URBAN HOUSEHOLD ENERGY DEMAND IN SOUTHWEST NIGERIA

By

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ABSTRACT

Urban population growth exerts pressure on energy demand resulting in inefficient supply. This consequently leads to increase in prices of energy sources. The literature on the determinants of urban household energy use in Nigeria has focused little attention on substitution possibilities as well as welfare implications of price increases. This study investigated the determinants of urban household energy demand, substitution possibilities and welfare implications of price increases in southwest Nigeria.

A microeconomic demand model, using the indirect utility maximising function, was estimated. A structured questionnaire was used to collect primary data. The major thematic areas included socio-economic and demographic characteristics, energy use profile, energy substitution and willingness, energy prices and welfare implications. The energy sources considered were: electricity, firewood, kerosene, liquefied petroleum gas (LPG) and petrol. Respondents' distribution was by low, middle and high income groups. One hundred Household Heads (HHs) in the capital of each of the six states (Ekiti, Lagos, Ogun, Ondo, Osun and Oyo) in southwest Nigeria were surveyed. These consisted of 25, 35 and 40 HHs in low, medium and high density residential areas respectively. Descriptive statistics, student t-test, and multiple regression were used to analyse the data at 0.05 level of significance.

Fifty-seven percent of the respondents were males, 41.8% had tertiary education and 37.2% were civil servants. The modal age was 40-49years while 50.2% lived in single room. The energy source for cooking irrespective of income group was kerosene (89.7%). The choice of energy type was influenced by convenience 59.2% for cooking and 62.3% lighting. Electricity was the most preferred for lighting (90.2%). Only 31.8% were willing to substitute kerosene for gas. The energy source for cooking was kerosene 52.7% for low, 92.3% medium and 91.3% high residential areas. Convenience (62.9%) low income, (59.0%) middle income and (36.7%) high income levels influenced the choice of energy for cooking. Demand response to price changes was inelastic. Occupation of the respondents **(**0.07), level of education (0.04) and price of energy sources (-0.87 electricity; -0.59 fuel wood; -0.08 kerosene; -0.97 LPG and 0.01 petrol) significantly explained household energy demand. A 1.0% increase in prices led to a less than 1.0% decrease in demand for energy types. The substitution effect between kerosene and firewood was -0.11. The income elasticity of demand for electricity (0.95) and kerosene (0.65) indicated that they were normal goods. Kerosene (40.0%) had the largest household's budget share. As energy prices increased, households' budget share to energy sources increased. There was a welfare loss of ₦3,682.15k as prices of energy sources increased.

Occupation, level of education, household size and energy price were the significant determinants of household energy demand in urban areas in southwest Nigeria. Government in partnership with private sector should ensure that the cost of cleaner fuel appliance is made available at minimum cost.

Keywords: Urban household energy demand, Energy use substitution, Household welfare

Word count: 488

DEDICATION

This work is dedicated to

My Priceless Jewels

Ibukunoluwa Ofure, Teniola Adesuwa and Oluwagbemileke Ivie

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Patricia Iyore EBHOHIME
October, 2014

CERTIFICATION

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CHAPTER ONE

INTRODUCTION AND PROBLEM STATEMENT

1.1 Statement of the problem

Energy is an essential component of growth and development, hence, its importance and wide ranging role in the development process cannot be over emphasized. According to (Iwayemi, 1998), energy demand, supply and pricing exerts great impact on social and economic development as well as the living standards and overall quality of life of the population. Energy use also affects environmental quality through deforestation associated with unsustainable biomas energy dependence and greenhouse gas emission from fossil fuel use resulting in global warming. One important aspect of energy is the household demand for it. There are multiple reasons why the study of household energy consumption pattern and their energy requirements is important especially for a large developing country like Nigeria. First, households are major consumers of energy and to a large extent they contribute to the amount of total energy use in the country. Second, household spending and consumption patterns give detail information of how people live. Also, a study of household energy requirements at a disaggregated level helps to provide information on the life styles of households at the individual level, their energy use and overall standard of living.

The household sector is responsible for about 15 to 25 percent of primary energy use in the Organization of Economic Cooperation and Development (OECD) countries with a higher magnitude in developing countries. Average per capita household energy use in developed countries is about nine times higher than in developing countries, even though in developing countries a large share of household energy is provided by non-commercial fuels (Dzioubinski and Chipman, 1999) that are often not reflected in official statistics. In developing countries, about 2.5 billion people rely on traditional fuels such as biomass, fuel wood, animal dung and charcoal to meet their energy needs for cooking (World Energy Outlook, 2006). These resources account for over 90% of household energy consumption. Energy plays an important role in the households in developing countries. Despite this, it is observed that modern energy services are neither available nor affordable for large sections of the population (Akinwumi *et al* 2009). The aggregate data shows significant disparities in household energy use between rural and urban populations, and between high and low income groups within a country and among countries.

The major factors contributing to these differences are levels of urbanization, economic development and living standards. Other factors are country or region specific, such as climate or cultural practices (Dzioubinski and Chipman, 1999). For most people in developing countries, Nigeria inclusive, energy comes from bio-energy sources (such as wood, dung, charcoal etc). Other commercial sources of energy include electricity, LPG and kerosene. Although electricity production, especially from hydro sources and liquefied gas has increased over the years, such commercial energy sources are unaffordable or inaccessible to the poor who comprise over 80% of the developing countries population (Aina and Odebiyi, 1998).

In Nigeria the household sector is the largest energy consuming sector in the economy. It accounts for about a quarter of total commercial energy and over 90% of traditional fuels especially fuel wood (Adegbulugbe and Akinbami, 1995; Dayo, 2004). Nigeria has a population of about 140 million and an annual growth rate of about 2.9 percent per annum (National Population Commission, 2006). It is an oil exporting and producing country with a high rate of urban growth. Urban population as a percentage of total population grew from 20% in 1970 to 34% in 1988 and 43.3% by the year 2000, it is estimated to be about 61.6% by the year 2025 (Adegbulugbe and Akinbami, 1995; UN-Habitat, 1996 and Adelekan and Jerome, 2006). This rapid rate of urbanization has been accompanied by complex urban problems such as, traffic congestion, security threat and inadequate supply of urban infrastructures including housing, clean water and the most significant of these problems is the inadequate supply of energy. Until the emergence of high cost energy in the post 1973 era, relatively cheap and abundant energy was a key feature of rapid industrialization and economic progress. The rise in the price of crude petroleum between 1973 and 1978 brought boom conditions to Nigeria and hence rapid urbanization. However, as a result of the decline in foreign exchange earnings due to a drop in the price of crude oil, economic crises set in. In a bid to put the economy back on track and in response to the World Bank's demand for renegotiating her debt repayment schedule, government introduced several austerity measures. These measures included the structural adjustment programme (SAP), control on importation and removal of subsidy on petroleum products. These policy measures resulted in significant increase in the prices of commercial energy. In the last two decades, the prices of petroleum products have been reviewed upwards several times. This increase in the price of commercial energy sources has resulted in a fall in real income thereby compelling many families to revert to the use of traditional fuels. The increase in prices of these energy products has been without a corresponding improvement in the welfare of the people, making it more difficult for households to afford some of these energy products. One of the outcomes of this economic situation is the change in the pattern of domestic energy consumption especially in the urban centres.

Much emphasis is laid on urban household energy demand in the literature (Hosier and Kipondya, 1993; World bank, 1999; Barnes, Krutilla and Hyde, 2004; World Energy Outlook, 2006; Maconachie, Tanko and Zakariya, 2009) because as population grows and urbanization rates increases it creates problems of adequate and efficient energy supply to the household sector. In the urban areas as prices of energy goods increase the low income earners tend to rely more on the use of traditional fuels than higher income earners. (Barnes et al, 2004) observes that lower income earners are usually burdened by increases in energy prices and they are also vulnerable to policy changes in energy markets than higher income earners.

Given the foregoing and for the purpose of implementing policies designed to increase access to clean and affordable energy, it is important to determine how household energy expenditure patterns differ across income groups and how these patterns change over time due to increases in energy prices. This is important for urban households because there are energy alternatives for many people in the urban centres. Apart from this, energy sources in the urban centres are also likely to be monetized and hence quantifiable. In addition, income of individuals have been relatively constant, while prices of energy goods have been on the increase, it is useful to investigate what energy sources (kerosene, LPG, electricity, fuel wood) the various income groups (low, middle and high income earners) in Nigerian urban centres use for cooking, lighting and operating electrical appliances. Hence three key issues addressed are (1) the factors that determines urban household energy demand (2) the extent of substitution possibilities among various energy carriers, that is, between electricity, LPG, fuel wood and kerosene, and (3) the welfare implication of a price change in energy products on the household.

1.2 Aim and Objectives of Study

The broad aim of this study is to analyze energy demand in the residential sector as well as the extent of substitution possibilities among the various energy carriers. The welfare implication on households of a price change is also analyzed. The specific objectives are to:

1. Evaluate the determinants of urban household energy demand.
2. Analyze the extent of substitution possibilities between electricity, LPG, kerosene and fuel wood.
3. Analyze the impact of a price change in energy products on the welfare of households.

1.3 Justification of Study

Urbanization is an integral part of socio economic growth of developing countries, although, the level of urbanization vary across countries. Population growth rate in urban cities is usually faster than in rural areas. This growth rate is due mainly to migration from the rural areas. Nigeria is an example of a country with high urban growth. Urban growth rate as a percentage of total population grew from as low as 5.7% in the 1970s to as high as 43% by the year 2000, and it is estimated that by the year 2015, 61.6% of the total population will be in urban areas (UNCHS, 1996).

Studies, Hosier and Kipondya, (1993); Quedraogo (2006); Barnes, Krutilla and Hyde, 2004), have shown that urban household energy consumption usually follows the energy ladder model. The energy ladder model is premised on the fact that as income of consumers increase they move completely away from the use of less efficient fuels to more efficient and clean fuels Heltberg, (2005), Barnes, Krutilla and Hyde, 2004). Studies on household energy demand model reveals that energy demand in the household is dependent on the income of consumers and prices of the energy goods (Pollak and Wales, 1978; Baker *et al*, 1989; Druckman and Jackson, 2008; Filippini and Pachauri, 2004; Pachauri, 2004). They also show that energy consumption differ by income group (Labandeira, 2006). In Africa, studies have also shown that urban household energy consumption differs between low and high income groups (Takama, Lambe, Johnson, Arvidson, Atanasov, Debede, Nilsson, Tella and Tsephel, 2011; Campbell, Vermeulen, Mangono and Mabugu, 2003; Quedraogo, 2006; Gregthemstra-van der Horst and Hovorka, 2008; Karekezi and Majoro 2002; Link, Axinn and Ghimire, 2012). Studies have also shown in Nigeria that disparities exist in urban household energy consumption between high and low income groups

(Adelekan and Jerome, 2006; Adebgulugbe and Akinbami, 1995; Maconachie, Tanko and Zakariya, 2008; Abd'razack, Medayese, Martins, Idowu, Adeleye and Bello, 2012). These studies made useful and interesting contributions to household energy sector consumption patterns. However, they did not analyze substitution possibilities in the household, and did not take into cognizance the welfare implication of a price change in energy products on the household. In addition these studies did not present a formal econometric analysis of the response of energy consumption to changes in price of energy products, income of the consumers and other household characteristics.

A diversity of approaches to the estimation of household energy demand can be found in the literature. Many of these studies use econometric tools to analyze energy consumption in the household,.see Pollack and Wales, 1978; Baker, Blundell and Micklewright, 1989; Druckman and Jackson, 2008; Brannlaund and Nordstrom, 2004). However, only full rank demand systems i.e systems with maximum column rank can maximize the degree of income flexibility of demands (Gabriela, Krishnakamar and Ranjan Basu, 2004). These full rank demand systems are also useful in the analysis of welfare measures. Three demand models of different ranks stand out in the analysis of welfare measures. They are the Linear Expenditure System (LES) of rank 1 (Stone, 1954); Almost Ideal Demand System (AIDS) of rank 2 (Deaton and Muellbauer, 1980) and the Quadratic Almost Ideal Demand System (QAIDS) of rank 3 (Banks, Blundell and Lewbel, 1997).

This study in an attempt to analyze for substitution possibilities and welfare impacts in the household adopts the Quadratic Almost Ideal demand System (QAIDS) proposed by (Banks, Blundell and Lewbel, 1997). The QAIDS is an extension to the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer, 1980). The QAIDS a rank 3 demand system is preferred to the almost ideal demand system which is a rank 2 demand system because the QAIDS has a property of non linear Engel function which is more appropriate to household data. The QAIDS allows for flexibility in income and on the level of expenditure. This demand system is also capable of giving a more realistic picture of the substitution, own price and income effects. By doing this, it permits goods to be necessities at some income level and luxuries at others. In addition, many cross section studies have used this application (Banks, Blundell and Lewbel, 1996; Blundell and Robin, 2000; Nicol, 2003; Lyssiotou, 2003; Labandeira, 2006). These studies have found the quadratic terms of the system very useful in describing consumer behavior. The application of the model to energy demand in Nigeria further lends credence to this study.

1.4 Scope of the Thesis

The study was carried out in the state capitals of the south west zone of Nigeria. Each of the state capitals in the zone was categorized into low, middle and high income residential areas. The target population was identified by further categorizing each of the state capitals into low density geographical area (high income), medium density (middle income) and high density (low income). The essence was to ensure that a whole range of household characteristics are captured among the various income levels. This will also give opportunity for comparison of results between the different categories of residential areas.

1.5 Plan of the study

Apart from this introductory chapter, the thesis is divided into five other chapters. Chapter two presents the background of study, while the literature and theoretical review is presented in chapter three. The theoretical framework and methodology is presented in chapter four. Chapter five presents analysis and discusses the result of household energy demand in urban centres in south west Nigeria. Chapter six presents a summary of findings, the implications of these findings for development, policy implications of the study and areas for further research.

CHAPTER TWO

BACKGROUND OF THE STUDY

This chapter provides the background and an overview of the Nigerian energy sector profile. In addition, the trend in domestic energy pricing and household energy consumption and supply mix is provided.

2.1 Nigeria's Energy Sector Profile

Located on an area of 923,768 Km^2 and lies between latitude 4^o and 14^o North of the Equator, and longitudes 3^o and 14^o East of the Greenwich Meridian, Nigeria is situated on the Gulf of Guinea in West Africa. It is bounded in the West by the Republic of Benin, in the North by the Republic of Niger and in the East by the Federal Republic of Cameroun. On the North-east border is Lake Chad which also extends into the Republic of Niger and Chad.

Nigeria is richly endowed with vast natural resources. These resources can be classified into renewable and non renewable; however crude oil is the main stay of the economy. Nigeria is the largest producer of crude oil in Africa and the tenth largest in the world with about 35 billion barrels of proven reserves. With production averaging about 2.3 million barrels per day, it shows that the energy sector is very strategic to the Nigerian economy and a realization of social and political objectives. The country has also been described to have more natural gas reserves than oil; this is estimated to be about 187 trillion Standard cubic feet. This includes associated and non associated gas reserves placing Nigeria among the top ten countries with the largest gas reserves in the world.

Table 2.1: Nigeria's Energy Reserves/Capacity as at December 2005

Energy Source	Reserves
Crude Oil	35.2 Billion Barrels
Natural Gas	187.44 Trillion scf
Tar Sands	30 Billion Barrels of oil equivalent
Coal and Lignite	639 million tones
Large Hydropower	11,250MW
Small Hydropower	3,500MW
Fuel wood	13,071,464 Hectares
Animal Waste	61 million tones/yr
Crop Residue	83 million tones/yr
Solar Radiation	3.3-7.0KWh/m^2-day
Wind	2-4m/s at 10m height

Sources: (1) *Energy Commission of Nigeria (2) National Energy Master Plan, 2006.*

Table 2.1 shows Nigeria's energy reserves and capacity. The table shows the reserve for crude oil, Nigeria's resource base stood at about 35.2 billion barrels in 2006. Proven natural gas reserves estimated at about 187.44 trillion standard cubic feet (scf) in 2005 are known to be substantially larger than its oil resources in energy terms. Gas discoveries in Nigeria are incidental to oil exploration and production activities (both in associated and non-associated form). Domestic utilization of natural gas are mainly in power generation which accounts for over 80% while the remaining are in the industrial sector and very negligible in the household sector. Coal and lignite stood at 639 million tones, tar sands at 30 billion barrels of oil equivalent and large scale hydropower at 11,250MW. Indeed, energy consumption in Nigeria is dominated by petroleum products.

Since independence, there has been in general an increase in demand for, and consumption of petroleum products. This increased demand and consumption is linked to the general increase in the use of energy resources in the nation. Figure 2.1 shows the trend in energy consumption between 1970 and 2011. It reveals a continuous upward trend in energy consumption between 1972 and 1982. It rose again in 1993. This was followed by another general decline until 2001 when it rose again. Between 2001 and 2006 energy consumption was fairly constant. It however dropped slightly in 2007 and 2008 and picked up again in 2009.

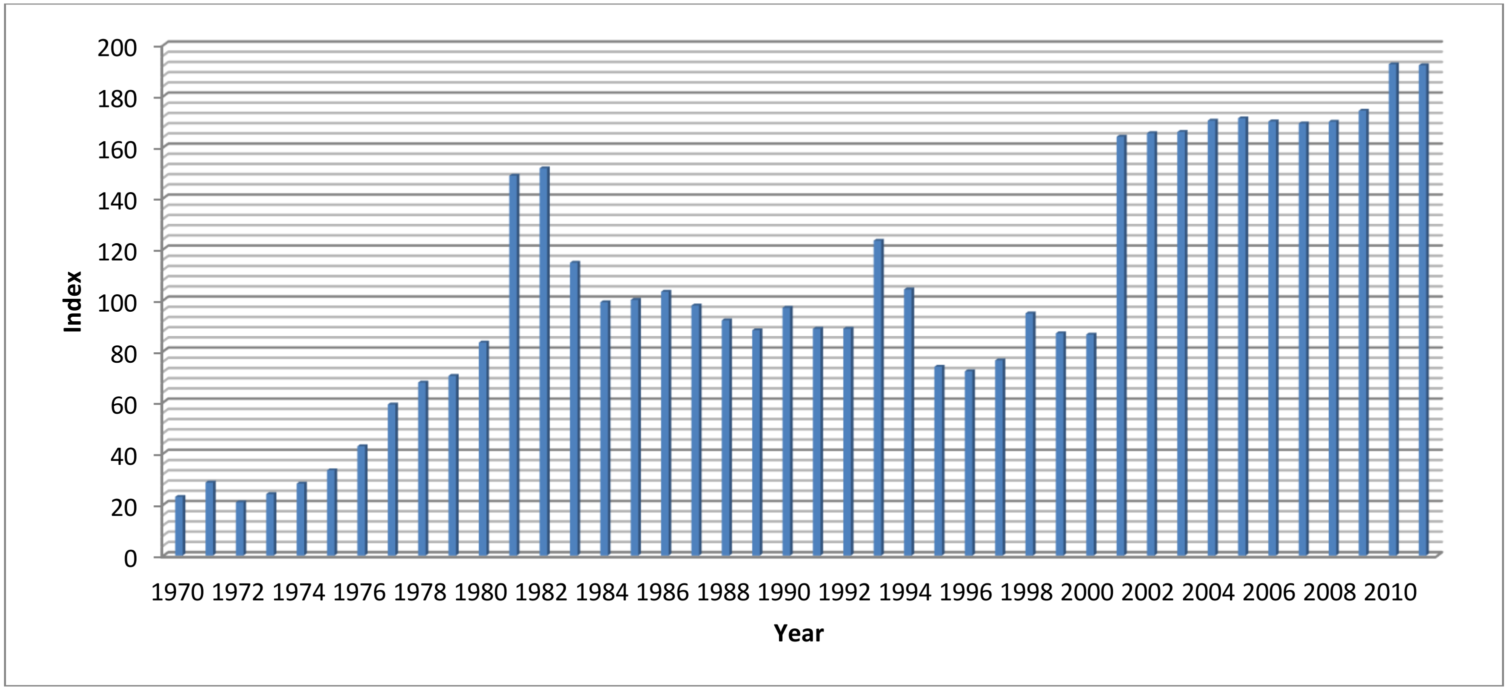

Figure 2.1: Index of Energy Consumption (1990 = 100)
Source: CBN Annual Report and Statement of Accounts (various issues)

The pattern and trend of energy use may be attributed to a number of factors. First there has been a rapid rise in the nation's population, and the associated rapid rates of urbanization growth. Rapid rates of urbanization tend to be associated with an increase in the utilization of commercial energy sources (Iwayemi, 1998). Coupled with the high rates of urbanization growth, the nation's industrial development drive was a second major factor in the increased consumption of energy products. It can be expected that as a nation's industrial activities expand and it moves from traditional towards more modern forms of production, its energy use would increase. In addition, as urban population grew rapidly, the energy needs of the household also increased.

Energy consumption in Nigeria is dominated by petroleum products. The percentage consumption levels and structure of the consumption of the major energy resources by types over the years 1980 – 2011 as shown in Figure 2.2 indicates that the primary energy resource is petroleum products.

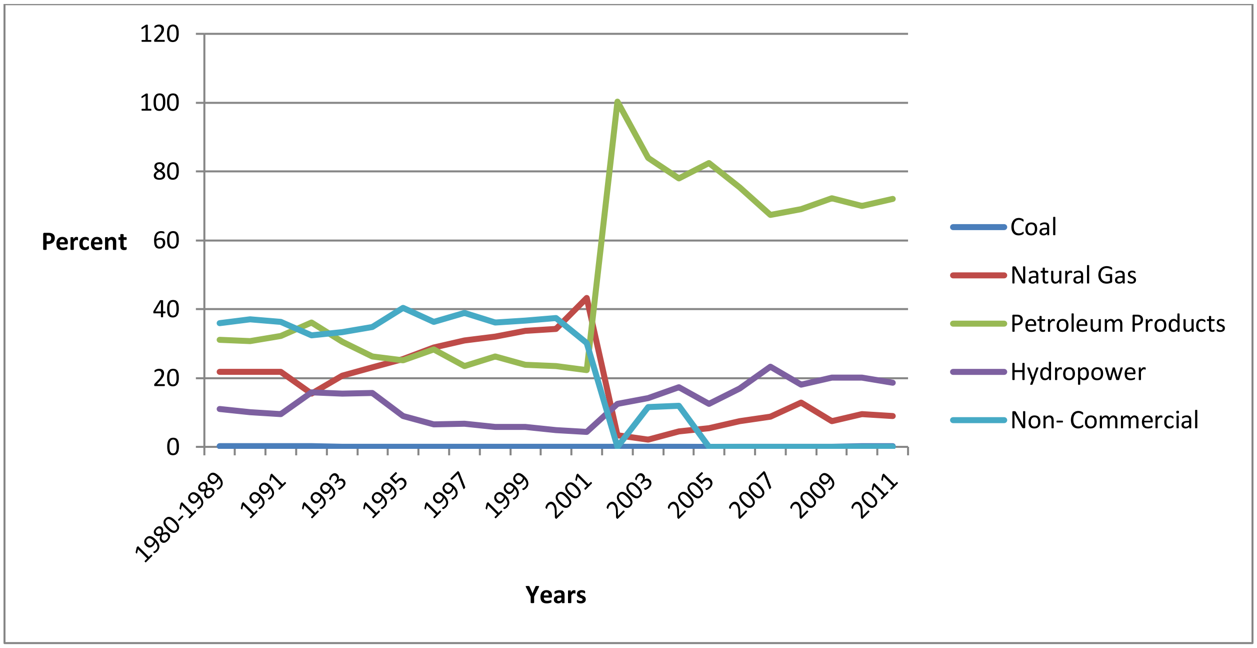

Figure 2.2: Structure of Primary Commercial Energy Consumption in Nigeria by Fuel type
Sources**:** (i) *National Energy Master Plan*, 2006 (ii) *CBN Annual report and statement of accounts, (various years)*

Between 1980 and 1990 the percentage share of oil in primary energy consumption was fairly stable, though low. However, between 1990 and 1992 it appreciated to 36.1 percent after which it consistently declined to 22.3 percent in 2001. It increased again in 2002 to 100 percent. This sharp increase was due to reforms in the petroleum sector which resulted in increase in domestic production and hence consumption. Between 2002 and 2011 consumption levels have reduced but not by as much as previous years. This is because government is augmenting domestic production with the importation of refined petroleum products.

The share of natural gas increased from about 22 percent in 1980 to 30.8 percent in 1997 when it surpassed petroleum products and by 2001 its contribution to total primary energy utilization was 43 percent. It declined thereafter, and has not been able to reach that level since then.

Unlike petroleum products, coal utilization decreased from about 67 percent of total commercial energy in 1950 to less than 1 percent in recent times. The decline resulted mainly from the switch from coal to diesel engines by the Nigerian Railway Corporation, the major user of Nigerian coal. To a lesser extent, the relatively high cost of coal compared to alternative fuels also contributed to the decline. Hydroelectricity consumption experienced phenomenal growth in the country. It rose from 1 percent in 1950 to 15.7 percent in 1992 after which it started to decline, it has been on the increase since 2002 though with slight fluctuations in between. From 1989 to 2001, the share of non-commercial energy fluctuated within the range of 30-40 per cent. This dropped drastically to 11.6 and 11.9 percent in 2003 and 2004 respectively.

The most highly consumed primary energy resource at the beginning of the decade was petroleum products (30.79%), consisting mainly of petrol and diesel for transportation and power generation. It also included kerosene (mainly used by households), aviation fuel (for transportation), fuel oil (industry), liquefied petroleum gas (used by households) as well as lubricating oil, bitumen and asphalt (for construction). Domestic utilization of natural gas is mainly in power generation which accounts for over 80% while the remaining is in the industrial sector and very negligible in the household sector.

2.2 Trends in Domestic Energy Pricing

Since the introduction of the Petroleum Products (uniform) Pricing Order of 1973, petroleum products prices have been set under a regulated regime in line with government's control and dominance of downstream logistic infrastructure. Hence pricing and investment decisions are taken by the government in Nigeria. This was done as a development strategy and as a means of promoting industrial development, thus, petroleum prices along with the tariffs on services of other key utilities such as electricity and telecommunications were set at low prices. This price fixing was premised on the notion that "Nigerian consumers should have access to cheap fuel at a uniform price across the country" (IMF, 2004:101). In addition, it set wholesale and retail prices for petroleum products, and also fixed the margin for the private retailers.

Before the era of upward review of domestic energy prices, energy products prices had been fairly stable until recent times. Between 1973 and 1986, energy prices changed only once. After 1986, there have been several upward reviews of domestic energy prices. In the past, some of the major reviews of energy prices upwards were part of government response to fiscal crises at various periods in time. But recently, price increases are usually explained by government as being necessary to reduce or completely remove subsidy on petroleum products much of which it has had to import as a result of the inability of the refineries to refine products to meet domestic demand. Although the nominal prices of energy products have been on the increase the real prices have consistently been declining. The economic impact of upward review of energy prices on households has either resulted in a total switch in the choice of energy preferred for domestic use or a combination of different types of energy by various households/income groups.

Figure 2.3 shows the trends in real prices of selected petroleum products in Nigeria. The real price of petrol consistently declined up to 1992 after which it appreciated slightly and fluctuated between 1992 and 2008. The real price of kerosene also fell up to 1992. Although the real price of LPG also fell over the years but not as much as that of the other petroleum products. The trend is similar for electricity. Prices of most commercial energy products in Nigeria are fixed administratively by the federal government. These prices are usually below their opportunity costs. Hence price has not been allowed to perform its role of signaling the real cost of energy use to consumers.

