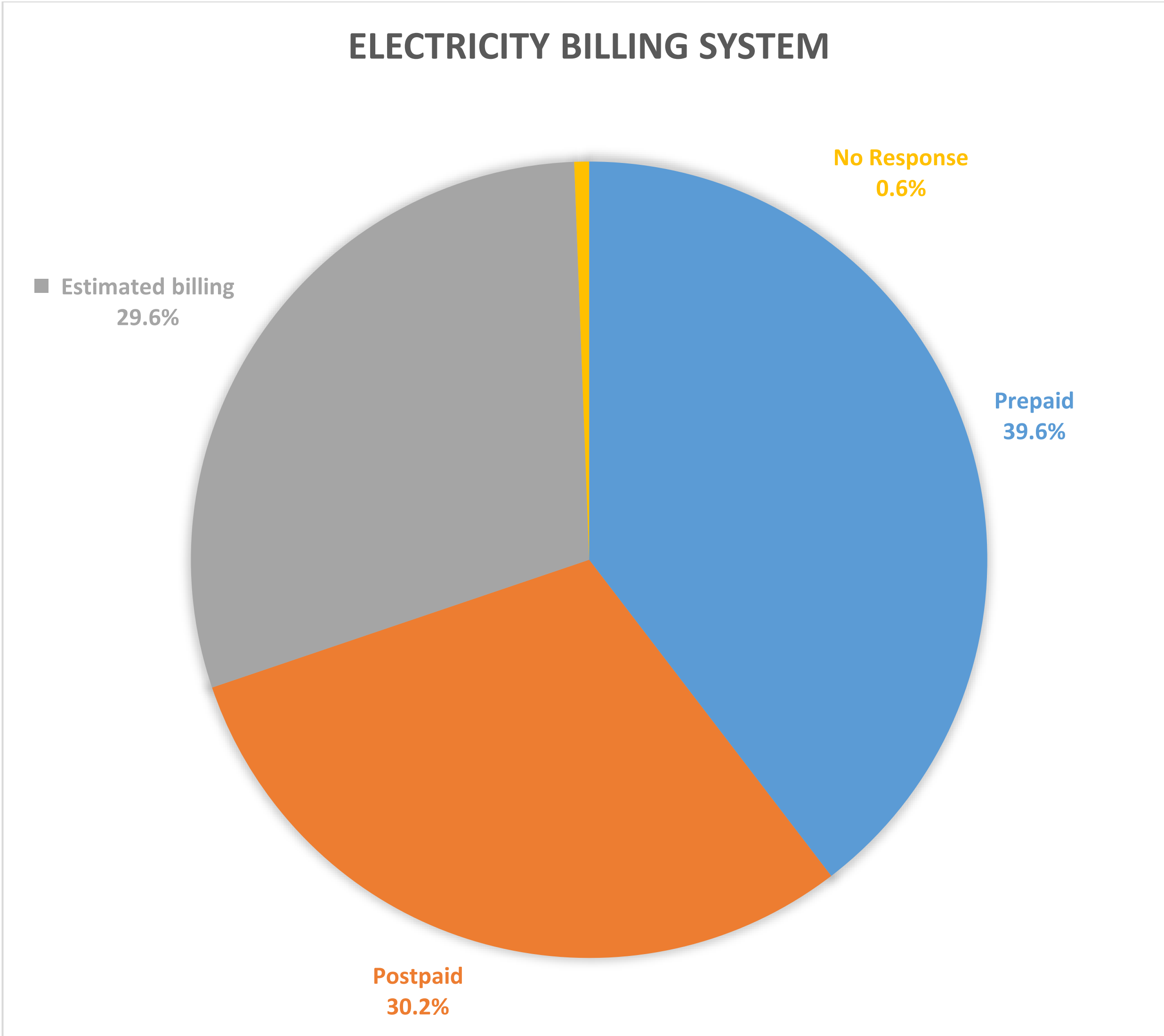


Figure 4.7: Electricity Billing System of all Respondents
Source: Field Survey, 2019

Figure 4.7b and 4.7c present the distribution of respondents' forms of electricity billing system under both Ikeja and Eko DisCos. 46.0% and 39.8% of the households under Ikeja and Eko DisCos used prepaid metering system, 32.3% and 30.7% used post-paid, while 21.1% and 28.9% used the old estimated billing system under both companies respectively. Although, about 0.6% of the total respondents did not provide information about their billing system, the study observed the dominance for pre and post-paid billing systems.

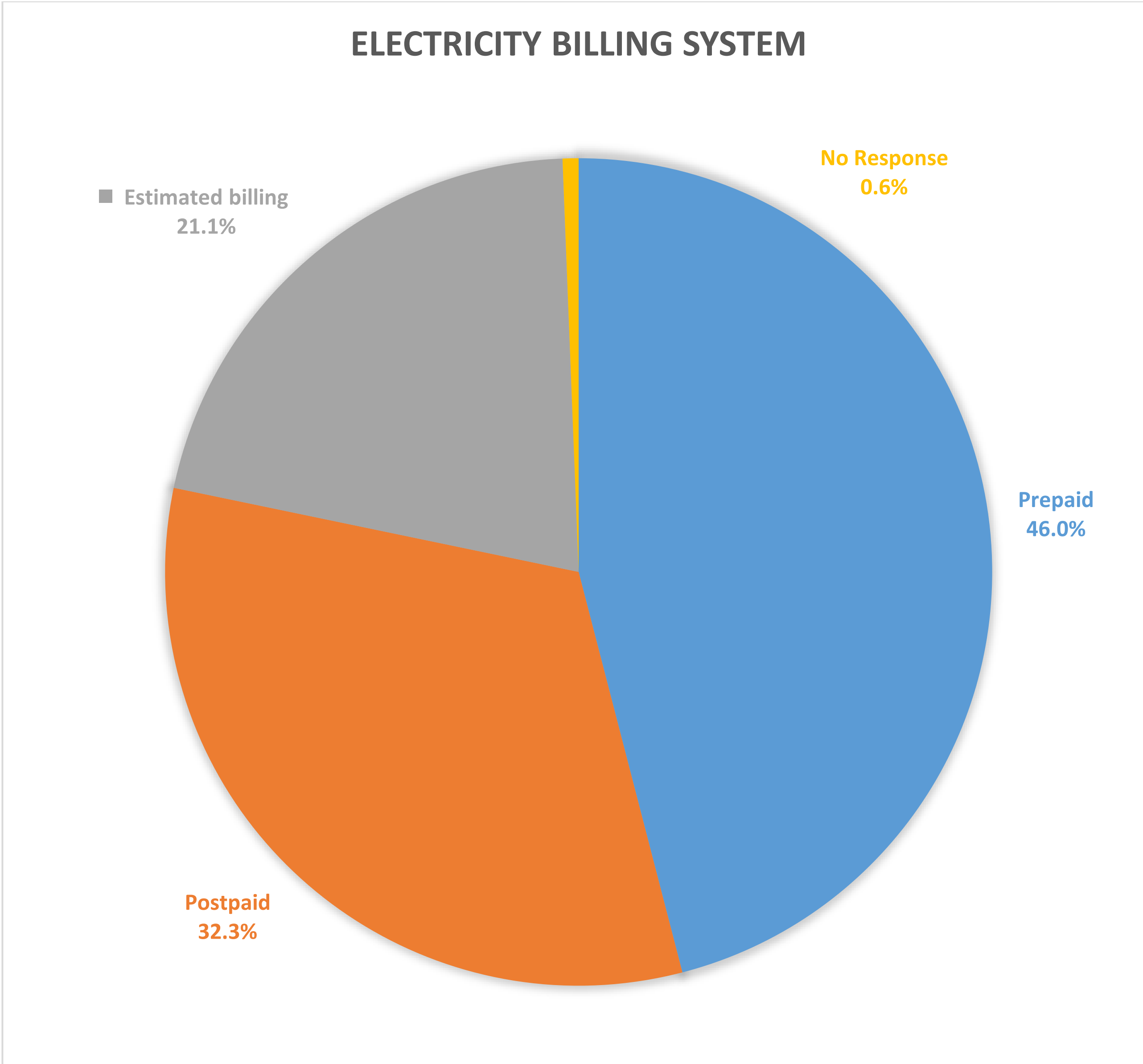


Figure 4.7b: Electricity Billing System of Respondents (Ikeja)
Source: Field Survey, 2019

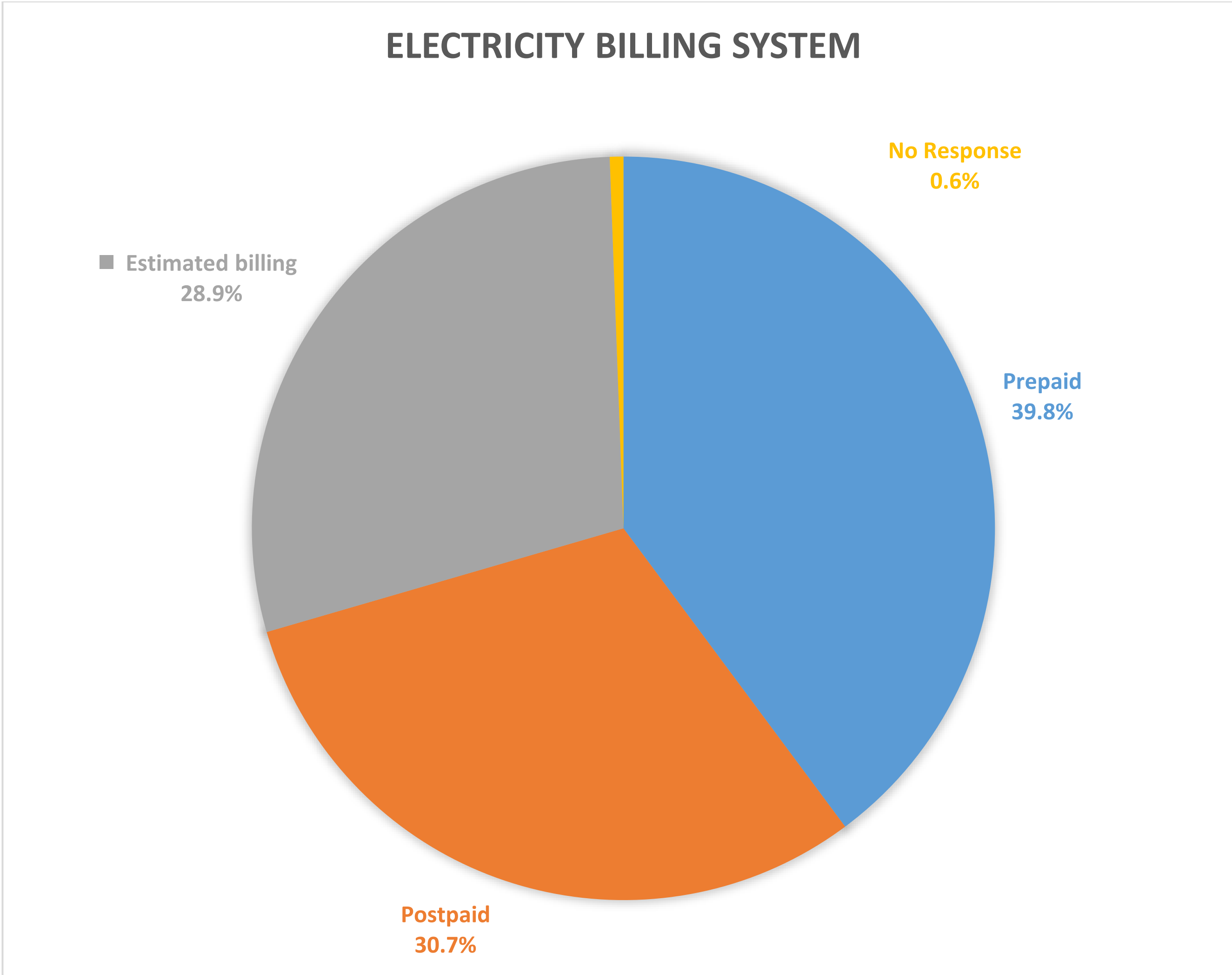


Figure 4.7c: Electricity Billing System of Respondents (Eko)
Source: Field Survey, 2019

Further questions were asked about respondents' use of electricity meter. The analysis of the responses gathered is presented in Figure 4.8. As shown in the figure, 54.0% of the respondents were independent users of electricity meter, while 43.0% were on a shared meter arrangement. In addition, 3.0% of the respondents failed to provide information on their use of electricity meter. In summary, independent electric meter users are more than other users in the study area.

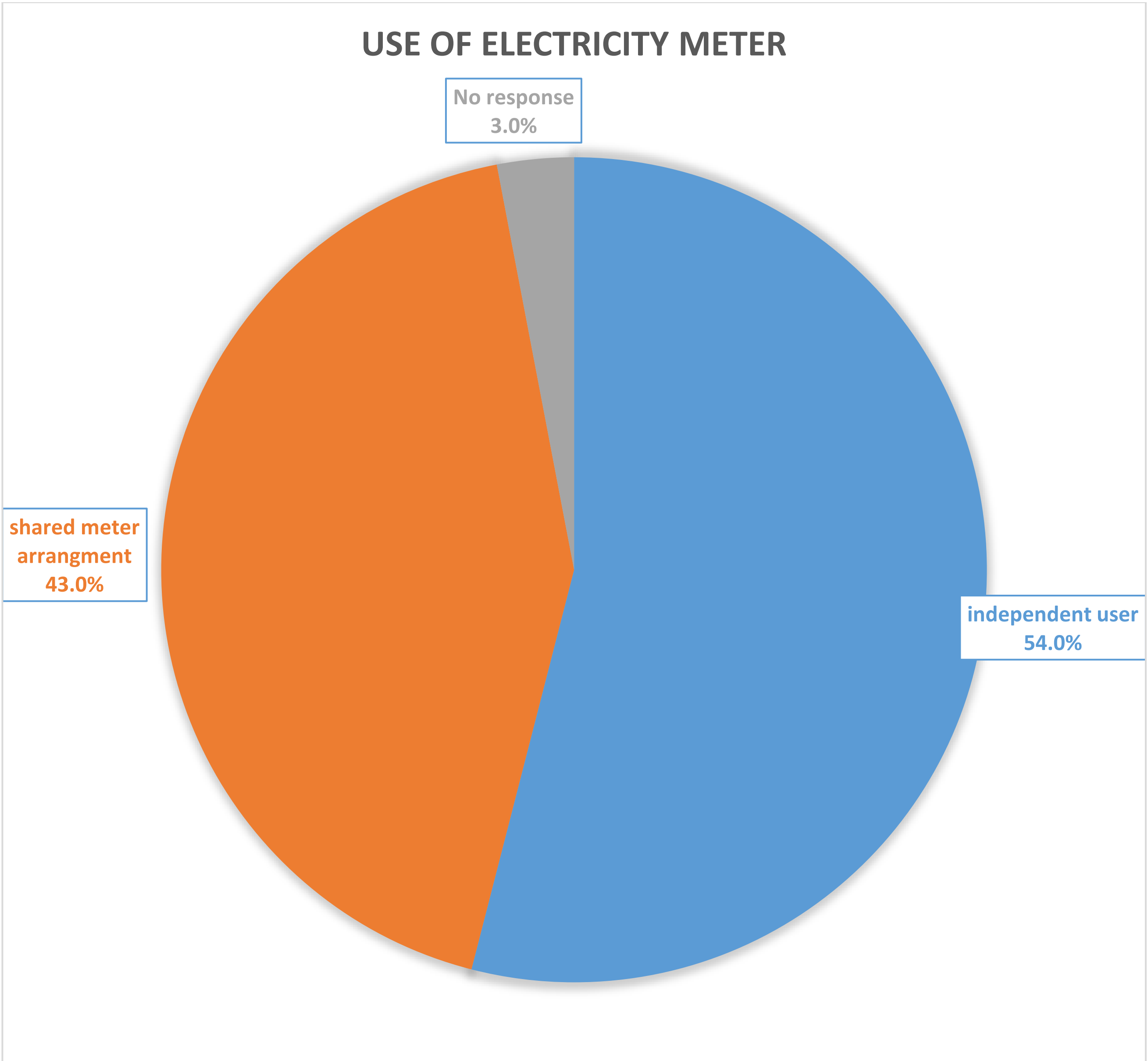


Figure 4.8: Uses of Electricity Meter among respondents
Source: Field Survey, 2019

Figure 4.8b reveals that 59.6% of the respondents were independent users of electricity meter, while 38.5% were on shared meter arrangement among the respondents. In addition, 1.9% of the respondents failed to provide information on their use of electricity meter under Ikeja Electric Plc. This study confirmed that majority of the sampled respondents under Ikeja electricity Distribution Company were independent meter users. Further to this result, 51.3% of the respondents under Eko electricity Distribution Company were independent users of electricity meter, while 45.1% were on shared meter arrangement with the remaining 3.5% of the respondents failing to provide information on their use of electricity meter.

