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The gender perspective of socioeconomic determinants of household cooking energy consumption in Lesotho

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Abstract

Unveiling gender dynamics in household energy consumption is a pathway to empowerment and sustainable development since the inaccessibility of electricity perpetuates gender inequality due to women's higher involvement in time-consuming and unproductive activities such as wood collection and cooking. This study investigates the variations in fuel consumption shares between female-headed and male-headed households and explores the determinants of these differences from a gender perspective. Using the Tobit regression model to analyse the 2017 Household Energy Consumption Survey (HECS) data, the study establishes the statistical significance of socioeconomic variables on household shares of biomass, paraffin, LPG, and electricity, assuming that the shares are left-censored. The findings reveal intriguing patterns, such as the increasing shares of dirty fuels with the age of the household head regardless of gender. However, education impacts female and male-headed households differently, with female-headed households generally increasing their share of high-end fuels while male-headed households opt for transition fuels. Increasing income and households in peri-urban and urban areas are also not discriminatory in terms of gender as both reduce the share of dirty fuels and rely more on cleaner alternatives. Conversely, increasing household size affects female-headed but not male-headed households as they are found to increase the shares of transition fuels in summer but reduce the share of cleaner fuels in winter. Therefore, the study emphasises the need for targeted education and economic empowerment programmes, awareness campaigns, and income-generating skills development policy interventions to foster clean energy access and improve the well-being of Basotho households.

List of abbreviations

CO_2	Carbon dioxide
GHG	Global greenhouse gas
GoL	Government of Lesotho
HECS	Household Energy Consumption Survey
kWh	kilowatt hour
LEC	Lesotho Electricity Company
LEWA	Lesotho Electricity and Water Authority
LPG	Liquefied Petroleum Gas
MW	Megawatt
NSDP	National Strategic Development Plan
RE	Renewable energy
SAPP	Southern African Power Pool
SDGs	United Nations Sustainable Development Goals
WHO	World Health Organisation

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1. Introduction

1.1. Background

The contribution of energy to social development and household welfare necessitates adequate energy access for all. To start with, energy facilitates the implementation of a wide range of economic activities and lengthens production time thereby increasing productivity. However, an estimated 1.1 billion people, that is, 14% of the global population, have been deprived of access to electricity since 2019 (Rahut et al., 2019). As a result, high reliance on paraffin, coal, and biomass continues to be observed in various parts of the world, especially in developing countries.

Due to the shortage of clean energy for various household and industrial applications, the energy sector is reportedly the major contributor to the total global greenhouse gas (GHG) emissions with a share of 73.2% in 2020 due to perpetual fossil fuel utilization (Ritchie et al., 2020). Reports show an increase in surface carbon dioxide (CO_2) emissions over the years from 1960 to 2020 as depicted in Figure 1, with a slightly higher rate of increase observed in the 21st century. This justifies the current climate change dilemma as the previous records of a 0.08 ℃ increase in global temperatures per decade from 1880 escalated to 0.18 ℃ since 1981, as shown in Figure 2. It is no wonder the wildfires have escalated at such an alarming rate in Europe, Northern America, and Northern Africa, with close to 70,000 incidences documented globally in 2022 (Hoover and Hanson, 2023).

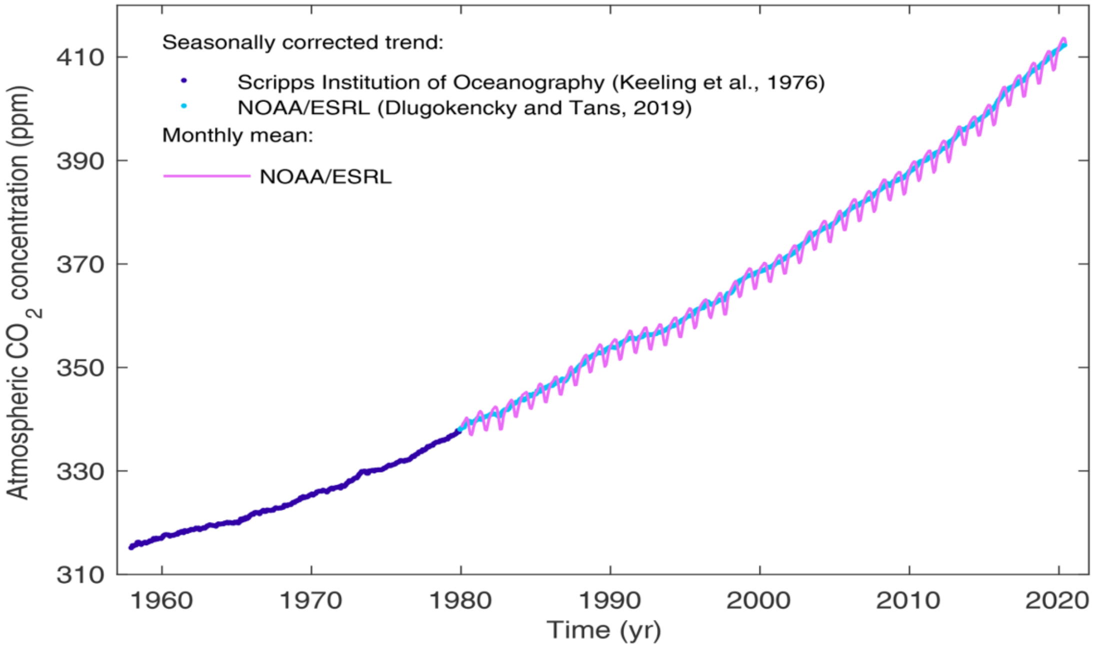


Figure 1: The global greenhouse gas emissions

Source: (Friedlingstein et al., 2020)

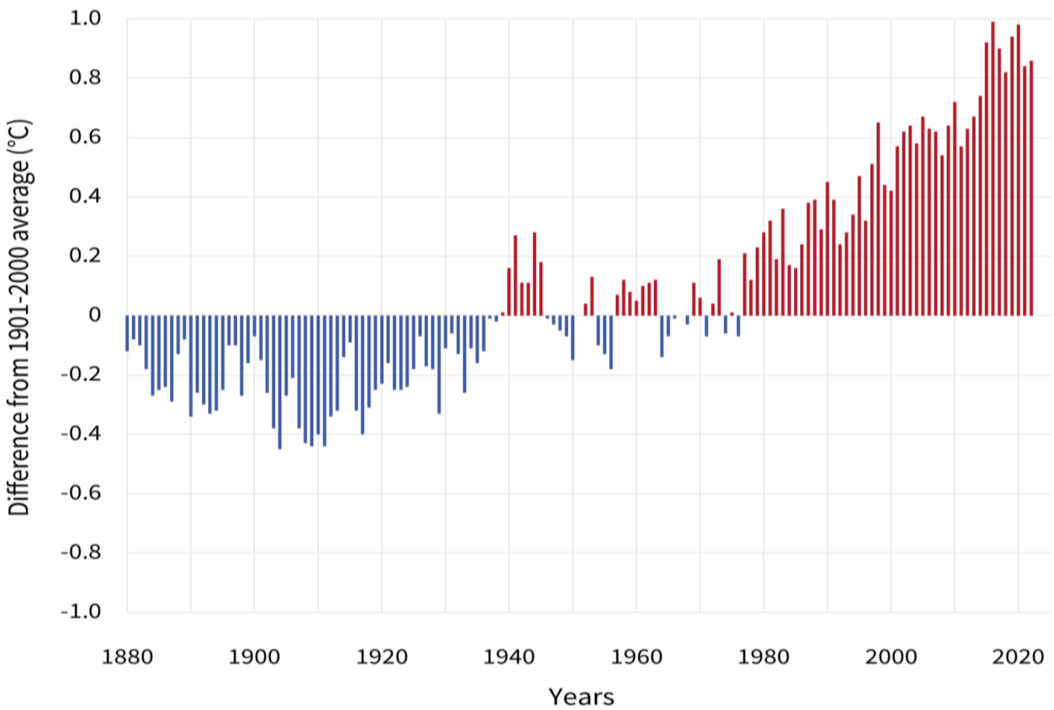


Figure 2: The average global temperature change

Source: (Lindsey et al., 2023)

As far as climate change mitigation strategies are concerned, the use of clean fuels and improved cooking devices is a low-hanging fruit to curb anthropogenic emissions. The body of literature highlights that 72% of the global GHG emissions emanate directly and indirectly from the residential sector, making it the priority target (Connolly et al., 2022; Dubois et al., 2019). The root cause is the indiscriminate biomass utilisation by 2.4 billion people who lack access to clean cooking fuels in developing countries as of 2022, particularly in African and Asian countries (WHO, 2022). Meanwhile, 90% of the energy consumed in the residential sector of developing countries is mainly for cooking (Mperejekumana et al., 2021). Thus, the type of cooking energy consumed in households is a critical aspect that predominantly affects and is affected by the household living conditions.

Nevertheless, as Matsumoto et al. (2022) opine, the household cooking energy consumption choices, patterns, and their respective triggers remain largely unknown in some developing countries and therefore hinder the implementation of the much-needed energy sector reforms. Owing to the low economic standards, households in developing countries such as China, India, Nigeria, Egypt, and Lesotho rely heavily on low-cost and/or freely available polluting fuels, especially traditional fuels like wood, animal dung and coal to meet their daily energy requirements for which there is hardly any records of fuel utilisation (Connolly et al., 2022; Mothala et al., 2022; Zou and Luo, 2019). This pattern, however, varies significantly within the countries where poor, mostly rural and female-headed households consume a bulk of the traditional fuels while the richer urban and male-headed households consume modern fuels more (Mothala et al., 2022; Nsabimana et al., 2022).

The social and cultural norms that have been practised for centuries in some developing countries hold women accountable for daily household management including cooking and fuel collection which undoubtedly compromises the quality of their health and well-being (Mperejekumana et al., 2021; Nwaka et al., 2020; Zhang et al., 2023). As Nwaka et al. (2020) assert, continued cooking on an open fire and using inefficient stoves not only encourage higher fuel usage, putting pressure on forest covers but also deteriorates the health quality of women and children as they bear the greatest exposure to indoor emissions. For instance, over 70% of the reported premature deaths due to respiratory tract infections in sub-Saharan Africa in 2022 are accounted for by women aged 15–49 and children below 5 years of age at the rate of 35.64% and 36.33% respectively (Emodi et al., 2022). The likes of early marriage, single parenthood, and lean income streams are the key factors that perpetuate female-headed households' biomass consumption and render them a critical group to combat polluting fuel consumption in the residential sector.

Besides directly advocating for accelerating access to affordable and clean energy for all by 2030, as laid out in the United Nations Sustainable Development Goal (SDG) 7 (United Nations, 2019a), the consumption of clean fuels for cooking fast-tracks the realisation of gender equity (SDG 5), quality education (SDG 4) and good health and wellbeing (SDG 3) among others (Nwaka et al., 2020). Since women and girls in most developing countries are forced to spend long hours in search of wood rather than taking on productive activities such as education and other forms of skills development, substitution with clean cooking fuels can potentially bridge the gender inequality gap (Elasu et al., 2023; Kyayesimira and Muheirwe, 2021). It would further protect the female wood collectors' safety, health, and well-being previously in jeopardy due to the nature of biomass collection areas (they are normally in the veld or forests, quite distant from the homesteads) (Kyayesimira and Muheirwe, 2021).

Despite the health implications, contribution to gender inequality, and negative impact on the environment, the 2022 Clean Cooking Alliance reports that clean cooking is the most unvalued initiative in climate change mitigation strategies, yet US$2.4 trillion is lost annually in response to climate and economic disruptions resulting from the continued use of polluting fuels (Clean Cooking Alliance, 2022). The 2022 World Health Organisation (WHO) reports on the other hand describe biomass utilisation as a "2-edged sword" as inefficient biomass burning contributes to GHG emissions while cutting off trees reduces the natural sinks increasing the global concentration in both ways (WHO, 2022). It further emphasizes the need to attract US$4.5 billion in funding annually to mobilise clean cooking solutions globally for the realisation of SDG 7 by 2030.

Advocacy for clean cooking energy utilization is an absolute necessity in Lesotho where almost 80% of the national energy mix is traditional fuels as of 2019 (Letete et al., 2019). However, there is a biased preference for either modern or traditional fuels based on the settlement type as shown in Figure 3, depicting a higher consumption of biomass for cooking in rural areas with a share of 80% as opposed to 7% in urban areas. The converse is true in the case of modern fuels. For instance, there is low use of electricity for cooking in rural areas with a share of 1.3% while it has a share of 23.6% amongst urban households. The 60.7% poverty rate reported amongst the rural residents rations their observed reliance on biomass since they barely afford to provide for their families (United Nations, 2019b).

