Determinants of fuels stacking behaviour among households in Bauchi Metropolis

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Abstract
Energy consumption is an important determinant of the socio economic status of citizens across the globe especially the consumption of modern energy. According to the energy ladder hypothesis households move along the energy ladder as their income increases. At the lower rung of the ladder are the low income and usually uneducated households who mainly consume traditional fuels while the middle class and those at upper echelon of the society largely consume transitional and modern fuels. However the prevalence of energy stacking behaviour where households adopt more than one fuel type has been observed even among the middle and upper income families. The question is why is the observed energy consumption pattern in violation of the energy ladder hypothesis? The paper assesses the combined influence of four variables which include income level of households, education level/exposure of households, households' size and modern fuels supply security on fuels adoption decisions of households. Multivariate analysis was conducted to assess the combined influence of the IVs on the DV. The model has an R2 value of .252 meaning that the model explains about 25% variation in the DV. Individually the variables that make significant and unique contribution to the model are educational level of households, income level of households and family size of households. We therefore recommend improved supply and diffusion of modern fuel as a way of reducing the prevalence of energy stacking behaviour of households, expanding access to modern energy, reducing the exposure of women and children to smoke related ailments and promoting environmental sustainability.
Classification: energy economics

1.0 Introduction

Energy consumption is a major determinant of the socio- economic life of the people. Energy is required for the satisfaction of numerous human needs; heating, cooking, preservation, movement, production of agricultural and industrial goods among others. In the post Neolithic revolution, biomass (crop residues, dung, firewood etc) was the dominant source of energy supply but it was later replaced by coal due to its (coal's) energy density.

Explanations on house hold fuel choice has for long been dominated by the energy ladder hypothesis which explains fuels choice in terms of energy transition based on the income level of the particular household making the choice. According to the energy ladder hypothesis as their incomes rise, households move up the energy ladder. Households move away from traditional fuels to transitional fuels such as kerosene and charcoal as their income increases before finally moving to modern fuels such as grid based electricity and LPG which are superior to traditional or transitional fuels (Leach, 1992; Farsi, et al, 2007). Modern fuels are preferred and distinguishable because of their high levels of efficiency, cleanliness and ease of use compared to crop residues, dung, firewood and other traditional biomass fuels. Though the fuel transition has largely been attributed to income, recently critiques of the energy ladder hypothesis show that other factors (such as infrastructure

availability, relative fuel and technology prices and the reliability of different fuel systems) also have some bearings on household fuels usage (Leach, 1992; Tiwari, 2000; Pachuari, 2004; ESMAP, 2003).
In fact recent empirical researches have questioned the validity of the energy ladder hypothesis in explaining the households' fuels choice or fuels transition (Smith, et al., 1994; Barnes and Floor, 1996; Elias and Victor, 2005). They have shown that energy transition does not follow the linear pattern prescribed by the energy ladder hypothesis (a series of simple, discrete steps prescribed by the energy ladder hypothesis) but rather a predominant multiple fuel use. Accordingly with increasing prosperity households adopt new fuels and technologies to serve as partial and not perfect substitute for traditional fuels ((Eberhard and Van Horen, 1995; Masera, et al., 2000; IEA, 2002; Leiwen and O'Neill, 2003). The prevalent use of multiple fuels has been observed in many countries and many communities. For example households in urban areas of Guatemala, simultaneously use firewood and LPG for cooking (ESMAP, 2003). Also in rural China, biomass and electricity are the most common fuel pairing in households (Leiwen and O'Neill, 2003). Additionally in Brazil, although firewood's fraction of fuel budgets falls as incomes rise; fuel wood use continues even at relatively high income levels (de Almeida and de Oliveira, 1995). Though domestic energy needs of households in Nigeria is largely limited to cooking and lighting, the use of multiple fuels for domestic energy utilization especially in the urban and semi urban and rural areas has been reported (Nnaji et al., 2012; Ogwumike, et al., 2014).

An important question that begs for answer is what compels the prevalence of multiple fuels use by households? In attempt to provide answer to this pertinent question the paper sets out to assess the combined influence of some variables on households' fuels usage in Bauchi metropolis. Few studies if any have been conducted to provide explanations to the prevalence of energy stacking behaviour amongst households especially in Bauchi State. Thus the justification for this study which seeks to provide explanations for multiple fuels usage by households in Bauchi metropolis. It is expected that the study will be of tremendous policy and research significance. Understanding of fuels choice behaviour and factors underlying such behaviour will enrich government policy on economic empowerment and poverty alleviation, on improving the health status of women and children, on the diffusion of modern fuels technology, on reducing the depletion of forest resources and on creating local micro enterprises that may engage in the provision and supply of cleaner cooking fuels. It is also expected that the paper will come out with findings that will enrich government energy security policy especially those that have to do with generation and distribution of electricity and the supply of other modern fuel such as LPG. Finally the outcome of the research is also expected to stimulate further research endeavour in the area of households' fuels choice, fuels utilizations, households' willingness to pay for reliable modern energy among others.