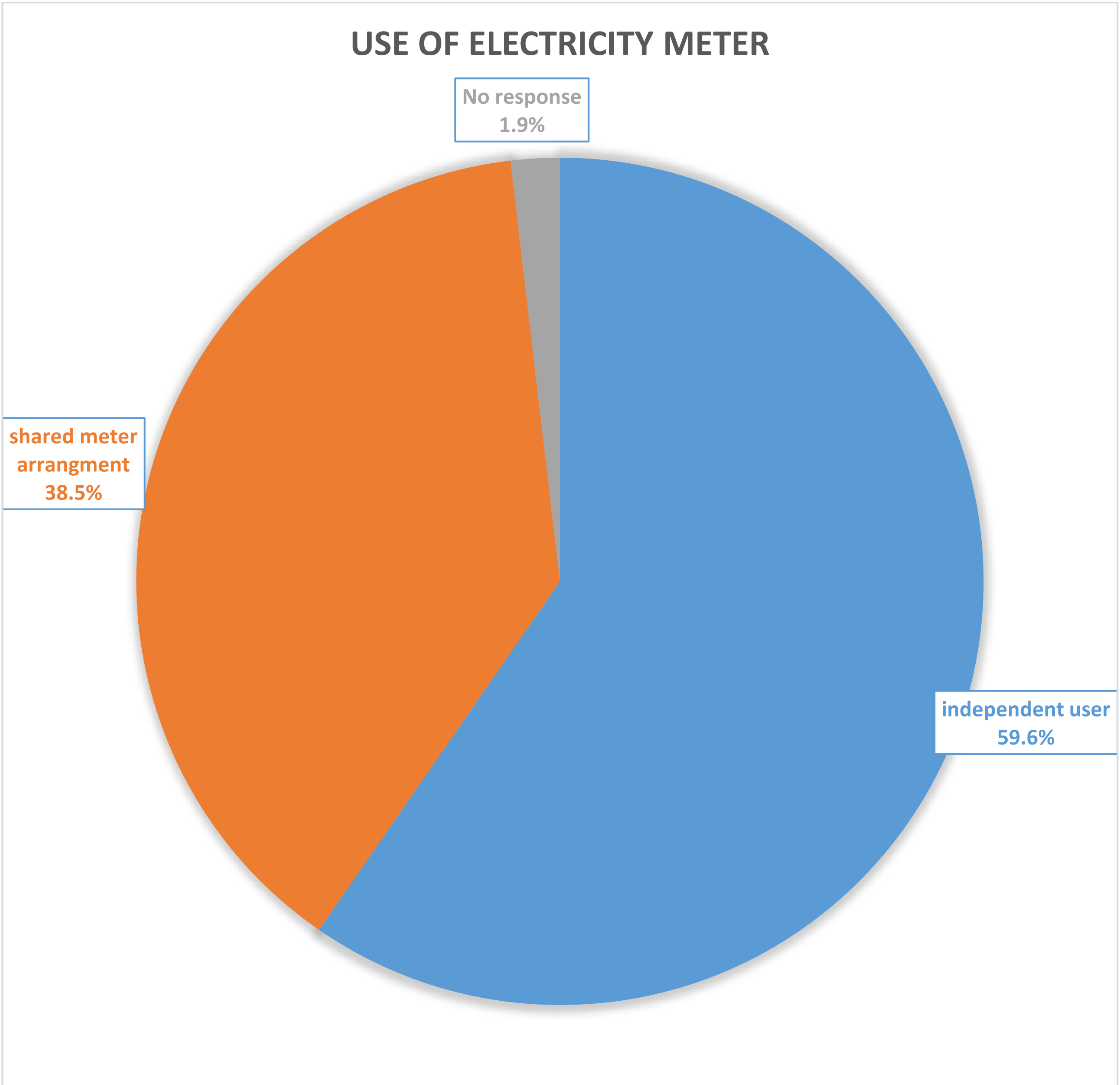


Figure 4.8b: Uses of Electricity Meter among respondents (Ikeja)
Source: Field Survey, 2019

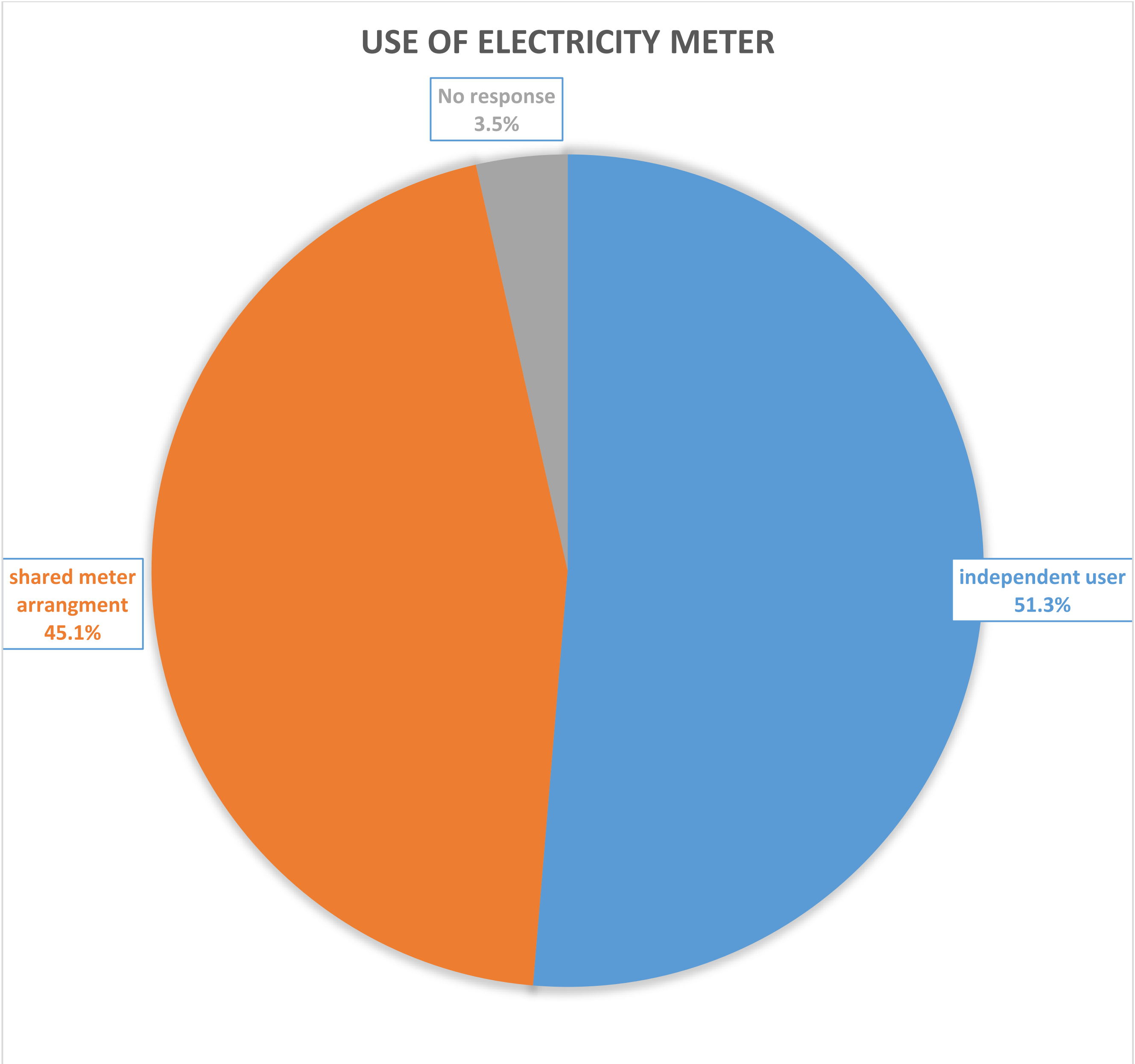


Figure 4.8c: Uses of Electricity Meter among respondents (Eko)
Source: Field Survey, 2019

4.2. Result presentation

4.2.1. Determinants of electricity theft in Lagos state

To investigate the determinants of electricity theft, we estimated the model stated and explained in equation (3.1) in chapter four. This study employed the use of probit regression model which was chosen over the logistic regression due to the fact that it is simple to interpret and appropriate to be used when the response variable is a binary or dichotomous variable and the predictors are either numerical or categorical.

This section is divided into five major sub-categories. The sub-categories are:

1. Analysis of electricity theft determinants in Lagos (Aggregate).
2. Analysis of determinant of electricity Theft (among Households' on Prepaid and postpaid meter) in Lagos State, Nigeria.
3. Analysis of determinants of electricity theft (among Households' on Pre-paid meter) in Lagos State, Nigeria. And later among (Post-paid meter users) in Lagos state
4. Analysis of determinants of electricity theft among Households' under each of the two DisCo's separately in Lagos State, Nigeria.
5. Analysis of determinants of electricity theft among households' on either prepaid or postpaid meter under each of the two DisCos in Lagos state, Nigeria.

The Probit regression results are presented in Table 5.4a through 5.4h.

4.2.2. Analysis of determinants of electricity theft in Lagos (all households).

The result of the aggregate analysis (all households) in Table 4.4a revealed that, among several selected electricity theft motivating factors, “price of electricity”, “epileptic electricity supply”, “estimated billing”, “corrupt practices of the Disco staff”, “presence of micro-business in households”, “weak legal enforcement”, “high level of poverty”, “unemployment”, “electricity billing system adopted in the households” were significant at 5% and 1% level.

Further analysis revealed that age, religion, marital status and income were positively related to electricity theft. Interestingly, the coefficient of age was positive and statically significant. The result implies that incidence of electricity theft was more likely to increase among households with increase in households’ members age (especially the younger members of the households). This result is similar to that of Gary, Alex, and Laurence, (2013), Farrington et al. (2013). These authors noted that criminal activity increases during adolescence, peaks around age 17 (with the peak somewhat earlier for property than for violent crime), and declines as individuals enter adulthood.

However, contrary to expectations, our analysis shows a positive relationship between households’ members’ income and incidence of electricity theft at the aggregate. The result indicated that income was statistically significant at 5%. This implies that with increase in income, households were not less likely to engage in incidence of electricity theft. This result is striking and thus, confirmed that households’ with higher income were not exempted from getting involved in incidence of electricity theft in the area of study.

The analysis also showed a positive relationship between “price of electricity”,” power outages” and negative relationship between “non-availability of task force to enforce laws against electricity theft” and electricity theft in the study area.

This implies that with increase in the “frequency of power outages”, households were more likely to get involved in the incidence of electricity theft. Again, the coefficient of “price of electricity” was positive and statistically significant. This implies that with increase in electricity tariff, households were more likely to engage in incidence of electricity theft. Furthermore, given that the coefficient of "the absence of task force to control electricity theft" was negative and statistically significant, raising an effective task force to combat electricity theft would make households less likely to get involved in the incidence of electricity theft in the study area. By this, it is implied that efforts being made to combat the problem of electricity theft in the study area should consider the need to set up a strong task force to sanction electricity theft offenders.

Another factor is the "status on the property". That is, whether or not the occupant is the owner of the house. The coefficient of this variable was positive and statistically significant. This indicated that households whose heads owned the property were less likely to get involved in the incidence of electricity theft in comparison to the households whose heads were tenants. More importantly, "households running micro-businesses" (using electricity to function) in the residential apartments were more likely to engage in electricity theft because the coefficient of this factor was positive and statistically significant.

In addition, our result showed that the coefficient of "unemployment" was negative but statistically significant. This implies that policy measures using reduction in the level of households' unemployment to bring about reduction in the level of electricity theft in the study area, were less likely to succeed. Our result corroborates that of Imrohoroglu *et al.*, (2000), Ehrlich (1973) and Fleisher, (1966) which states that unemployment rates has a negative relationship with crime rates.

Table 4.4a: Probit regression results for the determinants of electricity theft in Lagos, Nigeria (ALL HOUSEHOLDS)

Table 4.4a: **Aggregate Analysis (regardless of DisCo) ALL HOUSEHOLDS**

	Determinants Variables	Estimate	Std. Error	Z	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
PROBIT[a]	Age	-.006	.008	-.812	.417	-.022	.009
	Gender of respondents	-.004	.012	-.300	.764	-.028	.020
	highest level of education attainment	.001	.003	.414	.679	-.005	.008
	occupation	.042	.005	8.144	.000	.032	.052
	Accommodation type	.021	.006	3.396	.001	.009	.033
	status of property	-.041	.014	-2.978	.003	-.067	-.014
	price of electricity	.139	.017	-8.066	.000	-.173	-.105
	frequency of power outages	.101	.014	7.291	.000	.074	.129
	estimated billing	-.121	.017	-6.948	.000	-.155	-.087
	lack of punishment	.020	.017	1.143	.253	-.014	.053
	corrupt practices of the electricity distribution	.063	.019	3.349	.001	.026	.100
	non availability of task force to check electricity	-.139	.017	-8.145	.000	-.173	-.106
	income level	.006	.014	.391	.696	-.023	.034
	presence of micro business in household	.040	.013	-3.087	.002	-.065	-.015
	weak legal enforcement	.104	.015	7.036	.000	.075	.134
	high level of poverty	.256	.016	15.709	.000	.224	.288
	unemployment	-.253	.016	-15.912	.000	-.284	-.222
	Electricity billing system	.015	.008	1.979	.048	.000	.030
	Intercept	-1.030	.059	-17.408	.000	-1.089	-.971

a. PROBIT model: PROBIT(p) = Intercept + BX

Source: Author's estimation from SPSS 25. Note: statistical significance at 10%, 5% and 1% respectively.

4.2.3. Analysis of determinants of electricity theft among prepaid and post-paid households' in Lagos, Nigeria.

Results of the probit regression for the sub-sample (pre-paid and post-paid metering customers only) revealed that the electricity theft motivating factors were age of household members, gender of occupants, presence of micro-business that uses electricity for functioning within the household, weak legal enforcement, corrupt practices, high level of poverty, lack of punishment, unemployment and non-availability of task force etc. All these factors were significant at 1% and 5%.

The result showed a negative relationship between "education" and "accommodation type" on electricity theft in the area of study. Specifically, decrease in the level of religious belief", "level of education" and "accommodation type" had a likelihood of increasing the incidence of electricity theft among households in Lagos State as indicated by their respective coefficients: 0.15, 0.08, 0.07 and 0.06. In other words, as the members of households became more involved in religious activities, raised their level of education and moved into better and more luxurious apartments, the likelihood to get more involved in incidents of electricity theft began to wane.

Table 4.4breveals that "sex/gender", "income group", "price of electricity", "lack of punishment", "corrupt practice among the electricity company officials", "non-availability of task force to enforce electricity theft laws", "weak legal Institutions", "high level of poverty and unemployment" were the most important determinants of electricity theft in the study area. Precisely, given that the coefficient of "level of poverty" was positive and statistically significant, high level of poverty would make households more likely to get involved in the incidence of electricity theft in the area under the franchise of both Eko DisCo and Ikeja Electric Plc.

The coefficients of institutional related proxies such as "lack of Punishment", "corrupt practice among the electricity company officials", "non-availability of task force" "and weak legal institution" had different signs, though they all pointed to the same direction that weak institutions promoted electricity theft in Lagos, Nigeria. For example, the coefficient of "lack of punishment for the electricity theft offender "was positive and statistically significant. This implies that failure to punish electricity theft offenders either by fine or length of imprisonment or both made households more likely to get involved in incidence of electricity theft. The result had a similar interpretation with that of “non-availability of task force “whose coefficient was also positive and statistically significant. Lack of presence of task force to apprehend and punish electricity theft offenders, made households more likely to engage in incidence of electricity theft.

With increase in the level of “corrupt practices of the electricity company officials”, households were also more likely to get involved in the incidence of electricity theft given that the coefficient of the factor was positive and statistically significant. This result is similar to that of Depuru, *et al*. (2011) and Nielsen, (2012). They argued that weak institutions promote electricity instability and higher rate of electricity theft.

More importantly, households that had micro-businesses (using electricity to function) in the area of franchise under the two Discos were more likely to get involved in incidence of electricity theft. The coefficient for this factor was positive and statistically significant. Incidentally, lack of task force and as well as lack of punishment for earlier offenders also encouraged perpetrators to keep engaging in the act.