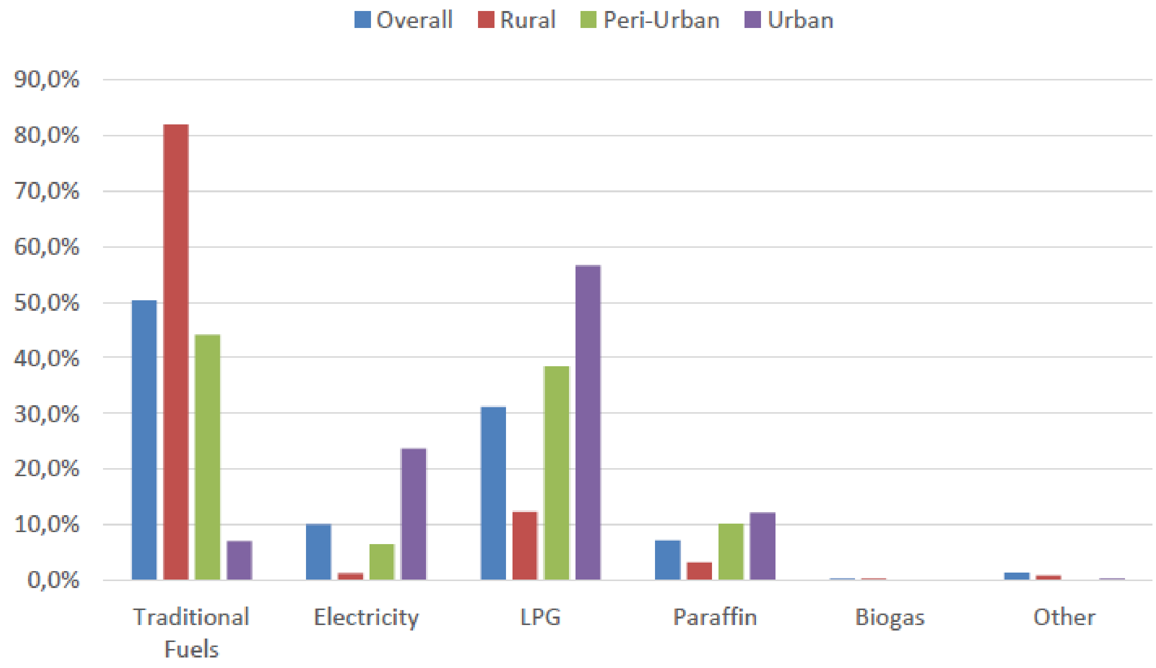


Figure 3: Lesotho's cooking energy mix categorised by settlement type

Source: (Mothala et al., 2022)

1.2. Problem statement

Electricity access remains low in parts of Lesotho, especially the rural areas where grid extension is uneconomical due to the mountaneous terrain (Taele et al., 2012). Inequalities in the households' socioeconomic characteristics also contribute substantially to uneven clean energy access throughout the country. For instance, 75% of the grid-connected rural households in Lesotho do not afford electricity since 2018 because of its continual annual increment of up to 23.6% (Mpholo et al., 2018). In these areas, energy demand is met through polluting fuels such as biomass especially during extremely cold winter months, significantly compromising the respiratory health of users.

Basotho women are particularly more vulnerable to indoor pollution than males since they spend hours by the open fire cooking as per the socially constructed norms and responsibilities (Kyayesimira and Muheirwe, 2021). From this stems other significant social injustices that are mostly borne by women such as drudgery and time poverty as wood collection and fire preparation are labour intensive. Nonetheless, the determinants and implications of varied clean energy consumption by different genders are seldom comprehensively reviewed, hence, this study seeks to bridge this gap in the literature by exclusively analyzing the interdependence of the gender of the household head and consumption of fuel shares in different seasons concurrently. No similar study, to the best of the author's knowledge, has been undertaken.

1.3. Research question

To provide a thorough understanding of the gender perspective of socioeconomic determinants of household energy consumption in Lesotho, this study seeks to address the question:

i. How does the gender of the household head affect the household share of fuel consumption in different seasons of the year?

1.4. Research objective

The following objective guides the fulfilment of this study to adequately answer the research question using data from the Lesotho Housing Energy Consumption Survey (HECS) of 2017:

i. To analyse and compare the determinants of the shares of cooking fuels consumed amongst female and male-headed households during different seasons of the year.

1.5. Justification

This study imparts knowledge, especially to Basotho, about their energy consumption state and its repercussions. It provides a guide to critical driving factors unto which timely corrective measures are essential. It is also of great importance to policymakers, as Gouveia et al. (2015) argue, that understanding energy consumption patterns informs marketing aggregation, advocacy policies for energy efficiency as well as proper and well-targeted energy projects rollout strategies, all of which are critical for the much-needed growth of Lesotho's energy sector to bridge the current 58% electricity capacity deficit reported by the Lesotho Electricity and Water Authority (LEWA, 2020) as of 2020.

Unlike some studies such as Mothala et al. (2022), this study contributes to the literature on the drivers of household energy consumption in several ways. First, instead of using qualitative response models like Logit and Probit probability models, which are commonly employed for discreet dependent variables the study uses the Tobit regression model to obtain unbiased and consistent estimators for its censored sample (Gujarati, 2008). The Tobit model employed in this study explains the household energy consumption trends by stipulating the shares of each fuel in the overall household energy consumption and further presents the degree of influence of the determinants on the observations made (Gujarati, 2008; Zou and Luo, 2019).

Secondly, this study fills the gap in the literature on the gender dynamics of household energy consumption which is generally under-investigated. It also integrates the impact of seasonality on the overall dynamics of household energy consumption by observing the energy consumption patterns of female and male-headed households in summer and winter independently. This overcomes the limitation of combining the samples into a single model that assumes the same slope coefficient for both genders as though the relationship between the predictors and the outcome variable is the same for both. This approach would overlook important differences in characteristics of the female and male-headed households and lead to biases in the estimated coefficients.

Lastly, with no follow-through on the energy policy framework in place in Lesotho since 2015, the institutional responsibilities remain undefined (Government of Lesotho, 2015). This poses a risk to private developers and therefore prohibits the maturing of the energy sector. Hence, this study contributes to the body of literature through the analysis of the shares of household cooking fuel consumption to the entire household energy demand with the intent to influence and inform the targeted policy instruments by pointing out the most critical aspects that need to be tackled for just and inclusive energy transition within the households. The study also briefs energy project developers since they ought to be informed about household energy consumption amounts and patterns to properly draw up plans and alleviate market risks due to unforeseen irregularities and unknown drivers for such.

1.6. The organisation of the study

The remainder of the study is organised thus: the context of the study presenting its significance and relevance in Lesotho is presented in Chapter 2. The relevant literature on household energy consumption models and attributes is critically reviewed in Chapter 3. Chapter 4 outlines the methodology and data employed whereas the obtained results are presented and discussed in Chapter 5, which is followed by the conclusions and policy recommendations in Chapter 6.

2. Context

2.1. Introduction

This chapter aims to provide a comprehensive understanding of Lesotho's energy situation and assess its role in the household energy mix. Section 2.2 describes Lesotho's energy sector including the electrification rates, the tariff trends, and the national energy policy. Section 2.3 discusses the national energy balance across the various sectors in the country while Section 2.4 delves into the country's renewable energy resource endowment and its implication to the transformation of Basotho households' energy consumption patterns.

2.2. Lesotho's energy sector

Lesotho shares most if not all sentiments with the fellow least developed countries globally like the low electrification rate, especially in the rural areas. In 2020, the national electrification rate stood at 47.4% and the odds are, by 2030, Lesotho will achieve a national household electrification rate of 54.2% (Mpholo et al., 2021; World Bank, 2020a). However, there will be a notable disparity in the distribution, as 95% of urban households and 19.4% of rural households are expected to be grid-connected by 2030 (Mpholo et al., 2021). This variance is mainly due to the rugged terrain and scattered settlement types in the rural areas which make grid extension uneconomical (Taele et al., 2012). For this reason, 90% of rural households are perpetual traditional biomass users as of 2019 (Letete et al., 2019).

With Lesotho's indigenous grid-scale electricity generation stuck at 72 MW since 1998, electricity imports are incorporated into the national grid to bridge the existing 58% capacity deficit as of 2020 (LEWA, 2020). These, however, come at a cost over 10 times higher than the local charges of 0.12 M/kilowatthour (M/kWh) and additional wheeling charges (Kao et al., 2021; LEWA, 2020). In this regard, it is undeniable that Lesotho's energy security and inherent affordability are questionable, especially with the anticipated 74% rise in the national electricity demand from 121 MW to 211 MW between 2010 and 2030 (Mothala et al., 2022; Mpholo et al., 2021; Thamae et al., 2015).

The effects of ever-increasing tariffs are already evident in Lesotho as the 23.6% increment within 10 years to 2018 imposed by LEWA rendered electricity unaffordable to 75% of grid-connected sampled rural households (Mpholo et al., 2018). A 60% drop in household electricity consumption in the period 2000 to 2016 despite the increasing number of connections proves that Basotho resemble an elastic market (Mpholo et al., 2020). For example, post the tariff increment, 42% immediately restricted their electricity consumption, and an additional 55% share the same intent to resort to cheaper yet polluting alternatives in the future (Mpholo et al., 2018).

On the other end, the Government of Lesotho (GoL) aims to remedy the situation through various development frameworks that guide and/or govern the energy sector operations. These include the 2015-2025 Lesotho Energy Policy, the 2017-2027 Lesotho National Climate Change Policy and the Implementation Strategy (CCPIS), the 2018-2023 National Strategic Development Plan (NSDP), and the 2018-2035 Electrification Master Plan, which collaboratively acknowledge the dire need for inclusion of the private sector in renewable energy (RE) generation to bridge the energy deficit and propel Lesotho towards the just achievement of SDG 7 (Government of Lesotho, 2015; United Nations and GoL, 2021). However, implementation remains a challenge as, for instance, the 2013 Renewable Energy policy remains a draft to date. The likes of this slow realization of the set targets like the proposed 200 MW from combined solar, wind and hydropower anticipated to be in operation by 2020, but has not materialised to date (United Nations and GoL, 2021).

Some government policies do stimulate household electricity consumption like the lifeline tariff that charges 0.72 M/kWh as opposed to the standard 1.47 M/kWh for 30 kWh consumed per month from 2020 (LEWA, 2020; Mpholo et al., 2020). The tariff, however, remains substantially high beyond the set lifeline margin due to cross-subsidization imposed to cover the utility’s operation costs (Mpholo et al., 2020). To this point, harnessing RE proves to be the most logical solution, not only for its cleanliness but also because it allows for creativity and affordable solutions that can transform traditional household energy choices. Besides, Lesotho is well endowed with RE resources.

2.3. National energy balance

A substantial amount of energy consumption in Lesotho is from the residential sector with a share of over 60% consistently from 2010 to 2018 as depicted in the trend of energy demand by sector according to Figure 4. Even though energy demand is also increasing in the transport and industry sectors in the same period, their combined contribution to the energy mix is far less than half of the household contribution. Of great concern is that this high energy consumption in households is predominantly polluting biomass which constitutes close to 80% of the national energy mix as of 2019 (AFREC, 2019; Letete et al., 2019).

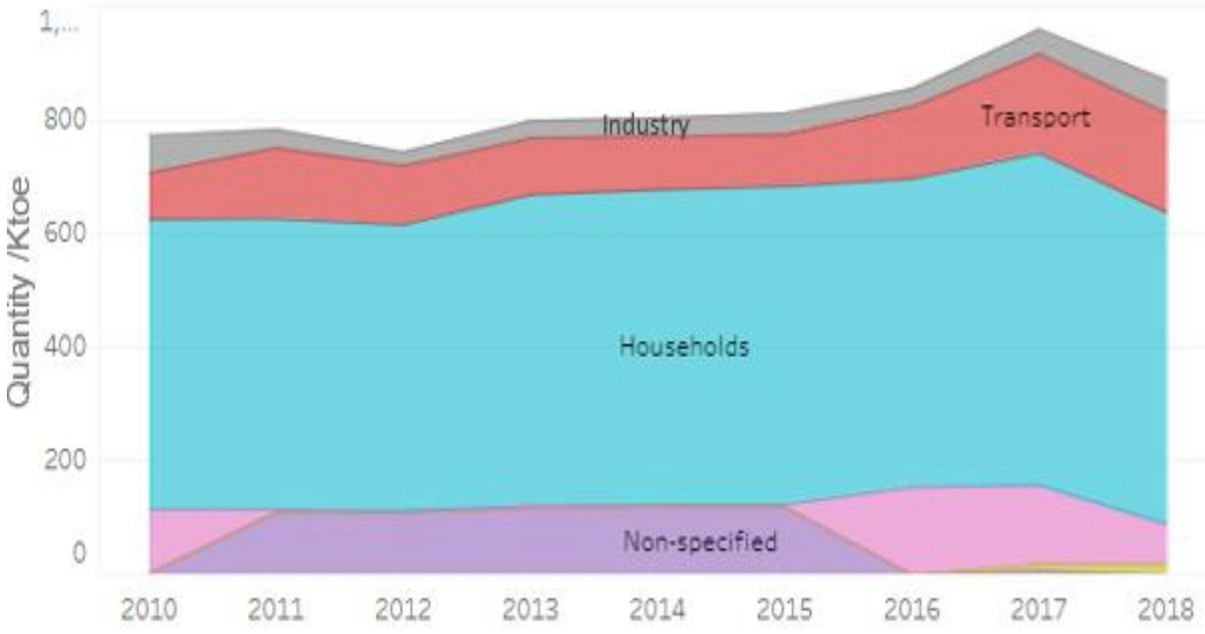


Figure 4: The final energy consumption by sector in Lesotho

Source: (AFREC, 2019)

However, biomass utilization is disproportionately higher in rural areas with penetration levels for cooking alone at 81.9% as opposed to 7% in urban areas (Mothala et al., 2022). The uptake of cleaner energy sources on the other hand remains substantially low in the rural areas with shares of 1.3% and 12.4% respectively for electricity and LPG contrary to 23.6% and 56.6% respectively in urban areas. Since rural communities are mostly subsistence farmers, affordability and accessibility influence their fuel choices. They are likely to choose biomass over modern fuels due to their ample supply of animal dung and straw (Rahut et al., 2019).