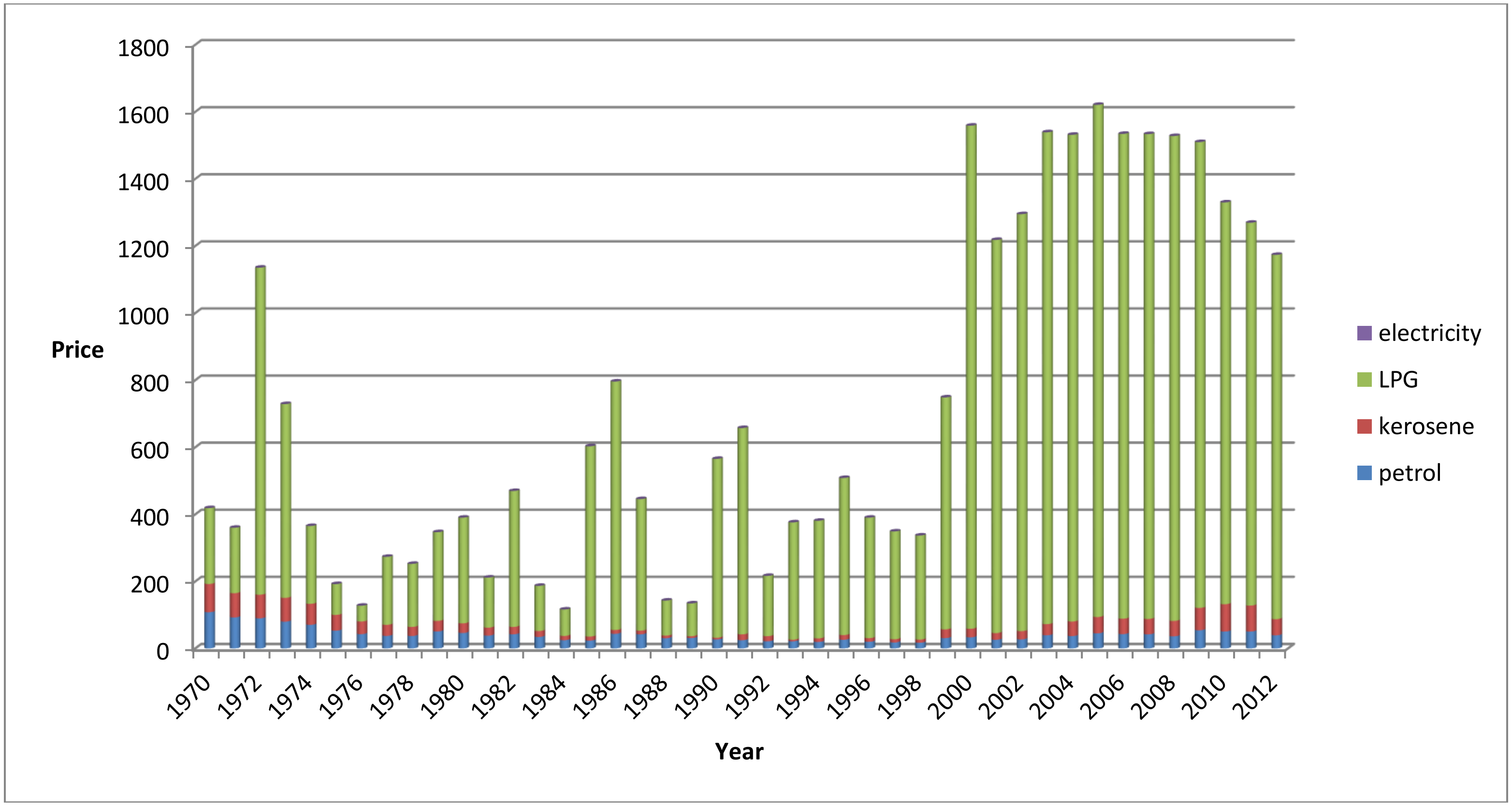

Figure 2.3: Real Prices of Selected Petroleum Products in Nigeria.

Sources: *(1) A. Iwayemi and A. Adenikinju, (1996)*

(2) NNPC Annual Statistical Bulletin various issues

(3)CBN Annual report and statement of accounts, various issues

2.3 Household Energy Consumption in Nigeria

In Nigeria, energy use in the household accounts for more than 60% of total final energy consumption (Oladosu and Adegbulugbe, 1994; Adegbulugbe and Akinbami, 1995). The major energy carriers are fuel wood, kerosene, liquefied petroleum gas (LPG) and electricity. Small amounts of charcoal and coal are also used. The energy consuming activities in the sector are cooking, lighting and operation of electrical appliances. The shares of these activities in final energy consumption were 91 percent, 6 percent and 3 percent respectively in 1995.

Fuel wood consumed in this sector constitutes about 80 percent of total residential final energy consumption. Fuel wood is used both in the rural areas and urban centres. It is used by about 70 percent of the population who reside in the rural areas this is because it is freely collected.It is used less in the urban centres because it is a traded good and also the type of housing unit may not be convenient for using fuel wood especially for cooking.

Kerosene is sold at subsidized prices now and its consumption has increased considerably over the years. Despite the continuous implementation of subsidy removal on petroleum products by the government, the consumption of kerosene seems to be on the increase especially in the urban centres. This may be due to the fact that there is more reliance on fossil fuels in the urban areas. The household sector also consumes about 70 percent of the national kerosene production.

Electricity is mainly used for lighting and operating electrical appliances, a small amount is used in urban areas for cooking. Electricity generation has increased over the years but not as much as the rate of increase in population; this in addition to obsolete equipment and lack of proper maintenance has resulted in low electricity generation or outright power outages. Electricity consumption until recently is favored by a low pricing policy, even at this price it has been estimated that only about 25 percent of Nigerian households have access to electricity from the national grid (Oladosu and Adegbulugbe, 1994).

A small amount of LPG is used by households this may be explained in terms of the high cost of the product and the cost of appliance for it. LPG is generally perceived as an efficient but expensive fuel for cooking. Its use is thus confined to urban middle and high income household.

Charcoal is consumed in urban areas where the transport costs of fuel wood are higher. Coal plays an insignificant role in this sector. These energy carriers are important elements in the

Nigerian socio economic setting. Figure 2.4 shows the percentage distribution of households according to the type of fuel used for cooking in Nigeria.

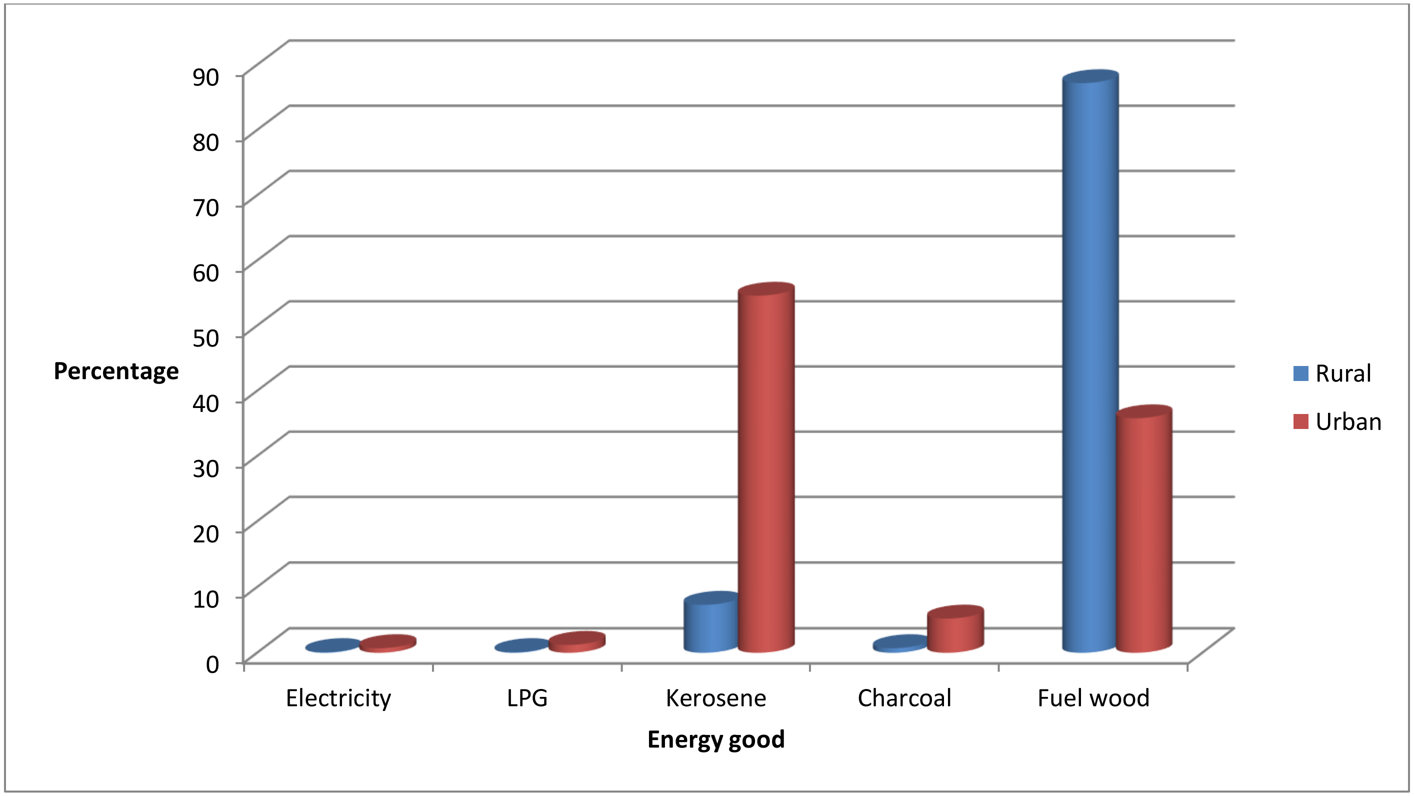

Figure 2.4: Household Energy Characteristics in Nigeria
Source: National Bureau of Statistics Multiple Indicator Cluster Survey (2007)

Again, cooking energy characteristics of households in Nigeria by location shows that fuel wood is used by most households in the rural areas. Kerosene is used by most households in urban areas for cooking. Generally, energy consumption is more in the urban centres for all the fuel used except for fuel wood in which the percentage consumption in rural areas is more than twice the consumption in urban centres. Liquefied petroleum gas (LPG) is used sparingly in both urban and rural areas. Electricity is not used by most households. This may be due to the epileptic power supply in the country and the high price charged for it.

Figure 2.5 shows the type of fuel used for cooking by geo-political zone. A look at type of cooking fuel by geo-political zone reveals an interesting picture. Fuel wood is used by most households in all the zones. The North West zone has the highest use of fuel wood. It is closely followed by North East and North Central. The others are South South, South West and South East. Kerosene is used more in the South West and North East zones. Charcoal is used sparingly in all the zones. LPG is used sparingly only in the North East and South-south zones. Electricity is hardly used for cooking possibly due to incessant power outages.

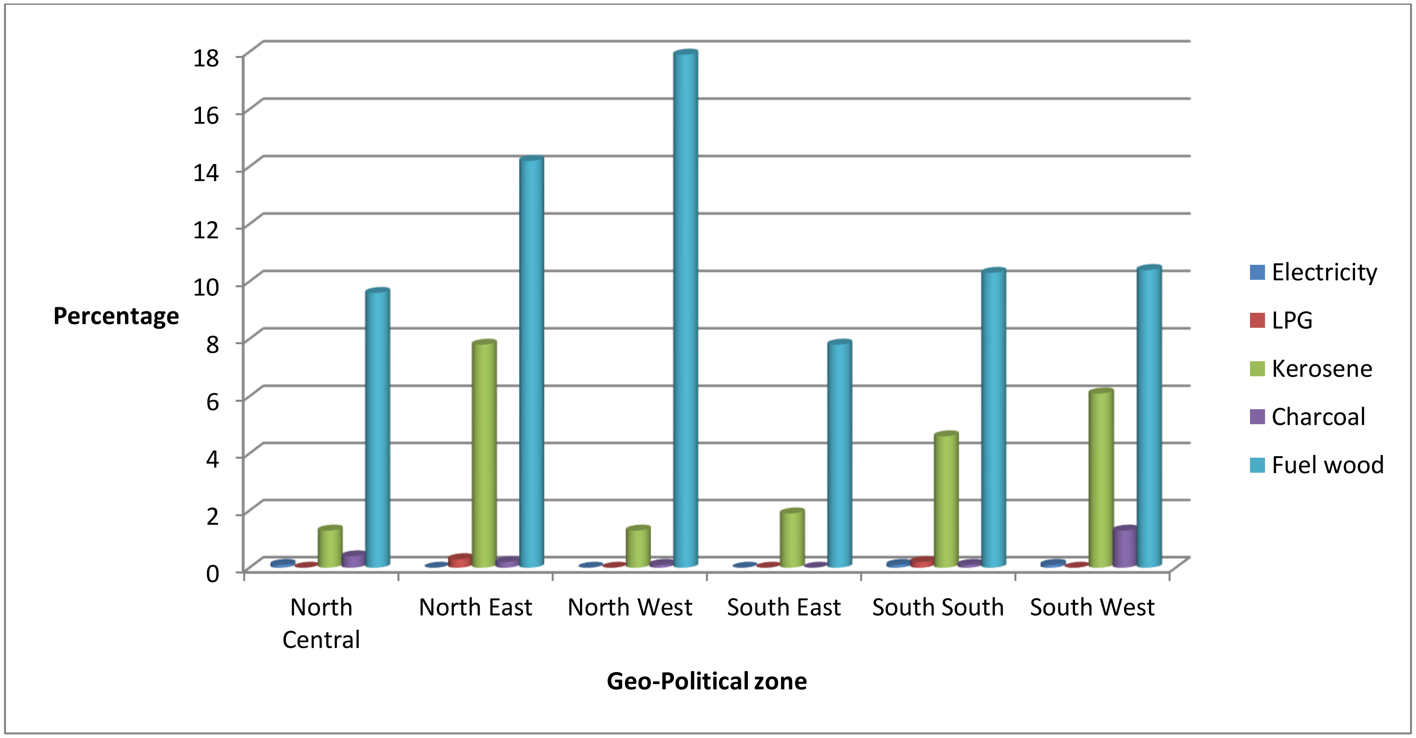

Figure 2.5: Type of fuel used for cooking by Geo-political zone.
Source: National Bureau of Statistics Multiple Indicator Cluster Survey, 2007.

2.4 Energy Consumption by Economic Sectors in Nigeria

Household energy consumption can further be explained by using a sector analysis approach. The sectors of the Nigerian economy considered are agriculture, industry and transport, commercial and residential. Data on final energy consumed derived from energy balances for various years in these sectors are used. Final energy is the energy content of energy carriers that are available to final consumers. It is the amount of energy that is utilized in end use technologies (Dayo, 2008).

Figure 2.6 shows the available energy data for the period 1990-2012 and it also shows substantial use of energy products in the energy profile of the Nigerian economy. The residential sector has the largest share of energy consumed. It accounted for more than half of total final energy consumed in the economy during this period. The residential sector uses a combination of feul wood, bio-fuels and other biomass fuels as well as fossil fuels such as kerosene, LPG, electricity and petrol for various activities such as cooking, lighting and operating electrical appliances.

The transport sector follows the residential sector, however its percentage share on energy consumption is not as large as that of the residential sector because only petroleum products (i.e oil) are consumed in the sector.

Energy consumption in the industrial sector has also improved over the years but not by as much as the residential and transport sectors, it only surpassed the transport sector between 2010 and 2011. Small amounts of energy are consumed in the commercial sector, while energy consumption in the agricultural sector is very insignificant.

Energy consumption in the five sectors shows the residential sector to have the largest share while the agricultural sector has the lowest share.

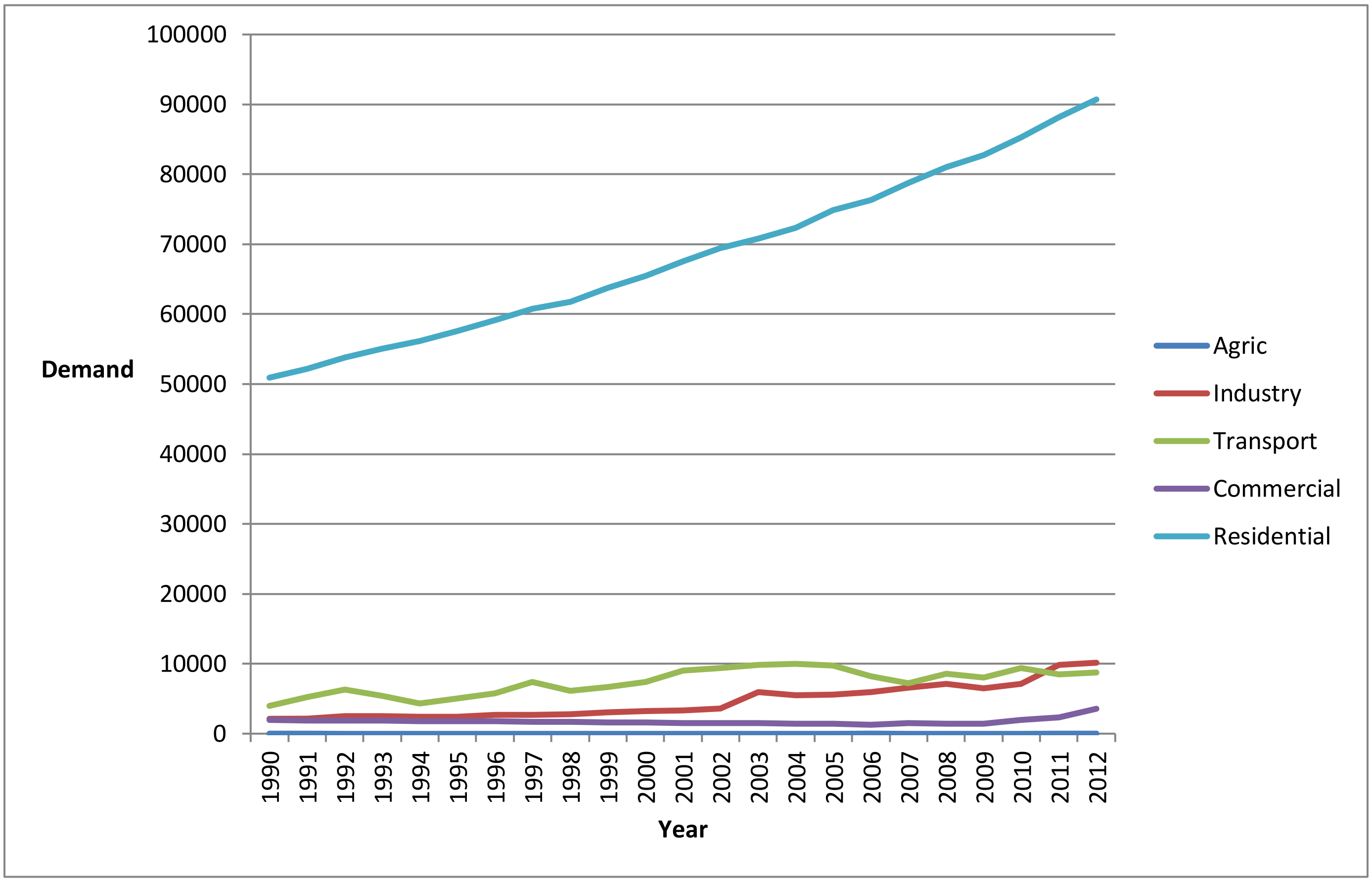

Figure 2.6: Energy Consumption by Economic Sectors in Nigeria
Source: International Energy Agency (IEA), Energy Balance for Nigeria (1990-2012)

CHAPTER THREE

LITERATURE REVIEW

An overview of the theory that explains demand analysis and household energy demand is undertaken in the first section of this chapter while empirical review of related literature is in the second section.

3.1 THEORETICAL REVIEW

3.1.1 Demand Analysis

In economics, the study of demand is aimed at describing the behaviour of consumers. The law of demand depicts a downward sloping curve. It shows that when the price of a commodity is raised (other things held constant), buyers tend to buy less of the commodity. Similarly, when the price is lowered the quantity demanded increases. This situation is known as the law of demand. There are two reasons for this law. First is the substitution effect, that is, when the price of a good rises, consumers substitute with other alternative goods. The second reason is the ‘income effect’. This comes into play when the price of a good increases, the purchasing power of the consumer’s real income falls. That is, the consumer will have less real income to spend on consumption activities. The income and substitution effects are useful concepts because they help to explain why people react to a price change. The size of these effects depends on a range of factors. These factors determine the shape of the demand curve. Consumer demand refers to the variations in the quantities of a commodity that a consumer is willing and able to buy at specified prices and time periods, assuming that the consumer’s income, price of other substitutes, tastes and preferences and all other determinants of demand remain unchanged. A simple hypothetical demand function is of the form;

$$Q_d = f(p, y, p^*, t, e) \qquad (1)$$

where,

Q_d= Quantity demanded of the commodity, P = Price of own commodity, Y = Income of the consumer, P* = Price of related commodities (substitutes and complements), t = tastes, e = expectations of future price changes. The demand equation (1) means that quantity demanded of a commodity is a function of (or is determined by) consumers income, price of own commodity, price of related commodity, tastes and expectations about future price of the commodity.

Demand theory shows an inverse relationship between the quantities demanded of a product and its own price, all other things being equal. This relationship is called the direct price effect which means that as the price of a commodity falls the quantity demanded increases and as the price increases the quantity demanded falls while holding constant all other factors that affect demand. Hence equation (1) can be re-written as:

$Q_d = f(p)$……………………………………………………………………………………….(2)

That is, the quantity demanded of a commodity is a function of its own price.

Demand analysis can be described as a science of consumer choice or preferences among different goods and services. The theory of consumer choice describes how consumers make decisions about what to buy. Consumers' demand for a good reflects their willingness to pay for it, therefore, analyzing consumer demand is essentially the act of analyzing consumer preferences. It describes how consumers choose to allocate their income among different products. The concept of utility is used to define the level of satisfaction or welfare that a consumer derives from a specific allocation of income among different products. The consumer will select a bundle of goods and services which maximizes his utility given his level of income. The consumer problem therefore, is that of how to maximize utility subject to a given level of income, also known as the budget constraint.

This can be expressed as:

$\max U(q_i q_3 - - - q_n)$ .... (3)

$s.t.\ \sum p_i q_i = x$

Where U is a measure of total utility and q is a vector of the quantities of goods and services consumed, while p is a vector of prices and x is consumer income (or total expenditure of the consumer).

Introducing λ in equation (3), which is the Lagrange multiplier associated with the budget constraint, the basic problem of the consumer narrows down to that of maximizing utility subject to income constraint as follows;

$Max\ u(q) + \lambda(x - \sum p_i q_i)$ ………………………………………………………………...(4)

(q, λ)

Maximizing equation (4) with respect to q and λ by setting up the Lagrangean function and solving for q yields a set of demand equations that express the quantity demanded for each good as a function of the price and total income.

$q_i = g_i(x,p)$ ....(5)

Equation (5) expresses quantity demanded of a good or service as a function of prices and income.

This type of demand function, based on utility maximization, is known as a Marshallian or uncompensated demand function. For a logarithmic utility function, both income and price elasticities can be calculated by taking the derivative of the Lagrangean function, resulting in the following equation,

$dlogq_i = \eta_i dlogx + \sum_{j=1}^{n} u_{ij} dlogp_j$ ....(6)

Where η_i is the income elasticity and u_{ij} the uncompensated price elasticities. So that changes in prices and total expenditure do not violate the budget constraint in the demand function, the following conditions on the elasticities must hold;

$\sum_{j=1}^{n} w_j \eta_i = 1 \; and \; \sum_{j=1}^{n} w_i u_{ij} + w_j = 0$ ....(7)

where, *w* is the budget share.

These two conditions are known as Engel and Cournot aggregation, respectively, and together are sometimes referred to as the adding-up restriction. The Marshallian demand function is the solution to the consumer's problem of maximizing utility subject to the budget constraint. However, the consumer's problem can also be expressed as one of minimizing total expenditures or costs subject to a predetermined utility level or

$minimize \; x = \sum p_k q_k$

$subject \; to \; v(q_{1,} q_{2 \ldots\ldots} q_n) = u$ ....(8)

The solution to this problem is the Hicksian demand function, which is equivalent to the Marshallian demand function when evaluated at the optimal utility level.

$q_i = h_i(u,p) = g_i(x,p)$ ....(9)

The Hicksian demand function is also known as the compensated demand function, because it represents demand when utility is held constant. Price elasticities derived from the Hicksian demand function are called "compensated" or "Slutsky" price elasticities and are equal to the uncompensated price elasticity (also called “Cournot” price elasticities) plus the product of the income elasticity and the budget share. This is stated as;

$\varepsilon_{ij} = u_{ij} + \eta_i w_j$ ....(10)

where,

ε_{ij} is the Slutsky price elasticity...(11)

3.1.2 Restrictions on Demand Equations

Apart from adding-up restriction, there are three basic restrictions on demand equations. These can be expressed in terms of the compensated price elasticities as follows:

Homogeneity: $\sum_{j=1}^{n} = \varepsilon_{ij}$ ....(12)

Symmetry: $\varepsilon_{ij} = \varepsilon_{ji}$..(13)

Negativity: $\sum_{j=1}^{n} \sum_{j=1}^{n} x_i w_j \varepsilon_{ij} x_j < 0$ for all x_i and x_j that are not constants...................(14)

The homogeneity restriction implies that a proportionate change in income and prices of all goods will leave consumption of any one good unchanged. The symmetry restriction means the increase in the price of any good *i* will cause an increase in the compensated quantity demanded of *j* equal to the increase in the compensated quantity demanded of *i* caused by an increase in the price of *j*. Without this restriction, inconsistent choices between products would be made and there would be no substitute or complement products. The negativity restriction comes from the convexity of the utility function, which is due to the fact that the utility is maximized in the Marshallian demand function, or alternatively, that costs are minimized in the Hicksian demand function. The adding-up, homogeneity, symmetry, and negativity restrictions represent the basic restrictions imposed on all demand functions. Determining income and price elasticities that meet these restrictions is the primary aim of demand analysis. Prices of other commodities are also important determinants of demand.

The price of a commodity in relation to other commodities is far more influential in altering the demand schedule for a particular commodity than the price of close substitutes. The influence of a price change of one good on the demand for another good can be estimated using the concept of elasticity.

3.1.3 Elasticity of Demand

In order to turn demand into a truly useful tool, it is important to know by how much demand responds to changes in price. The elasticity concept helps in understanding consumer behavior because it describes how consumers respond to prices and the other variables that determine demand. The two key elements of elasticity used for understanding consumer behavior are (i) price elasticity of demand (ii) income elasticity of demand. Income elasticity helps to determine which goods are necessities at some income levels and which goods are luxuries at others. Conceptually, elasticity measures the quantitative relationship between price and quantity purchased of a commodity. Specifically, it measures the degree of responsiveness of quantity demanded to a change in the price of a commodity. Demand elasticities are the best available indicators of how households may respond to policies which change relative prices and the level and distribution of income.

The elasticity of demand also shows that the relationships between the quantity demanded of one commodity and the price of other commodities may be positive, negative or zero. Relationships are expected to be positive for substitutes. This implies that an increase in the price of one good causes an increase in the demand for the other. For complementary goods the relationship is likely to be negative. This implies that an increase in the price of one commodity causes a decrease in the demand for the other. For independent goods, the relationship is expected to be zero. This implies that a price change in one of the commodities has no effect on the demand for the other. In economic theory, a direct relationship also exist between a consumer's income and the quantity demanded of a commodity at any given price. As consumers income (Y) increases, quantity demanded (Q) of several commodities should increase. These types of goods are referred to as 'normal goods'. However for some goods the quantity demanded decreases as income increases, such goods are referred to as 'inferior goods'.

In addition, in consumer demand analysis, it is important to recognize the relationship between income and expenditure patterns. An Engel curve shows this by the utility maximizing quantities of a commodity which a consumer will purchase at various levels of income. Engel curves vary with the peculiarities of the individuals concerned and also with the characteristics of each product. Hence to describe consumer behavior and welfare analysis there is the need to adequately specify both Engel curve and relative price effects that is consistent with utility maximization.

3.1.4 Price Elasticity of Demand

The most commonly used elasticity concept is the price elasticity of demand. Price elasticity of demand is defined as the percentage change in quantity demanded divided by the percentage change in price. That is it measures how much the quantity demanded of a good changes when its price changes. It is given as;

$$E_D = \frac{percentage\ change\ in\ quantity\ demanded}{percentage\ change\ in\ price} \qquad (15)$$

The price elasticity of demand varies enormously in their sensitivity to price changes. Demand for a good can either be ‘elastic’ or ‘inelastic’. Demand for a good is said to be elastic when a change in price causes a proportionately larger change in quantity demanded. In this case, the value of elasticity will be greater than 1. When the price elasticity of a good is greater than one (1), we say that the good has an “elastic” demand. This means that a small change in price will cause a more than proportionate change in quantity demanded. When the price elasticity of a good is less than one (1) the good is said to have an “inelastic” demand. That means the quantity demanded responds a little to changes in price. In order to determine which goods are substitutes and complements, the cross price elasticity of demand is used.

3.1.5 Cross Price Elasticity of Demand

The cross price elasticity of demand measures how the quantity demanded of a good changes as the price of another good changes (either a substitute or complement). The cross price elasticity of demand enables us to predict how much the demand curve for the first product will shift when the price of the second product changes. It is calculated as the percentage change in the quantity demanded of good ‘i’ divided by the percentage change in the price of good ‘j’. In symbols, it is written as;

$$e_{ij} = \frac{\%\Delta q_i}{\%\Delta p_j} = \frac{\partial q_i}{\partial p_j} . \frac{p_j}{q_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(16)$$

where

e_{ij} is the cross price elasticity for $i \neq j$, own price elasticity for $i = j$

p_i is the price on the j^{th} good and q_i is the quantity demanded for the i^{th} good.

