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Determinants of Liquefied Petroleum Gas (LPG) Use Among Households in Northern Ghana

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Abstract
This paper examines the determinants of Liquefied Petroleum Gas (LPG) use in Northern Ghana using a cross-sectional data obtained from 196 households. Data were analyzed for descriptive statistics as well as a binary probit regression for identification of factors that influence households' decision in the usage of LPG in northern Ghana. The results show that LPG use in northern Ghana by households is very low (37.8%). The findings of the paper also show that LPG use in northern Ghana is influenced by education, household size, household income, cost of LPG, residence of household, fear of LPG explosion and access to LPG. It can therefore be concluded that in order to promote the use of LPG in northern Ghana, efforts must be on public education to address perception of high risk of LPG use for cooking in households by Energy Commission (EC), National Petroleum Commission (NPA), Non-Governmental Organisations (NGOs), National Commission for Civic Education (NCCE) and Community Based Organisations (CBOs). There is also the need for government to create and sustain an enabling environment for the public and private sectors investors to establish large LPG bottle refilling plants, that are able to test, certify and refill LPG cylinders for the market and also offer incentives to encourage private LPG retail/service companies to build up distribution network and retail outlets. It is also recommended that, government should re-introduce the door to door marketing and distribution of filled LPG cylinders and also redirect the current subsidy away from LPG fuel to domestic LPG equipment/appliances to make it possible to retarget the subsidy at domestic users. There is the need to intensify poverty reduction strategies by government to reduce income poverty so as to increase the usage of LPG in addition to improving access and affordability of clean fuels especially LPG to rural households. Finally, Policies on promoting universal education should be bolstered as they have varied implications on the decision to use LPG.
Keywords: LPG, binary probit regression and northern Ghana

Introduction

Energy is crucial for achieving almost all of the Sustainable Development Goals, from its role in the eradication of poverty through advancements in health, education, water supply and industrialization, to combating climate change. This is why the SDG 7 is aimed to ensure access to affordable, reliable, sustainable and modern energy for all by the year 2030.

Increasing household use of liquefied petroleum gas (LPG) is one of several pathways to meet the goal of universal access to clean cooking and heating solutions by 2030, as stated in the United Nations' Sustainable Energy for All Initiative report (2012). The United Nations' Sustainable Energy for All Initiative, launched in 2011, sets as one of its three objectives universal access to modern energy services—electricity and clean cooking and heating systems—by 2030. According to the Sustainable Energy for All Initiative 2012 report, about three billion people rely on solid biomass or coal for cooking and heating, and smoke from such fuel use is estimated to cause four deaths every minute. Effective and sustained access to energy plays a significant role in improving people's living conditions, and contributes to economic and human development. Energy provides services to meet many basic human needs, particularly heat, mechanical power (e.g. water pumps and transport) and light. Business, industry, commerce and public services such as modern healthcare, education and communication are also highly dependent on access to energy services.

Indeed, there is a direct relationship between the absence of adequate energy services and many poverty indicators such as infant mortality, illiteracy, life expectancy and total fertility rate. Inadequate access to energy also exacerbates rapid urbanisation in developing countries, by driving people to seek better living conditions (Ghana Energy Commission, 2012).

Despite this, over 1.6 billion people in developing countries are deprived of access to reliable and affordable energy services such as electricity and LPG, and over 80% of the population of Sub-Saharan Africa use traditional biomass for cooking and heating (UNDP, 2004). With more than one-third of a household's budget being set aside for fuel costs in many countries, the region's population pays an onerous price for fuel (mainly biomass) that is of poor quality and not very effective.

The International Energy Agency (IEA) has forecasted that use of traditional biomass will decrease in many

countries, but it is likely to increase in South Asia and sub-Saharan Africa alongside population growth. Overall, the IEA forecasts that by 2030, the total number of people reliant on biomass will not have changed significantly. While the use of traditional energy sources is not necessarily undesirable in itself, concerns have been raised over how they are currently being used.