1.1Objectives

The major objective of the paper is to explain the reasons for multiple fuel adoption otherwise known as fuel stacking among households in Bauchi metropolis.
The specific objectives of the paper are
1. To assess the influence of income level of households on households fuel adoption
2. To examine the influence of households exposure (education) on households' fuels usage
3. To identify the role of family size in fuel adoption decisions of households in Bauchi metropolis
4. To examine the extent to which households' fuels usage decision is affected by modern fuels supply security.

1.2 Hypotheses

1. Households fuels adoption is independent of households' income level.
2. Level of households' exposure (Education) does not significantly affect households' fuels adoption decision.
3. Fuel stacking behaviour of households is not significantly affected by family size.

4. Modern fuels supply security does not significantly affect households' fuel adoption behaviour
The rest of the paper is organized as follows: section 2 presents the literature survey and the theoretical discussions; section 3 presents the methodology of the research while section 4 presents the results and discussions. Section 5 concludes the paper.

2. Literature Survey and Theoretical Discussions

2.1 Literature Survey

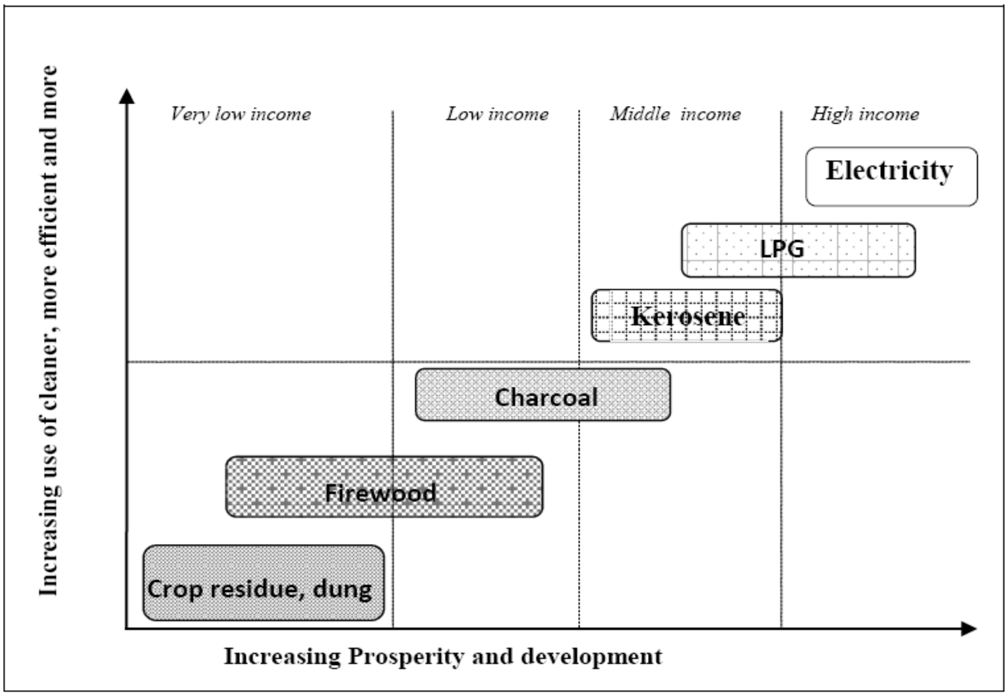
Energy is vital to human existence. Its availability and quality define the socio economic status of the citizenry and also define the progress of a society or nation. In satisfying their domestic energy quests, households at the lower rung of the society usually rely on biomass resources such as cow dung's, farm residues, wood fuels etc for their cooking and heating purposes. The reliance on biomass however comes with a lot of costs. Such costs include deforestation of the forest stock, serious health burden in the form of the respiratory diseases that women and their children get exposed to while cooking and the toll that biomass collection takes on women's time among others (Elias and Victor, 2005). Additionally the three stones stove used by lower income families has low heat intensity making it a highly inefficient way of energy utilization. FAO, (2006) reports that about 2 billion people in the world rely on biomass to satisfy their energy quests. This number is projected to rise to 2.6 billion by 2015 and 2.7 billion by 2030(IEA, 2006; Mekonnen, 2009).