Besides environmental degradation due to deforestation and soil erosion, inefficient burning of biomass in open fire emits lethal gases like carbon monoxide (CO) and particulate matter which causes indoor pollution that endangers human health (Elasu et al., 2023; Mothala et al., 2022). Since social norms and culture mostly hold females responsible for cooking and household chores, the general perspective is that they are more vulnerable to respiratory tract infections. However, in Lesotho, fewer death cases of females (0.166%) than males (0.196%) are reported as of 2016 (CEIC, 2016; Knoema, 2016).

Despite the declining mortality rate due to indoor pollution in Lesotho since 2006, the statistics remain considerably higher than the average in Sub-Saharan Africa since 2003 as shown in Figure 5 for the trend from 1990 to 2019. The idea is that Lesotho has a long way to go in terms of implementing mitigation strategies, especially clean cooking solutions relative to other countries in the region.

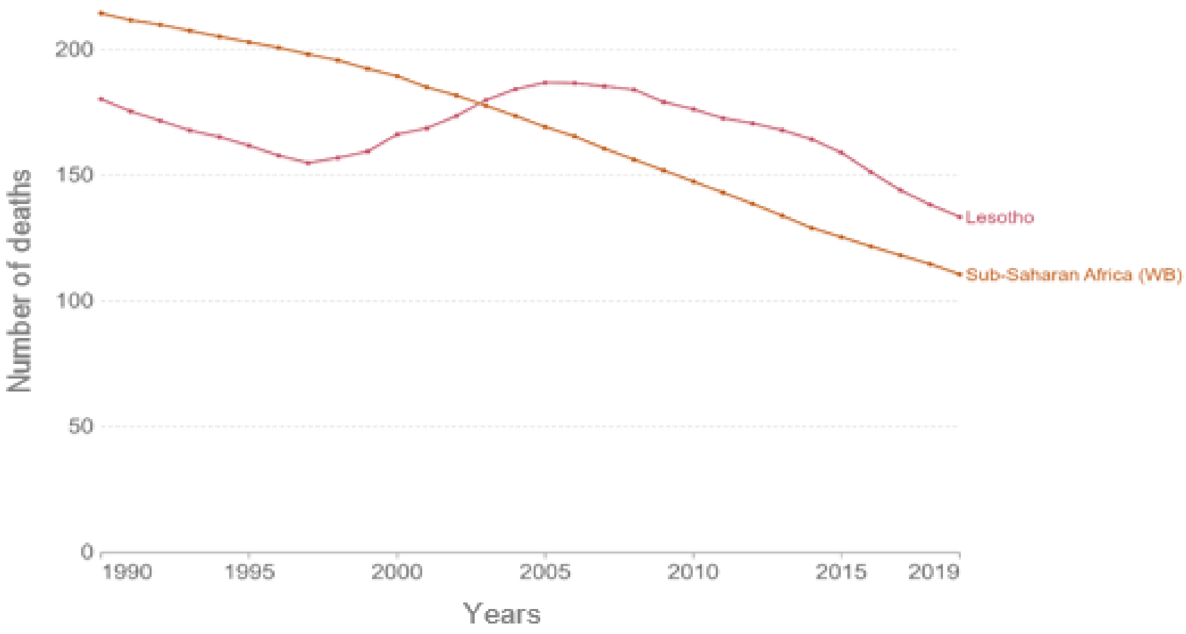


Figure 5: The register of deaths in Lesotho and Sub-Saharan Africa due to indoor pollution from 1990 to 2019

Source: (Our World in Data, 2020)

Since grid extension to certain parts of the country, especially in the rural areas, is uneconomical due to the rugged terrain and scattered settlements, alternative clean cooking technologies like improved cookstoves facilitate the delivery of clean energy in these marginalized societies (ACE One, 2019; Atmosfair, 2022; WAME, 2010). Reports show that cookstoves save up to 80% of energy and hence require less fuel. This conserves forests and the environment in general (Atmosfair, 2022). Each cookstove of one of the brands is for instance estimated to save over 10 MWh of electricity per year (WAME, 2010). The use of cookstoves also answers other global woes by affording women time to partake in constructive activities like education, arts and crafts, etc., and to curb the health implications of indoor pollution.

On the contrary, the majority of rural communities that are in dire need of improved cook stoves due to their high reliance on biomass find these to be unaffordable (UNFCCC, 2020). Over 60% of these families are reported to be below the poverty line hence showing sluggish adoption of these lifesaving appliances (United Nations, 2019b). This led to the inception of the likes of the SAVE80 subsidy schemes for portable cook stoves, heat retaining boxes and cooking utensils to make them accessible even to the less fortunate (UNFCCC, 2020; WAME, 2010). However, there is a requirement for more sustainable, equitable and just subsidy schemes to achieve the set SDGs and land reclamation in record time.

2.4. Lesotho's renewable energy resource potential

Lesotho is known for its high endowment of clean water resources, the bulk of which is exported to the Republic of South Africa alongside generating 72 MW of hydropower. The country's topography allows for the free flow of water at a sufficient head for electricity generation because of the high variance in altitude (1400 m to 3400 m). Cumulatively, the country's RE generation capacity from solar, wind, waste-to-energy and hydropower is estimated to be at least 2.3 GW (World Bank, 2020b), which surpasses the indigenous peak demand projections of 211 MW by 2030 (Mpholo et al., 2021) and 432 MW also by 2030 as anticipated by the Lesotho Electricity Company (LEC) (World Bank, 2020b). On the other hand, the feasibility studies undertaken by the government reveal the solar and wind potential of 6 GW with the highest power density wind regimes along the western borders of the country while the solar potential is distributed across the country (Government of Lesotho, 2019).

Despite having abundant renewable energy resources, the actual developments have been limited to solar farms. Currently, a 30 MW section of a 70 MW partially state-owned grid-scale solar power plant is operational at Haramarothole, along with the One Power mini-grid at Ha-Makebe (International Trade Administration, 2021; LEWA, 2021). Additionally, there are ongoing developments such as the 20 MW solar farm owned by One Power, and the remaining 40 MW of the partially state-owned grid-scale solar farms at Ha-Ramarothole, Mafeteng. Lesotho has a rich abundance of solar energy, making it both plentiful and the most cost-effective of all other energy sources to harness. The country experiences over 3000 sunshine hours per year, and the global horizontal irradiation measures over 5.3 kWh/m^2 (Taele et al., 2007; World Bank, 2020b).

Lesotho also has substantial wind and hydropower potential. Currently, 72 MW of hydropower is already harnessed at the 'Muela Hydropower station, accounting for 16% of the country's total hydropower potential of 450 MW (Taele et al., 2012). Looking ahead, there is untapped potential for an additional 4 GW of pumped storage hydropower, which the government hopes to harness in the future (Government of Lesotho, 2019). Moreover, there is enthusiastic anticipation for the realization of the 110 MW Hirundo-owned wind farms at various earmarked locations in the country (Hirundo Lesotho, 2021).

With this established high RE resource endowment, the country is actually at liberty to be the net exporter of electricity which, is much needed by South Africa due to its current 4 - 6 GW electricity deficit (Mamphogoro et al., 2022; Moyo, 2022). In addition, the Southern African Power Pool (SAPP) membership grants the country access to cross-border markets within the SAPP (SAPP, 2022). However, the existing energy policy fails to attract sufficient investment, hence, the substantial RE potential remains untapped and the realisation of clean energy access remains impossible for some Basotho households.

3. Literature Review

3.1. Introduction

This chapter reviews the literature on the disparities in energy consumption patterns between female-headed and male-headed households. Section 3.2 discusses the basic models that explain household energy consumption behaviour. Section 3.3 focuses on the household energy consumption attributes and how they vary, based on the gender of the household head while Section 3.4 synthesizes the discussed findings from the literature.

3.2. Energy consumption models

The household energy transition is explained by two models, the energy ladder and fuel stacking models which connect household energy consumption trends to socioeconomic behaviour. The latest literature argues that the energy ladder model is insufficient since it assumes that as households become wealthier, they tend to transit entirely from traditional energy sources to modern energies with the degree of elevation up the ladder proportional to the income increment (Leach, 1992). This falsely restricts energy consumption within the margins of availability and affordability whereas the reality suggests otherwise. For instance, a study undertaken to determine electricity consumption in Ethiopia, Uganda, Tanzania, and Malawi in 2017 demonstrates that only 3% of the respondents consumed electricity for multiple end-uses in the household while the other 97% either used it for a single purpose, mostly lighting, or not at all (Rahut et al., 2017).

The fuel stacking model, on the other hand, suggests simultaneous consumption of multiple energies in households, especially in the developing world. According to Yadav et al. (2021), households in developing countries partially adopt modern energies due to cost implications, personal inclinations and norms. Wassie and Adaramola (2021) also opine that households in Southern Ethiopia still consume biomass as a supplementary fuel despite development in their financial status or electrification because they find electric cooking utensils unaffordable. However, in urban Kenya, fuel stacking is inflicted by households' need for multiple stoves for the time-convenience of simultaneous meal preparation or because the primary stoves lack certain features, hence the consumption of multiple fuels (Ochieng et al., 2020).

On another note, women's inclusion in various energy and climate change decision-making platforms is gaining recognition as utterly important in the recent body of literature. As such, research currently advocates for a gender perspective in the analysis of household energy adoption and consumption characteristics. Initially, women's and men's responsibilities continue to be defined by the socio-cultural norms that hold women accountable for domestic chores and are therefore the dominant energy users in the household while men take on formal, mainly technology-based jobs for financial gain (Wang et al., 2021). They deny women time for social and self-development activities while also increasing their vulnerability to indoor pollution where polluting fuels are used (Sunikka-Blank et al., 2019). The consumption traits vary substantially between males and females and are therefore worthy of investigation.

3.3. Household energy consumption attributes

The household behaviour in all aspects is moulded by the occupants' individual and combined preferences, decisions and behavioural traits since they share roles that make up the character of the entire household. Energy consumption patterns are no exception since they are based on the decision-making attributes of the household. These differ substantially between men and women since men are more focused on the cause-effect logic which adds to their rationality and egoistic nature while women are intrigued by the significance of sustainability resulting in their intuitive and altruistic decision-making (Du and Pan, 2022; Imbulana Arachchi and Managi, 2021). The determinants for clean energy and technology adoption and the ultimate energy consumption in the household are, therefore, reviewed with respect to the gender of the household head.

3.3.1. Technology adoption

The inclusion of women in household energy decisions remains low in most developing countries with 40% male domination as opposed to 19.1% feminine domination reported in rural China despite the husband and wife holding equal statuses in the family (Wang et al., 2021). Perhaps the social norms that hold women responsible for non-productive domestic chores cause this imbalance though much better conditions exist in Lesotho with 88% of the females being involved in the major household equipment purchase (UNFCCC, 2020). Normally, decision-making is in favour of the financial status, behaviour, and biological make-up of the decision maker which varies significantly when undertaken individually and collaboratively by partners. For example, the findings from a study in Rwanda reveal that in

77% of male-headed households, men make all energy decisions on their own whereas women have minimal participation and often have to consult with their husbands on all ultimate decisions if they ever participate (Muza and Thomas, 2022). This often compromises women's needs since men make decisions that best suit their desired level of comfort, hence, women frequently report thermal discomfort in shared environments (Sintov et al., 2019).

Moreover, men generally spend more time out of their homes and therefore find most home appliances invaluable to them (Fingleton-Smith, 2018). Fingleton-Smith (2018) and Johnson et al. (2019) allege that men normally put minimal effort into purchasing home appliances and seldom prioritize their families, particularly their wives' needs. On the other hand, women may be reluctant to adopt certain technologies since owning appliances does not lighten their workload but leads to husbands abandoning previously shared responsibilities thus adding more domestic chores to their daily roster and having husbands spend even less time at home (Muza and Thomas, 2022).

Gender inequity can therefore also be declared a root cause of energy injustice as men have higher-paid jobs putting male-headed households in a better position to adopt clean energy technologies, unlike the masses in developing countries (Johnson et al., 2019; Pearl-Martinez and Stephens, 2016; Phogole et al., 2022). For instance, female-headed households in Turkey have a negative coefficient at a 10% significance level for willingness to pay for electricity if renewables integration in the national grid is increased from 20% to 30%, implying that male-headed households have a higher willingness to pay for modern energy. The income gap between males and females is the most probable underlying cause since access to finance is the prime enabler for modern energy adoption and appliance purchase (Muza and Thomas, 2022).