Modern energy sources, such as electricity and petroleum-based fuels, generally provide only a small part of the energy use of poor rural people. This is mainly because they are too expensive and because it is difficult to achieve regular supplies to isolated rural communities. The predominance of traditional fuels for cooking however takes a heavy toll on the environment through desertification and soil erosion, and the absence of modern fuels propels the poverty spiral further downward. The International Energy Agency estimates that more than 40 percent of households newly gaining access to modern household energy by 2030 in the universal-access scenario will do so by switching to LPG.

In recognition of the critical need to improve global access to sustainable, affordable and environmentally sound energy services and resources, the United Nations General Assembly has declared 2012 the International Year of Sustainable Energy for All (SE4ALL) and urged Member States and the UN system to increase the awareness of the importance of addressing energy issues and to promote action at the local, national, regional and international levels. In response, the UN Secretary General has launched a global Initiative to achieve "Sustainable Energy for All by the year 2030". The key objectives of this initiative are: (1) ensuring universal access to modern energy services; (2) doubling the rate of improvements in energy efficiency; and (3) doubling the share of renewable energy in the global energy mix.

According to the Energy Commission report in 2010 about 40.3 % of households in Ghana use firewood for cooking but the proportion of households in rural areas using firewood for cooking is much higher (62.1%) than in urban areas (25.8%), and also much higher in the Savannah (71.5%) than in the Forest areas (57.2%) and Coastal areas (52%). On average a household in Ghana uses 1,064.7kg of firewood annually, but there are regional and rural/urban disparities. Households in urban areas consume an average of 986.2kg of firewood per year compared to a rural household of 1,113.4kg. In terms of rural areas, households in rural forest consume an average of 1,085.2kg per year whilst a household in the savannah area is 1,165.5kg of firewood per year (Ghana Energy Commission report, 2010).

Available statistics from the National Petroleum Authority (NPA) 2015 report show that Northern, Upper East and Upper West Regions account for only 3% of the total national consumption of LPG in the country which stands at about 242,000,000 kilograms. This suggest that majority of the people in northern Ghana depend on the environment to meet their fuel needs. Thus, about 78.8% of households in the country use charcoal. The Northern Region has the highest proportion of households (90.5%) using charcoal. About 80.1% of urban households surveyed in the Region use charcoal whilst in rural areas, 76.1% of households use charcoal.

Averagely, a household in Ghana consumes 434.4kg of charcoal every year (NPA, 2015). However, households in the Northern Region consume an average of 510.1kg of charcoal per annum whilst their counterparts in the Upper-East Region consume an average of 363.9kg of charcoal per year. In the case of rural and urban households, it was estimated that an average of 440.2 kg of charcoal is consumed per year in a rural household whilst a household in urban area consumes an average of 430.7kg of charcoal per annum (NPA, 2015).

Heavy dependence on biomass for cooking and heating is also increasing the pressure on local natural resources and accelerating degradation. With the rapid increase of urbanization (currently 3.6%) (World Urbanization Prospects, 2009, UN, DESA) energy access will become a key urban issue as well in the near future with accelerated demand for wood fuel - especially charcoal - which is the fuel of choice for most residents in northern Ghana. However, unsustainable production and incomplete combustion of biomass is a significant contributor to climate change through the emission of greenhouse gases such as carbon dioxide and methane, and aerosols such as black carbon.

As the primary bearers of the burden of collection and use of biomass, women and children, are disproportionately exposed to health, safety, and security risks. Biomass use forces women and children to spend many productive hours each week gathering fuel wood. The UN-Energy report (2005) estimated that, in resource-depleted areas, people spend up to five hours gathering fuel wood, a burden that mostly falls on women and girls. Time spent on foraging for wood impedes investments in education and livelihood-enhancing activities.

Currently, less than 10 percent of Ghanaian households use LPG as their primary source of fuel for cooking (GLSS, 2006) with many households heavily dependent on biomass energy. With a deforestation rate of 2% (22,000 hectares) per annum, continual dependence on fuel wood from Ghana's tropical forest—estimated to be only 25 percent of its original size (UNDP, 2004)—is unsustainable and poses serious setbacks to the socioeconomic wellbeing of its citizens. Estimates indicate that demand for wood fuel could double by 2016 if urgent comprehensive actions are not taken to salvage the situation especially since the growth rate in demand surpasses the growth in supply of fuel wood in the country.