Table 4.4b: Analysis of the determinants of electricity theft in Lagos, Nigeria (pre-paid and post-paid metering customers)

	Parameter	Estimate	Std. Error	Z	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
PROBIT[a]	Age	.025	.010	2.570	.010	.006	.045
	Gender of respondents	-.071	.016	-4.587	.000	-.102	-.041
	highest level of education attainment	.000	.004	.059	.953	-.008	.009
	Occupation	-.002	.006	-.239	.811	-.014	.011
	Accommodation type	.063	.008	8.385	.000	.049	.078
	use of electricity meter	.104	.017	-6.017	.000	-.138	-.070
	status of property	.063	.017	-3.744	.000	-.096	-.030
	price of electricity	.224	.022	-10.072	.000	-.268	-.181
	frequency of power outages	.044	.018	-2.519	.012	-.079	-.010
	estimated billing	.149	.022	6.885	.000	.107	.192
	lack of punishment	.068	.021	3.171	.002	.026	.110
	corrupt practices of the electricity distribution	.073	.023	-3.197	.001	-.118	-.028
	non availability of task force to check electricity theft	.049	.020	2.407	.016	.009	.088
	income level	.079	.018	4.299	.000	.043	.114
	weak legal enforcement	.047	.020	2.378	.017	.008	.085
	high level of poverty	.069	.022	3.071	.002	.025	.113
	unemployment	-.140	.023	-6.146	.000	-.185	-.095
	presence of micro business in household	.061	.017	3.691	.000	.029	.093
	Intercept	-1.107	.075	-14.765	.000	-1.182	-1.032

a. PROBIT model: PROBIT(p) = Intercept + BX

Source: Author's estimation from SPSS 25. Note: Statistical significance at 10%, 5% and 1% respectively.

4.2.4. Analysis of electricity theft determinants among households using pre-paid metering system in Lagos, Nigeria

For households using pre-paid metering system, Table 4.4cpresents the result obtained from the probit regression for the sub-sample. The analysis revealed that the most important electricity theft determinants among households using pre-paid metering system were their “level of education”, “income”, and “presence of micro-business that uses electricity for functioning” in households. In other words, increase in the level of education (an additional year spent in school acquiring further education) of households’ members using pre-paid metering system would more likely lead to a reduction in incidence of electricity theft in Lagos. This suggests that improvement in the level of education among households’ using prepaid metering system was a key drive to reducing electricity theft in the area of study.

Again, as can be seen from the analysis, the coefficients of respondents’ “age” and “gender” were positive and statistically significant. This finding implies that, age and gender of the persons in the household had direct or positive relationship with incidence of electricity theft. In the same manner, it is also correct to infer that, the gender of the households’ head (whether male or female) contributed very significantly to electricity theft as households with men as the head were more likely to be involved in incidence of electricity theft compared with those households headed by women. With respect to the statistical significance of the household’ members’ “age”, it is implied that there was more likelihood that, the older the household members, especially the younger members of the households, the more likely the households’ would get involved in the incidence of electricity theft. This result corroborates that of Gary et al (2013) and Farrington et al (2013), these authors noted that criminal activity increased during adolescence age.

The result also indicated a negative relationship between “high level of poverty”, “lack of punishment” and electricity theft among pre-paid meter users. Specifically, a drastic reduction in poverty level and introduction of sanctions to combat electricity theft had a likelihood of leading to a decrease in the incidence of electricity theft among prepaid electric meter users in Lagos State. Intuitively, increase in “the level of religion knowledge”, “education” and “living in better accommodation types” were equally more likely to reduce the level of involvement of household members in the incidence of electricity theft in the state.

However, factors like "income", "being the owner of the property" (a landlord), "price of electricity", "running a micro-business that uses electricity for functioning within the household", "frequency of power outages" were the outstanding factors determining electricity theft among the prepaid meter users in the study area.

Our result under households using pre-paid metering system was similar to other studies like Ehrlich (1973) and Fleisher, (1966); Imrohoroglu *et al*., (2000) among others. These studies noted that unemployment rates were not important determinants of crime rates than income levels.

For emphasis, the coefficients of institutional related proxies such as "lack of Punishment", "corrupt practice of the electricity company officials", "non-availability of task force" and "weak legal enforcement" were positively related to electricity theft, except "non-availability of task force" which had negative coefficient. All the institutional coefficients pointed to the same direction that weak institution promoted electricity theft in the areas under the franchise of Eko DisCo and Ikeja DisCo in Lagos State. For example, the coefficient of "corrupt practices among electricity company staff" was positive and statistically significant. This implies that corrupt practices among the electricity company officials promoted electricity theft among the households. This result is similar to that of Depuru, *et al*. (2011) and Nielsen, (2012) which reported that weak institutions promoted electricity instability and electricity theft.

Table 4.4c: Probit regression results for the determinants of electricity theft: prepaid metering system in Lagos State

Electricity billing system		Parameter	Estimate	Std. Error	Z	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Prepaid	PROBIT[a]	Age	.015	.014	1.034	0.301	-.013	.043
		Gender of respondents	.037	.024	1.555	0.120	-.010	.083
		highest level of education attainment	.021	.006	3.306	0.001	.008	.033
		occupation	-.040	.009	-4.267	0.000	-.059	-.022
		Accommodation type	-.022	.012	-1.788	0.074	-.046	.002
		use of electricity meter	-.109	.027	-4.080	0.000	-.161	-.056
		status of property	.105	.025	4.164	0.000	.055	.154
		price of electricity	.010	.034	.297	0.767	-.056	.077
		frequency of power outages	.010	.027	.372	0.710	-.043	.063
		estimated billing	-.202	.033	-6.184	0.000	-.267	-.138
		lack of punishment	-.186	.033	-5.610	.000	-.252	-.121
		corrupt practices of the electricity distribution	.256	.032	7.902	.000	.192	.319
		non availability of task force to check electricity theft	.130	.028	4.577	.000	.074	.186
		income level	-.010	.026	-.370	.711	-.060	.041
		presence of micro-business in household	-.052	.023	-2.252	.024	-.098	-.007
		weak legal enforcement	-.073	.029	-2.513	.012	-.130	-.016
		high level of poverty	-.089	.030	-2.998	.003	-.148	-.031
		unemployment	.157	.029	5.382	.000	.100	.214
		Intercept	-1.126	.114	-9.892	.000	-1.240	-1.012

a. PROBIT model: PROBIT(p) = Intercept + BX

Source: Author’s estimation from SPSS 25. Note: Statistical significance at 10%, 5% and 1% respectively

Table 4.4d presents the result of the probit regression for the post-paid metering households and it revealed that the coefficient for "age" was positive and statistically significant. This indicated that the older the household members, particularly the younger members of the households, the more likely the households would engage in incidence of electricity theft. This contradicts the findings of Gary, Alex and Lawrence (2013, Farington *et al*., (2013which established that antisocial and criminal activity increases during adolescence, peaks around age 17 (with the peak somewhat earlier for property than for violent crime) and declines as individuals enter adulthood.

The overall result showed a negative coefficient for "use of electric meter", "status on the property" (whether Tenant or Landlord) and "price of electricity" (electricity tariff) on electricity theft in the study area. This implies that use of electric meter, living in a more comfortable apartment and prevalence of affordable electricity tariff were factors that promoted decrease in incidence of electricity theft among postpaid electricity meter users. Further analysis suggested that "weak legal institution" and "corrupt practice promoted increase in incidence of electricity theft among households using post-paid metering system.

Table 4.4d:Probit regression results for the determinants of electricity theft in Lagos, Nigeria: Post-paid metering among households

Postpaid	PROBIT[a]	Age	.052	.016	3.162	.002	.020	.084
		Gender of respondents	.098	.026	3.749	.000	.047	.149
		highest level of education attainment	-.003	.006	-.501	.617	-.015	.009
		occupation	.033	.010	3.377	.001	.014	.052
		Accommodation type	.024	.013	1.864	.062	-.001	.049
		use of electricity meter	-.042	.025	-1.714	.087	-.091	.006
		status of property	-.238	.035	-6.723	.000	-.307	-.169
		price of electricity	-.018	.031	-.575	.565	-.078	.043
		frequency of power outages	.050	.030	1.677	.093	-.008	.108
		estimated billing	.008	.041	.191	.849	-.072	.088
		lack of punishment	-.143	.035	-4.062	.000	-.211	-.074
		corrupt practices of the electricity distribution	.073	.033	2.197	.028	.008	.138
		non availability of task force to check electricity theft	.251	.037	6.884	.000	.180	.323
		income level	.101	.033	3.105	.002	.037	.165
		presence of micro-business in household	-.132	.026	-5.101	.000	-.183	-.081
		weak legal enforcement	-.125	.031	-3.976	.000	-.186	-.063
		high level of poverty	.121	.047	2.584	.010	.029	.212
		unemployment	-.049	.040	-1.222	.222	-.127	.029
		Intercept	-1.194	.111	-10.710	.000	-1.305	-1.082

a. PROBIT model: PROBIT(p) = Intercept + BX

Source: Author's estimation from SPSS 25. Note: Statistical significance at 10%, 5% and 1% respectively

4.2.5 Analysis of determinants of electricity theft among households' customers using post-paid meters and customers using prepaid meters under Eko DisCo.

Table 4.4e presents the result obtained from the probit regression for the analysis of determinants of electricity theft regarding the pre-paid electric meter users in area of franchise under Eko DisCo. The result revealed that the coefficient of "age", "gender" "accommodation type" "use of electric meter" "unemployment" "price of electricity" and "non-availability of task force to check electricity theft" had negative relationship with electricity theft. This implies that with increase in the level of these factors, there was strong likelihood of decrease in the incidence of electricity theft. However, that the coefficient of the "price of electricity" was negative was curious as it implied that households would have no compulsion in paying higher electricity tariff rather than resorting to electricity theft. They would be willing to accept increase in electricity tariff without recourse to stealing electricity.

Further analysis revealed that the coefficient of "lack of punishment" "corrupt practices" "high level of poverty" "frequency of power outages" "presence of micro-business that uses electricity for functioning in the households" had positive relationship with electricity theft and were statistically significant. This implies that these factors were strong determinants of electricity theft. The higher the increase in the levels of these factors, the more the likelihood of increase in incidence of electricity theft among households using prepaid metering system in the license area under Eko DisCo.

Table 4.4e; Probit regression result for the determinants of electricity theft among customers using prepaid meters under Eko Disco.

Electricity billing system		Parameter	Estimate	Std. Error	Z	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Prepaid	PROBIT[a]	Age	-0.039	.037	-1.039	0.299	-.112	.034
		Gender of respondents	-0.311	.075	-4.122	0.000	-.459	-.163
		highest level of education attainment	0.027	.013	2.131	0.033	.002	.052
		occupation	-0.101	.049	-2.075	0.038	-.196	-.006
		Accommodation type	-0.071	.033	-2.168	0.030	-.134	-.007
		use of electricity meter	-0.309	.104	-2.965	0.003	-.513	-.105
		status of property	0.009	.068	.131	0.896	-.125	.143
		price of electricity	-0.312	.121	-2.576	0.010	-.549	-.075
		frequency of power outages	0.066	.073	.896	0.370	-.078	.210
		estimated billing	0.075	.066	1.125	0.261	-.055	.204
		lack of punishment	0.373	.125	2.994	0.003	.129	.618
		corrupt practices of the electricity distribution	0.032	.151	.215	0.829	-.263	.328
		non availability of task force to check electricity theft	-0.610	.162	-3.767	0.000	-.927	-.293
		income level	0.028	.068	.416	0.678	-.105	.162
		presence of micro business in household	0.191	.076	2.513	0.012	.042	.340
		weak legal enforcement	0.306	.118	2.585	0.010	.074	.538
		high level of poverty	0.080	.073	1.092	0.275	-.063	.223
		unemployment	-0.112	.068	-1.654	0.098	-.244	.021
		Intercept	-0.032	.492	-.064	0.949	-.524	.461

b. PROBIT model: PROBIT(p) = Intercept + BX

Source: Author's estimation from SPSS 25. Note: Statistical significance at 10%, 5% and 1% respectively

4.2.6 Analysis of electricity theft determinants among customers using post paid meters under Eko DisCo

Table 4.4f presents the result obtained from the probit regression for the analysis of determinants of electricity theft among household customers of Eko DisCo using post-paid meters. The result revealed that the most important electricity theft determinants among household using post-paid metering system were “accommodation type”, “use of electric meter”, “status on the property”, “price of electricity” and “frequency of power outages”. The coefficients of all the factors were positive. Factors like the “presence of micro-business that uses electricity for functioning in household”, “weak legal enforcement” “income level” and “high level of poverty” had negative coefficient. The probable cause of this is that the factors do not really exist in this domain in significant proportion. This shows that there are major differences between the behaviour of prepaid electric power meter users and post-paid electric power meter users. Specifically, it appears that there was a level of sophistication associated with the post-paid meter users that motivated them not to be influenced by factors like” poverty” and “weak legal enforcement” as those factors were not statistically significant.

Table 4.4f: Probit regression results for the determinants of electricity theft among consumers using postpaid meters under Eko DisCo

Postpaid	PROBIT[a]	Age	-.216	.068	-3.187	0.001	-.349	-.083
		Gender of respondents	-0.109	.100	-1.094	0.274	-.305	.086
		highest level of education attainment	0.016	.014	1.151	0.250	-.011	.044
		occupation	0.028	.029	.986	0.324	-.028	.085
		Accommodation type	0.001	.037	.014	0.989	-.072	.073
		use of electricity meter	0.197	.073	2.717	0.007	.055	.339
		status of property	0.337	.107	3.142	0.002	.127	.547
		price of electricity	0.030	.093	.320	0.749	-.152	.212
		frequency of power outages	0.242	.100	2.414	0.016	.046	.439
		estimated billing	-0.373	.165	-2.263	0.024	-.695	-.050
		lack of punishment	0.432	.163	2.650	0.008	.112	.751
		corrupt practices of the electricity distribution	-0.205	.115	-1.781	0.075	-.431	.021
		non availability of task force to check electricity theft	-0.495	.126	-3.925	0.000	-.743	-.248
		income level	-0.309	.165	-1.878	0.060	-.632	.014
		presence of micro business in household	-.252	.085	-2.953	0.003	-.418	-.085
		weak legal enforcement	-0.168	.177	-.951	0.342	-.514	.178
		high level of poverty	-0.172	.184	-.935	0.350	-.534	.189
		unemployment	-0.143	.124	-1.152	0.249	-.386	.100
		Intercept	0.134	.564	.237	0.812	-.430	.698

a. PROBIT model: PROBIT(p) = Intercept + BX

Source: Author's estimation from SPSS25. Note: Statistical significance at 10%, 5% and 1% respectively

4.2.7. Analysis of electricity theft determinants among household customers using prepaid meters and customers using post-paid Meters under Ikeja DisCo

Table 4.4g presents the results of the probit regression for the analysis of the determinants of electricity theft among Ikeja Electric Plc (DisCo) customers using pre-paid metering system. The results revealed that regarding electricity theft motivating factors, the behavior of Ikeja DisCo (Ikeja Electric)prepaid meter users was not much different from that of Eko DisCo subscribers. Among households using the Prepaid billing system, the electricity theft motivating factors were “gender”, “corrupt practices of Disco staff”, “price of electricity”, “weak legal enforcement”, “high level of poverty”, “lack of punishment”, “un-availability of task force”, “presence of micro business that uses electricity for functioning” and “high level of poverty”. All these factors were significant at either 1% or 5%. This implies that households headed by men, collusion of corrupt utility staff with dishonest customers, non-sanctioning of electricity theft offenders served to promote incidence of electricity theft among the prepaid electric meter users in the area under Ikeja Electric Plc.

Table 4.4g: Probit regression result of the determinants of electricity theft among customers using prepaid meters under Ikeja DisCO.

Electricity billing system		Parameter	Estimate	Std. Error	Z	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Prepaid	PROBIT[a]	Age	-.017	.017	-1.027	0.304	-0.050	.016
		Gender of respondents	-.100	.028	-3.495	0.000	-0.155	-.044
		highest level of education attainment	.038	.009	4.488	0.000	0.022	.055
		occupation	-.040	.011	-3.694	0.000	-0.061	-.019
		Accommodation type	-.010	.014	-.701	0.483	-0.037	.018
		use of electricity meter	-.025	.031	-.815	0.415	-0.085	.035
		status of property	.090	.030	3.043	0.002	0.032	.148
		price of electricity	.393	.038	10.324	0.000	0.318	.467
		frequency of power outages	.004	.034	.113	0.910	-0.062	.070
		estimated billing	-.076	.042	-1.833	0.067	-0.158	.005
		lack of punishment	-.082	.041	-2.013	0.044	-0.163	-.002
		corrupt practices of the electricity distribution	-.137	.037	-3.727	0.000	-0.209	-.065
		non availability of task force to check electricity theft	-.104	.035	-3.015	0.003	-0.172	-.037
		income level	.023	.034	.684	0.494	-0.044	.090
		presence of micro business in household	.105	.028	3.767	0.000	0.051	.160
		weak legal enforcement	-.118	.033	-3.565	0.000	-0.183	-.053
		high level of poverty	-.097	.038	-2.526	0.012	-0.173	-.022
		unemployment	.045	.035	1.267	0.205	-0.024	.114
		Intercept	-1.053	.128	-8.246	0.000	-1.181	-.926

b PROBIT model: PROBIT(p) = Intercept + BX

Source: Author's estimation from SPSS 25. Note: Statistical significance at 10%, 5% and 1% respectively.