Moreover, the presence of a man in the household plays a tremendous role in its energy adoption characteristics as observed from the case study of Bhutan. The observations show parity at 22% between female and male-headed households that rely entirely on polluting fuels. However, in disaggregating female-headed households, the percentage rises to 26% for de jure (single mothers) female-headed households (Aryal et al., 2019). The variance herein stems from higher off-farm employment opportunities for males.

Besides income, the knowledge level of the household head and/or their spouse spurs green energy adoption behaviour in households (Mottaleb et al., 2017). This is the basis for observed variability amongst groups of female-headed households as Ravindra et al. (2019) show that in the rural areas of India, illiterate women and those with primary school education reported high reliance on solid biomass as the primary fuels, whereas graduate women have a higher preference for clean energy sources supplemented with solid biomass. Moreover, Wang et al. (2020) assert that in urban China, respondents with a Master's degree or higher are eager to acquire first-class energy-efficient products at costs up to 37.79% higher than basic products despite their gender. Thus, education drives clean energy adoption.

3.3.2. Household energy conservation

The household occupants' attitudes, behaviour and knowledge level of sustainable energy use collectively determine the ultimate energy intensity and conservation characteristics of a household (Jareemit and Limmeechokchai, 2019). According to Du and Pan (2022), these attributes are different in males and females mainly because of the biological makeup, sociocultural and environmental factors. Henceforth, household energy conservation mechanisms are classified into energy efficiency, which entails the use of energy-efficient appliances and consumption curtailment, which involves behavioural changes intended to reduce energy consumption in households (Wang et al., 2021).

Despite men having the vast majority of opportunities and a strong financial muscle resulting in male-headed households reporting a high preference for clean energy technologies, they are less fond of energy-efficient products than gender-neutral and female-headed households (Wang et al., 2021). This is because women opt to purchase high-quality, energy-efficient appliances and, hence, save more energy and reduce daily energy costs more than men (Mottaleb et al., 2017; Wang et al., 2021). This observation is in alignment with the literature since men have already been reported to be inconsiderate when it comes to the quality and efficiency of purchased appliances (Fingleton-Smith, 2018).

Women have been observed to be more energy conscious as they demand 1.2 - 1.5 times less energy contrary to their male counterparts in China (Wang et al., 2019). In the United Kingdom, electricity demand for one female is 13% less than that of a male due to differences in behaviour and preferences (Grünewald and Diakonova, 2020). This contradicts the findings that men have higher knowledge about energy conservation and confirms that the altruistic nature of women fuels their strong urge for responsible consumption to protect the environment for their children's wellbeing (Du and Pan, 2022; Imbulana Arachchi and Managi, 2021).

Furthermore, socio-cultural norms and expectations have kept women in check for ages. For instance, women in Rwanda fail to use the improved cookstoves because they are not allowed to cook in a standing position and women are generally expected to carry out the bulk of domestic responsibilities even when they have a productive engagement elsewhere (Johnson et al., 2019; Muza and Thomas, 2022). The likes of these and the imbalance in employment opportunities leave women vulnerable to energy poverty which puts additional emotional and physical strain on them (Petrova and Simcock, 2021; Shrestha et al., 2021).

3.4. Synthesis from the literature

Household energy consumption and analysis of its drivers is a dynamic concept with different indicators that are area-specific. These are spurred by the socio-cultural and household demographic characteristics hence their variability in different areas. The general trend observed is women's dedication to conserving energy and investing towards energy efficiency as the household heads or when allowed some decision-making power by the spouse. The presence of men in households is proven to be essential, particularly for renewable energy adoption since men occupy most of the highly-paid jobs and generally run more lucrative businesses than their female counterparts. There is, however, a conflict on which gender has better environmental education than the other but women's intuitive nature and men's rationality justify the fact that men may be more knowledgeable but negligent whereas women's feeling-based decision-making drives their passion to engage in energy conservation mainly for their children's future. Seeing that rich women are as high energy consumers as men questions whether women are indeed driven by their compassion or save energy to avoid or cope with their low-income induced energy poverty

Furthermore, most of the analysed literature is suited for hot and humid regions where there is a need for air coolers, hence, a slight deviation is probable in the findings of this study as Lesotho has moderate-to-cold weather conditions varying according to a geospatial location. This study, therefore, contributes to the empirical literature using the Tobit regression model. To the best of the author's knowledge, only Mothala et al., (2022) have contributed empirical literature in Lesotho through an econometric analysis of the determinants of choice of household energy consumption, using the multinomial logistic model. Nevertheless, the study did not integrate the impact of gender and seasonality on the overall dynamics of household energy consumption by observing the energy consumption patterns of female and male-headed households in summer and winter independently, which is a research gap that this study is intended to fill.

4. Methodology

4.1. Introduction

This chapter discusses the methodology used in this study. Section 4.2 delves into data description, encompassing the enumeration area and period, the employed sampling technique and the insights into the variables chosen for this study. Section 4.3 focuses on model specification while the model estimation strategy and model validation using diagnostic tests are discussed in Sections 4.4 and 4.5 respectively.

4.2. Data description

The Bureau of Statistics Lesotho (BoS) in partnership with the government's Department of Energy (DoE) undertook the 2017 Household Energy Consumption Survey (HECS) to update the household energy consumption dynamics which were last analysed in 1985. This data was intended to be a baseline for household energy consumption in Lesotho which was to be assessed at five (5) years intervals thereafter (International Households Survey Network, 2019). The survey was undertaken to account for the entire country with the questionnaire intended to extract information on the individual household energy-related behaviour.

4.2.1. Data collection area and time

The 2017 HECS was undertaken in two phases with phase 1 undertaken during the winter months from April to July 2017 while phase 2 was done from August to November 2017 covering the summer months. The data of the Primary Sample Units (PSU), the households, was collected in the same Enumeration Area (EA) as the 2016 national census where careful consideration was taken to execute the questionnaire in the same households in both phases. Furthermore, sampling was done across the 10 districts of Lesotho following a two-stage stratified sampling blueprint, carefully choosing EAs to include the rural, peri-urban and urban settlement types and also based on the four agro-ecological zones: the lowlands, the foothills, the highlands and the Senqu river valley (Bureau of Statistics, 2017). This dataset is strictly limited to the dynamics of the residential sector hence it matches the objective of this study.

4.2.2. Sample size and variables covered

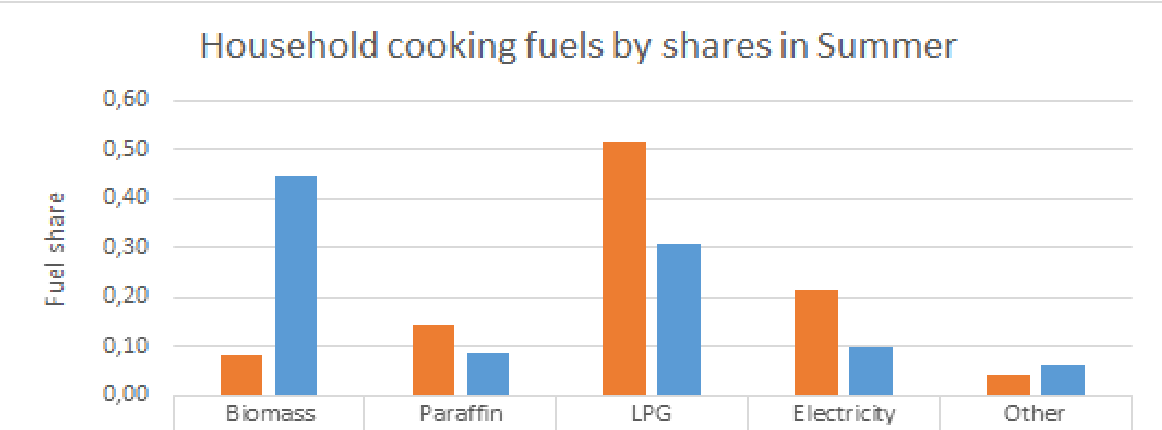
Upon selection of the EA, a total of 2877 households were sampled from which a 93% response rate was achieved. This data was collected through the Computer Assisted Personal Interview (CAPI) and it was carefully reviewed before synchronization with the BoS district servers. Since the questionnaire was executed in the same households in both phases, the generated data from both phases 1 and 2 of the survey reliably points out the differences.

A broad spectrum of variables was included in the prepared questionnaire including those with a direct and indirect relationship with the observed household energy consumption characteristics. These include the household location demographics, housing, economic characteristics, available cooking and kitchen utensils, ease of access to an automobile as well as traditional and modern energy sources including fossil fuels and solar energies used for cooking, lighting, as well as heating and cooling.

4.2.3. Variable selection and description

The variable selection is based on a crosscheck between the body of literature and the data collected by the BoS in the 2017 HECS. Henceforth, the household consumption of the most prominent cooking fuels in Lesotho, namely: traditional biomass, paraffin, LPG, and/or electricity across families under different genders of the household head is the regressand (dependent variable). The average shares of these energy fuels consumed in households in summer and winter are as presented in Figure 6 and Figure 7, categorised by the gender of the household head. Since the shares of other fuels such as cloth and aloe cumulatively account for less than 10% of the fuels consumed in households, they are not taken into consideration in this study.

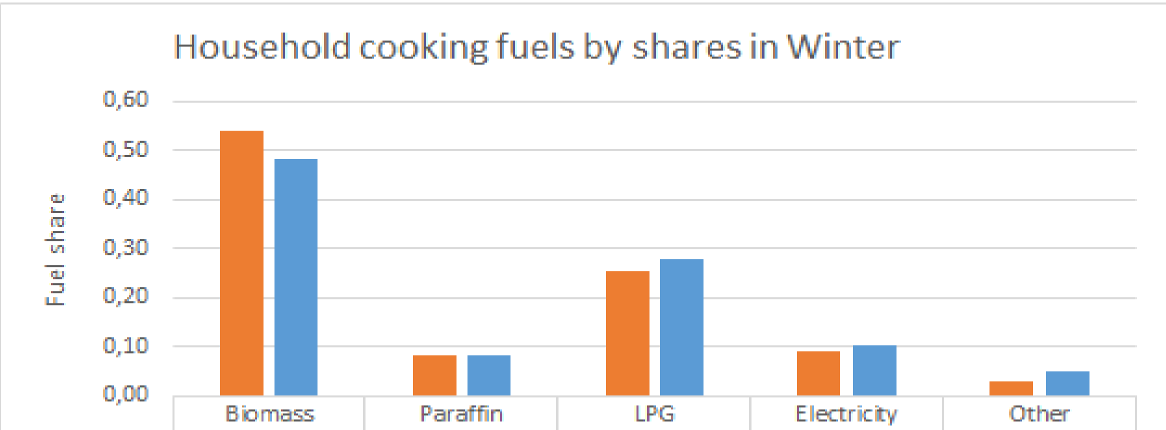
The observation, as per the details in Figure 6, is that female-headed households have a significantly higher share of cleaner fuels than male-headed households in summer. The bulk of energy consumed in female-headed households is LPG and electricity at 0.51 and 0.21 shares respectively whereas biomass and LPG are dominant in male-headed households with shares of 0.45 and 0.31 respectively. On the contrary, biomass is the least consumed energy (0.08 shares) in female-headed households showing substantial variance in energy consumption patterns based on the gender of the household head. The fuel shares presented in Figure 7 for winter, on the other hand, show a somewhat similar consumption pattern in female and male-headed households for all fuels wherein biomass stands out with the shares of 0.54 and 0.48 in female and male-headed households respectively. Despite the similarity in consumption patterns, female-headed households recorded a slightly higher share of biomass and slightly lower shares of paraffin, LPG, and electricity than male-headed households as depicted in Figure 7.



	Biomass	Paraffin	LPG	Electricity	Other
Females	0,08	0,14	0,51	0,21	0,04
Males	0,45	0,09	0,31	0,10	0,06

Figure 6: The shares of fuels consumed in male and female-headed households in summer

Source: own using the Lesotho BoS 2017 HECS data



	Biomass	Paraffin	LPG	Electricity	Other
Females	0,54	0,08	0,26	0,09	0,03
Males	0,48	0,08	0,28	0,10	0,05

Figure 7: The shares of fuels consumed in male and female-headed households in winter

Source: own using the Lesotho BoS 2017 HECS data

The regressors (independent variables) utilised in this study to explain the aforementioned dependent variables are presented in Table 1, spanning the socio-economic characteristics of the sampled households. Female household heads make up 38% of the survey respondents and they are on average 10 years older than males with more females (94.2% compared to 83%) having received a certain level of education. For both female and male-headed households, over 50% of the households are in rural areas and the majority of households fall in the lower income class despite the gender of the household head. However, remittances are received mostly by female-headed households. In addition, female-headed households have more members than male-headed households and most of both male and female-headed families are found to reside in lower-to-middle-class houses, the majority (over 50%) of which are family-owned.