Equation (16) implies the percentage change in quantity demanded for some good with respect to a one percent change in the price of the good (own price elasticity) or of another good (cross price elasticity). The cross price elasticity of goods could be positive, negative or zero. Positive cross price elasticity of demand mean the goods are substitutes. That is, if the price of good $'i'$ rises, a large shift in the purchase of $'j'$ will occur. Substitute goods are goods that can be used in place of one another. When the price of a good goes up, the demand for the substitute goes up. If they are complements e_{ij} is negative meaning that a rise in price of $'i'$ will lead to a fall in the purchase of $'i'$ while the quantity of $'j'$ purchased would decrease. If e_{ij} is zero, then there is no relationship between the commodities. That is, if the price of $'i'$ rises, there would be no change in the quantity of $'j'$ purchased. Complements are goods that are used in conjunction with other goods.

Price elasticities can either be derived from the Marshallian or the Hicksian demand equation. The Marshallian demand equation is obtained from maximizing utility subject to the budget constraint, while the Hicksian demand equation is derived from solving the dual problem of expenditure minimization at a certain utility level. Elasticities derived from Marshallian demand are called Marshallian or uncompensated elasticities, and elasticities derived from Hicksian demand are called Hicksian or compensated elasticities. Marshallian elasticities can be transformed into Hicksian elasticities through the Slutsky equation:

$$\epsilon_{ij}^{H} = \epsilon_{ij}^{M} + w_j \cdot e_i \quad \text{……(17)}$$

where ϵ^{H} represents Hicksian elasticity, ϵ^{M} represents Marshallian elasticity, w_j is the budget share on good j, and e_i is the income elasticity for good i. More detailed discussions on the Marshallian and the Hicksian demand relations and the Slutsky equation can be found in many standard economics textbooks.

3.1.6 Income Elasticity

Income elasticity of demand e_y measures how the quantity demanded of a good changes as consumer income changes. It is calculated as the percentage change in quantity demanded divided by the percentage change in income.

$$e_y = \frac{percentage\ change\ in\ quantity\ demanded}{percentage\ change\ in\ Income} \quad (18)$$

The coefficient of income elasticity is always positive for normal goods and negative for inferior goods. For normal goods an increase in income will lead to an increase in the amount purchased of the commodity while for inferior goods an increase in income will lead to decrease in the amount purchased. Even among normal goods income elasticities vary substantially in size. Necessary goods tend to have small income elasticities because consumers regardless of how low their incomes will buy some of these necessary goods. If e_y is greater than one (1), it implies that the commodity is a luxury good because an increasing proportion of a consumer's income is spent on the commodity as income increases. Total expenditure elasticity also captures the percentage variation of the demand for the i^{th} good for a 1 percent variation of total expenditure. Let η_i denote income elasticity. Demand for a 'normal' good should increase when the total expenditure increases ($\eta_i > 0$). If the variation is proportionally greater than the income growth ($\eta_i > 1$), the good is qualified as a luxury good. On the other hand, if despite the income increase the demand for the good decreases ($\eta_i < 0$), it is termed an inferior good.

3.1.7 Separability

Empirical consumption and demand studies have often used some form of separability assumption usually in the form of a two stage budgeting structure, to facilitate analysis. This assumption usually allows for within period expenditure allocation conditional on total expenditure during the period (Deaton and Muellbauer, 1980). Hence, the ability to group commodities by type or time period stands as one of the most valuable forms of restrictions on consumer preferences. For example, grouping prices 'price aggregation' has some implications from grouping commodities 'direct separability'. Without some form of grouping, all relative prices for all goods both within and outside the current period may have an independent effect on the commodity demand under consideration. This suggests that if consumers optimize at all, they probably will use some form of grouping to enable some simplification of the decision making process. The most obvious method of grouping and one which is used extensively in empirical applications rests on the hypothesis of two stage budgeting. The idea dates back to the work of Gorman (1959) and still underlies many innovations in applied consumer theory (see Macurdy, 1983: Baker et al, 1989).

Under the two stages budgeting the direct utility function is weakly separable and consumers allocate expenditure first to broad commodity groups and then to detailed within group demands. This enables allocation within groups to be determined solely by the within group relative prices and the allocation of expenditure to that group. This second stage of budgeting involves examining how households allocate total consumption expenditure among various categories of goods and services. This involves estimating the parameters of price and income elasticities. A necessary and sufficient condition for weak separability is that the marginal rate of substitution between any two goods within a group is independent of goods outside the group.

3.1.8 Functional Forms

The choice of functional form for the representation of consumer preferences stands as one of the most important issues in any aspect of the empirical analysis of consumer behaviour. The ability to assess the importance of preference restrictions relies on choosing a functional form that is tractable without being unduly restrictive (Chalfant, 1987). The widespread use of the consumer's cost or indirect utility function as a representation of preferences in empirical analysis has produced a number of attractive specifications. The first is the translog utility function (Christensen *et al*, 1975) which is one of a class of flexible functional forms (Diewert, 1974). Closely related to these flexible functional form models are the Muellbauer (1975, 1976) and Deaton and Muellbauer (1980). A convenient specification called "Almost Ideal" was developed from a more general class of Price Independent Generalized Linear (PIGL) models. For empirical studies of consumer demand, it is increasingly common to use a flexible form to approximate the consumer's indirect utility function. Roy's identity is usually applied to the approximating form to obtain share equations for estimation and then the parameters of the share equations are used to calculate elasticities or test hypothesis such as separability or symmetry. However, the appropriate flexible functional form remains an open question as both theoretical and empirical problems exist with most.

3.2 Review of Demand System Methods

The estimation of complete demand systems within a framework consistent with classical demand theory originated with Stone's (1954) pioneering contributions. Stone first estimated a system of demand equations derived explicitly from consumer theory. Since then many models have been proposed. Of all the models proposed, three demand systems have received considerable attention in the literature due to their relative empirical expediency. These are the Linear Expenditure System (LES) developed by Stone (1954), the Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer (1980) and the combination of these two systems into a Generalized Almost Ideal Demand System (GAIDS) proposed by Bollino (1990). Other complete demand systems in the literature but not as widely used are the Rotterdam model of Theil (1976) and Barten (1969) and the translog model of Christensen *et al* (1975). The Quadratic Almost Ideal Demand System (QUAIDS) proposed by Banks *et al* (1997) is another higher rank demand model. Out of all these demand systems three stand out in the literature and have been used for empirical analysis. They are the Linear Expenditure System of rank 1 (Stone, 1954), Almost Ideal Demand System of rank 2 (Deaton and Muellbauer, 1980) and Quadratic Almost Ideal Demand System of rank 3 (Banks, et al, 1997).

3.2.1 Linear Expenditure System

This is a generalization of the Cobb-Douglas function. This function incorporates the idea that certain minimal amounts of each good must be bought by an individual. Demand functions can be derived from this utility function in a way analogous to the Cobb-Douglas case by introducing the concept of supernumerary income (I'). This represents the amount of purchasing power remaining after purchasing the minimum bundle of goods. The LES is a system of demand equations which can be estimated from two periods of budget data. The demand equations corresponding to the LES (in expenditure form) is given by;

$$p_i x_i = p_i h^i(p,\mu) = p_i b_i + a_i(\mu - \sum p_k b_k) \qquad (19)$$

where, x_i denotes quantity of the i^{th} good, p_i its price and μ total expenditure on the n-goods.

The indirect utility function is

$$\Psi(p,\mu) = -\frac{\prod p_k^{ak}}{\mu - \sum p_k b_k} \qquad (20)$$

The additivity restriction is given by $\sum \alpha_i = 1$

Here a household whose demand equations is given by this form is described as first purchasing "necessary" before purchasing other goods. The LES shows the budget share of a good that is positively related to the minimal amount of that good needed and negatively related to the minimal amount of the other good required. Given that the notion of necessary purchases seems to be accepted with real world observations, the LES which was first developed by Stone (1954) is widely used for empirical analysis. However, the LES model does not capture the welfare effects of price changes in commodities.

3.2.2 Almost Ideal Demand System (AIDS)

The Almost Ideal Demand model of Deaton and Muellbauer (1980) is a flexible demand specification which begins with the cost function of the PIGLOG (Price Independent Generalized Logarithmic) class of preferences. These preferences are represented through the cost or expenditure function. This cost function defines the minimum expenditure necessary to attain a specific utility level at given prices. The cost function $c(u_,p)$ corresponding to the PIGL form is derived and shown to take the following PIGLOG form. We denote the function $c(u,p)$ for utility u, and price vector p and define the PIGLOG class by

$$\log c(u_{h,}p) = (1-u)log\{a(p)\} + u_h log\{b(p)\} \quad \ldots\ldots(21)$$

where, u_h is the utility indicator of household h and $a(p), b(p)$ are linear homogenous concave functions of price vector p.

Choosing the functional form

$$loga(p) = \propto_0 + \sum_i \propto_i logp_i + \tfrac{1}{2}\sum_i \sum_j \gamma_{ij}^* logp_i logp_j \quad \ldots\ldots(22)$$

$$logb(p) = loga(p) + \prod_i p_i^{\beta}$$

From this the AIDS model is obtained from the following PIGLOG expenditure function

$$\ln c(u,p) = \alpha_0 + \sum_{j=1}^{n} \alpha_i \ln p_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\gamma_{ij} \ln p_i \ln p_j + U^* \beta_0 \prod_{k=1}^{n} P_i^{\beta_i} \qquad (23)$$

where, c is the minimum level of expenditure that is necessary to achieve utility level U* at given prices, and $\alpha_i, \beta_i, \gamma_{ij}$ are parameters. Logarithmic differentiation of (23) gives the budget shares as a function of prices and utility;

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln(x/p) \quad \ldots\ldots(24)$$

where, x denotes total expenditure and P is a translog price index defined by

$$\ln P = \alpha_0 + \sum_{j=1}^{n} \alpha_i \ln p_i + \frac{1}{2} \sum_{j=1}^{n} \sum_{i=1}^{n} \gamma_{ij} \ln p_j \ln p_i \text{ ....(25)}$$

The following adding up conditions must be satisfied

$$\sum_{i=1}^{n} \alpha_i = 1 \; ; \; \sum_{i=1}^{n} \gamma_{ij} = 0 \; ; \; \sum_{i=1}^{n} \beta_i = 0 \text{ ....(26)}$$

The following additional restrictions are also implied

Homogeneity

$$\sum_{j} \gamma_{ij} = 0 \text{ ....(27)}$$

Symmetry

$$\gamma_{ij} = \gamma_{ji} \text{ ....(28)}$$

The estimation of the AIDS model is difficult using the translog price index, hence Stone's price index P* is often used instead of P.

$$\ln P^* = \sum_{i=1}^{n} w_i \ln P_i \qquad ; \qquad w_i = \frac{p_i x_i}{m} \text{ ....(29)}$$

Using the Stone index approximation can severely bias the results (Pashardes (1993), Buse (1994) and Alston *et al* (1994). This is because the approximation performance of the AIDS model is poor. In addition it is a locally flexible form and may have a relatively small regularity region.

3.2.3 Transcendental Logarithmic Model

This demand model was developed by Christensen *et al* (1975). They represent the utility functions that are quadratic in the logarithms of the quantities consumed. The functions also have a local second order approximation in any utility function. These utility functions allow expenditure shares to vary with the level of total expenditure thereby allowing for substitution patterns among commodities. This model also shows the duality between prices and quantities in the theory of demand. It employs the use of indirect function, that is, it represents the direct utility as indirect utility function. The utility function is a transcendental function of the logarithms of quantities consumed. Symmetry, adding up and homogeneity restrictions are imposed in estimation. The translog model performs well if substitution between all commodities is close to unity; they deteriorate fast when substitution diverges from unity.

3.2.4 Quadratic Almost Ideal Demand System (QAIDS)

The Quadratic Almost Ideal Demand system (QAIDS) was developed by Banks, Blundell and Lewbel, (1997). This demand system is a rank three demand system and it is an developed by Deaton and Muellbauer (1980). The quadratic logarithmic class nests both the Almost Ideal model of Deaton and Muellbauer (1980) and Translog Model of Christensen *et al* (1975). The QAIDS is constructed so as to nest the Almost Ideal model and have leading terms that are linear in logarithmic income and prices. The QAIDS has an important relationship with Engel curves. This is because a complete description of consumer behaviour welfare analysis requires a specification of both Engel curve and relative price effects consistent with utility maximization. This model uses indirect utilities that can be calculated from before and after the price increase in commodities. Compensating variations given by the difference in cost functions are used to calculate consumer welfare analysis. The general form of demand consistent with the empirical evidence on Engel curves is:

$$w_i = A_i(p) + B_i(p)\ln x + C_i(p)g(x) \quad \text{………………………………………………………(30)}$$

where, P is the N-vector of prices, x=m/a(p), and A_i(p), B_i(p), C_i(p) and g(x) are differentiable functions. Equation (30) indicates that expenditure shares are linear in log income. The C_i(p)g(x) term allows for nonlinearities whereas the Engel curves that look like PIGLOG have C_i(p) near zero. The rank of equation (30) equals the rank of the N X 3 matrix of Engel curve coefficients (Banks et al, (1997). Lewbel (1991) also defines the rank of any demand system to be the dimension of the space spanned by its Engel curves. All exactly aggregable demand systems in the form of equation (30) that are derived from utility maximization have the indirect utility function of the form;

$$\ln V = \left\{ \left[\frac{\ln m - \ln a(p)}{b(p)} \right]^{-1} + \lambda(p) \right\}^{-1} \quad \text{……………………………………………………...(31)}$$

The term $\left[\frac{\ln m - \ln a(p)}{b(p)}\right]^{-1}$ is the indirect utility function of a PIGLOG demand system (i.e a system with budget shares linear in log of total expenditure). The term λ is a differentiable homogenous function of degree zero in prices p.

To construct the quadratic logarithmic specification consistent with equation (30), Deaton and Muellbauer's (1980) Almost Ideal demand system is considered. The AI model has an indirect utility function given by equation (31) but with the λ term set to zero. $\ln a(p)$ has the translog form;

$$\ln a(p) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j \quad \text{……………………………………………….(32)}$$

While $b(p)$ is the Cobb-Douglas price aggregator, and it is an aggregation of all prices to be considered, and it is denoted as

$$b(p) = \prod_{i=1}^{n} p_i^{\beta_i} \quad \text{……………………………………………………………………………..(33)}$$

The Almost Ideal model is convenient because it has budget shares that are linear in prices and income, in order to construct a system that is similar as possible to the Almost Ideal model while allowing for Engel curve shapes, we define the indirect utility in V given by equation (31) and define λ_i as

$$\lambda(p) = \sum_{i=1}^{n} \lambda_i \ln p_i \qquad \text{where} \quad \sum_i \lambda_i = 0 \quad \text{…………………………………………….(34)}$$

Equations (31), (32), (33) and (34) together define the QAIDS (see Banks et al, 1997). Therefore the corresponding share equation system is

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left[\frac{m}{a(p)}\right] + \frac{\lambda_i}{b(p)}\left\{\ln\left[\frac{m}{a(p)}\right]\right\}^2 \quad \text{……………………………………...(35)}$$

Equation (35) allows the impact of demographic and other household characteristics to enter all the terms. To calculate QAIDS model elasticities, equation (35) is differentiated with respect to $\ln m$ and $\ln p_j$, respectively. The budget elasticities derived there from are given by

$e_i = \mu / w_i + 1.$ ……………………………………………………………………………(36)

The uncompensated price elasticities are given by:

$e_{ij}^u = \mu / w_i - \delta_{ij}$ ……………………………………………………………………………..(37)

where δ_{ij} is the Kronecker delta.

Slutsky equation $e_{ij}^c = e_{ij}^u + e_i w_j$ is used to calculate the set of compensated elasticities e_{ij}^c and assess the symmetry and negativity conditions.

These models (that is, AIDS, Translog and QAIDS) have been extensively estimated and have been used to test the homogeneity and symmetry restrictions of consumer demand theory. Furthermore (Gorman, 1959; Baker *et al*, 1989) have focused on aggregation and on the properties of approximation using various demand systems. Many applications also use demand systems of rank three (Banks et al, 1997; Nicol, 2001). However, a major breakthrough in the estimation of consumer demand systems can be attributed to Deaton and Muellbauer (1980). They proposed and estimated on post war British data a new system of demand equations, the Almost Ideal Demand System (AIDS). The AIDS aggregates over consumers and the model is derived from the consumer cost function corresponding to price independent, generalized logarithmic (PIGLOG) consumer preferences. The results show that the budget shares of the various commodities are linearly related to the logarithm of total expenditure and the logarithm of relative prices.

3.3 Review of Empirical Literature

The AIDS was extended to incorporate family size explicitly (Ranjan, 1982), by employing the Barten (1964) technique of translating as a way of introducing demographic variables into complete demand systems. Under this procedure the original demand system is first replaced by a new system which contains parameters suitable for introducing such variables and it is then assumed that these newly introduced parameters are the only ones which depend on the demographic variables. The process is completed by specifying the functional form relating these parameters to the demographic variables. A non-linear full information maximum likelihood showed that the size incorporating AIDS is a significant improvement over size ignoring AIDS in all cases for both rural and urban sectors. Also, estimates of expenditure, price and size elasticities obtained in time series data were quite different from corresponding estimates on pooled cross section data. However, the large number of price parameters of AIDS and the Barten (1964) mode of incorporating size effects through the price variables effectively constrained the number of demographic parameters that could be estimated.

Usually, in microeconomic demand system modelling, it is assumed that consumers follow a two stage budgeting process. In the first stage, consumers allocate expenditures over all commodities while in the second they disaggregate expenditure to specific commodity groups. Baker, et al, (1989) modelled household energy expenditures in the UK using micro data from the family expenditure survey (FES). A total of 80,000 households were surveyed for the years 1972 to 1983. The demand by households for gas and electricity were considered. They employed a two stage budgeting procedure. Under the two stage budgeting procedure, expenditure decisions on fuels and all other non-fuel goods are represented by a recursive structure as if the household first allocated income between fuels and non-fuel and then at a second stage chose its disaggregated fuel expenditures. This restrictions imposed on two stage budgeting are equivalent to assuming weakly separable household preferences between fuel and non-fuel goods. They concluded that the income elasticities of both fuels at the means of the data were small and positive suggesting that demand rises with income, although with strong variations across household types. Price elasticities were found to be large especially for electricity consumption. This reflected variation in consumption levels as well as reactions displayed by households in different seasons.

Similarly, Labandeira *et al* (2006), estimated an energy demand system with household micro data in Spain. The quadratic almost ideal demand system was used to analyze expenditure form for Spanish households by following the two stage budgeting process. They explored consumer choices on electricity, natural gas, LPG and car fuels for private transport. They also estimated the model in different sub samples to capture varying responses to energy price changes by households living in rural, intermediate and urban areas. The result showed a significant relationship between spending on different energy goods and the place of residence, household composition and the work status of household head (active or retired). They evaluated own and cross-price elasticity for the goods and found that energy products are inelastic. Cross price effects existed in some cases indicating limited substitution between electricity and natural gas in urban areas and LPG and electricity in all locations.

Brannlund and Nordstrom (2004) estimated the quadratic almost ideal demand system in expenditure form in Sweden. The QAIDS was used to analyze the effect of carbon tax simulations using a household demand model on consumer response and welfare effect due to changes in energy or environmental policy. Simulations are simplified when household specific stone price index is used instead of the translog form price index and set the price aggregator equal to one. The model employed is a two stage budgeting system that combined micro data from household expenditure survey and macro data from the national accounts in Sweden. They modeled the demand for petrol, public transport, residential heating and other non durable goods and used the compensating variation to evaluate welfare effects from tax (increases) reform. Results showed that a 100% tax increase on energy is regressive because the low income households bear a larger share of the tax burden than richer households.

In consumer demand empirical studies, it is common to use a flexible form to approximate the consumer's indirect utility function. Roy's identity is applied to the approximating form to obtain share equations. Chalfant (1987) combined the AIDS system with the Fourier expenditure system. The Fourier series approach suggested by Gallant (1981, 1982, 1984) is incorporated into the almost ideal demand system. The result is a flexible form derived to be consistent with the PIGLOG class of preferences. The model was used to estimate an aggregate demand system for meats and fish using annual US data from 1947 to 1978. The application of this demand system to U.S consumption of meats and fish show that it fits the data well and that the restriction to the usual specification is rejected. The Deaton and Muellbauer (1980) specification and the globally flexible system produce results that are consistent with expectations and they are fairly similar. This system combined the best features of both the almost ideal demand system and the Fourier flexible form.

A quadratic extension of the AIDS by Banks *et al*, (1997) was used to estimate an econometric model for non-durable consumer demand in Sweden that utilizes micro and macro data. Besides the QAIDS allowing flexible price responses within a theoretically coherent structure, they also have expenditure shares that are linear in Engel curves. They use the QAIDS to analyze effect of indirect tax changes, relative prices as well as real income change on consumer expenditure. The results show that the QAIDS has the ability of being able to account for goods being luxuries at some income levels and necessities at others.

Olivia and Gibson (2008) made use of budget survey data from 29,000 Indonesian households to estimate a demand system for five energy sources (kerosene, gasoline, oil, LPG and electricity). To achieve this, the marginal social cost of indirect taxes and subsidies are calculated for the five household energy sources. These marginal social costs depend on the rate at which household welfare falls as prices increase and on the rate at which net public revenue rises. The results suggest that with high levels of inequality aversion there is a case for reducing the large subsidies on kerosene thereby supporting the reforms introduced by government.

Leth-Petersen (2002) estimated household energy demand for a cross-section of Danish households using natural gas and electricity. A conditional demand function to analyze household energy demand and also test for separability between electricity and natural gas was used. The study showed that the demand for one energy form is separable from the demand for another, for example, the demand for electricity is separable from the demand for natural gas, and this is evidence in favour of single equations modelling of household energy demand. In conclusion the separability result suggested that single equations modelling of household energy demand is reasonable. Pitt (1997) also used the conditional demand function to estimate the demand for goods within the household and asked how the allocations to health, time and food consumption affect others. The study showed that formulating the problem in terms of an intra household conditional demand equation makes it more useful and easy to analyse.

Within the context of energy demand elasticities, several approaches were used. They ranged from analysis at the macro level to more disaggregated analysis (Baker et al, 1989; De Vita, et al 2006). Estimating petroleum products demand dynamics in Nigeria is useful because it helps to provide estimates of price and income elasticities. Iwayemi, et al, (2010) estimated the demand for petroleum products in Nigeria using a multivariate co integration approach to investigate the long run relationship between petroleum products demand, its price and income at the aggregate level. The aggregated demand for petroleum products in Nigeria is price inelastic and income elastic. The variation in price and income elasticities of petroleum products demand reflects the differences in services provided by the various fuels. Babatunde and Shuaibu (2011), Babatunde and Enehe (2011) derived price and income elasticities for energy demand at the aggregate level. They found that household electricity consumption was income and cross price inelastic. They also found household size, number of rooms in the house and hours of power supply as the main determinants of household electricity demand in Nigeria.

Holte dahl and Joutz (2004), analyzed residential demand for electricity in Taiwan as a function of disposable income, population growth, price of the energy good and the degree of urbanization. They showed that income elasticity of residential demand is unity in the long run. Rapid urbanization has contributed to the high demand for electricity in the residential areas. This showed that there exist significant variations in the energy consumption patterns of different population groups (Poyer et al 1997). Pachauri (2004) used micro level household survey data from India to model households' per capita expenditures. They showed that total expenditure per capita had the largest positive effect on household per capita energy consumption. Geographical location, household dwelling and family characteristics also had significant effects in explaining variations in per capita total energy requirements.

De Vita, et al (2006) examined energy demand at the aggregate level using an Auto Regressive Distributed Lag (ARDL) bounds testing approach to model long run elasticity estimates for energy demand by fuel type. Cross price effects were not found among the goods, however price elasticity was negative while income elasticity was positive. This implied that consumers retained their fuel mix and consumption level.

3.3.1 Empirical Review on Household Fuel Choice

Household energy demand/fuel choice is premised on the energy ladder theory. Energy ladder and energy transition are used inter-changeably in the literature. Energy ladder theory asserts that urbanization itself drives inter-fuel substitution (Leach, 1988). That is, as settlements grow and industrial development, increased incomes and the availability of modern fuels, households are expected to switch from dirty and inefficient traditional energy sources up the energy ladder of increasingly sophisticated fuels. Since the household sector is generally the largest energy consuming sector in developing countries (Akabah, 1990: Cline-Cole *et al,* 1990) and also in Nigeria (Oladosu and Adegbulugbe, 1994) energy transition has focused on fuel switching processes at the household level. Fuel switching behavior is seen to be regulated by household economic welfare relative to the costs of various energy sources and their appliances. Hence it is expected that households normally switch from low quality fuels to more ideal and sophisticated fuels as income increases permit or move down the ladder as income decreases (Campbell *et al,* 2003: Karekezi and Majoro, 2002: Hosier and Dowd, 1987: Hosier and Kipondya, 1993).

Household fuel choice which is often viewed through the lens of the ‘energy ladder’ model places heavy emphasis on income in explaining fuel choice and fuel switching. The energy ladder model envisions a three stage fuel switching process. The first stage is marked by universal reliance on biomass. In the second stage, households move to transition fuels such as kerosene, coal and charcoal in response to higher incomes and factors such as deforestation and urbanization. In the third stage, households switch to LPG, natural gas or electricity once their income is sufficient. The main driver affecting the movements up the ladder is hypothesized to be income and relative fuel prices (Leach, 1992; Barnes and Floor, 1999). Although the energy ladder model appears to imply that a move up to a new fuel is simultaneously a move away from fuels used before. However, this is usually not the case, as most households still retain old fuel appliances as a way of energy security. In other words, the risk of confusing fuel choice and fuel switching is embodied in the energy ladder. The major achievement of the energy ladder is its ability to capture the strong income dependence of fuel choices. However two major flaws are associated with the energy transition and energy ladder models. First, the energy ladder seems to assume a single-fuel substitution pattern. By contrast, multiple fuel use is the norm in most households (Karekezi and Majoro, 2002: Hosier and Kipondya, 1993). This explains why despite rapid urbanization, the transition to more sophisticated fuels has progressed slowly (Brouwer and Falcao, 2004). Second, although the energy ladder model emphasizes income as a determinant for fuel choice it does not provide guidance on how energy sector interventions can be designed to effectively promote welfare if there is a decrease in income of the consumer (Leach, 1992; Barnes and Floor, 1999).

A cross-sectional analysis of energy consumption across low, middle and high income countries suggests that the transition from traditional fuels to fossil fuels and electricity appears to be a basic feature of economic growth (Leach, 1992). O’Keefe and Munslow (1989) however noted that the factors that determine a transition away from dependence on biomass towards commercial fuels at the level of the individual household do not appear to be well understood. Leach (1987) in his study in South Africa found that income, relative fuel prices, the cost of appliances and the availability of commercial fuels were the most important variables. In a later work, Leach (1992) suggested that although an energy transition can be observed in urban areas of developing countries, it is progressing slowly. Having reviewed a large number of energy surveys, Leach and Gowan (1987) summarized the factors influencing fuel choice as shown in Table 3.1.

Table 3.1: Supply and Demand Factors Influencing Fuel Choice

Supply Variables	**Demand Variables**
Price and availability of fuels	Household Income
Time and effort spent on fuel collection and use	Household size
Non-fuel demand for biomass resources	Climate
Location: Urban, Peri-urban or Rural	Cultural factors (diet, cooking habits, feasts)
Fuel characteristics and preferences	Cost and performance of appliances

Source: *Leach and Gowan (1987)*

Hosier and Dowd (1987) on household fuel choice in Zimbabwe viewed the energy ladder as a concept used to describe the way in which households will move to more sophisticated fuels as their economic status improves. They applied a multinomial logit formulation of the energy ladder to household energy use data and found that households actually move away from wood to kerosene and electricity as their economic status improved but still retain the traditional stoves and use them along with modern fuels. However, in addition to economic status, a large number of other important factors such as ecological zone and the relative price or availability of different fuels also determines household fuel choice. They suggested that policies which will encourage institutions be put in place as this will prove more effective in urban areas where higher incomes provide higher flexibility. Urban fuel wood consumption with respect to proper planning and provision of urban needs showed that households do not only make use of fuel wood but use multiple fuels for the purpose of cooking (Soussan, et al, 1990) hence in order for fuel switching to take place there should be a wide range of fuels available to consumers on a secure basis. To achieve this, the necessary planning institutions must be flexible enough to respond to the specific needs of the consumers. Also institutions need to be enhanced to perform better in the supply of energy products. The importance of community participation in the planning and implementation processes was however stressed.

Hosier and Kipondya (1993), also studied urban household energy use in Tanzania, among various income level groups. They conducted a survey to find out how energy use varies by income group. The result showed that household energy in Tanzania is largely due to differences in local prices and availability of the goods. They discovered that charcoal is used by households at all income levels. However on a general note in the urban areas there seems to be a shift towards modern fuel use especially kerosene. This is attributed to the subsidy on kerosene which encourages households to switch away from wood fuels.