This paper therefore seeks to examine the factors that influence households' decisions on the usage of LPG

in Northern Ghana. The paper examines the socio-demographic and economic factors that influence the use of LPG in Northern Ghana. The findings of the paper are of immense relevance to policy as they would contribute to the National Petroleum Authority's (NPA) efforts to carry out effective campaign on the access and use of LPG in Northern Ghana and the country at large and also help the EPA to formulate strategies and policies to protect the environment. It would also provide concrete evidence on the need to intensify poverty reduction strategies to boost income levels so as to reduce dependence on the environment for the supply of cooking fuel to foster sustainable development. Again, this paper offers more evidence to policy makers on the need to promote afforestation programs to curtail the high rate of deforestation as a result of demand for biomass. It further reveals that a supply side constraint accounts partly for the huge dependence on biomass, hence the need to enhance distribution of LPG especially to rural areas.

Overview of Ghana's Energy Sector

Ghana is relatively well endowed with a variety of energy resources including biomass, hydrocarbons, hydropower, solar and wind. It also has the capacity to produce modern bio-fuels. The vision of the energy sector is to make energy services universally accessible and readily available in an environmentally sustainable manner (Energy Commission, 2017).

PG is produced by the nation's single oil refinery, the Tema Oil Refinery, together with other petroleum products such as gasoline and kerosene. LPG production levels have fluctuated over the years, ranging from 75,300 tonnes in 2005 to 31,600 tonnes in 2010. The shortfall in supply is compensated for through imports.

According to the National Petroleum Authority (NPA) 2012 report, the consumption of LPG has been rising steadily from 45,000 tonnes in 2000 to 178,400 tonnes in 2010. Gasoline, gas oil and other petroleum products also rose over the period. The consumption of kerosene however showed some fluctuations over the years

The bulk of energy supply in Ghana is met from wood fuels, i.e. firewood and charcoal. Wood fuels account for over 70% of total primary energy supply and about 60% of the final energy demand (Ghana Energy Commission, 2012). The supply of primary wood fuel in 2009 was estimated to be 20 million tonnes (Ghana Energy Commission, 2012). The supply of firewood was estimated to be 9.2 million tonnes, whilst that of charcoal was estimated to be 2.2 million tonnes in 2009.

According to the Ghana Energy Commission 2012 report, about 90% of wood fuels is obtained directly from the natural forest. The remaining 10% is from wood waste i.e. logging and sawmill residue, and planted forests. The transition and savannah zones of Ghana, mainly the Kintampo, Nkoranza, Wenchi, Afram Plains, and Damongo districts provide the bulk of dense wood resources for wood fuels. However, wood fuel resources are depleting at a faster rate as a result of unsustainable practices in the production and marketing of the product that incurs high levels of waste. According to the UN Food and Agriculture Organisation (FAO), the rate of deforestation in Ghana is 3% per annum (FAO, 2002).

In 2000, the annual production or yield of wood was about 30 million tonnes of which about 18 million tonnes was available and accessible for wood fuels (Ghana Energy Commission, 2012). Although the exploitation of wood resources for wood fuels is not the main cause of deforestation, there are indications that the preferred wood fuel species are gradually disappearing. The major charcoal production areas of Donkorkrom, Kintampo, Nkoranza, Wenchi, and Damongo show physical signs of depleted wood fuel resources. As a result, producers have to travel longer distances in search of wood for charcoal production.

Charcoal and fuelwood are normally transported from the production centres (mainly in the rural areas) to the major cities and other urban centers where they are sold by wayside retailers to final consumers. A fraction of the charcoal produced is, however, exported to West African and European markets. The wood fuel industry is handled almost exclusively by private individuals with little regulation by the Government. The most recent regulatory measure introduced by the Energy Commission is the ban on the export of charcoal produced from unapproved sources, that is, sources other than sawmills residue or forest planted for that purpose. Thus, exporting charcoal produced from the direct wood sources, that is, wood harvested from the natural forest, is not allowed. Since July 2003, all exporters of charcoal are required to obtain a permit or license from the Energy Commission.

