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Abdul Ganiyu Iddrisu, Euan Phimister and
Alexandros Zangelidis

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Women's Empowerment in Households and Energy Poverty in Ghana

Abdul Ganiyu Iddrisu[1] * Euan Phimister[1,2] and Alexandros Zangelidis[1]

[1]Business School, University of Aberdeen, Aberdeen, AB24 3QY, Scotland, UK.

[2]Stellenbosch Business School, Stellenbosch University, Cape Town, South Africa.

Abstract

The study explores the effect of women's empowerment on energy poverty in Ghana. Specifically, using data from the Ghana Living Standards Surveys administered in the years 1998/99, 2005/06, 2012/13 and 2016/17, and employing the ordered probit, multinomial probit, OLS and 2SLS-IV regressions, the study finds that households managed by female are more likely to use cleaner types of cooking fuel than male-headed households. Within the sub-sample of female-headed households, both *de jure* (absolute controlled) and *de facto* (partial controlled) female-headed households are more likely to use cleaner types of cooking fuel than their male-headed counterparts. However, the magnitude, at least in the case of firewood, is higher for *de jure* than *de facto* female heads, suggesting that the level of female empowerment in household potentially matters in reducing energy poverty. An analysis on household expenditure, reveals that female-headed households prioritise household food expenditure over expenditure on non-essential (such as alcohol, tobacco, and narcotics), compared to male-headed households. Avoiding expenditures on non-essentials (alcohol, tobacco, and narcotics) seems to help in the adoption of cleaner cooking fuel in female-headed households.

Keywords: Women's Empowerment, Energy Poverty, Household Head, Developing countries

JEL: D1, J16, O13

1. Introduction

Women's empowerment is a multifaceted concept, where women are regarded active subjects and agents of social change, rather than passive objects (Chaudhary, Chani and Pervaiz, 2012). In a household setting, the concept of empowerment is to rectify the power imbalance between men and women which severely constrains the achievement of household welfare. Previous literature has highlighted the importance of women's empowerment in households in the improvement of the general welfare of the household (see Guyer, 1980; Blumberg, 1988; Kennedy and Peters, 1992; Duflo and Udry, 2004; Malhotra and Schuler, 2005). In particular, the effect of female

* Corresponding author: a.iddrisu.19@abdn.ac.uk - agiddrisu1@gmail.com.

household headship on income, food security, and nutrition is evident in various existing studies (see Kennedy and Peters, 1992; Ozawa and Lee, 2006; Mallick and Rafi, 2010; Felker-Kantor and Wood, 2012; Sharaunga Mudhara and Bogale, 2016). However, the effect of female headship on household energy-poverty has not yet been given any empirical attention. Empowering women and eliminating energy-poverty are a crucial concern of the Sustainable Development Goals (SDGs) of the United Nations; understanding how women's empowerment influence energy-poverty in households is vital to inform policy.

In a developing country context, energy poverty is defined as the lack of access to modern energy services, namely electricity and clean fuels for cooking (International Energy Agency, 2010). It follows the energy ladder hypothesis, households that use advanced forms of cooking fuels (eg. electricity and gas) are said to be energy rich followed by those that use transition fuels (eg. charcoal), and those that use primitive fuels (eg. firewood) are said to be energy poorer households. Almost half of the world's population, including 700 million Africans rely on biomass fuels for cooking. Biomass fuels are typically burned in open fires, often indoors, leading to high levels of household air pollution from smoke. Women and children experience high exposures to smoke in and around the home due to gender-based domestic roles and these exposures have been linked to a range of adverse health outcomes (Gordon, Bruce & Grigg, 2014; WHO, 2014). It might be, expected that, if women are empowered in households, they are more likely to adopt cleaner forms of fuel, thus reducing energy poverty. Not least because women are often more likely to adopt healthier lifestyles than men (Mencher, 1988; Duflo and Udry; 2004).

Despite these important discussions, literature on how female headship in households influences energy poverty is limited. Although in the existing literature the gender of household head is often controlled for as a potential determinant of energy-poverty, to the authors' knowledge, there is no explicit study on the nexus between female headship or empowerment in households and energy poverty. Yet, understanding the issue is essential if policy makers are to enact targeted policy interventions towards the elimination or reduction of energy poverty. Does female empowerment in households influence the adoption of cleaner main cooking fuel? The study explores the above question and investigates the effect of female empowerment in households on household food expenditure and on non-essential expenditures using micro-level, repeated cross-sectional data from four (4) rounds of the Ghana Living Standard Survey (GLSS) administered in the years

1998/99, 2005/06, 2012/13 and 2016/17. In particular, this study investigates whether female-headed households adopt cleaner main cooking fuel compared to their counterpart male-headed households. Identifying the impact of women's empowerment on the adoption of cleaner main cooking fuel from other factors in this type of data is clearly challenging. To do this we consider different dimensions available in the data. We are able to distinguish between male headed households, *de jure* female- and *de facto* female-headed households expected to be important in the level of women's empowerment. Women, apart from being legal heads of the household as a result of being single, divorced or widowed (*de jure* heads), often also oversee household decisions in the absence of the man (*de facto* heads). Previous studies found that *de jure* female-headed households are more likely to be poorer but have similar physical assets with full control over them as their male-headed counterparts. In terms of agricultural production, they achieve similar levels of crop diversification compared to male-headed households (Horrell and Krishnan, 2007). Here we make a distinction between male-headed, partially female-headed (*de facto*) and fully female-headed (*de jure*) households to help identify the impact of women's empowerment on adoption of cleaner main cooking fuel.

Female-headed households, according to Rosenhouse (1989), are generally poorer and have less access to credit, and as such less able to smoothen consumption over their lifetime relative to male-headed households. However, previous literature has established that they have positive household management behaviours when they have control over household resources e.g. in terms of food consumption and avoiding expenditure on non-essential items (Mencher, 1988; Peters and Herrera, 1989; Duflo and Udry, 2004). There are therefore good reasons to expect the adoption of cleaner forms of main cooking fuel in their households despite their lower level of income. Mencher (1988) noted that in absolute terms, the amount of money devoted in male-headed households on sustenance is often greater than that in female-headed households, but in relative terms, as a proportion of income, it is lower than that in female-headed households. Further, Peters and Herrera (1989); Mencher (1988); Duflo and Udry (2004) indicated that, although most female-headed households allocate a larger share of their budgets to food, they spend less on alcoholic beverages than do male-headed households, suggesting better outcomes for all household members in terms of nutrition and health in female-headed households. In light of female heads' expenditure prioritisation, female-headed households are expected to favour the adoption of cleaner forms of cooking fuel when given decision making power in households, To support the hypothesis that

female headed households behave differently, we investigate the effect female empowerment in households has on household food expenditure and on expenditures that are non-essential to the household sustenance (alcohol, tobacco and narcotics[2]), relying on the Engel curve hypothesis. Expenditure on non-essential items may limit the household's ability to afford and use cleaner cooking fuels. To this effect, we examine whether reduced expenditures on non-essential items may help in the adoption of cleaner cooking fuel in female-headed households.

After controlling for household and individual characteristics, we found that female-headed households are more likely to use cleaner forms of cooking fuel, such as electricity or gas, compared to male-controlled counterparts. Within the sub-sample of female-headed households, the same patterns are estimated both in *de jure* (absolute controlled) and *de facto* (partial controlled) female-headed households, however, the magnitude of the effects is larger in *de jure* than *de facto* female-headed households. The analysis on household expenditure offers some insights that may help us explain these findings. Particularly, female-managed households are found to prioritise household food expenditure over non-essential (alcohol, tobacco, and narcotics) expenditure compared to male-headed households.

The results suggest that *de facto* female-headed households allocate higher budget share for food than male-headed households, male-headed households tend to allocate higher budget share for non-essential items than their female-headed counterparts. The results also suggest that avoiding expenditures on non-essential items helps in the adoption of cleaner cooking fuel in female-headed households. Specifically, female-controlled households who spend less on non-essential items tend to use cleaner cooking fuel in their households.

The rest of the paper is organized as follows: Section 2 presents an overview of literature, comprising women's empowerment in households, the energy ladder and expenditure preferences across gender and reviews related existing evidence. Section 3 presents discussion on the methodology (the model and estimation strategy, the data and variable measurement) employed to achieve our stated objectives. It also includes the summary and descriptive analysis of the data. Section 4 contains the results and analysis. Finally, in section 5 the study provided conclusion and recommendations.

[2] The available indicators of household non-essential expenditure in the data.