Furthermore, according to Table 1, there is parity between grid-connected households and those that are not despite the gender of the household head. All these households generally have less than 5 years of electrification. Comparatively, male-headed households have higher records for all wealth indices including the share of appliances, access to a private car, ownership of solar systems, and ownership of a generator. Moreover, no member bears the primary responsibility of wood collection in most households but the chore is mostly done by females. For instance, 17% of female household heads, compared to 12% of male household heads, are the main wood collectors, whereas in male-headed households 12% of the spouses bear this responsibility compared to 8% in female-headed households. On the other hand, there is a tie for both genders of the household head where children are the main wood collectors in the family, as presented in Table 1.

Table 1: The average percentage representation of respondents by gender for listed regressors

Variables		Gender	
		Females (%)	Males (%)
Gender of household head		38	62
Age (years)		56	46
Education:	None	6	19
	Non-formal	0,2	1
	Primary	61	47
	High school	24	25
	Vocational training	1	1
	Tertiary	8	9
Settlement:	Rural	54	53
	Peri-urban	11	9
	Urban	36	38
Income:	Lower	68	54
	Middle	26	36
	Upper	6	11
Remittance:	None	67	75
	Lower	20	14
	Middle	13	10
	Upper	1	2
Household size	(number)	5	4
House class:	Lower-mid	95	93
	Upper	5	7
House ownership:	Household	75	74
	Free private	3	4
	Rented private	19	20
	Government	1	1
Grid:	Not connected	49	50
	Connected	51	50
Electrification period (years)		2	3
Share of appliances		5	7
Private car:	Accessed	5	11
	No access	95	89
Solar system:	Own	8	10
	Don't own	92	90
Generator:	Own	2	3
	Don't own	98	97
Wood collector:	None	64	65
	Household head	17	12
	Children	9	9
	Spouse	8	12
	Relative	0,5	1

Source: Own using the Lesotho BOS 2017 HECS data

4.3. Model specification

The energy consumption patterns between female and male-headed households vary substantially, though ideally, households are expected to transition linearly from polluting low-end fuels to higher-end fuels with improvement in the economic standards as postulated by the energy ladder model (Leach, 1992). Instead, a substantial body of literature backs the fuel stacking model proving the significance of various social, economic and cultural factors in influencing household energy consumption traits (Rahut et al., 2017; Yadav et al., 2021). Of these, income streams, education, gender and age of the household head are the most popular determinants in both theoretical and empirical literature.

Though the influence of increasing age on the uptake of modern fuels over traditional fuels remains ambiguous, improvements in education and income commonly favour the adoption of modern energies (Mothala et al., 2022; Mottaleb et al., 2017). According to the theory discussed in the 2022 International Labour Organisation brief (ILO, 2023), males have considerably higher economic privileges compared to females as the gender gap in the global workforce in 2022 is 29.2% between males and females and soars to 42.6% when considering those with children. That is why male-headed households are anticipated to have higher wealth indices including ownership of cars, modern houses and a large array of appliances that can potentially encourage clean energy adoption.

In this study, the Tobit model is employed using Gretl modelling software to estimate the effect of household socioeconomic characteristics on energy consumption. The model is therefore expressed mathematically as in Equation 1 to account for various household dynamics that influence the observed patterns. The vector representation allows for simultaneous analysis of the influence of multiple independent variables on the consumed shares of biomass, paraffin, LPG, and electricity for cooking.

$$\boldsymbol{Y_i = \beta_1 + \beta_2' X_i} \qquad \text{Equation 1}$$

where Y_i represents the shares of the cooking fuels consumed in households herein referred to as the dependent variable, β_1 represents the slope and β_2' is the vector of the estimated coefficients that indicate covariance with the dependent variable, X_i is the matrix representation of all independent variables with rows designating individual households and columns being all independent variables utilised in the analysis.

4.4. Model estimation strategy

In this study, the Tobit regression model is used to estimate Equation 1. This choice is on the merits that the model takes into consideration the censored nature of the dataset when estimating the coefficients, thus, it maximises the likelihood of the observed data. Based on the principles of the multilinear regression model which utilises the maximum likelihood estimation strategies, the Tobit model qualified to account for both discreet and continuous dependent variables including zero values (Afaifia et al., 2021). In this instance, the linear regression model falls short as it fails to account for the zero values of the dependent variable while the logistic regression model is not suited for the continuous dependent variables utilised in this study as it takes on binary dependent variables instead (Gujarati, 2008).

As previously established from the literature, there is prominent fuel stacking in households in developing countries like Lesotho (Mothala et al., 2022; Musango, 2022), the combination of which presumably differs substantially based on the gender of the household head. As such, the dependent variable is herein expressed in the form of shares of consumed fuels that take on values in the range from 0 to 1. Thus, the final household energy consumption is the sum of the shares of biomass, paraffin, LPG, and electricity for such a household. According to Mothala et al. (2022), these collectively account for over 90% of the consumed energy in Basotho households.

Now, following Gujarati (2008) and the definitions established in Equation 1, the Tobit regression model is specified as in Equation 2.

$$\boldsymbol{Y_i = \begin{cases} \beta_1 + \beta_2 X_i + \mu_i, & if\ RHS > 0 \\ 0, & otherwise \end{cases}} \qquad \text{Equation 2}$$

where Y_i represents the shares of cooking fuels consumed in the household, β_1 and β_2 represent the slope and estimated coefficients that establish the relationship between fuel shares and the explanatory variables respectively, X_i is the matrix of all the explanatory variables and μ_i is the error term. RHS is an abbreviation for the right-hand side of the equation.

The observed variable (Y_i) is censored to the left, that is, it takes on all positive values but it is set to zero for all zero and non-positive values of the dependent variable. This allows for a reliable estimation of the relationship between the household consumption of shares of fuels and the determining variables presented in Table 1.

4.5. Model validation

To ensure the adequacy of the model in determining the relationship between household cooking fuel consumption and the established explanatory variables, two diagnostic tests namely, chi-square (χ^2) and log-likelihood test are conducted (Adkins, 2010). The chi-square statistical test is used to determine the model fitness by establishing the statistical significance of variance between observed and expected data. The model is said to be a good fit when the test gives a small p-value often benchmarked at the maximum of 0.05, proving that the relationship between the household fuel shares and the independent variables is statistically significant. The log-likelihood test, on the other hand, determines the model's ability to observe the dataset based on the model's estimated parameters. The model is said to be a good enough fit for high values of the log-likelihood test, ideally as close to zero as possible.

5. Results and Discussion

5.1. Introduction

This chapter presents and discusses the findings of this study in line with the research objective. Section 5.2 looks into the results of diagnostic tests run for model validation while Sections 5.3 and 5.4 focus on the presentation and discussion of the results respectively.

5.2. Model validation results

In the Tobit regression model, several diagnostic tests are conducted to assess the model's assumptions and evaluate the validity of the estimated coefficients. The log-likelihood and the chi-square (χ^2) diagnostic tests conducted gave the results presented in Table 2. The p-values generated by the chi-square test are far below the 0.05 significance level which indicates that the model is statistically significant. Moreover, all the obtained log-likelihood test values are in the set range from -500 – 0. Since these values are close to -500, the implication is that the model assumptions ought to be improved to better the model fitness for observing data. For this study, including variables like fuel prices would possibly improve the model's fitness if such data were available.

Table 2: Diagnostic test results for the Tobit regression model

Energy source	Season	test	Chi-square	p-value	Log-likelihood
Biomass	Summer	Female	1653	0	-533
		Male	2224	0	-942
	Winter	Female	789	0	-465
		Male	2322	0	-796
Paraffin	Summer	Female	793	0	-336
		Male	1221	0	-588
	Winter	Female	845	0	-284
		Male	1220	0	-504
LPG	Summer	Female	1519	0	-654
		Male	825	0	-1184
	Winter	Female	1433	0	-596
		Male	1502	0	-1049
Electricity	Summer	Female	825	0	-244
		Male	2031	0	-454
	Winter	Female	834	0	-217
		Male	1601	0	-437

Source: own using Gretl software Tobit results

5.3. Determinants of household cooking energy consumption

The socio-economic characteristics of households influence their choice and consumption of fuels which results in fuel stacking especially in developing countries. The driving factors for the variance in the consumption of dirty and modern fuels herein presented as shares of biomass, paraffin, LPG, and electricity in female and male-headed households are presented in Table 3 to Table 6. Sections 5.3.1 - 0 discuss the findings of the influence of the independent variables presented in Table 1 on the shares of biomass, paraffin, LPG, and electricity respectively, ranking them in order of cleanliness from dirty to modern fuels.

5.3.1. Biomass consumption results

Table 3 provides the estimated results for the drivers of biomass consumption in households. Despite its detrimental impact on human health and the environment, biomass continues to be observed in the household energy mix in Lesotho. According to the findings in Table 3, the age of the household head positively impacts the household share of biomass in both female and male-headed households at a 1% significance level in summer. The same impact is observed only for female-headed households in winter, as no significant impact is observed in male-headed households.

Compared to household heads with no education, an insignificant impact is observed in summer for household heads with non-formal education despite their gender. Female household heads with non-formal education, on the other hand, have a positive impact on the share of biomass in winter while male-headed households have an insignificant impact. Female household heads with primary education, however, have an insignificant influence on the biomass share while male heads have a negative influence at a 1% significance level both in summer and winter. Considering household heads with high school education, both females and males are found to negatively influence the biomass share by at least a 10% significance level in summer and winter. Likewise, household heads that have received vocational training and tertiary education generally have a negative impact on the share of biomass both in summer and winter despite the gender of the household head at a 1% significance level in most cases.

In observing the contribution of the household geographic location on fuel shares, the findings reveal that both female and male-headed households in peri-urban and urban areas have a negative influence on the share of biomass compared to those in rural areas at a 1% significance level in summer, as is the case in winter, except for female-headed households in peri-urban areas whose impact is rather insignificant. Contrary to households in the low-income class, households in the middle-income class have a negative influence on the household share of biomass in both seasons despite the gender of the household head. Similar observations are made for male-headed households in the upper-income class while female-headed households consistently show insignificant impact.

Amongst the families that receive remittances compared to those that do not, no significant impact is observed from households of either gender in the lower and middle remittance classes in summer and similarly in winter, except only for female-headed households in the lower remittance class who show a negative impact on the share of biomass at 1% significance level. Furthermore, both female and male-headed households in the upper remittance class negatively influence the share of biomass in both seasons. However, the household size is found to have no significant impact on the share of biomass despite the gender of the household head and the season of the year.

Though female-headed households living in upper-class houses, compared to those in lower-to-middle-class houses, have an insignificant impact on the share of biomass in summer, those headed by males have a negative influence at a 1% significance level. However, the impact is insignificant in both female and male-headed households living in the same house class in winter. In contrast to household-owned houses, the impact of families living in free private houses is insignificant despite the gender of the household head in summer though in winter, male-headed, but not female-headed, households have a negative impact on the share of biomass at a 5% significance level. On the other hand, both female and male-headed households that reside in rented private and government-owned houses negatively influence biomass share at a 1% significance level in summer and similarly in winter except for male-headed households dwelling in government-owned houses.

Electricity availability is observed to have a positive impact on the share of biomass at a 5% significance level in female-headed households but no effect on male-headed households in summer whereas it shows no significant influence on the biomass share in winter for both female and male-headed households. Moreover, the duration in years for which a household has been electrified seems not to significantly influence the share of biomass despite the gender of the household head in summer and in winter it still has no effect on female-headed households but it shows a negative impact on male-headed households at a 5% significance level. A negative relationship is also observed between the household share of appliances and the share of biomass at least at a 5% significance level despite the gender of the household head and both seasons.

The shares of biomass and the relationship of the main wood collector to the household head, on the other hand, show a negative relationship when there is no member designated for wood collection and a positive relationship when a child is responsible in both female and male-headed households for both seasons.