It is estimated that 20 million tonnes of wood fuel are consumed annually in the form of firewood or converted for use as charcoal (Ghana Energy Commission, 2012). According to the Energy Commission 2012 report, majority of households (about 80%) in Ghana depend on woodfuels for cooking and water heating in addition to commercial, industrial and institutional use, and the demand for wood fuel has for the past years been on the increase. If this trend of consumption continues, Ghana is likely to consume more than 25 million tonnes of wood fuel by the year 2020. Most of the wood fuel supply will come from standing stocks i.e. 15 million tonnes from standing stock and the rest 10 million tonnes from regeneration or yield. This means that wood fuel supply will no longer come from regeneration but from standing stock. The implication is a direct depletion of standing stocks hence an increase in the rate of deforestation.

Liquefied Petroleum Gas (LPG) Usage

In 1989, the Ministry of Energy embarked on a programme to promote the use of liquefied petroleum gas (LPG) as part of the Government's efforts to reduce deforestation of the country from the overdependence on wood fuels (GLSS, 1988). The promotion targeted households, public catering facilities and small-scale food sellers. As a promotional strategy, 14.5kg and 5kg LPG cylinders were distributed freely to the public. Consumers were either given free cylinders on request or were given cylinders filled with gas, but they were required to pay for the cost of the gas only.

Furthermore, to enhance fast distribution and delivery of LPG to consumers, the Ministry of Energy purchased and assigned pick-up trucks provided with 50 cylinders each to registered private individuals to retail LPG. The trucks operated "door-to-door" services to increase access and bring LPG closer to consumers conveniently. The promotional programme was extended to the educational institutions, hospitals and prisons, which benefitted from free plant and equipment installations. A fund, the LPG Fund was created with a levy placed on LPG purchases to fund the purchase and maintenance of cylinders, LPG tanks and kitchen equipment for institutions. The LPG Fund was used to finance the local component of the cost of constructing the Ghana Cylinder Manufacturing Company (GCMC) factory in Accra (Ghana Energy Commission, 2012).

These initiatives were successful, increasing the annual consumption of LPG from 5,000 tonnes in 1990 to 34,000 tonnes in 1994 (Ghana Energy Commission, 2012). Annual LPG consumption grew from 45,000 tonnes in 2000 to 220,000 tonnes in 2009 but dropped to 178,000 tonnes in 2010 due mainly to a long shutdown of the Tema Oil Refinery. In 2006, an estimated 9.5% of Ghanaian households used LPG as the main source of fuel for cooking (Ghana Energy Commission, 2012).

The demand for LPG has grown considerably averaging over 40% between 2000 and 2010 (Ghana Energy Commission, 2012). The existing infrastructure at Tema Oil Refinery is inadequate to meet the present demand. The refinery production facility in the country and has a daily production rate of 200-250 tonnes/day. This is a fraction of the daily demand of the country of about 1,000 tonnes (Ghana Energy Commission, 2012). The refinery has a current storage capacity of 6,300 metric tonnes which is insufficient for the growing demand for the product by both commercial and domestic users. The situation has resulted in intermittent severe shortages of LPG in the country. This has led to some households going back to the use of charcoal or at least using it as a back-up fuel for cooking.

Again, about 50% of LPG supplies could come from the Atuabo gas facility processing the wet associated gas from the Jubilee field. For instance, processing 100 mmscfd of the wet gas would provide at least additional 500 tonnes of LPG a day, which would be enough to meet the country's projected short to medium term demand of 400,000-450,000 tonnes per annum by 202061. Ability to meeting this supply requirement would translate into achieving the country's target of 50% penetration by 2020 (Energy Commission, 2017).

The purpose of the LPG programme was defeated when taxi cabs and other commercial vehicles started patronizing LPG as a fuel for their cars and the levy was also scrapped in February 1998. The country's weekly consumption of LPG is currently, estimated at 4,000 tonnes with the transport sector accounting for about 37% (Ghana Energy Commission, 2012). Commercial vehicle drivers have found LPG cheaper than other transport fuels due to higher price differential between LPG and gasoline. This price differential is mainly as a result of the subsidy component on LPG in the price build-up, which was designed for domestic users with the primary objective of helping households to meet their demand at an affordable price. The government of Ghana in 2013 spends about GH¢14 million subsidizing LPG every month and there are plans to review the LPG subsidy scheme because it is not benefiting only the intended beneficiaries, as well as the fact that the scheme was becoming unsustainable (NPA, 2013). In 1994, the Road Traffic (use of Liquefied Petroleum Gas) Regulations, 1994, LI 1592 were passed to regulate the use of LPG as fuel in vehicles. The enforcement of LI 1592 has been ineffective leading to the blatant abuse of the LPG subsidy by commercial vehicles.