2. Overview of the Literature

2.1 Women's Empowerment in Households

Women's empowerment refers to making women active subjects in decision making rather than passive objects (Chaudhary, Chani and Pervaiz, 2012). In the household setting, females often gain the power to oversee household decisions when they become head of the household. Previous household studies often group households by the gender of the head (thus, male- and female-headed households) to assess the effect of women's empowerment on various outcome variables. For example, Sharaunga Mudhara and Bogale (2016) try to identify the food security status of 300 primary female-headed households in Msinga, South Africa using the Household Food Insecurity Access Scale (HFIAS). They find that female-headed households with higher levels of economic agency, physical capital empowerment, psychological empowerment and farm financial management skills empowerment were more likely to be food secure. However, in Bangladesh, Mallick and Rafi (2010) find no significant differences in the food security between male- and female-headed households. Duflo and Udry (2004) find in Ivory coast that rainfall shocks associated with high yields of women's crops shift expenditure towards food. In rural Zimbabwe, Horrell and Krishnan (2007) find female-headed households' productivity to be lower only for growing cotton than male-headed households. Using data from Malawi and Kenya, Kennedy and Peters (1992) find that food security and preschooler good nutritional status are influenced by the interaction of income and the proportion of income controlled by women rather than simply one or the other. On the contrary, Felker-Kantor and Wood (2012) in Brazil find food insecurity to be higher among female-headed households compared to male-headed households, but the presence of adult females to reduces food insecurity.

Additionally, female-headed households are further divided into two subgroups, *de jure* and *de facto* female-headed households. *De jure* female-headed households are those in which a woman is considered the legal and customary head of the household. In Ghana, *de jure* households include unmarried women and those who are either divorced, separated or widowed. Typically, in *de jure* households, the female head of household is likely to have absolute control over most household income and assets. *De facto* female-headed households are those where a woman is the head often as a result of the absence of an adult male in the household. In these households, husbands or other male relatives often still play a role in basic decision making and make varying contributions to

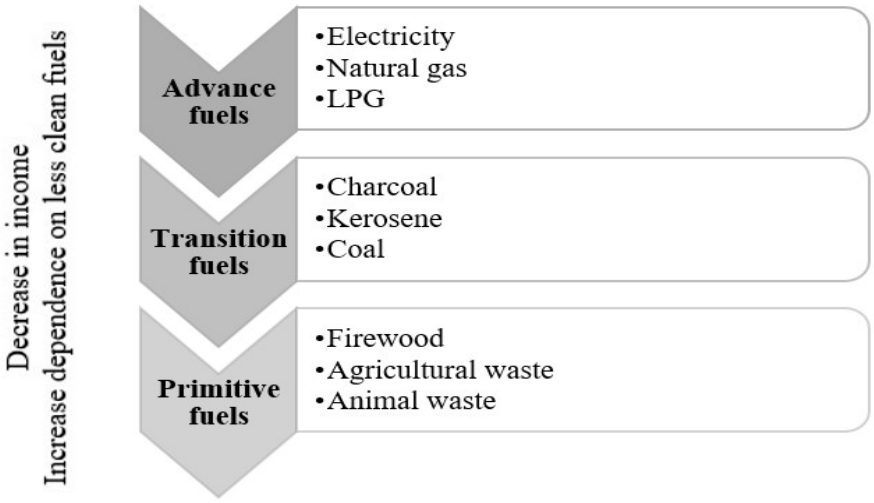
household incomes. Therefore, the head often does not have absolute control of income and assets in this household. Similar characterization is used in other countries, such as Malawi for example (Kennedy and Peters, 1992). Kennedy and Peters, 1992 found in both Malawi and Kenya that, *de facto* female-headed (partial female control) households had the lowest income but despite that, preschoolers' nutritional status was significantly better than in the higher income male-headed and *de jure* female-headed (full female control) households.

2.2 The Energy Ladder and Differences in Expenditure Among Male and Female Heads

The concept of the energy ladder points out the differences in energy-use patterns between households with different economic status. The energy ladder hypothesis is based on the economic theory of consumer behavior, using more of a particular fuel as income increase (Hosier and Kipondya, 1993). However, households do not only consume more of the same fuel as income increases, they also shift to higher quality and efficiency fuel. The energy ladder hypothesis is underpinned by the assumption that a low standard of living makes households more dependent on biomass fuels (Baland, Bardhan, Das, Mookherjee, Sarkar, 2007). Unlike in developed countries where energy poverty tends to be defined as when households are unable to provide sufficient heat to their homes (Hills, 2012; Phimister, Vera-Toscano and Roberts, 2015), the concept and its measurement in developing countries is based on the energy ladder hypothesis, households are energy poor if they are unable to use cleaner cooking fuels in their homes. Households that use advanced forms of fuel are said to be energy rich, while those in the transition fuel category are energy poor and those that use primitive fuels are the energy poorer households.

In the energy ladder hypothesis, emphasis is put on the role of income in the determination of fuel use, as can be seen in Figure 1 below, movement downwards the ladder is associated with decreasing income.

Figure 1: The energy ladder



Although the energy ladder argues strongly that income is a major determinant of household use of cleaner cooking fuel, it is also argued that the level of income controlled by women has a positive impact on household use of cleaner cooking fuel, an impact that is over and above the effect of income (Israel, 2002).

On the differences in expenditure among male and female heads, women are noted for devoting their earnings to the household sustenance (spend on food, fuel etc.) than their male counterparts (Blumberg, 1988; Kennedy and Peters, 1992). According to Mencher (1988) even though the amount of money devoted by males to household sustenance, in absolute terms, are sometimes greater than that of females, the proportion of male expenditure to male income is always lower than that of females. Again, women fully spend over 74% of their cash income on supplements to the family food supply and household needs including cooking fuel (Guyer, 1980; Mencher, 1988). Further, Peters and Herrera (1989) showed in Malawi that most female-headed households allocated a larger share of their budgets to food and spent 25-50% less on alcoholic beverages than male-headed households. Proportionately less is also spent on alcoholic beverages even for higher income female-headed households, whose overall budget allocations reflect more closely those of male-headed households. Similarly, Mencher (1988) noted that, men hold back a portion of their income for such leisure and "status production" activities as "eating food and drinking alcohol with friends in shops". Male-headed households are also said to spend a higher proportion of their incomes on other productive assets, such as inputs into cash crop production, including land, hired

labor and fertilizers (Kennedy and Peters, 1992). Therefore, other consumption needs of household members and investments in productive resources (land, hired labor) and other non-essential expenditure (as on alcohol) may compete with household's consumption of cooking fuel for a share of the budget in male-headed households where incomes are sufficiently high to allow those additional expenditures. This may undermine investment in cleaner, and costly, cooking fuels in these households.

There is also country-level empirical evidence on the role of gender in energy-poverty. The study of Sehjpal, Ramji, Soni and Kumar (2014) find in rural India that as women attain more formal employment, the chances of selecting cleaner fuels significantly increase. As well, sociocultural factors might play a bigger role in the determination of household energy choices aside from income. Further, access to electricity would positively impact energy choices for cooking only after a minimum threshold requirement has been met. Still in India, Malakar, Greig and van de Fliert (2018) emphasized on the role of gender norms on energy-use. They found that, using solid fuel for cooking is entangled with structural elements, like practices of traditional income generating, well-known traditions, a sense of belonging and gender norms. Johnson, Gerber and Muhoza (2019) found in rural northern Zambia that a shift to more modern energy services is not gender neutral. Thus, in spite of its community-wide benefits, there was unevenly distributed benefits of a new technology and service between women and men as a result of wider socio-cultural norms and practices.

To conclude based on the overall literature above, gender role in energy poverty determinants is not firmly established. Importantly, there seem to exist a possible link between women's empowerment and energy-poverty since their empowerment propels household welfare, which includes the use of cleaner cooking fuel. This is the knowledge gap this study aim to address.

3. Methodology

3.1 Main Framework

To fill the gap identified in the above literature, this study aims to investigate whether households managed by females adopt cleaner main cooking fuel compared to their male-headed counterparts in Ghana, focusing on, (i) the aggregate distinction between female- and male-headed households,

and (ii) a more detailed decomposition between *de jure* female- and *de facto* female-headed households and male-headed households. For this, we estimate the following empirical model;

$$fuel_{i,t} = \beta_1 + \beta_2 gendered\_head_{i,t} + \sum_{j=3}^{k} \beta_j X_{ij} + \delta_t + \lambda_{it} \qquad (1)$$

*w*here $fuel_{i,t}$ is an ordered categorical variable (1=firewood, 2=charcoal, 3=electricity/gas) which measures energy poverty of household i in survey round t. $gendered\_head_{i,t}$ is the gender of the head in household i in survey round t and is represented by either aggregating female heads ($femhead_{i,t}$) or distinguishing between *de facto* female heads ($defactofemale_{i,t}$) and *de jure* female heads ($dejurefemhead_{i,t}$). The variable X_{ij} are a set of $\{k\}$ variables controlling for household heads and household characteristics, these included household income and location, the head's age, education level, employment and marital status. $\beta's$ are the parameter vectors and the focus is on β_2s in equation (1). δ_t represents time fixed effects which control for unobserved survey round characteristics, and λ_{it} is the random error term of the equation.

The estimation strategy considers the multinomial choices and are implemented with the use of multinomial probit (MNP) and logit (MNL) models. Although the MNL has been widely used in the empirical literature, it has the well-known limitation associated with the implied "Independence of Irrelevant Alternatives (IIA)" assumption (Ben-Akiva and Lerman, 1985). The implication of the IIA for this study is that, for example, the choice of electricity/gas over firewood as a main cooking fuel should not be affected by the inclusion or exclusion of other alternative fuels (e.g., charcoal) in the choice set. This assumption is, however, very unlikely in the context of fuel use, particularly in developing countries where fuel switching behavior is predominant among households. In this study, the outcome variable is ordered in line with the energy ladder hypothesis. However, the MNP model will not account for the ordinal nature of the dependent variable. Ordered multiple-choice models are now commonly used as a framework for analyzing such responses and hence will be used alongside the MNP model.

