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HOUSEHOLD ENERGY CHOICES FOR COOKING IN THE MFANTSEMAN MUNICIPALITY, GHANA

GEORGINA SARQUAH

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2024

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BY

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GEORGINA SARQUAH

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Thesis submitted to the Department of Vocational and Technical Education of the Faculty of Science and Technology, College of Education Studies, Universities of Cape Coast, in partial fulfilment of the requirement for the award of Master of Philosophy degree in Home Economics Education

FEBRUARY 2024

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my original research and that no part of it has been presented for another degree at this university or elsewhere.

Candidate's Signature:..Date:...................

Name:…………………………………………………………………….................

Supervisor's Declaration

I hereby declare that the preparation and presentation of the thesis were supervised by the guidelines on supervision of thesis laid down by the University of Cape Coast.

Supervisor's Signature:.................................... Date:.................................

Name: …………………………………………………………………….................

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ABSTRACT

The study explored energy choices for household cooking in the Mfantseman Municipality. Pragmatic approach based on the mixed-method research approach as well as Cluster, random and purposeful samplings were for the study. Research instruments including questionnaires and interviews were used to collect data for the study. Descriptive statistics were employed in the analysis of the socio-demographic research questions one, two three and four. Braun and Clarke (2006) thematic approach was used in the qualitative data analysis. A multivariate statistical tool such as ANOVA was used to analyse the differences in means of energy choices in the selected communities. The findings showed that charcoal was the primary energy source for residents within the Mfantseman zone. LPG was the second-best thing to charcoal. Wood fuel, electricity, kerosene, and biogas were also key energy sources in Mfantseman. From the quantitative and qualitative results, income level, consumption level, and energy scarcity are the main factors that determine household energy use choices in the selected communities. However, other variables like market price of fuel, energy resource availability, efficient cooking, social status, and so on were also present. In light of the aforementioned discoveries, it was recommended that the development of woodlots in the Mfantseman region should be promoted. Agricultural expertise can educate individuals on woodlot development for charcoal manufacturing. An LPG sales station should be established in the Mfantseman region. This will increase the inhabitants' access to LPG consistently.

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KEYWORDS

Households

Energy choices

Resources

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Finally, I thank my brother for his thoughtfulness. Mr Maxwell Sakyi should graciously accept my warmest gratitude for his assistance in analysing my qualitative data. I also respect him for having the time to peruse my thesis work on occasion and contributing significantly to the research.

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DEDICATION

To my family: Samuel, Kenneth

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LIST OF ACRONYMS

LPG	Liquified Petroleum Gas
SDGs	Sustainable Development Goals
DME	Dimethyl Ether Gas
CO	Carbon monoxide
WHO	World Health Organisation

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CHAPTER ONE

INTRODUCTION

Energy provision has become one of the cornerstones of development, but its selection, usage and dependency for subsistence consumption have been reported to be non-uniform (Momoh, 2016; Norad, 2020). With the current rate of modernisation, several analyses foresee a move toward more contemporary fuels such as paraffin, gas and electricity. In light of rising energy costs, there is a need to increase awareness of energy consumption and the pattern of energy selection as well as health-related issues.

According to Sornette, Woodard and Zhou (2009), access to modern and clean energy sources is very low in developing countries like Ghana. In Ghana, many households depend on multiple energy sources in which the energy demand and substitution are often partial. This current study sought to explore the evidence of household choices of fuel for cooking in the Mfantseman Municipality in the Central Region and describe the structure of household demand for cooking fuel and establish energy choices for households in the Mfantseman Municipality. The study employed mixed method approach, and used cluster, simple random and convenience sampling approaches in sampling respondents. A questionnaire was used in soliciting data from residents in Mfantseman, whereas an interview was used to collect data from household heads. A statistical tool such as ANOVA statistical analysis would be used to compare the difference in energy choice and consumption between and among the study areas.

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Background to the Study

For a long time, energy has not been recognised as a crucial premise for describing humans and their wants, even though the supply of adequate, dependable and affordable energy is necessary for addressing fundamental human demands. Energy provision is a cornerstone of development due to the close linkages between energy services, economic progress, and accomplishing social goals (Zhao, Cai, Shen, Elshkaki, Liu & Varis, 2023). A means of managing current or recent use of electricity and LPG (a series of interconnected energy structures) has been found to have a powerful impact on human well-being by lowering disease-free states and the state of protection from hazards related to a long-established way of using energy (Momoh et al., 2016; Norad et al., 2020); reducing time constraints on household members, particularly women and children; increasing labour productivity and income (Purba, 2019) and positively impacting (Cecelski, 2002; Rukato, 2002).

Several factors influence the choice of alternate energy sources other than fuelwood. Several studies predict a shift to fuels like gas, electricity and paraffin as a result of the present rate of modernisation. Energy source selection, use and reliance for basic service are already documented as non-uniform across a region or among community members (Momoh et al., 2016; Shen et al., 2022).). The way people choose and use energy leaves a lot to be desired. The desire for greater comfort and cleanliness drives fuel selection and substitution (Almansour, 2022)). As modern fuels become more widely available, consumers buy contemporary

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appliances such as gas and electric stoves, air conditioners, radios, televisions and refrigerators (Leach et al., 2012; Almansour et al., 2022).

Nevertheless, as the energy ladder moves up, the cost of owning appliances and using new types of fuel is strongly linked up (Van-der-Kroon, 2013). Households with more money are more likely to switch to non-biomass fuels. However, the high cost of modern fuels discourages low-income people from using them (Sharma & Dash, 2022). Humankind's ability to coexist in peace with the ecosystem has, until now, depended on civilization's supply of energies (Januszkiewicz, Paszkowska-Kaczmarek, Duguma & Kowalski, 2021). Human civilization, for example, has increased energy somatically more than required for basic survival and harnessed it to improve human life, increase agricultural efficiency, and advance industry, health, culture and science (Evans et al., 2022).

Nevertheless, the global population growth has increased energy production (Panos, Turton, Densing & Volkart, 2015). This, in turn, affects human society, behaviour and social development. In the report of the International Energy Agency, developing countries have less access to green and modern energy sources (Sornette et al.,, 2009). Instead, they mostly depend on traditional fuel (woods, charcoal and crop residue). Thus, two billion people globally depend on biomass to meet their energy needs. Biomass accounts for about 20% of the world's energy supply (Morrison, 2006). Without new policies, the number of people globally that rely on biomass fuels is expected to increase to 2.6 billion by 2015 and 2.7 billion by 2030 due to population growth (Wirsenius, Azar & Berndes, 2010).

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Household energy for cooking excludes energy used in the processing and preparation of food before buying (Tharrey, Drogué, Privet, Perignon, Dubois & Darmon, 2020). It forms the largest part of most energy used in the families or households. The energy for cooking is in solid fuels and non-solid fuels. Solid fuels are fossil fuels (coal, pot) and biomass (wood, dung and agricultural products), while non-solid fuels consist of kerosene, liquefied natural gas and electricity (Tharrey et al., 2020). Over two billion people worldwide are not having access to a power supply (Volkart, Mutel & Panos, 2018). Humans depend on solid fuels for electricity for basic everyday tasks such as cooking, which is usually done over open fires or inadequate smoking burners. This difficulty is most evident in the villages of developing nations (Volkart et al., 2018).

Barnes et al. (2011); Ekouevi et al. (2012) noted that improving access to energy services will reduce poverty and ensure economic advancement. In undeveloped countries, households use more energy than any other end-use service. Thus, 1.26 billion publics globally are not having access to electricity, while 2.64 billion also depend on biological energy for cooking (Daioglou et al., 2012). According to Wang et al. (2013), access to safe and clean cooking energy in households will reduce by 2030.

In emerging countries, the extensive use of wood, biomass, and charcoal stoves may impact human health and the environment and contributes to vegetation destruction and global warming, which is among the greatest threats to human health in developing countries (Liao, Chang & Yang, 2015). Smith et al. (2014) stated that indoor air pollution from solid fuel cooking approximately resulted in

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3.5 million untimely deaths in 2010. In the same year, 500,000 people died in the developing countries of Asia and sub-Saharan Africa as a result of outdoor air pollution from the use of solid fuels for cooking.

The United Nations Sustainable Energy for All (SE4ALL) program 2013 was established to ensure individuals have equal privileges to green power and increase global energy productivity twofold. By 2030, the project aims to increase renewable energy accessibility fourfold (Moncada, Asdrubali & Rotili, 2013). Furnace combustion products are a major source of noxious and harmful combustion products, particularly in poorly ventilated dwellings (Troncoso & da Silva, 2017). Cooking with solid fuels in inefficient conventional open fires and ovens has a negative impact on rural families' environment, economy, and health.

The World Health Organisation report showed that air pollution affects about 1.6 million people annually (Mestl, Aunan, & Seip, 2007). According to WHO (2007), disease outbreaks due to indoor air pollution from solid fuel usage in Ghana in 2021 is increasing. Females and children bear the brunt of illness due to their high exposure in households. Beyond endangering the health of individuals, unhealthy cooking techniques have an impact on the environment (WHO et al., 2022).

One of the main contributors to deforestation, which currently destroys around 10 million hectares of forests annually in developing countries, is the harvesting of firewood (Kyere-Boateng & Marek, 2021). Due to the fuelwood shortages caused by this excessive deforestation in many nations, agro-waste and animal excrement are now used in place of firewood.

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According to a study conducted in Ghana, Celtis Zenker, once prized as fuelwood and utilized by 80% of households in two villages over the previous ten years, is no longer accessible (Yiran, Ablo & Asem, 2020). In addition, the depletion of conventional fuels in other regions, such as rural China, has spurred a shift to coal for domestic use, with its attendant implications. Nevertheless, energy demand is becoming a component of Ghana's developmental agenda. However, the government of Ghana has factored the energy choice of households into environmental sustainability to reduce households' dependence on traditional fuels (Bofah, Appiah-Konadu & Ngwu, 2022). Although there has been an attempt, this goal has not been achieved. The choice, use and reliance on energy sources for subsistence consumption have been observed not to be uniform across one area or among community members (Dumga & Goswami, 2023).

According to Dumga et al. (2023), many factors influence energy choice in Ghana. They also believe there is an increase in energy choices such as gas, electricity, paraffin, and increased oil prices in Ghana. Changes in fuel choices occur when available energy leads to increase household income. According to Afrane (2012), energy choices occur for consumers when efficient appliances are used. This suggests that the rising cost of non-biomass fuels is unlikely to impact richer households negatively. Households are, nevertheless, extremely vulnerable to the move to more complex options. Numerous countries have used studies to advise policymakers on energy and household fuel choice concerns using the energy ladder model and leap-frogging hypothesis (Afrane et al., 2012; Kakoma-Bowa, 2020; Asche, 2021).

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The Mfantseman Municipality is characterised by its diverse population, economic activities, and energy consumption patterns (Bugyei, 2020). Historically, households in the municipality have relied on a variety of energy sources for cooking, including traditional biomass fuels like firewood and charcoal, as well as modern energy sources such as liquefied petroleum gas (LPG) and electricity (Kodwiw & Mensah, 2021). Despite the availability of modern energy alternatives, many households in Ghana, Mfantseman municipality continues to use traditional biomass fuels for cooking (Kusi, 2020). This reliance on biomass has implications for energy sustainability, environmental conservation, and public health. Traditional cooking methods often involve inefficient stoves and open fires, leading to high levels of indoor air pollution and deforestation due to wood consumption. Additionally, the burden of collecting biomass fuels falls disproportionately on women and children, impacting their health and limiting their opportunities for education and economic activities (Awere, 2021). Therefore, this study seeks to explore the energy choice for household cooking in the Mfantseman Municipality.

Statement of the Problem

Ghana's development challenge is how to meet long-term home and commercial energy demands given the present electricity supply. One of the concerns now affecting Ghana's economic growth is the lack of sustainable, reliable renewable, efficient and environmentally friendly energy sources like solar and wind power. Remote societies and slum areas, where some families are incapable to rise above the sustainable level, are severely harmed. In the work of Nnaji et al. (2012); Adamu, Adamu, Ade and Akeh (2020); Ahmad, Kiran and Alamgir (2023),

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it has been argued that households with low-income levels rely on biomass fuels, such as wood and dung, while those with higher incomes consume energy that is cleaner and more expensive such as liquid petroleum gas (LPG). Those households in transition consume transition fuels, such as kerosene and charcoal.

As household wages increase, they transition to greener, better sustainable power systems to meet their domestic energy needs (Smith et al., 2014). However, this situation sometimes becomes complicated, particularly in the rural parts of Ghana (Balakrishnan et al., 2004). Households commonly use a variety of stove types and energy sources, often transitioning between different stages of the energy ladder, and energy substitution is frequently incomplete. In addition, people use different fuels to ensure they achieve energy security (Endalew, Belay, Tsega, Aragaw & Asratie, 2022). Households are forced to respond in two ways as fuel shortages worsen. Some households would need to switch to alternative fuels, while others would need to change their cooking habits. Some coping mechanisms can have nutritional and health implications. Economic considerations aside, various social-cultural behaviours affect people's fuel choices.

Studies on rural energy consumption in Ghana revealed that energy sources for household cooking are mostly wood fuel, charcoal, and kerosene (Karakara & Osabuohien, 2021; Twumasi, Jiang, Addai & Ding, 2021; Yousaf, Amin, Baloch & Akbar, 2021). In addition, Twumasi et al. (2021); Yousaf et al. (2021) also examined household energy choices for cooking. They asserted households primarily relies on traditional biomass fuels such as wood, charcoal, and crop residues, which have longstanding effects on health, environment, and socio-

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economic development. Moreover, the extensive reliance on biomass fuels contributes to deforestation and environmental degradation in the Mfantseman Municipality. The unsustainable harvesting of wood and other biomass resources not only threatens local ecosystems but also exacerbates climate change. Additionally, the time and effort required for fuel collection place a disproportionate burden on women and girls, limiting their opportunities for education and income-generating activities.

While the adverse effects of traditional biomass fuel use are well-documented, transitioning to cleaner and more sustainable cooking energy sources presents a complex challenge. The Mfantseman Municipality, like many rural areas in Ghana, faces economic constraints, limited access to modern energy infrastructure, and entrenched cultural cooking practices. As a result, households continue to rely on traditional biomass fuels despite the associated health and environmental risks. It is reported by Amegah et al. (2012) that less than 17% of households in the Mfantseman Municipality resorted to the use of LPG as their primary source of fuel for cooking. Generally, there have been some efforts of the government and other agencies in the areas of policy directives in encouraging households to switch from biomass fuel to modem fuel for cooking (Ren, Yu & Xu, 2019; Joshi & Bohara, 2017). Despite these efforts, many households prefer biomass fuel to modem fuel. Therefore, this study seeks to explore the energy choice for household cooking in the Mfantseman Municipality.

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Purpose of the Study

The purpose of the study was to explore the energy choice for household cooking in the Mfantseman Municipality. The study pursues these objectives:

1. Find out the energy types used for household cooking in the Mfantseman Municipality
2. Explore the level of knowledge of energy (fuel) use among households (head).
3. Find out determinants (factors) that influence household cooking fuel choices.
4. Explore health related risks associated with the use of household energy fuels.

Research Questions

Four research questions have been set to achieve the objectives of the study. These research questions are outlined as follows:

1. What are the types of energy sources households used in the Mfantseman Municipality?
2. What are the determinants of household energy choices used in the Mfantseman Municipality?
3. What are the health-related issues associated with the household energy choices?
4. How knowledgeable are the households (heads) using the energy (fuel)?

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Significance of the Study

This study explored the energy choice for household cooking in the Mfantseman Municipality. The findings of the study will provide valuable insights into the local energy landscape or energy choices for households in the Mfantseman Municipality. This would help energy planners, policymakers, and organisations working in the energy sector to tailor energy-related initiatives and policies to align with the existing practices and preferences of the community, ultimately leading to more effective and sustainable energy solutions. At the community level, the findings of this study could serve as a valuable resource for local authorities, policymakers, and non-governmental organizations (NGOs). By understanding the prevalent energy choices and factors influencing them within the Mfantseman Municipality, these stakeholders can develop targeted initiatives to promote cleaner and more sustainable energy sources for household cooking. This, in turn, could lead to improved air quality, reduced health risks, and enhanced overall well-being for residents.

Moreover, the study focused on assessing the level of knowledge regarding energy use among households in the Mfantseman Municipality and this is paramount importance in shed light on the awareness and information available to residents regarding different energy sources and their implications. This would help increase in knowledge about energy choices and their related health risks in the Mfantseman Municipality, helping guide educational efforts and campaigns aimed at enhancing energy literacy. The findings of the study would help empower households with information on energy-efficient and environmentally friendly

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cooking practices would not only improve their quality of life but also contribute to the overall environmental sustainability of the region.

Delimitations

This study focused exclusively on the Mfantseman Municipality in Ghana. Thus, the study did not encompass a nationwide or global assessment of household energy choices. The study was limited to household cooking energy choices which are not for commercial use. This study did not investigate other energy uses, such as lighting, heating, or transportation. The study was limited to energy choices or practices in the Mfantseman Municipality. and districts in the region. The study also focused on cooking energy choices in Ghana since they comprise the major source of fuel in the selected communities.

The study was delimited to a specific time frame and reflects the conditions and factors influencing household energy choices in the Mfantseman Municipality during the period of data collection. Changes or developments occurring after the data collection period are not considered. The research primarily gathered data from the heads of households within the Mfantseman Municipality. The study did not not capture the perspectives and experiences of all household members or other community members who may influence energy choices. The use of qantitative and qualitative data allowed for a more comprehensive understanding of household energy choices in the Mfantseman Municipality. This enabled the exploration of both statistical trends and the underlying motivations, beliefs and cultural factors influencing these choices.

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Limitations

The study relied on a specific sample of households within a single municipality, which may not fully represent the diverse range of energy choices and cooking practices prevalent in other regions of Ghana. Consequently, random sampling techniques such as lottery sampling technique was employed to ensure the generalization of the study's findings to the broader Ghanaian context to account for the regional variations in energy choices.

Respondents' ability to recall and report their energy choices accurately could be influenced by memory bias or social desirability bias. This introduces potential inaccuracies into the data, which could affect the reliability of the findings. Temporal factors, such as seasonal variations and economic conditions, were not comprehensively addressed in this study. Household energy choices can fluctuate over time due to these factors. Therefore, the study provides a snapshot of energy choices within a specific timeframe, and these choices may evolve over time.