Most second cycle schools, hospitals and prisons which embraced the LPG programme have also gone back to the use of charcoal and firewood for cooking because of supply difficulties. In 2006, the Household Energy Project (sponsored by the UNDP) also supported 22 schools to convert their kitchens to the use of LPG. After 6 months of use, the schools abandoned LPG because they found LPG more expensive than firewood.

In 2006, the UNDP assisted the Ministry of Energy to implement a Household Energy Project (HEP). The goal of the project was to enhance access to sustainable energy services for cooking in Ghana. A key objective of the project was to encourage the use of efficient charcoal and firewood stoves. The Implementation of the project resulted in (i) development of a woodfuel policy, (ii) development of safety standards for LPG in the household and commercial sectors and (iii) implementation of pilot projects to test policy recommendations.

Specifically, the project introduced improved wood burning stoves made from metal in 22 schools in the Northern and Upper-East regions. Unfortunately, 80% of the stoves were abandoned after 2 months of use primarily because they were not suitable for preparation of most traditional staple foods. However, modified traditional mud stoves were more acceptable to the users. The Ghana LPG Promotion Programme has received good responses from citizens. It has increased the consumption level year after year except 2010 (Anon, 2004).

Socio-economic and demographic variables that influence the use of LPG

The concept of household energy choice has often been explained within the context of the 'energy ladder hypotheses'. This hypothesis identifies income as the sole determinant of household fuel choice and fuel switching (Heltberg, 2003). It explains the transition in energy consumption from traditional biomass to modern sources along an imaginative ladder with improvement in the welfare (income) of households (Rajmohan and Weerahewa, 2009). Hosier and Dowd (1987) explain that households face an array of energy choices arranged in schematic order of increasing technological sophistication. The energy ladder hypothesis conceptualizes energy demand in three progressive stages. The first stage emphasizes universal dependence on biomass. Stage two involves fuel switching whereby households switch from biomass to 'transition' fuels such as kerosene, coal and charcoal in response to higher incomes and socioeconomic factors such as deforestation and urbanization. The final stage of the ladder however marks switching to the use of 'clean' modern energy such as LPG and electricity for cooking (Heltberg, 2003).

The socioeconomic and demographic variables that influence the choice of LPG usage include level of education, household size, residence (rural/urban), fear of LPG explosion, cost of LPG, household income and accessibility to LPG facilities, among others. Empirical studies of the energy ladder hypothesis include the work of Hosier and Dowd (1987) which analyzed household fuel choice in Zimbabwe using a multinomial logit model. Findings from their study despite confirming the energy ladder hypothesis that income is a major determinant of the choice of fuel type also reveal a myriad of factors (household size, location of household, i.e. urban households) that influence the type of household fuel use. Reddy (1995) also finds that although households in Bangalore, India ascend an energy ladder and the choice is largely determined by income, factors such as family size and occupation of the head of the household also influence the household's cooking fuel choice. Ouedraogo (2006) shows that the inertia of household cooking energy preferences in Burkina Faso are due to poverty factors such as low income, poor household access to electricity for primary and secondary energy, low living standard, household size, high frequency of cooking certain meals using wood fuel as cooking energy. Bello (2011) also finds households' economic wealth as a major determinant of the type of cooking energy used by households in Nigeria. Similar findings were obtained by Gangopadhyay et al., (2003), Campbell et al, (2003) and Farsi, et al, (2005).

Methodology

The study used the mixed approach. Thus combining both the qualitative and quantitative methods of data collection. The data covered the social, economic and demographic characteristics of the survey sample. These include the age of the respondent, household size, level of education, household income, residence of the respondent and accessibility to LPG facilities. The data were used to identify important characteristics influencing the use of LPG.