Table 3: Biomass consumption results

		Summer		Winter	
		Female	Male	Female	Male
Constant		0,78 ***	0,68 ***	0,97 ***	0,97 ***
Age (years)		0,003 **	0,005 ***	0,002 **	0,002
Education: *None*	Non-formal	-0,12	-0,18	0,64 ***	0,15
	Primary	-0,02	-0,10 ***	-0,05	-0,07 **
	High school	-0,15 *	-0,23 ***	-0,27 ***	-0,22 ***
	Vocational training	-3,70 ***	-0,26	-0,39 ***	-3,36 ***
	Tertiary	-0,63	-0,67 ***	-0,52 **	-0,40 ***
Settlement: *Rural*	Peri-urban	-0,22 ***	-0,28 ***	-0,05	-0,23 ***
	Urban	-0,62 ***	-0,63 ***	-0,58 ***	-0,58 ***
Income: *Lower*	Middle	-0,32 ***	-0,16 ***	-0,26 ***	-0,15 ***
	Upper	-0,12	-0,45 ***	-0,27	-0,34 ***
Remittance: *None*	Lower	0,03	-0,001	-0,13 ***	0,01
	Middle	-0,06	-0,05	-0,08	-0,06
	Upper	-2,15 ***	-0,51 **	-0,55 **	-0,36 **
Household size (number)		-0,01	0,001	0,01	-0,01
House class: *Lower-mid*	Upper	-0,20	-0,35 ***	-0,05	-0,18
House ownership: *Household*	Free private	-0,03	-0,13	-0,09	-0,22 **
	Rented private	-0,84 ***	-1,08 ***	-0,70 ***	-0,81 ***
	Government	-2,92 ***	-3,12 ***	-0,47 **	-0,02
Grid: *Not connected*	Connected	0,21 **	-0,05	-0,16	0,04
Electrification period (years)		-0,01	-0,02	-0,004	-0,02 **
Share of appliances		-2,92 ***	-1,53 **	-2,47 ***	-1,66 ***
Private car: *Accessed*	No access	-0,15	-0,01	-0,09	-0,08
Solar system: *Own*	Don't own	0,04	0,004	0,10 *	0,04
Generator: *Own*	Don't own	0,04	0,001	-0,20	-0,05
Wood collector: *Household head*	No member	-0,10 *	-0,13 **	-0,13 ***	-0,22 ***
	Children	0,10	0,13 **	0,16 ***	0,08 *
	Spouse	0,01	0,09	0,03	0,01
	Relative	0,06	-0,04	0,09	-0,15

Source: own using Gretl software Tobit results

Notes: ****, **, and * represent 1%, 5%, and 10% statistical significance levels respectively. The base variables for all categorical variables are listed in italics by each variable.*

5.3.2. Paraffin consumption results

Table 4 presents the findings for the determinants of the household consumption of paraffin as part of cooking fuels. In this study, the age of the household head is found to have no significant impact on the share of paraffin despite the gender of the household head and the season of the year. However, female-headed households whose head has informal education negatively influence the household share of paraffin both in summer and winter but male-headed households have no significant influence in both seasons. On the other hand, families whose female head has either a primary or high school education level have no significant impact on the share of paraffin in summer whereas male-headed households show a positive significant influence on the household paraffin share at a 5% level in both instances. In winter, however, there is no significant relationship established between the education levels of both genders. Similarly, receiving vocational training and tertiary education has no significant impact on the share of paraffin in both seasons and genders of the household heads except for male-headed families whose head has vocational training which has a negative influence at a 1% significance level.

According to the settlement type, the households in both the peri-urban and urban settlements, compared to those in the rural areas, generally have a positive significant impact on the household share of paraffin mostly at a 1% level in both seasons. Both female and male-headed households in the middle-income class on the other hand show no significant effect on the share of paraffin in summer and winter, whereas they both have a negative influence on households in the upper-income class in both seasons at least at 5% significance level. In comparison with households that do not receive remittances, those in the lower and middle classes generally have no significant impact on the paraffin share in both seasons despite the gender of the household head except for male-headed households in the middle remittance class that, instead, have a negative influence at 5% significance level. However, female-headed households in the upper remittance class have a negative influence at a 1% significance level both in summer and winter whereas male-headed households have no significant influence in both seasons.

The household size is observed to have a positive significant influence at a 10% level in female-headed households in summer but not in male-headed households. Furthermore, in contrast to families living in household-owned houses in both seasons, male-headed families in rented private houses positively influence the share of paraffin at least at a 5% significance level while female-headed households have no impact. Male-headed families in government-owned houses on the other hand have a negative influence at a 1% significance level but female-headed households still show no significant influence.

Grid-connected female-headed households compared to those not electrified show a negative influence on the share of paraffin in summer at a 5% significance level while male-headed households have no impact. However, grid-connected female-headed households have a positive influence on the share of paraffin in winter but male-headed households still have no impact. The share of electrical appliances owned by a household negatively affects the share of paraffin in both female and male-headed households in summer at a 1% significance level whereas it only affects male-headed households and not female-headed households similarly in winter.

Moreover, among households that own assets like a generator compared to those that do not, there is no relationship established in female-headed households in summer but there is a positive impact in male-headed households at a 10% significance level. In winter, however, owning a generator negatively influences the household share of paraffin at a 1% significance level. Having no primary wood collector in the households is observed to positively influence the household share of paraffin at a 5% significance level in male-headed households but has no effect in female-headed households in summer. Conversely, having a relative as the main wood collector negatively influences the share of paraffin at a 1% significance level in female-headed households but not in male-headed households both in summer and winter.

Table 4: Paraffin consumption results

		Summer		Winter	
		Female	Male	Female	Male
Constant		-2,41 ***	-2,20 ***	-3,80 ***	-2,41 ***
Age (years)		0,01	0,002	0,002	0,003
Education: *None*	Non-formal	-5,16 ***	0,39	-5,73 ***	0,08
	Primary	0,31	0,29 **	0,16	0,25
	High school	0,04	0,36 **	0,30	0,11
	Vocational training	-0,03	0,77	0,75	-6,27 ***
	Tertiary	-0,16	-0,04	0,76	0,13
Settlement: *Rural*	Peri-urban	0,40	0,80 ***	0,50 *	0,16
	Urban	1,28 ***	0,80 ***	1,48 ***	1,08 ***
Income: *Lower*	Middle	0,001	-0,06	-0,05	-0,15
	Upper	-6,09 ***	-0,66 **	-1,45 **	-0,79 **
Remittance: *None*	Lower	-0,19	0,07	-0,01	-0,22
	Middle	0,20	-0,50 **	0,06	-0,001
	Upper	-6,16 ***	0,02	-7,27 ***	-0,42
Household size (number)		0,04 *	-0,01	0,05	0,03
House class: *Lower-mid*	Upper	0,54	-0,01	-0,07	-0,53
House ownership: *Household*	Free private	0,70 **	0,04	-0,02	0,49 *
	Rented private	0,27	0,42 **	0,27	0,71 ***
	Government	0,06	-6,03 ***	-0,49	-6,15 ***
Grid: *Not connected*	Connected	-0,60 **	0,25	1,02 ***	0,28
Electrification period (years)		0,01	-0,02	0,01	0,03
Share of appliances		-5,57 ***	-7,20 ***	-4,01	-5,97 ***
Private car: *Accessed*	No access	-0,05	0,09	0,84 *	-0,13
Solar system: *Own*	Don't own	-0,16	-0,25	-1,40 ***	-0,13
Generator: *Own*	Don't own	-0,57	0,52 *	-6,79 ***	-6,08 ***
Wood collector: *Household head*	No member	0,01	0,44 **	0,32	-0,04
	Children	-0,21	-0,31	-0,09	-0,09
	Spouse	-0,18	0,32	0,37	0,02
	Relative	-5,93 ***	0,96	-5,43 ***	-0,19

Source: own using Gretl software Tobit results

Notes: ****, **, and * represent 1%, 5%, and 10% statistical significance levels respectively. The base variables for all categorical variables are listed in italics by each variable.*

5.3.3. LPG consumption results

Liquefied Petroleum Gas (LPG) is one of the high-end fuels that households progress towards with improvements in their socioeconomic conditions as per the energy ladder model (Leach, 1992). The observations generated from this analysis are presented in Table 5 showing all independent variables and their influence on the household consumption of a share of LPG. According to the study results, there is no significant relationship between the share of LPG and the age of the household head in spite of their gender orientation and season of the year.

The education level of the household head, on the other hand, does influence the share of LPG compared to those who have not received any education. In the latter case, female household heads with non-formal education influence the household share of LPG negatively at a 1% significance level both in summer and in winter but no impact is observed in male-headed households in both seasons. For both female and male household heads with at least primary education, a positive impact is commonly observed in both seasons at least at, at least, a 5% significance level.

Table 5: LPG consumption results

		Summer		Winter	
		Female	Male	Female	Male
Constant		-1,22 ***	-1,45 ***	-1,50 ***	-1,48 ***
Age (years)		-0,003	-0,002	-0,003	-0,001
Education: *None*	Non-formal	-5,16 ***	0,22	-4,39 ***	0,14
	Primary	0,12	0,43 ***	0,58 **	0,44 ***
	High school	0,48 **	0,55 ***	0,76 ***	0,51 ***
	Vocational training	0,81 **	0,11	0,84 **	0,46
	Tertiary	0,22	0,33 **	0,57 **	0,31 **
Settlement: *Rural*	Peri-urban	0,59 ***	0,45 ***	0,39 ***	0,74 ***
	Urban	0,78 ***	0,70 ***	0,66 ***	0,74 ***
Income: *Lower*	Middle	0,45 ***	0,41 ***	0,50 ***	0,40 ***
	Upper	0,49 ***	0,48 ***	0,68 ***	0,38 ***
Remittance: *None*	Lower	0,06	-0,06	0,36 ***	0,02
	Middle	0,36 ***	0,34 ***	0,36 ***	0,32 ***
	Upper	0,15	0,62 ***	1,04 ***	0,62 ***
Household size (number)		0,01	-0,01	-0,04 **	0,02
House class: *Lower-mid*	Upper	-0,15	0,36 ***	-0,01	0,17
House ownership: *Household*	Free private	-0,49 **	-0,21	-0,46 *	0,06
	Rented private	-0,09	-0,12	-0,12	-0,21 **
	Government	-0,08	-0,50	0,54 **	0,17
Grid: *Not connected*	Connected	0,32 **	0,23 **	-0,14	-0,34 ***
Electrification period (years)		0,002	0,01	-0,01	-0,002
Share of appliances		-0,70	-1,19 **	-0,24	-0,92
Private car: *Accessed*	No access	-0,04	0,07	-0,39 *	0,10
Solar system: *Own*	Don't own	0,04	0,24 **	0,22	0,21 *
Generator: *Own*	Don't own	0,55 **	0,09	0,83 ***	0,50 ***
Wood collector: *Household head*	No member	0,07	0,35 ***	0,46 ***	0,45 ***
	Children	-0,25	-0,01	-0,36 *	-0,17
	Spouse	-0,03	-0,15	0,02	0,04
	Relative	-5,67 ***	0,65	-5,02 ***	0,38

Source: own using Gretl software Tobit results

Notes: ****, **, and * represent 1%, 5%, and 10% statistical significance levels respectively. The base variables for all categorical variables are listed in italics by each variable.*

Similarly, households in the peri-urban and urban areas compared to those in the rural areas positively influence the share of LPG at a 1% significance level irrespective of the gender of the household head and the season of the year. A positive impact is also observed at a 1% significance level in considering middle and upper-class households in contrast to lower-class households for both female and male-headed households in both seasons. Furthermore, between families that receive remittances and those that do not, households in the middle and upper remittance classes commonly impact the share of LPG positively at a 1% significance level despite the gender of the household head and the season.

Though the household size is observed not to significantly affect the share of LPG in summer for both genders of the household head, it has a negative influence on female-headed households at a 5% significance level in winter but not in male-headed households. Compared to the families that live in lower-to-middle-class houses, those in upper-class houses do not affect the share of LPG in female-headed households in summer but have a positive influence at a 1% significance level under the male household head. On the other hand, both female and male-headed households that are grid-connected, in contrast to non-electrified households, positively influence the household share of LPG at a 5% significance level in summer whereas they have no influence in female-headed households in winter but negatively affect the LPG share in male-headed households at 1% significance level. The electrification period of households has, however, no impact in this regard despite the gender of the household head and the season.

Based on wealth indices such as ownership of solar PV systems, no impact is observed on the share of LPG in female-headed households in either season while it positively influences this share in male-headed households at least at a 10% significance level both during summer and winter. Moreover, ownership of a generator positively impacts the LPG share in female but not male-headed households at a 5% significance level in summer while it positively affects this share at a 1% significance level for both genders of the household head.

In wrapping up, households without a wood collector compared to those where the household head is the primary wood collector commonly have a positive effect on the household share of LPG at a 1% significance level despite the gender of the household head with female-headed households in summer as an exception. Conversely, having a relative compared to the household head as the main wood collector negatively influences the share of LPG in female but not male-headed households in summer and, similarly, in winter, both at a 1% significance level.

5.3.4. Electricity consumption results

Electricity is the top-tier energy due to its efficiency, cleanliness, and convenience. The factors that influence the share of electricity used for cooking in female and male-headed households are presented in Table 6. Both in summer and in winter, age is found to influence the share of electricity in female-headed households negatively at a 10% significance level in both instances but not in male-headed households. Compared to the households whose heads have received no education, those whose heads have non-formal education have a positive impact on the share of electricity in female-headed households while they have a negative influence under the male leadership at a 1% significance level in summer. In winter, however, female-headed households have a negative influence on the household share of electricity at a 1% significance level while male-headed households have no significant impact. Households whose heads have a primary, high school, and tertiary education also show no impact on the share of electricity despite the gender of the household head and seasons.

Oddly, the household settlement, income, and remittance classes as well as household size are found not to have a significant influence on the household share of electricity for both genders of the household head and in both seasons. On the other hand, female-headed households living in upper-class houses compared to those in lower-to-middle-class houses positively influence the household share of electricity at a 5% significance level in summer while male-headed households have a negative impact at a 10% significance level. No influence is observed in winter for both genders of the household heads.