3.1.1 Underlying Mechanisms

To support the hypothesis that female-headed households behave differently, the study first investigates how household heads prioritise household expenditures. This investigation aims to offer a possible explanation on why female heads may favour the adoption of cleaner forms of

cooking fuels more than male heads. Analysis here is based on the Engel curve hypothesis, which describes how household expenditure on a particular good or service varies with household income. It is based on the identifying assumption that the share of the budget devoted to food expenditure correctly indicates welfare differences between households of different demographic composition. We refer to the works of Deaton (1997) and Lewbel and Pendakur (2008) and consequently estimate the following empirical models using the OLS.

$$w(x)_{i,t} = \mu_1 + \mu_2 gendered\_head_{i,t} + \mu_3 size_{i,t} + \sum_{j=4}^{k} \mu_j X_{ij} + \rho_t + \varepsilon_{it} \qquad (2)$$

where $w(x)_{i,t}$ is a household i's Engel curve budget shares given total expenditures x in survey round t (we considered budget shares on food and on alcohol, tobacco and narcotics), $gendered\_head_{i,t}$ and X_{ij} are the same as in equation (1) above, and $size_{i,t}$ is the size of household i in survey round t. In addition, $\mu's$ are the parameter vectors, here the focus is on μ_2s in equation (2) , and they are all expected to be positive for food expenditure and negative for non-essential expenditure. ρ_t represents time fixed effects which control for unobserved survey round characteristics, and ε_{it} is the random error term of the equation.

Expenditure on non-essential items may limit the household's ability to afford and use cleaner cooking fuels. Hence, households that want to adopt cleaner forms of cooking fuel that typically have a higher market price, may decide to reduce expenditure on non-essentials and save towards it. We empirically investigate this by exploring whether a lower budget allocation on non-essentials is positively associated with the adoption of cleaner (and more expensive) cooking fuel, and whether there are differences between female and male-headed households.

We therefore augment equation (1) to investigate the following: (i) the effect of female headship in household on energy-poverty, (ii) the effect non-essential spending (in this case, expenditure on alcohol, tobacco and narcotics) on energy-poverty, and particularly (iii) the interaction effect of female headship in household and non-essential spending on energy-poverty. We estimate equation (3) below;

$$fuel_{i,t} = \varphi_1 + \varphi_2 femhead_{i,t} + \varphi_3 nonessenl_{i,t} + \varphi_4 (femhead_{i,t} * nonessenl_{i,t}) + \sum_{j=5}^{k} \varphi_j X_{ij} + \omega_t + \pi_{it} \qquad (3)$$

where $fuel_{i,t}$ is defined as in equation (1), $femhead_{i,t}$ is the gender of household i head in survey round t, $nonessenl_{i,t}$ measures the budget share allocated on non-essential items (alcohol, tobacco and narcotics), ($femhead_{i,t} * nonessenl_{i,t}$) is the interaction between the head's gender and non-essential expenditure variables, the variable X_{ij} are a set of controls as in equation (1) and (2) above. $\varphi's$ are the parameter vectors, we focus on φ_4 to see the effect of the interaction term (female*non-essential) on the type of main cooking fuel choice. ω_t represents time fixed effects which control for unobserved survey round characteristics, and π_{it} is the random error term of the equation.

We employ the ordered probit technique due to the ordinal nature of the dependent variable (fuel) alongside with the CMP and 2SLS-IV techniques. To account for any potential endogeneity bias, the study also estimates equation (5) using the seemingly unrelated regressions (SUR) with the conditional mixed-process (CMP) technique proposed by Roodman (2011). This technique allows building recursive multi-equation models similar to the two-stage least squares technique to deal with endogeneity bias in a model (Roodman, 2011; Cupák, Kolev and Brokešová, 2019). In addition, the Two Stage Least Squares-Instrumental Variable (2SLS-IV) estimation technique is employed as a further robustness check. This also enable us to calculate the magnitude of the effect of the interaction term, since it is difficult to evaluate the marginal effect of an interaction term in non-linear models. The use of IV-techniques is necessitated due to the potential endogeneity bias in the model emanating from omitted variable bias due to unobserved individual characteristics that affect both consumption on non-essentials and choice of cooking fuel. The presence of endogeneity is suspected to lead to biased and inconsistent estimates in the relationship between energy-poverty and non-essential spending (Koomson, Villano, Hadley, 2020a; Churchill and Marisetty, 2019).

The IV models require the use of instruments that are relevant to the endogenous treatment variable (in our case, expenditure on non-essential items), but exogenous to the outcome variable (main cooking fuel). Factors such as the religious affiliation of the head, the geographical region or the ethnic group of the head of the household are expected to influence household's expenditure on non-essential items, but not the choice of cooking fuel. Specifically, for the case of Ghana, religious denomination influences the consumption of alcohol, tobacco and narcotics in the sense that some denominations prohibit their consumption (and the level of adhesion differs across

denominations). Again, the geographical region a household finds itself can influence the consumption of alcohol, tobacco and narcotics. Whiles the northern regions are dominated by the Islamic faith, the southern regions are Christian dominated. Further, some ethnic groups recognise alcoholic beverages (for instance) as part of their traditional foods. This may influence the expenditure on alcoholic beverages of households belonging to such ethnic groups. For the CMP and 2SLS-IV regressions, the study explores the instruments as follows: (i) the religious denomination of the head (no religion, Muslim, Christian, Traditionalist, other), (ii) the geographical region the household is located (10 regions), and (iii) interaction terms between the 'female head' dummy and each of the above instruments.

3.2 Data

This study employs micro level data from four rounds of the Ghana living standards survey (GLSS) based on wider coverage of households and availability of observations. These survey rounds included the GLSS 4 administered in 1998/1999, GLSS 5 in 2005/2006, GLSS 6 in 2012/2013 and GLSS 7 in 2016/2017 and are pulled together to form a repeated cross-section data. The GLSS is a nationally representative household survey, the sampling frame for the survey is the population living in private households in Ghana. The above sample frame is divided into primary and secondary sampling units. The primary sampling unit is the census Enumerated Areas (EAs) that are formed within the then ten administrative regions of Ghana based on proportional allocation using the population in each of the regions. The second sampling unit on the other hand is the households living in each of the EAs.

For the fourth round of the GLSS, the two-stage sampling resulted in the selection of 300 EAs at the first stage and a fixed number of 20 households from each EA. Out of the total of 6,000 households selected, 5,998 were successfully covered in the survey representing 99.7 percent coverage. Similarly, in the fifth round of the GLSS, two-stage stratified random sampling approach was adopted, where in the first stage 580 EAs were considered, while in the second stage, 15 households per EA was considered. The combined outcome of the two-stage sampling resulted in a total of 8,700 households' nationwide. In the end, however, 8,687 households were successfully interviewed representing a 99.85 percent response rate for the GLSS5 sample. The sixth round followed a similar sampling approach and 1,200 EAs were considered in the first stage and 15 households from each primary sample unit, leading to a total of 18,000 households. Out of this,

16,772 were successfully interviewed comprising a response rate of 93.2 percent. The seventh round of the GLSS, like the previous rounds was proposed to study about 15,000 households in 1,000 EAs. At the end 14,009 households were successfully interviewed constituting 93.4 percent of the total households. These four rounds of data sets were pulled together to form a larger cross-sectional data. The following table shows the various waves and sample administered.

Table 1: Household sample administered for various waves

Wave	Year	Sample administered
GLSS 4	1998/1999	5,998 (99.7%)
GLSS 5	2005/2006	8,687 (99.85 %)
GLSS 6	2012/2013	16,772 (93.2%)
GLSS 7	2016/2017	14,009 (93.4%)

3.3 Variable measurement

Using the above survey design, data were extracted on the following key variables: Energy-poverty, following the energy ladder as discussed in section 3 we measured this by an ordered categorical variable 'fuel' that takes the value of 1 (one) if the household uses firewood as a main cooking fuel, 2 (two) if charcoal and 3 (three) if electricity or gas. This variable is computed from a question in the data that seek to know the main cooking fuel of the household. The order of the categories is also chosen to reflect primitive, transition, and advance categories of fuel respectively as in the energy ladder, and also based on the response rate. The responses also included kerosene, crop residue, dung cake, saw dust and others, but these cases were excluded from the analysis due to insignificant numbers reported. This is a self-reported measure which is widely accepted and can provide accurate and efficient assessments of objective states (Cleary, 1997).