4.2.8 Analysis of electricity theft determinants among customers using postpaid meters under Ikeja DisCo

Table 4.4h presents the results of analysis of determinants of electricity theft among Ikeja Electric Plc' post-paid electric meter users customers. Among households using the Post-paid billing system, the electricity theft motivating factors were highest level of "education attained"," status on the property", "frequency of power outages", "accommodation type", "occupation", "price of electricity", "presence of micro-business that uses electricity for functioning" in the household, "non-availability of task force to check electricity theft" and high "level of poverty". Although, these factors had various coefficients signs but they were significant at 1% and 5%.

Table 4.4h: Probit regression result of the determinants of electricity theft among customers using postpaid meters under Ikeja DisCo.

Postpaid	PROBIT[a]	Age	.094	.020	4.616	0.000	0.054	.134
		Gender of respondents	-.059	.032	-1.865	0.062	-0.121	.003
		highest level of education attainment	.025	.009	2.686	0.007	0.007	.044
		Occupation	-.054	.014	-4.003	0.000	-.081	-.028
		Accommodation type	.076	.016	4.605	0.000	.044	.108
		use of electricity meter	-.142	.030	-4.716	0.000	-.200	-.083
		status of property	-.199	.047	-4.202	0.000	-.292	-.106
		price of electricity	-.062	.042	-1.477	0.140	-.143	.020
		frequency of power outages	-.124	.033	-3.693	0.000	-.189	-.058
		estimated billing	.145	.049	2.963	0.003	.049	.241
		lack of punishment	.005	.038	.131	0.896	-.069	.079
		corrupt practices of the electricity distribution	-.023	.039	-.587	0.557	-.099	.053
		non availability of task force to check electricity theft	.125	.054	2.311	0.021	.019	.231
		income level	.069	.038	1.813	0.070	-.006	.144
		presence of micro business in household	.192	.039	4.899	0.000	.115	.269
		weak legal enforcement	.009	.036	.240	0.810	-.061	.078
		high level of poverty	-.232	.058	-3.965	0.000	-.347	-.117
		unemployment	.087	.053	1.644	0.100	-.017	.191
		Intercept	-1.138	.136	-8.375	0.000	-1.274	-1.002

a. PROBIT model: PROBIT(p) = Intercept + BX

Source: Author’s estimation from SPSS 25. Note: Statistical significance at 10%, 5% and 1% respectively.

4.2.9. Analysis of electricity theft determinants among customers: Logit regression (All households)

The study further probed into the determinants of electricity theft, using logit regression estimation technique (Table 4.4i). The analysis covered the entire participants. The results revealed that the coefficients of respondents' age, gender, status on property (landlord or tenant), and unemployment were all negative and statistically insignificant. This implied that the log odd of getting involved in the crime of ET decreases the older the average age of the household. . This is aligns with the argument of Gary, Alex, and Laurence, (2013), Farrington, (1986); Farrington et al. (2013); Piquero et al. (2003), (2007) where it was established that antisocial and criminal activity increases during adolescence, peaks around age 17 (with the peak somewhat earlier for property than for violent crime), and declines as individuals enter adulthood. Similarly, the less the log odd of individuals participating in ET, the longer the period they have occupied the property, especially if they did not own it. , In addition, the log odd of partaking in the incidence of ET declines the more the households' head was a female. In the same manner, the more the individual was unemployed, the higher the log odd of committing the crime of ET.

However, for the purpose of policy measures aimed at mitigating the problem of ET, since the predictors were not statistically significant, concentrating on them as arrow heads of power policy thrust are less likely to produce the desired result

. On the other hand, coefficients of electricity tariff, frequency of power outages, lack of punishment, bribery and corruption, income level, presence of micro-business within residential apartment, weak legal enforcement, and non-availability of task force were positive and statistically significant. This implied that the higher the rate of frequency of power outages, electricity tariff, bribery and corruption, presence of micro-business within residential apartments and weak legal enforcement of existing anti-electricity theft laws, the higher the log odd of households involvement in the crime of ET. The study agrees with Jamil and Ahmad 2013; Katiyar 2013; Gaur and Gupta 2016 who discovered positive correlation between electricity tariff and incidence of ET. Gaur and Gupta (2016) advocated for power rates that take into account a region's socioeconomic characteristics and economic structure. Gumusdere (2004) claimed in a model of electricity theft in

Turkey that the better the electricity infrastructure, the smaller the loss of power at the time of transmission and distribution.

In the same manner, the more the neglect of the authority to institute task force responsible for apprehending the perpetrators of ET, the higher the log odd of households' involvement in ET. Just as noted under the probit regression, the coefficient of income contradicted apriori expectation. Here, the coefficient was positive and statistically significant indicating that the log odd of the rich households to be involved in the crime of ET is as high as that of the less affluent. This indicated clearly that perpetration of the crime of ET cut across all income groups. As a result, power policy initiatives targeted at mitigating incidence of ET would find tinkering with these predictors more effective. It would be observed that there is no substantial difference between the outcome of Probit regression model and Logit regression. However, due to the functional form of each model, all the coefficients of the predictors of logit regression are slightly bigger in terms of magnitude despite the fact that they all have the same sign.

.

Table 4.4i Analysis of electricity theft determinants among customers (All households) : Logit Regression

	Parameter	Estimate	Std. Error	Z	Sig.	95% Confidence Interval Lower Bound	Upper Bound
LOGIT[a]	Age group	-.016	.012	-1.333	.183	-.040	.008
	Gender of respondents	-.015	.020	-.750	.453	-.054	.024
	highest level of education attainment	.021	.005	1.400	.579	-.011	.031
	occupation	.062	.009	4.133	.000	.044	0.080
	Accommodation type	.031	.008	3.875	.000	.015	.047
	status of property	-.061	.022	-2.773	.005	-.104	-.018
	price of electricity	.159	.025	-6.360	.000	-.208	-.110
	frequency of power outages	.121	.026	4.654	.000	.070	.172
	estimated billing	-.121	.029	-4.172	.000	-.178	-.064
	lack of punishment	.050	.027	1.852	.968	-.003	.103
	corrupt practices of the electricity distribution	.074	.024	3.083	.001	.027	.121
	non availability of task force to check electricity	-.145	.026	-5.577	.000	-.196	-.094
	income level	.016	.019	.842	.800	-.021	.053
	presence of business venture in household	-.060	.018	-3.333	.000	-.095	-.025
	weak legal enforcement	.124	.026	4.769	.000	.073	.175
	high level of poverty	.267	.026	10.269	.000	.216	.318
	unemployment	-.271	.026	-10.423	.000	-.322	-.220
	Electricity billing system	.035	.010	3.500	.000	.015	.055
	Intercept	-2.010	.159	-12.642	.000	-2.322	-1.698

a. LOGIT model: LOGIT(p) = Intercept + BX

4.2.10. Analysis of the marginal effects of electricity theft determinants among customers: Logit regression (All households)

This study went further to do the marginal effects of the analysis of the determinants of ET in Table 4.4j. The advantage of this is that it enables the researcher to report the magnitude of the coefficients of the explanatory variables rather than just interpret the signs which had been the case hitherto.

The coefficient of the level of education attained is positive (0.003) indicating that for every additional year spent in school studying, the likelihood of the household getting involved in ET increased by 3%. The implication of this is that, the more educated the household, the higher the log odd of committing the crime of ET. This is rather surprising but can be explained by associating higher education with higher level of exposure and knowledge that can make household members more able to "do it themselves" and more daring. Same thing applied to the coefficient of electricity tariff. It was positive, (0.016), indicating that for every 1% increase in electricity tariff, households were 16% more likely to get involved in the practise of ET.

The coefficient of frequency of power outage was positive, (0.018). The implication of this is that the log odd of households getting involved in the incidence of ET increases by 18% for every additional 1% increase in the incidence of power outage. Also, the coefficient of estimated billing was, (-0.017), indicating that for every 1% reduction in "crazy " electricity billing, households were 17% more likely to refrain from the incidence of ET. This is a problem that has plagued the services of both Eko DisCo and IE Plc for a while. Their customers had continuously protested against estimated billing which in most cases were adjudged to be unfair and usually far in excess of the actual level of electricity consumed.

In the same vein, the coefficient of "lack of punishment", "bribery and corruption", "running micro business within residential apartment", and "non-establishment of task force" were positive at 0.060, 0.005, 0.05, and 0.007 respectively. This implied that lack of punishment of earlier offenders was probably one of the strongest drivers of ET as continuous neglect to .show example out of the offenders attracted households' involvement in the act by 60%. The same explanation was true of the other predictors.

Table 4.4j: Average marginal effects of the determinants of electricity theft among customers (All households): Logit regression

	dy/dx	Std.Err.	z	P>z	[95%Conf.	Interval]
Age group	0.003	0.033	-0.080	0.934	-0.067	0.062
Gender of respondents	0.018	0.024	0.740	0.458	-0.029	0.064
Religious	0.038	0.015	2.610	0.009	0.009	0.066
Marital status	-0.005	0.009	-0.530	0.595	-0.023	0.013
Highest level of education attainment	0.003	0.014	0.030	0.980	-0.027	0.028
Occupation	0.029	0.020	1.460	0.143	-0.010	0.069
Income level	0.008	0.020	0.380	0.707	-0.032	0.047
Electricity billing system	0.015	0.016	0.930	0.355	-0.017	0.047
Length of staying on property	-0.012	0.017	-0.690	0.493	-0.044	0.021
Accommodation type	0.017	0.036	0.470	0.642	-0.053	0.086
Usage of electricity meter	0.041	0.036	1.150	0.251	-0.029	0.111
Status in property (tenant or landlord)	0.095	0.036	2.670	0.008	0.025	0.165
Price of Electricity	0.016	0.039	-0.400	0.686	-0.093	0.061
Price of Gasoline and Diesel	0.091	0.036	2.520	0.012	0.020	0.162
Frequency of power Outage	0.018	0.041	0.440	0.663	-0.063	0.099
Estimated Billing	-0.017	0.045	-0.380	0.704	-0.106	0.071
Lack of Punishment	0.060	0.040	1.510	0.132	-0.018	0.137
Corrupt practice of the electricity company	0.005	0.034	3.070	0.002	0.038	0.171
Non-availability of task force	0.007	0.034	0.210	0.835	-0.059	0.073
Presence of business venture in household	0.050	0.032	1.570	0.117	-0.013	0.113
Absence of meter	0.001	0.038	0.020	0.981	-0.075	0.076
Taking responsibility to fix major electricity faults	0.044	0.046	0.970	0.332	-0.045	0.134
Weak legal enforcement	-0.012	0.041	-0.300	0.767	-0.092	0.068
High level of poverty	0.005	0.043	0.110	0.911	-0.080	0.090
Unemployment	-0.038	0.040	-0.960	0.337	-0.117	0.040

4.3 Prevalence of electricity theft among households in Lagos State

This study sought to estimate the size of the household respondents who had been directly involved in incidence of electricity theft by asking them directly using the questionnaire They were asked whether they had ever been personally involved in any form of electricity theft. The analysis of the responses received is presented in Figure 4.9 Fourteen per cent of the respondents claimed to have either being a party to or single-handedly perpetrated the act of electricity theft while 86.0% claimed innocence of the practise. This study concluded that in the license area under both Eko DisCo and Ikeja Electric Plc. 14 % of the respondents felt no compulsion about stealing electricity.

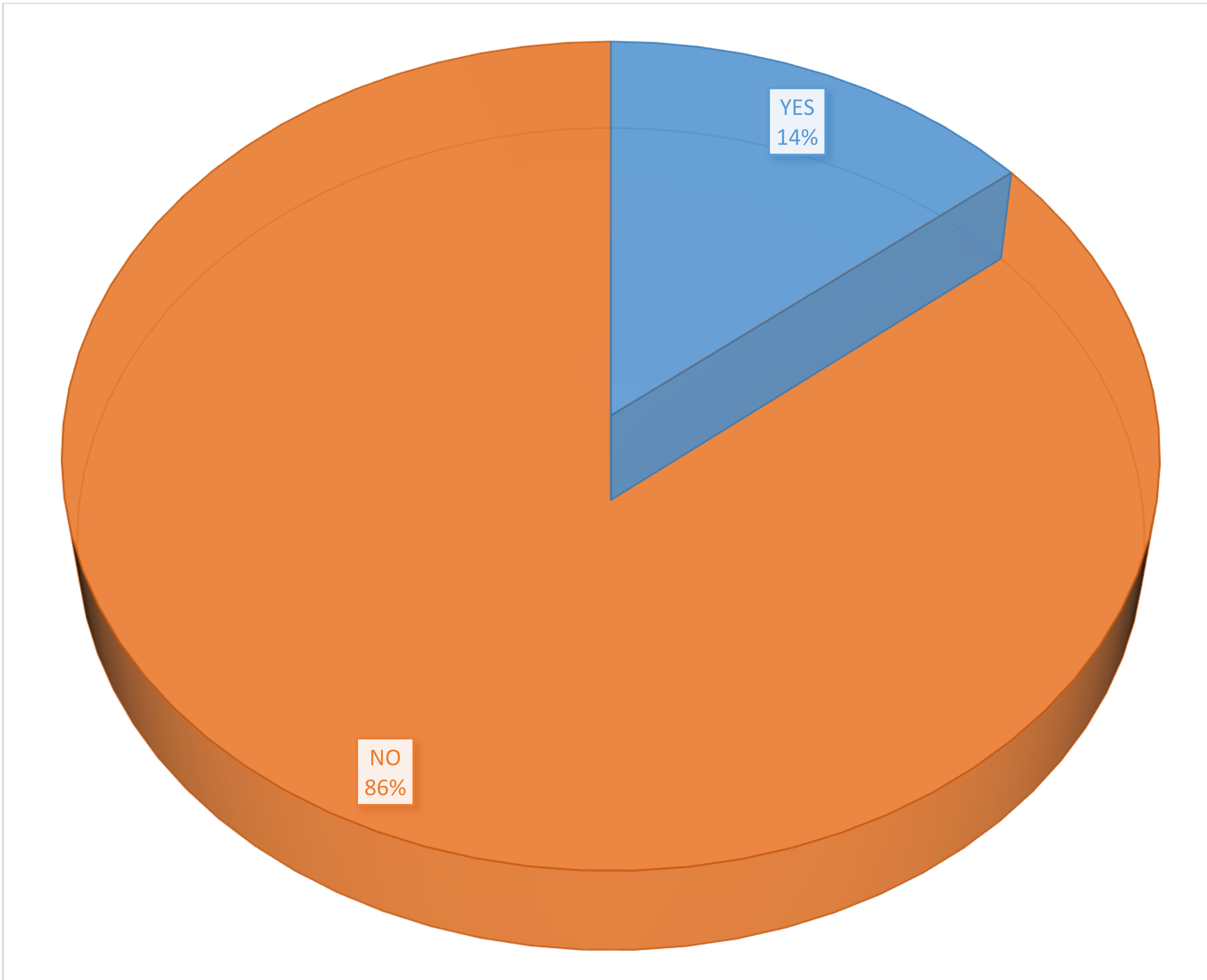


Figure 4.9: Magnitude of Electricity Theft among all Household respondents
Source: Field Survey, 2019

Figure 4.9b reveals that 11.2% of the respondents claimed to have either being a party to or single-handedly engaged in electricity theft in the franchise area under Ikeja DisCo, while only 88.8% claimed innocence of the practice.