Considerably, families that live in rented private houses compared to those living in their own houses positively influence the share of electricity when headed by a female in summer but male-headed households have no effect. However, both female and male-headed households in rented private houses have a positive impact in winter at 5% and 1% significance levels respectively. For families dwelling in government-owned houses contrary to those in household houses, female-headed households have no impact in summer but male-headed households have a positive impact at a 10% significance level while in winter female-headed households have a negative impact at a 1% significance level but males do not have any impact.

Electricity availability is crucial for it to even become an option for adoption in households. Compared to non-electrified households, grid-connected households under both female and male heads positively influence the share of electricity in summer while they both negatively influence it in winter at a 1% significance level. In addition, in spite of the gender of the household head and season, the share of appliances owned by the household positively influences the share of electricity at a 1% significance level. Ownership of a solar PV and generator on the other hand is observed to negatively influence the share of electricity in female-headed households at a 1% significance level for both seasons while no significant influence of these is recognised in male-headed households.

Lastly, having a child compared to the household head as the main wood collector negatively influences the share of electricity in both female and male-headed households in summer at 1% and 10% significance levels respectively while there is no influence for both in winter. When the spouse takes on this responsibility, no significant impact is detected in female-headed households while there is a negative impact for male-headed households at a 1% significance level. However, female-headed households that have a relative as the main wood collector have a positive impact on the share of electricity at a 1% significance level in summer but male-headed households have no influence. In considering winter, no significant impact is detected in female-headed households whereas male-headed households are observed to negatively influence the share of electricity at a 1% significance level.

Table 6: Electricity consumption results

		Summer		Winter	
		Female	Male	Female	Male
Constant		-3,50 ***	-7,06 ***	-0,90	-1,68 ***
Age (years)		-0,01 *	-0,01	-0,01 *	-0,003
Education: *None*	Non-formal	1,92 ***	-6,13 ***	-5,24 ***	0,48
	Primary	0,49	0,15	-0,26	0,12
	High school	0,43	0,13	0,01	0,18
	Vocational training	0,26	0,80 *	-6,15 ***	0,95 **
	Tertiary	0,41	0,43	-0,31	0,45
Settlement: *Rural*	Peri-urban	0,43	-0,07	-0,03	0,05
	Urban	0,38	0,30	0,24	0,17
Income: *Lower*	Middle	0,19	0,07	-0,04	0,12
	Upper	-0,07	-0,14	-0,05	0,01
Remittance: *None*	Lower	0,11	0,12	0,30	-0,26
	Middle	0,004	0,18	-0,35	-0,17
	Upper	0,39	-0,64	-5,82 ***	0,15
Household size	(number)	-0,03	-0,01	0,01	0,01
House class: *Lower-mid*	Upper	0,57 **	-0,32 *	0,08	-0,16
House ownership: *Household*	Free private	0,004	0,24	0,13	-0,13
	Rented private	0,39 **	0,11	0,48 **	0,52 ***
	Government	0,49	0,60 *	-6,97 ***	-0,42
Grid: *Not connected*	Connected	1,62 ***	6,11 ***	-5,41 ***	-1,38 ***
Electrification period (years)		0,01	-0,001	0,03 **	0,01
Share of appliances		2,50 ***	4,00 ***	4,78 ***	5,35 ***
Private car: *Accessed*	No access	-0,16	-0,10	0,29	-0,24
Solar system: *Own*	Don't own	-3,51 ***	0,17	-3,86 ***	-5,73 ***
Generator: *Own*	Don't own	-5,47 ***	-0,45	-5,39 ***	0,03
Wood collector: *Household head*	No member	0,47	-0,29	-0,31	-0,31
	Children	-5,51 ***	-0,82 *	-0,48	-0,59
	Spouse	0,03	-1,37 ***	-0,30	-0,36
	Relative	1,78 ***	0,19	0,66	-6,03 ***

Source: own using Gretl software Tobit results

Notes: ****, **, and * represent 1%, 5%, and 10% statistical significance levels respectively. The base variables for all categorical variables are listed in italics by each variable.*

5.4. Discussion of results

Household energy consumption, as described by the fuel stacking models is multifaceted with various fuels consumed simultaneously. Their combinations differ due to many socioeconomic factors. As such, each fuel contributes a certain share to the final household energy consumption structure. According to the results presented in Table 3 to Table 6 for determinants of household shares of biomass, paraffin, LPG, and electricity respectively, as both the female and male household heads age, they tend to increase the household share of polluting biomass in both seasons. Female household heads also tend to reduce their share of electricity but the impact on cleaner fuels is insignificant for male-headed households. These are in line with the idea that older women in Central Europe consume polluting fuels due to a shortage of cleaner fuels (Bouzarovski and Petrova, 2015) but they contradict the perception of Elasu et al. (2023) that older people prefer clean fuels due to lack of manpower for wood collection.

As the education status of the household head improves, female-headed households tend to reduce their share of dirty fuels and opt for modern fuels in summer while male-headed households are generally observed to also reduce the share of dirty fuels but instead settle for transition fuels like paraffin and LPG as they also reduce their share of electricity. Though both female and male-headed households are found to generally reduce their shares of dirty biomass in winter, they are found to be mostly reliant on LPG and female-headed households reduce their share of electricity while male-headed households contrarily increase theirs. These corroborate Rahut et al. (2019) who opine that women put more consideration into clean energy services since they bear the cooking responsibility in their homes. Education is also said to improve employment opportunities as well as health and environmental awareness which promotes clean fuels adoption (Mahmood, 2020; Swain and Mishra, 2020; Wassie and Adaramola, 2021). However, Wassie and Adaramola (2021) established an insignificant relationship between household choice of clean energy services and education.

In both seasons, both female and male-headed households in the peri-urban and urban areas, contrary to those in the rural areas, reduce the share of dirty fuels and rely more on the transition and high-end fuels such as paraffin and LPG but their behaviour towards electricity is inconclusive. The findings of Muza and Thomas (2022) that cultural norms and low-income streams prohibit the adoption of clean cooking technologies in rural areas at similar scales to those of richer urban areas corroborate these findings. The reluctance of rural dwellers to upgrade their energy consumption is also said to stem from their ownership of animals and farms which are the sources of abundant dung, straw and other combustible residue (Rahut et al., 2019).

Expectedly, as the household financial status improves in both female and male-headed households, the households reduce their shares of dirty fuels and lean towards cleaner fuels, especially LPG despite the season of the year. These findings are in line with the postulates of the energy ladder model (Dogan and Muhammad, 2019; Rahut et al., 2019; Wang et al., 2021;

Yadav et al., 2021). However, female-headed households that are in the upper remittance class contrary to those who do not receive any remittances, are found to reduce their share of electricity in winter but the male-headed households have no significant effect in this case. The justification is that personal preference for the likes of food taste sometimes overpowers fuel affordability, hence, they continue to use biomass (Muza and Thomas, 2022; Wassie and Adaramola, 2021).

According to the findings of this study, household size has a significant impact on the household energy consumption pattern only in female-headed households but not male-headed households. As the number of female-headed household occupants increases, the household share of low-end fuels increases in summer and the share of cleaner fuels declines in winter. This is consistent with the allegations that large households have high expenses and are usually poor but since they have enough manpower for wood collection rampant biomass use is common among them (Elasu et al., 2023; Rahut et al., 2019; Wassie and Adaramola, 2021). Contrary to the families dwelling in household-owned houses, female-headed households living in free private houses tend to reduce the share of cleaner fuels and lean more towards transition fuels such as paraffin in summer whereas male-headed households are observed to reduce the share of dirty biomass while also resorting to the transition fuels. Conversely, for both female and male-headed households living in rented private and government-owned houses, the general trend shows lower consumption of dirtier fuels, thus lowering the shares but increasing the shares of high-end fuels such as electricity.

Electricity availability is the ultimate determinant of whether electricity is even an option in the choice of fuels in households. In comparison to non-electrified households, grid-connected female-headed households are found to increase their share of both dirty and clean fuels but reduce their share of paraffin in summer while male-headed households only increase their share of cleaner fuels. Contrarily, in winter both female and male-headed grid-connected households generally reduce their shares of cleaner fuels and opt for dirtier transition fuels such as paraffin. This is in accordance with the observed decline in electricity consumption despite the increasing number of grid connections in Lesotho due to the low-income status of most Basotho families (Mpholo et al., 2020).

Regardless of the gender of the household head, increasing the share of electrical appliances in households leads to a reduction in the shares of dirty fuels and an increased share of modern energies, particularly electricity in both seasons. Likewise, ownership of other energy sources such as solar PV and generators is indiscriminate of the gender of the household head in driving households towards consumption of lower shares of transition fuels like paraffin and higher shares of LPG while they reduce the share of electricity.

Having no primary wood collector compared to having the household head of either gender as the main wood collector leads to a reduction in the household share of dirty biomass and an increase in the share of cleaner alternatives such as paraffin and LPG. Contrary to this, households that have any other member of the family responsible for wood collection versus those in which the household head is responsible generally prefer to increase the share of dirty fuels and to reduce the shares of cleaner fuels despite the gender of the household head and the season of the year.

Figure 8 to Figure 11 expand on the discussion of obtained results as they depict the impact of different variables on the household shares of biomass, paraffin, LPG, and electricity respectively graphically. These give perspective to the results presented in Table 3 to Table 6. From Figure 8 to Figure 11, each colour code represents a particular gender of the household head in a given season (winter and summer). For consistency and clarity, the same colour coding is maintained throughout. The size of the bars is proportional to the statistical significance of the variable influencing the dependent variable i.e. household share of a fuel. All variables that negatively influence the fuel shares are shown below the zero mark as they reduce the household shares of a given fuel whereas those that positively influence fuel shares are shown above the mark implying that they increase the fuel shares in the household energy mix.

The categorical variables in Figure 8 to Figure 11 are defined as; household head education level is compared to those with no education, Sett. represents household settlement type compared to households dwelling in the rural settlement, income and remittance classes are compared to households in lower income class and no remittance categories, H. owner represents house ownership compared to household owned house while collector represents the main household wood collector compared to having the household head as the main wood collector.

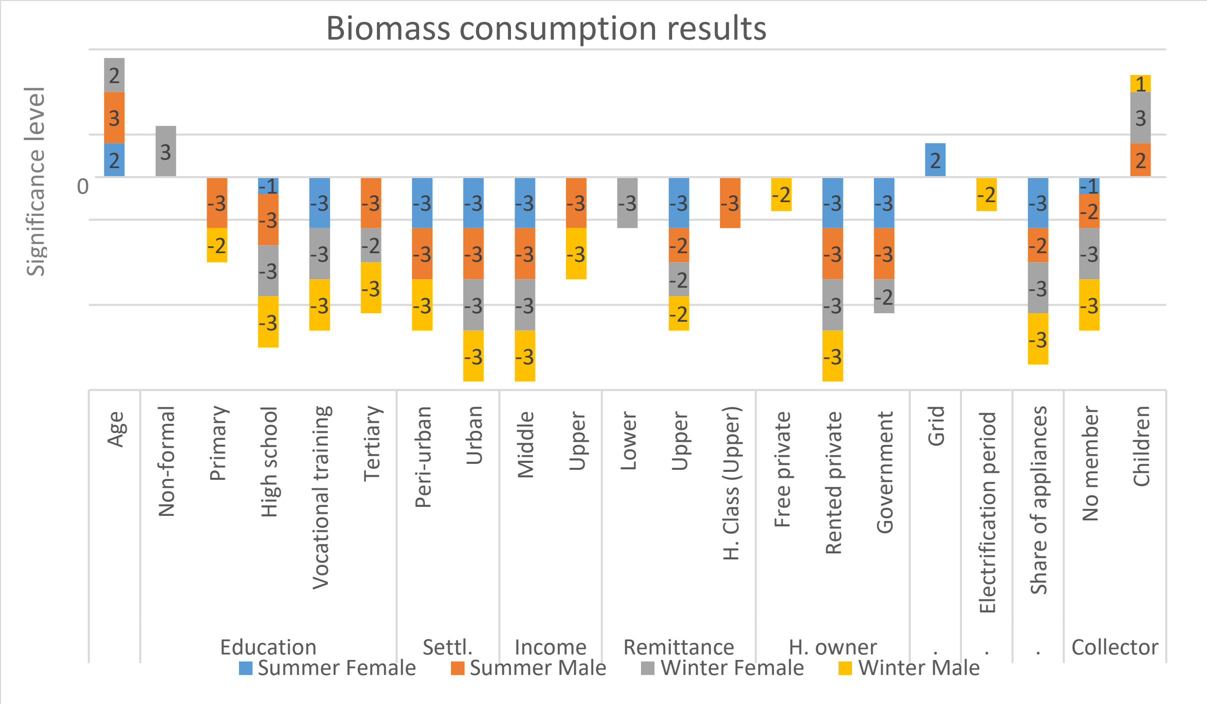


Figure 8: Graphical representation of biomass consumption results

Source**:** own using Gretl software Tobit results

Notes: *3, 2 and 1 represent 1%, 5%, and 10% statistical significance levels respectively*