There is a risk that the sample selected for qualitative interviews might not fully represent the larger population surveyed in the quantitative phase. This limitation could affect the generalizability of qualitative findings. Qualitative data are inherently subjective, as they rely on participants' perspectives and interpretations. This subjectivity could introduce bias and limit the generalizability of qualitative findings. There might be a risk of response bias, where participants provide socially desirable responses rather than accurate information about their energy choices.

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Organisation of the Study

The study consists of five chapters. The first chapter will deal with the general introduction, the background, the problem statement and purpose, research questions, significance, delimitation and limitations of the study. The second chapter will consist of review on existing literature on the variables of the present study. The third chapter will describe the research methods. It will describe the research design, study area, population, sample and sampling procedures, research instruments, data collection procedures and data processing and analysis. The fourth chapter will focus on the results presentation and discussion. Finally, the fifth chapter will summarise the research findings, conclusions based on the findings, recommendations and suggestions for further research.

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CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter is a review on related studies on the topic. This chapter is an overview of the world's energy resources and consumption, energy resources in Ghana, sharing and uses of the main cooking fuels in Ghana, energy ladder and energy stacking model. It also covers the reasons for the use of particular energy, factors affecting household cooking fuel choices and consumption of traditional fuels and their side effects. It also includes determinants of cooking fuel choice in households, household cooking energy, health and environment and conceptual framework for the study.

Conceptual Review

Overview of the Worlds Energy Resources and Consumption

Energy has been contributing significantly to the development of countries since the discovery of fire (Lombardi, Rocco & Colombo, 2019). Energy takes on diverse forms, including refined fuels and electricity, and serves a multitude of purposes, from powering transportation to generating electricity (Razi & Dincer, 2022). In 2020, a significant portion of the world's primary energy consumption was dominated by oil at 31.2%, closely followed by coal at 27.2%, while natural gas constituted 24.7% (Zhang, Liu, Nie, Wu & Wang, 2022). Renewable energy sources, such as hydro and others, collectively accounted for 12.6%, with hydro contributing 6.9%, and nuclear power making up 4.3%. As of 2022, fossil fuels still contribute approximately 80% of the world's energy consumption, posing

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substantial challenges in achieving sustainability goals (Faiz, Zoitsas, Altmann, Baruch & Close, 2020). Energy consumption demonstrates a steady annual increase of approximately 1-2%, except for solar and wind energy, which experienced remarkable average growth of 20% per year during the 2010s (Ali-Taleshi, Squizzato, Bakhtiari, Moeinaddini & Masiol, 2021).

Energy used in cooking makes the consumption of foodstuffs possible and improves food safety. Man's use of fire for cooking expands their range to higher altitudes and latitudes, changing social development. According to Benson and Loftesness (2012), man has altered the environment through energy sources. Access to adequate energy service levels is a crucial prerequisite for developing any country (Ali-Taleshi et al., 2021). In renewable energy, economic and social changes lead to the discovery and manufacturing of technology to explore new energy sources to increase energy consumption. The processing of energy, whether it originates from fossil fuels or alternative sources, is integral to making it suitable for end-users. However, a pressing concern tied to energy production and consumption centres on greenhouse gas emissions. Out of the roughly 50 billion tonnes of annual global greenhouse gas emissions, a staggering 36 billion tonnes of carbon dioxide, primarily from fossil fuels, were emitted in 2021 (Mishra, Saini, Saha, Chauhan, Kumar & Maity, 2022).

The issue of global energy access reveals significant disparities, with approximately 13% of the world's population, equivalent to about 940 million people, lacking access to electricity in their homes (Jayasinghe, Selvanathan & Selvanathan, 2021). This energy gap raises concerns about the well-being and

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developmental opportunities for a substantial portion of the global populace (Tang, 2022). Simultaneously, a staggering 3 billion individuals, or 40% of the world's population, lack access to clean cooking fuels, often relying on solid fuels like charcoal and wood. This reliance on traditional cooking methods comes at a considerable health cost, with indoor air pollution being linked to over 1.6 million premature deaths annually (Abdullah-Al-Mahbub & Islam, 2023). Consequently, there is an urgent need for a transition to low-carbon energy sources like renewables and nuclear power to mitigate the impact of greenhouse gas emissions.

Despite the growth of low-carbon energy, the absolute consumption of fossil fuels continues to rise, resulting in escalating CO2 emissions (Mohsin, Taghizadeh-Hesary & Shahbaz, 2022). Nevertheless, certain countries serve as beacons of hope, successfully transitioning to low-carbon energy systems and showcasing the potential for accelerated shifts toward cleaner energy (Griffiths & Sovacool, 2020; Pereira, da Silva, dos Santos & Peyerl, 2023). These nations, such as Iceland, Norway, Sweden, France, and Finland compared to African countries like Ghana and Nigeria, draw a significant portion of their energy from nuclear and renewable sources, demonstrating the possibilities with innovative energy technologies, particularly when coupled with the growing potential of solar and wind power (Maestre, Ortiz & Ortiz, 2021; Aytekin, 2022; Liu & Feng, 2023). Additionally, the electricity sector offers a promising avenue for decarbonization, boasting a higher proportion of low-carbon sources compared to other energy sectors like transport and heating, which present more significant challenges in

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transitioning to cleaner alternatives (Jafari, Botterud & Sakti, 2022; Qureshi, Yusuf, Kamyab, Vo, Chelliapan & Vasseghian, 2022).

Energy Resources in Ghana

‘Ghana has different energy resources (Kiage, 2014). However, there is a dearth of more advanced sources of energy, high per-person energy use, excessive reliance on bioenergy, and extremely inefficient biomass energy use. Biomass makes up 94.5 percent of the nation's entire energy resource base (Omar, Shafie, Hami, Othman & Djaohari, 2023). Crop waste and dung, according to the literature, are last-resort fuels (Kiage et al., 2014). They have a significant impact on the supply and demand of energy in areas where forest resources are reduced, particularly in the household sector. About 1.1 million tonnes/year of the nation's entire potential energy resources come from these two biomass resources (Nelson, 2023).

The country's biomass resource suffers from a very unequal geographic distribution on a variety of spatial scales. The main issue facing the nation now is this incredibly unequal spatial distribution. Wood fuel resources are under intense strain in the region of county try situated in the north-northeast of Ghana (Arthur, Baidoo, & Antwi, 2011; Barr, 2022). The lack of prospective resources in Ghana's energy sector is not the only issue; the country also lacks the capability to explore its potential resources and the capacity and ability to use its currently produced and readily accessible energy resources (Nelson et al., 2023).

There is evidence that Ghana has large hydropower resources, but that they have only been developed and utilised to a minimal extent (Abdul-Wakeel &

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Dasmani, 2019). After biomass, hydropower is the largest indigenous renewable energy source in the nation, and it is virtually solely used to produce electricity. 1,652MW of installed generation capacity is made up of 550MW of thermal energy and 1,072MW of hydropower. The Volta River is thought to account for the majority of the hydropower generated from this potential.

There are around 1,300 MW of medium hydro potential in total, with a projected yearly rate of 4544 GWh (Souza Júnior, Koch, Siegmund-Schultze & Köppel, 2021). However, despite Ghana's enormous hydropower potential, it has only partially been utilized due to financial limitations for dam construction and a lack of significant demand to support system development (Hoff, Ogeya, de Condappa, Brecha, Larsen & Liersch, 2023). Those who study the solid, liquid, and gaseous matter that make up the Earth and other terrestrial planets point out that certain fossil fuel resources with promising locations exist both on land and offshore. The Saltpond fields produced very small amounts of crude oil. Ghanaian crude oil production temporarily returned in 1993 (Arthur et al., 2011). Recently, Ghana discovered commercial quantities of oil in Cape Three Points. The majority of petroleum products are now imported while exploration is still in its early stages. Approximately 80% to 83.3% of crude oil and 15% to 19% of petroleum products were found (Hoff et al., 2023).

Energy Consumption Patterns in Ghana

The energy consumption in households (for cooking and lighting) Ghana is the highest. It was roughly 50% of the nation's energy use (Shahi, Rijal & Shukuya, 2020). According to Karakara and Osabuohien (2021) estimation, the country's

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overall final energy consumption was 6 million tonnes in 2000 and around 7.1 million tonnes in 2022. The primary energy source is biomass, specifically fuelwood and charcoal. According to estimates, this accounted for 66.9% of the nation's overall final energy conujhbsumption in 2004 (Shupler, Mangeni, Tawiah, Sang & Pope, 2021).

Ghana has some of the lowest global energy consumption rates and shares of both traditional and contemporary energy sources (Twumasi et al., 2021). In reality, it is estimated that each person uses 360 kg of oil equivalent per year (toe) (Ohene, Hsu & Chan, 2022). Additionally, the percentage was lower than the country's overall 2000–2003 use of power and petroleum products. In Ghana, the sector made for 32% of the household and 5% of the population, respectively. The primary consumer of modern energy, which primarily relies on petroleum products, is the transportation industry (Twumasi et al., 2021).

In 2004, the transportation sector alone accounted for up to 81% of total petroleum product consumption. Aside from transportation, the industrial sector is typically one of the primary consumers of modern fuel in emerging nations (Guthrie, Giles, Dunkerley, Tabaqchali & Manville, 2018). Ghana experiences a similar situation.

Supply and Consumption of the Main Cooking Fuels in Ghana

This section describes the current state of usage and market for several types of cooking energy in rural Ghana (fuelwood, charcoal, kerosene, and LPG). In Ghana, 94% of families cook with wood (Ahmad, Nawaz, Kiran, Dagar, Bhatti & Hussain, 2023). While charcoal is mostly utilised in metropolitan centres, firewood

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is the primary fuel used in rural regions. Only 4% of households utilise LPG for cooking, and those are mostly in metropolitan areas.

Woodfuel

In 2000, the domestic area used around 11 million tonnes of oil equivalent wood fuel. In 2003, this figure was 13 million (Brożyna, Strielkowski, Fomina & Nikitina, 2020). The power industry creates both discharges and inflows into the economy, and hence indirectly contributes to GDP through its usage as production inputs. According to financial results, wood fuel was the second most popular fuel in the economy. From 2000 to 2003, an estimated $400-600 million was spent on wood fuel. Between 2000 and 2003, the percentage of total national power bills devoted to wood fuel ranged from 29 to 36%, trailing only petroleum (Chukwuma, 2020).

According to Kedir (2021), the traditional ground heap process converts approximately 50% of firewood to charcoal with a 12.5% efficiency (6–8 kg of firewood produces 1.0 kilogramme of charcoal). If the effectiveness of the charcoal production operation increases, the quantity of wood fuel used will be lower. The yearly per head use of wood fuels is expected to be approximately 1,080 kg, while yearly wood utilisation for power generation is anticipated to be over 14 million m3. According to recent records, individuals find it hard to shift to another fuel, so wood fuel usage in Ghana might reach 20 million m3 by 2020. (Shankar, Quinn, Dickinson, Williams, Masera, Charron & Rosenthal, 2020).

The traditional stoves are the ones that are most frequently used for cooking in both rural and urban settings. Their relative efficiencies for firewood and

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charcoal stoves are 14% and 18%, while those for electricity and LPG stoves are 65% and 45%. (Gould, Schlesinger, Molina, Bejarano, Valarezo & Jack, 2020). The production of firewood and charcoal in Ghana is neither continuously regulated nor managed, despite there being limited initiatives in place at the Forestry Commission (wood lots for the private sector) and the Energy Commission (better fuelwood burners) (Maji & Kandlikar, 2020). The Energy Commission's predictions, which show that fuelwood consumption is anticipated to double by 2020 under the business as usual scenario and might quadruple by 2020 under the high growth scenario, underscore the need to aggressively manage the sustainability of the conventional fuelwood industry (Vuola, Korkeakoski, Vähäkari, Dwyer & Phonhalath, 2020).

Kerosene and LPG

Kerosene and LPG (liquefied petroleum gas) serve crucial roles in Ghana, particularly in the context of household energy needs (Nelson et al., 2021). Traditionally, kerosene has been a primary source of lighting for homes without access to electricity. It provides a reliable and accessible means to illuminate households in remote or underserved areas. In contrast, LPG finds its predominant usage in the realm of cooking (Codjoe, Appeaning-Addo, Addoquaye-Tagoe, Nyarko & Abu, 2020). The year 2004 marked a significant milestone in LPG consumption in Ghana, with a total of 67,576 tons of LPG being utilized. This shift towards LPG as a household energy source can be attributed to its convenience, efficiency, and environmental benefits (McIntyre, Kosinski & Naumova, 2022).

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In the early 2000s, the home sector was the primary consumer of LPG, accounting for approximately 76% of its usage. However, LPG also found applications in the industrial (14%) and commercial (10%) sectors during this period (Lamb et al., 2021). Nevertheless, it is worth noting that LPG adoption in Ghana is not uniform across regions. Approximately 8.5% of households in Ghana rely on LPG for cooking, with substantial disparities between rural and urban areas (Venugopal, Shukla & Siqueira, 2020). In rural settings, only 1.2% of households use LPG for cooking, whereas in the Greater Accra region, this figure rises significantly to 29% (Sime, Tilahun & Kebede, 2020).

One notable challenge associated with LPG adoption in low-income households is its cost, encompassing not only the price of the gas itself but also the expense of acquiring the necessary hardware, including cylinders and burners (Leary, Menyeh, Chapungu & Troncoso, 2021). As a result, LPG remains beyond the financial reach of many low-income families, limiting its widespread adoption in this demographic. Thus, while LPG offers numerous advantages in terms of efficiency and environmental impact, affordability remains a barrier to its equitable distribution and utilization among all socioeconomic groups in Ghana (Knizkov & Arlinghaus, 2020). Efforts to address this affordability issue and promote cleaner and more sustainable energy sources in rural areas are critical for improving the overall quality of life and environmental sustainability in the country (Nkadimang, 2023).

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Firewood

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For many people, especially poor and rural households, firewood is an important source of energy. Most African countries still use firewood as the primary fuel for cooking. It is estimated that Africa consumes around 500,000 tons of firewood every day (Wei & Liao, 2018). The dominance of firewood as the primary fuel for cooking in rural areas can be linked to its availability as free fuel. Most often, firewood is collected, not bought. The missed opportunities and external costs associated with collection and incineration are not reflected in these little or no immediate costs. Women spend most of their time harvesting wood (Wood, Ansah, Rivers III & Ligmann-Zielinska, 2021).

Firewood is often burned in open stoves (traditional three-stone stove, mud stove) resulting in low energy density and low total energy efficiency on combustion, often between 10 per cent and 20% (Bawakyillenuo, Crentsil, Agbelie, Danquah & Menyeh, 2021). The dominance of firewood as the primary fuel for cooking in rural areas can be linked to its availability as free fuel. Most often, firewood is collected, not bought. The missed opportunities and external costs associated with collection and incineration are not reflected in these little or no immediate costs. Women spend most of their time harvesting wood (Maji & Kandlikar, 2020; Petrokofsky, Harvey, Petrokofsky & Ochieng, 2021).

Charcoal

Charcoal is often produced in low-efficiency mound kilns in impoverished countries, resulting in significant pollutant emissions (Pennise et al., 2009). This increases the demand for wood. Losses are increased when consumed in inefficient

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furnaces. The entire system efficiency is extremely low, as only around 5% of the energy in the raw biomass is transformed into usable energy for cooking using charcoal burners that are often found in urban houses (Yeatts et al., 2012). For instance, it is estimated that a household in Nairobi using just charcoal requires 240–600 kg of charcoal each year. 1.5 to 3.5 tons of biomass are required to generate this amount of charcoal (Alstone, Gershenson & Kammen, 2015).

Charcoal is increasingly being used as a cooking fuel in developing countries, but more wood is needed per meal using charcoal than firewood to produce the same amount of energy as using firewood. As a result, supporting a switch to charcoal could exacerbate environmental harm and fuel shortages (Schlag & Zuzarte, 2008). Residents in crowded urban areas choose charcoal for several reasons: it has a higher energy density, burns cleaner (reduces exposure to hazardous pollutants), is easier to transport, handle, and store, resists insect attack and burns with little smoke or flame (Van-der-Plas et al., 2020). For the urban poor, charcoal burners are a more attractive fuel than alternative options such as LPG or electricity (Broto, Maria de Fátima & Guibrunet, 2020). Charcoal is a product that can be produced domestically and supports the economy. It also poses fewer respiratory health hazards to the user than certain other conventional fuels (Xiang, Ma,, Chen, Cai, Feng & Ma, 2022).

Biogas

The anaerobic digestion of biodegradable material in digesters can result in the production of biogas, which is a valuable source of fuel for cooking. Agricultural waste, human excreta, cow manure, chicken droppings, and other

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renewable raw materials can all be used to create biogas (Selormey, Barnes, Kemausuor & Darkwah, 2021). Methane gas, which makes up 40–70% of biogas, carbon dioxide, which makes up 30–60% of biogas, and a small quantity of other gases make up the combination, which is combustible (Korbag, Omer, Boghazala & Abusasiyah, 2020). The calorie content of gas is approximately 6 kWh, which is comparable to the energy in about half a liter of diesel oil, according to GTZ and ISAT (Selormey et al., 2021). One cubic meter of gas can produce enough energy to cook three meals for a household of five to six people, drive a one horsepower engine for two hours, and produce 1.25 kilowatts of electricity (Emetere, Agubo & Chikwendu, 2021).

The potential for household use of biodigesters is larger in areas where inputs like manure and water are readily available (Nelson, Darkwa & Calautit, 2021). The nations renowned for having the most extensive plans for the spread of this technology are China and India. Five million of China's seven million biodigesters for home use that were constructed as part of the biogas programme between 1973 and 1978 were still in good working order in 1994 (Garf et al., 2016). At the household level, biogas experiences in Africa have been significantly more limited and largely negative. Additionally, the required maintenance, administrative support, and capital costs were higher than anticipated. According to Garf et al. (2016), the experience with distributing biodigesters for cooking demonstrates that there is very little hope of its residential use increasing in the near future.

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Producer gas

Biogas can be substituted with production gas (Awafo & Amenorfe, 2021). According to Awafo et al. (2021), producer gas produced by the gasification of biomass has been utilized for cooking, ionary electricity, heating homes and businesses, and motor vehicle uses. This gas served as the main fuel for stationary and automotive engines in Europe and Asia during the Second World War. After the war, there was an increase in the availability of less expensive fossil fuels, and demand for gas fell. In comparison to natural gas and LPG, producer gas has a lower heating value that is 5.2 lower (Seglah, Wang, Wang, Gao & Bi, 2022). Producer gas has a lower heating value than LPG or kerosene, yet it still emits fewer emissions overall as a result of consumption. Since the seventeenth century, several nations in Europe and Asia have used producer gas as a substitute biogas for cooking foods and warming homes (Seglah et al., 2023).