Adegbulugbe and Akinbami (1995) in a survey on urban household energy use pattern in Nigeria showed the dominance of kerosene, LPG and electricity in all the income groups but fuel wood being the most preferred in the low income groups. This has made it very difficult for poor urban households to make the transition to more efficient fuels. They concluded that though, non-traditional fuels are the preferred choices for all household activities, not every household can afford these non-traditional fuels.

Furthermore, the effect of increasing petroleum prices on the pattern of energy use for cooking in low and middle income households showed that before the removal of subsidies most households used kerosene and LPG for cooking (Adelekan and Jerome (2006). However after the removal of subsidy on petroleum products and also due to worsening economic situations, there was a change in the pattern of energy consumption. Increase in the price of petroleum products resulted in increase in the price of modern/commercial fuels, thus households' that could use these fuels before could no longer do so. This resulted in many households' reverting to the use of fuel wood and other traditional fuels for cooking. Again households' access and preference to cooking fuels in Abuja, Ajah, (2013), shows that there is a significant lack of access to modern cooking fuels in Nigeria. Firewood was the main cooking fuel followed by kerosene, charcoal and electricity while the least accessible cooking fuel was LPG. Similarly, (Farsi et al, 2007), reveals that fuel choices follow the energy ladder with the economic variables such as income of the consumer and price of the energy goods having significant effect on energy use. Also socio-demographic factors such as education and sex of the head of household were important factors influencing fuel choice in urban Indian households. In addition firewood is the most used energy while LPG is the least, kerosene is used in between.

Israel (2002), examined household fuel choice and firewood use in Bolivia using the Heckman selection approach to model both the choice of fuel type and firewood expenditures, and estimation using a maximum likelihood. They found that income played a key role in determining the type of fuel that households use. Education also had a strong effect on the type of energy used. They also showed that as incomes increased the use of firewood decreased. This is consistent with the energy ladder model, where households switch to cleaner fuels as their income increase (Hosier and Kipondya, 1993).

Campbell *et al* (2003), examined energy transition in small towns in Zimbabwe. They ascertained that the simple energy transition proposed by the energy ladder may not be realistic because households' rather than use one fuel exclusively, use a combination of fuels (Hosier and Dowd, 1987; Barnes et al 2004). Although energy transition from wood to kerosene and electricity occurred in these cities, however, electricity is used more than kerosene. Even the wealthiest electrified households' also use a combination of other fuels (ESMAP, 1990) because fuel prices and supplies in developing countries are not stable hence the use of several fuels provides energy security (Soussan, et al, 1990). The increased use of electricity is attributed to government policies that promote electrification and electricity use for domestic purposes such as cooking and lighting.

Heltberg (2005) used a multinomial logit analysis to derive household fuel preferences in Guatemala. The energy goods used for cooking in Guatemala are wood, LPG, charcoal, electricity and kerosene. Although household income exerts a great influence on fuel choice used, the price of the energy good is a major determinant to the type of energy eventually used. Education is also a strong determinant of fuel choice, as the higher the level of education of individuals the more likelihood of using only LPG. Household size was not significant to the type of fuel used in Guatemala. He also found that in urban areas the number of rooms is significantly associated with switching away from fuel wood to LPG exclusively.

Quedraogo (2006), identified the determinants of cooking fuels in Quagadougou using a multinomial logit analysis. Wood energy remains the preferred fuel of most urban households due to poverty exacerbated by low income levels, low access to electricity, large households, and high cooking frequency of meals among others. Given these, fuel wood remains the primary source of energy for households as only less than 30% are linked to the national grid. LPG is used by only households in the upper income quintiles where the household head is well educated. A price subsidy policy for liquid petroleum gas (LPG) and its cooking stove would significantly decrease the utilization of wood energy.

Pachauri and Jiang (2008) compared household energy transition in India and China. Both countries are in energy transition though they differ sharply in several respects. China's residential energy consumption is three times that of India. While households in China have universal access to electricity, a large proportion of the urban population lack access to the national grid in India. However the key drivers of transition in both countries are income, energy prices, energy access, local fuel availability and rapid urbanization.

Pachauri (2004) in an enquiry into the nature of variations in the pattern of consumption between different households with varied lifestyles, reveals that there are large variations in the pattern of energy consumption across different classes of households'. In addition total household expenditure, household size and age of the head of household are related to higher household energy requirements.

Maconacchie, et al, (2009) identified prices and availability of modern fuels as the main factors influencing household fuel choice in Kano state, Nigeria. As economic conditions worsened the price of petroleum products increased thereby compelling many households especially the low and middle income earners to revert to the use of fuel wood. In like manner Naibbi et al, (2013) corroborate the findings of Maconachie et al, (2009) and also revealed that Northern Nigeria, especially Kano state still relies on traditional fuels. This implies that most Northern states are descending the energy ladder while the Southern states seem to be ascending the energy ladder. In addition the proportion of households' using fuel wood in Minna has also increased (Abd'razack, et al, 2013). Nnaji et al, (2012) also showed that fuel wood is the main energy used for cooking by households in the Eastern zone. They found household size, level of education, occupation of households' and type of cooking appliance to greatly influence the type of energy used by households. This can be attributed to dwindling real incomes of households (Karekezi, et al, 2002) as well as non availability of modern fuels for domestic use. A reassessment of the energy ladder model and its implication for household fuel choice showed that the model seems to have a significant weakness in the fuel transition process because it assumes a switch away from traditional and less efficient fuels to modern fuels (Hosier and Kipondya, 1993; Davies, 1998; Karekezi and Majoro, 2002; Campbell, et al, 2003; Greg Hiemstra-van der Horst, et al, 2008).

Also access to electricity supply has been found to be an important determinant of energy transition (Campbell et al, 2003; Davis 1998; Quedraogo, 2006). Babatunde and Shuaibu, (2011), found residential electricity consumption is a normal good whose expenditure increases as income rises. In addition, Babatunde and Enehe (2011), also showed that socioeconomic variables, such as household size, number of rooms in the household and hours of power supply were some of the determinants of electricity demand in Nigeria.

In terms of own price and cross price elasticities, Filippini and Pachauri (2004), showed that the income elasticity for electricity reveals electricity to be a necessary good, and also income and price inelastic. Whereas cross price elasticity estimates shows that electricity is a complementary good to LPG. Similarly, Babatunde and Enehe (2011), also found electricity consumption to be income and cross price inelastic suggesting also that electricity is a necessary good and also a complementary good to other energy goods. Furthermore, an enquiry into the nature of variations in the pattern of consumption between different households with varied lifestyles reveals that there are large variations in the pattern of energy consumption across different classes of households, Pachauri, (2004). Also total household expenditure, household size and age of the head of household are related to higher household energy requirements.

3.3.2 Empirical Review on Household Welfare Measurement

The objective of consumer demand analysis is to maximize utility subject to certain constraints. Utility is a construct that represents household welfare, yet utility is unobservable. In order to measure household welfare, something that is observable and a good indicator for welfare is required. Household consumption is a good indicator. Duality theory is often used to express consumer decisions in terms of expenditure functions, which specify money needed to attain a given level of utility (King, 1983; Glewwe, 1991). Since utility cannot be measured directly, the basic approach to measuring changes in welfare is to use ‘money metric’ measure. The welfare changes will thus be measured by real income or total expenditure (Barnes, 1995; Dumagan and Mount, 1992). Theoretically, a consumer has a utility function representing the consumer’s level of welfare expressed as a function of the consumption level of different goods. The consumer also faces a budget constraint with the purchase of each good given their prices and the consumer’s income. By maximizing the utility function subject to this budget constraint, the consumer’s purchase of goods can be summarized by his demand functions, which give the quantities demanded of each good at different prices given the prices of the other goods and income. If the demand functions are substituted into the original utility function, utility becomes a function of prices and income (Dumagan and Mount, 1992). This is generally known as the consumer's indirect utility function, it describes the consumer's level of welfare as a non-increasing function of prices, non-decreasing function of income and homogenous of degree zero in prices and income. All things being equal, consumer welfare decreases (increases) when prices rise (falls); increases (decreases) when income rises (falls); and remains the same when all prices and income change by equal proportions in the same direction. Most measures of welfare changes attempt to give a monetary value corresponding to an amount of income that is lost or gained.

The literature has shown that a diversity of approaches is used to measure consumer welfare. Among them is the consumer surplus, compensating and equivalent variations and the money metric measures; however money metric measure is the most common method for welfare measurement. The indirect utility form of the quadratic almost ideal demand system which incorporates log of prices of the goods and budget shares was used to measure welfare costs of tax or price reforms. (Banks, et al, 1996) showed that estimating demand functions using the second order approximations produced improvements in welfare measures by highlighting useful estimation of price and income elasticities. To analyze consumer welfare effects of price changes in food and energy (Huang and Huang, 2009), developed a Hicksian compensating variation as a function of all commodity prices and compensated price elasticities in order to quantify consumer welfare loss or gain. The welfare effects of an increase in food and energy prices incurred a consumer loss of which the burden is heaviest on low income households.

Issues of welfare effect of increasing household energy prices in Poland resulted in a loss to low income households and gain to higher income households (Freund and Wallich, 1996). In order to determine the gainers and losers from price adjustment, they estimated the welfare cost to households in different income groups from increasing household energy prices to efficient levels. The consumer surplus was used to determine the size of welfare losses associated with increasing energy prices. The loss in consumer surplus was calculated as a percentage of total expenditures. This was based on a range of price elasticities from zero to minus one in order to determine the size of welfare losses associated with increasing energy prices. All losses in consumer surplus were calculated as a percentage of total expenditure. They found that the policy of subsidizing energy prices is regressive. Although such programs will help the poor by providing them with lower cost energy, they are more useful to the rich who consume more energy. Hence they ruled out the often used social welfare argument for delaying energy price increases but rather advocated a social assistance program. Energy price increases in developing countries also show that when energy prices are raised they are done administratively. This is a way of subsidizing prices of such energy products. Subsidizing prices of energy goods are often done as a welfare measure on the basis of equity (Freund and Wallich, 1996; Hope and Singh, 1995) to enable low income households afford energy products. However this policy drive has always benefitted the rich households more than the poor households.

Preston and Walker (1999), examined measurement of individual welfare in labour supply models which allow for the impact of income taxation and income support schemes on labour supply decisions in the United Kingdom for single mothers. They adopted a discrete choice labour supply model and computed money metric and intercept income measures of welfare change and compare them with simple net income changes. They found a close correlation between these measures and with net income.

Dumagan and Mount (1992), implemented a generalized logit demand system in the measurement of consumer welfare effects of carbon penalties. They showed that the generalized logit demand system conforms better to the theory of consumer behaviour than standard flexible functional forms. The demand model and money metric were combined to measure the consumer welfare effects of carbon penalties on electricity and fuels. They conclude that the application of money metric and the estimated parameters of the generalized logit model to the evaluation of welfare effects on emission penalties can occur due to wider range of applications than conventional methods of analysis.

Brannlund and Nordstrom (2004), estimated an econometric model for non-durable consumer demand in Sweden that utilizes micro and macro data. They adopted the quadratic extension by Banks et al, (1997) to Deaton and Muellbauer’s (1980) almost ideal demand model (AIDS). The QAIDS model has a flexible functional form of consumer preferences which can handle non-linear expenditure effects and still be exactly aggregated. They analyzed the effect of carbon tax simulations using a household demand model on consumer response and welfare effect due to changes in energy or environmental policy. One of the results from the simulation showed that welfare effect, measured as compensation variation (cv) differed substantially between household categories. However, relative to disposable income, the welfare loss was greater for low income households. The conclusion from the simulations is that CO_2 tax has regional distribution effects in the sense that households living in sparsely populated areas carry a larger share of the tax burden.

Irvine and Sims (1993) examined the welfare effects of alcohol taxation. They analyzed how to appropriately tax alcoholic beverages at a disaggregated level. By using the theory of tax reforms the social cost of raising revenue from different alcoholic beverages is calculated. The discrete change in price is measured by the equivalent variation (EV) resulting from a change in the price of a single good. In addition, the Hicksian demands for a particular drink in a beverage group is derived by substituting the Marshallian demand into the expenditure function and the demand functions for each of the commodities. They approached this problem by building a multistage budgeting model of expenditure which is necessitated by the lack of elasticity information at the required level of desegregations. They conclude that there is considerable difference in the social costs of raising revenue from different sources. They found secondary market distortions to be a major factor in determining the social cost of raising tax revenue as a result of the different own-price elasticities for the three product groups.

3.3.3 Empirical Review on Inter-fuel Substitution in the Residential Sector

Understanding the dynamics of inter-fuel substitution has become an important issue because more households get access to modern fuels particularly within the urban and peri-urban sectors. Understanding inter-fuel substitution is also critical for policies aiming at facilitating sustainable development. Most of the current understanding about inter-fuel substitution describes the process of moving from wood to a higher value modern fuel as a linear one-way or natural process driven by increasing household income as envisioned by the energy ladder (Masera and Navia, 1997). However, this explanation has proved largely incomplete as many households switch only partially to modern fuels, using each fuel for the task where it best performs, or using multiple fuels to acquire energy security (Masera, et al, 2000; Leach, 1992; Hosier and Dowd, 1988). Given this, it is worthwhile estimating elasticities of substitution between any two types of energy sources in the residential sector. It is also important to have estimates of the own price and cross price elasticities for various fuels used in the residential sector in order to ascertain substitution effects between any two types of energy commodities. Consumers' behaviour in the residential sector can be approached from two points of view. On the one hand, each consumer wants to maximize utility subject to a budget constraint and that utility is a function of goods and services consumed (Rushdi, 1986). Therefore, it is assumed that consumption is an activity in which goods, singly or in combination, are inputs and in which the output is a collection of characteristics. One formulation of this latter approach is to consider the households as producers who determine the optimal uses of inputs by minimizing costs for a given level of output- the level of output being determined by the consumer's budget constraint. This means that individuals in maximizing utility (minimizing cost) would equate the marginal rate of substitution between two commodities with the ratio of their prices. Given this behavioural condition, it can be assumed that residential energy demand is a function of the prices of energy, the prices of substitutes and complements and the level of income.

Most studies in the literature on inter-fuel substitution has been largely limited to the industrial/manufacturing sector (see Bjorner and Jensen, 2002; Jones, 1995; Steinbuks, 2012). Few studies on household inter-fuel substitution exists (Rushdi, 1986; Masera and Navia, 1997; Masera, et al, 2000; Serletis, et al, 2010). The studies on residential inter-fuel substitution are largely based on the energy ladder model which seems to assume a linear fuel switching process, but in reality what obtains is a multiple fuel stacking. Most studies on inter-fuel substitution were based on aggregate time series data (Jones, 1995; Steinbuks, 2012). A few of the studies (Bjornrer and Jensen, 2002; Serletis, et al, 2010) are however based on disaggregated data. The literature on energy demand and inter-fuel substitution employed locally flexible functional forms especially the translog form of (Christensen, et al, 1975). Rushdi (1986) used a translog cost function to estimate inter fuel substitutability and price elasticities. South Australian data for the period 1960-1982 was used to estimate the translog cost function. Own and cross-price elasticities were estimated for various energy sources and for substitution possibilities between any two types of energy as a prerequisite for proper planning and pricing of energy sources. They applied Shephard's Lemma to the cost function to derive share equations for individual fuels. The results revealed that electricity was found to be a substitute for both gas and oil, while oil and gas appeared to be non-substitutes. Own price elasticities were found to be large and significant. Income elasticity for total energy demand was significantly less than one. This implies that income elasticity would decline as the level of income increases. This means that if all energy prices and per capita income increase by the same percentage, household energy consumption will decline despite the increase in income.

Other econometric methods used in inter-fuel analysis and combined with the translog model are the linear logit model by (Considine and Mount, 1984; Jones, 1995) and the generalized linear logit model by (Dumagan and Mount, 1992). These logit models give a better overall fit than their static version. Serletis, *et al* (2010) estimated inter-fuel substitution elasticities in selected developing and industrialized economies at the sector level. They employed the use of a locally flexible normalized quadratic functional form to investigate inter-fuel substitution. They showed that inter-fuel substitution elasticities were consistently below unity, revealing limited ability to substitute between major energy commodities, that is between coal, oil, gas and electricity. On the average industrial and residential sectors tend to exhibit higher potential for substitution between energy inputs. However, evidence on inter-fuel substitution in the residential sector fails to detect any distinctive pattern regarding either the substitution between any particular fuels or the relationship between inter-fuel substitution and the level of economic development. Therefore, it seems natural that inter-fuel substitution in the residential sector in the United Kingdom is only a function of a country's economic structure, its geographical location and the available natural resources. Steinbuks (2012), investigated inter-fuel substitution for different energy types in the UK manufacturing sector. Electricity was found to be a poor substitute for other fuels based on aggregate data and separately for heating process. An increase in real fuel prices due to climate change resulted in higher substitution elasticities based on aggregate data and lower substitution based on separately heating process.

One of the few studies of inter-fuel substitution based on disaggregated data is that of Bjorner and Jensen (2002) in an estimated econometric analysis of inter-fuel substitution between different types of energy in Danish industry sector. They estimated two models for inter-fuel substitution between electricity and other fuels using micro panel data set containing information for most Danish industrial companies between 1983 and 1987. Their estimated cross price elasticities of substitution showed that inter-fuel substitution is low within the companies especially between electricity and other fuels.

In terms of residential fuel substitution Masera and Navia (1997), studied the pattern of household fuel wood use and inter-fuel substitution in three villages of rural Mexico. They showed that the process of inter-fuel substitution has started in Mexico. But this inter-fuel substation can be likened to households retaining old energy appliances with the modern ones. This suggests that the type of substitution that exists is that of using different appliances to cook depending on the type of food to be cooked. This cannot be said to be a linear fuel switching process as suggested by the energy ladder which should take care of substitution to better fuels. Rather, most households are engaged in multiple fuels stacking as a way of having fuel security (Masera, et al, 2000).

Table 3.2: Summary of Selected Empirical Issues on Energy Demand

Author/Year	Variables Used	Methodology used	Conclusions
Deaton and Muellbauer (1980)	Total expenditure on fuel, food, housing services, transportation and communication.	Almost Ideal Demand System (AIDS) model and OLS.	The budget shares of the various commodities are linearly related to the logarithm of total expenditure and the logarithm of total prices.
Ranjan (1982)	Household total expenditure, price index and family size.	Non-linear FIML using an iterative Newton-Raphson method and OLS	The size incorporating AIDS is a significant improvement over the size ignoring AIDS for both rural and urban sectors.
Baker et al (1989)	Expenditure on different types of fuel ie gas, electricity, coal and non-fuel goods.	Two stage budgeting procedure and OLS	Income elasticities of both fuels positive suggesting that demand rises with income.
Israel (2002)	Household income, total expenditure and head of household.	Heckman selection approach using maximum likelihood.	Income plays a key role in determining the type of fuel type used by the household.
Leth-Peterson (2002)	Dwelling size, Stock of appliances, family size, income, and the price of energy products.	Conditional demand functions and OLS	Separability is tested by estimating the demand for one type of energy conditional on the demand for another type. This allows for endogeneity of the conditional variable, suggesting that single equation modelling of the household energy is reasonable.
Labandeira et al (2006)	Household income, household size, energy price and total expenditure.	Quadratic Almost Ideal Demand System (QAIDS) model, Instrumental Variable (IV) method and OLS.	Significant relationship between spending on different energy goods and the place of residence, household composition, and household head work status.
Chalfant (1987)	Price of meat and fish	Combination of the AIDS and the Fourier expenditure system.	The AIDS specification and the globally flexible system produce results that are consistent with expectations.
Olivia and Gibson (2006)	Five energy sources (kerosene, gasoline, oil,LPG and electricity)	Marginal social cost of indirect taxes is used to capture welfare losses of households.	There exists high level of inequality in the households.
Heltberg (2005)	The prices and usage of fuel wood, kerosene, charcoal, and LPG in Guatemala.	Multinomial logit analysis.	The level of education and income is a strong determinant of fuel choice.
Serletis et. al (2010)	Coal, oil, gas and electricity	Locally flexible normalized quadratic functional form to investigate inter-fuel substitution	Inter-fuel substitution in the residential sector fails to detect any distinctive pattern regarding substitution between fuels. It is a function of a county's economic structure.
Masera and Navia (1997)	Fuel wood and Liquefied Petroleum Gas	Kitchen performance test and controlled cooking test were applied to measure	Shows that the dimension of switching is a complex process.

	(LPG)	savings in household fuel use.	
Rushdi (1986)	Electricity, gas and oil	Translog cost function is used to estimate inter feul substitutability	Electricity was found to be a substitute for both gas and oil.
Dumagan and Mount (1992)	Electricity and other fuels	A generalized logit demand system was used to measure household welfare	The generalized logit demand system conforms better to the theory of consumer behaviour than standard flexible functional forms.
Adegbulugbe and Akinbami (1995)	Fuel wood, kerosene, LPG and electricity	Survey	Found dominant use of kerosene, LPG and electricity in all income groups. Feul wood most used by low income groups.
Adelekan and Jerome (2006)	Kerosene. LPG, fuel wood	Field survey	After the implementation of subsidy removal, many households reverted to the use of fuel wood and other less efficient energy sources for cooking.
Maconachie et al (2009)	Traditional and modern fuels	Field survey	Prices and availability of modern fuels influence household fuel choice in Kano state, Nigeria. However as economic conditions worsen many households' revert to the use of fuel wood.
Ajah (2013)	Traditional and modern fuels	Field survey conducted in Abuja, Federal Capital Territory.	Fuel wood the most used energy source, while kerosene, charcoal, electricity the least used energy source.

Source: *Author's Compilation (2013)*

3.4 Gaps in the literature

The literature on household energy demand choices in Nigeria has dwelt mainly on the determinants of type of fuel used by households' for cooking and lighting (see Adegbulugbe and Akinbami, 1995; Oladosu and Adegbulugbe, 1994; Adelekan and Jerome, 2006; Maconachie et al, 2009; Nnaji et al, 2012; Abd'razack et al, 2012 and Naibbi et al, 2013). These studies showed the factors that influence the choice of energy used by households. They however did not show if there are substitution possibilities among the energy carriers (that is, electricity, fuel wood, kerosene, LPG and petrol) as envisioned by the energy ladder model. These studies did not also show the welfare implications of energy price increase on households.

Though the importance of household energy demand has been established in the literature, the following issues are yet to be addressed in Nigeria. (i) There is a large void on inter-fuel substitution in the household sector. (ii) The welfare impact of increasing energy prices on households is not addressed. (iii) The determinants of urban household energy demand are not clear.

CHAPTER FOUR

THEORETICAL FRAMEWORK AND RESEARCH METHODOLOGY

This chapter provides the theoretical framework and methodology employed for this study. The model specification and model estimation techniques are also discussed.

4.1 Theoretical Framework

4.1.1 Quadratic Almost Ideal demand System (QAIDS)

Demand models play an important role in the evaluation of consumer welfare analysis. For many commodities however, standard empirical demand models do not provide an accurate picture of observed behaviour across various income groups. Deaton and Muellbauer (1980) developed a demand system that aggregates over consumers. Although, it is a flexible demand specification derived from the PIGLOG class, its approximation performance is poor because it has a relatively small regularity region. This necessitated the development of higher rank models with larger regularity regions that can better approximate non-linear Engel curves. The Quadratic Almost Ideal Demand System (QAIDS) developed by Banks *et al* (1997) is a rank 3 demand model that can approximate more non-linear Engel curves. Since higher rank demand models are better used to analyze welfare of households, this study adopted the Banks et al (1997) QAIDS framework. This is because the system allows for flexible income and price responses and it does not have constant elasticities since they depend on the level of expenditure. This option (QAIDS) thus enriched the demand model and leaves less space for misspecification.

As usual in microeconomic demand system estimation, it is assumed that consumers follow a two stage budgeting process. Under the two stage budgeting process, expenditure decisions on fuels and all other non-fuel goods can be represented as if the household first allocated income between fuels and non-fuel, and then at a second stage choose its disaggregated fuel expenditures (Baker et al 1989). When developing empirical models of energy demand, previous studies (Atkinson et al, 1990; Lewbel, 1991; Hausman et al, 1995) have showed the importance of allowing for non-linear relationships between the level of total expenditures and demand. Empirical demand systems have been developed that allows for extended expenditure (income) effects. The QAIDS is an example of a system where expenditure shares are quadratic in the logarithm of total expenditures. The QAIDS specification is based on a generalization of preferences represented by the Price-Independent Generalized Logarithm (PIGLOG) class. The

PIGLOG class arise from the indirect utility functions that are themselves linear in the logarithm of total expenditures (ln m), Muellbauer, (1976). An example of the PIGLOG specification is the Almost Ideal demand System (AIDS) of Deaton and Muellbauer, (1980).

The QAIDS is based on the following indirect utility function

$$\ln V = \left\{ \left| \frac{\ln m - \ln a(p)}{b(p)} \right|^{-1} + \lambda(p) \right\}^{-1} \quad \text{...(38)}$$

The first term within the square brackets is the indirect utility function of a PIGLOG demand system (i.e, a system with budget shares that are linear in log of total expenditure). M is total expenditure and p is observed price. The second term λ is a differentiable homogenous function of degree zero in prices p.

To construct the QAIDS consistent with equation (30) we follow Deaton and Muellbauer's 1980 AIDS. Equation (30) is restated thus

$$w_i = A_i(p) + B_i(p)\ln x + C_i(p)g(x) \quad \text{...(30')}$$

The traditional AIDS has the same indirect utility function given by equation (38) but with the λ term set to zero. $\ln a(p)$ has the translog form given as ;

$$\ln a(p) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j \quad \text{...(39)}$$

And $b(p)$ is the Cobb-Douglas price aggregator, it is an aggregation of all prices to be considered, and it is denoted as

$$b(p) = \prod_{i=1}^{n} p_i^{\beta_i} \quad \text{...(40)}$$

Where $\alpha_i , \beta_i and \ \gamma_{ij}$ are unknown parameters and n the number of commodities in the system. To complete the specification $\lambda(p)$ is defined as

$$\lambda(p) = \sum_{i=1}^{n} \lambda_i \ln p_i \ : \text{Where } \sum_{i=1}^{n} \lambda_i = 0 \quad \text{...(41)}$$

Equation (41) is as given by (Banks et al, 1997).

From equation (38) – (41) the indirect utility function can be represented as:

$$\ln V = \left\{ \left[\frac{\ln m - \left\{ \alpha_0 + \sum_{i=1}^{n} \alpha_j \ln p_j + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j \right\}}{\prod_{i=1}^{n} p_i^{\beta_i}} \right]^{-1} + \sum_{i=1}^{n} \lambda_i \ln p_i \right\}^{-1} \quad \text{..................(42)}$$

Applying Roy's identity to equation (42) gives the budget shares as;

$$w_{ih} = \alpha_i + \sum_{j=1}^{i} \gamma_{ij} \ln p_j + \beta_i \ln\left(x_h / a_h\right) + \frac{\lambda_i}{b_h} \left[\ln\left(x_h / a_h\right)\right]^2 + u_{ih} \quad \text{..................................(43)}$$

Where w_{ih} is the share of good i in total expenditure by household h.

x_h is total income expenditure; and ln P is price index.

4.1.2 Calculations of Compensated and Uncompensated Price and Expenditure Elasticities

An important element of the understanding of consumer behavior is provided by income and price elasticities of demand. Income elasticity captures the percentage change in the quantity demanded of a good for a percentage change in the income of the consumer. Let η_i denote income/total expenditure elasticity. For normal goods, higher income raises the quantity demanded of the good. Here because quantity demanded and income change in the same direction, normal goods have positive income elasticity. That is ($\eta_i > 0$). For an inferior good higher income lowers the quantity demanded. Because quantity demanded and income move in opposite directions, inferior goods have negative income elasticities, that is, ($\eta_i < 0$). For luxury goods the demand is proportionally greater than the income growth, that is, ($\eta_i > 1$). Among normal goods income elasticities vary substantially in size. Necessary goods tend to have small income elasticities (inelastic demand), because consumers regardless of how low their income choose to buy some of these goods. Luxury goods on the other hand, tend to have high income elasticitits (elastic demand) because consumers feel they can do without these goods if their income is too low.

To calculate the income elasticity for good i and household h, equation (43) is differentiated with respect to total expenditure to give

$$e_i^h = 1 + \frac{\mu_h^i}{w_i^h} \quad \ldots\ldots(44)$$

Where $\mu_i^h = \beta_i + \left[2\lambda_i \ln \frac{x_t}{a(p)}\right]\frac{1}{b(p)}$ ……(45)

Equation (44) denotes the income elasticity for good i and household h. While equation (45) is the uncompensated Marshallian price elasticity and it implies that each good can be either a necessity or a luxury for different households, depending on the distribution of total expenditure. The uncompensated elasticity of good i with respect to the price of good j for household h is obtained by also differentiating equation (43) with respect to the price of good j to obtain

$$e_{ij}^{uh} = \frac{\mu_{ij}^h}{w_i^h} - \delta_{ij} \quad \ldots\ldots(46)$$

Where $\mu_{ij}^h = \gamma_{ij} - \mu_i^h \left\langle \alpha_j + \sum_{k=1}^{N} \gamma_{jk} \ln p_k \right\rangle - \frac{\lambda_i \beta_j}{b(p)} \left\{ \ln\left[\frac{m}{a(p)}\right] \right\}^2$ ……(47)

δ_{ij} Is the kronecker delta and it represents price indices of the energy products in consideration. Slutsky equation is used to derive the Hicksian compensated price elasticities given by

$$e_{ij}^{ch} = e_{ij}^{uh} + e_i^h w_j^h \quad \ldots\ldots(48)$$

The effect of changes in prices on the expenditure pattern of households was captured by price elasticities.