A multi-stage sampling procedure using both non-probability and probability techniques were used to collect the data. Northern, Upper East and Upper West regions were selected for the study because they are the three regions in the country with the lowest consumption of LPG. Simple random sampling was then used to select nine (9) districts (3 districts in each region) and six (6) communities in each district. In all, 196 respondents were selected for the study.

The empirical model

The decision of respondents to use LPG is dichotomous between two mutually exclusive alternatives i.e., the individual chooses either to use or not to use LPG. The probit model has been used in a number of empirical studies to capture the factors influencing individual decision (Kebede et al, 1990; Adesina, 1996). The decision of the i^{th} individual can be represented by a random variable y_i that takes the value of 1 if one uses LPG and 0 for non-use. It is assumed that the average utility derived from a decision by an individual respondent to use LPG is based on the attributes of the decision, which are specific to the individual. The underlying utility function which ranks the preference of the i^{th} individual is assumed to be a function of individual-specific characteristics, *'X'* (examples of such characteristics include age, sex, level of education, household income, etc) and a normally distributed error term (zero mean and constant variance): $U_{i1}(X) = \beta_1 X_i + \varepsilon_{i1}$ for use and

$U_{i0}(X) = \beta_0 X_i + \varepsilon_{i0}$ for non-use.

The utilities and the i^{th} individual would choose the alternative 'use of LPG' if and only if $U_{i1} > U_{i0}$. Therefore, for the i^{th} individual, the probability of LPG use is given by:

$$\wp(1) = \Phi(\beta X_i), \qquad (1)$$

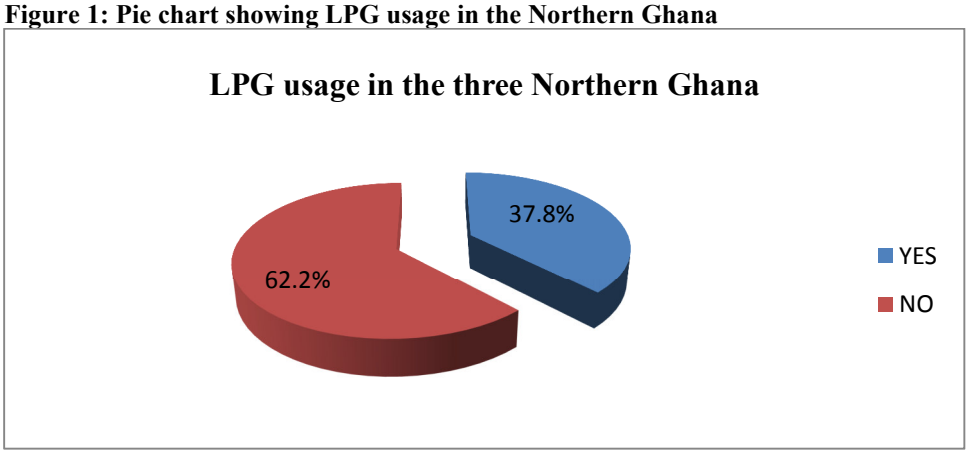
where Φ is the cumulative distribution function for ε. The functional form of Φ depends on the assumptions made about the distribution of ε. A probit model arises from assuming the normal distribution for ε (Nkamleu

and Adesina, 1999). Thus for the i^{th} individual, the probability of an individual choosing to use LPG is given by:

$$\Phi_f(\beta X_i) = \int_{-\infty}^{\beta X_i} \frac{1}{\sqrt{2\pi}} \exp\left(\frac{-t^2}{2}\right) dt \qquad (2)$$

Equation 2 can then be estimated using the probit technique (Goldberger, 1964; Dagenais, 1969; Judge et al., 1985). Ten variables (factors) were hypothesised to influence the decision to use LPG. These are gender (1 = male and 0 otherwise), age of respondent, household size, log of household income, residence of household (Dummy; 1 urban and 0 rural), fear of LPG explosion (1 = yes and 0 otherwise), cost of LPG (1 = yes and 0 otherwise), access to LPG (1 = access and 0 otherwise), inconvenience of refilling LPG (1 = inconvenient and 0 otherwise) and level of education of respondent (Dummy; 1 if respondent is educated and 0 otherwise). The dependent variable is LPG use and represented by a dummy (1 if respondent uses LPG and 0 otherwise).