Recently, the producer gas made from coal and biomass has attracted more attention as a potential intervention to lessen air pollution caused by the burning of unprocessed biomass and mined coal. According to Seglah et al. (2023), the systems are small-scale (5-100 k W) and can be utilized for lighting or cooking in a single family or community. Sadly, biomass gasification is not yet widely commercialized, despite the fact that numerous projects of all sizes have been conducted and have produced useful lessons (Situmorang, Zhao, Yoshida, Abudula & Guan, 2020).

For instance, since 1996, when research projects that fueled the development of this technology started, the household use of producer gas for food

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preparation has been substantially established in China. Twenty gasifiers that create gas and provide residences with it via a piped gas system currently exist in the Shangdong region. According to Situmorang et al. (2020), 216 households in Tengzhai, a region of Shangdong, benefited from this technology in 1996. It is predicted that China would be able to create enough energy to meet the demand for cooking in all of the nation's rural areas by using 60% of the agricultural wastes that are currently accessible for energy purposes (Situmorang et al., 2016). However, research is being done to lessen the tar generation that occurs during the manufacture of the gas's negative effects on the environment. The soil and surface water may become contaminated and polluted by the tar created by producing gas. Given that CO makes up 20% of the gas, research activities also attempt to prevent accidents that can occur due to CO leakage when the gas is burned.

Dimethyl Ether Gas (DME)

Dimethyl ether gas (DME), which is utilized as a cooking gas and for other industrial and energy-related purposes, has qualities similar to those of LPG (Haider et al., 2021). DME is an extremely safe and non-toxic cooking fuel that is gaseous at ambient temperature but can be transported and stored as a liquid. It can be created using syngas catalytic synthesis from any carbonaceous fuel (Devarajan et al., 2022). DME fuels could be easily delivered in canisters by truck or donkey cart to far-flung, dispersed houses in addition to the reduction in toxicity (Haider et al., 2021).

However, the creation of the gas on a technological level. huge scale are still in the early stages. Around 150,000 t/year of the gas is produced globally, and between

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2010 and 2015, according to UNDP and Larson & Tingjin (as reported in Holmgren, 2015), the technology is expected to be ready for commercial use. According to Garf et al. (2016), DME is a particularly promising clean cooking fuel for Chen and Niu. It has the potential to significantly reduce the terrible health effects of cooking with coal and biomass. If it were widely accessible in underdeveloped nations, the negative effects of air pollution on human health might be significantly reduced (Xing, Stuart, Spence & Chen, 2021).

Solar Cooker

Solar cookers use just the energy from the sun to cook food, thus there is no smoke. They cannot be used on overcast days or in gloomy regions at night; they must be put in an outside area with direct sunshine. Average daily insulation should be more than four kilowatts per square meter (kWh) every month (Abdul-Ganiyu, Quansah, Ramde, Seidu & Adaramola, 2020). Additionally, using the sun to cook frees up a virtually limitless supply of energy, lessens the burden on women, and lessens the negative health impacts associated with cooking. Additionally, fewer trees are cut down, halting deforestation and the spread of desertification while also preventing global warming (Ohene, Hsu & Chan, 2022). It must be acknowledged that decades of work have not resulted in a breakthrough for solar cookers. Solar cookers have so far only really taken off in Tibet's treeless plateaus; China accounts for about half of the world's estimated million solar cookers. Each of these stoves saves between 600 and 1.000 kg of firewood annually (Ohene et al., 2022).

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Energy ladder

The "energy ladder" hypothesis explains household energy choice in developing countries (Meried, 2021). It describes the pattern in economic terms (Meried et al., 2021). The model is based on the association between income and current fuels (e.g. electricity) uptake. The energy preference ladder ranks fuels: modern fuels such as electricity and LPG are considered superior fuels due to their high efficiency, cleanliness and convenience of storage and usage and are located higher up the ladder than traditional fuels, or inferior fuels (Adusah-Poku, Adams & Adjei-Mantey, 2023).

According to the model, households transit from outmoded energy systems to modem energy systems up the ladder at speed (Ruiz-Mercado & Masera, 2015). Energy ladder theory dwells on the microeconomic theory of rational choice. It assumes that all types of fuel (traditional to modern) are available and there is a universal set of fuel preferences. The model seeks to help individual to reduce income dependency of energy choices in households.

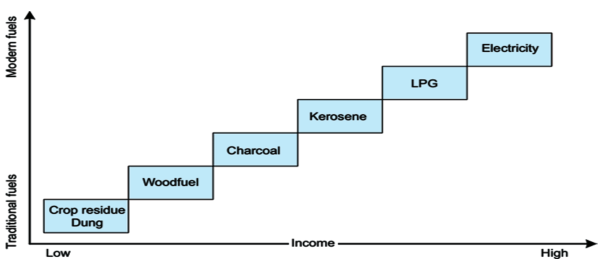

Figure 1: The Classic Energy Ladder

Source: A classic energy ladder model (Kowsari and Zerriffi 2011)

Energy Stacking Model

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The fuel transition is not unidirectional and people can return to traditional biofuels even if they have already adopted modern energy sources (Malode et al., 2021). Fuels are imperfect substitutes for one another, and often certain fuels are preferred for certain tasks. Rather than simply switching between fuels, we need to think about how we choose our fuels (Shrestha, Mustafa, Htike, You & Kakinaka, 2022).

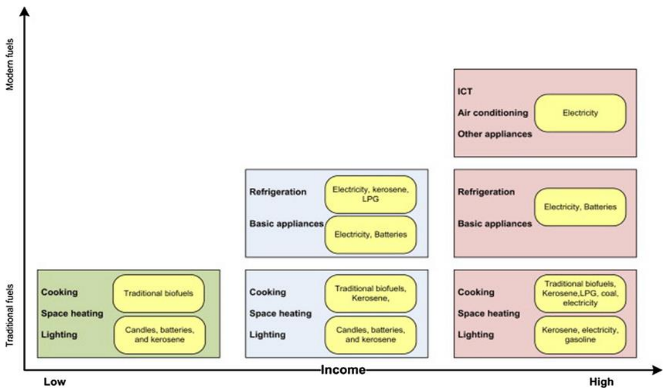

Figure 3: The illustration of energy stacking- including a few examples of energy systems.

Source: *The energy stacking model (Kowsari & Zerriffi, 2011)*

When it comes to cooking, studies have shown that LPG is not a perfect replacement for traditional biofuels and that there are clear fuel preferences based on cooking practices (Ruiz-Mercado & Masera, 2015). Even in Brazil, where the share of traditional biofuels in total energy consumption has decreased with increasing income, full fossil fuel conversion occurred with high-income levels (Ekouevi & Tuntivate, 2012). Fuel stacking, which entails the frequent use of conventional and modern energy technologies, is common in rural and metropolitan

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areas underdeveloped (Christiaensen & Heltberg, 2014). In nations like Ghana and Nepal, practically the entire population is affected.

Maintaining traditional energy mechanisms as health insurance against the failure of modern energy suppliers; reducing susceptibility to current energy price variations by expanding energy use and no available capital to buy contemporary energy change machineries (e.g. using firewood for cooking) are all examples of fuel stacking (Christiaensen & Heltberg, 2014; Davis, Grondin, Johnson, Sciaky, McMorran, Wiegers, & Mattingly, 2019; Elias & Victor, 2005)

Factors Affecting Household Cooking Fuels Choice

Ahiekpor et al. (2015) studied the determinants of urban household cooking fuel choice in Ghana. The survey included 52 towns. According to the research, wood fuel (charcoal and firewood) dominates in the city at 40.4 %, higher than the national average of roughly 20%. However, low income costs less, and availability also impacts energy usage. Wassie et al. (2021) have researched the determinants of Household Energy Choices in Rural Sub-Saharan Africa: An Example from Southern Ethiopia. The study included a cross-sectional survey of 660 sample houses and direct observational investigations. It was discovered that income level, family size, road access, location, education level, cost of technology, and distance to market all impact rural home energy choices for lighting. Adeyem and Adereleye (2016) delved into the variables of a house and its occupants cooking choice of energy in Ondo state, Nigeria. The research area's 409 houses were sampled using a random sampling approach. The multinomial logit results demonstrate that level of education, household income, household size, type of dwelling home, respondent

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occupation and ownership of the dwelling house are major factors influencing fuel choice.

An increasing amount of empirical research suggests that family energy decisions are impacted by various factors, including fuel availability, access to power, awareness, education level, household size, culinary culture, and many more (Campbell et al., 2011). In rural India, for example, research by Narain, Gupta, and Van't Veld (2008) discovered that the consumption of fuelwood rose with the accessibility of forest vegetation, regardless of the household's financial scale. Households often use a variety of energies (fuel control) and do not always switch to more economical or higher quality fuels for cooking, including socioeconomic factors, fuel accessibility, and cultural, environmental, and political regulations (Ruiz-Mercado & Masera, 2015).

Socio-Economic Factors

Studies' results have found that a variety of sociodemographic factors, such as wealth, schooling, family size, spending time at home or property, maturity level, and style of dwelling, all impact the choice of household cooking fuels (Yan, Jiao, Wang, Huang & Han, 2020; Iddi, Muindi, Gitau & Mberu, 2022). As illustrated, when per capita income goes up, families are more likely to switch to greener, more practical domestic energies for cooking, as demonstrated by several experiments. Bansal, Saini, and Khatod (2013) in rural India, Chaudhuri and Pfaff (2003) in Pakistan, Heltberg (2005) in Guatemala, and Nlom and Karimov (2014) in northern Cameroon show that family finance is one of the most influential predictors in decision-making about fuels for cooking. A study of urban families cooking fuel

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discovered that as family income increased, the rate of fuelwood consumption decreased (Edelenbosch, Miu, Sachs, Hawkes & Tavoni, 2022).

Arthur et al. (2011) present comparable results and claim that family income drives the switch from biomass to hydropower in Mozambique. However, other recent research contradicts the idea of power hierarchy and indicates that as household wealth increases, they switch to modern renewable resources. In rural India, for example, Sehjpal, Ramji, Soni, and Kumar (2014) discovered that family income has become less important in the choice of clean fuels than other sociological and cultural drivers. Based on research in several developing nations, Cooke (2008) claim that the income effect of fuelwood consumption is insignificant.

In addition, surveys by Hiemstra-van der Horst et al. (2008) in Botswana, Brouwer and Falcllo (2004) in Mozambique, and Bhagavan and Giriappa (1995) in India showed that families of all income brackets prefer firewood. Also, Davis et al. (2019) in South Africa, Campbell (2003) in Zimbabwe and Brouwer and Falcao (2004) in Mozambique find that low-income families use electricity and LPG for cooking (Broto, Maria de Fátima & Guibrunet, 2020). Finally, through a case study, Mekonnen and Kohlin (2008) claim that increasing prosperity, particularly in metropolitan areas, contributes to a diversity of renewable fuels rather than just replacing one fuel with another.

Apart from money received, especially regularly for work or through investments, a family's decision to spend money on cooking fuel is influenced by various socio-demographic factors. For example, the likelihood of changing from

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the use of firewood to kerosene or charcoal is affected by education or understanding. Suliman (2010) reported equivalent results in Sudanese, while Heltberg (2004) found comparable results in eight emerging areas. According to Pandey and Chaubal (2011), the population of young women aged 10-50 and the average level of household education have a favourable and significant impact on the possibility of using biofuels for cooking among the Indian population.

Relating to or characteristic of a town or city's situation, studies by Mekonnen and Kohlin (2008) and Gebreegziabher (2012) in Ethiopian country and Farsi et al. (2007) in India showed that families with much more knowledgeable individuals appear to be more likely to choose alternative energy. Oyekale (2012) shows that access to electricity and contemporary alternative household fuels has increased dramatically among urban and educated households but has declined among rural northern Nigeria residents, based on the 2008 Nigerian Demographics and Health Survey results.

An additional consideration is the cost of gas. Given the cost of unique and reliable fuels, Indian families have been left to rely on older fuels which do not achieve maximum productivity(Qureshi et al., 2022). Rising energy prices prompted families in SSA to increasingly use conventional energy, according to Schlag and Zuzarte (2008). The elements of turnover and pricing complement each other (Kowsari & Zerriffi, 2011). Hsu, Forougi, Gan, Muchiri and Puzzolo (2021) found that advancing in schooling and the price of other cooking fuels in general increase the usage of LPG, drawing on statistics from family studies in 10 underdeveloped nations in the SSA, South Asia (SA), and Latin America and the

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Caribbean (LAC) areas. Nevertheless, research undertaken in remote Beijing by Jingchao and Kotani (2012) found that while there were no replacement implications between coal and LPG, a rise in these costs seemed to have a high-demand impact, resulting in increased usage of both cooking fuels.

In addition, many demographic and social determinants have a combined effect on family choice. For example, in India's rural and urban areas, Narasimha Rao and Reddy (2007) discovered that family spending, family affiliation, and literacy are all linked to influencing fuel preferences in Indonesia, and Andadari (2014) found the same. Penget et al. (2010) used a regression model to find that domestic energy preferences in rural China are influenced by salary, fuel costs, demographics, and terrain. According to the researchers, coal is often substituted for biomass in rural families, leading to adverse health effects. According to Nakamura and Steinsson (2014), fluctuations in coal and LPG, used mainly for cooking, have negligible substitution effects with alternative energy sources in Beijing's rural counties. This is mainly due to significant differences in income levels, consumption levels, and the accessibility of renewable energy sources.

The choice of fuels for food preparation can even be influenced by variables such as family size. For example, Ranjan and Singh (2023) discovered that firewood is now the fuel of choice in rural areas for a large proportion of families with comparatively larger proportions. According to Dietz, Rosa and York (2007) and Carr (2005), family growth was also associated with increased fuelwood use due to increased energy use and the availability of more labour for fuelwood harvesting.

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Similarly, Shallo, Ayele and Sime (2020) showed that in central and eastern Uganda, the likelihood of a household using biomass energy improves as family age decreases, livestock numbers increase, family numbers increase, male family heads increase, and conventional fuel consumption increases. The possibility of integrating the gases, on the other hand, decreases with increasing distance from the place of residence and increasing household area, according to the findings. Numerous experimental investigations underpin this energy stack hypothesis by demonstrating the use of different energy carriers (Cao, Meng & Gao, 2021).

By and large, the use of burners and the choice of energy for cooking in the home are completely incompatible. Several analyzes in research focus on finding a variety of socio-demographic characteristics that impact ICS implementation. Jan (2012) in rural northwest, Pakistan et al. (2011) in rural Mexico, for example, discover that household willingness to use simply improved combustion burners is primarily determined by education and family income. According to a detailed statement for urban Ethiopia, the cost of commodities, family income, and wealth are the key drivers for such clean energy technology incorporation.

In Addis Ababa (Ethiopia), Takama et al. (2012) assess the relative magnitude of variables associated with minimum solvency and discover commodity parameters such as cost of their use, stove prices, safety, and smokey to have a significant impact on furnaces and energy selection. Alem, Hassen, and Khlin (2014) found that the cost of electricity and fuelwood and the availability of credit are by far the main crucial predictors of electrical burner uptake and energy conversion in urban Ethiopia residential data over the period. El-Tayeb and

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Mohamed (2003) indicate that perhaps the implementation rate of LCS is quite sluggish in Khartoum, Sudan, predicated just on the less programme in remote Mexico. This is mostly related to female householders' shortage of learning and academic degrees.

Lambe and Atteridge (2021) discovered that, notwithstanding households' desire to acquire ICS, the cost of the ICS retained the far more important factor in this selection decision in the rural state of Haryana, India. Timilsina and Malla (2021) employ length evaluation in urban Ethiopia to discover that livestock costs, income levels, and affluence all impact biofuel ICS adoption. According to the study, the variety of accessible electric and metal cooking stoves tends to stymie ICS adoption. According to a review of research, ICS adoption is assisted by a high home income, whereas a low-income family income is a hindrance.

Behavioural and Cultural Factors

Cooking fuel choices are also influenced by behavioural and cultural variables such as household inclinations, dietary propensities, cooking techniques, and cultural perceptions (Wang, Shen, Springer & Hou, 2021). Residents who live in rural Mexico, for instance, prefer to use fuelwood even though they can manage to use greener and newer energies. This is because preparing tortillas with LPG takes longer and negatively influences their flavour (Ruiz-Mercado and Masera, 2015). Similarly, to make traditional bread, Indian households choose wood burners (Ting, Mitchell, Allan, Liu, Spracklen & Williams, 2018).

Using 2000 Guatemalan LSMS survey data, van der Kroon et al. (2013) said conventional traditional recipes and dietary preferences, according to the

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investigators, might cause individuals to choose firewood over cleaner options, especially when fuel is more pricey. However, Dickinson et al. (2015) discovered that, even with the accessibility and affordability of LPG, migrant families in Guatemala frequently use the old method of preparing food. Accordingly, Gould and Urpelainen (2020) discovered that Islamic households in rural India were less likely to utilise LPG than firewood fully. According to Ougadougou (2021), preparing a full local course of grain, sorghum or corn more frequently increases the likelihood of using firewood. In particular, the high regularity of rice preparation in families reduces the potential for the use of firewood, according to the study.

The implementation of ICS is influenced by various social variables and interactions with people. For instance, in Karnataka and, Latchem (2012) discovered that perhaps the situations of family and friends who had already taken over all the stoves had a considerable impact on household purchase decisions for ICS. Similarly, Miller and Mobarak (2013) and Pine et al. (2011) found that in rural Bangladesh, the perception of local leadership impacts the implementation of ICS. According to Vigolo et al. (2018), residents in remote Mexico are driven to implement and then use ICS for various reasons, including aesthetic grace and societal acceptance. However, Vigolo et al. (2018) and Timilsina and Malla (2021) also showed that the inability to prepare traditional meals in larger pots and changes in culinary practices were somehow associated with a reduced chance of ICS implementation. According to Sesan et al. (2018), the mere proliferation of a slightly more effective system like 1CS would hardly be enough to have a lasting

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impact on suburban neighbourhoods in western Kenya. According to the study, before considering the implementation of ICS, it is crucial to understand the needs and customs of the local community and their goals and views.