Though Nigeria is an energy rich country possessing abundant variety of energy resources, a great number of households rely on traditional or primary fuels for cooking and other domestic activities such as lighting. In fact ECN, (2003) reports that about 60% of Nigerians rely on fuel wood for cooking and other domestic uses (Nnaji et al, 2012). Also NBS (2004) reports some startling statistics on households' energy usage in Nigeria: the percentage of households that rely on biomass for cooking rose from 47% in 1980 to 70.8% in 2004, the percentage of households that used kerosene for cooking declined from 49.0% in 1980 to 26.6 per cent in 2004, also the percentage of households that use electricity for cooking declined from 2.6% in 1980 to 0.5% in 2004, while households that used LPG for cooking increased marginally from 0.8 per cent in 1980 to 1.0 per cent in 2004. The heavy reliance on fuel wood for cooking is adversely impacting on the environment causing deforestation, air pollution, soil erosion and desertification in most parts of the country especially in the Sahel Savannah ecological zone (Ogwume, 2014). Also NBS, (2004) reports that due to the erratic nature of electricity supply and petroleum products, households use other sources of energy such as candles, batteries, generators as standby means for lighting their houses.

According to the energy ladder hypothesis households adopt newer and more efficient fuels and technologies as their incomes improve. Thus households ascend the energy ladder with increase in incomes. The energy ladder hypothesis therefore based the transition of households in the fuel scale on household income status. Accordingly households are classed into three different classes of energy usage. The first stage is the stage of total reliance on biomass while in the second stage households rely on transitional fuels such as kerosene, coal or charcoal. In the third phase, households switch to LPG, natural gas or electricity. According to the energy ladder hypothesis the main driver for the energy switching behaviour of households' is income and relative fuel prices (Leach, 1992; Barnes and Floor, 1999 Barnes, Krutilla, and Hyde, 2002). Thus the energy ladder hypothesis holds that households' fuel adoption is income dependent (Heltberg, 2003).

In reality however households especially in developing countries do not linearly transit from traditional to modern fuels as described by the energy ladder hypothesis (Pachauri and Spreng 2004; Elias and Victor, 2005; Ouedraogo, 2006; Demurger and Fournier, 2011; Ogwume, 2014). Empirical researches conducted in different parts of the world reported energy stacking as the dominant fuel adoption behaviour by households. For example Ogwume, et al, (2014) found that in Nigeria instead of households abandoning traditional fuels as income (or expenditure on energy) increases, households tend to stack different forms of fuels which is consistent with consumer preferences in the face of supply constraints. Thus households even at higher income group still use firewood for cooking (Ogwume, 2014). Also Masera et al, (2000) using longitudinal data reported fuel stacking behaviour among households in Jaracuaro village and some states in Mexico. Additionally Mekonnen et al, (2009) found evidence of fuel stacking among households in Tigrai and other major cities of Ethiopia.

Figure: 1 Energy Ladder Model



Source: WHO 2006 as cited in Mensah and Adu, (2013): An Empirical Analysis of Households Energy Choice in Ghana.

Although modern energy fuels and technologies are more efficient and more convenient in their use compared to the traditional fuels, their adoption in many developing countries especially by low income families is hampered by high upfront capital costs and lack of infrastructure for their transport and distribution (Elias and Victor, 2005).

The paper is therefore designed to measure the combined influence of some pertinent variables on fuels usage by households in Bauchi metropolis as an attempt to provide explanations to the observed fuels stacking behaviour among households.

2.2 Theoretical and Empirical Issues

The theory of consumer behaviour provides the theoretical foundation for the analysis of fuels choice of households. The basic postulate of the consumer behaviour is that households as economic agents are rational agents that always act rationally to maximise their utilities. Consequently as rational consumers, households always choose the most preferred bundle from a set of feasible alternatives (Varian, 2010). As their income increases, households do not consume more of the traditional fuels, but they shift to newer, more improved fuels which are more efficient and user friendly indicating that traditional fuels are inferior goods while the modern fuels are normal economic goods (Rajmohan and Weerahewa, 2007; Demurger and Fournier, 2011)**.** Thus low level of income means more dependence on traditional fuels due to a combination of income and substitution effect (Baland et al, 2007; Ogwumike, et al 2014).

Recent studies (Masera et al., 2000; Heltberg, 2005; World Bank, 2003; Mekonnen and Köhlin, 2008; Ogwumike, et al 2014 among others) have however argued that households choice of fuels are not affected by income alone but by a myriad of factors some of which are economic and others non economic (Ogwumike, et al 2014).