Household head gender is measured by a binary variable (Female head) that is 1 for female heads and 0 for male heads. To further assess whether female heads having absolute control relative to partial control over the household matters, we sub divided the aggregate female-headed households into *de jure* (absolute household controllers) and *de facto* (partial household controllers) female-headed households. Therefore, three binary variables are constructed: '*de jure*-female', '*de facto*-female' and 'male head' variables. The '*de jure*-female' takes the value of 1 if it is *de jure* female-headed households, and 0 otherwise. Similarly, the '*de facto*-female' takes 1 if it is *de facto* female-

headed households and 0 otherwise. Finally, the 'male head', which is the reference dummy in this study is 1 for male-headed households and 0 for all female-headed households. Household expenditure on food and on alcohol, tobacco and narcotics are expressed as a share of total household expenditures. Household expenditure on alcohol, tobacco and narcotics are used as indicators of non-essential expenditures. These were the only items in the data the study could rely on. Also, to control for other factors that may influence household energy-poverty and expenditures, we include as covariates: (i) the log of equivalized household income , (ii) the household size, (iii) the age of the household head in years, (iv) controls for marital status of the head (never married, married, cohabitating, divorce and widowed), (v) indicators for educational level of the head (no education, primary, middle, secondary and tertiary), (vi) employment status of the head, and finally, (vii) whether the household is in an urban or rural area.

3.4 Descriptive Statistics

Table 2 presents summary of mean values of the variables used in the study as discussed in section 3.3 above. Data in the table show a number of differences in household demographics, both between male- and female-headed households and within the subgroups of female-headed households. For marital status, male heads record higher percentages of the following categories; never married, married and cohabitating compared to female heads. However, female heads record the highest in the divorce and widowed category. In terms of level of education, there is significant difference in household heads' attainment of higher education in favour of male-headed households. Specifically, female heads who had no education are more than male heads who had no education. Female heads again are the highest in the primary category compared to male heads, with both almost having equal percentage of middle level education, albeit slightly higher for female heads. However, for secondary and tertiary categories, male heads record highest percentages of about 15% and 14% respectively as against about 11% and 8% respectively for female heads.

Within female-headed households, about 17% of *de facto* heads have no education as compared to about 16% of *de jure* heads. For the various categories, *de facto* heads record about 20%, 45%, 9% and 9% for primary, middle, secondary and tertiary respectively, compared to about 23%, 42%, 12% and 8% recorded by *de jure* heads. Female heads on average are older than their male counterparts, whiles within female-heads, *de jure* heads have the highest average age. This is

consistent with extant literature that *de jure* heads are mostly older. Male-headed households have larger household size than the aggregate of female-headed households. Within female-headed households, *de jure* female-headed households have the smallest household size. The rural areas record the highest male-headed households compared to the aggregate female-headed households. Within female-headed households, *de facto* female households in the rural areas are slightly above their *de jure* counterparts.

On employment, income and expenditures, the percentage of employed male-headed households was about 67% compared to about 54% for their aggregate female-headed counterparts. This may be partly driving the income differences in favour of male-headed households, by an average of Ghc 319.12 equalized income. Among female-headed sub-group, similar pattern was repeated in favour of *de facto* heads, about 55% of *de facto* heads are employed as against about 53% of *de jure* heads with average income difference of about GHc295.00. The total expenditure differences across male-headed and aggregate female-headed households and also within the female sub-groups are consistent to the corresponding income differences. Male-headed households in total spend an average of Ghc954,586.00 over and above the expenditure in female-headed households. However, for expenditure shares on food and on alcohol, tobacco and narcotics, female-headed households devote an average of about 3% more of their budget on food and about 1.3% less of their budget respectively on alcohol, tobacco and narcotics compared to their counterparts male-headed households. It is important to note that, these differences among male- and the aggregate female-headed households are tested to be significant at 1% level, as indicated in Table 2. Within the female-headed sub-sample, in absolute terms, an average of Ghc854,037.00, was spent in total by *de facto* heads over and above the recorded expenditures by *de jure* heads. However, *de jure* heads devote a slightly higher budget shares on food and on alcohol, tobacco and narcotics than *de facto* heads.

Table 2: Descriptive Statistics

	Total	Male	Female	T-test Difference	De facto Female	De jure Female
Heads	1.00	0.702	0.298		0.088	0.209
Marital Status	---	---	---	---		
Never married	0.106	0.107	0.102		---	0.144
Married	0.568	0.715	0.220		74.01	---
Cohabitating	0.096	0.104	0.077		25.99	---
Divorce	0.114	0.051	0.264		---	0.376

Widowed	0.116	0.023	0.338		---	0.480
Education Level	2.953	3.037	2.723	0.3135***		
No education	0.128	0.114	0.166		0.175	0.162
Primary	0.180	0.167	0.216		0.198	0.225
Middle	0.428	0.427	0.428		0.448	0.419
Secondary	0.139	0.151	0.107		0.091	0.116
Tertiary	0.125	0.140	0.082		0.089	0.079
Age	45.867	44.591	48.878	-4.29***	42.146	51.718
Household Size	4.235	4.594	3.388	1.206***	3.892	3.175
Rural	0.576	0.604	0.510	0.094***	0.515	0.508
Employed	0.630	0.669	0.537	0.132***	0.554	0.530
Equalized Income	1682.31	1777.3	1458.18	319.12***	1665.556	1370.485
Expenditures						
Total	4050307	4334461	3379875	954586.3***	3980133	3126096
Food (% of total)	0.505	0.496	0.526	-0.030***	0.512	0.532
Alco/Toba/Narc(% of total)	0.014	0.018	0.005	0.013***	0.004	0.005
Main cooking fuel	1.602	1.575	1.663	-0.087***		
Wood	0.55	0.580	0.482		0.480	0.483
Charcoal	0.298	0.265	0.373		0.366	0.376
Electricity/Gas	0.152	0.1553	0.145		0.1538	0.141

'---' means not applicable (***de jure*** households include unmarried, divorced/separated and widowed women. ***de facto*** consist of only married/cohabitating women).

*** p<0.01 (Here, a simple t-test is performed by household head gender and revealed significant differences in the variables including income and expenditures)[3].

Finally, on the type of cooking fuels used in households, despite the higher income level in male-headed households, there is significant difference in the adoption of cleaner forms of cooking fuels in favour of female headed households. In particular, 58% of male-headed households use firewood whiles about 26% use charcoal as their main cooking fuel, compared to about 48% use of firewood and about 37% use of charcoal in the aggregate female-headed households. However, about 16% of male-headed households use electricity or gas compared to about 15% use of electricity or gas in female-headed households. Similarly, within the female-headed sub-group, about 15% of *de facto* heads use electricity or gas compared to about 14% in *de jure* headed households. However, there is equal use of firewood of about 48% in both sub-groups, but higher usage of charcoal in *de jure* headed households of about 38% as against about 37% use in *de facto* headed households[4].

[3] This will be useful in our analysis, particularly the difference in income and expenditures.

[4]The correlation between the independent variables is generally low (< 0.70). The low correlations between the variables suggests less collinearity among them which will not cause estimation issues.

4. Empirical Results

4.1 Empirical Estimations and Discussions

The aim of this sub-section is to analyse the empirical results of the nexus between women's empowerment in households and energy-poverty in Ghana. The results shown in Table 3 are estimates of the multinomial probit (3a) and ordered probit (3b) models. The aim is to assess the effect female headship on household choice of ordered cooking fuel (firewood, charcoal and electricity or gas). The paper accounts for the respective households' income level, size, and location, as well as the household head's age, education level, marital status and employment status. To further analyse whether the degree of women's empowerment in the household matters, we present estimates of the multinomial probit (4a) and ordered probit (4b) model in Table 4 that compare *de jure* (absolute control) and *de facto* (partial control) female heads to male heads. In each table, the first two columns of 3a and 4a contain the multinomial probit estimates whiles the first column of 3b and 4b contains the ordered probit estimates. The remaining columns contain the marginal effects. The estimates of the ordered probit model are included as a robustness check because it accounts for the ordinal nature of the outcome variable (*fuel*). All regressions are corrected for robust standard errors, controlled for year and region effects of various data rounds.

Table 3

Table 3a: Estimates of equation (1) using multinomial probit

Dependent Variable: Fuel (Firewood=1, Charcoal=2, Elec/Gas=3)

	M. Probit: (Base outcome= Charcoal)		**Marginal Effects (dy/dx)**		
Independent Variables	**Firewood**	**Elec/Gas**	**Firewood**	**Charcoal**	**Elec/Gas**
	(1)	(2)	(3)	(4)	(5)
Female Head	-0.271***	0.066*	-0.048***	0.028***	0.020***
	(0.037)	(0.037)	(0.006)	(0.007)	(0.005)
Observations	28,552	28,552	28,552	28,552	28,552
Other controls	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes	Yes

Table 3b: Estimates of equation (1) using ordered probit

	Ordered Probit	**Marginal Effects (dy/dx)**		
		Firewood	**Charcoal**	**Elec/Gas**
	(1)	(2)	(3)	(4)
Female Head	0.171***	-0.042***	0.011***	0.031***
	(0.020)	(0.005)	(0.001)	(0.004)
Observations	28,552	28,552	28,552	28,552
Other controls	Yes	Yes	Yes	Yes

Year Effects	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The coefficient of the control variables and year dummies is not reported for brevity. Full estimates are provided in Appendix I (3a) and Appendix II (3b). Other controls include head's age, education level, marital status and employment status; household's size, income and location.