Rath (2005) discovered that time savings from increasing accessibility to contemporary electricity were being used for various reasons by men and women in China, Indonesia, and Sri Lanka, encompassing revenue occupations, housekeeping, time with family youngsters, and leisure. According to Bielecki and Wingenbach (2014), conventional cooking burners are valued as heating generators, lighting, and even communal gathering places for families in remote Guatemala.

Other External Factors

A family's ability to choose between cooking and heating is influenced by various extraneous variables, including supply of fuel, immediate surroundings, and governmental legislation. For instance, Malla and Timilsina (2014) discovered that enhanced family accessibility to organisations and availability in the local community, such as B. work, financing, education, healthcare, education, and transportation, improve the usage of alternate energy sources in Nepal. Likewise, Bandyopadhyay and Shyamsundar (2021) find strong links between fuelwood consumption and participation in community forests in India, and household participation has had a significant positive impact on fuelwood consumption.

Madubansi et al. (2007) found that increasing access to electricity did not impact firewood consumption in five rural settlements in the Bushbuckridge area of South Africa. Indeed, according to Wang, Yang, and Zhang (2012), non-

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agricultural jobs and agricultural specialities are the strongest determinants of fuelwood replacement for families in remote Southeast Asia. According to the research, fuelwood replacement resulted in unexpected advances in restoring hilltop ecosystems, particularly in controlling soil erosion and forest degradation, implying higher potential costs of gathering fuelwood, higher family incomes, and lower domestic energy use to prepare food due to feed and heat in winter.

Bacon et al. (2010) showed that although natural gas is more readily available in urban areas, a significantly higher percentage of indigenous families at all income levels in Pakistan prefer LNG to their urban peers. However, researchers point out that high-income families still use bioenergy in underdeveloped countries for various reasons. This includes the affordability, lack of security of supply and accessibility of modern energy, culinary practices, and cultural trends related to fuel price, petroleum reliability and accessibility, culture and tradition. Some families are returning to conventional bioenergy after turning to modern energy sources. Drawing on the Ghana LSMS study statistics, Olao (2019) finds solid evidence that the preferred energy source is LPG, followed by charcoal, and kerosene is the least preferred energy. In addition, the study found a geographic difference between various fuels associated with LPG, including firewood, mostly in the lowland tropics, and kerosene, mostly in the plains and forested areas.

As part of the CSI research, Shankar et al. (2020) noteds that the government's fuel replacement programme has made significant progress in encouraging Indonesian families to switch from kerosene to LPG for culinary needs. Gender could be an influence. According to Shankar et al. (2020), female

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families, for example, prefer contemporary energies more than male families, and vice versa. Women generally have a significant responsibility in the family structure regarding nutrition. Based on the Household Survey of Access, Woolley et al. (2022) found that women were particularly apt to switch to cleaner fuels for cooking when they were directly involved outside the home in the community involvement Switching to Better Fuels for Cooking in Sri Lanka. According to Miller and Mobarak (2013), women in remote Bangladesh, who face disproportionately high cooking costs, preferred ICS but did not have the power to acquire it.

According to Greenstone and Jack (2015), financial or organizational imperatives to shift beyond small farms led to ICS adoption. According to a survey, 2% of Nepalese households using ICS reduced domestic firewood consumption. According to Nepal, Nepal and Grimsrud (2011), these households are more likely to use the same amount of firewood or even more firewood than someone using traditional mud or open burners. Although additional research is needed, the report concludes that the boomerang effect (reduced shadow prices). This left the burner on for longer periods to heat their homes, and more routine food preparation is the main reason for the increased firewood consumption in all ICS families. According to Malla and Timilsina (2014), numerous ICS initiatives have various architectural difficulties that led to burner customizations among users, reduced kiln efficiency, and encouraged the use of traditional kilns. In households that alternate between indoor and outdoor food preparation at different times of the year, stove portability is indeed important, as shown in the study.

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A study in rural India by Bhojvaid et al. (2014) found that when it comes to medical benefits, time savings were considered. Other variables (gender, schooling, and previous experience with sparkling clean herds) are sociocultural ones. Variables about neighbourhood behaviour are indeed an essential contribution to the promotion of modern ICS. In the absence of professional publicity, Ramirez, Dwivedi, Ghilardi, and Bailis (2014) discover that males in western Honduras play an important role in the protracted spread of ICS, while females interact mostly over short distances. According to Urmee and Gyamfi (2014), engaging local consumers and artisans in developing a self-sustaining business are critical to ICS programs' sustainability.

Although preferences vary, Jeuland et al. (2015) discover that families in Uttarakhand, India, have a particular preference for stoves that they are willing to spend more than the CO_2 equivalent counting. Significantly reduce exhaust gasesThe features of ICS were significantly fewer requirements and more flexibility, such as the number of cooking surfaces. According to Hanna, Duflo and Greenstone (2016), there is no evidence of welfare benefits or reductions in fuel consumption due to the introduction of IeS in rural Orissa, India. According to the report, the inability to use burners regularly and appropriately and thus a lack of sufficient family contributions to maintain ICS are the causative factors. Given the benefits of improving health and saving time, and even preserving forest areas and ecosystems, namely by reducing anthropogenic environmental warming, family acceptance of KS, including clean and contemporary cooking energy, appears to

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have been surprisingly slow (Cassidy & Barnes, 2012). In developing countries, there are several key obstacles to implementing fuel choice (Pye et al., 2020).

Ekouevi and Tuntivate (2012) summarise the challenges for ICS initiatives in developing countries to gain economic benefits. Poor local support or restrictive burner designer expertise are just a few other challenges. Given the same ongoing socio-cultural and environmental benefits of ICS, Sarah, Peter, Mike, Charlotte, and Temilade (2020) list organizational, economic and political, strategic, socio-cultural and attitudinal, technical and educational, and communication barriers to their dissemination and implementation from the Literature. Particularly crucial in implementing technological advances are trustworthiness, societal acceptance, and the practice of domesticating modern innovation that considers consumers g problems and difficulties (Fouquet & Pearson, 2012). According to Malla and Timilsina's study, a barrier to wider implementation of ICS is the unavailability of globally recognized ICS regulations and verification facilities, a lack of knowledge about the medical benefits of ICS and fuel treatments, and the expensive cost of ICS (2014).

Aside from direct investments in access to energy, Barnes (2010) emphasizes indirect investments in developing and implementing programs that can effectively address the barriers that help households switch to better fuels and appliances, such as B. Adequate generation and transmission for rural electrification and availability of LPG. Based on the study results in Indonesia, ASTAE proposes solutions to expand the use of clean biomass stoves, including centralized leadership, cross-sector cooperation and the formation of a sustainable

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market (Malla & Timilsina, 2014). According to the report, the commercial market for ICS in the country is quite limited.

Consumption Of Traditional Fuels And Its Side Effects

Biomass use is the major household fuel in Sub-Saharan Africa, spanning from 55% in Senegal to 92 in Tanzania, as noted at the beginning of this chapter and proved by the selected cases (Menegaki & Tugcu, 2016). However, most South and North Africa households employ cleaner energy sources such as power generation, LPG, and paraffin. Sub-Saharan Africa has a more serious household energy dilemma since it continues to rely on ineffective and unviable conventional biomass. The key issues that the household sector in Sub-Saharan Africa faces are then highlighted.

Indoor Air Pollution

Any wooden material gathered and used for fuel, a porous black solid consisting of an amorphous form of carbon is obtained as a residue when wood, bone, or other organic matter is heated in the absence of air. Also, other biomass may indeed be burned efficiently with the right burners using appropriate energy procedures, generating mostly atmospheric CO_2 and water (Ajibola et al., 2020). Conversely, these circumstances are challenging to determine, particularly those lacking sufficient money to live at a standard considered comfortable or normal in society (urban and rural dwellers) where relatively insignificant, cheap wood-fired combustion systems are used. Incomplete Combustion Products (PIC) are formed when wood fuels are not fully combusted to form carbon dioxide, a health hazard.

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Carbon monoxide (CO), an odourless and indiscernible but noxious smoke can leave both short and long lived health effects, ranks first in PIC in terms of total weight and emission elements. Hundreds of simple and complex hydrocarbons, organic molecules, and numerous gases and solids are listed here. Some of the PIC is also emitted as pollution or as all organic carbon in the form of tiny microscopic particles. The amount of each pollutant emitted is determined by combustion parameters such as energy content, combustion temperatures, and ventilation and exhaust emission rate, which also change over time and are therefore influenced by burner design (Benti et al., 2020).

Determinants of Cooking Fuel Choice in Households

It is clear from the preceding sections that the well-being and environment of users suffer when wood fuel is used exclusively for domestic energy. Indeed, in trying to implement appropriate regulatory measures to ensure such families switch to greener energy, it is imperative to understand what variables drive the demand for these energy sources. Assuming a guaranteed minimum income, the fuel consumption pyramid suggests that families in developing countries will initially consume cheaper, more polluting fuels but gradually switch to much more costly alternative fuels as their wages increase (Ruiz-Mercado & Masera, 2015). Allocation of alternative energy sources based on family wealth (used here as a proxy for household income). It should have been emphasized that only the main energy is used here to define a specific house as a consumer of this fuel. That would be the energy the household uses to prepare its staple foods—this relationship between the choice of primary cooking fuel and wealth level. Most households use

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biomass fuels, even in the top income bracketsCrop wastes are used by people from all socioeconomic classes, not just the poor. Its use is still prevalent among the highest income brackets and reaches its peak in the center of the income distribution. The upshot is that the substitution of filthy fuels like dung will not result from economic expansion and rural income improvement.

The possibilities for explanation are similar to those for the firewood puzzle and this circumstance. More land is frequently owned by and is more easily accessible to the rural elites. In general, users of crop residues may not view these fuels as undesirable, and some traditional cuisines or methods of preparation occasionally call for crop residue. The utilization of firewood and charcoal is still prevalent at all socioeconomic levels. It is confusing that wood fuels continue to have a significant role in income distribution. It suggests that household income and the accessibility of alternatives cannot be the main factors influencing the usage of firewood and undermines the energy ladder paradigm. Kerosene usage does not consistently increase or decrease throughout the income spectrum. Kerosene is primarily used for cooking in metropolitan settings. The most typical trend is for kerosene consumption for cooking to initially rise with expenses and then fall. The idea that kerosene might serve as a transition fuel at the middle rung of the energy ladder between solid fuels and LPG is supported by this information.

According to the energy ladder idea in chapter 2, factors such as resource availability and other household characteristics, in addition to income level, are important in determining the kind of cooking fuels used by households. In light of these findings, further research was undertaken to learn more about the many

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alternative energy sources for food preparation available to the community's selected households. The various variables affected a family's likelihood of earning specific energy sources for Choosing food preparation over other consumption decisions. However, a family income fuel for cooking can be understood by looking at everything through a constrained utilitarian minimization paradigm (Pundo & Fraser, 2006; Nyoike et al., 2014) that is vulnerable to the following financial: non-constraints (equation 1). Free market energy costs and family income are two socioeconomic issues to consider. Family geographic and infrastructural variables are examples of non-economic factors

Household Cooking Energy, Health and Environment

Improper burning of household fuels, mostly solid fuels in underdeveloped countries, releases large amounts of toxic chemicals and toxins into the atmosphere. Hazardous air pollutants include combustion products (CO), get out of more than 100 chemicals called polynuclear aromatic hydrocarbons benzene, and naturally occurring compounds compound with the formula CH_2O. Chemical pollutants such as ash, sulfur, and mercury are among them (Melody & Johnston, 2015; Schulze et al., 2017). Exposure to some of these air elements and toxins has been shown to have adverse effects on human health. Consequently, carbon dioxide (CO2 and black CO2 emissions from household energy used for cooking) endanger the complete state of mental, physical and social wellbeing by causing temperature changes.

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Cooking and Human Health

For more than 30 years, difficulties with solid fuels as a pure energy source for cooking have been a concern. Although the amount and type of fuels used and the duration of vulnerability to p, pollutant emissions vary. Thus, almost all have adverse effects on the overall physical, social and psychological condition of humans, including inflammatory infection of the air sacs in one or both lungs in children, COPD and a type of cancer that starts in the lungs (Whitehouse, 2021; Manisalidis et al., 2020; Kelly & Fussell, 2011). According to WHO figures, an infection that inflames the air sacs in one or both lungs kills two million every year, predominantly youngsters. In addition, COPD kills 511,000 people every year due to smoking within a building or behind closed doors (WHO, 2006a). According to a comparative risk assessment (Whitehouse et al., 2021), HAP is the second most prevalent potential risk amongst investigated women globally.

Balakrishnan et al. (2014) identified fuels that are classified as solid for cooking to have caused roughly 31.4 million among disables and 1.04 million premature deaths every year in India (Balakrishnan et al., 2014). According to the International Energy Agency (IEA), untimely fatalities from domestic biomass burning will outnumber those caused by HIV/AIDS by 2030. (Sulaiman et al., 2017). Three recent meta-analyses (Balmes, 2019; Pope et al., 2015; Laumbach & Kipen, 2012) demonstrated that carbon from biomass burning fuel for preparing food and warming is linked to something like a heightened risk of COPD. Exposure to HAP has also been linked to impaired mental function, low birth weight, cervical

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cancer, poor pregnancy outcomes, asthma, and TB in children (Awopeju, 2021; Timilsina, 2017; Amegah, 2014).

Epstein, Bates, Arora, Balakrishnan, Jack, and Smith (2013) found that infants born to households that used plant matter as fuel to generate heat or electricity and coal-dependent fuel were more likely to lower birth weight have born than those in households that use LPG. According to the study, the average birth weight of newborns born in houses whose parents used the technology to generate electricity and heat from coal, biomass and waste is much lower than the average low Birth weight of babies born in homes using LPG. According to other studies, women in Trujillo, Peru, who prepare (food, a dish, or a meal) by combining and heating the ingredients using firewood or kerosene had higher PAH vulnerability than women who used liquefied petroleum gas or a lightweight black carbon residue produced by strongly heating wood in minimal oxygen to remove all water. In addition, volatile constituents had higher PAH vulnerability than women who prepare food using liquefied petroleum gas or a lightweight black carbon residue (Mutlu et al., 2016).

According to Abdullahi et al. (2013), cooking done by a Chinese native or inhabitant or a person of Chinese descent contributes significantly more PAH to biological material than cooking done by a foreign fast-food restaurant. According to surveys done in Nepal and India, women who do not smoke anything but are exposed to organic matter used as a fuel, especially in a power station for the generation of electricity, have quite a higher risk of dying from diseases and disorders of the airways and the lungs that affect human respiration than daily

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smokers who are also men (Singh & Agarwal, 2022). Mohammed and Akuoko (2022) utilise a survey method to uncover that biomass and kerosene fuels are linked to the death or loss before or during delivery among married women aged 15–49, who account for around 12% of all deaths and loss of babies in India. Women are more concerned about the acquisition, transportation, and preparation of biomass energy than the actual effect of combusting biomass fuels. According to Parikh (2011), conventional cooking fuels in Indian families have a significant physical load and health impact on women. According to Bu et al. (2021), cooking with solid fuels reduces pressure in the lungs in Southeast Asia (Indonesia).

Obtaining and storing fuel for a domestic stove poses an obvious health hazard gathering ring of biomass fuel is associated with several mechanical injuries caused by falling, pulling and splitting of wood, confrontations with creatures such as reptiles and scorpions, aggression, including contact with mosquitoes of many contagious diseases. A real-world illustration in Uganda revealed a high probability of sleeping sickness as a result of collecting firewood. Likewise, the storage of fuel can endanger humanity. In Costa Rica, for example, removing stored firewood has been recognized as an important strategy to prevent Chagas disease by denying triatomine beetles near homes. (Grijalva et al., 2022). Exposure of children to kerosene for food preparation has been reported in several countries, most notably India (Karlsson, Kim, Joe & Subramanian, 2020). Liquid or gaseous fuels are associated with fires and burns, household chores that require energy in almost all developing countries.

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Environmental Effects

It is undeniable that a billion people worldwide use biomass fuels to boil water and prepare meals regularly. Consequently, every day, 2 million tones of biomass go up in flames (Forsberg, 2021). When the growth of new trees surpasses consumer needs, that might not be a concern. On the other hand, timber harvesting may significantly strain ecosystems in areas where wood is sparse and the number of inhabitants is high. The need for firewood, especially in subtropical and semi-desert parts of the Middle East, leads to massive forest degradation and its negative implications.

Fuelwood scarcity, instead of inadequate agricultural and cattle production, restricts the bearing capacities of the ground in dry and semi-desert portions of West Africa. Wood fuel harvesting may even be comparable only to peasant farmers' food production as a source of forest loss in Africa. In 1998, Cameroon (Africa's largest timber exporter) collected four times more wood for firewood than for commercial logs. In 1999, biofuels (mostly firewood and charcoal) constituted 80 per cent of Cameroon's energy demand.

The dearth of firewood is not limited to remote communities. Power supplies in metropolitan regions remain sporadic throughout many emerging economies and do not always serve disadvantaged communities. Because so many households do not have enough money to pay for kerosene or an explosive mixture of hydrocarbon gases, most commonly propane, butane, and propylene (LPG), much of the lower classes tend to depend on firewood for their energy source. Because of the severity of chopping near cities, along highways, and then from

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more remote locations, some claim that fuelwood consumption in big cities is now damaging forests more than rural needs.

The use of metropolitan wood fuel, mostly in the Sahel, is expected to eventually surpass rural regions. The most serious issue arises whenever bioenergy supplies are insufficient to meet the demand for firewood. Impoverished households in such situations revert to utilising agricultural leftovers and dung as fuel instead of wood, limiting the availability of food for animals and compromising soil conservation. Furthermore, excessive bio-mass use may upset the balance of biodiversity and hydrology. Particularly when these kinds of wood are preferred or planted for fuel utilisation rather than the forest areas and plants (Farrell, Plevin, Turner, Jones, O'hare, & Kammen, 2006).