4.1.3 Model Specification

Consumer demand patterns typically found in micro data sets vary considerably across households with different household characteristics and with different levels of income. As indicated in Banks, *et al* (1997), some goods are non-linear in expenditure while some are linear. A flexible functional form of consumer preferences which can handle non-linear expenditure effects and still be exactly aggregated is the quadratic extension (Banks *et al*, 1997) to Deaton and Muellbauer's almost ideal model (AIDS).

Having reviewed the literature on the estimation of demand models, this study adopted the quadratic almost ideal demand system (QAIDS) proposed by Banks, *et al* (1997), The QAIDS was adopted because the model can accommodate the aggregation of the energy products considered (electricity, kerosene, fuel wood, LPG and petrol). The model is more flexible in income and price responses and it depends on the level of expenditure rather than income. The QAIDS also allows price and income elasticities to vary with income. It also gives a more realistic picture of substitution as well as own price and income elasticities. The quadratic term of the QAIDS helps in describing consumer behavior.

The QAIDS model was thus adopted as the basic model and following the specification given in Labandeira *et al* (2006).

The equation estimated was equation (43) and restated thus as equation (43')

$$w_{ih.} = \alpha_i + \sum_{j=1}^{i} \gamma_{ij} \ln p_j + \beta_i \ln\left(x_h / a_h\right) + \frac{\lambda_i}{b_h}\left[\ln\left(x_h / a_h\right)\right]^2 + u_{ih} \quad \text{......................................} \quad (43')$$

Where,

w_{ih} = the share of good *i* in total expenditure by household h

α_i = the constant coefficient in the *ith* share equation.

γ_{ij} = the estimated coefficient of prices

$\ln p_j$ = is the price of the *jth* good

β_i = the estimated expenditure coefficient

x_h = is the total expenditure on the commodities being analyzed.

a_h = is the log of price index.

$\frac{\lambda}{b_h}$ = the estimated coefficient of the square of expenditure.

u_{ih} = error term

Equation (43') gives the share equations in an *n* number of goods systems. The energy products analyzed in the system included electricity, LPG, kerosene, fuel wood and petrol. The shares of expenditure in each of the five energy goods were dependent on prices, expenditure and a range of other explanatory variables. Equation (43’) was also subjected to the homogeneity, additivity and symmetry conditions. Since household energy surveys have several observed demographics, this model was flexible enough to allow shifts in both the intercept and slope of the share equations. The model used several dummy variables that modify the intercept and try to capture heterogeneity in the characteristics of households. In the empirical literature, these preceding variables are usually found to be significant (Baker *et al* 1989). The income of the household is an important explanatory variable as it is expected to have a significant effect on the purchase of energy goods. This is captured as the expenditure on energy goods (Freund and Wallich, 1996). Household size is also an important explanatory variable because the consumption of energy goods is expected to be a function of the number of household members. The educational level of household head is an important factor in energy consumption because the level of education of the household head is expected to influence positively the type of energy used. Hence, dummies were included for the educational level of heads of household (i.e., formal education, secondary education, and tertiary education), ownership of the house, the number of household members, geographical location and nature of occupancy (whether privately owned or rented).

Given this the final specification including demographic variables becomes;

$$w_{ih} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(x_h / a_h\right) + \frac{\lambda_i}{b_h}\left[\ln\left(x_h / a_h\right)\right]^2 + \sum_{p=1}^{5} demographics + u_{ih} \quad \ldots\ldots\ldots\ldots\ldots (49)$$

Since there are five energy sources [i = 5], equation (49) becomes a system of 5 equations which have to be estimated simultaneously. However given that the dependent variables [share of goods in total expenditure] are dependent, the error term [u_h] are also expected to be correlated across the equations.

The five demographic variables considered are measured thus:

Occupation: this represented the occupation of the respondent.

Occupation was classified into farming, artisan, public/civil service and trading. For the construction of the dummies, the public/civil servant group was used as the reference category. Three dummies were thus constructed for each of farming, artisan and trading.

(a) Dummy-artisan: A dummy variable that takes the value of unity when a respondent's occupation status belongs to artisan group and zero otherwise.

(b) Dummy-farming: A dummy variable that takes the value of unity when a respondent's occupation status belongs to farming group and zero otherwise.

(c) Dummy-trading: A dummy variable that takes the value of unity when a respondent's occupation status belongs to trading activities and zero otherwise.

Education: this represented educational status of a respondent.

Educational status was classified as no formal education, primary, secondary and tertiary. For the construction of the dummies, the tertiary education group was used as the reference category; hence three dummies were constructed for each of primary, secondary and no-formal education;

(a) Primary: A dummy variable that takes the value of unity when a respondent's maximum educational qualification is primary and zero otherwise.

(b) Secondary: A dummy variable that takes the value of unity when a respondent's maximum educational qualification is secondary and zero otherwise.

(c) No-formal: A dummy variable that takes the value of unity when a respondent's has no formal education and zero otherwise.

Ownership of House (personal or rental): represented the dummy for owning a house or not. Not owning a house was used as the categorical variable. Thus the dummy variable is constructed for owning personal house, which takes a value of one if the respondent own a personal house and zero otherwise.

Household size: this was not represented as a dummy, but as the actual number of people in households.

Geographical location: Urban centres were the state capitals of each state in south west zone, Nigeria. The sates used are Ekiti, Lagos, Ogun, Ondo, Osun and Oyo. They were represented as dummy variables, for the construction of the dummies, Lagos state was used as the reference category and because it is the largest of all the states. Hence five dummies were constructed for each of the states.

4.1.4 Welfare Analysis

Utility cannot be measured directly and therefore the basic approach to measuring changes in welfare is to use "money metric" measure. In general, utility theory is purely ordinal in nature and there is no unambiguous right way to quantify utility changes. However, for some purposes, it is convenient to have monetary measure of changes in consumer welfare. This is necessary so as to have an idea of the magnitude of a welfare change for the purpose of establishing priorities. In order to compare the benefits and costs accruing to different consumers, it is necessary to choose a standard measure of utility differences. A reasonable measure to adopt is the indirect money metric utility function. The indirect money metric utility function gives the minimum expenditure at prices and income. It measures how much income the consumer would need to be as well off as facing prices and having income. Two measures, equivalent and compensating variations are employed to do this.

The compensating variation (CV) is defined as the change in money income at the new level of prices. That is, it is defined as the amount of money to compensate a consumer for the price change. It is also known as the amount of money that will give the consumer the same level of utility as before the price increase. Compensating variation uses the after change in prices and asks what income change would be necessary to compensate the consumer for the price change. Equivalent variation uses the current prices as the base and asks what income change at the current prices would be equivalent to the proposed change in terms of its impact on utility. Both approaches are reasonable measures of the welfare effect of a price change. This study uses the compensating variation as is usually done when attempting to measure welfare loss after a price increase.

4.1.5 Estimation Technique

The econometric method used is the Seemingly Unrelated Regression Estimation [SURE] technique. The SURE technique is a generalization of a linear regression model that consists of several equations. Each equation is a valid linear regression on its own and can be examined separately. SURE helps to estimate equation by equation using standard ordinary least squares with a specific form for the variance covariance matrix. This method also accounts for heteroskedasticity and contemporaneous correlation in the errors across the five equations estimated. In terms of theoretical restrictions, it is noted that each equation is a linear combination of the others. Hence, to avoid singularity of the variance covariance matrix of errors, one of the equations needs to be left out of the estimation. In our case, to achieve a good result, the equation for fuel wood was dropped in one of the models. In the other model, the share equation for gas was dropped and that of fuel wood was included. However for the estimated demand systems to be coherent with consumer theory, symmetry and zero degree homogeneity conditions are imposed.

A priori it is expected that household income should have a positive and significant effect on the purchase of energy goods. It is expected that household size should have a positive and significant effect on the demand for a particular type of energy. As the household size increases it is expected to exert a positive impact if a particular type of energy source is predominantly demanded for.

4.2 Study Area

This study was conducted in the south west geo-political zone. The study area is one of the six geo-political zones that make up Nigeria. Located in the south western corner of Nigeria from where it derives its name, the area lies between longitude $2^{o}\ 31^{I}$ and $6^{o}\ 00^{I}$ East of the Greenwich Meridian and Latitude $6^{o}\ 21^{I}$ and $8^{o}\ 37^{I}$ North of the Equator. The area covered is approximately 78,771 Km^2 which represents about 8.5 per cent of the federation's territorial landmass of about 923,768 Km^2. The zone is bounded in the North by Kwara state, in the east partly by Kogi, Edo and Delta states, in the west by the Republic of Benin and in the south by the Gulf of Guinea. It stretches for more than 270 kilometers along the Guinea coast of the Atlantic Ocean. Like all other zones in the country, it falls entirely within the tropics. The southwest geo-political zone is made up of six administrative states: Ekiti, Lagos, Ondo, Ogun, Osun, and Oyo. The south west geo-political zone had a population of about 27,722,432 as at the last national census held in 2006. The states that comprise the zone also had the following population statistics, Lagos state had a population of 9,113,605, Ondo (3,460,877), Ekiti (2,398,957), Oyo (5,580,894), Ogun (3,751,140) and Osun (3,416,959). The current population of the zone is estimated to be about 40,000,000 given the population growth rate of about 3 percent per annum and the 2006 provisional census results (Ajide and Yusuf, 2011)

An interesting feature of southwestern Nigerian cities is the rate at which they are growing. This is evident in the temporal and spatial patterns of urbanization in the zone. Accompanying this growth in urbanization is the rate of use of energy resources especially in the residential sector. Significant proportion of the residents lack access to clean energy sources for various activities such as cooking, lighting and heating. Energy consumption in the southwest zone shows that majority of the residents use kerosene for cooking, although a substantial amount of fuelwood is also used, fuel wood is used more in the rural areas. Electricity and liquefied petroleum gas (LPG) are used sparingly perhaps as a result of irregular electricity and the high cost of LPG (NPC, 2006). Currently more than a third of the population in the zone lack access to clean and affordable energy sources (NPC, 2006)

4.2.1 Survey Objectives and Design

Due to lack of existing data on household energy demand, a survey was carried out. The survey was conducted in the state capitals of the six states that comprise the south west geo-political zone in Nigeria. The survey was designed to collect relevant data and information on energy use pattern, substitution possibilities and the factors that influence urban household energy demand pattern. The survey also collected relevant data and information which helped in the analysis of welfare loss to the household as prices of energy products rise. The survey covered source of energy supply, cooking end use appliances, type of housing and expenditure on energy goods and preferences derived from using these energy goods.

A household energy demand survey was conducted to elicit information on the type of domestic energy used for cooking and lighting. A random representative sample that cuts across all the state capitals was involved in the survey. A total of 600 hundred households were selected from all the urban clusters, while a total of 100 households were canvassed per state. This was done by following the NBS household survey standard. Households were stratified into three income classes on the basis of geographical location. The income groups were selected as follows, low income (high density), middle income (medium density) and high income (low density) geographical areas. This was to ascertain how households in the different income groups consume and spend on energy.

A multi stage cluster sampling design based on a two stage systematic random sampling procedure was used. The first stage involved the selection of Enumeration Areas (EAs) in each state capital from the National Integrated Survey of household (NISH) master sample frame provided by the National Bureau of statistics (NBS). In the second stage, 10 EAs were selected across low, middle and high density residential areas. A total of 10 households (HHs) were systematically selected in of the EAs (see Table 4.1). The households were systematically selected with equal probability and with a random start. Major streets were identified in the EAs. In the major streets identified houses were selected at 4 intervals. In each of the houses, a household head was identified and the questionnaire was administered.

Table 4.1: List of Enumeration Areas (EAs)

S/No	State	Population Density	Code	Enumeration Area	Locality
1	Ekiti	High	1206	Jesus Chapel	Ado-Ekiti
			1076	Jossy Feaba Block	Ado-Ekiti
			0344	Jimoh Aliu	Oke Alafia
			2648	Alhaji B.	Ojumose
		Medium	2518	Adanridisu Adesina	Ado-Ekiti
			0566	Patric Oladeru	Ado-Ekiti
			2878	Beacon International School	Ado-Ekiti
			0484	Alhaji Odeyemi	Ado-Ekiti
		Low	0354	Atanda Yussuf	Ado-Ekiti
			1410	Mr. Abe	Ado-Ekiti
			0484	Alhaji Odeyami	Ado-Ekiti
2	Lagos	High	1128	Ladoke Akintola	Alawusa
			0136	Ashafa Strees	Ojodu Area
			1128	Ladoke Akintola	GRA Ikeja
		Medium	0870	Unity/Omoyemi/Adesogo	Unity Street
		Low	1128	Ladoke Akintola	GRA Ikeja
3	Ogun	High	0632	Ago Ojo Mosque	Ago Ojo
		Medium	0474	Chief M. Oyeneye	Iporo Ake
		Low	0988	General Oil	Ibara Housing Estate
4	Ondo	High	0680	Saribu Abe	Akure
			0634	Sule Oladele	Akure
			0948	Ademola Jonathan	Akure
			0200	Dada Omosebi	Akure
		Medium	2132	Paradise Hotel	Akure
			0038	CAC	Akure
			0822	Sule Akanji	Akure
			2618	Samuel Kutimu	Akure
		Low	4204	Chief Elemuletu	Akure
			0164	Aye John	Orita Obele
			2132	Paradise Hotel	Akure
5	Osun	High	0530	Mohammed Raji	Osogbo
			1124	Rasaq Adeagbo	Sabo, Osogbo
			1300	Opaleye Alade	Osogbo
			1418	Rtd. Major Idris	Osogb
		Medium	1584	J.S. Ogunleye	Kola Balogun
			1550	Matanmi Hall	Osogbo
			1330	Alhaji Durosimi	Osogbo
			0622	Kareem Olojo	Osogbo
		Low	0536	Yemi Odesina	Ofatedo,
			0508	Okerente Housing Estate	Osogbo
			0622	Kareem Olojo	Osogbo
6	Oyo	High	2994	Kupelegbe Compound	Bere Area
			1044	Alumumini Mosque	Agbamu Sanyo
			1762	Oyelami Olola	Born Photo Gege
			0128	Adebayo Badmus	Kobomoje
		Medium	1642	Alhaji Bashiru	Oolmi
			1310	Yisu Aade	Aponmode
			0896	Areyetele Pharmacy	Ashi
			2628	Azeez Ayoola	Orogun
		Low	2164	Bishop Wale Oke	Olubadan Estate
			2122	Dr. Lekan Are	Oluyole Area

			0204	Pastor Olasunkanmi	Akobo

Source: National Bureau of Statistics-NBS, (2012)

4.2.2 The Data and Methodology

The data used for this study was collected from the primary source by direct questionnaire survey using the National Bureau of Statistics (NBS) existing framework for household survey. The questionnaire was administered to the head of a household or accredited representative in each of the identified houses. For this survey, 42 types of information were requested of each household interviewed. The questionnaire is divided into six sections. Section one is the identification section. Section two contains background information on sex, age and educational qualification of the household head. Section three contains socio-economic and demographic characteristics of the household. It includes the size of the family, occupation, type of house unit, type of kitchen and average income per month. Section four contains the energy-use profile of households. It includes the type of fuel used by household, the reason for using that type of fuel for various activities, the monthly expenditure on each of the energy types used and the quantity of energy consumed. Section five is on cooking end use, it includes appliance used for cooking and lighting and the willingness to substitute with cleaner fuels. Section six deals with how consumers rate their preferences for the various types of energy products.

The survey included data on the consumption of 9 different energy types for various activities such as cooking, lighting and fuelling cars. Of all of these, data on the consumption of candles, sawdust, charcoal and lantern were discarded, because there were many errors associated with their data. Data for the remaining five fuels, that is, kerosene, LPG, electricity, fuel wood and petrol were recorded in different measurement units. Kilowatt hour (kwh) is for electricity, litre (Lit) is for petrol and kerosene, while, kilogram (kg) is for LPG and fuel wood. Formal statistical evaluation of factors that affect household energy requirements were carried out both statistically and econometrically. The two sets of analysis performed on the data involved (1) Descriptive methods to show the pattern of household energy consumption across the income groups and (2) Empirical analysis. By this the QAIDS model was used to test for the relationship between household energy demand and some variables. Some of the variables include economic variables such as; expenditure, income, type of housing, area and environment. Demographic variables include age, household size, education and other social variables like, status and lifestyle. All these and more helped to determine to a large extent the energy use pattern of households in urban areas surveyed.

CHAPTER FIVE
DESCRIPTIVE AND EMPIRICAL ANALYSIS

This chapter presents the descriptive analysis of the socio-economic characteristics of respondents as well as energy demand profile by income level. The empirical analysis and the discussion of results are also undertaken.

5.1 Income Level Analysis

An income level analysis of the households and energy use is undertaken in this section. This is on the basis of ascertaining how income groups consume energy for various purposes.

5.1.1 Socio-economic and Demographic Characteristics of Respondents.

Table 5.1 shows that 150 (25.0%) of the respondents belong to the high income households while 210 (35.0%), and 240 (40.0%) belong to middle and low income levels respectively. Over fifty per cent of the respondents in any of the income groups are males, while over sixty-two per cent are heads of household. Indeed, 164 (68.3%) of those in the low income group are heads of household.

Age distribution of the respondents' shows that 48 (32.0%) and 74 (35.2%) belong to the modal age of 40-49 years for high income and middle income group respectively, while in the low income group 56 (23.3%) fall within the modal age 30-39. Generally, not less than twenty per cent of the respondents in the low income group are aged between 30-39, 40-49, 50-59, and 60-69 years, while it is only between ages 30-39 and 40-49 years where the respondents are more than twenty per cent in the middle income group. The situation is slightly different with the high income group where 48 (32.0%) of the respondents are aged between 40-49 years.

Table 5.2 indicates that majority of the heads of households and their spouses have tertiary education. For instance, 120 (80.0%) and 114 (76.0%) head of households and spouses have tertiary education in the high income group. The converse is the case with the low income group where 108 (45.0%) and 91 (37.9%) of the head of households and their spouses have secondary education. Also, 42 (17.5%) and 34 (14.2%) of the head of households and spouses have no formal education. The occupational profile of respondents in Table 5.3 shows that whereas, 223 (37.2%) and 167 (27.8%) of all the respondents indicated that they are civil servants and traders for primary occupation, 480 (80.0%) did not specify their secondary occupation.

Table 5.1: Socio-economic Characteristics of Respondents

Income level	Status	High Income		Middle Income		Low Income		Total	
Gender	Male	94	(62.7)	112	(53.3)	136	(56.7)	342	(57.0)
	Female	56	(37.3)	98	(46.7)	104	(43.3)	258	(43.0)
	Total	150	(100.)	210	(100.0)	240	(100.0)	600	(100.0)
HH Head	Yes	98	(65.3)	131	(62.4)	164	(68.3)	393	(65.5)
	No	52	(34.7)	79	(37.6)	76	(31.7)	207	(34.5)
	Total	150	(100.0)	210	(100.0)	240	(100.0)	600	(100.0)
Age (Years)	20-29	6	(4.0)	16	(7.6)	30	(12.5)	52	(8.7)
	30-39	21	(14.0)	51	(24.3)	56	(23.3)	128	(23.3)
	40-49	48	(32.0)	74	(35.2)	49	(20.4)	171	(28.5)
	50-59	41	(27.3)	39	(18.6)	55	(22.9)	135	(22.5)
	60 yrs >	34	(22.7)	30	(14.3)	50	(20.8)	114	(19.0)
	Total	150	(25.0)	210	(35.0)	240	(40.0)	600	(100.0)
	Modal Age	40-49		40-49		30-39			

Note: Figures in parentheses are percentages
Source: Author's Analysis, 2012

Table 5.2: Educational Status of Respondents

Educational Level	High Income		Middle Income		Low Income		Total	
	HH	SP	HH	SP	HH	SP	HH	SP
No formal	3 (2.0)	2 (1.3)	17 (8.1)	11 (5.2)	42 (17.5)	34 (14.2)	62 (17.5)	47 (14.2)
Primary	6 (4.0)	7 (4.7)	33 (15.7)	44 (21.0)	51 (21.3)	58 (24.2)	90 (21.3)	109 (24.2)
Secondary	18 (12.0)	20 (13.3)	67 (31.9)	66 (31.4)	108 (45.0)	91 (37.9)	193 (45.0)	177 (37.9)
Tertiary	120 (80.0)	114 (76.0)	93 (44.3)	72 (34.3)	38 (15.8)	35 (14.6)	251 (15.8)	221 (14.6)
Others	3 (2.0)	1 (0.7)	0 (0)	1 (0.5)	1 (0.4)	0 (0)	4 (0.4)	2 (0)

Note: HH – Household Head; SP - Spouse
Figures in parentheses are percentages
Source: Author’s Analysis, 2012

Table 5.3: Occupational Profile of the Respondents

Income Level	High Income				Middle Income				Low Income				Total			
Occupation	Primary		Secondary		Primary		Secondary		Primary		Secondary		Primary		Secondary	
Farming	3	(2.0)	3	(2.0)	3	(1.4)	6	(2.9)	19	(7.9)	13	(5.4)	25	(4.2)	22	(3.7)
Trading	25	(16.7)	14	(9.3)	65	(31.0)	19	(9.0)	77	(32.1)	20	(8.3)	167	(27.8)	53	(8.8)
Artisan	6	(4.0)	1	(0.7)	34	(16.2)	7	(3.3)	54	(22.5)	9	(3.8)	94	(15.7)	17	(2.8)
Civil servants	91	(60.7)	6	(4.0)	81	(38.6)	5	(2.4)	51	(21.3)	3	(1.3)	223	(37.2)	14	(2.3)
Not specified	3	(2.0)	120	(80.0)	1	(0.5)	168	(80.0)	8	(3.3)	192	(80.0)	12	(2.0)	480	(80.0)
Others	22	(14.7)	6	(4.0)	26	(12.4)	5 (2.4)		31	(12.9)	3	(1.3)	79	(13.1)	14	(2.3)

Note: Figures in parentheses are percentages
Source: Author's Analysis, 2012

Over fifty per cent of the respondents in any of the income groups are civil servants while between 25 (16.7%) and 72 (32.1%) in the high and low income groups have trading as their primary occupation. Majority of the respondents across the income groups were not willing to divulge information on their secondary source of income.

Average monthly income in Table 5.4 varies markedly amongst the income groups. The average monthly income for the low income group is ₦40,273.33, it is ₦193,923.11 for the high income households. The implication of this is that the average income of the high income group is about five times that of the low income group.

Table 5.4: Average Monthly Income (₦)

S/No	Income level	Wages	Gifts	Personal business	Others	Mean of Total Income
1	High income	142456.97	35600.00	150049.18	50600.00	193923.11
2	Middle income	56377.50	14791.14	32867.35	13978.95	61016.90
3	Low income	42387.96	7311.96	28126.76	10268.29	40273.33

Source: Author's Analysis, 2012

Table 5.5 shows that 280 (46.7%) of all the respondents live in rented apartments. This include 122 (50.8%) and 108 (51.4%) in the low and middle income groups while 86 (57.3%) of the respondents in the high income group live in personal houses. The table further shows that whereas, 83 (55.3%) and 91 (43.3%) of the respondents in high and medium income groups live in flats, 197 (82.1%) of the respondents in low income group live in single room apartments. Indeed, over fifty per cent of all the respondents live in single room apartments. While 261 (43.5%) of the respondents live in houses with inbuilt kitchen facilities, 195 (32.5%) have shared facilities. However, these facilities are lopsided to the 126 (52.5%) low income earners. As many as 121 (80.7%) of the high income earners live in houses with inbuilt kitchen facilities. Also, 92 (43.8%) and 66 (31.4%) of the middle income earners have inbuilt and shared kitchen facilities respectively.

Table 5.5: Housing Characteristics of Respondents

S/No	Characteristic	Status	High Income		Middle Income		Low Income		Total	
1	Ownership	Family	7	(4.7)	23	(11.0)	59	(24.6)	89	(14.8)
		Personal	86	(57.3)	57	(27.1)	49	(20.4)	192	(32.0)
		Rented	50	(33.3)	108	(51.4)	122	(50.8)	280	(46.7)
		Free	4	(2.7)	20	(9.5)	8	(3.3)	32	(5.3)
		Subsidized	3	(2.0)	2	(1.0)	2	(0.8)	7	(1.2)
		Total	150	(100.0	210	(100.0)	240	(100.0)	600	(100.0)
2	House Type	Single	4	(2.7)	100	(47.6)	197	(82.1)	301	(50.2)
		Flat	83	(55.3)	91	(43.3)	23	(9.6)	197	(32.8)
		Duplex	18	(12.0)	0	(0.0)	2	(0.8)	20	(3.3)
		Bungalow	45	(30.0)	18	(7.5)	18	(7.5)	81	(13.5)
		Others	0	(0.0)	1	(0.5)	0	(0.0)	1	(0.2)
		Total	150	(100.0)	210	(100.0)	240	(100.0)	600	(100.0)
3	Kitchen Type	Separate	24	(16.0)	37	(17.6)	38	(15.8)	99	(16.5)
		Shared	3	(2.0)	66	(31.4)	126	(52.5)	195	(32.5)
		Open Air	2	(1.3)	15	(7.1)	28	(11.7)	45	(7.5)
		Inbuilt	121	(80.7)	92	(43.8)	48	(20.0)	261	(43.5)
		Total	150	(100.0)	210	(100.0)	240	(100.0)	600	(100.0)

Note: Figures in parentheses are in percentages

Source: Author's Analysis, 2012

5.1.2 Energy Use Profile

The energy use profile in Table 5.6 shows that kerosene is the primary source of energy used for cooking by all the income groups. Not less than eighty three per cent of the respondents in any of the income groups use kerosene for cooking. Indeed, as many as 538 (89.7%) of all the respondents use kerosene for cooking. However, 79 (52.7%) and 50 (33.3%) of the respondents in the high income group indicated that they use gas and electricity for cooking. In the low income group, 219 (91.3%) and 82 (34.2%) respondents use of kerosene and fuel wood respectively for cooking. About ninety per cent of the respondents in all the income groups use electricity for lighting. Whereas, 92 (64.7%) of the respondents in the high income group use of generators, 106 (44.2%) in the low income group use of kerosene for lighting.

Clearly, Table 5.7 shows that 355 (59.2%) and 407 (67.8%) of all the households use of kerosene because it is cheap and available. Availability of kerosene is indicated by 96 (64.0%), 148 (70.5%) and 163 (67.9%) households in the high, middle and low income groups respectively as the reason for its use as the main energy for cooking. It is only in the high income group where 32 (21.3%), 55 (36.7%), 50 (33.3%) and 51 (34.0%) of the households consider the use of gas for cooking as cheap, convenient, clean and available. Only 57 (23.8%) of the respondents in the low income group consider the use of fuelwood as cheap and available. In the same vein, Table 5.8 clearly shows that electricity is mostly preferred by 374 (62.3%) and 336 (44.0%) of all the respondents for being convenient and available for lighting, while 214 (35.6%) and 107 (17.8%) consider it as cheap and clean. Convenience is considered by 89 (59.3), 140 (66.7%) and 145 (60.4%) in high, middle and low income groups respectively as the most important reason for using electricity of lighting. Kerosene is however considered by 43 (28.7%), 73 (34.8%) and 113 (47.1%) of the respondents in the high, middle, and low income groups for its availability for lighting.

The sources of household energy demand in Table 5.9 indicates that whereas kerosene is mostly demanded within own neighbourhood by 84 (40.0%) and 109 (45.4%) of the respondents in the middle and low income groups, 55 (36.7%) of the respondents in the high income category demand kerosene from the next neighbourhood. Electricity is also demanded by not less than sixty per cent of the respondents in any of the income categories within own neighbourhood.