The results in Table 3a suggest that female-headed households are less likely to use firewood compared to charcoal but more likely to use electricity or gas compared to charcoal as their main cooking fuel in their households than male headed households. Particularly, female-headed households are about 5 percentage points less likely to use firewood as their main cooking fuel compared to their male-headed counterparts (Table 3a, column 3). However, they are about 3 percentage points more likely to use charcoal as their main cooking fuel than male-headed ones (Table 3a, column 4). Similarly, female-headed households are about 2 percentage points more likely to use electricity or gas as their main cooking fuel than male-headed ones (Table 3a, column 5). These results were supported by the ordered probit estimates in Table 3b. Specifically, female-headed households are about 4.44 percentage points less likely to use firewood as their main cooking fuel compared to their male-headed counterparts (Table 3b, column 2), are about 1.02 percentage points more likely to use charcoal as their main cooking fuel than male-headed ones (Table 3b, column 3), and are about 3.42 percentage points more likely to use charcoal as their main cooking fuel than male-headed households (Table 3b, column 4).

These findings clearly showed the commitment of female-headed households in general to using cleaner cooking fuel. Does the level of empowerment in the household matter? Table 4 presents results that compare *de jure*- and *de facto*-female headed to male headed households. *De jure* female-headed households are those in which a woman is considered the legal and customary head of the household (full control), whiles *de facto* female-headed households are those where a woman is the head as a result of the absence of the man (partial control). The results in Table 4 suggest that female heads having absolute control over the household matter, at least in the case of firewood. The coefficient equality test at the bottom of tables 4a and 4b revealed unequal coefficients of '*de jure*-female' and '*de facto*-female' only in the multinomial probit model (p-value= 0.0731), particularly for use of firewood (p-value= 0.0452), the coefficient equality test has a null hypothesis of equal coefficients of two regressors, rejecting the null hypothesis suggests that the coefficients are not equal.

Table 4

Table 4a: Estimates of equation (1) using multinomial probit

Dependent Variable: Fuel (Firewood=1, Charcoal=2, Elec/Gas=3)					
	M. Probit: (Base outcome= Charcoal)		**Marginal Effects (dy/dx)**		
Independent	**Firewood**	**Elec/Gas**	**Firewood**	**Charcoal**	**Elec/Gas**
Variables	(1)	(2)	(3)	(4)	(5)
De facto female	-0.219***	0.047	-0.038***	0.023**	0.015**
	(0.048)	(0.051)	(0.008)	(0.009)	(0.007)
De jure female	-0.351***	0.089	-0.062***	0.036***	0.026***
	(0.056)	(0.055)	(0.009)	(0.010)	(0.008)
Observations	28,552	28,552	28,552	28,552	28,552
Other controls	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes	Yes
De facto female = De jure female: Chi sqr=3.21 (p-value=0.0731)			4.01 (0.0452)	0.85 (0.3569)	1.19(0.2753)

Table 4b: Estimates of equation (1) using ordered probit

	Ordered Probit	**Marginal Effects (dy/dx)**		
		Firewood	**Charcoal**	**Elec/Gas**
	(1)	(2)	(3)	(4)
De facto female	0.156***	-0.038***	0.010***	0.028***
	(0.027)	(0.007)	(0.002)	(0.005)
De jure female	0.190***	-0.046***	0.012***	0.034***
	(0.030)	(0.007)	(0.002)	(0.005)
Observations	28,552	28,552	28,552	28,552
Other controls	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes
De facto female = De jure female : chi sqr =0.74 (p value=0.3907)		0.74 (0.3908)	0.74 (0.3910)	0.74 (0.3907)

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The coefficient of the control variables and year dummies is not reported for brevity. For the coefficient equality test, we presented chi square values with p-values in parenthesis. Full estimates are provided in Appendix III (4a) and Appendix IV (4b). Other controls include head's age, education level, marital status and employment status; household's size, income and location.

The coefficients of both '*de jure*-female' and '*de facto*-female' have strong statistical significance level (at least 5%) across all the columns of Table 4, except in column (2) of multinomial probit estimates (Table 4a) which is expected due to their lower levels of income. They are negative in column (1) of Table 4a, suggesting that both '*de jure*-female' and '*de facto*-female-headed households are less likely to use firewood compared to charcoal as their main cooking fuel in their households than male headed households. To be specific, in column (3), whereas *de jure* female-headed households are about 6.2 percentage points less likely to use firewood as their main cooking fuel, *de facto* female-headed households are about 3.8 percentage points less likely to use it compared to male-headed households, and there is a statistically significant difference across *de jure* and *de facto* female-headed households in the use of firewood. In columns (4) and (5), the marginal effects were positive for both *de jure* and *de facto* female-headed households in the use

of charcoal and electricity or gas respectively, with yet again higher impact for *de jure* female-headed households in each case but no significant difference (equal coefficients). Consistent findings were recorded in the ordered probit estimates (Table 4b), however, the coefficients were found to be equal in all cases. The results in column (1), suggest that both *de jure* and *de facto* female-headed households are more likely to use cleaner forms of main cooking fuels in their households compared to their male-headed counterparts. Again, consistently negative marginal effects were found for the use of firewood and positive for the use of charcoal and electricity or gas as main cooking fuel for both *de jure* and *de facto* female-headed households (with higher impact for *de jure* female-headed households) in columns (2) to (4).

It is therefore observed that *de jure* female-headed households, despite having the lowest level of income (as shown in Table 2) are potentially less likely to use firewood as main cooking fuel in their households compared to charcoal and electricity/gas. This is probably because of the absolute control they have over their households compared to their *de facto* female-headed counterparts. To conclude, the above findings indicate that the choice of cleaner cooking fuel in households depends largely on whether the household is controlled by female, and potentially the amount of control they have over the household. These findings provide empirical support to the argument that women fully spend over 74% of their cash income on supplements to the family food supply and household needs including cooking fuel (Guyer, 1980; Mencher, 1988).

4.2 Differences in Household Expenditure in Gendered-Headed Households

To provide some insight that may help us understand the findings above, that female-headed households are more likely to use cleaner cooking fuel in their households compared to their male-headed counterparts, this sub-section investigates how household heads prioritise household expenditures. The study relies on the analysis of the Engel curve hypothesis and consequently estimates equation (2) above, where budget shares for food and for alcohol, tobacco and narcotics are used as the dependent variables with the main independent variables being the aggregate female heads dummy and also *de jure*- and *de facto*-female heads dummies. In particular, the study compares how female- and male-headed households prioritise the allocation of budget shares on food, which is essential for household sustenance, and on items that are non-essential to sustaining the household (in this case, expenditure on alcohol, tobacco and narcotics). Again, it compares the aggregate female-headed households to male-headed households and also *de jure*- and *de facto*-

female heads to male heads. Using the Ordinary Least Squares (OLS) estimation technique and the repeated micro level data from four rounds of the Ghana living standards survey (GLSS) as described earlier, we present the estimates of equations (2) in Table 5.

Table 5: Estimates of equation (2) using OLS

Depend. Variables:	**Food expenditure/ Total expenditure**		**(Alcohol, Naccotics,Tobacco.) expenditure/ Total expenditure**	
Ind. Variables	(1)	(2)	(3)	(4)
Female Head	0.002		-0.015***	
	(0.002)		(0.001)	
De facto female		0.007**		-0.009***
		(0.003)		(0.0005)
De jure female		-0.003		-0.022***
		(0.004)		(0.001)
Year Effects	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes
Other Controls	Yes	Yes	Yes	Yes
Observations	28,552	28,552	21,000	21,000
R-squared	0.126	0.126	0.117	0.121
De facto female = De jure female: Chi sqr=3.73 (p-value=0.0534)			Chi sqr=97.29 (p-value=0.0000)	

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The coefficient of the control variables and year dummies is not reported for brevity. For the coefficient equality test, we presented chi square values with p-values in parenthesis. Full estimates are provided in Appendix V. Other controls include head's age, education level, marital status and employment status; household's size, income and location.

The results from column (1) of Table 5 indicate no significant difference in the allocation of budget share for food among female- and male-headed households, despite the significantly high food expenditure in absolute terms[5] in male-headed households compared to their female-headed counterparts. This provides empirical support for the assertion of Mencher (1988) that, even though the amount of money devoted by males to household sustenance, in absolute terms, are sometimes greater than that of females, the proportion of male expenditure to male income is always not greater than that of females. Within female-headed households, *de facto* female-headed households allocate higher budget share for food than male-headed households. This is evident in column (2), the coefficient of '*de facto* female' was positive with 5% level of statistical significance, indicating that there is about 0.7 percentage point increase in the budget share for food in *de facto* female-headed households than male-headed households, all else equal. However, there was no significant difference in budget allocated for food in *de jure* female- and male-headed households (the coefficient of '*de jure* female' was not significant).

[5] A simple t-test of food expenditure, in absolute terms by household head gender indicates a significantly high expenditure on food by male-headed households compared to their female-headed counterparts.