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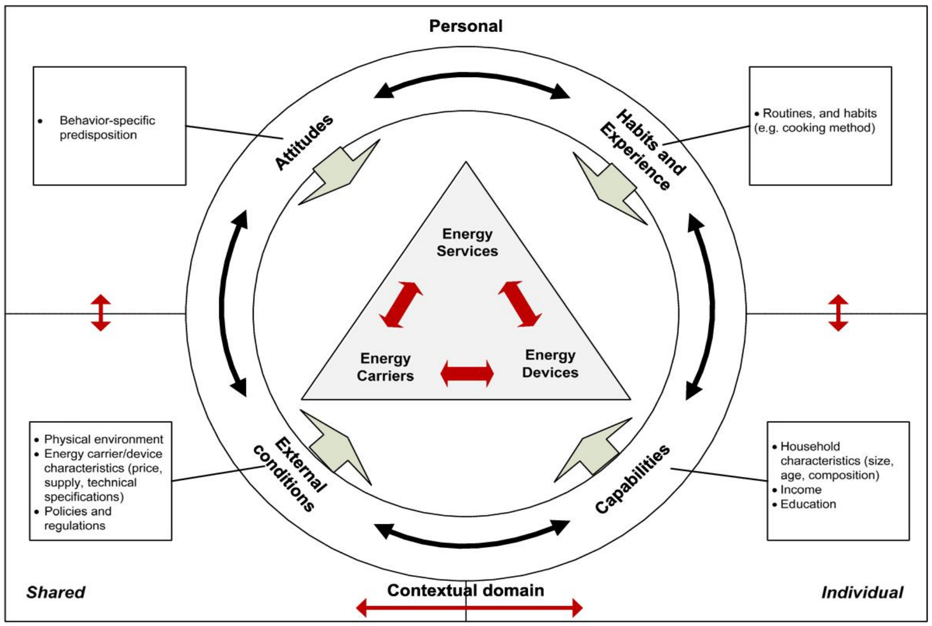

Figure 4: Endogenous and exogenous factors influencing energy profile

Source: Three-dimensional energy profile (Kowsari & Zerriffi, 2011).

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Conceptual framework

A variety of variable shapes the setting in which families make choices. The "home choice ecology," which represents a complicated and interacting network of influences that impact behaviour (Zhu, Cantwell, Jia & Wang, 2023). To structure and explain the decision environment, the study employed the framework of Van der Kroon, Brouwer, and Van Beukering (2014). The framework focuses on the choice between subsistence and market orientation, including the degree of market integration, where subsistence orientation refers to a farmer who predominantly produces for his own family's consumption. In a developing country context, the choice between self-sufficiency and market dependence plays an important role in the choice of energy carriers (Bekkering & Nap, 2023).

According to the framework, endogenous factors, such as the availability of energy sources and household practices, are crucial in shaping the choices made by households regarding their energy sources for cooking (Bharadwaj, Malakar, Herington & Ashworth, 2022). Factors like the accessibility of liquefied petroleum gas (LPG), kerosene, electricity, and solid fuels like wood and charcoal, along with the adoption of energy-efficient practices, play significant roles in these decisions. Additionally, the knowledge levels of household heads regarding different energy types and their associated health and environmental impacts impact their choices. Socioeconomic status, including income levels and affordability, also plays a pivotal role in determining which energy sources households can access and utilize (Raza et al., 2020). Furthermore, the condition of infrastructure, such as LPG

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distribution networks and electricity grids, is another influential endogenous factor (Raza et al., 2020).

Exogenous factors, on the other hand, include elements like government policies and regulations, climate and weather conditions, technological advancements, and cultural and social norms (Bekkering et al., 2023). Government interventions, often in the form of policies and regulations, can substantially affect household fuel choices (Ramakrishnan, Kalkuhl, Ahmad & Creutzig, 2020). Climate and weather conditions, particularly seasonal variations and temperature extremes, influence the suitability and preference for specific energy sources. Technological advancements in energy-efficient stoves, appliances, and alternative energy technologies also impact households' decisions. Additionally, cultural and social norms, influenced by traditions and societal preferences, shape fuel choices within households (Ramakrishnan et al., 2020).

The household can be seen as a unit producing and consuming goods and services (Liu et al., 2021). This is especially relevant in a rural and peri-urban energy context, where firewood still plays a central role in fulfilling the household's energy needs. The amount of firewood consumed by the household depends on the quantity produced by the household through fetching and the quantity purchased on the market. In addition, households can opt to use commercial fuels such as charcoal and LPG, depending on the market (Liu et al., 2021). As the energy ladder shows, commercial fuels are ranked higher. Hence, moving up the energy ladder involves a similar process from self-sufficiency to market dependence. The choice to participate in the market depends on the allocation of labour and time within the

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household and the corresponding time and budget constraints households face. For example, a household could divide its time between farm labour, off-farm labour, leisure, and fetching firewood. Depending on the marginal utility derived from each activity, a household will divide its labour capacity. Where markets have developed and dominated energy choices, households prefer to allocate their time previously dedicated to fetching firewood to other, more productive or utility-enhancing activities. Productive or utility-enhancing activities, so families pay a retail price for their power, limiting their overall electricity consumption and spending plans (Sajid, Niu, Xie & ur Rahman, 2021).

The template differentiates three kinds of contributing variables: the nation's macroenvironment, which shapes the limits whereby a society must operate (like weather, geographical position, and genealogy); the choice set, which reflects family and national variables predicated mostly on organisational, governmental, and business circumstances of a precise area (variables involve financial system, regulatory frameworks, and consumer markets); and the chosen setting, which reflects family and country-internal factors based on the demographics and factor endowment of the household (Palmioli et al., 2020). The choice atmosphere, distinctive to every family, is determined by the interplay of elements throughout the classifications. The home possibility group is the foundation of a family's survival strategy. It influences a household's ability to minimise susceptibility and limits or expand its golden possibilities. The typical household's wealth is crucial to its opportunity set. Human capital is seen as critical in the fuel decision-making procedure (van der Kroon, Brouwer & van Beukering, 2013). This includes

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education and expertise and features of home makeup such as workforce accessibility, family membership, maturity, and sexuality.

The dearth of knowledge about alternate fuels and the advantages connected with their utilisation is regarded as a crucial impediment to adaptation (Bryan, Deressa, Gbetibouo & Ringler, 2009). Families with advanced degrees use fewer renewable energy sources, probably because the opportunity costs of biomass gathering rise (van der Kroon, Brouwer & van Beukering, 2013). Numerous investigations have discovered that the rising accessibility of the family workforce is a decisive factor, particularly in remote regions where biomass collecting is significant (Jan 2012; van der Kroon, Brouwer & van Beukering, 2013). According to Heltberg (2004), larger families are more inclined to use various fuels than change energy.

The study explored several dependent variables, such as household cooking fuel choices, knowledge of energy use, determinants influencing fuel choices, and health-related risks. These variables will be assessed through surveys and interviews conducted among households in the Mfantseman Municipality. Mediating variables, such as household behavior and practices and government interventions, are examined to understand how endogenous and exogenous factors translate into actual changes in fuel choices and the associated health risks. The first objective of the study aims to identify the energy types used for household cooking. This can be elucidated by examining both endogenous and exogenous factors. Endogenously, the availability of different cooking fuels and related infrastructure plays a pivotal role. For instance, the presence of liquefied petroleum

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gas (LPG) distribution networks may lead to higher LPG usage compared to areas with limited access to this fuel source. Exogenous factors, such as economic conditions, influence fuel choices, as households may opt for the most affordable option. Government policies and regulations can also shape the energy landscape, further affecting household choices. Thus, analyzing the types of energy used for cooking necessitates considering a wide array of both internal and external factors.

The second objective delves into exploring the level of knowledge among household heads regarding energy use. Here, endogenous factors like household practices and management strategies are integral. Households with knowledge of energy-efficient practices may be more inclined to use certain fuels or technologies. On the other hand, exogenous factors, such as government initiatives to educate residents on energy usage, can also influence knowledge levels. The extent to which household heads are informed about available energy options and their benefits or drawbacks is pivotal in understanding energy consumption patterns.

The third objective aims to uncover the determinants influencing household cooking fuel choices. The availability of different fuels and infrastructure (endogenous) and economic factors like income levels (exogenous) are among the determinants shaping these choices. Additionally, government policies and regulations can either promote or deter the use of specific energy sources. By examining these determinants comprehensively, the study can offer insights into the complex decision-making processes behind household energy choices in the Mfantseman Municipality.

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The fourth objective focuses on exploring health-related risks associated with household energy fuels. Endogenous factors, such as the implementation of energy-efficient practices and proper ventilation, play a crucial role in mitigating health risks. For example, households using solid fuels like wood or charcoal for cooking may face indoor air pollution issues if not adequately ventilated. On the exogenous front, climate and weather conditions can affect the health-related risks associated with energy use. Extreme temperatures may impact the choice of energy source and influence how health risks manifest. Additionally, advancements in technology, such as the availability of cleaner and safer cooking stoves, can be essential in addressing health concerns.

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CHAPTER THREE

RESEARCH METHODS

This chapter outlines the study's research methodologies under eight sub-sections. The research paradigm, research design, study area, population, sample and sampling procedure, and research instruments, as well as pre-testing procedures, data collection procedures, and data analysis, are all examined.

Research paradigm

The study took a pragmatic approach. According to Nudzor (2009), pragmatism is a philosophical perspective that values practical consequences and action-oriented solutions. It posits that the worth of an idea or method is determined by its effectiveness in addressing real-world problems. Pragmatists focus on the practical implications of theories and methods, considering them as tools for problem-solving rather than as abstract or dogmatic principles (Giddens, 2009).

In the context of the study, this approach is particularly relevant as it centers the research process on the pressing problem of household energy choices in a specific region (Teo, Tan, Ong & Choy, 2021). One of the defining characteristics of pragmatism is its problem-centric nature (Divjak et al., 2022). In the view of Divjak et al. (2022), pragmatists place the research problem at the forefront of inquiry, recognizing it as the driving force behind their investigation. This aligns seamlessly with the study's objective of understanding and potentially improving energy choices within households in the Mfantseman Municipality.

Pragmatism also values flexibility, allowing researchers to select the most appropriate methods and techniques for data collection and analysis (Hiver, Al-

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Hoorie & Larsen-Freeman, 2022). Given the complexity of factors influencing energy choices, this flexibility is invaluable in ensuring the research effectively addresses the multifaceted issue. Pragmatists rely on real-world data and experiences to guide their research, advocating for practical solutions that can be derived from empirical findings (Allemang, Sitter & Dimitropoulos, 2022). In the study, this entails engaging with the local community, collecting data on energy usage, and analyzing the information to draw actionable insights.

Mixed methods research, a natural companion to pragmatism, is closely related to this study (Mukumbang, 2023). Pragmatists argue that the choice between qualitative and quantitative methods should depend on what is most suitable for addressing the research questions (Allemang et al., 2022). In the context of household energy choices, the mixed methods approach offers a comprehensive understanding of the issue. It enables the collection of quantitative data on fuel usage while also providing qualitative insights into the underlying reasons. This combination is essential for unraveling the intricate web of factors that influence energy choices, considering socio-economic, cultural, and environmental variables (Dawadi, Shrestha & Giri, 2021).

Some critics argue that it might lack a strong theoretical foundation, potentially leading to superficial analyses (Crotty, 2020). Additionally, an overemphasis on utility, which is a central tenet of pragmatism, may sometimes overshadow important ethical considerations or deeper philosophical exploration (Dawadi et al., 2021). Hence, while pragmatism provides a valuable framework for this study, researchers must strike a balance between practicality and the ethical

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and theoretical dimensions of their research (Ryu, 2020).The pragmatist perspective ultimately strengthens the study by ensuring that it remains grounded in the real-world context of the Mfantseman Municipality. This approach fosters adaptability, enabling the research to respond effectively to the unique challenges and opportunities presented by the region. Furthermore, pragmatism's problem-solving focus ensures that the research outcomes will not remain theoretical but will contribute practical solutions to improve energy access and sustainability in the area (Ghiara, 2020).

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Research design

The study was based on the mixed-method research approach, particularly sequential explanatory design. Sequential explanatory design begins with the collection and analysis of quantitative data, followed by the collection and analysis of qualitative data. The applicability and usefulness of this research paradigm to this investigation will influence its selection. The researcher will utilise this research technique since the goal of this study is to provide an in-depth interpretation and knowledge of energy choices for household cooking in the Mfantseman Municipality. Thus, data analysis will concentrate on quantitative measures and qualitative themes that will provide knowledge of energy choices for home cooking, concerning topics such as frequency, number, amount, intensity, or pervasive character.

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By using these methodologies, the researcher will be able to give a full study of energy choices for home cooking as well as the quality of their replies as they occur spontaneously. To provide a foundation for the use of a mixed-method

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approach in research, Snape and Spencer (2003); Ogah (2013) assert that when the data are very detailed with rich and extensive information, analysis that is open to emergent concepts and ideas and that may be detailed description and classification, identify patterns of association, or develop typologies and explanation, as is the focus of this study, the qualitative approach becomes the appropriate paradigm or approach. The strength of this research technique is its capacity to elicit rich and comprehensive information from respondents, but its shortcoming is its inability to provide objective and verified data. Several sorts of this strategy in conducting research have been identified (Snape & Spencer, 2003; Ogah, 2013).

This approach aligned with the study's objectives of understanding factors influencing energy choices and exploring health-related risks. Given the pragmatic approach of the study, a sequential explanatory design would allow researchers to first establish patterns and trends through quantitative data and then delve deeper into the "why" and "how" questions through qualitative data.

Study area

The study was conducted in the Mfantseman Municipality. The Municipality is situated along the Atlantic coastline of the Central Region of Ghana. It stretches approximately 21 kilometres along the coastline and about 13 kilometres inland, constituting an area of 300.662 square kilometres. The proportion of the land area of the Municipality to that of the region is 3.1 percent. The administrative capital of Mfantseman is Saltpond. Mfantseman is bounded on the West by Abura-Asebu-Kwamankese District, on the NorthEast by Ajumako-Enyan-Essiam District, on the East by Ekumfi District and on the South by the Gulf

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of Guinea (Atlantic Ocean). It stretches from Eguase (the most western point) to Mankessim (the most Eastern point). The population of Mfantseman Municipality, according to the 2021 Population and Housing Census, is 168,905 which constitute 6.6 percent of the population of Central Region. Females consist of 53.8%while males form 46.2%. Approximately 64.9 of the population are in urban localities with the remaining 35.1% living in rural localities. The Municipality has a household population of 135,823 with a total number of 35,673 households. The average household size in the district is 3.8 persons per household.

Due to Mfantseman's proximity to the sea, it has rich fishing grounds along the coast and has made fishing a major activity along the coastal towns and villages notable among which are Biriwa, Anomabo, Abandze, Ankaful and Kormantse. Trading is an important economic activity and is carried out virtually in every area in the Municipality with Mankessim being the largest market centre in the Municipality, rivalling Techiman in the Brong Ahafo Region. Other significant trading centres are Saltpond, Anomabo and Yamoransa.

Saltpond, Anomabo, and Mankessim were the study communities. It has a population of 24,689. Saltpond is home to two senior high schools: Mfantsiman Girls' Senior High School and Saltpond Methodist Senior High School. Maize farming is prominent, as is bee-keeping. The town also has a district hospital, a geological survey department, a meteorological department, a police office, and an educational resource centre.

Anomabu is a settlement in Ghana's Central Region on the coast of the Mfantsiman District Municipality. It has a total area of 612 square kilometres,

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including 21 kilometres of shoreline and 13 kilometres of the interior. According to oral tradition, the name "Anomabu" was formed when a hunter from the Nsona tribe discovered the territory and decided to stay with his family, eventually building his village. The hunter supposedly saw numerous birds atop a rock and called the location "Obo noma," which became the town's first name. The fishing industry in Anomabu is extremely gendered and, as a result of the patriarchal context in which it functions, it hinders women's ascension. Women are critical to the industry and manage the majority of the fish trade. Even though the prevailing patriarchal structure puts males at the centre of the fisheries sector, females have recently begun to gain relevance in aquaculture. The purchase of a small boat has given females both esteem and prestige within their household and in society as a whole.

Mankessim was the birthplace of Ghana's Fante ethnic group. Its origins may be related to three valiant warriors (Obrumankoma, Odapagyan, and Oson) who supported the migration of settlers from Techiman to Adoagyir's Brong Ahafo. The town has a population of 26,909. Mankessim is the native vernacular of all valet-speaking peoples, and it is linked to the hallowed grove of Nananom Pow in Obidian. It has a vast market that draws merchants from across the globe.

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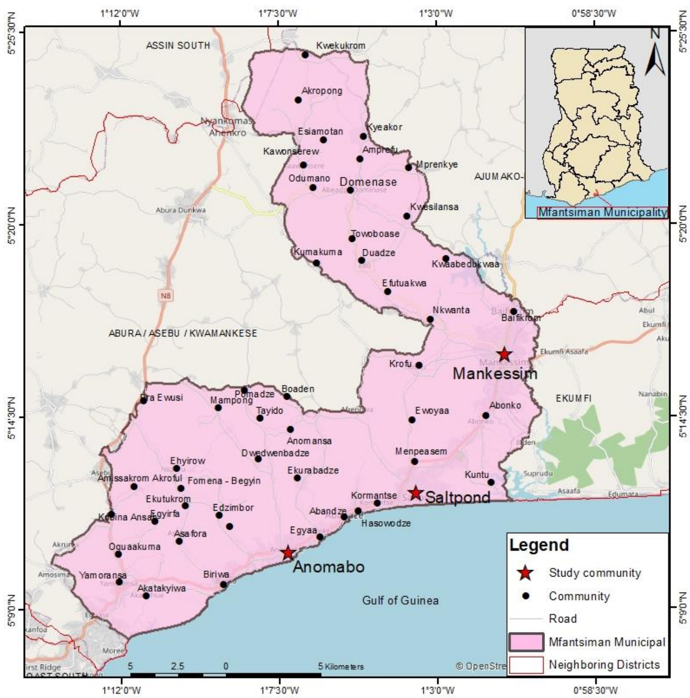

Source: Department of Geography and Regional Planning, UCC (2021)

Figure 6: Map of Mfantseman Municipality

Population

The study population consisted of households residing in the Mfantseman Municipality in the Central Region of Ghana. The study population comprised a diverse range of households living in urban, peri-urban, and rural settings within the municipality. The population consisted of individuals with different ages, from from 18 years and above.

Accessible population of 384 households heads was used for the study. This population is comprised of domestic users of energy for cooking in the Mfantseman Municipality. In view of this, 98, 130 and 156 households were selected from

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Anomabu, Saltpong and Mankessim, respectively, for the study. This population was selected to capture the variations in household energy choices, knowledge, and practices across different geographical contexts. This population has selected because by examining the energy choices and associated factors within this diverse study population, it would help shed light on the complex dynamics of household energy decisions and contribute to informed policy recommendations for sustainable and clean energy transitions in the Mfantseman Municipality and similar regions in Ghana.