Households' fuels choice has generated a lot of research interests. Consequently many empirical researches examine fuel choice behaviour of households. Empirical studies have confirmed the energy ladder hypothesis and fuels stacking behaviour. Hosier and Dowd,(1987) examined households' fuels choice in Zimbabwe using multinomial logit model. Though their findings confirm the energy ladder hypothesis, they also discovered the influence of other factors such as size of households and location of households in the fuels choice decisions of households (Mensah and Adu, 2013). Mekonnen and Kohlin, (2008) also studied the fuel choice behaviour of households in Ethiopia. Their results confirmed the existence of multiple fuels choice among households in major Ethiopian cities**.** Ouedraogo, (2006) using multinomial logit model analysed factors determining urban households cooking energy preferences in Ouagadougou. They found that households reliance on traditional fuels for cooking are due to poverty factors such as low income, households' poor access to electricity for primary and secondary energy uses, low housing standards and household size (Ogwumike, 2014).

2.3 Conceptual Framework

The conceptual model used for the study is described in figure 1 below. The figure depicts the four constructs of the study which are income level of households (ILH), educational level of households (ELH), family size of households (FSH) and modern fuels supply security (MFSS) and their relationship with DV households fuels usage decisions (HFUD).

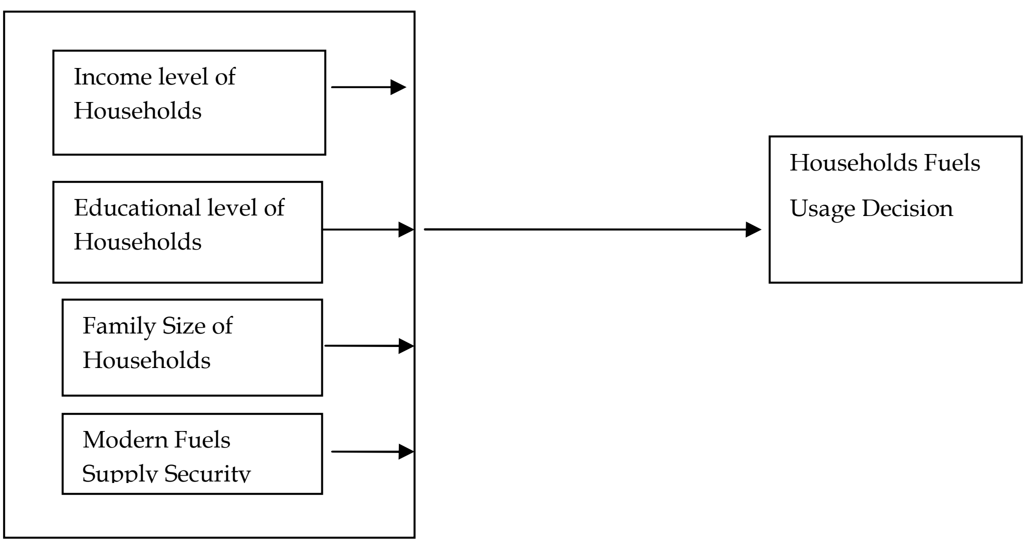


Figure 2: Conceptual Framework

The constructs are operationalised as follows

2.3.1 Income level of households. Refers to the income earned by the household head that usually caters for the family. Normally the households' heads' income in many Nigerian households determine the economic level of buoyancy of the family. In recent times women increasingly are working and earning money which in some communities help to supplement the expenditure of the households. According to the energy ladder hypothesis income determine the choice of cooking fuels and the amount of energy consumed by the particular household. As income increases households switch away from traditional to modern to fuels a process referred to fuel switching or inter fuel substitution (Leach 1992;Heltberg, 2003,

2.3.2 Educational level of households. Educational levels of household heads determine the choice the households make in terms of cooking fuels. Education affects the level of social exposure of the households which also affect the adoption decision of households of cooking fuels. Educational status of household's head also affects the awareness level of the household about the existence of modern fuels and their advantages over traditional fuels (Hertberg, 2003; Suliman, 2010)

2.3.3 Family size of households. Refers to the number of people in a particular household. The bigger the number the more fuels consumption of that family and also the more expenditure the family incurs in meeting the cooking fuels needs of the family. In most cases family size compels the use of diverse fuel sources (Suliman, 2003).

2.3.4 Modern fuels supply security. Refers to the availability and sustainability of the fuel supply in the market. In many developing countries modern fuels (such as LPG and electricity) supply is erratic due to a number of reasons. Such reasons include inadequate generation, transmission and distribution infrastructure in the case of electricity supply in Nigeria, poor roads that hamper steady supply of LPG products especially to semi urban areas etc. The insecurity of such fuels supply ultimately affects the adoption behaviour of households with regards to cooking fuels as households use both traditional and modern fuels together instead of substituting one with the other (Masera, et al, 2000). Security of supply is dependent on such factors as the route and frequency of delivery among others (Masera, et al, 2000),

2.3.5 Households fuels usage decisions. The dependent variable measures households' fuels decision. It has to do with the decisions that households make in the choice of fuels for cooking. The study measures the influence of the four variables on the DV.