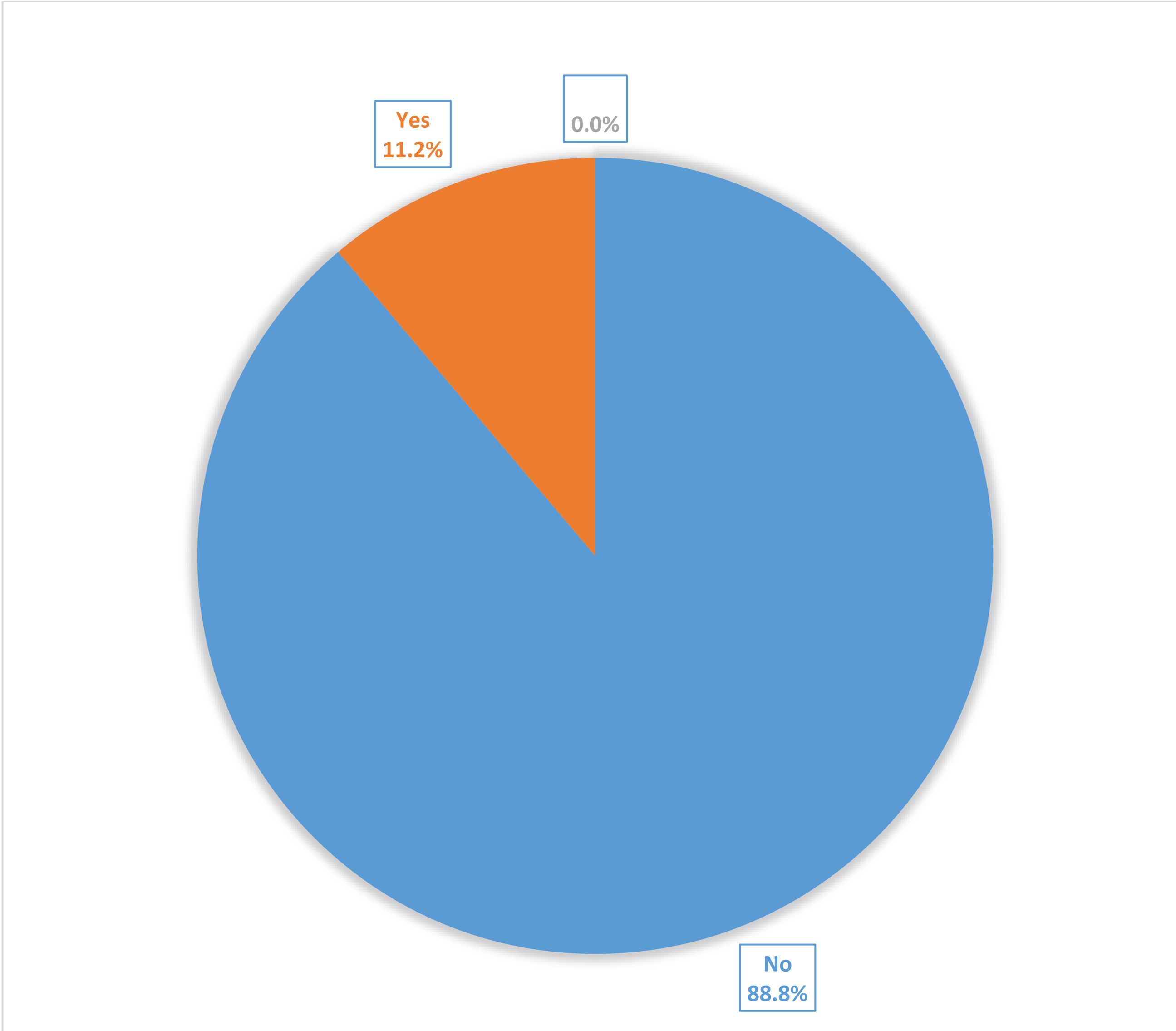


Figure 4.9b: Magnitude of Electricity Theft among Household respondents (Ikeja)
Source: Field Survey, 2019

In the license area under Eko electricity Distribution Company, 15.6% of the respondents claimed to have either being a party to or single-handedly engaged in electricity theft, while 84.4% claimed ignorance of the practise. Therefore, this study concluded that among the respondents, 15.6% had no compulsion about stealing electricity under Eko DisCo, while among the respondents under Ikeja Electric Plc., 11.2 % represented the proportion who had no compulsion about stealing electricity.

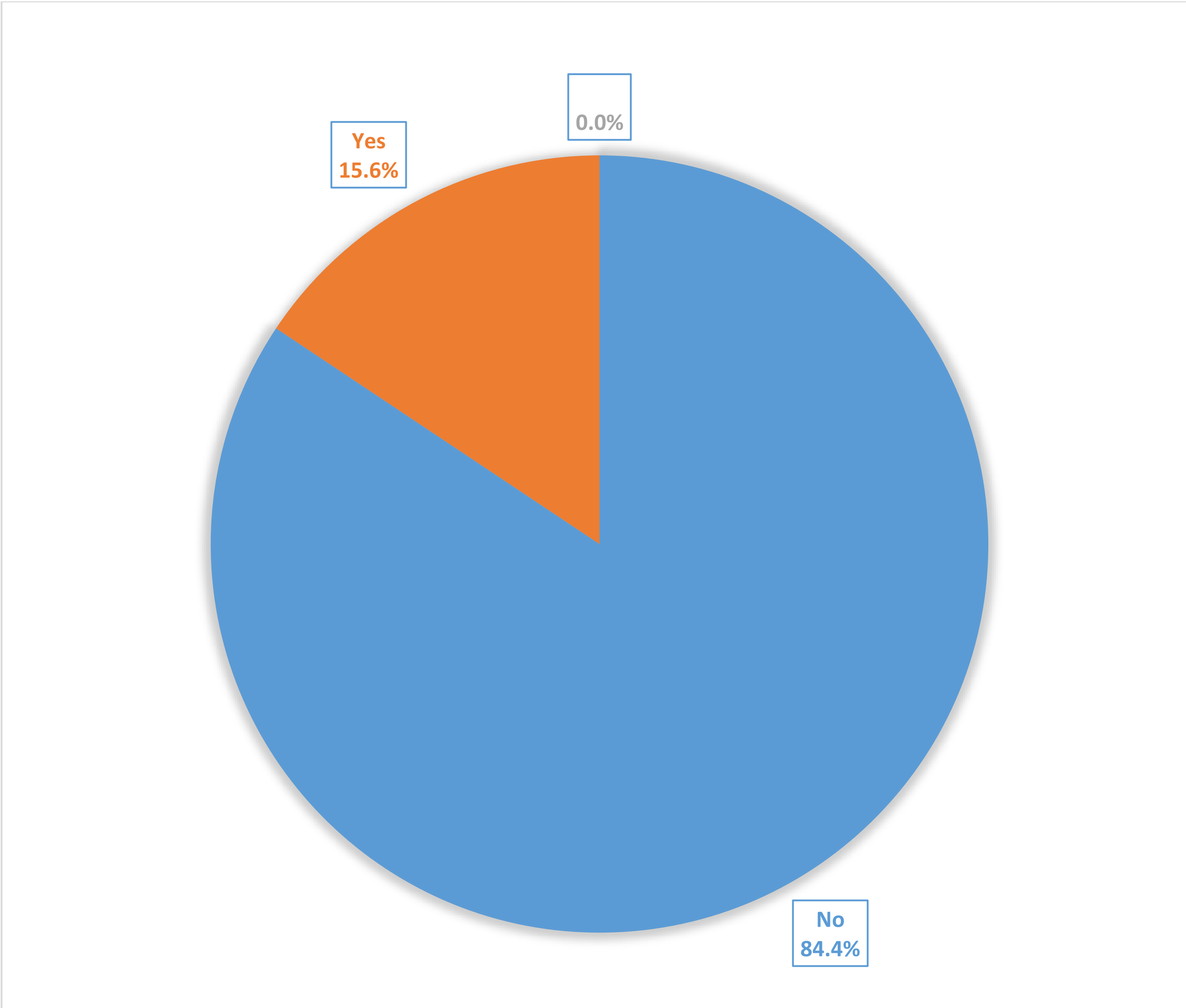


Figure 4.9c: Magnitude of Electricity Theft among Household respondents (Eko)
Source: Field Survey, 2019

4.4 Effects of electricity theft among households in Lagos State

In this sub-section, the respondents were presented with a number of alternatives in the questionnaire out of which they were requested to choose what they believed were effects of electricity theft on households. They were also told to state the effects which they were personally experiencing as result from electricity theft even when such effects were not listed in the questionnaire.

The questionnaire contained thirteen (13) key major possible effects of electricity theft. The analysis of the responses received indicated that 72.4% of the respondents believed that electricity theft would lead to lack of enough power to distribute. Many of the respondents, 63.2%, said that overloading of electricity equipment such as transformers was a possible outcome of electricity theft. This result was supported by the findings of Katiyar (2013) and Jamil and Ahmad, 2013 which stated that electricity infrastructure had a positive association with power theft.

The results in Table 4,5a further show that low current - 79.4%, damage to household appliances - 64.4%, high estimated electricity billing - 76.2%, anger from customers who pay their bills regularly - 61.4%, high electricity tariff - 80.6%. Above all, it is easy to conclude that households' believed strongly that electricity theft would lead to high electricity tariff, epileptic electricity supply, low current or brown-out and more frequent power outage among others.

Table 4.5a: Effects of electricity Theft in areas of Franchise under Ikeja and EkoDisCos

Effects	Yes	No	No Response
Lack of enough power to distribute	362(72.4%)	127(25.4%)	11(2.2%)
Overload of electricity equipment e.g. Transformer	316(63.2%)	175(35.0%)	9(1.8%)
Difficulty for Government and Distribution company to plan for service delivery	341(68.2%)	149(29.8%)	10(2.0%)
Frequent power outage	397(79.4%)	94(18.8%)	9(1.8%)
Low current (Brownout)	366(73.2%)	126(25.2%)	8(1.6%)
Damage to power equipment	322(64.4%)	170(34.0%)	8(1.6%)
Very high estimated electricity billing	381(76.2%)	109(21.8%)	10(2.0%)
Damage to household appliances	307(61.4%)	165(33.0%)	28(5.6%)
Electricity tariff goes up	403(80.6%)	70(14.0%)	27(5.4%)
The cost of power generation by buying diesel and petrol goes up	326(65.2%)	161(32.2%)	13(2.6%)
Social life adversely affected	223(44.6%)	254(50.8%)	23(4.6%)
Disposable income of an individual reduces due to additional expenses on self-power generation.	258(51.6%)	207(41.4%)	35(7.0%)

Source: Field Survey, 2019

The results in Table 4,5b further show that low current - 79.4%, damage to household appliances - 64.4%, high estimated electricity billing - 76.2%, anger from customers who pay their bills regularly - 61.4%, high electricity tariff - 80.6%. Above all, it is easy to conclude that households' believed strongly that electricity theft would lead to high electricity tariff, epileptic electricity supply, low current or brown-out and more frequent power outage among others.

Table 4.5b: Effect of electricity Theft in Nigeria in areas of Franchise under Ikeja Electric (DisCo)

Effects	Yes	No	No Response
Lack of enough power to distribute	122(75.8%)	36(22.4%)	3(1.9%)
Overload of electricity equipment e.g. Transformer	98(60.9%)	60(37.3%)	3(1.9%)
Difficulty for Government and Distribution company to plan for service delivery	112(69.6%)	44(27.3%)	5(3.1%)
Frequent power outage	137(85.1%)	21(13.0%)	3(1.9%)
Poor voltage e.g. low current or supply	125(77.6%)	33(20.5%)	3(1.9%)
Damage to household appliances	110(68.3%)	47(29.2%)	4(2.5%)
Very high estimated electricity billing	128(79.5%)	29(18.0%)	4(2.5%)
Anger from customers who pay their bill regularly	105(65.2%)	49(30.4%)	7(4.3%)
Electricity tariff goes up	139(86.3%)	14(8.7%)	8(5.0%)
The cost of power generation by buying diesel and petrol goes up	111(68.9%)	45(28.0%)	5(3.1%)
Social life is adversely affected	62(38.5%)	86(53.4%)	13(8.1%)
Disposable income of an individual reduces due to additional expenses on self-power generation.	82(50.9%)	65(40.4%)	14(8.7%)

Source: Field Survey, 2019

The results in Table 4.5c further show that low current - 79.4%, damage to household appliances - 64.4%, high estimated electricity billing - 76.2%, anger from customers who pay their bills regularly - 61.4%, high electricity tariff - 80.6%. Above all, it is easy to conclude that households' believed strongly that electricity theft would lead to high electricity tariff, epileptic electricity supply, low current or brown-out and more frequent power outage among others.

Table 4.5c: Effect of electricity Theft in Nigeria (Eko)

Effects	Yes	No	No Response
Quantity of power available for distribution reduces	240(70.8%)	91(26.8%)	8(2.4%)
Overload of electricity equipment e.g. Transformer	218(64.3%)	115(33.9%)	6(1.8%)
Difficulty for Government and Distribution company to plan for service delivery	229(67.6%)	105(31.0%)	5(1.5%)
Frequent power outage	260(76.7%)	73(21.5%)	6(1.8%)
Poor voltage e.g. low current or supply	241(71.1%)	93(27.4%)	5(1.5%)
Damage to household appliances	212(62.5%)	123(36.3%)	4(1.2%)
High electricity tariff	253(74.6%)	80(23.6%)	6(1.8%)
Low revenue for Distribution companies	229(67.6%)	97(28.6%)	13(3.8%)
Anger from customers who pay their bill regularly	202(59.6%)	116(34.2%)	21(6.2%)
Electricity tariff goes up	264(77.9%)	56(16.5%)	19(5.6%)
The cost of power generation by buying diesel and petrol goes up	215(63.4%)	116(34.2%)	8(2.4%)
Social life is adversely affected	116(47.5%)	168(49.6%)	10(2.9%)
Disposable income of an individual reduces due to additional expenses on self-power generation.	176(51.9%)	142(41.9%)	21(6.2%)

Source: Field Survey, 2019

4.5. Synthesis of empirical results and study objectives

Objective 1: Investigate the determinants of electricity theft in among house hold electricity end-users in Lagos State, Nigeria

This objective was achieved by estimating Equation (3.1) using probit estimation regression technique. The results obtained from regression of data sourced from franchise areas under both DisCos were similar and showed that running a micro-business that uses electricity to function within residential apartments, price of electricity (electricity tariff), lack of punishment of earlier offenders, bribery and corruption, non-availability of task force put in place solely to confront electricity theft offenders, weak enforcement of existing anti-electricity theft laws were the most important determinants of electricity theft. At the same time, the results indicated clearly that the practice of electricity theft cut across all income groups which did not only run contrary to the a-priori expectation but is unique to the area of study, Earlier studies conducted in US, Europe and Asia had reflected inverse relationship between income level and practice of electricity theft. This is also the first study that identified running micro business within residential apartment as a driver for ET. This is perhaps unique to Lagos State, Nigeria.

Objective 2 Determine the prevalence of electricity theft among households in Lagos, Nigeria

This study relies on the descriptive statistics to satisfy the objective. The prevalence of electricity theft was measured by analysing the responses to questionnaire administered with respect to whether the sampled respondents had ever being a party to or directly perpetrated the act of electricity theft. The analysis reflected that 14% of the respondents had had no compulsion stealing electricity among the households in area of franchise under both EkoDisCo and Ikeja Electric Plc combined together. However results from further analysis of data collated from franchise area under each of the two DisCos revealed that the practice of electricity theft was higher under EkoDisCo at 15.6% than under IE Plc. at 12.2%. It is important to also note that all results were in two digits which is excessive in comparison to electricity theft rates in developed countries like in the US and West Europe which ranged between 1-2% and 7% respectively.

Objective 3: Investigate the effects of electricity theft in Lagos, Nigeria

This study also relies on the descriptive statistics to satisfy this objective. Our analysis revealed that the effects of electricity theft among household electricity end-users in Lagos State included: epileptic electricity supply, damage to electric power equipment such as transformers, low current (Brownout), damage to household appliances and more power shortage. This result is similar to that of Gaur and Gupta (2016) which stated that electricity tariffs that took into consideration the socio-economic conditions and the economic structure of specific regions was more likely to reduce electricity theft.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of findings

Adopting the random sampling technique to gather data from 500 households from communities with diverse socio-economic characteristics (rural, semi-rural and urban) across Lagos state of Nigeria, the study employed probit regression technique to analyse the determinants of electricity theft among households in license areas under Eko DisCo and Ikeja Electric Plc, and the following findings were revealed.

Contrary to a priori expectations, a positive relationship exists between households' members' income and electricity theft. This implies that in the study area, the high income earners were not exempted from involvement in incidence of electricity theft. This result is striking as it indicated that among households' in Lagos state, even the rich steal electricity.

The results also showed a positive relationship between "price of electricity", "frequency of power outages" and electricity theft. This implies that with increase in "electricity tariff" or "frequency of power outages", households were more likely to get involved in incidence of electricity theft in Lagos.

The coefficients of institutional related proxies such as "lack of Punishment", "corrupt practices involving electricity company officials", "non-availability of task force to check electricity theft "and "weak legal Institution "had positive signs, except "non-availability of task force" which had negative coefficient.

