GENDERED ENERGY TRANSITION IN MOZAMBICAN URBAN HOUSEHOLDS

By

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Dissertation presented for the degree of

Doctor of Philosophy

in the

Faculty of Economic and Management Sciences

at

Stellenbosch University

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December 2022

DECLARATION

By submitting this dissertation, I, Adélia Filosa Francisco Chicombo, declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Date: December 2022

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ABSTRACT

The demand in urban environments for solid fuels is responsible for the unprecedented forest degradation in developing countries. Not surprisingly, solid fuels comprise the bulk of urban energy demand, and a marginal number of urban households use clean energy sources for their most energy-intensive services. Evidence shows that biomass consumption has a disproportional effect on women. However, mainstream energy transition scholars are arguably circumscribed by the Developed countries, where access to modern energy sources is no longer the subject of debate. Instead, the energy transition debates are driven mainly by the climate change paradox. Three objectives guided this study: (1) to develop a theoretical framework for a gendered energy transition for urban households; (2) to assess gendered energy profiles and energy services in urban households in Mozambique; and (3) to examine pathways to gendered urban energy transitions in Mozambique at the household level (Figure *4.1* depicts the detailed avenues that were followed). The first objective was accomplished using a systematic integrative literature review. The findings revealed that the existing energy transition frameworks lack a *gender perspective*. With this narrative, the study augmented and illustrated the theoretical framework for the gendered energy transition in urban developing households. This led to one of this study's arguments, which is the need for a *localised* and *contextual analysis* approach to better inform decision-makers for developing suitable gendered energy policies and strategies. For that, the study used Mozambique as a case study and surveyed 381 families in Maputo city. The results show that energy consumption patterns within households are deeply gendered. Also, the households are mainly male-headed, and there is an inverted direction between who uses the fuel and the gender who pays for it. The gender of the household head did not influence decisions on fuel choice; rather, it was the educational level of the household heads that influenced their fuel choices. Women are responsible for most of the household's energy services, especially cooking and washing clothes and dishes. Through a deductive-inductive approach, informed by the theoretical framework, exploratory interviews and the survey results, the study developed gendered energy transition pathways. The study suggests the need to implement gender-sound strategies based on a local assessment of gendered energy services. This requires interaction between the market, government and civil society. Finally, the study recommends further analysis of fuel prices and households' purchasing power to evaluate other factors contributing to traditional fuel-stacking. There is also a need to debate the efficacy of the existing gender strategy through *gender audit* research.

OPSOMMING

Die vraag van stedelike omgewings na vaste brandstowwe is verantwoordelik vir ongekende agteruitgang in bosse en woude in die Globale Suide. Dit is nie verbasend nie, want vaste brandstowwe behels die meerderheid van die stedelike vraag na energie en slegs ’n marginale aantal stedelike huishoudings gebruik skoon energiebronne vir hulle energie-intensiefste dienste. Daar is bewys dat biomassaverbruik ’n disproporsionele effek op vroue het. Hoofstroom kenners van die energie-oorgang vakgebied word deur die Globale Noorde omskryf, waar toegang tot moderne energiebronne nie meer ’n kwessie van debat is nie. Daar word die energie-oorgangsdebatte hoofsaaklik gedryf deur die klimaatsverandering paradoks. Drie doelwitte het hierdie studie gedryf: (1) om ’n teoretiese raamwerk vir ’n geslagtelike energie-oorgang vir stedelike huishoudings te ontwikkel; (2) om die geslagtelike energie-profiele en energiedienste in stedelike huishoudings in Mosambiek te assesseer; en (3) om ondersoek in te stel na paaie na geslagtelike energie-oorgange op die huishoudelike vlak in Mosambiek (Figure *4.1* verskaf ’n gedetailleerde voorstelling van die weë wat gevolg is). Die eerste doelwit is deur middel van ’n sistematiese integrerende literatuuroorsig bereik. Die bevindinge het getoon dat die bestaande energie-oorgangsraamwerke nie ’n *geslagsperspektief* bevat nie. Op grond hiervan het die studie die teoretiese raamwerk vir geslagtelike energie-oorgang in stedelike huishoudings in ’n ontwikkelende konteks aangevul en geïllustreer. Dit het gelei tot een van die studie se argumente, naamlik dat daar ’n behoefte is aan ’n *gelokaliseerde* en *kontekstuele analise* om besluitnemers beter in te lig oor die ontwikkeling van toepaslik geslagtelike energiebeleide en strategieë. Hiervoor het die studie Mosambiek as ’n gevallestudie gebruik en is onderhoude met 381 gesinne in Maputo gevoer. Die resultate toon dat energieverbruikspatrone in huishoudings diep geslagtelik is. Die hoofde van die huishoudings is ook hoofsaaklik mans en daar was ’n omgekeerde rigting tussen wie die brandstof gebruik en die geslag wat daarvoor betaal. Die geslag van die hoof van die huishouding het nie die besluite oor brandstofkeuse beïnvloed nie; dit was eerder die opvoedkundige vlak van die hoofde wat dit beïnvloed het. Vroue is verantwoordelik vir die meeste van die huishouding se energiedienste, veral kook en die was van klere en skottelgoed. Deur ’n deduktief-induktiewe benadering wat deur die teoretiese raamwerk, verkennende onderhoude en die resultate van die opname geïnformeer is, het die studie geslagtelike energie-oorgangspaaie ontwikkel. Die studie stel voor dat geslagsgegronde strategieë geïmplementeer moet word op grond van ’n plaaslike assessering van geslagtelike energiedienste. Dít vereis interaksie tussen die