Sample Size

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Out of accesssible population of 384, a sample size of 384 households from the Mfantseman Municipality was selected for the study. This sample size was determined using the well-established formula proposed by Krejcie and Morgan (1970) for finite populations, ensuring statistical validity. In the calculation of the sample size, a 5% margin of error and Z-value of 1.96 were selected.

Sampling procedure

To efficiently select representative clusters within the municipality, a multistage sampling procedure was employed. The municipality was divided into different towns, considering factors such as population density and predominant occupation. This clustering allowed for the inclusion of various geographical areas within the study, recognizing that energy choices can differ significantly based on location. Three towns—Anomabo, Saltpond, and Mankessim—were strategically chosen due to their higher population densities, providing insight into both urban and peri-urban settings.

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Within each selected town, primary sampling units (PSUs) were identified. These PSUs represented smaller geographic units or neighborhoods and were chosen with the aim of ensuring fair and even representation across the town. This stage was crucial in structuring the subsequent sampling process and ensuring that different areas within the towns were adequately covered.

To select households for the study, a systematic random sampling method was employed within each PSU. This method ensured that each household had an equal and independent chance of being included in the research, minimizing potential biases. The lottery approach, where numbered and unnumbered sheets were mixed and drawn by household heads, was a transparent and fair method used to make the final selections.

Additionally, the research incorporated a qualitative component through purposive sampling. For in-depth interviews, five respondents were purposively selected based on their knowledge and experiences related to cooking fuel energy choices. This qualitative aspect aimed to provide rich insights and a deeper understanding of the factors influencing household energy decisions.

Data collection instruments

Data was gathered through the use of questionnaires and interviews. A questionnaire is appropriate due to its "ability to contact respondents who reside at widely distributed addresses" and the "cheap cost of data collection" (Rahman, 2021, p.1). The 54-item questionnaire was constructed using current literature on energy decisions. The questionnaire had been grouped into four segments (A–D). Section A elicited demographic data from Mfantseman inhabitants, such as gender,

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marital status, and educational attainment. Section B consisted of ten items that elicited information on the different forms of energy consumed. Section C had 30 items that elicited data on the factors that influence home energy usage.

The 14 items in Section D were designed to elicit information about health risks linked with the use of cooking fuels. All of the items in the questionnaire would be measured using a four-point Likert-type scale, with four indicating strong agreement, three indicating agreement, two indicating disagreement, and one indicating significant disagreement. Because it is a four-point Likert scale, the greatest mean of a component is four, while the lowest mean is one. Furthermore, the criterion for deciding whether a mean is high or low was discovered after computing the middle of two extreme scores (4 and 1). The midpoint of a factor on a four-point Likert scale is 2.50. As a result, any factor with a mean of 2.50 or above would be deemed the highest mean, that is when compared to the already acquired criterion, whilst factors with a mean of less than 2.50 would be considered the lowest mean.

There were five sections in the interview guide (A-E). Section A enquired about the backgrounds of residents in households. Section B sought information on the sorts of energy options used by residents in their homes. Section C is intended to ascertain the level of awareness about energy use among families. Section D inquired about the factors influencing home cooking fuel choices. Section E learned about the health risks associated with the use of domestic energy sources.

All of the five interviewees in this research share comparable traits. The samples share the fact that they all reside in the Mfantseman neighbourhood and

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consume cooking fuel. As a result, homogenous sampling, a sort of purposive sample, will be acceptable.

Pretesting of instruments

The questionnaire was pretested at Cape Coast. They were able to relate to the questionnaire topics since the people had environmental and cultural characteristics with the research location. Akinyode and Khan (2018) proposed that a new test instrument be field-tested with a population similar to that from whom the research sample was drawn. The questionnaire was administered to thirty resident heads from various homes. The usage of this number was appropriate since Sudman, as stated in Burr (1993) and Gupta, Christiansen, Hanisch, Bay, Burr, and Holtermann (2017), advised that pretesting questionnaires should have a minimum of 12 to 50 participants. The following was the outcome of the pretesting of the questionnaire sections:

a. The Cronbach alpha value for Section B of the questionnaire, which includes items concerning several forms of energy sources, was 0.80.
b. b. The Cronbach alpha value for Section C of the questionnaire, which contained items on variables (factors) that impact home cooking fuels, was 0.87.
c. Section D included health-related matters concerning the usage of domestic energy fuels. Cronbach's alpha was 0.72.
d. The questionnaire's total Cronbach alpha value was 0.87.

It had been suggested that the minimum alpha value for a standardised questionnaire should be 0.7, the Cronbach alpha values found are regarded reliable

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(Pallant & Manual, 2010; Nunnally, as cited in Sullivan, 1994). (Pallant & Manual, 2010; Nunnally, as cited in Sullivan, 1994). The pre-testing had the following goals: to determine whether the research instruments utilized were appropriate and, if necessary, change or create new ones; to create a research protocol that would guide the inquiry; and to determine whether the research protocol is workable and feasible. To assess the effectiveness of the sample frame and the research methodology, pre-testing was done. It addressed logistical issues that may arise while employing the recommended approaches. Again, it assesses result variability to assist in determining sample size. It also collects preliminary data and determines what resources (both financial and otherwise) are required for the main investigation. Furthermore, pretesting evaluates the suggested data analysis methodologies to identify any issues. Finally, it verifies the study topic and research strategy and develops an alternative if required.

However, the ability to generalize the findings of the current investigation is critical. The pre-testing ensured that the final instruments had as little uncertainty as possible. It also assisted in determining the time required to reply and in testing the coding scheme (Cohen, Arnold, Klaunig & Goodman, 2016). The Cronbach Alpha was employed to assess the questionnaire's reliability during its pre-testing. The Cronbach alpha coefficient of a scale should ideally be greater than.7 (“SPSS survival manual,” 2013). Cronbach alpha values, on the other hand, are highly dependent on the number of items on the scale. Cronbach alpha values are frequently found to be relatively low on short scales (e.g., scales with less than 10 elements) (0.5). In this scenario, reporting the items' mean inter-item correlation

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may be more suitable. Briggs and Cheek (1986) propose a range of 0.2 to 0.4 for inter-item correlation.

The dependability of a scale varies depending on the sample. As a result, you must double-check that each of your scales is accurate with your specific sample. If your scale has any negatively phrased items (which are prevalent in psychological tests), they must be 'reversed' before reliability testing. A total of five residents' heads were interviewed. The respondents were told of the goal of the pretesting and their signed consents were obtained for ethical grounds. Before the interview, they were called. Some details concerning the interview were provided, as well as the date and location of the interview. Pre-testing the interview guide would aid the researcher in estimating the time it would take to conduct the interviews and the kind of queries residents who use cooking fuels could have.

Validity and reliability

The questionnaire and interview schedule were sent to the current study's chief supervisors for assessment to ensure the validity of the tools. This was appropriate since expert opinion can be used to assess face or content authenticity (Gay, Mills & Airasian, 2011). They incorporated their ideas to rearrange the items. According to Amedahe (2001), the validity of the assessment scores is determined by the quality of the interpretations offered to them, not by the instrument itself. The instrument is considered to be valid if it measures what it is supposed to measure and the findings are used for the intended purpose. The pre-testing assisted

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in the refinement of the research tools. Based on the feedback received during the pilot research, the questionnaire was revised.

Cronbach's alpha was used by the researcher to determine the questionnaire's internal consistency (Kimberlin & Winterstein, 2008). Cronbach's alpha is a correlation coefficient that ranges from zero to one in value. The test is more trustworthy if the reliability coefficient value is near to one, whereas the test is less reliable if the reliability coefficient value is close to zero. (Gay et al., 2009). The total questionnaire has a reliability coefficient of 0.87. As a result, it was judged reliable.

Data collection procedures

An introduction letter was obtained from the University of Cape Coast's Department of Vocational and Technical Education. The letter was addressed to the Ghana National Household Registry (GNHR) to obtain authorization to conduct the research. The researcher also requested approval from the University of Cape Coast Institutional Review Board (UCCIRB) and the Graduate School for Ethical Clearance, which allowed him to conduct the research.

The researcher went to the field with two assistant researchers to collect data. The data was collected by going to the houses of the residents. The researcher was assisted in locating residences for data collection by residents of the communities. The questionnaire indicated that participation was entirely optional. Furthermore, when it came to gathering sensitive information from respondents, they were given ample time to determine whether or not they wanted to share it with the researcher, with no big enticement. The questionnaire took each responder

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about thirty minutes to complete. The surveys were sealed and placed in brown envelopes when they were finished. The data collection process takes a month.

Regarding the interview segment, five residents were purposefully chosen for the interview. The candidates were chosen based on their use of energy fuel for 10 years or more and their marital status. Before the interview, each interviewee was given a copy of the interview guide to review. This is done to make it easier for the interviewer and interviewees to engage. To avoid disrupting their regular routines, the interviewers were given the option of choosing the time, day, and location.

Furthermore, residents were guaranteed anonymity and that their names would not be revealed at any moment. No one was forced or compelled to take part in the study. The informed consent and voluntarism norms were properly followed (Denscombe, 2010; Cohen, Manion & Morrison, 2013; Frankfort-Nachmias & Nachmias, 2000). The interviewees were given the option of selecting the location of the interview (home or their offices).

The interviewee's agreement to tape-record the session was requested to guarantee that the data were appropriately documented. The recording was also played back to each interviewee following the interviews. Residents would be able to rectify remarks, provide extra information, or just confirm what they said during the interview if this were possible.

Data Processing and Analysis

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Descriptive statistics were used to analyze socio-demographic, research questions one, two, three, and four variables. The researcher employed theme analysis to analyze the qualitative part of the study. To get significant results, the research was carried out methodically (Attride-Stirling, 2001). The thematic analysis would assist the researcher in identifying, analyzing, and locating themes in the empirical data (Braun & Clarke, 2006). Thematic analysis is a powerful tool for examining empirical qualitative data in terms of participant viewpoints, similarities, and contrasts (Braun & Clarke, 2006).

The researcher used Braun and Clarke's (2006) theme approach to qualitative data analysis in this study. Although Nowell, Norris, White, and Moules (2017) contend that the six phases should not be rigorously followed, Braun and Clarke (2006) presented six processes for assessing qualitative data. The researcher started by transcribing the interviews and familiarizing himself with the information acquired (Braun & Clarke, 2006).

The researcher had to study the data frequently and start looking for patterns in the responses of the respondents (Nowell, Norris, White & Moules, 2017). Second, the researcher turned the data into codes, which are defined as data that sticks out and is intriguing to the researcher or thoughts that arise repeatedly (Braun & Clarke, 2006). According to Nowell et al. (2017) coding allows for the clarification of data and the targeting of certain qualities (2017).

Third, the researcher sorted and integrated the codes into comprehensive themes, thus the term "thematic analysis" (Braun & Clarke, 2006). This procedure aids in the discovery of underlying assumptions and patterns (Attride-Stirling,

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2001). The researcher went through the themes again, examine the patterns, and develop the themes so that they could capture the right blend of wide and narrow data sets (Nowell et al., 2017). It is critical, however, that the researcher maintains the data's authenticity and that the themes are compatible with the respondent's views (Braun & Clarke, 2006).

The fifth stage is to be pleased with the themes, to give them names, and to polish them so that their fundamental concepts do not overlap (Braun & Clarke, 2006). In the last phase, the report is finalized and everything is written up. To lend authenticity to the analysis and to explain to the reader how it all ties together, it is necessary to clarify the themes extracted in the previous sections. It's also crucial to add quotes from respondents to give the study more depth; otherwise, it'll be too detailed (Braun & Clarke, 2006).

ANOVA statistical tool (one-way ANOVA) was used to compare the means differences among and between the energy choices and consumption levels of the three towns. That is, one-way ANOVA helps compare the significant mean differences between and among the energy choices and consumption levels of the study areas.

Analysis of Variance (ANOVA) Test

Research Hyptheses:

H_0: There are no significant differences in energy choices between and among the study communities.

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H_A: There are significant differences in energy choices between and among the study communities.

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Analysis of variance (ANOVA) was used to determine the difference in energy choices among households in the Mfantseman Municipality. Specifically, ANOVA was used to analyze the responses to the first research question (Q1), which aimed to understand the variations in household energy choices for cooking. This enabled the researcher to examine whether there were significant variations in the choices of cooking fuels among households residing in different geographical locations within the municipality.

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In the Anova analysis, an alpha-value of 0.05 was considered and thus, when the p-value is less than the alpha value, there is statistical significance between and among the energy choices of the study areas. When the p-value is less than the alpha-value (p-value < 0.05), it means there is a statistically significant difference between and among the means of the energy choices of the three towns. Hence, the null hypothesis would be rejected, while the alternative hypothesis is failed to be rejected. However, when the p-value is greater than the alpha value (p-value > 0.05), it means the alternative hypothesis is true, thus, there are no statistically insignificant differences between and among energy choices of the study areas.

Ethical Consideration

First and foremost, the researcher sought informed verbal agreement from residents before their involvement in the study. The fact that the participants' involvement was completely optional was made clear to them. They were informed

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that they may refuse or accept participation in the study. Additionally, the study took into account the respondents' anonymity. Oliver (2010) contends that anonymity, which permits respondents to conceal their identity, is a crucial issue in research ethics.

No names or other identifying information was gathered from respondents in order to uphold the moral principle of anonymity. This had been done to shield participants from harm in the event that other parties found their responses objectionable. Regarding confidentiality, all reasonable measures were taken to keep the responses secret. Respondents were assured that the study would keep their responses confidential, that no one they knew would have access to the data they provided, and that their identities would not be revealed.

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CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the findings of the study. However, the results are organised into tables and complemented by explanations and discussions. The findings have been explained as presented and organised into sub-themes to reflect the research questions and hypotheses. The major sub-themes in this chapter included:

1. Energy choice used for household cooking
2. Determinants (factors) that influence household cooking fuels choices
3. Health issues related to the use of household energy fuels
4. Level of knowledge of energy (fuel) use in households

This section provides answers to research Questions One and Two were tested with mean and standard deviation and were presented on bar charts. Research question three was tested with mean and standard deviation and its results were also presented on the table. Contingency tables and bar charts were used to depict socio-demographic characteristics such as gender, marital status, and level of education as well as ANOVA statistical analysis on the energy choices among the study areas. Three hundred and eighty-four household heads were used as the sample size.

The information in this section is meant to address research questions one to four. Households are given code IDs, and certain words and phrases are

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highlighted to draw attention to them. Also, italics and single quote marks are used for verbatim answers. Five families from various villages were interviewed.

Socio-demographic information

This portion of the chapter includes a study of the questionnaire respondents' background data. Gender, marital status, and degree of education are among the background variables for the quantitative portion of the study. Five houses were interviewed as part of the background data for the qualitative research. All five interviewees in the home were females, and they were all married. Four were uneducated, while one was a JSS graduate.

Table 1: ***Gender Distribution of Respondents***

	F	~~Per cent~~%
Male	196	51.04
Female	188	48.96
Total	384	100.0

Source: Field Survey, (2021)

The gender breakdown of responders is seen in table 1. The male had a frequency of 196 and a percentage of 51.04, while the female had 188 and a percentage of 48.96. It may be assumed that the majority of those who participated in the study were men.

Table 2: ***Marital Distribution of Respondents***

	F	%
Married	112	29.17
Never Married	86	22.39
Cohabitating	51	13.28
Divorced	51	13.28

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Widowed	44	11.46
Separated	40	10.42
Total	384	100.0

Source: Field Survey, (2021)

Table 2 shows the marital status of respondents. It revealed that those who are married account for 112 people with a percentage of 29.17, while those who are separated account for 40 people with a percentage of 10.4. Those who had never married numbered 86, accounting for 22.39 % of the total, while those who had cohabited or been divorced numbered 51, accounting for 13.28 per cent of the total. As a result, the study's respondents were more likely to be married.

Education Level of Respondents

Figure 7 depicts the respondents' educational attainment. Bachelor's degree holders accounted for 91 people or 24 per cent of the total population. SHS and post-graduate education accounted for 14% and 14%, respectively. Those with a JHS diploma and those with a post-secondary diploma each had 11%. On the other hand, 9% did not have any formal education. As a result, the vast majority of the study's participants were educated.

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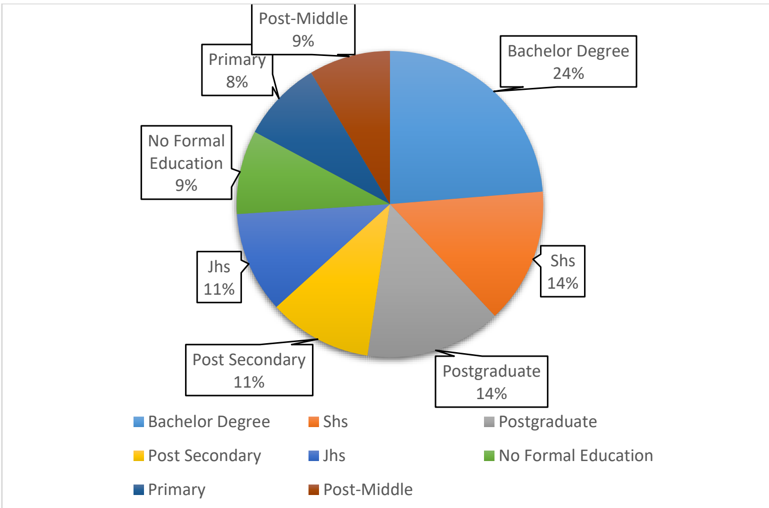

Figure 7: Education Level of Respondents

Source: Field Survey, (2021)

Energy Choice used for Household Cooking

Research Question One: What are the types of energy sources households used in the Mfantseman Municipality? The first research question was presented on a bar chart. Figure 7 shows the different types of energy sources used by households.