Table 5.6: Type of Household Energy Demand/for various activities

S/No	Income Level	Cooking				Lighting				Car fuel
		Gas	Kerosene	Electricity	Fuel wood	Gas	Kerosene	Electricity	Generator	Petrol
1	High	79 (52.7)	125 (83.3)	50 (33.3)	13 (8.7)	0 (0.0)	31 (20.7)	136 (90.7)	92 (61.3)	97 (64.7)
2	Middle	37 (17.6)	194 (92.3)	35 (16.7)	41 (19.5)	1 (0.5)	66 (31.4)	195 (92.9)	66 (31.4)	62 (29.5)
3	Low	6 (2.5)	219 (91.3)	26 (10.8)	82 (34.2)	0 (0.0)	106 (44.2)	210 (87.5)	48 (20.0)	31 (12.9)
	Total	122 (20.3)	538 (89.7)	111 (18.5)	136 (22.7)	1 (0.2)	203 (33.8)	541 (90.2)	206 (34.3)	190 (31.7)

Note: Figures in parentheses are in percentages
Source: Author's Analysis, 2012

Table 5.7: Reason for Choice of Energy Demand for Cooking

S/No	Income Level	Type of Fuel															
		Gas				Kerosene				Electricity				Fuel wood			
		a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
1	High	32 (21.3)	55 (36.7)	50 (33.3)	51 (34.0)	43 (26.7)	82 (54.7)	5 (3.3)	96 (64.0)	28 (18.7)	39 (26.0)	21 (14.0)	45 (30.0)	13 (8.7)	6 (4.0)	0 (0.0)	15 (10.0)
2	Middle	13 (6.2)	24 (4.0)	27 (12.9)	23 (11.0)	70 (33.3)	124 (59.0)	15 (7.1)	148 (70.5)	25 (11.9)	37 (14.3)	19 (9.5)	34 (16.2)	35 (16.7)	19 (9.1)	2 (1.0)	37 (14.3)
3	Low	1 (0.4)	2 (0.8)	5 (2.1)	3 (1.25)	71 (30.0)	149 (62.1)	19 (7.9)	163 (67.9)	19 (7.9)	28 (11.7)	4 (1.7)	23 (10.0)	57 (23.8)	29 (12.1)	2 (0.8)	57 (23.8)
	Total	46 (7.7)	81 (13.5)	82 (13.7)	77 (12.8)	184 (30.7)	355 (59.2)	39 (6.5)	407 (67.8)	72 (12.0)	104 (17.3)	44 (7.3)	102 (17.0)	105 (17.5)	54 (9.0)	4 (0.7)	109 (81.8)

Note: a – Cheap b – Convenience c – Clean d – Availability
Figures in parentheses are percentages
Source: Author’s Analysis, 2012

Table 5.8: Reason for Choice of Energy Demand for Lighting

		Type of Fuel															
		Petrol				Gas				Electricity				Kerosene			
S/No	Income Level	A	b	c	d	a	b	c	d	a	B	c	d	a	b	c	d
1	High	13 (8.7)	56 (37.3)	5 (3.3)	81 (54.0)	1 (0.7)	6 (4.0)	1 (0.7)	5 (3.3)	62 (41.3)	89 (59.3)	34 (22.7)	80 (53.3)	23 (15.3)	33 (22.0)	4 (2.7)	43 (28.7)
2	Middle	7 (3.3)	43 (20.5)	1 (0.5)	70 (33.3)	1 (0.5)	0 (0.0)	1 (0.5)	1 (0.5)	69 (32.9)	140 (66.7)	41 (19.5)	130 (61.9)	40 (19.0)	49 (23.3)	4 (1.9)	73 (34.8)
3	Low	2 (0.8)	24 (10.0)	0 (0.0)	27 (11.3)	0 (0.0)	3 (1.3)	1 (0.4)	5 (2.1)	83 (34.6)	145 (60.4)	32 (13.3)	126 (52.5)	68 (28.3)	63 (26.3)	7 (3.0)	113 (47.1)
	Total	22 (3.7)	123 (20.5)	6 (1.0)	178 (29.7)	2 (0.3)	9 (1.5)	3 (0.5)	11 (1.8)	214 (35.6)	374 (62.3)	107 (17.8)	336 (44.0)	131 (21.8)	145 (24.2)	15 (2.5)	229 (61.8)

Note: a – Cheap b – Convenience c – Clean d - Availability

Source: Author's Analysis, 2012

Table 5.9: Source of Household Energy Demand

S/No	Income level	Source of supply	LPG		Kerosene		Fuel wood		Electricity		Petrol	
1	High	Own Neighbourhood	13	(8.7)	41	(27.3)	4	(2.7)	100	(66.7)	19	(12.7)
		Next Neighbourhood	38	(25.3)	55	(36.7)	5	(3.3)	34	(22.7)	54	(36.0)
		Outside local area	24	(16.0)	30	(20.0)	7	(4.7)	5	(3.3)	53	(35.3)
2	Middle	Own Neighbourhood	11	(5.2)	84	(40.0)	13	(6.2)	140	(66.7)	27	(12.9)
		Next Neighbourhood	24	(11.4)	79	(37.6)	25	(11.9)	59	(28.1)	46	(21.9)
		Outside local area	5	(2.4)	33	(15.7)	5	(2.4)	10	(4.8)	25	(11.9)
3	Low	Own Neighbourhood	2	(0.8)	109	(45.4)	33	(13.8)	147	(61.3)	18	(7.5)
		Next Neighbourhood	2	(0.8)	88	(36.7)	33	(13.8)	46	(19.2)	29	(12.1)
		Outside local area	2	(0.8)	30	(12.5)	13	(5.4)	11	(4.6)	20	(8.3)

Source: Author's Analysis, 2012

The willingness to use the same energy currently being used, Table 5.10, is such that only 14 (9.3%), 30 (14.3%), and 51 (21.3%) of the respondents in the high, middle and low income groups are willing to change. The willingness to switch to another energy type should the price of kerosene ever increase by hundred per cent is also indicated by only 22 (14.7%), 38 (18.1%) and 61 (25.4%) of the respondents in the high, middle and low income groups (see Table 5.11).
Table 5.12 shows that should there be an increase in the price of kerosene, 84 (14.0%) and 32 (5.3%) of all the respondents will prefer to switch to fuelwood for cooking and kerosene for lighting. Only 8 (1.3%) will prefer the use of gas.

Table 5.10: Willingness to Remain on Current Energy if Price Increase

S/N	Income level	YES	NO
1	High Income	14 (9.3)	136 (90.7)
2	Middle Income	30 (14.3)	180 (85.7)
3	Low Income	51 (21.3)	189 (78.8)

Note: Figures in parentheses are percentages
Source: Author's Analysis, 2012

Table 5.11: Willingness to Switch to another Energy Type should the Price of Kerosene Increase by 100%

S/N	Income level	Yes	No
1	High Income	22 (14.7)	128 (85.3)
2	Middle Income	38 (18.1)	172 (81.9)
3	Low Income	61 (25.4)	179 (74.6

Note: Figures in Parentheses are Percentages
Source: Author's Analysis, 2012

Table 5.12: Preferred Energy Type with an Increase in the Price of Kerosene

S/N	Income Level	LPG		kerosene				Electricity				Fuel wood			
		Cooking		Cooking		Lighting		Cooking		Lighting		Cooking		Lighting	
1	High	1	(0.7)	3	(2.0)	6	(4.0)	3	(2.0)	4	(2.7)	7	(2.7)	0	(0.0)
2	Middle	5	(2.4)	11	(5.2)	13	(6.2)	7	(3.3)	10	(4.8)	27	(12.9)	0	(0.0)
3	Low	2	(0.8)	11	(4.6)	13	(5.4)	4	(1.7)	14	(5.8)	50	(20.8)	3	(1.3)
	Total	8	(1.3)	25	(4.2)	32	(5.3)	14	(2.3)	28	(4.7)	84	(14.0)	3	(0.3)

Source: Author's Analysis, 2012

Table 5.13 shows that the average monthly expenditure varies from ₦46418.05 for the low income households to ₦107031.08 for high income households. Generally, food takes the highest percentage of households' expenditure. The table clearly shows that food account for not less than thirty per cent of all households in all the income groups. It accounts 30.8%, 32.2% and 32.8% in the high, middle and low income households respectively. Car fuel also accounts for 17.5%, 21.3% and 18.4% in the high, middle and low income households in this order. This is followed by transportation which accounts for 6.97%, 8.30% and 9.74% in the high, middle and low incomes households.

Table 5.14 indicates that the average monthly expenditure on household energy demand varies from ₦6210.98, ₦10290.96, and ₦24968.36 for the low, middle and high income groups respectively. This suggests that average monthly expenditure in the high income group is more than four times that of the low income earners. The unit price of household energy demand, in spite of government regulation of electricity, and petroleum product, also varies among the income group (see Table 5.15).

Table 5.13: Average Monthly Expenditure on Household Needs

S/N	Income Level	Food	Transport	Electricity	Kerosene	Petrol	Gas	Fuel wood	Car Fuel	Other energy	Other expenditure	Total
1	High Income	33050.00 (30.8)	7467.50 (6.97)	3092.19 (2.88)	2159.39 (2.01)	8749.01 (8.17)	3928.95 (3.67)	1385.29 (1.29)	18817.60 (17.5)	3525.00 (3.29)	24856.15 (23.2)	107031.08
2	Middle Income	19402.38 (32.2)	5005.42 (8.30)	1476.65 (2.44)	2223.65 (3.68)	4366.85 (7.24)	2815.54 (4.67)	995.33 (1.65)	12896.00 (21.3)	3085.71 (5.11)	8021.52 (13.3)	60289.05
3	Low Income	15237.39 (32.8)	4521.43 (9.74)	1349.87 (2.90)	2215.43 (4.77)	4017.30 (8.65)	3233.33 (6.96)	1445.38 (3.11)	8581.60 (18.4)	694.44 (1.49)	5121.88 (11.03)	46418.05

Source: Author's Analysis, 2012

Table 5.14: Average Monthly Expenditure on Household Energy Demand

S/No	Income Level	Energy Type					
		Gas	Kerosene	Electricity	Fuel wood	Petrol	Av. Monthly Exp.
1	High Income	3298.70	2275.52	3115.00	5113.33	20479.57	24968.36
2	Middle Income	2819.53	2237.14	1553.40	1484.22	11258.72	10290.96
3	Low Income	1011.43	2314.17	1959.91	1270.59	6140.78	6210.98
	Average	3125.44	2277.31	2099.57	1737.63	14101.12	12285.15

Source: Author’s Analysis, 2012

Table 5.15: Unit Price for Household Energy Products (₦)

S/No	Income level	Type of Energy: Price/Quantity				
		Petrol (Litre)	Electricity (kwh)	Gas (kg)	Kerosene (Litre)	Fuel wood (kg)
1	High Income	97.00	379.64	2743.89	331.03	529.17
2	Middle Income	97.00	151.92	2071.69	372.16	289.50
3	Low Income	97.00	133.91		346.03	302.50

Source: Author's Analysis, 2012

5.1.3 Cooking End Use

Table 5.16, shows that kerosene stove is most frequently used for cooking. A total of 417 (69.5%) of all the respondents across the income groups use kerosene stove for cooking. This is as indicated by 65 (43.3%), 157 (74.8%) and 195 (69.5%) of the respondents in high, middle and low income categories. This is followed by gas cooker which is frequently used by 66 (44.0%) and 36 (17.1%) of households in the high income and middle income group but used frequently by only 4 (1.7%) among the low income households. Fuel wood is also used by 21 (10.0%) and 51 (21.3%) of the households in the middle and low income categories. In like manner, fuelwood is sparingly used by 17 (11.3%), 32 (15.2%) and 54 (22.5%) of high, middle and low income households. In addition, 65 (43.3%) and 157 (74.8%) households in the high and middle income groups use kerosene stove sparingly, while only 23 (9.6%) low income households use it sparingly. The willingness to substitute kerosene for gas cooker shown in Table 5.17 is by only 191 (31.8%) of all the respondents across the income groups. A total of 53 (35.3%), 55 (26.2%) and 83 (34.8%) high, middle and low income households are willing to substitute kerosene for gas cooker. Clearly, over sixty per cent of the households in any of the income groups are not willing to substitute kerosene for gas cooker. The reason given for this is that, LPG is very expensive and not readily available. While some others for security reasons are not willing to substitute kerosene for gas.

Table 5.16: Frequency of Use of Cooking Appliances

S/No	Income level	Energy Type/frequency of Use for Cooking											
		Gas Cooker		Electric Cooker				Kerosene Stove			Fuel wood Stove		
		Frequently	Sparingly		Frequently	Sparingly		Frequently	Sparingly		Frequently	Sparingly	
1	High	66 (44.0)	13 (8.7)		29 (19.3)	30 (20.00		65 (43.3)	54 (36.0)		6 (4.0)	17 (11.3)	
2	Middle	36 (17.1)	2 (1.0)		11 (5.2)	20 (9.5)		157 (74.8)	38 (18.1)		21 (10.0)	32 (15.2)	
3	Low	4 (1.7)	3 (1.3)		10 (4.2)	13 (5.4)		195 (81.3)	23 (9.6)		51 (21.3)	54 (22.5)	
	Total	106 (17.7)	18 (3.0)		50 (8.3)	63 (10.5)		417 (69.5)	115 (19.2)		78 (13.0)	103 (17.2)	

Note: Figures in Parenthesis are Percentages

Source: Author's Analysis, 2012.

Table 5.17: Willingness to Substitute Kerosene for Gas

S/No	Income Level	Yes		No		Total	
1	High	53	(35.3)	97	(64.7)	100	(100.0)
2	Middle	55	(26.2)	155	(77.8)	100	(100.0)
3	Low	83	(34.6)	157	(65.4)	100	(100.0)
	Total	191	(31.8)	409	(68.2)	600	(100.0)

Note: Figures in Parenthesis are Percentages
Source: Author's Analysis, 2012

Table 5.18 indicates that between 33.3% in the high income and 37.5% in the low income households are willing to use efficient cooking appliances. A total of 36 (72.0%), 50 (61.7%) and 50 (55.6%) in the high, middle and low income households are willing to pay for efficient cooking appliances.

Table 5.18: Willingness to Use and Pay for Cooking Appliances

		Use Efficiently		Pay for Efficient Cooking App.	
S/No	Income level	Yes	No	Yes	No
1	High	50 (33.3)	100 (66.7)	36 (72.0)	14 (28.0)
2	Middle	81 (38.6)	129 (61.4)	50 (61.7)	31 (38.3)
3	Low	90 (37.5)	150 (62.5)	50 (55.6)	40 (44.4)
	Total	221 (36.8)	379 (63.2)	136 (61.5)	85 (38.5)

Note: Figures in Parenthesis are Percentages
Source: Author's Analysis, 2012

5.1.4 Energy Services

The efficiency of the various energy types for cooking and lighting in Table 5.19 reflects that 152 (72.4%) and 201 (83.8%) of the middle and low income households rate kerosene as very efficient for cooking against only 70 (46.7%) of the high income households. Not less than sixty-two per cent of the households in any of the income category rate electricity and fuelwood as moderately efficient for cooking. Not less than sixty-two per cent of households in any of the income categories rate electricity as very efficient for lighting, kerosene is however rated moderately efficient by 107 (71.3%), 128 (61.0%), and 128 (53.3%) in the high, middle and low income groups respectively.

The order of preference for energy services for cooking and lighting amongst the household categories in Table 5.20 indicates whereas 67 (44.7%) and 55 (36.7%) of the households in the high income category mostly prefer LPG and kerosene for cooking, 152 (72.4%) and 186 (77.5%) of the middle and low income households prefer kerosene stove for cooking. Nonetheless, 41 (17.1%) of the low income households mostly prefer fuelwood for cooking. Between twenty and thirty-six per cent of the low and high income households however fairly prefer electricity for cooking. It is clear from the table that almost all the households in the various income groups most prefer electricity to other forms of energy for lighting, and fairly prefer kerosene lantern. Indeed, 124 (59.1%) and 114 (47.5%) of the middle and low income households fairly prefer kerosene lantern for lighting. The various reasons adduced are as shown in Table 5.21.

Table 5.19: Efficiency of Energy Types for Cooking and Lighting

S/No	Energy Type	Income level	Cooking			Lighting		
			VE	MD	LE	VE	MD	LE
1	Electricity	High	11 (7.3)	98 (65.3)	31 (20.7)	100 (66.7)	36 (24.0)	14 (9.3)
		Middle	18 (8.6)	155 (73.8)	37 (17.6)	156 (74.3)	38 (18.1)	16 (7.6)
		Low	18 (7.5)	177 (73.6)	45 (18.8)	149 (62.1)	63 (26.3)	28 (11.7)
2	LPG	High	74 (49.3)	71 (47.3)	5 (3.3)	4 (2.6)	125 (83.3)	21 (14.0)
		Middle	41 (19.5)	139 (66.2)	30 (14.3)	1 (0.5)	151 (71.9)	58 (27.6)
		Low	18 (7.5)	173 (72.1)	49 (20.4)	2 (0.8)	187 (77.9)	51 (21.3)
3	Kerosene	High	70 (46.7)	73 (48.7)	7 (4.6)	24 (16.0)	107 (71.3)	19 (12.7)
		Middle	152 (72.4)	55 (26.2)	3 (1.4)	46 (21.9)	128 (61.0)	36 (17.1)
		Low	201 (83.8)	36 (15.0)	3 (1.3)	46 (19.2)	128 (53.3)	36 (15.0)
4	Fuelwood	High	6 (4.0)	117 (78.0)	27 (18.0)	0 (0.0)	0 (0.0)	0 (0.0)
		Middle	25 (11.9)	152 (72.4)	33 (15.7)	0 (0.0)	0 (0.0)	0 (0.0)
		Low	39 (16.3)	149 (62.1)	52 (21.7)	0 (0.0)	0 (0.0)	0 (0.0)
5	Petrol	High	0 (0.0)	0 (0.0)	0 (0.0)	52 (34.7)	91 (60.7)	7 (4.7)
		Middle	0 (0.0)	0 (0.0)	0 (0.0)	38 (18.1)	135 (64.3)	37 (17.6)
		Low	0 (0.0)	0 (0.0)	0 (0.0)	23 (9.6)	168 (70.0)	49 (20.4)

Note: VE- Very Efficient MD- Moderate LE- Less Efficient

Source: Author’s Analysis, 2012

Table 5.20: Order of Preference for Energy Services

S/No	Energy Type	Income Level	Cooking			Lighting		
			MP	FP	LP	MP	FP	LP
1	Electricity	High	25 (16.7)	54 (36.0)	38 (25.3)	127 (84.7)	12 (8.0)	9 (6.0)
		Middle	17 (8.1)	61 (29.0)	87 (41.4)	188 (89.5)	14 (6.7)	5 (2.3)
		Low	16 (6.7)	48 (20.0)	86 (35.8)	198 (82.5)	28 (11.7)	1 (0.4)
2	LPG	High	67 (44.7)	15 (10.0)	17 (11.3)	0 (0.0)	21 (14.0)	34 (22.7)
		Middle	37 (17.6)	26 (12.4)	30 (14.3)	1 (0.5)	13 (6.2)	61 (291)
		Low	5 (2.1)	21 (8.8)	70 (29.2)	1 (0.4)	7 (2.9)	59 (24.6)
3	Kerosene	High	55 (36.7)	49 (32.7)	33 (22.0)	7 (4.7)	40 (26.7)	52 (34.7)
		Middle	152 (72.4)	42 (20.0)	12 (5.7)	12 (5.7)	124 (59.1)	49 (23.3)
		Low	186 (77.5)	37 (15.4)	4 (1.6)	43 (17.9)	114 (47.5)	37 (15.4)
4	Fuelwood	High	2 (1.3)	19 (12.7)	44 (29.3)	0 (0.0)	0 (0.0)	0 (0.0)
		Middle	10 (4.8)	74 (35.2)	57 (27.1)	0 (0.0)	0 (0.0)	0 (0.0)
		Low	41 (17.1)	87 (36.3)	45 (18.8)	0 (0.0)	0 (0.0)	0 (0.0)
5	Petrol	High	0 (0.0)	0 (0.0)	0 (0.0)	20 (13.3)	85 (56.7)	19 (12.7)
		Middle	0 (0.0)	0 (0.0)	0 (0.0)	10 (4.8)	85 (40.5)	57 (27.1)
		Low	0 (0.0)	0 (0.0)	0 (0.0)	8 (3.3)	59 (24.9)	70 (29.2)

Note: MP - Most Preferred FP - Fairly Preferred LP – Less Preferred
Figures in parenthesis are percentages
Source: Author's Analysis, 2012

Table 5.21: Reason for Preference Ordering of Energy Type for Cooking and Lighting

S/No	Energy Type	Income level	Cooking								Lighting							
			a		b		c		d		A		b		c		d	
1	Electricity	High	28	(18.7)	35	(23.3)	48	(32.0)	35	(23.3)	63	(42.0)	85	(56.7)	41	(27.3)	65	(43.3)
		Middle	22	(10.5)	38	(18.1)	23	(11.0)	28	(13.3)	80	(38.1)	132	(62.9)	60	(28.6)	87	(41.4)
		Low	22	(9.2)	34	(14.2)	9	(3.8)	23	(9.6)	89	(37.1)	149	(62.1)	52	(21.7)	103	(42.9)
2	LPG	High	28	(18.7)	55	(36.7)	48	(32.0)	35	(23.3)	2	(1.3)	3	(2.0)	7	(4.6)	3	(2.0)
		Middle	12	(5.7)	33	(15.7)	28	(13.3)	26	(12.4)	1	(0.5)	9	(4.3)	3	(1.4)	10	(4.7)
		Low	3	(1.3)	8	(3.3)	14	(5.8)	1	(4.1)	-	(0.0)	2	(0.8)	4	(1.7)	4	(1.7)
3	Kerosene	High	46	(30.7)	67	(44.7)	10	(6.7)	64	(42.7)	32	(20.3)	36	(22.9)	1	(0.6)	43	(27.4)
		Middle	78	(37.1)	121	(57.6)	18	(8.6)	123	(58.6)	52	(24.8)	54	(25.7)	1	(0.5)	89	(42.4)
		Low	78	(32.5)	138	(57.5)	24	(10.0)	125	(52.1)	83	(34.6)	69	(29.8)	7	(2.9)	99	(41.3)
4	Petrol	High	-	(0.0)	-	(0.0)	-	(0.0)	-	(0.0)	21	(14.0)	58	(38.7)	6	(4.0)	65	(43.3)
		Middle	-	(0.0)	-	(0.0)	-	(0.0)	-	(0.0)	8	(3.8)	44	(21.0)	2	(1.0)	68	(32.4)
		Low	-	(0.0)	-	(0.0)	-	(0.0)	-	(0.0)	6	(2.5)	28	(11.7)	2	(0.8)	37	(15.4)

Note: a – Cheap b – Convenience c – Clean d - Availability

Source: Author's Analysis, 2012

5.2 Empirical Results

This section contains the empirical analysis and thus addresses the objectives of the study. It contains discussion on the determinants of household energy demand. The extent of substitution possibilities and the impact of price change on household welfare.

5.2.1 Determinants of Household Energy Demand

This subsection addresses the first objective of the thesis. Table 5.22 presents the factors that determine urban household energy demand in Nigeria using the estimated Quadratic Almost Ideal Demand System (QAIDS) model. The energy groups estimated include Premium Motor Spirit (PMS) commonly called petrol, Electricity, Liquefied Petroleum Gas (LPG), Dual Purpose Kerosene (DPK) and fuel wood. The demand models in the five energy groups were found to be significant at 1 percent level ($p<0.01$). The R^2 values are 84.19%, 96.29%, 44.64%, 88.14% and 77.28% for petrol, electricity. LPG, kerosene and fuel wood respectively.

Table 5.22: Factors that influence Household Energy use

Variable	Petrol	Electricity	Gas (LPG)	Kerosene	Wood
Price Co-efficients					
Price of Petrol	0.011*** (.0007157)	-0.001*** (.000182)	-0.001*** (.0003469)	-0.009*** (.0005595)	-0.0005 (.0004101)
Price of Electricity	-0.188*** (.0083521)	0.227*** (.0021246)	-0.011** (.0040486)	-0.013** (.0065293)	-0.017*** (.0047857)
Price of Gas	-0.0002 (.0002328)	-0.0001 (.0000592)	0.0018*** (.0001128)	-0.0014*** (.000182)	-0.0001 (.0001334)
Price of kerosene	-0.0055*** (.0005812)	-0.0006*** (.0001478)	-0.0006** (.0002817)	0.0078*** (.0004544)	-0.0009*** (.000333)
Price of Wood	-0.0068*** (.0009501)	-0.0009*** (.0002417)	-0.0005 (.0004606)	-0.00893*** (.0007428)	0.0173*** (.0005444)
Expenditure	-0.461*** (.0516495)	0.053*** (.013022)	-0.083*** (.0249153)	0.486*** (.0403776)	0.005 (.0295949)
$Expenditure^2$	0.047*** (.0042544)	-0.005*** (.0010822)	0.007*** (.0020623)	-0.048*** (.003326)	-0.001 (.0024378)
Household Socio-demographic Characteristics					
No formal Edu	-0.0809*** (.0314223)	-0.0073 (.0079931)	-0.0072 (.0152319)	0.0162 (.0245647)	0.0793*** (.0180048)
Primary Edu	-0.0925*** (.0270632)	0.0121* (.0068843)	-0.0253* (.0131188)	0.01259 (.021157)	0.0931*** (.0155071)
Secondary Edu	-0.0154 (.0219198)	-0.0011 (.0055759)	-0.0203* (.0106256)	-0.0027 (.0171361)	0.0397*** (.01256)
Artisan	0.0700*** (.021781)	-0.0083 (.0055406)	0.0041 (.0105583)	-0.0671*** (.0170276)	0.0013 (.0124804)
Farming	0.0189 (.021902)	-0.0051 (.0055714)	-0.0065 (.0106169)	-0.0189 (.0171222)	0.0117 (.0125497)
Trading	-0.0110 (.0270125)	0.0001 (.0068713)	0.0007 (.0130942)	0.0074 (.0211173)	0.0026 (.015478)
Personal House	-0.0145 (.0186247)	-0.0005 (.0047377)	-0.0036 (.0090283)	-0.0043 (.0145601)	0.0230** .0106718)
Expenditure- No formal edu	-0.0002 (5.19e-06)	-1.63E-07 (1.32e-06)	-3.46e-06 (2.52e-06)	0.0008* (4.06e-06)	-0.0002 (2.98e-06)
Expenditure Primary edu	0.0003 (4.69e-06)	-0.0002 (1.19e-06)	-1.52e-06 (2.28e-06)	0.0005 (3.67e-06)	-0.0004 (2.69e-06)
Expenditure Secondary edu	-0.0004 (3.04e-06)	-3.55E-07 (7.74e-07)	-2.05e-06 (1.47e-06)	0.0008*** (2.38e-06)	-0.0002 (1.74e-06)
Expenditure Artisan	-0.0001*** (2.29e-06)	8.49E-07 (5.82e-07)	4.07e-07 (1.11e-05)	0.0009*** (1.79e-06)	-0.0001 (1.31e-06)
Expenditure Farming	-0.0005* (3.42e-06)	6.74E-07 (8.69e-07)	-0.0008 (1.66e-06)	0.0005** (2.67e-06)	1.19E-07 (1.96e-06)
Expenditure Trading	0.0001* (6.06e-06)	-7.61E-07 (1.54e-06)	6.45e-07 (2.94e-06)	-0.0007 (4.74e-06)	-0.0004 (3.47e-06)
Expenditure Personal House	-2.93E-08 (2.09e-06)	4.22E-07 (5.32e-07)	-7.81e-07 (1.01e-06)	0.0002 (1.63e-06)	-0.0001* (1.20e-06)
Household size	-0.007** (.0027497)	-0.001 (.0007086)	-0.001 (.0013558)	0.006*** (.002151)	0.003*** (.0015896)

Osun	-0.054*** (.0185959)	- 0.004(.0050357)	-0.04*** (.0096383)	0.062*** (.0152726)	0.037*** (.0097755)
Ogun	0.001 (.0182741)	-0.002 (.0049792)	-0.025*** (.0095304)	0.034** (.0150995)	-0.008 (.0094733)
Ekiti	-0.07*** (.0187299)	0.018*** (.005109)	-0.041*** (.0097791)	0.057*** (.015493)	0.035*** (.0096846)
Ondo	0.012 (.0185442)	0.002 (.004999)	-0.027*** (.0095677)	0.019 (.0151624)	-0.005 (.0098456)
Oyo	0.035** (.0164024)	-0.004 (.0053503)	-0.021** (.0102508)	-0.01 (.016182)	
Constant	1.5421*** (.1726544)	-0.2205*** (.0443394)	0.2751*** (.0844944)	-0.5913*** (.1362657)	-0.0054 (.0998765)
R^2	0.8419	0.9629	0.4464	0.8814	0.7728
Prob	0.0001	0.0001	0.0001	0.0001	0.0001
Root MSE	0.1332	0.0339	0.0646	0.1041	0.0763

Source: Own calculations from field survey, 2012

*, **, *** are significance levels at 10%, 5% and 1% respectively, standard errors in parentheses.

Factors determining households' demand for energy goods in Nigeria, is shown in table 5.22. Demand for the energy goods considered (that is, petrol, electricity, LPG, kerosene and fuel wood) were significant at 1 percent level of significance. The price of each of the energy good, occupation of the consumer, the level of education, household size and ownership of a house were significant at $p<0.01$, $p<0.01$ and $p<0.05$ respectively. This consistent is with the work of Labandeira et al (2006), Nnaji et al (2012) and Maconachie et al, (2009) which suggests that fuel choice is not determined by economic factors alone but also by socio demographic factors such as the level of education, household size and owning a house.