3. Methodological Issues and Data Analysis

3.1 Methodological Issues

Survey research design was used to collect data from the sampled respondents using structured questionnaire.

Multiple regression analysis was employed to assess the combined influence of the constructs (income level of households' educational level of households, family size and modern fuels supply security) on the dependent variable (households' fuels usage decisions). The population of the study was made up of heads of households in Bauchi metropolis that are also connected to the national grid being supplied by the Jos Electricity Distribution Company (JED). The sampling frame is drawn from the population of JED electricity consumers which stood at 33,339 consumers. Sample was selected from the population through simple random sampling. The sample size was determined using Yarmane, (1992) formula for normal approximation at 95% confidence level and 5% error margin which translated into about 400 respondents as per below;

$n = N/1+Ne^2$ .... (1)

Where;

N = the population size (33,339), n = sample size, e = error margin.

Thus $n = 33,339/1+ 33,339(.05)^2 = 400$ respondents.

The sample size arrived at meets the sample size requirements of multiple regressions analysis as recommended by Green, (1991); Hair et al (1995); Oppenheim, (1996); Tabbachnic and Fiddel, (2007) and Pallant, (2007; 2011). However 420 questionnaires were distributed to the respondents in order to reduce the influence of non returned or non correctly filled questionnaire.

3.2 Data Analysis

3.2.1 Respondents' Energy Use Characteristics

About 420 questionnaires were distributed to responding households. 342 questionnaires were returned correctly filled representing about 81% of the questionnaires sent out. 209 or 61% of the respondents use energy for cooking and lighting while 23.4% or 80 respondents use energy cooking and for heating purposes. On the other hand 25 or 7.3% of respondents reported using energy for cooking, lighting and heating. Additionally 18 or 5.2% of the respondents reported using energy for cooking, lighting and water heating while 10 respondents or 2.9 of the respondents surveyed reported using energy for cooking, lighting, heating and entertainment. Thus majority of households use energy for largely for cooking and lighting which is in tandem with previous studies on households' energy usage in developing countries (Masera, et al, 2000; Ogwumike et al 2014).

With regards to the educational attainment or exposure of responding households' heads 49 respondents or 14.3 % have senior secondary certificate, 112 respondents or 32.7% have a diploma certificate while 92 respondents or 26.9% are educated up to degree level. Households' heads qualifications above master's degree represent 25.7% or 88 respondents.

On the occupation of respondents about 51 respondents or 14.9% were farmers, 107 or 51.7% were public servants. On the other hand 42 respondents or 12.3% of respondents were business men and women while 35 or 1.02% of the respondents were in engaged in other forms of engagement such micro business, tailoring, entertainment etc The Gender distribution of the respondents are 293 or 85.7% male and 49 or 14.3% of respondents or female. The households' heads covered in the study are largely headed by male representing about 85.7 while households with female heads represent only 14%. Some studies have shown that technology adoption by households is affected among other factors by the sex of the households' heads (Heltberg, 2003, Suliman, 2010).

On the expenditure on cooking fuels it was discovered that about 51respondents representing about 15% of the respondents spend less than 1000 or about 5 dollars per month. Households that spend between N1000-N3000 (5 dollars to 16 dollars) on cooking fuels numbered about 166 representing about 48.5% of the households surveyed while households whose spending on cooking fuels ranged from N3500-N5000 (18 to 25 dollars) reached about 81 households or 23.7%. Also 34 households representing about 9.9% of households studied spend between N5, 500-N10, 000 (27.6 to 55 dollars). Only 10 households incur expenditure above N10000 (55 dollars) per month on cooking energy representing about 2.9% of the total respondents. Households' expenditure on cooking energy and also generally on energy is taken to signify households' income level the quality of life enjoyed by such a households among others (Leach, 1992, Masera et al, 2000; Heltberg, 2003;Suliman, 2010).

On the percentage of income spent on energy for cooking, 183 or 53.5% of the households spend about 1-5% of their income on cooking fuels while about 75 respondents representing about 22% of the households spend between 6-10% of their income on cooking fuels. On the other hand 50 respondents or about 15% of respondents spend between 11-15% of their income on cooking fuels monthly. Only 35 households that represent about 10.2% spend above 15% of their income on cooking fuels monthly. Percentage of income spent on cooking fuels signifies a number of things. Firstly it indicates the quantum of energy consumption of the family and by extension the type of fuels use by the family as modern fuels are relatively more expensive. It also indicates the level of income of households as greater percentage shows higher income even though poor households who earn meagre income have to spend large percentage of their income on to meet their energy needs.