In relation to household expenditure on non-essentials such as alcohol, tobacco and narcotics, female-headed households are found to allocate a smaller share of their budget than male-headed households. Specifically, there is about 1.5 percentage point decrease in the budget share for alcohol, tobacco, and narcotics in female-headed households than male-headed households, all else equal. Within the female-headed sub-group in column (4), the finding was same where *de facto* and *de jure* female-headed households allocate lower share of their budget for alcohol, tobacco, and narcotics than their male-headed counterparts. The coefficients were all negative and statistically significant at 1% level, indicating specifically about 0.9 percentage point and about 2.2 percentage points decrease in the budget share for alcohol, tobacco, and narcotics respectively in *de facto* and *de jure* female-headed households than male-headed households, all else equal. Results of the coefficient equality test at the bottom of Table 5 suggest unequal coefficients for *de facto* and *de jure* female heads in columns (2) and (4). Thus, consistent with our expectation, *de jure* female heads significantly devote lower budget shares for non-essential items than their *de facto* counterparts. In sum, despite the insignificant difference in the budget allocated for food particularly among *de jure* female- and male-headed households, the findings suggest that female-headed households prioritize food (which essential for household sustenance) to alcohol, tobacco, and narcotics (which are non-essential to sustaining the household) than male-headed households in Ghana.

Finally, the study investigates whether less prioritization of non-essential expenditure translates to the adoption of cleaner main cooking fuel among female-headed households, by estimating equation (3) above. Equation (3) has the fuel (1=firewood, 2=charcoal, 3=electricity/gas) as dependent variable, and the effect of the interaction term (female*nonessential) on the dependent variable is our primary focus. For lower budget shares on non-essential items (alcohol, tobacco, and narcotics) to be helpful in the adoption cleaner cooking fuels in female-headed households, we expect the coefficient of the interaction term to be negative and significant. This is very likely because of the household sustaining behaviour of female heads compared to male heads. Table 6 presents estimates of equation (3) using ordered probit, ordered probit-IV (CMP) and 2SLS-IV estimation techniques. For the CMP and 2SLS-IV regressions, we explore instruments based on the religious denomination of the head and geographical location of the household. Our working assumption is that these factors are likely to affect household expenditure on alcohol, tobacco, and narcotics, but not the choice of main cooking fuel. From the regression, the overall F statistics

which test for weak identification of the endogenous regressors ('non-essential expenditure' and 'female*non-essential expenditure') is reported as 46.825 which is higher than the Stock-Yogo (2005) critical values suggesting that the endogenous regressors are strongly identified. Furthermore, the Hansen J test provides supporting evidence for the exogeneity of the overidentifying restrictions. The study relies on the CMP and 2SLS-IV results since the issue of potential endogeneity bias is being controlled for in both cases.

Table 6: Estimates of equation (3) using Ordered probit, CMP and 2SLS-IV

Dependent Variable: Fuel (Firewood=1, Charcoal=2, Elec/Gas=3)			
Independent Variables	**Ordered Probit**	**O. Probit-IV (CMP)**	**2SLS-IV**
Non-essential exp. (% of total)	**-2.257*** **	**-19.068*** **	**-27.641*** **
	(0.337)	**(0.702)**	**(2.716)**
Female head*(Non-essential)	**0.098**	**-13.775*** **	**-22.517** **
	(1.271)	**(3.855)**	**(9.414)**
Female head	**0.144*** **	**0.021**	**-0.260*** **
	(0.025)	**(0.030)**	**(0.051)**
Underid test			145.329(0.000)
Hansen J (overid)			2.090(0.3517)
Endogeneity test			398.784(0.000)
F-stat			46.825
Year Effects	Yes	Yes	Yes
Region Effects	Yes	No	No
Other controls	Yes	Yes	Yes
Observations	19,766	19,766	19,766
R-squared			-0.721

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The coefficient of the control variables and year dummies is not reported for brevity. For the under identification, Hansen J. (overidentification) and endogeneity tests, we report the test values with p-values in parentheses. Full estimates are provided in Appendix VI. Other controls include head's age, education level, marital status and employment status; household's size, income and location.

From Table 6, the results indicate that as households budget shares on non-essentials (alcohol, tobacco, and narcotics) increases, they tend to use less cleaner cooking fuels. In particular, with the 2SLS-IV estimate, the coefficient of 'non-essential' is negative and significant at 1% level suggesting that a percentage point increase in the household's budget share for non-essentials decreases its ability to adopt cleaner main cooking fuel by about 0.28 percentage points, all else equal. The results are also consistent with our expectation that female-controlled households who allocate lower budget shares on non-essentials tend to use cleaner main cooking fuel in their households, than male-headed households. Specifically, the coefficients of the interaction term 'female head*non-essential' in the CMP and 2SLS-IV regressions are negative and significant at

1% and 5% level respectively. This suggests that the effect of non-essentials expenditure on the choice of cooking fuel is even stronger for female-headed households. All else equal, the 2SLS-IV results suggest that a percentage point increase in the household's budget share for non-essentials in female-controlled households tends to further decrease their ability to adopt cleaner main cooking fuels by about 0.23 percentage points, compared to male-controlled households. In sum, less prioritization of non-essential expenditure translates to the adoption of cleaner cooking fuel among female-headed households in Ghana.

5. Summary, Conclusion and Policy Implications

Women's empowerment has attracted the attention of researchers as an active area of research since 1980s, yet its influence on energy poverty is yet to be known. In developing countries, energy poverty is estimated to have an adverse impact on health, with these effects being more pronounced among women, largely due to gender-based domestic roles. Therefore, if women are more empowered and participate more actively in the household decision making, they may favour the adoption of cleaner forms of household cooking fuel, thus contributing to the reduction of energy poverty. Also, empowering women and eliminating energy poverty are central to the United Nation's Millennium Development Goals, and understanding how women's empowerment influence energy poverty in households is vital to inform relevant policy initiatives. Hence, the relationship between women's empowerment in households and energy poverty in developing countries should be of perennial interest. However, the relevant literature and empirical evidence is rather limited.

To fill this literature gap, this study is dedicated to the nexus between women's empowerment and energy poverty in developing countries. Specifically, using micro level data from Ghana and employing various identification strategies, the study provided detailed analysis of the relationship between female empowerment in households and energy poverty in Ghana, by investigating whether households that are fully or partially controlled by females adopt cleaner main cooking fuel compared to their counterparts male controlled households. The study also supported the findings by investigating the effect of female empowerment in households on household food expenditure and on non-essential (alcohol, tobacco and narcotics) expenditure. Furthermore, it explored possible trade-offs between expenditures on non-essentials and investment in a cleaner form of cooking fuel, to ascertain whether money saved from avoiding such expenditures is partly

channelled to the adopting of cleaner cooking fuel in these households. This enabled us to shed light and understand better how male and female-headed households allocate their budget, the level of income they may devote on household sustenance, part of which also includes the choice of cooking fuel, and the relative trade-offs such decisions entail.

The results indicated that households controlled by female are more likely to adopt cleaner forms of main cooking fuel than their male-controlled counterparts. Within the female-headship sub-sample, the results suggested that the level of women's empowerment potentially matters. In particular, both *de jure* (fully empowered) and *de facto* (partially empowered) female-headed households are more likely to use cleaner forms of cooking fuels than their male-controlled counterparts. However, the magnitude, especially in the case of firewood, is higher for *de jure* than *de facto* female heads despite their lower level of income. This is probably because of the absolute control *de jure* female heads have over their households and the allocation of household resources, compared to *de facto* female heads. Indeed, the results suggest that female-controlled households prioritize expenditure on household food over non-essential expenditure on alcohol, tobacco and narcotics, compared to male controlled households. Furthermore, the analysis reveals possible trade-offs between non-essential expenditure and investment in cleaner cooking fuel. In summary, the results suggest that female-headed households may focus more on improving household welfare, than male-headed-households, as they spend less on non-essentials and tend to use cleaner cooking fuel in their households.

The study, therefore, concludes that, empowering women in households, thus, making them active subjects in household decision making may potentially help in reducing energy poverty in Ghana. The more empowered women are, the more likely the adoption of cleaner forms of cooking fuel is, and the subsequent reduction of energy poverty. The policy implication of this study is that large-scale blanket social interventions may not be very effective in the fight against energy poverty in Ghana, and by extension in other developing countries with similar characteristics. Instead, policy initiatives that focus on empowering women in households and enhancing their role in household decision making may prove to be more successful in reducing energy poverty.