Petrol

Households' demand for petrol is significant at $p<0.01$. The price of petrol had a significant effect on its demand at 1percent level. The expenditure estimates for petrol was found to be positive, suggesting that an increase in the price of petrol will lead to increase in the quantity demanded. This is not consistent with the work of Huang and Huang (2009), which found petrol to be an essential good. This may be so due to the fact that in Nigeria, because electricity supply is not stable households and organizations use petrol to generate electricity in the home and to run businesses as well as fuel cars. Therefore increase in the price of petrol increases the budget share allocation to it by households as well as increase the quantity bought.

Electricity

The expenditure estimates for electricity is positive and inelastic at 0.2267 and significant at $p<0.01$. This implies that an increase in the price of electricity would induce little or no change in the quantity demanded. This is consistent with the results of Babatude and Enehe, (2011), Filippini and Pachauri, (2004), Labandeira et al, (2006), they found that when prices of electricity increase, it results in little or no change in the quantity of electricity consumed. This is so because households' demand for electricity is due to the multiple services it performs. In the household electricity is needed to operate electrical and cooking appliances. The demand for electricity also increased due to changes in income and lifestyle of households and acquisition of modern appliances used in the home (Sanchez, 2008). Also variations in households' demand for electricity may exist between high, middle and low income groups Pachauri, (2004). In addition, the factors contributing to the variations in the use of electricity are usually the level of urbanization and some socio economic characteristics that are household specific, Babatunde and Enehe, (2011) and Adelakan and Jerome, (2006).

Liquefied Petroleum Gas (LPG)

The expenditure estimate for LPG is inelastic and positive at 0.0018 and significant at $p<0.01$. This suggests that a 1 percent increase in the price of gas will decrease the quantity demanded. Thus an increase in the price of gas reduces its demand by less than 1 percent. This is consistent the results derived by Nnaji et al, (2012), NAibbi and Healy, (2013), Ajah Julius, (2013), Maconachie et al, (2009), Adelakan and Jerome, (2006) and Farsi et al, (2007). They found that increase in the price of LPG reduces the quantity demanded. Other factors aside the price of gas that influences its demand is the level of education of the consumer and it is significant at 1 percent. In addition the unavailability of gas within residents' locality and safety reasons further hinder the use of it in many households.

Kerosene

Households' demand for kerosene is significant at $p<0.01$. The expenditure estimates suggests that an increase in the price of kerosene reduces the quantity demanded of it by less than 1 percent. This is consistent with the work of Ajah Julius, (2013), Adelekan and Jerome, (2006) and Adegbulugbe and Akinbami, (1995). This suggests that among the income groups considered some households will actually reduce the quantity consumed of the product while others will revert to the use of fuel wood. On the other hand households that reduce the quantity consumed also reduce the number of meals cooked per day, as well as reduce cooking foods that take longer time to prepare. Other factors influencing the demand for kerosene is the occupation and level of education. The results show that expenditures by artisans and farmers were also very significant at $p<0.01$ and $p<0.05$ respectively. Most often these category of consumers (artisan and farmers) are usually classified as low income earners, hence their use of kerosene (see Leach and Gowan, (1987), Hosier and Kypondya, (1993) and Barnes et al, (2004).

Fuel wood

The demand for fuel wood is significant at $p<0.01$. Expenditure estimates for fuel wood shows that an increase in its price reduces the quantity demanded of it but by less than 1 percent. Other factors influencing the demand for fuel wood were level of education significant at $p<0.01$ and owning a personal house significant at $p<0.05$ level of significance respectively. This result is consistent with that of Labandeira et al, (2006). Households' with low levels of education significantly used fuel wood while owning a personal house also contributed to the use of fuel wood Farsi et al, (2007) and Helrberg et al, (2000).

The variables used to assess socio-demographic effects are the household size, level of education and geographical location. The results indicate that the use of LPG, kerosene, fuel wood, electricity and petrol are statistically significant for all the locations. However, households' in all the locations tend to spend more on kerosene than other energy goods. This can be explained as kerosene being the most widely used energy good by all the income groups in all the locations. LPG is also statistically significant for all the locations, but the expenditure on it is lower than that of kerosene. The explanation for this would be that only a few households' in the high income group use LPG more than any of the other income groups. Fuel wood use is also minimal. Electricity was not statistically significant for most of the locations except in Ekiti state. This is explained as electricity been very irregular in supply in the country. On the other hand, expenditure on petrol was statistically significant, this is so because households' used it to generate power supply as a result of epileptic supply from the national grid.

The results of the parameter estimates showing the factors that influence urban household energy demand for urban areas in southwest Nigeria showed that expenditure on energy goods is very sensitive to price changes. The magnitude of increase in demand can either be greater than 1 percent or less than 1 percent. Here the magnitude in the demand for petrol and electricity is greater than 1 percent. Because electricity in Nigeria is not stable people demand for petrol to generate light at home and for their businesses, hence when the price of petrol increases the demand for it will also increase. On the other hand when the price of electricity increases there is little or no change in the demand for it, this can be attributed to the multiple services it provides as well as been relatively cheaper, cleaner, non-polluting and more convenient than using petrol. Although increase in the price of other energy goods leads to a reduction in their demand but by less than 1 percent. This to some extent may suggest some level of substitution among them. Basically the factors that influence energy demand in the household are price of the energy good, price of other related energy goods and occupation of the consumer. Other socio-demographic characteristics that play important roles in determining household energy demand patterns include level of education, household size and owning a personal house. Owning a personal house is significant to fuel wood use because consumers' have enough space in their homes to use fuel wood and thus not constitute health hazards to others. They can actually cook their meals with fuel wood if their household size is large and in some cases tastes derived from cooking with fuel wood may be a contributory factor (Adegbulugbe and Akinbami, (1995). Other factors such as climate and cultural factors, hypothesized by Leach and Gowan, (1987), Heltberg, (2005) to influence household energy demand were found to be insignificant in this study.

5.2.2 Extent of Substitution between Electricity, LPG, Kerosene and Fuel wood

This sub section addresses objective 2 of the thesis.

Table 5.23 and 5.24 reports the uncompensated (Marshallian) and the compensated (Hicksian) own price elasticities in Nigeria using the QAIDS specification.

Table 5.23: Marshallian (Uncompensated) Own Price Elasticity (QAIDS)

Variable	Price of Petrol	Price of Electricity	Price of cooking gas (LPG)	Price of Kerosene	Price of fuel wood
Petrol	-1.09	-0.93	0.02	-0.12	0.01
Electricity	-0.88	0.09	-0.89	-0.87	-0.89
Gas (LPG)	-0.20	-0.16	-0.96	-0.24	-1.62
Kerosene	0.09	0.06	0.00	-0.85	0.01
Fuel wood	-0.11	-0.11	-0.11	-0.11	-0.74

Source: Author’s Analysis, 2012

The Marshallian own price elasticity also known as the uncompensated own price elasticity as shown by the diagonal matrix are all negative with the exception of electricity. This shows that an inverse relationship exists between price and demand for such energy goods. The own price elasticity of the goods reveal that they are inelastic and have absolute values less than one with the exception of petrol. The implication of this inelastic price elasticity of demand for all the energy goods is that a percentage increase in the price of each of the goods leads to a less than one percent decrease in their demand. This may due to the fact that the prices of energy products in Nigeria are regulated and usually fixed by the government. In addition the price of petrol and kerosene are reviewed upwards more often than the price of other energy goods.

Own price elasticity for petrol is elastic but with negative sign, this suggests that the expenditure on it is far greater than growth in income. The cross price elasticity shows that petrol is a complementary good to the other energy goods and not a substitute.

The own price elasticity for electricity is inelastic and has a positive co-efficient. The irregular supply of electricity may be responsible for the positive co-efficient coupled with the fact that electricity has been low priced and regulated in Nigeria over the years. The cross price elasticity shows that there is a complimentary relationship between electricity and LPG, kerosene and fuel wood since the coefficients on the price of these energy goods is positive. This reveals that electricity has no substitute. The fact that electricity has no substitute energy good can be adduced to the multiple services it performs. This is in line with the result found by Labandeira, (2006) and Filippini and Pachauri, (2004).

The consumption of kerosene is own price inelastic while the cross price elasticity in relation to other energy goods is significant and has positive coefficients. This implies that gas, electricity and fuel wood can be substituted for kerosene. Kerosene is used by most households for cooking and lighting because it is more readily available, convenient and relatively cheaper than using gas and electricity (see Filippini and Pachauri, (2004) and Holtedahl and Joutz, (2004).

The own price elasticity for LPG is inelastic while the cross price elasticity shows that LPG is a complementary good to electricity, kerosene and fuel wood. The own price elasticity for fuel wood is inelastic, while the cross price elasticity of fuel wood also reveals that fuel wood complements all the other energy goods.

Table 5.24: Hicksian (Compensated) Elasticity Expenditures (QAIDS)

Variable	Price of Petrol	Price of Electricity	Price of cooking gas LPG	Price of Kerosene	Price of fuel wood
Petrol	-0.66	-0.50	0.46	0.31	0.45
Electricity	-0.67	0.29	-0.69	-0.67	-0.69
Gas (LPG)	-0.16	-0.12	-0.91	-0.19	-1.58
Kerosene	0.34	0.31	0.25	-0.60	0.26
Fuel wood	-0.05	-0.04	-0.04	-0.05	-0.67

Source: Author's Analysis, 2012

The Hicksian compensated price elasticities also followed similar trends like the Marshallian uncompensated price elasticities. Majority of the goods are inelastic and negative except for electricity that is positive at 0.29. Compensated cross price elasticities for all the goods show that they complement each other. Compensated cross price elasticities for petrol showed that it complements electricity. Electricity complements the other energy goods likewise LPG while kerosene is a substitute for LPG, electricity and fuel wood. Fuel wood complements all other energy goods. The result of the compensated price elasticities are similar to what was obtained in the uncompensated price elasticity.

In summary, the results on own and cross price elasticities derived from this study reveals that electricity and LPG have no substitute energy good this differs from what obtains in literature where electricity was found to be a substitute for gas and oil (see Rushdi, 1986; Bjorner and Jensen, 2002). Kerosene on the other hand can be substituted for gas, electricity and fuel wood. Although LPG have no substitute but can be used alongside other energy goods while fuel wood complements all the energy goods considered.

Table 5.25: Income Expenditure Elasticity

Variable	Income Expenditure Elasticity
Petrol	1.4138
Electricity	0.9536
LPG	1.4199
Kerosene	0.6509
Fuel wood	1.0239

Source: Author's Analysis, 2012

The income expenditure elasticity shows normal, inferior or luxury goods. Income elasticity captures the percentage variation of the demand for the ith good for a 1 percent variation of total expenditure. If η_i denote income elasticity, it means that for a normal good total expenditure increases when demand increases that is, ($\eta_i > 0$). If the variation in expenditure is proportionally greater than the growth in income, that is, ($\eta_i > 1$), the good is referred to as a luxury good. If despite increases in income the demand for a good decreases ($\eta_i < 0$) it is an inferior good.

The income expenditure elasticity for all the energy goods is positive and ranges from 0.65 (kerosene) to 1.42(LPG). Of all the energy goods considered electricity and kerosene are normal goods, having values less than unity. This result is consistent with that of Filippini and Pachauri, (2004) and Babatunde and Shuaibu, (2011).

On the other hand, petrol, LPG and fuel wood were found to be luxury goods having elasticity greater than one respectively. This may be so in the sense that the locations used for this study were selected according to income group and as such the increase in income elasticity can be attributed to the interactions between the demographic locations and the income groups. In effect it means these energy goods are luxuries to some households and necessities to others. For low income and some medium households, LPG is a luxury good because it is perceived to be expensive. The use of petrol is generally perceived to be expensive by most households. Apart from its use to fuel cars, households also use it to fuel generating sets. Due to the almost non-existent power supply in Nigeria, many households as well as businesses own generating sets to generate own power supply for domestic and business use. It suffices to say that only high income households can afford to run on generators for long hours. On the other hand low income households cannot afford to do same and so resort to using alternate fuels such as candles and lantern. Compared to kerosene, fuel wood may be a luxury to very low income households' because they have to buy it, in urban areas fuel wood is a traded good while it is freely collected in the rural areas.

Table 5.26: Budget Share Allocation by Households

Energy Good	Budget share of goods	Expenditure coefficient	Impact of demographics
Petrol	0.3080	-0.04608	0.0460
Electricity	0.2109	0.0452	-0.0043
Gas	0.0320	-0.0761	0.0070
Kerosene	0.3836	0.4863	-0.0485
Fuel wood	0.0655	0.0054	-0.0003

Source: Author’s Analysis, 2012

Furthermore, Table 5.26 shows the budget share allocation by households to each of the energy goods. About 40 per cent and 30 per cent of budget share are allocated to consumption of kerosene and petrol respectively in urban areas in South West Nigeria. Electricity, fuel wood and LPG are allocated 21, 6 and 3 per cent respectively. These allocations of budget shares further showed that kerosene is the main energy source for cooking and lighting in urban areas in south west Nigeria. The share of electricity is shown to be low compared to petrol. This is attributed to the fact that electricity supply is epileptic in Nigeria. In addition, the high budget share allocated to petrol is due to the fact that a large number of people have to generate their own electricity as well as fuel their cars thus making the demand for petrol high. Compared to fuel wood, the allocation to gas is the lowest. This is so because gas is considered an expensive energy good and it is also not used due to safety reasons. Fuel wood on the other hand is used by some households as an alternative to kerosene but the proportion that uses it is very small.

5.2.3 Impact of Price Change in Energy Good on Household Welfare

This subsection addresses objective 3 of the thesis. To analyze consumer welfare effects of price changes in energy, the compensating variation which is the change in income necessary to restore the household to the original indifference curve is employed. This approach incorporates the direct and cross commodity effects of a demand system with the welfare measurement.

Assuming an expenditure function, $E(p,u)$, is defined as the minimum amount of expenditure necessary to get to a given level of utility u and a vector of prices p. If at some initial price level p^0 and expenditure level, $E(p^0,u^1)$, the consumer achieves utility u^0. The compensating variation (cv) reflects the change in expenditures necessary to compensate consumers for the effect of price changes. Based on the estimated demand elasticities the slutsky equation is used to calculate demand elasticities for measuring compensating variation under price changes. Since energy prices have been reviewed upwards frequently, we estimate the loss of consumer welfare caused by the price increase in petrol between 2010 and 2012.

Welfare analysis is motivated by the fact that in Nigeria energy goods are widely traded commodities both at the local and international level. The domestic prices of these energy commodities also greatly depend on international price fluctuations. In Nigeria the price of energy goods are administratively fixed and have been increased regularly over the years.

Between 2010 and 2012 the price of petrol increased from N65.00 to N97.00. Thus the average price increase of petrol rose by 49.1%.

Table 5.27: Measure of Welfare Loss due to Energy Price increase

Price Change	Compensating Variation (N)
Increase in Petrol (49.1%)	3,682.15

Source: Author's Analysis, 2012

Based on the compensating variation the average welfare loss of a higher price of petrol (by 49.1%) resulted in a N3,682.15k fall in utility per household. The implication of this fall in utility is that it reduces the purchasing power of the consumers. However, the impact of this welfare loss is greater for low income households who can afford it least.

CHAPTER SIX

SUMMARY AND CONCLUSION

Chapter six presents the summary of findings, policy recommendation and areas of further research.

6.1 SUMMARY OF THE STUDY

This study investigated the determinants of urban household energy demand, the extent of substitution possibilities and welfare impact of energy price increases in southwest Nigeria. The study was carried out because the literature on urban household energy use in Nigeria has focused little attention on substitution possibilities as well as welfare implications of price increases on households. The energy sources considered were, electricity, firewood, kerosene, liquefied petroleum gas (LPG) and petrol.

A microeconomic demand model that uses the indirect utility maximizing function was estimated. Descriptive statistics, student t-test and multiple regressions were used to analyze the data at 0.05 level of significance. The QAIDS model was adopted to analyze for substitution possibilities and welfare impact of energy price increases.

This research was conducted in the capital of each of the six states that make up the southwest zone, that is, Ekiti, Lagos, Ogun, Ondo, Osun and Oyo. The target population were identified by disaggregating each of the state capitals into low density geographical area (high income group), medium density (middle income) and high density (low income).

A structured questionnaire was used to collect primary data; this was done in collaboration with NBS. The major areas of the questionnaire included socio demographic characteristics, energy use profile, energy substitution and welfare implications. Two sets of analysis were performed on the data; (i) descriptive analysis, (ii) regression analysis. (1) For the descriptive analysis a random representative sample that cuts across all the state capitals was involved in the survey. A multi cluster sampling technique based on a two stage systematic random sampling procedure was used. The first stage involved the selection of Enumeration Areas (EAs) from the National Integrated Survey of Household, master sampling frame provided by the National Bureau of Statistics (NBS). In the second stage 10 EAs were selected across low, middle and high density residential areas. A total of 600 households were selected from all the urban clusters, while a total of 100 households were interviewed per state. (2) the QAIDS model was also used to test for the relationship between household energy demand and some economic variables such as expenditure, income and price of energy goods.

The major findings of this study reveal that kerosene is the most widely used energy good among the various income groups, while LPG is the least used energy good. Electricity is the preferred energy good by all income groups for lighting but it is sparingly used because it is not regular in supply. Generally, the demand response to price changes was inelastic, this implied that a 1% increase in prices led to a less than 1% decrease in demand for energy goods. Price of energy goods, occupation of the consumer, level of education and owning a personal house influenced the type of energy used. There is no significant substitution among the energy goods, however kerosene can be substituted for fuel wood and gas. The study further showed electricity and kerosene to be normal goods, kerosene also gets the largest allocation to energy consumption by households. There is a welfare loss in monetary terms as prices of energy sources increased.

6.2 SUMMARY OF FINDINGS

Forty and thirty-five per cent of the respondents are low and medium income earners. Over fifty per cent of the respondents in any of the income groups are males, while over sixty-two per cent are heads of household. Majority of the respondents in the low income group are heads of household. Also, majority of the heads of high income households and their spouses have tertiary education. The converse is the case with the low income group heads of household and their spouses have secondary education. A few of the heads of household and spouses have no formal education. Majority of the respondents are engaged as civil servants and traders for primary occupation, and do not have secondary occupation across the income categories. The average monthly income of the high income group is about five times more than that of the low income group.

An overwhelming majority of the respondents in middle and low income categories live in single room rented apartments, while those in the high income groups live in flats and bungalows with inbuilt kitchen facilities. Not less than eighty three per cent of the respondents in any of the income groups use kerosene for cooking. The use of gas and electricity for cooking is common with the high income group. The low income group use kerosene and fuel wood more profoundly. Generally, kerosene appears to be the most widely used energy for cooking across the households. Availability of kerosene is indicated as the reason for its use as the main energy for cooking. The high income households consider the use of gas for cooking as cheap, convenient, clean and available while the low income group considers the use of fuelwood as cheap and available. In the same vein, electricity is mostly preferred for being convenient and available for lighting. This is closely followed by kerosene.

The sources of household energy indicates that whereas kerosene is mostly demanded within own neighbourhood by the respondents in the middle and low income groups, those in the high income category demand kerosene from the next neighbourhood because it is not sold in their immediate environment. Electricity is demanded by not less than sixty per cent of the respondents in any of the income categories within own neighbourhood. The willingness to use the same energy currently being used shows that very few respondents in any of the income groups are willing to change. The willingness to switch to another energy type should the price of kerosene ever increase by hundred per cent is also indicated by very few respondents. However, a few of the respondents prefer to switch to fuel wood for cooking and kerosene for lighting.

Generally, food takes the highest percentage of households' expenditure. This is clearly so as food account for not less than thirty per cent of all households income in all the income groups. The average monthly expenditure on household energy goods varies from amongst income groups. Indeed, the average monthly expenditure in the high income group is more than four times that of the low income earners. The unit price of household energy demand, in spite of government regulation of prices on petroleum product, varies marginally among the income group. Kerosene stove is most frequently used for cooking especially by the middle and low income households. The high income households most frequently use gas cooker. Clearly, over sixty per cent of the households in any of the income groups are willing to substitute kerosene stove for gas cooker, this is due to high cost of gas appliance and also safety reasons, especially for families with little children. Whereas, about one third of all the respondents in any of the income categories are willing to use efficient cooking appliances, more than fifty-five per cent in any of the groups are willing to pay for efficient cooking appliances.

The middle and low income households rate kerosene as very efficient for cooking. Not less than sixty-two per cent of the households in any of the income category rate electricity and fuel wood as moderately efficient for cooking. Also, not less than sixty-two per cent of households in any of the income categories rate electricity as very efficient for lighting, kerosene is however rated moderately efficient by high, middle and low income groups in this order. All the income categories mostly prefer LPG and kerosene for cooking while electricity is preferred for lighting.

The estimated household energy demand in urban areas in Nigeria using the QAIDS specification shows that the main determinants of urban household energy demand in south west Nigeria are price of the enrgy product, occupation of the consumer, level of education and owning a personal house. Other demographic characteristics in literature such as household size and other cultural factors hypothesized to influence energy demand in urban areas were not significant. Specifically a significant relationship is found between spending on different energy goods and occupation of the consumers.

All energy products are found to be inelastic for own-price elasticities except for electricity. This shows the existence of an inverse relationship between price and the demand for such energy goods. Cross price effects exists between kerosene and gas and fuel wood. In terms of income elasticity, electricity and kerosene are normal goods while petrol and LPG are luxury goods. Furthermore, the analysis of budget share allocation shows that expenditure on kerosene has the largest budget share in households. This is closely followed by budget share allocation for petrol. Welfare effect shows that increase in price of energy products result in loss in welfare in monetary measure and a fall in utility.

6.3 CONCLUSION

This study estimated a five equation demand system that includes 5 energy products for south west geo-political zone, Nigeria. The reason for this is to ascertain the factors that determine household energy demand in Nigeria with respect to energy prices effects.

Our contribution to literature on household energy demand has been twofold; (i) this study has used primary disaggregated data in terms of energy goods to analyze the extent of energy substitution in the household especially for cooking and lighting. (ii) an analysis of welfare loss to households due to energy price increase in urban areas in south west was performed. Total expenditures instead of income were used as a basis for the analysis. This is due to under reporting or falsification of income during household survey. Therefore total expenditure appeared to be a better way of capturing the welfare of the sample population.

6.4 POLICY RECOMMENDATION

The findings of this study have shown that kerosene is the main energy type used for cooking by all the income groups. It has also shown that there is little substitution between kerosene and other energy goods, as such there is little willingness to substitute to cleaner fuels due to low income of majority of the population. Income elasticity revealed that kerosene and electricity are normal goods. Since kerosene is the most widely used energy in the household in Nigeria, a better supply distribution channel of the product is needed. This will help to reduce the hardship faced by consumers. In addition government needs to ensure that the price of kerosene is stable over a long period of time. Electricity should be seen as a basic need of households and as such it should be made available on a regular basis. In addition to ensuring that there is regular power supply, there is the need to diversify to other sources of energy to generate electricity. Private organizations, banks and government should partner to provide other sources of energy such as solar and wind energy at reduced costs.

This study further revealed that LPG is the least energy used by households. This is because it is too expensive for most households to use. As a policy measure and in order to reduce carbon emissions in the atmosphere, there is the need to invest in LPG infrastructure so as to reduce the cost of acquiring such appliances. Although, smaller gas cylinders (3kg, 6kg) have been introduced in the market, there should be concerted efforts to ensure that subsequent re-fill of gas cylinders are provided at an affordable rate.

Finally whatever policy measure is put in place should be made to reflect the true cost of energy if any meaningful result is to be achieved.

6.5 LIMITATIONS AND AREAS FOR FURTHER RESEARCH

The analytical framework used provided useful insight to understanding the determinants of energy demand in southwest Nigeria. A detailed understanding of the dynamics of fuel use, fuel preferences, socio- economic changes and the transition to cleaner and efficient fuels should provide the basis for policy formulation and planning needed to address the growing trend of supply/demand imbalance of fuels to Nigerian households. Knowing the fuel performance/choices of the various income groups considered will assist policy makers to adequately make necessary provision for the availability of these fuels and at affordable prices.

Given that Nigeria is an oil producing and exporting country, the findings from this study will go a long way in planning for the energy needs of households in urban areas. However, this study is limited in scope in the following ways (i) it did not cover the entire country due to lack of finance (ii) lack of time series data and inability to identify energy price variations in cross-sectional data also limited the estimates concerning price terms hence this study analyzed expenditure on energy goods in the household and (iii) the unrest in some parts of the country made it difficult to conduct any meaningful research on energy demand in such areas. However, further research will be useful to include other household items such as food, clothing and leisure.

REFERENCES

Abd'razack, N.T.A, Medayese, S.O., Martins, V.I., Idowu, O.O., Adeleye, B.M., and Bello, L.O. (2012), "An Appraisal of Household Domestic Energy Consumption in Minna, Nigeria. Journal of Environmental science, Toxicology and food Technology. Vol.2 Issue 3 (Nov-Dec), pp16-24

Abiodun, J.O. (1996), "Environment, Poverty and Sustainable Development in Nigerian Cities", *Annals of the Social Science Academy of Nigeria*, No. 8, pp. 9-18.

Adegbulugbe, A.O. and J.F.K. Akinbami (1995), "Urban Households Energy use patterns in Nigeria". Natural Resources Forum, vol.19, No.2 pp 125-133.

Adelekan, I and A, Jerome (2006),"Dynamics of household energy consumption in a traditional African city, Ibadan", *Environmentalist*, Springer Science, No.26, pp103-116.

Aina, O.I. (2000), "Domestic Energy Situation in Nigeria: Technological Implications and Policy Alternatives", *Annals of the Social Science Academy of Nigeria,* No. 12, pp. 105-126.

Aina, O.I., and A.I. Odebiyi, (1998), Domestic Energy Crisis in Nigeria: Impact on women and Family Welfare. *African Economic History*, No.26. pp 1-14

Ajah Julius (2013), 'Households' Access and Preference to Cooking Fuels in Abuja, Nigeria. Journal of Environmental Sciences and Technilogy.

Ajide, Kazeem B. andYusuf, D.O. (2011), Analysis of housing characteristics in the South-West Geo-Political zone of Nigeria. Ibadan planning journal vol.1 No.2 pp 215-226.

Akabah, E.M (1990), Real incomes and the consumption of wood fuels in Ghana; An analysis of recent trends. Energy Economics 12 (3) pp 227-231.

Akinbami, J-F.K., IIori, M.O., Oyebisi, T.O., Akinwumi, I.O. and Adeoti, O, 2001, "Biogas energy use in Nigeria: Current status, future prospects and policy implications", *Renewable and Sustainable Energy Review,* 5, 97-112.

Akinwumi, I.O, I.B, Obioh A.S, Momodu and J.F.K Akinbami (2009), An evaluation of alternatives for cooking energy in Nigeria's household energy mix. Journal of Resources, energy, and development. Vol.6, Issue 1, March.

Alston, J., K.A. Foster and R. Green (1994), Estimating elasticities with the linear approximation ideal demand system: some Monte CARLO RESULTS. *Review of Economics and Statistics* 76: pp. 351-356.

Amulya K.N. Reddy amd B. Sudhakara Reddy (1994), Substitution of Energy Carriers for Cooking in Bangalore. Energy vol.19 No. 5 pp 561-571.

Anozie, A.N., A.R. Bakare, J.A. Shonibare and T.O. Oyebisi (2007), 'Evaluation of cooking energy cost, efficiency, impact on air pollution and policy in nigeria'. Energy 32, pp 1283-1290.

Atkinson, A.B., J. Gomulka and H.H. Stern, (1990), Spending on Alcohol: Evidence from the Family Expenditure Survey 1970-1983. Economic journal 106. 808-827.

Babatunde Adetunji M. and Jonathan E. Enehe (2011), Determinants of Household Electricity Demand in Nigeria. Economic and Financial review. Vol.49 No.2. Central Bank of Nigeria.

Babatunde Adetunji M. and M. Isa Shuaibu (2011), The Demand for residential Electricity in Nigeria. Pakistan Journal of Applied Economics. Vol.21 Nos. 1 & 2, pp 1-13.

Baker Paul, Richard Blundell and John Micklewright (1989), Modelling Household Energy Expenditures Using Micro data. The Economic Journal, vol.99 No.397 pp 720-738

Banks, J., Blundell, R. and Lewbel, A. (1997), Quadratic Engel Curves and consumer Demand. *The Review of Economics and Statistics*, 527-539.

Banks, J.R., Blundell and A. Lewbel (1996), Tax Reform and Welfare Measurement: Do we need demand system estimation?. Economic Journal 106, pp 1227-1241.