This implies that all the institutional coefficients pointed to the same direction indicating that weak institutions promoted electricity theft in Lagos. For example, bribery and corruption among the staff of electricity distribution companies showed a positive coefficient that was statistically significant. This implies that high level of corrupt practices among the electricity company officials promoted incidence of electricity theft among households in the study area

On the other hand, since findings indicated that coefficient of “task force responsible for apprehending electricity theft offenders” was negative and statistically significant, the more the authority delay/decline to set up a strong task force to regularly arrest and sanction electricity theft offenders, the more likely the involvement of households in incidence of electricity theft under both Eko DisCo and Ikeja Electric Plc.

Our results further revealed that the most important electricity theft determinants among households using pre-paid metering system were their “level of education”, “presence of micro-business” that uses electricity for functioning in households, “level of poverty”, “lack of punishment” and “corrupt practices”.

Put differently, increase in level of education (such as additional year in school acquiring further education) among households’ members’ using pre-paid metering system would more likely lead to a reduction in incidence of electricity theft among prepaid electric meter users in Lagos. This suggests that improvement in the level of education among households’ using prepaid metering system was a key drive to reducing electricity theft in Lagos state. On the other hand, among the households where micro-business using electricity for functioning exists, households on prepaid metering system were more likely to engage in electricity theft.

Among post-paid metering system users, factors like the “presence of micro-business that uses electricity for functioning in household”, “weak legal enforcement” “income level” and “high level of poverty” had negative coefficient. The probable cause of this is that the factors do not really exist in this domain in significant proportion. This shows that there were differences between the behaviour of prepaid electric power meter users and post-paid electric power meter users. Specifically, it appeared that there was a level of sophistication associated with the post-paid electric meter users that motivated them not to be influenced by factors like” poverty” and “weak legal enforcement” as those factors were not statistically significant.

This study revealed further that the effects of electricity theft in Lagos included epileptic electricity supply, low current (or brown out), further reduction in the quantity of electricity available for household use, and general low power quality delivery leading to electric power companies calling for higher tariff.

In conclusion, 14 % of the households' electricity end users in areas under the operational license of both Eko Disco and Ikeja Electric Plc clearly had no compulsion in stealing electricity. Further analysis revealed that this practice was higher among customers of Eko DisCo than that of Ikeja Electric Plc. The incidence of electricity theft was in two digits and considered high in comparison with rate of electricity theft in US and West Europe which is 1-2 % and 7% respectively. This is the closest any study has got into estimating the magnitude or prevalence of electricity theft among households' electricity end users in Lagos state and in Nigeria's electric power sector as a whole as no prior study of this nature currently exists.

5.2 Conclusion

Electricity theft among the households in Lagos State, Nigeria exists in high proportion (i.e. in two digits at 14%) and urgent steps are required to address it by addressing the factors that motivate consumers to engage in it. In this study, we found that there was a nexus between running micro-business (using electricity for functioning) in residential apartments, bribery and corruption, weak enforcement of anti-electricity theft laws and prevalence of electricity theft. Households where micro-businesses requiring electricity to function (such as laundry and dry cleaning, welding, mini-supermarkets, ice-block manufacturing, restaurants etc.) exist in Lagos, incidence of electricity theft exists. Clearly, the practice of electricity theft cuts across all the social economic classes. It is evident, therefore, that electricity end users don't steal electricity because of privation but because the cost of committing the infraction is too low. The study has shown that the reasons for electricity theft are diverse even though a few factors such as bribery and corruption could be common to many households. Policies formulated to combat electricity theft should therefore take into cognizance the specific characteristics to ensure relevance and potency.

5.3. Some policy recommendations

The findings from the study present various policy implications for Nigerian's policy makers in their attempts to reduce to the barest minimum the problem of electricity theft in order to boost the avenues for revenue generation necessary to bring about the much needed improved electricity service delivery.

- **Institutional reforms to strengthen compliance with anti-electricity theft laws**

Any law or legal provision aimed at behavioural change can only be effective when there is strong and transparent enforcement. Nigeria statue books are replete with provisions for dealing with individuals or groups of people found to be engaging in electricity theft but the enforcement of these laws is horribly weak. For instance, Section 286(2) of the Penal Code LFN 2004 states that "whoever dishonestly abstracts, diverts, consumes or uses any electricity or electrical current is said to commit theft". This crime is punishable under Section 287 of the Penal Code with imprisonment for a maximum term of five years or with a fine or with both fine and term of imprisonment. In addition, under section 10 of the Miscellaneous Offences Act, "any person, who unlawfully disconnects, removes, damages, tampers, meddles with or in any way whatsoever interferes with any electric fittings, meters or other appliances used for supplying or selling electricity shall be guilty of an offence and liable on conviction to imprisonment for a term not exceeding 21 years". The EPSR Act 2005 also makes ample provision for dealing with perpetrators of this crime. It affirms that any person who receives any electric lines or materials or infrastructure in parts or in whole knowing or having reasons to believe the same to be stolen property, shall be found guilty of an offence under Section 427 of the Criminal Code, Sections 317, 318, 319A of the Penal Code and Section 94 of the EPSR Act 2005and shall be punishable upon conviction with a term of imprisonment as provided under Section 427 of the Criminal Code, Section 317, 318, 319 of the Penal Code or Section 94 of the EPSR Act 2005 as applicable.

In the opinion of this study, the cost of committing the crime of electricity theft is presently too low to dissuade perpetrators from the act and it would be sufficiently raised to discourage the behaviour only if the probability that an individual who steals electricity would be arrested and convicted is very high. This particular measure is very important in view of the fact that our results indicated that stealing of electricity is a practice that has been found to cut across all income groups. Hence, strong deterrent measure using instruments of enforcement of the law is highly recommended.

- **Enlightenment campaign against electricity theft**

Bearing in mind that federal government of Nigeria is the biggest single investor in Nigeria's electric power industry post-privatization, (20% shares in GenCos, 100% shares in TCN, 40% shares in DisCos), it should compel its Agencies: Nigeria Electricity Regulatory Commission (NERC) and Nigeria Orientation Agency (NOA)to add to their regular functions the duty of public advocacy. They should embark on massive enlightenment of the electricity consumers to the consequences of electricity theft. Electricity theft ultimately leads to shortage of a service that is already in short supply because it denies the entire electric power value chain the revenue needed to function optimally.

- **Establishment of power task force**

Presently, only either the Police or the agents of the power utility (the DisCos) exercise the power to apprehend and impose fine on individuals involved in electricity theft. This arrangement leaves the arrest of the power thieves completely at the discretion and convenience of the two bodies. Without doubt, they have been ineffective in performance of this duty probably because they have to perform this function along with other functions. This is why suggestion of a Power Task Force is apt. The task force should comprise staff of Nigeria Civil Defence Corps, the Economic and Financial Crimes Commission (EFCC) and officials of the Ministry of Power. The taskforce' primary assignment would be to move from house to house detecting cases of electricity theft. It should be empowered through the act of parliament to have unrestrained access to electricity consumers' residences and facilities with a view to inspecting premises, arresting offenders and imposing fine or prosecuting defaulters where necessary. The staff of the Power Task Force should be well trained and incentivized. Finally, a technique of monitoring and evaluating their performance should be put in place such that bad eggs among them are promptly sanctioned. Government (being a core investor in the industry) should collaborate with other stakeholders in NESI to finance the operations of the task force. The Act setting up the Power Task Force should be reviewed from time to time as the need may arise to guarantee efficiency.

- **Corruption targeting policy**

Policies formulated to combat electricity theft should take into account measures that would reduce collusion between utility staff and dishonest customers to the barest minimum. In practice, considerable amount of revenue is usually generated from all cases of electricity theft that are successfully busted. In view of this, it is recommended that an attractive incentive package be designed and made available to any utility staff who successfully uncovers cases of electricity theft in which revenue recovery is made. This monetary incentive should be made a fraction of the revenue recovered and the policy should be adopted by all DisCos. If the hard working and upright staff know that they can earn more legitimately by working hard, they may find it unattractive to operate on the wrong side of the law. In the same vein, the corruptible ones, when caught, should always be dealt with promptly according to the law to serve as deterrent to others. Similarly, household electricity end users should be encouraged to report cases of electricity theft noticed in their communities through the whistle blower policy. A percentage of the revenue recovered through each reported case should be made available to the whistle blower. Mischief-makers who are found to be reporting false incidence of electricity theft through the whistle blower policy should equally be visited with commensurate punishment for wasting government's time and resources.

5.4 Contribution to knowledge

Some of the contributions of the study to knowledge include:

- This study offers contribution to a body of literature on energy studies particularly in the field of electricity theft as it has added to the limited empirical studies on the subject by providing evidence from Nigeria given that other research efforts by Kwakwa, P. A (2018), Mirza *et al.*, (2015), Jamil (2013)and Golden and Min (2012), have modelled electricity theft for some other countries.
- Second, there is no indication of any study especially focusing on a particular sector of the economy among the previous studies on this issue. In that regard, this study differs from all previous ones in that it disaggregated the economy and focused just on residential electricity end-users. Examining the micro determinants of power theft ensures a policy strategy capable of addressing the issue at its source. As a

result, the study has the potential to not only assist Nigerian policymakers in implementing decreased ET measures, but also to add to the current literature on ET mitigation techniques.

- Additionally, previous empirical studies have identified the following factors as determinants of electricity theft: temperature, illiteracy, terrorist attacks, electoral cycle, agricultural production rate, electricity bill collection efficiency, electricity tariff, number of electricity consumers, low income, inefficient electricity usage, and bribery and corruption. Except for electricity tariffs, bribery and corruption, and income level, all of these elements are location-specific. However, no previous study has looked into how the presence of a micro-business in the home, the lack of a task force, and the weak legal enforcement of existing anti-electricity theft laws contribute to ET events. This study extends existing literature by incorporating these factors.
- Finally, the other prior studies that used econometric technique to investigate the determinants of electricity theft used all the predictors as continuous variables. In this study our predictors are used as categorical variables to examine how they account for incidents of electricity theft.

5.5 Some limitations and possible areas of further research

The refusal of the two Electricity Distribution Companies in Lagos (where the research was conducted) to work hand in hand with the researcher in the area of sharing expertise, knowledge, and data was the first major limitation encountered throughout the course of this study.

Letters of introduction from the Director, CPEEL, to pave way for rapport were presented to the Managing Directors of both organizations at different times but same were rebuffed by both of them. While Eko Electricity Distribution Company pretended to be putting together a legal team to advise the company on the propriety and implication of attending to the researcher thereby wasting valuable time, Ikeja Electric Plc was out-rightly hostile.

On receiving the letter of introduction and following persistent urge for a response, the company (IE Plc.) contacted the (CPEEL) Director's office to authenticate the letter. Having confirmed its authenticity, the researcher was told point blank that the letter merely conveyed a request for assistance which they were not under obligation to assent to. He was further informed that one of their fears was that he, the researcher, could be a mole, being sponsored by their competitors to obtain their trade secret under the guise of conducting a research! That was the end of the story as far as efforts towards getting secondary data and sharing their experiences concerning the subject matter at the head office of each of the companies was concerned.

Second, given its importance and capacity to make a difference, this type of research should not be limited to a single state or geographical zone. Clearly, this study's funding was a major obstacle. With sufficient resources, the research should be expanded to cover all aspects of operations for the country's eleven electricity distribution companies. This would allow for a more complete approach to tackling the plague, as well as a broader view of the problem.

Third, the scope of this research is limited to households. In addition to this, many electricity end-users under the franchise of Eko Disco and Ikeja Disco are yet to have either a prepaid or post-paid meter. Incidents of electricity theft cannot accurately be estimated in the absence of electric meters. As such, the conclusions reached concerning the prevalence of electricity theft in Lagos, Nigeria in this study would be conclusive only when future research has examined other sectors of the economy such as electricity theft in commercial and industrial sectors and when more meters have been made available to customers and when all areas under the franchise of the currently existing eleven DisCos are brought under focus.

REFERENCES

Aliyu, A., Ramli, A. and Saleh, M. 2013. 'Nigeria electricity crisis: Power generation capacity expansion and environmental ramifications'. *Energy*, 61(8): 354–67.

Anumaka, M.C. 2012. Scenario of electricity in Nigeria. *International Journal of Engineering and Innovate Technology (IJELT).* ISSN: 1(6), 1- 8. http://www.ijeit.com/vol%201/Issue%206/IJELT1412201206_32.pdf. Accessed at 00.20hrs, 22nd April, 2018.

Association of Nigeria Electricity Distributors.2019.http://www.anedng.com/ Accessed on September 18.

Atieno, P. A, 2009. An Analysis of the Strengths and Limitations of Qualitative and Quantitative Research Paradigms. *Problems of Education in the 21stcentury*, 13(13). https://scientiasocialis.lt/pec/files/pdf/Atieno_Vol.13.pdf. Accessed on August 15, 2018

Awosope, C.A. 2014. Nigeria electricity industry: Issues, challenges and solutions. Covenant University 38th Public Lecture. *Public Lecture Series.* 3 (2), October 2014.

Becker G S., 1968. "Crime and punishment: An economic approach," *Journal of Political Economy* 76(2): 169-217.

Becker, G.S. 1968. Crime and Punishment: The economic approach. *Journal of Political Economy.*76(2):169-217. The University of Chicago Press. http://www.nber.org/chapters/c3625.pdf accessed at 00.30hrs, April 22nd, 2018.

Becker G., Stigler G., 1974. Law enforcement, malfeasance, and compensation of enforcers. *Journal of Legal Studies* 3:1-19.

Bhatia, B., Gulati, M., 2004. Controlling electricity theft and improving revenue. In edited book, *Reforming the power sector: Public Policy for the Private Sector*. The World Bank Group no. 272, September

Bhattacharyya, S., 2005. The Electricity Act 2003: will it transform the Indian power sector? *Util. Policy* 13 (3), 260-272.

Block. M. K. and R. C. Lind 1975a. Crime and punishment reconsidered. *The Journal of Legal Studies*. 4 (1).

Bo, E. D, and Rossi M. A. 2007. Corruption and inefficiency: Theory and evidence from electric utilities. *Journal of Public Economics* 91 (5-6): 939-962.

Bureau of Public Enterprises. 2015. Overview of the Nigerian electricity industry (Roles, responsibilities, structure, expectation). Presentation at the Nigeria power sector investment forum - Lagos, Dubai, London, New York and Johannesburg.https://docplayer.net/21349671-Overview-of-the-nigerian-electricity-industry-roles-responsibilities.html Accessed on October 10, 2018

Cardenas, A.A., Amin, S., Schwartz, G.R., Dong, S. and Sastry, A. 2016. A game theory model for electricity theft detection and privacy-aware control in AMI systems. *IEEEXplore Digital Library.* https://ieeexplore.ieee.org/documents/6483444/citations. Accessed: April 22nd, 2018.

Carr-Hill, R. A. and R. H. Stern. 1979. Crime, the Police and Criminal Statistics. An analysis of official statistics for England and wales using econometric methods. 280-309

Cochran, W.G. 1963.Sampling Techniques, *Wiley Online Library*, Wiley, New York. https://onlinelibrary.wiley.com/doi/abs/10.1002/zamm.19630431039. Accessed: April 28th, 2018.

Clarke G. and L. C. Xu. 2004. Competition and Corruption: How characteristics of bribe takers and payers affect bribe payments to utilities. *Journal of PublicEconomics*88: 2067-2097.

David, N. 2018. The Effects of Energy Theft on Climate Change and Its Possible Prevention Using Smart Meters: Case Study Nigeria. *International Journal of Scientific & Engineering Research*, 9(1)

Davis, M.J. 2014. “Procurement practices influencing service delivery: A Case of Kenya Power” *European Journal of Logistics, Purchasing and Supply Chain Management,* 20 (3): 79 – 137.

Dangar, D. and Joshi, S.K. 2014.Electricity theft detection techniques for distribution system in GUVNL. *International Journal of Engineering Development and Research.* 13, 11-17 https://www.ijedr.org/papers/1JEDRCP1402003.pdf. Accessed: April 23rd, 2018.

Depuru SS, Wang L, Devabhaktuni V.2011. Electricity theft: overview, issues, prevention and smart meter based approach to control theft. *Energy Policy*; 39: 1007–15.

Edison A.C., Neto, A. and Coelho, J. 2013.Probabilistic methodology for technical and non-technical losses estimation in distribution system. *Electric Power Systems Research.*97: 93-99

EkoDisCo. https://ekedp.com/page/our-operations. Accessed December 15, 2019

Ehrlich, I. 1973. Participation in illegitimate activities: a theoretical and empirical investigation. *Journal of Political Economy* 81(3)/ May-June. https://www.journals.uchicago.edu/doi/abs/10.1086/260058

Eskeland G.S and H. Thiele. 1999. Corruption under moral hazard. The World Bank, Washington D.C. Policy Research working Paper 2204.