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Appendices

Appendix I: Estimates of equation (1) using multinomial probit

Dependent Variable: Ordered Fuel (Firewood=1, Charcoal=2, Elec/Gas=3)					
Independent Variables	**M. Probit: (Base outcome= Charcoal)**		**Marginal Effects (dy/dx)**		
	Firewood	**Elec/Gas**	**Firewood**	**Charcoal**	**Elec/Gas**
	(1)	(2)	(3)	(4)	(5)
Female Head	-0.271***	0.066*	-0.048***	0.028***	0.020***
	(0.037)	(0.037)	(0.006)	(0.007)	(0.005)
Age	0.003	0.049***	-0.001	-0.005***	0.007***
	(0.006)	(0.008)	(0.001)	(0.001)	(0.001)
Age squared	0.0001	-0.001***	0.00003***	0.0001***	0.0001***
	(0.0001)	(0.0001)	(0.00001)	(0.00001)	(0.00001)
(Never married)					
2.ind_married	0.115**	0.094*	0.015*	-0.025**	0.009
	(0.057)	(0.052)	(0.009)	(0.010)	(0.007)
3.ind_cohabitating	0.146**	-0.340***	0.037***	0.015	-0.052***
	(0.060)	(0.061)	(0.010)	(0.011)	(0.008)
4.ind_divorce	0.077	-0.373***	0.026**	0.028**	-0.054***
	(0.065)	(0.064)	(0.011)	(0.012)	(0.009)
5.ind_widowed	0.094	-0.207***	0.024*	0.009	-0.033***
	(0.078)	(0.080)	(0.013)	(0.015)	(0.011)
(No education)					
2.ind_edu_primary	-0.190***	0.200***	-0.040***	0.014	0.025***
	(0.047)	(0.076)	(0.008)	(0.010)	(0.007)
3.ind_edu_middle	-0.456***	0.584***	-0.101***	0.017*	0.084***
	(0.045)	(0.069)	(0.008)	(0.009)	(0.007)
4.ind_edu_secondary	-0.746***	1.165***	-0.181***	-0.015	0.196***
	(0.057)	(0.074)	(0.010)	(0.011)	(0.009)
5.ind_edu_tertiary	-0.987***	1.887***	-0.271***	-0.095***	0.365***
	(0.064)	(0.074)	(0.010)	(0.011)	(0.010)
Log of income	-0.111***	-0.113***	-0.014***	0.026***	-0.012***
	(0.025)	(0.027)	(0.004)	(0.005)	(0.004)
Household size	0.140***	-0.042***	0.025***	-0.014***	-0.011***
	(0.009)	(0.011)	(0.002)	(0.002)	(0.002)
(Unemployed)					
Employed	-0.425***	0.205***	-0.079***	0.033***	0.046***
	(0.043)	(0.043)	(0.007)	(0.008)	(0.006)
(Urban)					
Rural	1.964***	-0.346***	0.341***	-0.216***	-0.125***
	(0.028)	(0.035)	(0.003)	(0.005)	(0.004)
Year Effects	Yes	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes	Yes
Observations	28,552	28,552	28,552	28,552	28,552

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Appendix II: Estimates of equation (1) using ordered probit

Dependent Variable: Ordered Fuel (Firewood=1, Charcoal=2, Elec/Gas=3)				
Independent Variables	**Ordered Probit**	**Marginal Effects (dy/dx)**		
		Firewood	**Charcoal**	**Elec/Gas**
	(1)	(2)	(3)	(4)
Female Head	0.171***	-0.042***	0.011***	0.031***
	(0.020)	(0.005)	(0.001)	(0.004)
Age	0.016***	-0.004***	0.001***	0.003***
	(0.004)	(0.001)	(0.0002)	(0.001)
Age squared	-0.0002***	0.0001***	-0.00002***	-0.00004***
	(0.00004)	(9.18e-06)	(2.40e-06)	(6.81e-06)
(Never married)				
2.ind_married	0.005	-0.001	0.0003	0.001
	(0.030)	(0.007)	(0.002)	(0.006)
3.ind_cohabitating	-0.186***	0.045***	-0.012***	-0.033***
	(0.032)	(0.008)	(0.002)	(0.006)
4.ind_divorce	-0.167***	0.041***	-0.011***	-0.030***
	(0.034)	(0.008)	(0.002)	(0.006)
5.ind_widowed	-0.103**	0.025**	-0.007**	-0.019**
	(0.042)	(0.010)	(0.003)	(0.008)
(No education)				
2.ind_edu_primary	0.124***	-0.033***	0.015***	0.018***
	(0.028)	(0.008)	(0.004)	(0.004)
3.ind_edu_middle	0.417***	-0.112***	0.044***	0.067***
	(0.027)	(0.007)	(0.003)	(0.004)
4.ind_edu_secondary	0.849***	-0.224***	0.068***	0.156***
	(0.032)	(0.009)	(0.003)	(0.006)
5.ind_edu_tertiary	1.370***	-0.345***	0.062***	0.283***
	(0.034)	(0.008)	(0.003)	(0.007)
Log of income	0.022	-0.005	0.001	0.004
	(0.014)	(0.003)	(0.001)	(0.003)
Household size	-0.099***	0.024***	-0.006***	-0.018***
	(0.006)	(0.001)	(0.0004)	(0.001)
(Unemployed)				
Employed	0.283***	-0.069***	0.018***	0.051***
	(0.023)	(0.006)	(0.002)	(0.004)
(Urban)				
Rural	-1.331***	0.325***	-0.084***	-0.241***
	(0.018)	(0.003)	(0.001)	(0.003)
Year Effects	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes
Observations	28,552	28,552	28,552	28,552

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Appendix III: Estimates of equation (1) using multinomial probit

Dependent Variable: Ordered Fuel (Firewood=1, Charcoal=2, Elec/Gas=3)					
Independent Variables	**M. Probit: (Base outcome= Charcoal)**		**Marginal Effects (dy/dx)**		
	Firewood	**Elec/Gas**	**Firewood**	**Charcoal**	**Elec/Gas**
	(1)	(2)	(3)	(4)	(5)
De facto female	-0.219***	0.047	-0.038***	0.023**	0.015**
	(0.048)	(0.051)	(0.008)	(0.009)	(0.007)
De jure female	-0.351***	0.089	-0.062***	0.036***	0.026***
	(0.056)	(0.055)	(0.009)	(0.010)	(0.008)
Age	0.003	0.049***	-0.001	-0.005***	0.007***
	(0.006)	(0.008)	(0.001)	(0.001)	(0.001)
Age squared	0.0001	-0.001***	0.0003***	0.0001***	-0.0001***
	(0.0001)	(0.0001)	(0.00001)	(0.00001)	(0.00001)
(Never married)					
2.ind_married	0.078	0.107*	0.009	-0.021*	0.013
	(0.061)	(0.058)	(0.010)	(0.011)	(0.008)
3.ind_cohabitating	0.104	-0.326***	0.029***	0.019	-0.048***
	(0.065)	(0.067)	(0.011)	(0.012)	(0.009)
4.ind_divorce	0.104	-0.380***	0.031***	0.024*	-0.055***
	(0.067)	(0.066)	(0.011)	(0.012)	(0.009)
5.ind_widowed	0.134*	-0.217***	0.031**	0.005	-0.035***
	(0.081)	(0.081)	(0.013)	(0.015)	(0.011)
(No education)					
2.ind_edu_primary	-0.188***	0.199***	-0.039***	0.014	0.025***
	(0.047)	(0.076)	(0.008)	(0.010)	(0.007)
3.ind_edu_middle	-0.455***	0.582***	-0.101***	0.017*	0.084***
	(0.045)	(0.069)	(0.008)	(0.009)	(0.007)
4.ind_edu_secondary	-0.744***	1.163***	-0.181***	-0.015	0.196***
	(0.057)	(0.074)	(0.010)	(0.011)	(0.009)
5.ind_edu_tertiary	-0.984***	1.886***	-0.270***	-0.095***	0.365***
	(0.064)	(0.074)	(0.010)	(0.011)	(0.010)
Log of income	-0.108***	-0.113***	-0.014***	0.025***	-0.012***
	(0.025)	(0.027)	(0.004)	(0.005)	(0.004)
Household size	0.141***	-0.042***	0.025***	-0.014***	-0.012***
	(0.009)	(0.011)	(0.002)	(0.002)	(0.002)
(Unemployed)					
Employed	-0.423***	0.204***	-0.079***	0.033***	0.045***
	(0.043)	(0.043)	(0.007)	(0.008)	(0.006)
(Urban)					
Rural	1.964***	-0.346***	0.341***	-0.216***	-0.125***
	(0.028)	(0.035)	(0.003)	(0.005)	(0.004)
Year Effects	Yes	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes	Yes
Observations	28,552	28,552	28,552	28,552	28,552
De facto female = De jure female				Chi sqr=3.21 (p-value=0.0731)	

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. For the coefficient equality test, we presented chi square values with p-values in parenthesis.