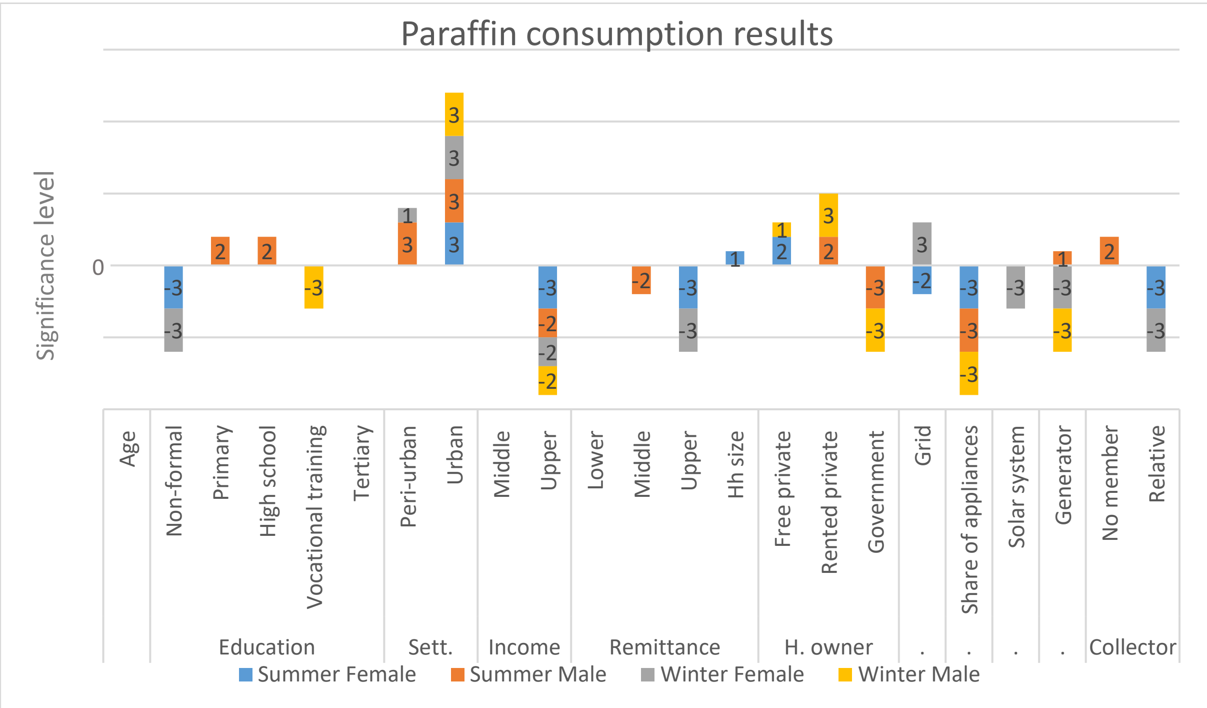


Figure 9: Graphical representation of paraffin consumption results

Source: own using Gretl software Tobit results

Notes: *3, 2 and 1 represent 1%, 5%, and 10% statistical significance levels respectively*

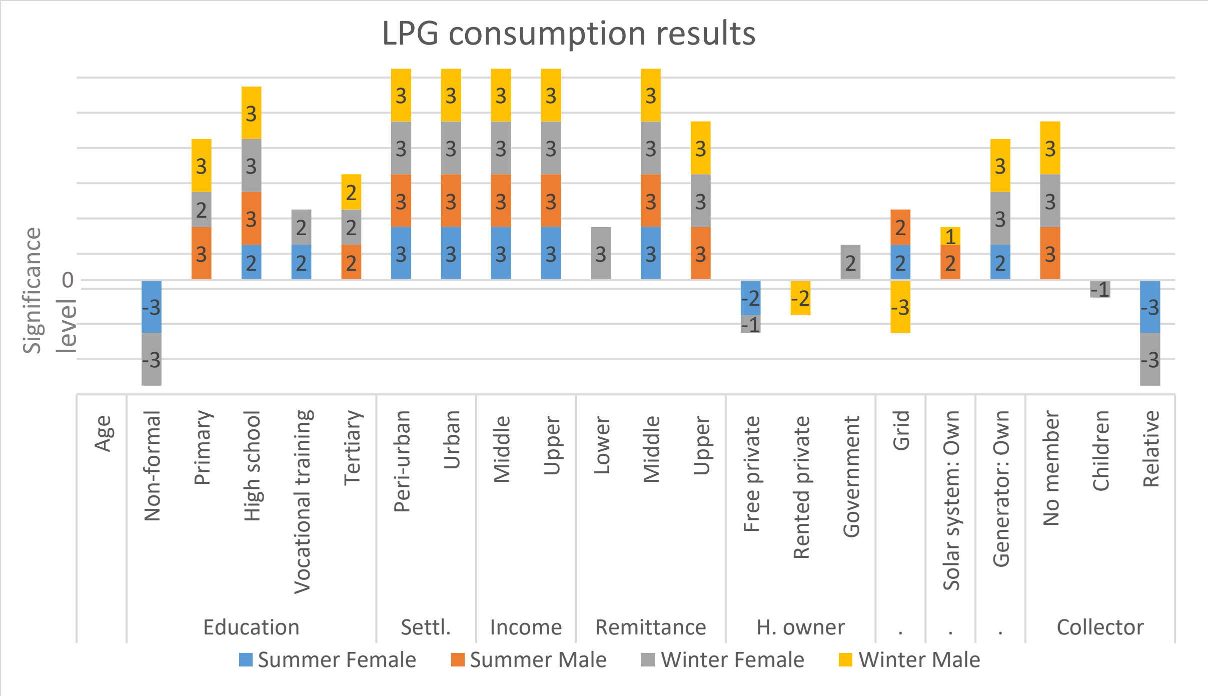


Figure 10: Graphical representation of LPG consumption results

Source: own using Gretl software Tobit results

Notes: *3, 2 and 1 represent 1%, 5%, and 10% statistical significance levels respectively*

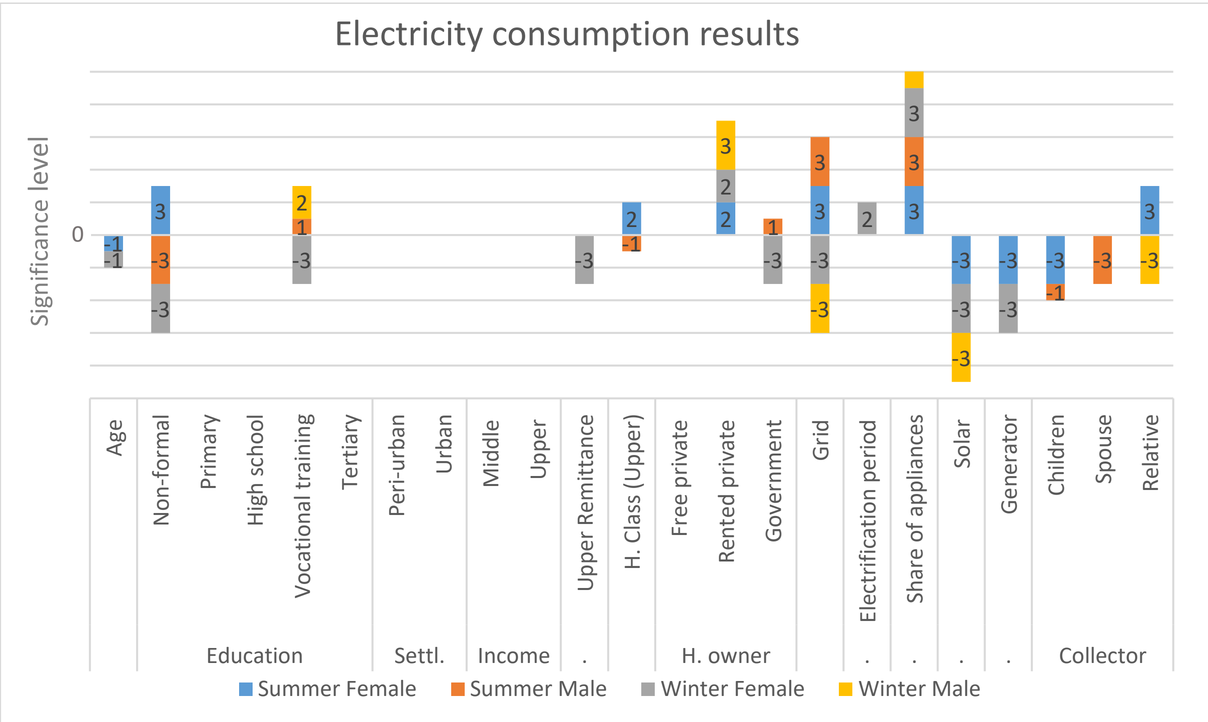


Figure 11: Graphical representation of biomass consumption results

Source: own using Gretl software Tobit results

Notes: *3, 2 and 1 represent 1%, 5%, and 10% statistical significance levels respectively*

6. Conclusions and Policy Recommendations

The inaccessibility of electricity promotes perpetual biomass consumption in Basotho households. This renders females more than males vulnerable to gender inequality and compromises their health quality since the social norms and culture tie them to time-consuming unproductive activities such as wood collection and cooking. This study, therefore, aims to determine the variation in the shares of fuels consumed in female versus male-headed households and to then analyse the determinants of the observed difference from a gender perspective. The Tobit regression model is used to analyse the 2017 BOS HECS data to establish the statistical significance of the influence of various socioeconomic variables on household shares of biomass, paraffin, LPG, and electricity, assuming that shares are left censored.

The main findings of the study suggest that the age of the household head is indiscriminate of gender in relation to dirty fuels as their share increases with an increase in age although female, but not male-headed, households reduce the share of electricity. Education is found to affect female and male-headed households slightly differently as in summer despite both genders reducing the household share of dirty fuels, female-headed households tend to increase their shares of modern fuels while male-headed households opt to increase their share of transition fuels. Another variance is observed in winter as educated female-headed households are found to reduce the share of electricity while their male counterparts increase theirs.

On the other hand, the geographic location of a household does not indicate any variance in the behaviour of female and male-headed households as those in peri-urban and urban areas. As opposed to the rural areas, both reduce the share of dirty fuels and rely more on cleaner alternatives. In summer, the increase in income, similar to location, results in the households reducing the shares of dirty fuels while increasing shares of cleaner fuels despite the gender of the household head and season. Slight variance is observed in winter, however, because female-headed households in the upper remittance class, as compared to those with no remittance; reduce their share of electricity whereas their male counterparts have no significant impact on it. Likewise, an increase in the household size only affects female but not male-headed households as they increase the share of transition fuels such as paraffin in summer, while in winter they tend to reduce the share of cleaner fuels such as LPG.

Although the behaviour of electrified female and male-headed households is similar, they tend to increase the share of clean fuels in summer whereas it is reduced in winter in favour of dirtier transition fuels such as paraffin. Likewise, increasing the share of electrical appliances in the household reduces the share of dirty fuels and promotes the share of modern energies, especially electricity in both seasons regardless of the gender of the household head. The households with other energy sources like solar PV and generators also show similar behaviour irrespective of the gender of the household head and season by increasing the shares of clean fuels like LPG while reducing the share of transition fuels but also that of electricity. Lastly, there is no gender-related variation in households without a wood collector, compared to those whose head bears this responsibility as they reduce their share of dirty fuels and increase that of clean fuels despite the gender of the household head. Households with a wood collector of any relation to the household head, on the other hand, show increased shares of dirty fuels and a decline in shares of cleaner fuels despite their gender. Observations made in this study do resemble typical Basotho households and can therefore influence and/or inform the national energy policy reform in various regards.

Old household heads, especially females, have been observed to be in favour of dirty fuels as opposed to cleaner alternatives possibly due to their weak financial muscle and illiteracy. Hence, it is essential to devise education and economic empowerment programmes targeted at this societal group to advance their knowledge about the health implications of biomass usage as well as improve their financial standing to afford modern fuels. Furthermore, the findings indicate that households whose female head, in particular, has received non-formal education are more drawn to clean fuels than traditional fuels but male behaviour is uncertain. This proves the significance of education in the realisation of clean energy access for all and therefore the likes of awareness campaigns in collaboration with the private sector could make a great addition to the national policy instruments. Since household financial security also undoubtedly steers higher uptake of modern fuels, the inclusion of stringent clauses that oblige project developers to equip locals with income-generating skills in areas of energy projects rollout can render clean energy affordable to many. Likewise, clean fuel and cooking devices subsidization and/or implementing business models such as pay-as-you-go could also make great additions to the policy in support of poor communities such as those in rural areas by minimising their monthly expenditure, as suggested by Blimpo and Cosgrove-Davies (2019) and Emodi et al. (2022).

To ensure a comprehensive understanding of household energy consumption behaviour in Lesotho, further exhaustive studies can be undertaken to investigate the level of energy access and affordability in different regions of Lesotho post the major international shocks like the Covid-19 pandemic and the Ukraine-Russia war. An additional research area could involve evaluating the impact and economic advantages of energy efficiency measures within Lesotho households, with a focus on their role in promoting renewable energy adoption and energy conservation. Lastly, further research could involve the investigation of adoption rates of improved cookstoves in Lesotho rural households, the driving factors, and the impact assessment of fuel demand and air quality in comparison to conventional stoves.

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