The family size of the responding households differs considerably. Family size refers to the number of people in a particular household. Usually the larger the family size the more the energy consumption of such a household (Suliman, 2010). 190 or 56% of the responding households have 3-6 persons per household. 93 households representing about 27% of the responding households have between 7-10 members per households. Households with a family size of between11-14 numbered 37 households or 10.8% of the responding households. Households with family size above 14 are 21 households or 6.1 of the responding households. Family size is an important determinant of fuels house choice and fuels stacking behaviour (Suliman, 2010).

On the fuels type use by households for cooking purposes the result indicate households' reliance on more than one fuels type. About 80 households depend exclusively on biomass representing about 23%. Responding households that use kerosene and charcoal are 196 households or 57%. Households that rely on LPG and biomass are 35 respondents which accounting for 10.2% of the responding households. While households that combine electricity and all other forms of fuels including LPG, kerosene, charcoal and biomass are 30, accounting for about 9% of the households.

Number of time cooking is done is an indicator of the extent of energy consumption for cooking purposes. 20 households cook once daily representing about 6% of the respondents while households that reported cooking twice per day were 101 respondents which represent about 30% of the respondents. On the other hand households that cook three times per day were 220 representing about 64% of the households surveyed.

Before the commencement of data analysis and hypothesis testing the data was subjected to descriptive analysis in order to ensure data normality which is central to the conduct of multiple regressions analysis. The data was observed to be normal as the data largely lie on the diagonal line in the Normal PP Plot graph in figure 3.

Multicolinearity test was also conducted to ensure that all the constructs were on their own and independent that is no construct measures more than one construct. From the table 3 Beta coefficient, the tolerance and VIF were used to test the multicolinearity among the variables. All the tolerance values were not more than 0.10 and VIF value is not more than 10, as such there was no multicolinearity among the constructs (Pallant, 2007).

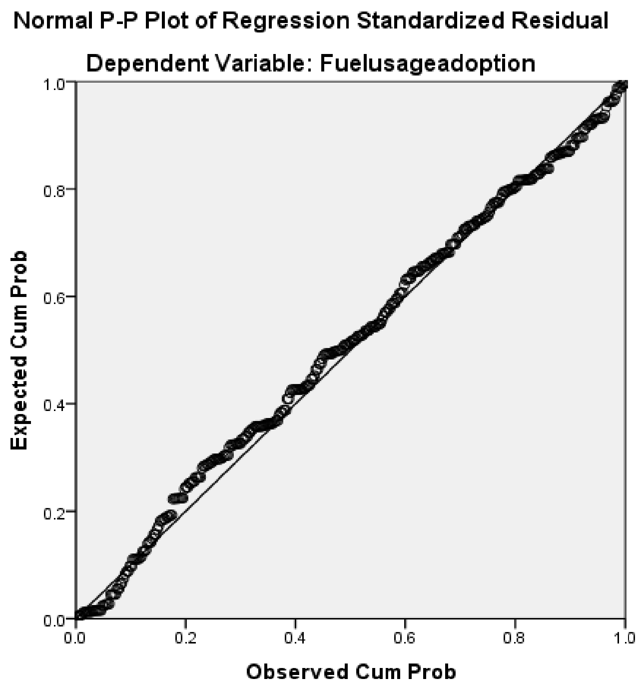


Figure 3: Normal PP Plot.

3.2.3 Validity test

The validity of the scale was tested using IBM SPSS's factor analysis with aid of exploratory factor analysis using Principal Component Analysis (PCA). In respect of the first construct; Household income/expenditure, the sample size is 342 which is above 300 sample size that is considered good sample size according to Tabanick and Fidell (2007). The Kaiser-Meyer-Olkin (KMO) is 0.611 which is above the minimum standard and considered suitable. Bartett's test of sphericity Approx. Chi-square is 77.862, df is 10 and sig. is 0.000, which is less 0.50. Also the communalities were above the minimum standard of 0.50, except HIE3 with 0.476. In addition, from the total correlation matrix, some of the coefficients were above 0.30. The variance explained of the entire variables was 62% which can be considered satisfactory according to Hair et al (2010). Therefore, only HIE1, HIE2, HIE4 and HIE5 are valid to measure construct.