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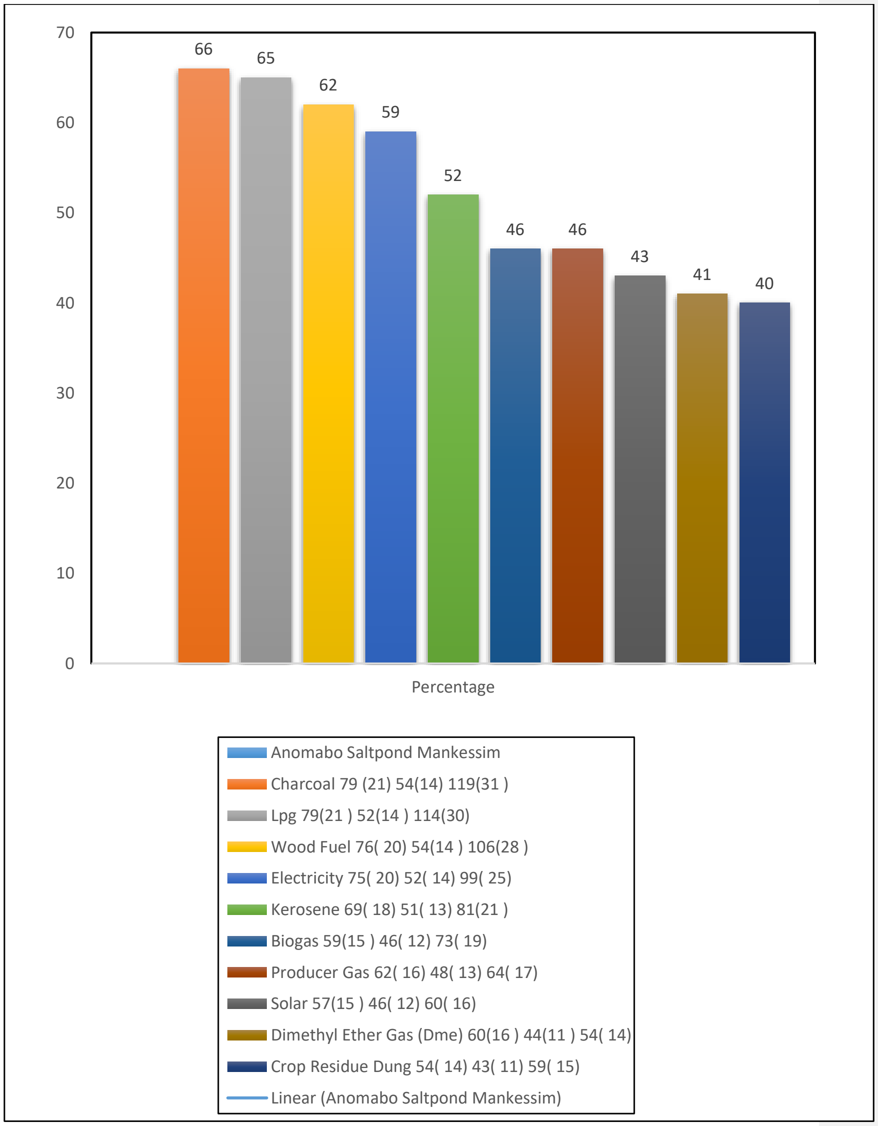

Figure 8: Household energy sources by Mfantseman area

Source: Field Survey, (2021)

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Figure 8 displays the energy sources used by households in the Anomabo, Saltpond, and Mankessim areas. In these three areas, charcoal accounted for 66% of home energy sources. This was followed by LPG at 65%, wood fuel at 62%, electricity at 59%, and so on. Crop leftover dung, which generated 40% of household energy, was the least efficient source. This finding shows that charcoal, LPG, wood fuel, electricity kerosene, and biogas were the most common household energy sources in the Mfantseman Municipality.

From the interview conducted on the energy sources used by homes of Mfantseman Municipality, two out of five of the respondents said that they solely cook with firewood in their homes. Again, two responders used firewood and charcoal. The last respondent thought that she exclusively cooks with charcoal in her home. Their perspectives are:

*"I use **firewood** for cooking and nothing else"* (**Respondent 1**)
*"Only **firewood** for cooking"* (**Respondent 3**)

*"I use **firewood and charcoal** for cooking mostly in my household"* **(Respondent 2)**
*"**Firewood and charcoal** have been the energy for cooking in the household"* **(Respondent 4)**

*"I use **charcoal** for cooking"* **(Respondent 5)**

The findings from the questionnaire and interviews provide valuable insights into the energy sources used by households in the region. According to the responses, it is evident that firewood and charcoal are among the most prevalent energy sources in Mfantseman households. Some households rely exclusively on these traditional biomass fuels for their cooking needs, while others use a combination of firewood and charcoal.

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This finding of the study, however, affirms findings by the Energy Commission (2005); Energy Commission (2006); Forestry Development Master Plan (1996-2020); Kammen (2006); Riegelhaupt (2001); Schlag and Zuzarte (2008) who reinforced the significance of charcoal and woodfuel in the region. These sources support the observation that these traditional energy sources are consistently used, particularly in rural areas. The Forestry Development Master Plan's projection that wood fuel usage in Ghana could reach 20 million underscores the extent of reliance on these resources.

Additionally, the quantitative data reveals the diversity of energy sources used in Mfantseman households. While charcoal and wood fuel are primary, liquefied petroleum gas (LPG) emerges as the second most commonly used fuel, in line with findings by Wang et al. Furthermore, electricity and kerosene are also reported as cooking fuels. This diversity indicates that households in Mfantseman utilize a mix of energy sources to meet their cooking needs, reflecting the evolving energy landscape in the region. Mfantseman households draw upon a range of energy sources, with traditional biomass fuels remaining central, while also incorporating modern alternatives like LPG and electricity, highlighting the complex energy dynamics within the community.

Determinants of Household Energy Use Choice

Research Question Two: -What are the determinants of household energy choices used in the Mfantseman Municipality? The research question looked into determinants of household energy choices used in the Mfantseman Municipality. Questionnaire was used to collect the data to answer this question of the study. In

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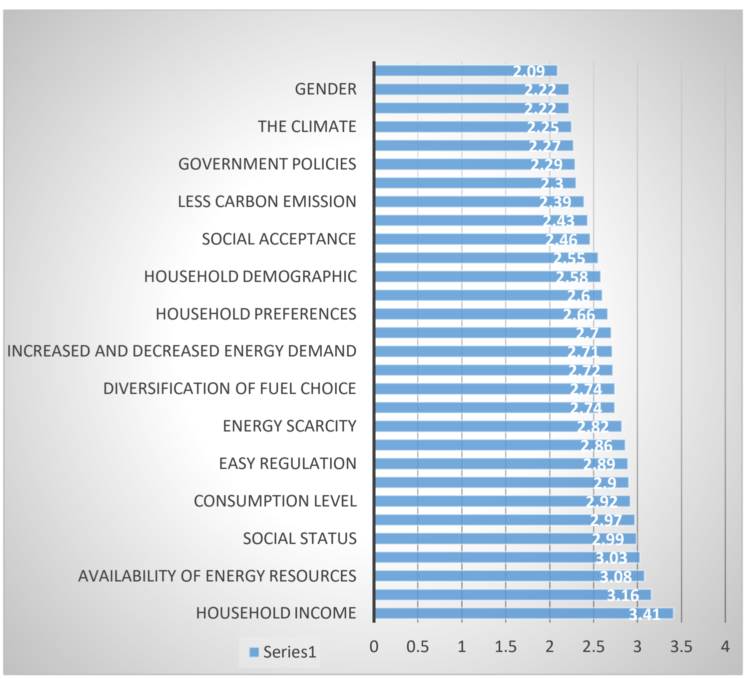
the analysis of this question, descriptive statistics such as mean and standard deviation were used. The factors of household energy usage option items are scored on a four-point Likert scale, with strongly agreed equaling four and strongly disagreed equaling one. On a four-point Likert-type scale, the greatest mean is four, and the lowest mean is one. The average of the two extreme values on a four-point Likert-type scale is used as the comparative cut-off point. In contrast, 2.5 is the cut-off mark. As a result, any indicator of household energy usage choice with a mean of 2.5 or above is deemed high. Low factors are those about a household's energy source that is less than 2.5 times the mean. Figure 9 lists the factors that influence household energy consumption decisions in ascending order.



Source: Field Survey, (2021)

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Figure 9: Determinants of household energy use choice

Figure 9 depicts determinants of household energy choices used in the Mfantseman Municipality. The determinants with a mean of 2.5 or higher on the bar chart included household income, availability of energy resources, social status, consumption level, easy regulation, energy scarcity, diversification of fuel options, and so on. On the other hand, societal acceptance, lower carbon emissions, government policy, the environment, and gender were not identified as variables influencing home fuel consumption.

Findings obtained using the interview guide also revealed income level, consumption level, and energy scarcity to be among the determinants of household energy use choice. Respondents were allowed to choose two or more determinants that influence their household's cooking fuel usage. Below are their views:

"Income level" **(respondent 1)**
"Income level" **(respondent 3)**
"Income level" **(respondent 4)**
"Income level" **(respondent 5)**

"Consumption level" **(respondent 1)**
"Consumption level" **(respondent 2)**

"Energy Scarcity" **(respondent 2)**
"Energy Scarcity" **(respondent 3)**

According to the respondents' remarks, income level was the most important factor influencing the use of home cooking fuel. It was followed by both the amount of consumption and the scarcity of energy.

The key influence on fuel choices was found to be income level. Arthur et al. (2010), Bansal (2013), Chaudhuri and Pfaff (2003), Heltberg (2005), Mekonnen

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and Kohlin (2008), and Peng et al. (2010). These writers discovered that people's fuel choices are influenced by their income.

For example, Chaudhuri et al. (2003) discovered that the cost of fuelwood falls as household income rises. The implications of having a high or low income are that people will live better or poorer lives. This will have an impact on the goods and services people purchase, especially cooking fuel. As a result of this, it is natural to conclude that people with higher incomes will use cooking fuels that are less harmful to their health.

Low income, on the other hand, may push people to use cooking fuels that are harmful to their health. In addition to income, the quantitative and qualitative findings demonstrated that consumption level and energy shortage were also determinants in household energy use decisions. Thus, both the quantitative and qualitative results reveal that the main determinants of household energy use choice were income level, consumption level, and energy scarcity, though there were other factors such as the market price of fuel, availability of energy resources, efficient cooking and social status.

The participants also provided different views on the determinants of household energy choices used in the Mfantseman Municipality. Some of them are as follows:

> *"Firewood **cooks food faster** than the rest of the energy types"* **(respondent 1)**

> *"I **cannot read** to use gas"* **(respondent 2)**

> *"**Easy accessibility**"* **(Respondent 3)**

> *"Food prepared by firewood **tastes good and smells better** than others especially rice."* **(Respondent 5)**

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Other novel factors of home energy consumption choice indicated by comments from respondents 1, 2, 3, and 5 were cooking meals faster, cannot be read, easy accessibility, and improved aroma.

Table 3: Anova Analysis of Types of Energy Use

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Energy use	8652.5	3	2884.2	41.9	7.8E-12	2.9
Within Energy use	2476.6	36	68.8			
Total	**11129.1**	**4**				

SS = sum of squares, Df = degree of freedom, MS = mean sum of squares

Table 3 displays an ANOVA analysis of the energy consumption levels of the study towns. From Table 3, the F-critical and p-value were 2.9 and 7.8^{-12}, however, the p-value was less than the alpha value (0.05), meaning it is statistically significant. Based on the p-value, the null hypothesis is rejected, indicating that there is a significant difference between and among the energy consumption level of the study areas (Anomabo, Saltpond and Mankessim). This means that energy choices and consumption, including charcoal, kerosene, biogas, LPG, electricity, wood fuel, producer gas, solar, dimethyl ether gas and crop residue dung consumption or choices in the study areas (Anomabo, Saltpond and Mankessim) are not the same. Notwithstanding, the ANOVA test can be related to how income level, household size and education level influence energy use in the three areas. According to Maruejols, Höschle and Yu (2022); Rao, Tang, Chau, Iqbal and Abbas (2022), income level determines energy choices or use in households in countries. Therefore, the energy choices and consumption levels are not uniform, deepening

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the need for the government to make provisions for clean and safe energy sources for the people in the study areas (Anomabo, Saltpond and Mankessim).

Health-related Issues of Household Energy Use

Research Question Three: What are the health-related issues associated with the household energy choices? Research question three was analysed using descriptive statistics such as mean and standard deviation. Research question three seeks to provide an answer to the health-related issues of household energy use. Health-related issues of household energy use are shown in Table 4.

Table 3: Health-related issues of household energy use

Health-related issues	Mean	Std. Deviation
Indoor Air Pollution	3.1295	0.82387
Eyes Problem/infection	3.1151	0.73306
Injuries	3.0719	0.71870
Waist Pains	2.9784	0.87201
Fatigue	2.8129	0.72799
Backache	2.8058	0.78830
Headaches	2.7482	0.83487
Chest Pains	2.6403	0.86817
Stiff Neck	2.4820	0.71579
Skin Irritation	2.4245	0.83387
Insect And Pest Bites	2.4173	0.87559
Sinus Problems	2.4101	0.77845
Snake Bites	2.4029	0.87410
Fungus Infection	2.1739	0.73408

Source: Field Survey, (2021) **n= 384**

Table 3 demonstrates the health concerns that arise as a result of consuming a certain amount of energy at home. The greatest mean was "Indoor Air Pollution" (M = 3.1295, SD =.82387), while the lowest mean was "Fungus Infection" (M = 2.1739, SD = 0.73408). Apart from indoor air pollution, "Eye Infection" (M =

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3.1151, SD =0.73306), "Injuries" (M = 3.0719, SD = 0.71870), "Waist Pains" (M = 2.9784, SD =0.87201), "Fatigue" (M = 2.8129, SD = 0.72799), "Backache" (M = 2.8058, SD = 0.78830), "Headaches" (M=2.7482, SD = 0.83487) and "Chest Pains" (M = 2.6403, SD = 0.86817) were among the health-related concerns associated with household energy usage.

Table 4 further revealed "stiff neck" (M = 2.4820, SD = 0.71579), "skin irritation" (M = 2.4245, SD =.83387), "insect and pest bites" (M = 2.4173, SD = 0.87559), "sinus problems" (M = 2.4101, SD = 0.77845), and "snake bites" (M = 2.4029, SD = 0.87410) were among the least health-related issues of household energy use.

These results of the study also demonstrated that cooking fuels are associated with health issues. Other issues relating to specific energy consumption were mentioned by respondents. Respondents 1 and 3 mentioned a single issue. Respondents 4 and 5 mentioned dozens of new issues about a certain energy source. Their thoughts on the other issues are as follows:

> *"When I cook late, the smoke stays in my bedroom making **sleeping difficult**"* **(respondent 1)**

> *"**Too tired and weak** when I go close to the naked fire"* (**Respondent 3**)

> *"Gas causes the **death of people**. It **burns** people and leaves serious scars on them. Firewood gives **eye problems**."* (**Participant 4**)

> *"**Respiratory problems, headaches**, **eye problems**. **Snakes and scorpions** hide in the heaps of firewood and **bite** people who come close to their hiding places."* (**Respondent 5**)

Comments from respondents 1 and 3 revealed that other related problems to particular energy use were "sleeping difficulty" and "being too tired and weak".

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Respondent 4 reported "death of people", "burns, and eye problems". Respondent 5 reported "respiratory problems", "headaches", "eye problems", and "snakes and scorpion bites" as other problems associated with particular energy use. From their comments, respondents 4 and 5 made mention of eye problems.

As a result, even though there are other issues linked with the use of a certain energy, the eye problem was the most significant issue. Respondents were asked to list any concerns their neighbours had with certain energy consumption. Burns, snake/scorpion bites, eye issues, anaemia, and weakness have all been reported by respondents' neighbours. The following are the responses of the respondents:

> *"Someone used gas for cooking and as a result of a fault the gas **burnt her face"*** **(respondent 1)**

> *"Yes sometimes **snakes and scorpions** hide in the firewood and attack them later"* **(Respondent 2)**

> *"Yes, **Eye problems"*** **(respondent 3)**
> *"Yes smoke from the firewood causes **eye problems"*** **(Respondent 4)**

> *"Yes, they say when one works with open fire for a long time it causes **anaemia** and **weakness** so it is not good for the aged."* **(respondent 5)**

Respondents 3 and 4 said that their neighbours experienced eye problems as a result of certain energy consumption in their remarks. As for neighbours' difficulties with the usage of certain energy sources, respondents 1, 2, and 5 reported burns, snake/scorpion assaults, anaemia, and weakness, respectively. As a result, the most significant neighbour concern associated with the use of a specific energy source was an eye problem.

According to the data, the most common cause of eye problems is the use of cooking fuel. This finding is in line with those of James et al. (2020), Patel et al.

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(2020), Pokhrel et al. (2005), and Saha et al. (2005). According to the authors, smoke from cooking fuels causes eye issues and air pollution.

As a result, it can be inferred that the problems related to the use of cooking fuels were dominated by eye problems, albeit there were other issues as well. Indoor air pollution, eye infections, injuries, waist pains, weariness, backaches, headaches, and chest pains were all reported as health problems as a result of energy use.

Research Question 4: How knowledgeable are the households (heads) using the energy (fuel)? Research Question 4 sought to assess the level of knowledge among household heads regarding the energy sources or fuels they use. This question is essential for understanding the awareness and familiarity of individuals with the energy resources they employ for various purposes, such as cooking and heating. Interviews guide was used to gather information on the knowledge households have about the fuels they use. Results from the interview guide were analysised as followes.

Reason for the use of particular energy

Respondents provided answers to the reason for the use of particular energy. Three of the respondents were of the view that the reason for using particular energy is that they do not waste money on that energy. The views of the respondents are as follows:

> *"They are on my farm so I **do not buy them"*** **(Respondent 1)**
> *"They are in my neighbourhood so **I do not buy** and I get them anytime"* **(Respondent 2)**
> *"I do **not waste money** on it. It is free in the village"* **(Respondent 5)**

Two other respondents' reasons were readily available and abundant. Their views are as follows:

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*"This is because the fuel is **readily available"*** **(Respondent 3)**
*"Firewood is in **abundance** in my locality"* **(Respondent 4)**

Comments from respondents show that reasons for choosing particular energy were because they waste no money on fuel, readily available and abundance in their locality.

This finding is consistent with research by Ahiekpor, Antwi, Bensah, and Ribeiro (2015). People consume various forms of energy because it is inexpensive and readily available, according to the authors. The outcome is in line with previous research (Adeyem and Adereleye, 2016; Wassie et al. 2021). Because of low income, family size, road access, location, education level, and technology cost, the writers have all disclosed that individuals consume a specific amount of energy for cooking.