Barnes Douglas, F., K.Krutilla and William Hyde (2004), The Urban Househols Energy Transition: Energy Poverty and the Environment in the Developing World. A World Bank Publication, March.

Barnes, D. and W. Floor (1999), 'Biomass energy and the poor in the developing countries'. *Journal of International Affairs* 53: 237-259

Barnes, D. F. and U. Qian (1992), "Urban Interfuel Substitution, energy use and equity in developing Countries", *World Bank Industry and Energy Department Working Paper, Energy Series Paper* 53, Washington, DC

Barnes, D.F. (1992), "Understanding Fuelwood Prices in Developing Nations" *Industry and Energy Working Paper, Energy Series*, Paper, No. 56. The World Bank Washington, D.C. USA

Barten, A.P. (1964), 'Family Composition, Prices and Expenditure Patterns, in P.E. Hart. G. Mills and J.K. Whittaker, eds. *Econometric analysis for national economic planning* (Butterworth, London.

Barten, A.P. (1969), "Maximum Likelihood estimation of a complete system of demand equations". *European Economic Review* 1, 7-73

Bjorner, T.B and Henrik H. Jensen (2002), Inter-fuel Substitution within Industrial Companies: An analysis based on Panel Data at company level. Energy Journal, vol.23, No.2: 27-50.

Blundell, R., and J. Robin (2000), Latent Separability, grouping goods without weak separability. Econometrica 68, pp 53-89

Blundell, R.; P. Pashardes and G. Weber (1993), "What do we Learn about Consumer Demand Pattern from Micro Data". The American Economic Review, Vol. 83, No. 3, pp. 570-579.

Blundell, R.W. and J.M. Robin (1999), "Estimation in Large and Disaggregated Demand Systems: An Estimator for Conditionally Linear Systems". *Journal of Applied Economics* 14: 209-232.

Bollino, C. (1990), A Generalized version of the Almost Ideal and Translog demand System. Economic letters 34, pp 127-129.

Bowander, B, S.S.R. Prasad and N.U.M. Unni (1988), "Dynamics of Fuelwood Prices in India: Policy Implications", *World Development*, Vol. 16, No 10, pp. 1213-1229

Brannlund, R. and J. Nordstrom (2004), Carbon Tax Simulations Using a Household demand Model. *European Economic Review*, 48 pp 211-233.

Brouwer and Falago, (2004), Wood fuel consumption in Maputo, Mozambique. Biomass and Bioenergy 27, pp 233-245.

Buse, A. (1994), Evaluating the linearized Almost Ideal Demand system. *American journal of Agricultural Economics*, vol.76, pp.781-793.

Campbell, B.M, S.J. Vermeulen, J.J. Mangono and R. Mabugu (2003), The Energy Transition in action: Urban domestic fuel choices in a changing Zimbabwe. Energy Policy vol.31, pp 553-562.

Cecelski, E. and Glatt, S. (1982), *The Role of Rural Electrification in Development. Energy in developing countries* series, discussion paper D_73E Resources for the Future.

Chalfant, J. A. (1987), "A Globally Flexible Almost Ideal Demand System". *Journal of Business and Economic Statistics*, vol.5, No. 2, pp 233-242

Chambwera, Muyeye and Henk Folmer, (2007), Fuel switching in Harare: An almost ideal demand system approach. Energy Policy vol.35 pp 2538-2548

Christensen, L.R., D.W. Jorgenson and L.J. Lau, (1975), "Transcendental Logarithmic Utility Functions", *American Economic Review* 65, 367-83

Cline-Cole, R.A, H.A.C Main and J.E Nichol, (1990), On Fuel wood Consumption, Population Dynamics and Deforestation in Africa. World Development, vol. 18 No.4, pp 513-527.

Considine, T. J. and Mount, T.D (1984), The Use of Linear Logit Model for Dynamic Input demand Systems. Review of Economics and statistics vol.66, pp 434-443.

Davis, M. (1998), "Rural Household Energy Consumption: The Effects of Access to Electricity-evidence from South Africa", *Energy Policy* 26: 207-217

Dayo, F.B (2008), *Clean Energy Investment in Nigeria: The Domestic Context*. International Institute for sustainable development.

Dayo, F.B. and A.O. Adegbulugbe (1987), "Oil Demand Elasticities in Nigeria". The Energy Journal, Vol. 8, No. 2, pp. 31-41.

De Vita. G., K. Endresen and L.C. Hunt (2006), An Empirical Analysis of Energy Demand in Namibia. Energy Policy vol.34 pp 3447-3463.

Deaton, A. (1978), "Specification and Testing in Applied Demand Analysis". *The Economic Journal*, Vol.88, pp. 524-536.

Deaton, A. and J. Muellbauer (1980), "An Almost Ideal Demand System", *American Economic*

Diewert, W.E. (1971), An Application of the Shephard duality theorem: a generalized Leontief production function. *Journal of Political economics,* vol.79, pp. 481-507.

Diewert, W.E. (1974), "Applications of Duality Theory", In: *Frontiers of Quantitative Economics,* II (eds. M.D. Intriligator and J.W. Kendrick). North-Holland.

Druckman, A and T. Jackson (2008), Household Energy Consumption in the UK: A Highly Geographically and Socio-Economically Disaggregated Model. Energy Policy 36 pp 3177-3192.

Dumagan, Jesus C. and Timothy D. Mount (1992), Measuring the Consumer Welfare effects of carbon penalties. Theory and Applications to Household energy demand. Energy Economics, April, 1992.

Dzioubinski, O. and R. Chipman (1999), *Trends in Consumption and Production: Household Energy onsumption.* DESA Discussion Paper No.6, United Nations.

Energy Commission of Nigeria (2006), Energy Master Plan.

Farsi Mehdi, Massimo Filippini and Shonali Pachauri (2007), 'Fuel Choices in urban Indian Households'. Environment and Development Economics 12, 757-774.

Filippini, Massimo and Shonali Pachauri (2004), Elasticities of electricity demand in urban Indian households. Energy Policy 32, pp 429-436.

Freund, C. L and C. I. Wallich, (1996), The Welfare Effects of raising Household Energy Prices in Poland, the Energy Journal vol 17, No 1

Gabriella Flores, Jaya Krishnakamar and Sudip ranjan Basu (2004), Demand Systems estimations and Welfare comparisons: Application to Indian Household Data. Department of Econometrics, University of Geneva.

Gallant, A. R (1981), "On the Bias in Flexible Functional Forms and an Essentially Unbiased Form" The Fourier Flexible Form". *Journal of Econometrics,* 15, 211-245.

Gallant, A. R (1984), "The Fourier Flexible Form". *American Journal of Agricultural Economics*, 66, 204-208.

Gallant, A.R. ((1982), "Unbiased Determination of Production Technologies". Journal of Econometrics, 20, pp. 285-323.

Gorman, W.M. (1959), “Separable Utility and Aggregation”. *Econometrica*, vol.27, pp. 469-81.

Gorman, W.M. (1968), “Conditions for additive Separability”. *Econometrica,* vol. 36, pp.605-659.

Greg Hiemstra-Van der Horst and A.J. Hovorka (2008), Reassessing the “energy ladder”: Household energy use in Maun, Botswanw. Energy Policy, vol.36, pp 553-562.

Heckman, J. (1979), Sample Selection Bias as a specification error. *Econometrica*, vol.47, pp.153-161.

Heltberg, R. (2005),“Factors Determining Household Fuel Choice in Guatemala”. *Journal of Environmental and Development Studies*, Vol.10, pp. 337-361

Heltberg, R., T.C. Arndt and N.U. Sekhar, (2000), Fuelwood Consumption and Forest Degradation: A Household model for Domestic Energy Substitution in Rural India. *Land Economics,* Vol. 76, pp 213-232

Henri Theil (1965), “The Information Approach to Demand Analysis”. *Economterica*, 33, 67-87

Henri Theil (1976), *Theory and Measurement of Consumer Demand*. Vols.1 and 2. Amsterdam.

Holtdahl, P. and Frederick, L. Joutz (2004), Residential Electricity demand in Taiwan. Energy Economics vol.26, pp 201-224.

Hope Eirnar and Singh Balbir (1995), Energy Price Increases in Developing Countries. Case studies of Colombia, Ghana, Indonesia, Malaysia, Turkey and Zimbabwe. Energy Research working paper. The World Bank Policy Research Department, Public Economics Division. March.

Hosier, R and W., Kypondya (1993), Urban Household Energy use in Tanzania: Prices, Substitute and Poverty. Energy Policy, vol.21: 453-473

Hosier, R.H and J Dowd (1987), Household Fuel Choice in Zimbabwe. An Empirical Test of the Energy Ladder Hypothesis. Resurces and Energy, vol.9: 347-361

Huang Kuo S. and Sophia Wu Huang (2009), ‘How Increased Food and Energy Prices affect Consumer Welfare’. Selected Paper for presentation at the agricultural & Applied Economics Association 2009 AAEA & ACCI Joint meeting Milwaukee, Wisconsin, July 26-29.

Imran, M. and P. Bames (1990), *Energy Demand in the Developing Countries: Prospects for the Future,* World Bank Staff Working Paper, No 23. The World Bank, Washington D.C, U.S.A.

International Monetary Fund (IMF) (2004), The Petroleum Products Market in Nigeria, selected issues and Statistical approach. IMF Country report No. 04/242 (Washington DC: IMF).

Irvine, I. J. and W. A. Sims (1993), “The Welfare Effects of Alcohol Taxatio’’. *Journal of Public Economics.* vol 52 pp 83-100.

Israel, D. (2002), “Fuel Choice in Developing Countries: Evidence from Bolivia”, *Journal of Economic Development and Cultural Change*, pp. 865-890.

Iwayemi, A. (1998), *Energy Sector Development in Africa*. A background paper prepared for the African Development Report.

Iwayemi, A. and A. Adenikinju (1996), “Macro-Economic Implications of Higher Energy Prices in Nigeria”. Pacific and Asian Journal of Energy, Vol. 6, No. 1.

Iwayemi, A., A. Adenikinju and M.A. Babatunde (2010), “Estimating Petroleum Producs Demand Elasticities in Nigeria: A Multivariate Co-integration Approach”. Energy Economics, Vol. 32, pp. 72-85.

Karekezi, Stephen and Lugard Majoro (2002), Improving Modern Energy Services for Africa’s Urban Poor. Energy Policy 30 pp 1015-1028.

Keen, M. (1986), "Zero Expenditures and the Estimation of Engel Curves". *Journal of Applied Econometrics.* 1: 277-286.

Ketker, K.W and S.L Ketker (1987), Population dynamics and consumer demand, *Applied Economics,* vol.19, pp 1483-1495

King, M.A. (1983), Welfare Analysis of Tax Reforms Using Household data. Journal of Public Economics vol 21 pp 183-214, North Holland.

Kuo. S. Huang and Sophia Wu Huang (2009), How Increased Food and Energy Prices affect Consumer Welfare. Paper presented at the agricultural and Applied economics Association, Annual Meeting Wisconsin, July 26-29.

Labandeira, X., Labeaga, J.M. and Rodriguez, M. (2006), A Residential Energy Demand System for Spain. *The Energy Journal*, vol.27 No.2

Leach, G. (1987), "Energy Transition in South Asia" In: *Transitions between Traditional and Commercial Energy in the Third World.* Surrey Energy Economics Centre. Discussion paper series no. 35. University of Surrey.

Leach, G. (1992), "The Energy Transition" *Energy Policy,* 20(2) 116-123

Leach, G. and M. Gowan (1987), "Household Energy Handbook. An Interim Guide and Reference/Manual. *World Bank Technical Working Paper,* No.67,World Bank, Washington D.C, U.S.A.

Leth-Petersen, S. (2002), "Micro Econometric Modelling of Household Energy Use: Testing for Dependence between Demand for Electricity and Natural Gas", *The Energy Journal,* Vol. 23, No.4, pp.57-84.

Lewbel, A. (1991), The Rank of Demand Systems: Theory and Non-parametric Estimation", Econometrica, Vol. 711-730.

Link, Cynthia F., William G. Axinn and Dirgha J. Ghimire, (2012), Household Energy Consumption; Community context and the fuel wood transition. Social science Research, vol. 41, pp 598-611.

Lyssiotou, P. (2003), On Estimating the cost of characteristics Indices from Consumer Demand Analysis. Canadian Journal of Economics vol.36, pp 326-349.

Maconachie, R., Adamu Tanko and Mustapha Zakariya (2009), Descending the Energy Ladder? Oil Price shocks and Domestic Fuel Choices in Kano, Nigeria. Energy 32, pp 1283-1290.

Macurdy, T.E. (1983), "A Simple Scheme for Estimating and Inter-temporal Model of Labour Supply and Consumption in the Presence of Taxes and Uncertainty". International Economic Review, Vol. 24, pp. 265-289.

Madlener, R. (1996), "Econometric Analysis of Residential Energy Demand: A Survey". *Journal of Energy Literature* II 2:3-32.

Masera O.R and J. Navia (1997), Fuel Switching or Multiple cooking fuels?. Understanding Inter-fuel Substitution Patterns in Rural Mexican Households. Biomass and Bioenergy vol.12, No.5, pp 347-361.

Masera, O.R., B.D. Saatkamp, and D.M., Kammen (2000), From Linear Fuel Switching to Multiple Cooking Strategies: A Critque and Alternative to the Energy Ladder Model. World Development 28; 2083-2103.

Mudassar, Imran and Phillip Barnes (1990), *Energy Demand in the Developing Countries: Prospects for the Future.* World Bank Staff Working Papers No.23. The World Bank Washington, D.C. USA.

Muellbauer, J. (1975) "Aggregation, Income Distribution and Consumer Demand", *Review of Economics Studies*. Vol.62, pp.525-543

Muellbauer, J. (1976), Community Preferences and the Representative Consumer, *Econometrica* 44, 978-999

Muellbauer, J. (1977), Testing the Barten model of Household Composition effects and the cost of children, *Economic Journal* 87, 460-487

Naibbi Ali . I. and Richard G. Healy (2013), Northern Nigeria's Dependence on Fuel wood: Insights from Nationwide Cooking Fuel Distribution Data. International Journal of Humanities and Social Science. Vol. 3 No. 17 September.

National Bureau of Statistics Bulletin (2007), The Nigerian Statistical fact Sheets on Economic and Social Development.

National Population Commission (2006), Population and Housing Census of the Federal Republic of Nigeria.

National population Commission (2006), Housing Characteristics and Amenities Tables.

Nicol C. (2003), Elasticities of Demand for Gasoline in Canada and the United States. Energy Economics vol. 25, pp201-214.

Nicol, C. (2001), The Rank and Model Specification of Demand Systems: Am Empirical Analysis using United states microdata. Canadian journal of Economics vol. 34 pp 259-289.

Nnaji C.E., E.R. Ukwuwze and J.O. Chukwu, (2012), 'Determinants of Household Energy Choices for Cooking in Rural Areas: Evidence from Enugu state, Nigeria'. Continental Journal of Social Sciences, vol.5 No.2 pp 1-11.

O'Keefe, P. and Munslow, B. (1989), Understanding fuelwood. A critique of existing interventions in Southern Africa. *Natural Resources Forum* 13(1), pp2-11

Oladosu, G.A. and Adegbulugbe, A.O. (1994), Nigeria's Household Energy Sector: Issues and Supply/Demand Frontiers. *Energy Policy,* 22(6), pp 538-54

Olivia, S. and J. Gibson (2008), Household Energy Demand and the Equity and Efficiency Aspects of Subsidy Reform in Indonesia. *The Energy Journal,* vol. 29, No.1

Pachauri Shonali (2004), An Analysis of Cross Sectional Variations in Total Household Energy Requirements in India Using Micro survey data. Energy Policy vol.32 pp 1723-1735.

Pachauri, S. (2004), An Analysis of Cross Sectional variations in total household energy requirements in India using mocro survey data. Energy Policy 32, pp 1723-1735.

Pachauri Shonali and Leiwen Jiang (2008), The Household Energy Transition in India and China. Energy Policy vol.36 pp 4022-4035.

Pashardes, P. (1993), Bias in estimating the Almost Ideal Demand system with the Stone index approximation. *Economic journal,* vol. 103, pp.908-915.

Glewwe, Paul (1996), Investigating the Determinants of Household welfare in Cote d; Ivoire. Journal of Development Economics vol. 35 pp 307-337 North Holland.

Pitt, M.M (1985), "Equity, Externalities and energy Subsidies: The Case of Kerosene in Indonesia", *Journal of Development Economics,* Vol.17 (3), pp. 201-17

Pitt, M.M (1997), 'Specification and Estimation of the Demand for Goods within the Household' in L. Haddad, J hoddinott and H. Alderman, eds. *Intrahousehold Resource Allocation in Developing Countries for the International Food Policy Research Institute.* The John Hopkins University Press, Baltimore and London.

Pollak and Wales (1978), Estimation of Complete demand systems from household budget data: the linear and Quadratic expenditure systems. The American Economic Review vol.68, No.3 pp 348-359.

Popoola, L. (1992), An Assessment of the Effect of Structural Adjustment Programme on Fuelwood Consumption in Nigeria", *Journal of Tropical Forest Resources*, Vol. 7 & 8, pp. 30-38.

Poyer, David. A., Lenneal Henderson and Arvind P.S. Teotia (1997), Residential Energy Consumption across different population groups: Comparative analysis for Latino households in USA. Energy economics, vol.19, pp 445-463.

Preston, Ian and Ian Walker (1999), Welfare Measurement in Labour supply Models with Non-linear budget Constraints. Journal of Population Economics vol. 12, No.3, pp 343-361.

Quedraogo, Boukary (2006), Household Energy Preferences for cooking in Urban Quagadougou, Burkina Faso. Energy Policy 34, pp 3787-3795

Ranjan, R. (1982), "The Testing and Estimation of Complete Demand Systems on Household Budget Surveys: An Application of AIDS". *European Economic Review*, Vol.17, No. 3, pp 349-369.

Review, Vol.70, No.3, pp. 312-326.

Rushdi, A.A (1986), Inter-fuel Substitution in the Residential sector of South Australia. Energy Economics, pp 1-29.

Sanchez, L (2008), "Inequality and Household Energy Consumption in Urban Mexico". El Colegio de Mexico.

Serletis, A. Timilsina, G.R and O. Vasetsky (2010), International Evidence on Sectoral inter-fuel Substitution. Energy Journal vol.31 No.4 pp 1-29

Soussan J, P. O'Keefe and B. Munslow (1990), Urban Fuelwood, Challenges and Dilemmas. Energy Policy vol.18 No.6 July/August.

Stone, J.R.N. (1954), linear expenditure systems and demand analysis: An application to the pattern of British demand, *Economic journal*. 64, 511-52

Takama, T., Lambe F., Johnson, F.X., Arvidson, A., Atanasov, B., Debebe, M., Nilsson, L., Tella, P., and Tsephel, S.A. (2011), Will African Consumers buy Cleaner Fuel and Stoves? Stockholm Environmental Institute Research report. April. Available at www.sci-international.org

UNCHS Habitat (1996), An Urbanizing Wotld: Global Report on Human Settlements. Oxford University Press, Oxford.

Varian, H.R. (1992), Microeconomic Analysis, Third Edition. W.W. Norton and Company Inc. New York.

APPENDIX I **QUESTIONNAIRE**

FACULTY OF THE SOCIAL SCIENCES
DEPARTMENT OF ECONOMICS
UNIVERSITY OF IBADAN

S/No………..

Dear Respondent,

This questionnaire is designed to collect information on "Domestic/Household Energy Use in Urban Centers in Nigeria", being a PhD Research. Please, be assured that all information provided will be treated in confidence and used for academic purposes only.

Thank you.

SECTION 1: IDENTIFICATION

Interviewer's Name………………………. Code………………………………………
Supervisor's Code……………………….. Survey Month……………………………..
Survey Year………………………………
HH Listed…………….. HH Sampled………… State………………………………………
LGA………………………. …………….
EA Code………………. ………………. EA Name…………………………………

SECTION 2: BACKGROUND INFORMATION

Please, tick the appropriate answer or fill in the blank spaces as may be applicable.

1. Sex of the Respondent (i) Male (ii) Female

2. Is Respondent the Head of household: (i) Yes (ii) No

3. Age of the household Head: (i) 20-29 years (ii) 30-39years (iii) 40-49years (iv) 50-59years (v) 60 years and above

4. Highest Educational attainment of the household head
   (i) No formal Education (ii) Primary Education (iii) Secondary Education (iv) Tertiary Education (v) Others (specify)……………………………………

5. Highest Educational attainment of the Spouse
   (i) No formal Education (ii) Primary Education (iii) Secondary Education (iv) Tertiary Education (v) Others(specify)………………………………………

SECTION 3: SOCIO-ECONOMIC AND DEMOGRAPHIC INFORMATION

6 What is the number of people in your household within the following age brackets?
   (i) 0 – 15 yrs old……………….. (ii) 16 yrs and above…………………………

7. How many people live in your household?

Identity	Male	Female	Total
Spouse			
Children			
Others			
Total			

8. Type of Occupation:

S/N	Occupation	Main /Primary	Subsidiary/Secondary
i.	Farming		
ii.	Trading		
iii.	Artisan		
iv.	Civil/Public servant		
v.	Others (Specify)		

9. What is your average income per month?
(i) Wages and Salary…………………………… (ii) Gifts ----------------------
(iii) Personal/Household business------------------- (iv) Others ……………….

10. Ownership of the house (i) Family House (ii) Personal House (iii) Rental Apartment (iv) Rental Free (v) Subsidized Rental

11. Monthly Rent in (Naira) for housing unit

12. Type of housing unit (i) Single Room (ii) Flat/Self contained (iii) Duplex (iv) Bungalow (v) Others (Specify)…………………………………………………………

13. Kitchen Type (i) Separate kitchen (ii) Kitchen shared with other households (iii) Open air (iv) Kitchen within the apartment

14. Number of Cars in the household?..

SECTION 4: ENERGY USE PROFILE

15. Type of Fuel used for the Listed Activities.

S/N	Energy Type	Cooking	Lighting	Car Fuels
i.	Gas			
ii.	Kerosene			
iii.	Electricity (PHCN)			
iv.	Fuelwood/Charcoal			
v	Petrol/Diesel (Generator)			
vi	Others (Specify)			

16. Monthly Expenditure on each of the Energy Types used for the Listed Services

S/N	Energy Type	Cooking	Lighting	Car/Generator
i.	Gas			
ii.	Kerosene			
iii.	Electricity (PHCN)			
iv.	Fuelwood/Charcoal			
v	Petrol/Diesel			
vi	Others (Specify)			

17. Reasons for Choice of Energy Used for Cooking

Energy Type	Cheapness	Convenience	Cleanliness/ Non-polluting	Availability	Others (specify)
Gas					
Kerosene					
Electricity					
Fuelwood/ Charcoal					
Others (Specify)					

Code for Availability column: 1-Easy to obtain 2-Difficult to obtain 3-Very difficult to obtain

18. Reasons for Choice of Energy Used for Lighting

Energy Type	Cheapness	Convenience	Cleanliness/ Non-polluting	Availability	Others (specify)
Petrol (generator) Diesel (generator					
Gas					
Electricity					
Kerosene					
Others (Specify)					

Code for Availability column:1-Easy to obtain 2-Difficult to obtain 3-Very difficult to obtain

19. Reasons for Choice of Energy Used for Car Fuel

Energy Type	Cheapness	Convenience	Cleanliness/ Non-polluting	Availability	Others (specify)
Petrol (generator) Diesel (generator					
Gas					
Electricity					
Kerosene					
Others (Specify)					

Code for Availability column: 1-Easy to obtain 2-Difficult to obtain 3-Very difficult to obtain

20. Household Energy Use: Price/Quantity

Type of Fuel	Unit	Price per Unit	Qty used per week	Qty used per month
Petrol/Diesel	Litre			
Electricity	Kwh			
Gas	Cylinder 12.5kg			
Kerosene	Litre/Gallon			
Fuel wood/ Charcoal	Kg. Equivalent			

21. Source of Energy (Tick Appropriately)

Source of supply	LPG (Gas)	Kerosene	Fuelwood/ Charcoal	Electricity	Petrol/Diesel	Others (Specify)
Own neighbourhood						
Next neighbourhood						
Outside local area						

22. If there is a price increase in energy products, would you stop buying the current type of energy product(s) being used? (i) Yes (ii) No

23. If the price of kerosene or gas or firewood increases by 100% would you switch to another type of energy? (i) Yes (ii) No

24. If yes to qs. 22, which of the energy types will you switch to for the listed activities.

S/N	Energy Type	Cookng	Lighting	Car Fuels
i.	Gas			
ii.	Kerosene			
iii.	Electricity (PHCN)			
iv.	Fuelwood/Charcoal			
v	Petrol/Diesel (Generator)			
vi	Others (Specify)			

SECTION 5: COOKING END USE

25. Which is/are the main cooking appliance(s) in your household?
(i) Electric Cooker (ii) Gas Cooker (iii) Kerosene Stove
(iv) Fuel wood Stove (v) Charcoal stove (vi) Sawdust
(vii) Others (Specify) ……………………………………………………………..

26. How often do you use the following energy type for cooking?

For Cooking

Appliance Used	Frequently Used	Sparingly Used	Not used at all
Gas Cooker			
Electric Cooker			
Kerosene Stove			
Charcoal/Fuelwood stove			
Others (Specify)			

For Lighting

Electricity (PHCN)			
Fuel Generator			
Diesel Generator			
Gas lamp			
Kerosene lantern			
Candle			
Solar			
Inverter			
Others (Specify)			

27. Will you be willing to substitute kerosene for Gas, Electricity, and Fuel wood?

28. If Yes, why?...,,,,,,,
………………………………………………………………………………………..

29. If No, why?..
………………………………………………………………………………………..

30. How will you measure the efficiency of each energy type for the following activities?

Cooking

Type of Energy	**Very Efficient**	**Moderate**	**Less Efficient**
Electricity			
LPG			
Kerosene			
Fuel wood/Charcoal			
Petrol/diesel			
Solar/Inverter			

Lighting

Electricity			
LPG			
Kerosene			
Fuel wood/Charcoal			
Petrol/diesel			
Solar/Inverter			

31. What is the average monthly expenditure on?

1. Food ……………………….,,,
2. Transport …………………..
3. Energy (a) Electricity …………………..,,,,,,,,,,,,,,,,,,,,,,,
   (b) Kerosene …………………………………
   (c) Petrol/Diesel………………………………
   (d) Gas ……………………….......................
   (e) Fuel wood/Charcoal ……………………..
   (f) Car fuels …………………………………..
   (g) Other energy ……………………………..
4. Other expenditures ……………………………………………
   Total …………………………………………….

32. Are you willing to use more efficient cooking appliances? (i)Yes (ii) No

33. If YES are you willing to pay more for such appliance(s)? (i) Yes (ii) No

34. Indicate the type of energy product used and the amount spent last year and currently.

Energy Type	**Last year/Amount spent**	**Current year/Amount spent**
Petrol/Diesel		
Electricity		
Gas		
Kerosene		
Fuel wood/charcoal		
Others (specify)		

35. State reasons why you changed to present type of energy being used?
....
....
....

SECTION 6: ENERGY SERVICES

36. Order the following energy services used for cooking in order of preference

Type of Energy	
Electricity	
LPG	
Kerosene	
Fuel wood/Charcoal	
Others (specify)	

Code: 1-Most Preferred, 2-Fairly Preferred, 3-Not Preferred, 4-Indifferent.

37. What informed this preference ordering for cooking in Qs. 36?

Energy Type	**Cheapness**	**Convenience**	**Cleanliness/ Non-polluting**	**Availability**
Petrol (generator) Diesel (generator				
Gas				
Electricity				
Kerosene				
Others (Specify)				

38. Order the following energy services used for lighting in order of preference

Type of Energy	
Electricity	
Gas Lamp	
Kerosene Lamp	
Petrol/Diesel Generator	
Others (specify)	

Code: 1-Most Preferred, 2-Fairly Preferred, 3-Not Preferred, 4-Indifferent.

39.What informed this preference ordering for lighting in Qs. 38?

Energy Type	**Cheapness**	**Convenience**	**Cleanliness/ Non-polluting**	**Availability**
Petrol (generator) Diesel (generator				
Gas				
Electricity				
Kerosene				
Others (Specify)				

40. If prices and availability are not constraining factors, will the ranking in Qs 36 & 38 remain the same? (i) Yes (ii) No

41. If No, what will be your new ranking for cooking?

Energy Type	
Gas	
Kerosene	
Electricity	
Fuelwood/ Charcoal	
Others (Specify)	

Code: 1-Most Preferred, 2-Fairly Preferred, 3-Not Preferred, 4-Indifferent.

42. If No, what will be your new ranking for lighting?

Energy Type	
Electricity	
Gas Lamp	
Kerosene Lamp	
Petrol/Diesel Generator	
Others (specify)	

Code: 1-Most Preferred, 2-Fairly Preferred, 3-Not Preferred, 4-Indifferent.