With regard to Education level/exposure of household, the sample size is 342, the Kaiser-Meyer-Olkin (KMO) is 0.659, Bartett's test of sphericity Approx. Chi-square is 122.002, df is 10 and sig. is 0.000. All the items have communalities above 0.50, except EEH3 with 0.469. Therefore, EEH1, EEH2, EEH4 and EEH5 are the only items to measure the construct. In the case of family size of household, the sample size remains 342, the Kaiser-Meyer-Olkin (KMO) is 0.542, which is above the minimum standard of 0.05. Bartett's test of sphericity Approx. Chi-square is 173.053, df is 10 and sig. is 0.000 which is less than 0.05. Communalities for HFS1 is 0.304 where as the remaining items have the communalities above 0.50. As such, only HFS2, HFS3, HFS4 and HFS5 are the only items to measure the construct. The modern fuel supply security also has the sample size of 342, the Kaiser-Meyer-Olkin (KMO) is 0.607, Bartett's test of sphericity Approx. Chi-square is 209.440, df is 28 and sig. is 0.000 which is less than 0.05. The MFS4 has the communalities of 0.459, MFS7 has 0.334 and MFS8 has 0.486, while MFS1, MFS2, MFS3, MFS5 and MFS6 have their communalities above 0.50. Therefore, MFS1, MFS2, MFS3, MFS5 and MFS6 are the only items to measure the construct. In the case of Fuel Usage/adoption by household, the sample size is 342, the Kaiser-Meyer-Olkin (KMO) is 0.738, Bartett's test of sphecricity Approx. Chi-square is 161.384, df is 15 and sig. is 0.000 which is less than 0.05. The communalities for FUH2 is 0.249 and FUH3 is 0.391 while the remaining items have the communalities above 0.05. As such only FUH1, FUH4, FUH5 and FUH6 are the only items to measure the construct.

Table 1: Factor loading: Rotated Component Matrix of Household income/expenditure, Education/Exposure, Household family size, Modern fuel supply and Fuel choice adoption.

Code	Items	Component
HIE2	Though my income has increased in recent times, I still use biomass for cooking	0.557
HIE3	It cost a lot of money to acquire modern stoves for cooking	.577
HIE4	One of the ways to promote the use of modern energy fuel is through the subsidising of the acquisition of the fuel technologies.	.540
HIE5	Higher prices of modern fuel make household to mix modern fuel with traditional fuel that are relatively cheaper.	0.525
EEH1	Household with highly education heads usually LPG or electricity for cooking.	.625
EEH2	We use modern fuel such as electricity and LPG because my friends also use them	.527
EEH4	Using different fuel satisfy my taste.	.679
EEH5	Household fuels choice is affected by fuel choice of family relations, friends and associates.	.528
HFS2	It cost a lot of money to rely on modern fuel in large household.	.750

HFS3	We use traditional fuel during celebration such as naming and weeding ceremonies due to the number of people that partake in the security.	.620
HFS4	Family size induces multiple fuel choice behaviours as a way of ensuring fuel security.	.599
HFS5	Large households indicate the availability of labour for biomass collections.	.683
MFS1	Electricity supply in my neighbourhood is erratic.	.570
MFS2	There is constant supply of electricity in my neighbourhood.	.671
MFS3	There is constant supply kerosene in my neighbourhood	.533
MFS5	Though I use electricity for cooking but I still use fuel wood and charcoal because of the supply reliability challenges of modern fuel.	.681
MFS6	Nigeria roads are in good condition so it is easy to transport energy resources.	.574
FUH1	I use modern energy because it is clean.	.549
FUH4	I use fuel wood for cooking because the kind of food I cook is best cooked using fuel wood.	.519
FUH5	Though I use gas I complement it with other fuels because of the high cost of gas and electricity.	.503
FUH6	Number of times I cook determines my fuel choice	0,509

3.2.4 Regression analysis and Test of Hypotheses

After meeting the key assumptions of regressions analysis (figure 2 and table 3) data analysis was conducted the result used to test the hypotheses of the study using and multiple regression and simple linear regressions analyses.

Table 2: Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
W1	.502[a]	.252	.243	.54143

a. Predictors: (Constant), Modern fuel supply, Household Income, Family size of household, Education level and exposure

b. Dependent Variable: Fuel usage/adoption

The model summary depicted in table 2 shows the r and the r^2 value of the model. It can be seen that the model has an r value of .502 and an r^2 value of .25. It means that the model explains about 25% variation in the dependent variable. Thus the four variables together explain about 25% variation in the model.