Fama, E. F. and M. C. Jensen, 1983. Agency problems and residual claims. *Journal of Law and Economics.* 26 (2): 145-159.

Farrington, D. P; A. R., Piquero and W. G Jennings. 2013. Offending from childhood to late middle age: Recent results from the Cambridge study in delinquent development. New York: Springer

Fleisher, B. M. 1966. The effect of income on delinquency**.** *The American Economic Review* 56(1/2): 118-137

Freeman, R. B. 1994. Crime and the job market. *The National Bureau of Economic Research.* NBER Working Paper No. 4910 Issued in October. https://www.nber.org/papers/w4910

Gary S, Alex R. Piquero Laurence Steinberg. 2013. Age and the explanation of crime, revisited*. Journal of Youth ad Adolescence* 42(6): 921-938. https://link.springer.com/article/10.1007/s10964-013-9926-4

Garoupa: 2003: Optimal law enforcement when victims are rational players. *Conflict and Governance*. Pp. 123-134

Garoupa, N. 2003 "Behavioral economics analysis of crime: A critical review," *European Journal of Law and Economics* 15: 5-15

Garoupa N. 2014.Economic theory of criminal behavior. In: Bruinsma G., Weisburd D. (eds) Encyclopedia of Criminology and Criminal Justice. *Springer,* New York, NY https://link.springer.com/referenceworkentry/10.1007%2F978-1-4614-5690-2_409

Gaur, V. and Gupta, E. 2016. The determinants of electricity theft: An empirical analysis of Indian states: *Energy Policy.* 93: 127 – 136.

Groenendijk, N.A. 1997. A principal agent model of corruption. *Crime, Law and SocialChange* 27: 207-229.

Groh S, Pachauri S. and R..Narasimha 2016. What are we measuring? An empirical analysis of household electricity access metrics in rural Bangladesh. *Energy for Sustainable Development* 30: 21-31.

Gujarati, D.N. and Porter, D.C. (2009).*Basic Econometrics.* Published by McGraw-Hill Irwin, New York, USA. ISBN: 978-007-127625-2

Hussain, Z., Memon, S., Shah, R., Bhutto, Z.A. and Aljawarneh, M., 2017. Methods and techniques of electricity thieving in Pakistan. *Journal of Power and Energy Engineering* 4: 1-10.

IEA Statistics © OECD/IEA. 2015. Electric power transmission and distribution losses (% Output) https://data.worldbank.org/indicator/EG.ELC.LOSS.ZS. Accessed: April 24th, 2018

Ikeja Electric Plc. https://www.ikejaelectric.com/ikeja-electric-networks/.AccessedDecember19, 2019.

Imrohoroglu, A, A. Merlo, P. Rupert. 2000. On the political economy of income redistribution and crime. *International Economic Review*, 41(1): 1-26. https://onlinelibrary.wiley.com/doi/abs/10.1111/1468-2354.00053

Iwayemi, A. 2016. Options for financing government programmes: public-private-partnership in infrastructure. Paper presented at CPEEL seminar series, University of Ibadan.

Iwayemi, A. 2020."Controlling Electricity Theft in Nigeria: Analytical and Policy Issues". *CPEEL Seminar Series*. Centre for Petroleum, Energy Economics and Law, University of Ibadan.

Jamil, F. 2013. On the electricity shortage, price and electricity theft nexus. *Energy Policy.* 54: 267-272.

Jamail, F. and Ahmad, A. 2010.An empirical study of electricity theft from electricity distribution companies in Pakistan. National University of Science & Technology Islamabad, Pakistan. pp. 1-28. http://pide.org.pk/psde/pdf/AGM29/papers/Faisal%20jamil.pdf. Accessed: April 22nd, 2018.

Jamail, F. and Ahmad, A. 2013.An economic investigation of corruption and electricity theft. Pakistan institute of development economics working papers.2013.92 https://econpapers.repec.org/paper/pidwpaper/2013_3a92.htm Accessed: April 22nd, 2018

Jamail, F and Ahmad, E. 2014. An empirical study of electricity theft from electricity distribution companies in Pakistan: *The Pakistan Development Review* 53(3): 239-254.

Jensen, M. C. and Meckling, W. H. 1976. Theory of the firm: Managerial behaviour, agency costs and ownership structure. *Journal of Financial Economics*, 3(4): 305-360

John, D. and MacArthur, C.T. From genesis to date: Understanding the history and evolution of the Nigeria electricity supply industry, *Empower Nigeria* July 5, 2015: 15-25.

Kaplow, L. and Shavell, S. 2002. Economic analysis of law. *Handbook of Public Economics*. 3: 1661-1784

Katiyar, S.K. 2005. "Political economy of electricity theft in rural areas: A Case study from Rajasthan". *Economic and Political Weekly*, 40(7): 644 – 648.

Kennedy-Darlington, J. Hoyt, N. Murao, K. and Ross, A. 2008. The energy crisis of Nigeria: An Overview and Implications for the Future. The University of Chicago: 1-28

Kwakwa. 2013. The was used to estimate the drivers of Ghana's EPL, using annual time series data from 1971 to 2013.

Lagos State Government. 2013. Energy Sector Projects: Ministry of energy and mineral resources/Lagos State electricity board. *Executive Summary*.

Lattimore, P, K, Baker, J. R. And Witte, A. D. 1992. The influence of probability on risky choice: A parametric examination. *NBER Technical Working Paper Ser*ies. https://www.nber.org/papers/t0081.pdf Accessed on August 14th, 2020.

Lewis, F.B. 2015. Costly 'Throw-Ups': Electricity theft and power disruptions. *The Electricity Journal*. 28(7): 118-135

Marjit, S. and H. Shi, 1998.On controlling crime with corrupt officials. *Journal of Economic Behaviour & Organization*. 34(1): 163-172

Mbanjwa, T. 2017. An analysis of electricity theft: The case study of KwaXimba in eThekwini, KwaZulu-Natal. *Doctoral Thesis*. University of KwaZulu-Natal, South Africa.

Min B. and Golden M. 2014. Electoral cycles in electricity losses in India. *Energy Policy* 65: 619-625.

Mimmi, L.M. and Ecer, S. 2010. An econometric study of illegal electricity connections in the urban favelas of Belo Horizonte, Brazil. *Energy Policy*. V 38, 5081 – 5097.

Mira, F.M., Hashmi, M.S. and Saad, M.M. 2015. Long run determinants of electricity theft in Pakistan: An Empirical Analysis: *Pakistan Journal of Social Sciences* 35(2): 599-608.

Mookherjee, D. and Png, I. P. L. 1995. Corruptible law enforcers: how should they be compensated? *The Economic Journal*. 105(428): 145-159.

Monedero, I., Biscarri, F., Leon, C., Guerrero, J.I., Biscarri, J. and Millan, R. 2012.Detection of frauds and other non-technical losses in a power utility using Pearson coefficient, Bayesian networks and decision trees. *Electrical Power and Energy Systems*. 34: 90-98.

Mutebi R.M., Otim, J. S, Okou, R, and Sebitosi, B. 2015. Electricity theft in Kampala and potential ICT solutions. In: Nungu A., Pehrson B., Sansa-Otim J. (eds) e-infrastructure and e-services for Developing Countries.

Nielsen M. 2012. Imitation, pretend play, and childhood: Essential elements in the evolution of human culture. American Psychological Association. Journal of Comparative Psychology. https://psycnet.apa.org/record/2011-18196-001

Nigeria power baseline report.2015.The advisory power team, office of the Vice President, Federal Government of Nigeria in conjunction with Power Africa. Aug. 15. https://mypower.ng/wp-content/uploads/2018/01/Baseline-Report.pdf

Nigeria Electricity Regulatory Commission. http://www.nercng.org/ Accessed on April 18, 2018.

Nigeria electricity system operator. History of system operations: Brief history. https://www.nsong.org/AboutUS/History.aspx. Accessed: April 27th, 2018.

Nunoo, S. and Attachie, J.C. 2011.A methodology for the design of an electricity theft monitoring system. *Journal of Theoretical and Applied Information Technology*, 26(2): 112 – 117

Oladipo, F. and Temitayo, O. 2014. The Nigerian power system till date: A Review. *International Journal of Advance Foundation and Research in Science & Engineering (IJAFRSE)* 1(5): 20-33

Olaoluwa, O. G. 2017. Electricity Theft and Power Quality in Nigeria. *International Journal of Engineering Research & Technology*. 6(6), 1180-1184

Osigwe A. C. Onyimadu. 2018. Electricity theft in Nigeria: How effective are the existing laws? *Journal of Energy Technologies and Policy* 8(8): 8-13

Oseni, M.O. 2011. An analysis of the power sector performance in Nigeria: *Renewable and Sustainable Energy Reviews*, 15: 4765 – 4774

Patton, M. 1990. Qualitative evaluation research methods, Beverly Hills, CA, Sage.169-186.

Piquero, A. R; McGloin, J. M; and Christopher, J. S 2007. Local Life Circumstances and Offending Specialization/Versatility: Comparing Opportunity and Propensity Models. *Journal of Research in Crime and Delinquency*, 44(3) https://journals.sagepub.com/doi/abs/10.1177/0022427807302664 Accessed on august 18, 2019

Polit D. Cherry, E. B. and Beck, T. 2010. Generalization in quantitative and qualitative research: Myths and strategies. *International Journal of Nursing Studies* vol. 47(11): 1451-1458. https://www.sciencedirect.com/science/article/abs/pii/S0020748910002063?via%3Dihub Accessed on Oct. 22, 2019.

Pyle, D.J. 1983. The economic approach to the optimal choice of punishment. *The Economics of Crime and Law Enforcement.* The Macmillan Press Ltd. London and Basingstoke. https://link.springer.com/book/10.1007%F978-1-349-05245-5. Accessed April 24th, 2018.

Saini, S. 2018: Malpractice of Electricity theft: A major cause of distribution losses in Haryana. *International Research Journal of Management and Commerce.* 5(1): 284 – 313. aarf.asia/download.php?filename=../current/2018/Feb/yadeYaEaqotr71.pdf.Accessed: April 23rd, 2018.

Sambo A.S. 2008.: Matching electricity supply with demand in Nigeria. *Fourth Quarter.* 32-36. https//www.iaee/org/documents/newsleterarticles/408sambo.pdf.Accessed April 24th, 2018.

Sambo, A. S; Garba, B; Zarma, H.I; Garji, M. M. 2010.Electricity generation and the present challenges in the Nigerian power sector. A paper presentation. Energy Commission of Nigeria, Abuja-Nigeria. https://www.osti.gov/etdeweb/biblio/21423178 Accessed April 24, 2018.

Sardar, S. and Ahmad S. Detecting and minimizing electricity theft: A review. *Research Gate Article* November 2015. https://www.researchgate.net/publication/308207798. Accessed April 24, 2018.

Savelsberg, J. 1987. “The making of criminal law norms in welfare states: Economic crime in West Germany.” *Law and Society Review* 21(4): 529 – 562.

Schram, G. 1990. Electric power in developing countries: Status, problems, prospects. *Annual Review of Energy* 15(3): 07-33.

Selvapriya, C. 2014. Competent approach for inspecting electricity theft. *International Journal of Innovative Research in Science, Engineering and Technology* 3(3): 1763-1766.

Sharmaa, Pandey, Punia, and Rao 2016, Of pilferers and poachers: Combating electricity theft in India. *Energy Research and Social Science* 11: 40-52

Shulman, E. P., Steinberg, L. D., and Piquero, A. R. 2013.. The age–crime curve in adolescence and early adulthood is not due to age differences in economic status. *Journal of Youth and Adolescence*, 42(6): 848–860

Smith, T.B., 2004. Electricity theft: a comparative analysis. *Energy Policy* 32 (18): 2067–2076.

Soma, S.S.R.D., Wang, L. and Devabhaktuni, V. 2011. Electricity theft: Overview, issues, prevention and a smart meter based approach to control theft. *Energy Policy.*Vol. 39: 1007 – 1015.

Ssekika, E. 2013.Uganda loses Shs 76bn annually to power theft: The Observer, Kampala, Uganda. http://observer.ug

Steadman, K. 2009. Electricity theft in Jamaica. Ph.D. Thesis. State University of New York, Binghamton.

Subair, K. and Oke, D.M. 2008. Privatization and trends of aggregate consumption of electricity in Nigeria: an empirical analysis. *African Journal of Accounting, Economics, Finance and Banking Research.* 3(3): 18-27

Tallapragada, P. V. S. N.2009 Nigeria's electricity sector- electricity and gas pricing barriers. *Research Gate* https://www.researchgate.net/publication/237298286_Nigeria's_Electricity_Sector_Electricity_and_Gas_Pricing_Barriers

Tasdoven, H. B. Fiedler, A. Garayev, V. 2012.Improving electricity efficiency in Turkey by addressing illegal electricity consumption: A governance approach. *Energy Policy.* 43: 226-234

Taro-Yamane .1962.*Englewood Cliffs, New*. Jersey: Prentice-Hall.

Tsebelis, G. 1989. The abuse of probability in political analysis: the Robinson Crusoe fallacy. *American Political Science Review,* 83: 77-92.

Tsebelis: G. 1990. Are Sanctions Effective? A Game-theoretic analysis. *Journal of Conflict Resolution*. 34 (1): 3-28

USAID. 2019.Eko Electricity Distribution Company (Ekedc), Nig Engendering utilities partner Profile: EKEDC, Nigeria. https://www.usaid.gov/energy/engendering-utilities/partners/ekedc-nigeria. Accessed: October 15, 2018

U.S. Department of Energy. 2017. Valuation of energy security for the United States report to Congress. https://www.energy.gov/policy/downloads/valuation-energy-security-united-states-report-congress. Accessed: October 15, 2018.

US Legal.com 2017 *https://definitions.uslegal.com/e/economic-crime*. Accessed on November 7, 2017 at 13.30 hours.

Winther, T. 2012. Electricity theft as a relational issue: A comparative look at Zanzibar, Tanzania, and the Sunderban Islands, India. *Energy for Sustainable Development.* 16: 111 – 119.

Worldbank databank. 2014. “Access to electricity”. Available online at: www.worldbank.com. Accessed on 11th November, 2017

Yakubu, O, Babu, N, Adjei, O. 2018. Electricity theft: Analysis of the underlying contributory factors in Ghana. *Energy Policy*, 123: 611-618.

Yurtseven, C. 2015. The causes of electricity theft: An econometric analysis of the case of Turkey. *Utilities Policy*. 37: 70-78.

Other sites visited included the following: Klitgaard (1988); Groenendijk (1997)].