Reason for Not Changing Particular Energy Used

Four out of five respondents commented on the reason for not changing the type of energy used. Their views are as follows:

*"No, **I do not have money** to buy charcoal"* (**Respondent 1)**
*"No, because **I cannot afford** charcoal and gas"* (**Respondent 3)**
*"No, because wood and charcoal are the **only available fuel** seen in my locality"* (**Respondent 4)**
*"No, because **I do not buy it**."* (**Respondent 5**)

It can be deduced from the comments of respondents one and three that their reasons for not changing particular energy are related to money. Respondent four does not change it because it is the only available fuel. Respondent five does not spend money on fuel. Thus, the reasons for not changing the particular energy used are money-related, the availability of fuel, and getting fuel for free. This discovery is in line with Ahiekpor, Antwi, Bensah, and Ribeiro's study (2015). According to

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the writers, people use numerous sources of energy since it is affordable and easily available. The findings are consistent with earlier research (Adeyem and Adereleye, 2016; Wassie et al., 2021). Individuals use a certain quantity of energy for cooking due to poor income, family size, road access, location, education level, and technological cost, according to the authors.

Knowledge About Energy Used

Respondents were asked about their understanding of the energy they consume. The respondents' understanding of energy consumption was that it blackens pots and kitchens, cooks faster, and is inexpensive. Here's what the respondents had to say:

> *"It **blackens my pots** because of the smoke"* **(Respondent 1)**
> *"Firewood gives smoke and **blackens the kitchen…** It **cooks faster**… It is **cheap** and the smoke disturbs our sleep…* **(Respondent 3)**
> *"It **blackens my pot**… It produces smoke that pollutes the air. It **cooks faster** than charcoal. It is **not expensive**."* **(Respondent 5)**
> *It **cooks faster**. It is **less expensive**…* **(Respondent 4)**

Respondents 1, 3, and 5 stated that the energy used blackened pots and kitchen appliances. The only thing Respondent 4 knew about the fuel was that it cooks faster. Even though respondents 3 and 5 had mentioned blackening their pots and kitchens, they also agreed with respondent 4's assertion that the energy used for cooking cooks faster. Respondent 4 stated once more that the energy used was less costly. Respondent 5 stated that the energy she needed for cooking was not expensive, agreeing with respondent 4.

As a result of the respondents' remarks, it can be determined that their understanding of energy was in the areas of blackening pots and kitchens, cooking faster, and it being inexpensive. The present outcome is comparable to Momoh's

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findings (2016). This author believes that LPG gas cooks faster, and more efficiently, and is better for the environment. The present conclusion is consistent with Northern Energy's (2014) understanding of cooking fuels. According to Northern Energy (2014), LPG is more ecologically beneficial than other energy sources. They indicate that individuals use LPG since they are aware that alternative energy sources cause pots to blacken.

Knowledge About Energy You Do Not Use

Respondents reported what they knew about the energy they did not use. Respondents were of the view that energy they do not use—do not blacken pots, do not black kitchens, do not get gas to buy—kills people, is dangerous, expensive, explodes and burns. Below are their views:

*"This is because they **do not blacken pots**"* **(Respondent 1)**
*"They do not **blacken the kitchen**"* **(Respondent 3)**

*"Sometimes they **do not get gas to buy**..."* **(Respondent 2)**

*"It also **kills people"*** (**Respondent 2**)
*"I know that gas is **dangerous** and **expensive**"* **(Respondent 4)**
*"I do not use gas but I know they are **expensive**."* **(Respondent 3)**
*"Gas **explodes and burns** people. Charcoal does not cook faster as firewood."* **(Respondent 5)**

Respondents 1 and 3 stated that the only knowledge they have about the energy they do not use is that they do not blacken pots or the kitchen. Respondents 2, 4, and 5 are concerned about the dangers of not using energy.

They claim that the energy they do not use kills, is harmful, explodes, and burns people. As a result, it is possible to deduce that respondents' awareness of energy they do not use is related to the blackening of pots and kitchens as well as danger. This conclusion agrees with Northern Energy (2014). According to the

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author, people choose LPG because they know alternative energy sources cause pots to blacken. In terms of the dangers of cooking fuels, the study confirms the conclusions of Belie, Mofikoya, Fadeyibi, Ugburo, Buari, and Ugochukwu (2020). During the research period, 347 patients were treated for burns, with 49 of them suffering from burns caused by a cooking gas explosion, according to the authors. Moreover, the findings of the study are congruent with those of Ombati, Ndaguatha, and Wanjeri (2013). In both studies, the majority of the respondents (63 per cent) purchased kerosene from fuel vendors, and practically all of the explosions were caused by the wick type of burner (98 %).

Chapter Summary

The study's findings were extensively analysed in this chapter about the research topics. After the conversations, quantitative and qualitative findings indicated that Mfantseman inhabitants used charcoal, LPG gas, wood fuel, electricity, and kerosene as energy sources. Although there were elements such as the market price for fuel, availability of energy resources, efficient cooking, social standing, and so on, the primary predictors of household energy shown by both quantitative and qualitative results were income level, consumption level, and energy scarcity.

Other new drivers of home energy usage include cooking meals faster, being unable to read, having easy access, and improving scent. The qualitative results revealed that the reasons for choosing specific energy were that they wasted no money on fuel and that they were widely accessible and abundant in their neighbourhood, whereas the reasons for not changing the specific energy used were

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money-related, fuel availability, and obtaining fuel for free. The difficulties linked to the use of cooking fuels were dominated by eye problems, but there were other issues as well.

Respondent's awareness of energy usage was limited to blackening pots and kitchen appliances, cooking faster, and it being inexpensive. Respondents' comprehension of non-used energy has more to do with the blackening of pots and kitchens, as well as hazards. From the ANOVA analysis, energy choices and consumption levels in the study areas are not the same.

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CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

The study generally sought to find the energy sources, uses and choices for household cooking, health issues related to the use of household energy fuels and strategies used to conserve the energy sources in the Mfantseman Municipality. Specific objectives comprised:

1. Find out the energy choice used for household cooking in the Mfantseman Municipality
2. Find out determinants (factors) that influence household cooking fuel choices.
3. Investigate the health issues related to the use of household energy fuels.
4. Explore the level of knowledge of energy (fuel) use among households (head).

As a research paradigm, the study used the pragmatic viewpoint. A mixed-methods approach was adopted as the study design for seeking responses from inhabitants and household heads in Mfantseman. A sample size of three hundred and eighty-four respondents was used for the study. The study focused on the residents of the Mfantseman district. Cluster, simple random and convenience sampling methods were used for sampling respondents. A questionnaire was used in soliciting data from residents in Mfantseman, whereas an interview was used to collect data from household heads. Descriptive statistics were used to analyse

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socio-demographic and research questions one, two, three and four. The researcher followed Braun and Clarke's (2006) thematic way of analysing qualitative data.

Key findings

The study's findings indicated that Mfantseman inhabitants used charcoal, LPG gas, wood fuel, electricity, and kerosene as energy sources. Primary predictors of household energy were income level, consumption level, and energy scarcity. The key influence on fuel choices was income level. The quantitative and qualitative findings demonstrated that consumption level and energy shortage influence household energy use decisions. Thus, both the quantitative and qualitative findings reveal that income level, consumption level, and energy scarcity are the main determinants of household energy use choice.

One noteworthy finding is that respondents demonstrated a reasonable level of knowledge about the various energy choices available to them. This indicates that awareness campaigns or educational efforts in the community have been successful in disseminating information about energy sources. However, the effectiveness of these campaigns and their impact on actual energy choices and health outcomes should be further investigated.

The qualitative findings of the study confirmed that cooking fuels are associated with health issues. Indoor air pollution, eye infections, and injuries emerged as the most frequently reported health problems.

The study identified a significant difference in household energy choices within the surveyed population. This disparity can be attributed to various factors, including income disparities, access to specific energy sources, and individual preferences.

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Summary

1. According to the demographic factors of household heads, the majority of participants who took part in the survey were men. In addition, the survey found that a higher proportion of respondents were married. Again, a higher proportion of participants who took part in the survey possessed a bachelor's degree.
2. Charcoal was the primary source of energy for residents in the Mfantseman area. LPG was the second-best thing to charcoal. Wood fuel, electricity, kerosene, and biogas were also key sources of energy in Mfantseman.
3. According to both quantitative and qualitative results, the main determinants of household energy use choices were income level, consumption level, and energy scarcity, though other factors such as the market price of fuel, availability of energy resources, efficient cooking, social status, and so on were also present.
4. Other unique characteristics revealed by the qualitative results as impacting energy consumption included the ability to cook meals faster, the inability to read, easy accessibility, and the ability to improve aroma.
5. Indoor air pollution, eye infections, injuries, waist pains, weariness, backaches, headaches, and chest pains were all reported as health problems as a result of energy use. The qualitative element of the survey, on the other hand, identified an eye problem as the most prevalent concern with energy usage.

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6. The reason for using a certain amount of energy appeared as a new subject in the qualitative study. The reasons were that they did not want to waste money on fuel, that it was readily available, and that it was abundant in their area.
7. The reasons for not changing a specific energy source surfaced as a topic in the qualitative study as well. It was discovered that individuals do not use specific types of energy in their homes due to low income, easy access to fuel, and the ability to get fuel for free.
8. Another common theme was knowledge of the energy consumed. It was discovered that respondents' understanding of energy utilisation was in the areas of blackening pots and kitchens, cooking faster, and being affordable.
9. Respondents were also knowledgeable about the energy they did not use. Their awareness of the energy they did not use was in the areas of blackening pots and kitchens, as well as danger.
10. There was a significant difference between and among the energy choices of the study areas (Anomabo, Saltpond and Mankessim). Thus, energy choices in the study areas are not the same.

Conclusion

The study looked at the energy used in household cooking in the Mfantseman Municipality. According to the present findings, household decisions regarding energy sources are intricately linked with income levels and the broader socioeconomic context. Recognizing the economic determinants of energy choices

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is essential for crafting effective policies and interventions that align with the diverse financial circumstances of the population.

Furthermore, the findings highlight a pressing need for cleaner and safer cooking alternatives to enhance public health outcomes. The prevalence of health issues related to indoor air pollution, eye infections, and injuries underscores the urgency of transitioning to more sustainable and health-conscious energy sources. Public health initiatives and energy transition programs should be designed with a focus on mitigating these health risks and improving the overall well-being of the community.

A positive aspect revealed by the study is the notable level of knowledge demonstrated by respondents concerning their energy choices. This indicates that educational efforts and awareness campaigns have been effective in disseminating information about available energy sources. Nevertheless, it remains crucial to assess the practical impact of this knowledge on actual energy choices and health outcomes, as well as to ensure that education continues to play a central role in the community.

Lastly, the study emphasizes the significant variation in energy choices across different communities within the research area. This diversity can be attributed to a range of factors, including income disparities, access to specific energy sources, and individual preferences. Acknowledging and understanding this variability is instrumental in tailoring energy policies and interventions to accommodate the unique needs and circumstances of each community.

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Recommendations

The following recommendations are made based on the findings of the research for policy and practice:

1. Policy initiatives and interventions should prioritize making modern and cleaner energy sources affordable and readily accessible to households in the Mfantseman municipality. This could involve subsidies, incentives, or financing options to facilitate the transition to cleaner cooking fuels and technologies.
2. Expansion of LPG Infrastructure: To promote the use of LPG as a cleaner alternative, it is essential to establish more LPG sales stations in the Mfantseman municipality. Increasing the availability of LPG will ensure consistent access for households, reducing the reliance on less eco-friendly energy sources.
3. Support for Energy-Saving Initiatives: Collaboration between the charcoal industry, LPG gas sector, and electricity companies is encouraged to launch programs aimed at supporting households in the Mfantseman municipality in enhancing their energy-saving practices. These initiatives could include educational campaigns, energy-efficient appliance distribution, and guidance on sustainable energy use.

Suggestions for Further Research

1. Qualitative research may be conducted on factors such as market fuel prices, availability of energy supplies, efficient cooking, and social status. This will aid in gathering detailed information on the determinants of household energy use,

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as the quantitative part of the study did not elaborate on how these factors affect household energy consumption.

2. This study should be expanded to include the whole Cape Coast Municipality and maybe the Central Region so that Ghanaians' cooking fuel trends can be extensively assessed to influence policies on energy usage and conservation.

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APPENDIX A

INTERVIEW GUIDE FOR HOUSEHOLD COOKING FUEL USERS

SECTION A: BACKGROUND INFORMATION

1. Please what is your gender?
2. What is your marital status?
3. What is the level of your education?

SECTION B: TYPES OF ENERGY CHOICE USED FOR HOUSEHOLD COOKING

4. What are the most frequently energy you use in your household for cooking?
5. Why the use of that particular energy in your household for cooking?
6. Do you think of changing the energy you use for cooking? If yes why? If No why?

SECTION C: THE LEVEL OF KNOWLEDGE OF ENERGY (FUEL) USE AMONG HOUSEHOLDS (HEAD)

7. What do you know about the energy you use for cooking in your household?

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8. What do you know about the energy you do not use? Why do you not patronise such energy for cooking in your household?

SECTION D: THE DETERMINANTS (FACTORS) THAT INFLUENCE HOUSEHOLD COOKING FUELS CHOICES

9. Which of the following factors do influence you in choosing your household cooking fuel?
   i. Income
   ii. Energy scarcity
   iii. Consumption level
   iv. Social status

10. What other determinants can you think of to be influencing your choice of household cooking fuel?

SECTION E: THE HEALTH ISSUES RELATED TO THE USE OF HOUSEHOLD ENERGY FUELS

11. What health problems have you encountered as a result of the use of particular energy for cooking?

12. Has anybody in your area had problems with the type of energy they use at home? Any example?

13. What other problems have you encountered or anybody encountered as a result of the use of a certain type of energy?

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APPENDIX B

INFORMED CONSENT FORM

Title: Exploring the energy choice for household cooking in the Mfantseman Municipality.

Principal Investigator: Georgina Sarquaah

Address: University of Cape Coast/ Department of Vocational and Technical Education

General Information about Research

The purpose of the study was to explore energy choices for household cooking in the Mfantseman Municipality. The study will find out the types of energy choices used for household cooking in the Mfantseman Municipality. In addition, the research will explore the level of knowledge of energy (fuel) use among households (head). Moreover, the research will find out determinants (factors) that influence household cooking fuels choices. Lastly, health issues related to the use of household energy fuels will be investigated. Questionnaire and interviews will be useful in the collection of data from residents and household heads.

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Procedures

Fill out a survey which will be provided by Georgina Sarquaah and collected by Maxwell Sakyi, a research consultant, who supervises and critiques my work. You are being invited to take part in this discussion because we feel that as resident/household head, you can provide adequate information about energy choices for household cooking. The researcher and research assists will administer the questionnaire. The interview will be conducted personally by the researcher. This will enable researchers and her assistance to clarify the aims of the study and create rapport with participants. An informed consent, outlining the goal of the study and promise of confidentiality and anonymity to responders will precede the questionnaire and the interview. The survey will only be accessible by Georgina Sarquaah and Dr. Augustina Araba Amissah, my supervisor, as the data collected is deemed secret. The survey should take around 30 minutes to complete, and each household head interview should take 45 minutes.

Possible Risks and Discomforts

To minimize the risk of loss of confidentiality, the researcher will only collect personal information that is essential to the research activity. If personal data must be collected, it should be coded as early in the activity as possible and securely stored so that only the researcher and authorized staff (supervisor) may access it. Identities of individual subjects must never be released without the express consent of the subject. In addition, if an investigator wishes to use data for a purpose other than the one for which it was originally collected and the data are

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still identifiable (e.g. a code list for the data still exists), the investigator may need to obtain consent from the subjects for the new use of the data.

Possible Benefits

There are no tangible benefits related to participating in the study, but your participation will influence and fine-tune government policies holistically in solving problems for fishing families at Moree. Also, it will help the Ministry of Fisheries and Aquaculture to be acquainted with the knowledge of the current status of fishing families and their activities at Moree.

Confidentiality

The information you give to the researcher in this study will be kept confidential. Your name will not be used in any reports or advertisements. Your name will appear only on this consent form which will be kept in a locked file cabinet by the researcher conducting this study. The survey results will be analysed by the researcher alone and no one will have access to the information without your consent.

Compensation

Participants especially those the household heads will be paid two Ghana per minute.

Contacts for Additional Information

Contact the researcher, Georgina Sarquaah (0246644124) and supervisor, Dr Augustina Araba Amissah, (+233244512560) with your questions.

Your rights as a Participant

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This research has been reviewed and approved by the Institutional Review Board of the University of Cape Coast (UCCIRB). If you have any questions about your rights as a research participant you can contact the Administrator at the IRB Office between the hours of 8:00 am and 4:30 p.m. through the phones lines 0558093143/0508878309 or email address: irb@ucc.edu.gh.

VOLUNTEER AGREEMENT

The above document describing the benefits, risks and procedures for the research alternative livelihood strategies of fishing families at Moree in Abura Asebu Kwamankese District has been read and explained to me. I have been allowed to have any questions about the research answered to my satisfaction. I agree to participate as a volunteer.

________________________ __________________________________

Date Name and signature or mark of volunteer

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APPENDIX C

TABLE FOR DETERMINING SAMPLE SIZE FROM A GIVEN POPULATION

N*	S!	N	S	N	S	N	S	N	S
10	10	100	80	280	162	800	260	2800	338
15	14	110	86	290	165	850	265	3000	341
20	19	120	92	300	169	900	269	3500	346
25	24	130	97	320	175	950	274	4000	351
30	28	140	103	340	181	1000	278	4500	354
35	32	150	108	360	186	1100	285	5000	357
40	36	160	113	380	191	1200	291	6000	361
45	40	170	118	400	196	1300	297	7000	364
50	44	180	123	420	201	1400	302	8000	367
55	48	190	127	440	205	1500	306	9000	368
60	52	200	132	460	210	1600	310	10000	370
65	56	210	136	480	214	1700	313	15000	375
70	59	220	140	500	217	1800	317	20000	377
75	63	230	144	550	226	1900	320	30000	379
80	66	240	148	600	234	2000	322	40000	380
85	70	250	152	650	242	2200	327	50000	381
90	73	260	155	700	248	2400	331	75000	382
95	76	270	159	750	254	2600	335	100000	384

N is the population size

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S is the sample size

Source: Krejcie and Morgan (1970). p 607-610

APPENDIX D

TABLE OF ANOVA ANALYSIS

Summary

Towns	*Number of households*	*Sum*	*Average*	*Variance*
Anomabo	100	136	13.6	64.489
Saltpond	130	165	16.5	27.833
Mankessim	154	202	20.2	89.511
	384	503	50.3	93.344

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