Appendix IV: Estimates of equation (1) using ordered probit

Dependent Variable: Ordered Fuel (Firewood=1, Charcoal=2, Elec/Gas=3)				
Independent Variables	**Ordered Probit**	**Marginal Effects (dy/dx)**		
		Firewood	**Charcoal**	**Elec/Gas**
	(1)	(2)	(3)	(4)
De facto female	0.156***	-0.038***	0.010***	0.028***
	(0.027)	(0.007)	(0.002)	(0.005)
De jure female	0.190***	-0.046***	0.012***	0.034***
	(0.030)	(0.007)	(0.002)	(0.005)
Age	0.016***	-0.004***	0.001***	0.003***
	(0.004)	(0.001)	(0.0002)	(0.001)
Age squared	-0.0002***	0.0001***	-0.00002***	-0.00004***
	(0.00004)	(9.19e-06)	(2.40e-06)	(6.81e-06)
(Never married)				
2.ind_married	0.016	-0.004	0.001	0.003
	(0.033)	(0.008)	(0.002)	(0.006)
3.ind_cohabitating	-0.174***	0.043***	-0.012***	-0.031***
	(0.035)	(0.009)	(0.002)	(0.006)
4.ind_divorce	-0.173***	0.042***	-0.011***	-0.031***
	(0.035)	(0.009)	(0.002)	(0.006)
5.ind_widowed	-0.111***	0.027***	-0.007***	-0.020***
	(0.042)	(0.010)	(0.003)	(0.008)
(No education)				
2.ind_edu_primary	0.124***	-0.033***	0.015***	0.018***
	(0.028)	(0.008)	(0.004)	(0.004)
3.ind_edu_middle	0.417***	-0.111***	0.044***	0.067***
	(0.027)	(0.007)	(0.003)	(0.004)
4.ind_edu_secondary	0.848***	-0.224***	0.068***	0.156***
	(0.032)	(0.009)	(0.003)	(0.006)
5.ind_edu_tertiary	1.370***	-0.345***	0.062***	0.283***
	(0.034)	(0.008)	(0.003)	(0.007)
Log of income	0.021	-0.005	0.001	0.004
	(0.014)	(0.003)	(0.001)	(0.003)
Household size	-0.099***	0.024***	-0.006***	-0.018***
	(0.006)	(0.001)	(0.0004)	(0.001)
(Unemployed)				
Employed	0.283***	-0.069***	0.018***	0.051***
	(0.023)	(0.006)	(0.002)	(0.004)
(Urban)				
Rural	-1.331***	0.325***	-0.084***	-0.241***
	(0.018)	(0.003)	(0.001)	(0.003)
Year Effects	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes
Observations	28,552	28,552	28,552	28,552
De facto female = De jure female			chi sqr =0.74 (p value=0.3907)	

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. For the coefficient equality test, we presented chi square values with p-values in parenthesis.

Appendix V: Estimates of equation (2) using OLS

Depend. Variables:	**Food expenditure/ Total expenditure**		**(Alcohol, Naccotics,Tobacco.) expenditure/ Total expenditure**	
Ind. Variables	(1)	(2)	(3)	(4)
Female Head	0.002		-0.015***	
	(0.002)		(0.001)	
De facto female		0.007**		-0.009***
		(0.003)		(0.0005)
De jure female		-0.003		-0.022***
		(0.004)		(0.001)
Age	-0.005***	-0.005***	0.001***	0.001***
	(0.0004)	(0.0004)	(0.0001)	(0.0001)
Age squared	0.00005***	0.00005***	-8.56e-06***	-8.68e-06***
	(4.55e-06)	(4.55e-06)	(1.13e-06)	(1.13e-06)
(Never married)				
2.ind_married	0.002	-0.001	-0.004***	-0.007***
	(0.004)	(0.004)	(0.001)	(0.001)
3.ind_cohabitating	0.014***	0.011**	0.0005	-0.003***
	(0.004)	(0.004)	(0.001)	(0.001)
4.ind_divorce	0.014***	0.016***	0.006***	0.008***
	(0.004)	(0.004)	(0.001)	(0.001)
5.ind_widowed	0.009*	0.012**	0.002	0.005***
	(0.005)	(0.005)	(0.001)	(0.001)
(No education)				
2.ind_edu_primary	-0.004	-0.004	-0.005***	-0.005***
	(0.003)	(0.003)	(0.001)	(0.001)
3.ind_edu_middle	-0.029***	-0.029***	-0.008***	-0.008***
	(0.003)	(0.003)	(0.001)	(0.001)
4.ind_edu_secondary	-0.068***	-0.068***	-0.011***	-0.010***
	(0.004)	(0.004)	(0.001)	(0.001)
5.ind_edu_tertiary	-0.111***	-0.111***	-0.013***	-0.013***
	(0.004)	(0.004)	(0.001)	(0.001)
Log of income	-0.009***	-0.008***	-0.003***	-0.003***
	(0.002)	(0.002)	(0.0004)	(0.0004)
Household size	-0.007***	-0.007***	-0.001***	-0.001***
	(0.001)	(0.001)	(0.0001)	(0.0001)
(Unemployed)				
Employed	-0.010***	-0.010***	-0.001	-0.001
	(0.003)	(0.003)	(0.001)	(0.001)
(Urban)				
Rural	0.038***	0.038***	0.005***	0.005***
	(0.002)	(0.002)	(0.0005)	(0.0005)
Year Effects	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes
Observations	28,552	28,552	21,000	21,000
R-squared	0.126	0.126	0.117	0.121
De facto female = De jure female:	Chi sqr=3.73 (p-value=0.0534)		Chi sqr=97.29 (p-value=0.0000)	

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. For the coefficient equality test, we presented chi square values with p-values in parenthesis

Appendix VI: Estimates of equation (3) using Ordered probit, CMP and 2SLS instrumental variables (IV)

Dependent Variable: Ordered Fuel (Firewood=1, Charcoal=2, Elec/Gas=3)					
Independent Variables	**Ordered Probit**	**O. Probit-IV (CMP)**	2SLS-IV		
			stage 1		**stage 2**
			Fem*(Nonessenl)	Non-essential	
Non-essential	**-2.257*** **	**-19.068*** **			**-27.641*** **
	(0.337)	**(0.702)**			**(2.716)**
Fem*(Non-essential)	**0.098**	**-13.775*** **			**-22.517** **
	(1.271)	**(3.855)**			**(9.414)**
Female Head	**0.144*** **	**0.021**	-0.001	-0.011***	**-0.260*** **
	(0.025)	**(0.030)**	(0.001)	(0.001)	**(0.051)**
Age	**0.010** **	**0.010*** **	0.0001***	0.001***	**0.031*** **
	(0.004)	**(0.003)**	(0.00002)	(0.0001)	**(0.004)**
Age squared	**-0.0002*** **	**-0.0002*** **	-9.68e-07***	-8.85e-06***	**-0.0003*** **
	(0.00004)	**(0.00003)**	(2.32e-07)	(1.14e-06)	**(0.00004)**
(Never married)					
2.ind_married	**0.006**	**-0.046** **	0.00002	-0.003***	**-0.127*** **
	(0.036)	**(0.023)**	(0.0002)	(0.001)	**(0.032)**
3.ind_cohabitating	**-0.137*** **	**-0.126*** **	0.0002	0.001	**-0.092*** **
	(0.040)	**(0.026)**	(0.0002)	(0.001)	**(0.034)**
4.ind_divorce	**-0.152*** **	**-0.135*** **	-0.0003	0.006***	**0.024**
	(0.041)	**(0.028)**	(0.0003)	(0.001)	**(0.043)**
5.ind_widowed	**-0.085** *	**-0.093*** **	0.001**	0.003**	**-0.003**
	(0.048)	**(0.032)**	(0.0005)	(0.001)	**(0.047)**
(No education)					
2.ind_edu_primary	**0.027**	**0.029**	-0.001***	-0.006***	**-0.157*** **
	(0.039)	**(0.028)**	(0.0003)	(0.001)	**(0.041)**
3.ind_edu_middle	**0.400*** **	**0.266*** **	-0.001***	-0.008***	**-0.070** *
	(0.035)	**(0.026)**	(0.000)	(0.001)	**(0.041)**
4.ind_edu_secondary	**0.825*** **	**0.562*** **	-0.001***	-0.010***	**0.118** **
	(0.040)	**(0.033)**	(0.0003)	(0.001)	**(0.046)**
5.ind_edu_tertiary	**1.527*** **	**1.000*** **	-0.001***	-0.012***	**0.376*** **
	(0.045)	**(0.042)**	(0.0003)	(0.001)	**(0.049)**
Log of income	**-0.016**	**0.081*** **	-0.001***	-0.006***	**-0.117*** **
	(0.017)	**(0.010)**	(0.0001)	(0.0004)	**(0.020)**
Household size	**-0.099 *** **	**-0.090*** **	0.0001***	-0.0001	**-0.053*** **
	(0.007)	**(0.005)**	(0.00003)	(0.0001)	**(0.005)**
(Unemployed)					
Employed	**0.319*** **	**0.223*** **	0.0001	-0.001	**0.149*** **
	(0.029)	**(0.020)**	(0.0001)	(0.001)	**(0.023)**
(Urban)					
Rural	**-1.268*** **	**-0.884*** **	0.0002**	0.005***	**-0.579*** **
	(0.021)	**(0.029)**	(0.0001)	(0.0005)	**(0.020)**
religion			-0.00003**	0.002***	
			(0.00001)	(0.0004)	
femhead_religion			0.001**	-0.002***	
			(0.0005)	(0.001)	
Region			-0.0001***	0.001***	
			(0.00001)	(0.0001)	
femhead_region			0.001***	-0.001***	

			(0.0001)	(0.0002)	
Underid test					145.329(0.000)
Hansen J (overid)					2.090(0.3517)
Endogeneity test					398.784(0.000)
F-stat			11.45(0.000)	38.26(0.000)	46.825
Year Effects	Yes	Yes			Yes
Region Effects	Yes	No			No
Observations	19,766	19,766			19,766
R-squared					-0.721

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. For the under identification, Hansen J. (overidentification), endogeneity and F-stat tests, we report the test values with p-values in parenthesis.