Figure 1: Pie chart showing LPG usage in the Northern Ghana



Source: Field Survey, 2016

Figure 1 above shows that, 37.8% of all the respondents in the three northern regions said they use LPG whilst the remaining 62.2% of them do not use it. There are regional disparities in the usage as shown in table 1 below.

Table 1: Proportion of LPG usage by region

Region	**Do you use LPG**		**Total**
	yes	No	
Northern	34 (33%)	69 (67%)	103
Upper East	17 (42.5%)	23 (57.5%)	40
Upper West	23 (43.4%)	30 (56.6%)	53
Total	**74 (37.8%)**	**122 (62.2%)**	**196**

Source: Field Survey, 2016

Results and discussions

The parameter estimates of the probit model are shown in Table 1. The R^2 is 0.81, which means that the explanatory variables used in the model were able to explain 81% of the variation in the use of LPG in Northern Ghana.

Table 2: Probit model estimates of the factors affecting LPG use in Northern Ghana: Dependent variable is LPG use

Variable	Marginal effect	Std. Error	P value
Age	0.0032	0.00493	0.524
Sex	0.0071	0.08823	0.936
Education	0.0256***	0.0081	0.002
Household size	-0.0165**	0.00842	0.050
Log of household income	0.3353***	0.00012	0.005
Residence	0.2769***	0.08607	0.001
Fear of LPG explosion	-0.1283*	0.09209	0.064
Cost of LPG	-0.0703**	0.11476	0.044
Access to LPG	0.2187**	0.1012	0.031
Inconvenience of refilling LPG	-0.0011	0.10694	0.992
No. of obs = 196 Pseudo R2 = 0.4309 LR chi2(12) = 111.96			
Prob> chi2 = 0.0000 Log likelihood = -73.940145			

Note: significant levels are *** p<0.01, ** p<0.05, * p<0.1

The result shows that household size, fear of LPG explosion and cost of LPG have significant negative effects on the probability of using LPG in Northern Ghana. This implies that as the household size increases, the probability of using LPG would decrease by 0.0165, and again, as the cost of LPG increases the usage of it would also fall by 0.0703. Again, as the fear of LPG explosion is reduced among respondents, the chance of using LPG would increase.

Education, household income, residence and access to LPG were also having a significant positive effect on the probability of using LPG in northern Ghana. This implies that having access to education increases the probability of a household using LPG relative to those without education. Also households with higher income tend to use LPG more as compare to those with low household income. The study also reveals that urban households are more likely to use LPG relative to their counter parts in the rural areas and finally, households having access to LPG are also more likely to use it than those having difficulty in having access to it.

Conclusions and policy implications

This paper investigates the factors that influence household's decision to use LPG in Northern Ghana using household survey data to identify the factors that informed their decision. The binary probit model was adopted to identify the factors that influence household's decision to use LPG. The results indicate that the use of LPG in northern Ghana is influenced by education, household size, household income, cost of LPG, residence of household, fear of LPG explosion and access to LPG. It can therefore be concluded that in order to promote the use of LPG in northern Ghana, efforts must be on public education to address the perception of high risk associated with the use of LPG for cooking among households in Northern Ghana. There is also the need for government to create and sustain an enabling environment for the public and private sector investors to establish large LPG bottle refilling plants(one close to the Gas Processing Plant, one in Tema and eventually one each in Kumasi and Tamale), that are able to test, certify and refill LPG cylinders for the market and also offer incentives to encourage private LPG retail/service companies to build up distribution network and retail outlets and re-introduce the door to door marketing and distribution of filled LPG cylinders. Again, it is recommended that government should redirect the current subsidy away from LPG fuel to domestic LPG equipment/appliances to make it possible to retarget the subsidy at domestic users, encouraging more of them to move away from unsustainable wood fuels for cooking, and to address the problem of unintended subsidy leakage to vehicle users and also establish PPP (Private-Public Partnerships?) with LPG retailers/marketing companies to build up distribution network and retail outlets in the north. There is the need to intensify poverty reduction strategies to reduce income poverty so as to increase the usage of LPG in addition to improving access and affordability of clean fuels especially LPG to rural households. Finally, Policies on promoting universal education should be bolstered as they have varied implications on the decision to use LPG.