Table 3: Beta Coefficients[a] Collinearity Statistics

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.627	.288		2.179	.030		
	Income level of Households	.204	.057	.176	3.556	.000	.909	1.100
	Education level/exposure	.229	.054	.221	4.251	.000	.823	1.216
	Family size of household	.320	.057	.284	5.582	.000	.857	1.166
	Modern fuel supply security	.048	.060	.042	.795	.427	.813	1.229

a. Dependent Variable: Fuels usage /adoption

The Beta coefficient and collinearity statistics table shows the individual construct contributions to the model and the tolerance and variance inflation factor. From the table three constructs make unique and significant contribution to the model. FSH (family size of households) makes the greatest unique contribution to the model contributing about 28% of the variance in the DV with a p value of .000 which is less than 0.05($p<0.05$). This is followed by the construct ELH (educational level / exposure of households) which makes the second biggest contribution to the model contributing about 22 % of the variance in the DV with a p value of .000 which is less than 0.05. Construct ILH (income level of households) makes the third unique and significant contribution to the model. The construct contribute about 18% of the variance in the DV with a p value of 0.000 which is less than 0.05($p<0.05$). MFSS (modern fuels supply security) contributes about 4% of the variance in the DV with a p value .427 which is greater than 0.05. Thus the contribution of the construct is insignificant.

3.2.5Test of Hypotheses

The hypotheses to be tested are restated below.

2. Education Level of households /exposure level does not significantly affect households' fuels usage decision.
3. Fuel stacking behaviour of households is not significantly affected by family size.
4. Modern fuels supply security does not significantly affect households' fuel adoption behaviour.

The decision rule guiding hypothesis testing is provided below:

Reject Ho if $P < 0.05$

Accept Ho if $P > 0.05$

1. Going by the decision rule above and on the basis of the data in table 3 the null hypothesis which states that *households' fuels adoption decision is independent of households' income level* is rejected and the alternate hypothesis which states that *households' fuels adoption decision is dependent on the income level of households level* is accepted.

2. Going by the decision rule and the data in table 3 the null hypothesis which states that *Education exposure level of households does not significantly affect households' fuels usage decision* is *rejected and the alternate hypothesis which states that education/exposure level of households significantly affect the fuel usage decision of households* is accepted.

3. Going by the decision rule and data in table 3 the null hypothesis which states that *family size of households does not affect the fuel stacking behaviour* is rejected and the alternate hypothesis which states that *family size does not significantly affect fuel stacking behaviour of households* is accepted.
4. Going by the decision rule and the data in table 3 the null hypothesis which states that *modern fuel supply security does not significantly affect households' fuels adoption behaviour* is accepted.

4.1 Summary of findings

The findings from the study indicate the use of multiple fuels by households in the study area. The findings also show the glaring absence of linear transition by households in terms of fuels usage. Thus the findings negate the energy transition prescribed by the energy ladder model. These findings are in line with the works of Leach, (1992), Masera et al, (2000) Heltberg, (2003) Suliman, (2010).

The findings also show the income level of household's impact reasonably on households' choice of cooking fuels but does not largely infer transition from traditional to transitional and finally to modern fuels. As income increases households tend to adopt newer or probably modern fuels but not perfectly substituting traditional fuels with modern or transitional fuels. These findings tally with the findings of Leach, (1992), Masera et al, 2000; Heltberg, (2003) Suliman, (2010) Ogwumike et al, (2014).

Another important variable that affects considerably the choice of modern fuels by households is the educational level or exposure of household's head. The more educated or exposed households are usually more inclined to adopt modern fuels. Though the findings of this study show widespread adoption by more educated households but the findings also show widespread fuels stacking as shown by the works of Hertberg, (2003) Suliman, (2010) Mensah and Adu, (2013).
Finally findings on modern fuels supply security show that modern fuels supply challenges caused by frequent power outages, non availability of LPG are other supply disruptions doe not in a significant way affect fuel stacking behaviour fo households. These findings sharply contrast with previous findings by Leach, (1992), Masera et al, (2000), Heltberg, (2003), Mekennon, (2009), Suliman, (2010) Ogwumike et al, (2014).

4.3 Research Limitations and.

The study has some limitations that are worth noting. These include the following:
1. The study surveyed households in Bauchi metropolis which is the capital of Bauchi State. The energy consumption pattern maybe different from what obtains in rural and semi urban areas. It may be construed that the data obtain from this study may help to explain households choice of cooking fuels or other general characteristics. We recommend for caution in that regard.
2. The constructs or IVs of the study used in the study are only four. The choice of the constructs was guided by the previous dominant literature. However the model explains only about 25% variance in the DV leaving room for about 75% of the influence to other constructs not used in the study.
3. Finally the study focused on cooking fuels used by households instead of general energy utilization by households.

4.4 Suggested Areas for Future Researches

We submit that the following research areas are germane and have immense research potentials. They include
1. Households willingness to pay for improved supply of modern fuels
2. Economic costs of indoor pollution resulting from biomass dependent cooking
3. Modern fuels supply challenges in rural areas of Northern Nigeria

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