Ambode. A (2017).Lagos state Government Portal.

https://lagosstate.gov.ng/blog/2016/12/25/our-targets-to-make-lagos-third-largest-economy-in-africa-ambode/. Accessed on October 26, 2017 at 09.00 hours.

http://www.vanguardngr .com/2017/02/ambode-targets-3000mw-24-hr-power-generation-lago Accessed October 25, 2017 at 23:00 hours.

https://www.nsong.org/AboutUS/History.aspx. Accessed: April 27th, 2018.

https://pdfs/semanticscholar.org/presentation/4f3b/0d89dff271090b85769d31becc0c082088d8.pdf.

https://nerc.gov.ng/index.php/library/industry-statistics/mfi/129-annual-fin-reports

https://ekedp.com/news/detail/28

“Sample size calculator.”[Online]. Available: http://www.surveysystem.com/sscalc.htm

https://punchng.com/losing-n238bn-monthly-theft-power-firm/

https://www.pmnewsnigeria.com/2018/02/22/electricity-theft-eko-disco-loses-n1-2-billion-monthly/

https://www.vanguardngr.com/2017/08/electricity-theft-ikeja-electric-set-to-name-and-shame-culprit/

https://businessday.ng/news/article/energy-theft-eko-disco-promises-whistle-blowers-20/

http://www.energy.gov.ng/papers/Status%20Of%20Energy%20Access%20in%20Nigeria%20-WEC%20Johannesburg,%20Feb,%202013.pdf

APPENDIX

Table 2.1: Summary of some Methodology Review

Scholars	Approach	Models	Methods	Findings
Osman Yakubu, NarendaBabu C, OseiAdjei (2018).	This research looks on the elements that contribute to electricity theft in Ghana. The authors used data from Ghana's Ashanti Region, which is the country's most populous region.	Qualitative	Cross-sectional data	In this research, increasing electricity rates, poor power quality, corruption, and a lack of enforcement of the law against corruption Theft of electricity was discovered to be one of the most common causes of Theft of electricity
Gaur and Gupta (2016)	The impact of socioeconomic and governance factors in affecting the degree of electricity thefts in India is investigated in this study.	Feasible Generalized Least Square (FGLS) model	Used Time series Data	Lower corruption, a higher state tax-to-GDP ratio, higher collection efficiency of power bills by state utilities, a bigger fraction of private installed capacity, and higher income are all linked to electricity theft, according to the findings.
Hashmi and	The long-term	ARDL	The study makes use	The findings show a

Saad (2015)	factors Mirza of energy theft in Pakistan are investigated in this study.	approach to co-integration	of annual time series data dating back to 1970. The long-run cointegrating relationship between electricity theft, per capita income, electricity price, number of consumers, and economic openness was discovered using the ARDL approach to co-integration.	strong and negative link between per capita income and electricity theft. Furthermore, in the long run, electricity theft is positively connected to the price of electricity and the number of consumers. Electricity theft has a statistically insignificant association with economic openness.
Lewis (2015)	For over 100 countries, a comparative analysis of electricity theft was conducted, as well as the value of lost load as a result of power outages.		Estimate the direct cost of an electrical outage using a production function approach and input-output analysis (in terms of lost production time)	The findings demonstrate that between 1971 and 2011, energy theft increased not only in many individual countries, but also in most regions around the world. 2) Between 2007 and 2013, the cost of one kWh of electricity not delivered grew in all industries around the world, with the

				exception of transportation, storage, and communication, and mining and quarrying.
Jamil, Ahmad (2015)		The fixed effects models are estimated using the least squares dummy variable technique and the generalized method of moments.	For the period 1988–2010, annual panel data from nine power distribution firms was collected for empirical study.	With sufficiently high coefficient values, the results show that per capita income has a considerable negative effect on electricity theft and electricity pricing has a large positive effect on electricity theft.
Yurtseven (2015)	For the estimation, provincial electricity theft and socio-economic data for the period of 2002 – 2010 are employed	Constant elasticity mode	The three-stages-least-square (3SLS) method.	Findings revealed that in Turkey, electricity theft leads to loss of substantial amount of revenue annually. The following: Income, social capital, rural population rate, temperature and agricultural production rate were

				identified as significant determinants of electricity theft.
Jamil (2013)	Electricity demand and the relationship between electricity shortfalls, tariff rate and electricity theft in the background of Pakistan electricity crisis using the data for the period		Granger causality test through error correction model and out-of-sample causality through variance decomposition method 1985 – 2010	The study indicates that electricity theft is the leading cause of electricity crisis in the country (Pakistan)
Edison, Neto, Coelho (2013)	Comparing the Measured Energy consumption in the feeder with the Billed Energy by the utility plus the Technical Losses, the energy balance is computed and the Non-Technical Losses are estimated.		Probabilistic methodology for the Technical and Non-Technical Losses estimation.	They conclude that this methodology is useful for measuring technical and non-technical losses in the electric power systems in countries where resources are scarce.
Winther (2012)	The study examines the phenomenon of power theft in two distinct developing contexts: Zanzibar, Tanzania and Sunderban Islands,	Qualitative	The methods used included participant observation, interviews and an extended household survey in Uroa village for 10	In both places findings show that customers' level of trust in their electric power supplier becomes jeopardised, but for

	West Bengal, India.		months in 2000 – 2001. The survey covered 114 of 480 (23%) households in the village and was primarily conducted in the form of structured interviews with both male and female members of each household	rather different reasons leading to high rate of theft.
Min and Golden (2012)			Time Series data: Data from Uttar Pradesh Power Corporation 2000 – 2009	Results show that the level of electricity theft is high. In addition the extent of theft varies with the electoral cycle of the state. In years when elections to the State Assembly are held, electricity theft is significantly greater than in other years.
Cardens, Amin Schwartz, Dong and Sastry (2012	They first formulated a game between the distribution utility and electricity, thieves, and tried to find the Nash		Game theory	They found that the Nash equilibrium of the game was a probability density function that attackers and defenders must

	equilibrium of the game			choose in order to send AMI (Advanced Meter Infrastructure) measurements.
Monedero, Biscarri, Leon, Guerrero, Biscarri and Millan (2011)	Detection of Non-technical losses in the customers of Endesa Power Utility Company in Spain.		Pearson coefficient. Bayesian Networks and decision trees.	Non-Technical Loss is an important issue in power utilities because it has a high impact on company profits. Second, the methodology of detection of non-technical losses of the companies is very limited since these companies use detection methods that do not exploit the use of data mining techniques.
Depuru, Wang, Devabhaktuni and Gudi (2010)	A review of various factors that influence the consumer to make an attempt to steal electricity and illustrates several methods to quantify and control theft			Total losses incurred by utility companies because of theft are very large and capable of running the company into bankruptcy. Secondly, the corrupt employees in

				the same system are found to be less dedicated towards implementation of measures to reduce theft.
Mimmi and Ecer (2010)	Based on an original, dataset of 15,279 low-income households, this paper studies the incidence and determinants of illegality (power theft) in the context of low-income urban “favelas” (slums)	Estimating a simple probit model and then estimate an instrumented variables probit model, and finally a recursive bivariate probit model to capture and control for the potential correlation between the underlying processes that are responsible for the variables.		The findings from the analysis of the Conviver program data (carefully controlling for endorgeneity of certain variables) verify the intuitive explanation that low income leads to illegality, but, importantly, also prove how income is not the only relevant factor.
Smith (2004)	Comparative		Cross-sectional data	He found out that

	analysis		sample of one-hundred and two (102) countries for 1980 and 2000	power theft is increasing in most regions of the world, while financial impacts of theft are reducing income from the sale of electricity thereby increasing the necessity to charge more to consumers.

QUESTIONNAIRE ON THE DETERMINANTS OF ELECTRICITY THEFT IN NIGERIA

IMPORTANT NOTICE

You have been asked to complete this survey as part of a research project being conducted by Michael Ojo Obafemi, a student at University of Ibadan. The research project is titled "Determinants Electricity Theft in Nigeria" and is designed to investigate factors that contribute that contribute to electricity theft in Nigeria's electric power sector. Your responses are entirely voluntary, and you may refuse to complete any part of this survey. This survey is designed to be anonymous, meaning that there should be no way to connect your responses with you. Toward that end, you are not required to sign your name to the survey or include any information in your responses that makes it easy to identify you. By completing and submitting the survey, you affirm that you give your consent for the researcher to use your answers in his research. If you have any questions about this research before or after you complete the survey, please contact Professor Adeola Adenikinju, Director, Centre for Petroleum, Energy Economics and Law (CPEEL), University of Ibadan, Oyo State, Nigeria at cpeel@ui.edu.ng. If you have any concerns or questions about your rights as a participant in this research, please contact the Chair of the Board of the Post Graduate College, University of Ibadan at postgrad@mail.ui.edu.ng

No	QUESTIONS AND FILTERS	CODING CATEGORIES	CODES	SKIP
1	State			
2	LGA			
3	City/Town			
4	Age Group	16 – 20	1	
		21 – 40	2	
		41 – 64	3	
		65 & above	4	
5	Gender of Respondent	Male	1	
		Female	2	
6	Religious affiliation	Islam	1	
		Christianity	2	
		Traditional	3	
		Other (Specify)	4	
7	Marital Status	Never Married	1	
		Married	2	
		Separated	3	
		Divorced	4	
		Widow	5	
8	Highest Educational Attainment	No Formal Education	1	
		Primary School not Completed	2	
		Primary School Completed	3	
		Secondary School not completed	4	
		Secondary School Completed	5	
		Post-Secondary Education	6	
		Koranic Education	7	
		Other (Specify)	8	
9	Occupation	Farming; fishing; etc.	1	
		Trading	2	
		Skilled (electrician, plumbing, mechanic, carpentry, etc.)	3	
		Lower white collar (Nursing, teachers, clerk, non-graduates, etc.)	4	
		Professional (managerial, medicine, law, accountancy, architect, banker, university teacher, higher civil servant etc.)	5	

		Other (specify)	6	
10	Income group			
		N1000 – N29,000	1	
		N30,000 – N50,000	2	
		N51,000 – N200,000	3	
		N201,000 – N500,000	4	
		N501 and Above	5	
11	Electricity Billing System	Pre-paid	1	
		Post-paid	2	
		Estimated Billing	3	
12	How long you have been living in this property?	Less than one year	1	
		1 – 3 years	2	
		3 – 6 years	3	
		More than 6 years	4	
13	Accommodation type	One room apartment	1	
		Room and parlour self-contained	2	
		2/3 bedroom flat	3	
		Bungalow	4	
		Duplex	5	
14	Usage of electricity meter	Independent user	1	
		Shared meter arrangement	2	
15	Status in property	Tenant	1	
		Landlord/Landlady	2	
	Factors contributing to electricity theft in Nigeria			
16	**Will these factors influence electricity theft in Nigeria**			
	Price of Electricity	YES	1	
		NO	2	
	Price of Gasoline and Diesel	YES	1	
		NO	2	
	Frequency of power outages	YES	1	
		NO	2	
	Estimated billing	YES	1	
		NO	2	
	Lack of punishment	YES	1	
		NO	2	
	Corrupt practices of the Electricity Distribution Company	YES	1	
		NO	2	
	Non availability of task force to check electricity theft	YES	1	
		NO	2	
	Income level	YES	1	
		NO	2	
	Presence of business venture in household (e.g. ice block, dry cleaning, welder)	YES	1	
		NO	2	

	Absence of meter	YES	1	
		NO	2	
	Taking responsibility to fix major electricity faults	YES	1	
		NO	2	
	Weak legal enforcement	YES	1	
		NO	2	
	Response of electricity officials to addressing electricity faults	YES	1	
		NO	2	
	High level of property	YES	1	
		NO	2	
	Unemployment	YES	1	
		NO	2	
	Other (specify)			
17	Are you aware people engage in electricity theft?	YES	1	
		NO	2	
18	Have you ever engaged in any form of electricity theft	YES	1	
		NO	2	
19	Is the distribution company aware of your electricity connection?	YES	1	
		NO	2	
20	Is your meter accessible to the electricity distribution company?	YES	1	
		NO	2	
21	If you are officially metered, is there any appliance in your home that is not connected to the electricity pole directly without passing through the meter	YES	1	
		NO	2	
22	Have you ever tampered with your meter before?	YES	1	
		NO	2	
23	Have you ever had agreement with the distribution staff to bypass your meter?	YES	1	
		NO	2	
24	Have you ever given bribe to the staff of the electricity distribution company after being caught bypassing your meter?	YES	1	
		NO	2	
25	**Do you consider the following as effects of electricity theft?**			
	Low revenue to the distribution company	YES	1	
		NO	2	
	Overload of Electricity equipment e.g. transformer	YES	1	
		NO	2	
	Difficult for Government and Distribution company to plan for service delivery	YES	1	
		NO	2	

	Frequent cut off of electricity supply	YES	1	
		NO	2	
	Poor voltage e.g. low current or too high current	YES	1	
		NO	2	
	Damage to household appliances	YES	1	
		NO	2	
	Very high electricity billing	YES	1	
		NO	2	
	Reluctant from customers who steal electricity paying their bill	YES	1	
		NO	2	
	Anger from customers who pay their bill regularly	YES	1	
		NO	2	
	Other (Specify)			
26	Common methods of electricity theft	Meter bypass	1	
		Illegal connection to electricity pole	2	
		Direct connection of high electricity consuming equipment e.g. pumping machine etc.	3	
		Tampering with the meter	4	
		Illegal connection from neighbours	5	
		Other (specify)	6	
27	Electricity tariff is too high and encourage electricity theft	YES	1	
		NO	2	
28	The cost of power generation by buying diesel and petrol is too high and encourage electricity theft	YES	1	
		NO	2	
29	Do you think social status (Professor, Manager, Imam, Pastor) can prevent electricity theft in Nigeria?	YES	1	
		NO	2	
30	Do you think the level income of an individual can encourage electricity theft?	YES	1	
		NO	2	
Strategy for Combating Electricity Theft in Nigeria				
31	Please rate the following strategies at addressing electricity theft	Strong legal enforcement	1	
		Adequate enlightenment campaign against electricity theft	2	
		Establishment of power task force	2	
		Monitoring and Evaluation	4	
		Prosecution of corrupt electricity distribution company officials	5	
		Incentives for loyal customers	6	

		Community involvement in fighting electricity theft	7	
		Collaboration between security agents and community	8	
		Other (Specify)	9	
32	Which institutions do you find most supportive of preventive electricity theft Nigeria?	DISCO	1	
		Police	2	
		Neighbourhood Association	3	
		Ministry of Power	4	
		NGOs	5	
		Other (Specify)	6	
33	Generally, do you think the effort to reduce electricity theft is achieving success?	YES	1	
		NO	2	
34	Are you involved in Neighbourhood Association that tackles electricity theft?	YES	1	
		NO	2	
35	If No, are you willing to become actively involved in managing electricity theft in your area?	YES	1	
		NO	2	
36	In your own opinion, how do you think electricity theft can be effectively prevented and managed?	Comment….		

THANK YOU VERY MUCH

ELECTRICITY DISTRIBUTION COMPANY (DISCO)

Sir/Madam,

1. What is the name of your company? -------------

2. From your record, how often is power loss experienced in the system?---------------
-

3. What percentage, of total power supply usually ends up in electricity loss according to your records? Both technical and non-technical? -------------------------

4. On the average, what fraction or percentage of the electricity loss is due to technical factors? ---

5. From your experience, what forms of non-technical losses does your company encounter on regular basis? Tick as appropriate the under listed factors.

(i.) Refusal to pay accumulated bill by uniformed and non-uniformed people. ----------

(ii.) By-passing of electricity meter.________________

(iii.) Tampering with the meter to reduce its efficiency and accuracy. ____________

(iv.) Directly connecting business facilities to overhead or underground power supply cable ______________

(v.) Connecting households and businesses to underground cable _____________

(vi.) Tapping of electricity from legal consumer by other unauthorised persons.________

(vii.) Deliberately connecting only a few of household appliances to the meter. _______

(viii.) Deliberate or wilfully damaging the meter to prevent its accuracy. ____________

(ix.) Others ____

6. In cases where non-technical losses have been discovered, what class of people in the society are usually involved?

(i.) The illiterate------------

(ii.) The fairly educated (school cert holders) -----------

(iii.) The well educated people (university graduate) --------------

(iv.) The technically skilled people. --------------------------------

(v.) All of the above--------------

7. From your experience, electricity theft is perpetrated mostly by:

(i.) The poor-------------------

(ii.) The middle class-------------

(iii.) The rich and influential-------------------

(iv.) The uniformed persons----------------

(v.) All the above-----------------------------

(vi.) Others -----------------------------------

8. Given your experience, what factors predispose individuals to electricity theft? Who is more likely to indulge in electricity theft?

(i.) The Nigerians who live in Nigeria-------------------------

(ii.) The foreigners who do business and live in Nigeria----------------

(iii.) Those in police or military uniform------------------------

(iv.) The illiterate---------------------

(v.) The highly educated--------------------

(vi.) The business owner who wants to make huge profit. ----------

(vii.) The greedy-----------------------------

(viii.) Well placed government officials--------------------

(ix.) Those in position of authority---------------------------

(x.) The low income group-----------------------------------

(xi.) The high income group-----------------------------------

(xii.) The politically influential group-------------------------

(xiii.) Others. ---

9. What factors from your experience promote/provoke electricity theft?

(i.) Weak institutions to fight crime--------------------------------

(ii.) Lack of deterrence ---------------------------------------

(iii.) Desire to make huge profit by business owners ---

(iv.) Desire for survival ---

(v.) Lack of information (ignorance on the part of the consumer) -----------------

(vi.) Societal acceptance of criminal activity as a way of life---------------------

(vii.) Absence of legal framework to combat the scourge of electricity theft--------------

(viii.) Lack of will of government officials to combat the scourge----------------------------

(ix.) Desire to make extra money by electric power officials who collude with criminal elements in the society---------------

(x.) Others---

10. What fraction of electricity distributed according to your records is usually paid for on regular basis? --

11. What major challenges does electricity theft pose to your organisation? -------------
----

12. Suggest ways to reduce electricity theft please

(1.) --

(2.) --

(3.) --

(4.) --

13. Have you ever caught any staff of your company engaging in electricity theft? -----

14. Do you sublet some aspects of your operation to contractors? E.g. maintenance of your installations. Yes/No -------------- If yes, explain ---------------------------

15. Other than electricity theft, what other forms of non-technical losses does your company encounter from time to time?

a) --

b) --

c) --

d) --

e) --

Thank you for your time.