REFERENCES

Adesina, A.A. (1996) "Factors affecting the adoption of fertilizers by rice farmers in Cote d'Ivoire", *Nutirent Cycling in Agroecosystems* 46: 29-39. *Agricultural Economics* 4 (1): 27 - 43. Elsevier Science Publishers B.V.

Anon (2004), ―"Liquefied Petroleum Gas (LPG) -Substitution for Wood Fuel in Ghana–Opportunities and Challenges", INFOLINK, United Nation Development Programme in Ghana, pp. 1 – 8.

Bello, M., (2011). "Impact of Wealth Distribution on Energy Consumption in Nigeria": A Case Study of Selected Households'in Gombe State.

Campbell, B.M., Vermeulen, S.J., Mangono, J.J., and Mabugu, R., (2003). "The Energy Transition in action:

Urban Domestic Fuel Choice in a changing Zimbabwe". *Energy Policy 31,553–562.*

Dagenais, M. G. (1969) "A Threshold Regression Model". *Econometrica* 37: 193-203

Farsi, M., Filippini M., and Pachauri S., (2005). "Fuel Choices in Urban Indian Households". CEPE Working Paper No. 42.

Gangopadhyay, S., Ramaswami, B. and Wadhwa, W., (2003). "Access of the Poor to Modern Household Fuels in India". SERFA Report for the World Bank.

Ghana Energy Commission (2017) Report. 2017 Energy (Supply and Demand) Outlook for Ghana. Ghana Energy Commission.

Ghana Energy Commission, (2012) Report. "Energy Use in Ghana": An Outlook for the Future. Working Document. Ghana Energy Commission

Ghana Energy Commission, 2012 Report. "Ghana Action Plan for Sustainable Energy for All by 2030". Working document. Ghana Energy Commission.

Ghana. Statistical Service. (2007). *Pattern and trends of poverty in Ghana, 1991-2006*. Ghana Statistical Service.

Goldberger, A. S. (1964) Econometric Theory. John Wiley and Sons Inc., New York.

Heltberg, R., (2004). Fuel switching: Evidence from eight developing countries, *Energy Economics 26, 869–887.*

Hosier, R. H. & Dowd, J., (1987). "Household Fuel Choice in Zimbabwe" – An Empirical Test of the Energy Ladder Hypothesis. *Resources and Energy, 9, 347-361.*

Kebede, Y., Gunjal, K., and Coffin, G. (1990) "Adoption of New Technologies in Ethiopian Agriculture: The case of Tegulet-Bulga District, Shoa Province"

National Petroleum Authority (NPA) (2012) report. "Pattern of Energy consumption in Ghana, Accra".

Nkamleu, G.B. and Adesina, A. (1999) "Modelling Farmers Decisions on Integrated Soil Nutrient Management in Sub-Saharan Africa: A Multinomial Logit Analysis in Cameroon", Agricultural *Economics* (submitted).

Ouedraogo (2006). "Household energy preferences for cooking in urban Ouagadougou, Burkina Faso". *Energy Policy 34. 3787–3795.*

Rajmohan K. and Weerahewa J., (2009). "Household Energy Consumption Patterns in Sri Lanka". http://www.sljol.info/index.php/SJAE/article/download/1833/1526

Reddy, A, N and Reddy, B.S., (1994): "Substitution of energy carriers for cooking in Bangalore". *Energy- The International Journal, Vol 19, No 5, pp 561-572.*

United Nations (2005). The Energy Challenge for Achieving the Millennium Development Goals. UN Energy Paper June 22, 2005.

United Nations Development Programme (2004). "Liquefied Petroleum Gas (LPG) Substitution for Wood Fuel in Ghana – Opportunities and Challenges". A Brief Analysis of the LPG Sector in Ghana. Environment and Energy: Infolink No. 1 November 2004.