mark, die regering en die burgerlike samelewing. Laastens beveel die studie aan dat 'n verdere analise van brandstofpryse en huishoudings se koopkrag onderneem word om ander faktore wat tot tradisionele brandstof-stapeling bydra, te evalueer. Daar is ook 'n behoefte om die doeltreffendheid van die bestaande geslagstrategie deur *geslagsoudit-navorsing* te debatteer.

ACKNOWLEDGEMENTS

Several people and institutions contributed to the success of this work, and I would like to thank them for their valuable assistance and support:

- First, I would like to thank the Almighty God for guidance, protection, wealth, and wisdom to finish this work successfully.
- My deepest and sincere gratitude goes to my supervisor, Professor Josephine Kaviti Musango, and co-supervisors, Professor Sampson Mamphweli and Professor Zwelinzima Ndevu, for their supervision, unconditional support and encouragement. They were unequivocally pivotal for the success of this work and provided proper assistance whenever needed.
- I express my deepest gratitude to my employer, University Eduardo Mondlane, for allowing me to pursue my PhD. I also want to thank Dr Pedro Marizane Pota for his wisdom and vision, which inspired me to become a better professional.
- My acknowledgement also goes to the Kingdom of Netherlands for funding my scholarship through Project NICHE-MOZ-231.
- A special thanks and gratitude to Fatiota Cunama and Romão Simango – your help processing data in SPSS was extraordinary.
- For the co-researchers, Justino, Bernardo, Charnice, Emerson and Timóteo, thank you for your hard work with the data collection and compilation.
- I also acknowledge my cousin Telma and my dearest friends Onésia, Éssita, Ester and Christer for their support and encouragement.
- To Thuli Dlamini, thank you for the moral support and for being there for me whenever I needed guidance and advice.
- I also want to express my gratitude to all the survey participants who provided the required information for the research.
- Finally, I thank the informants from the *Ministério dos Recursos Minerais e Energia*, *Electricidade de Moçambique*, *Fundo Nacional de Energia* and *Empresa Nacional de Hidrocarbonetos* for the information provided during the exploratory interviews.

DEDICATION

With the grace and blessing of God, I dedicate this work to my son, Leví, for giving me the strength to continue with my studies. I also dedicate this work to my mother, Maria Marondo, and to my siblings, Narciso, Benedito, Tomé, Ana Dulce, Óscar and Anário. *"Esta é a prova daquilo que o papá dizia, '*book*' era única saída para o assunto Chaissa"*.

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ABBREVIATIONS AND ACRONYMS

EDM	Electricidade de Moçambique (Mozambique Electricity Utility)
ENH	Empresa Nacional de Hidrocarbonetos (National Hydrocarbons Company)
ENI	Ente Nazionale Idrocarburi (National Hydrocarbons Authority – Italian Company)
FUNAE	Fundo Nacional de Energia (National Energy Fund)
GAD	Gender in Development
GDP	Gross Domestic Product
HAP	Household Air Pollution
HCB	Hidroeléctrica de Cahora Bassa (Cahora Bassa Hydroelectric Power Plant)
IEA	International Energy Agency
INE	Instituto Nacional de Estatística (National Institute of Statistics)
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
IT	Information Technology
LPG	Liquefied Petroleum Gas
MGCAS	Ministério do Género, Criança e Acção Social (Ministry of Gender, Children and Social Action)
MIREME	Ministério dos Recursos Minerais e Energia (Ministry of Mineral Resources and Energy)
MLP	Multi-Level Perspective
MT	Meticais (Mozambican currency)
MuSIASEM	Multi-Scale Integrated Analysis of Social and Ecosystem Metabolism
OECD	Organisation for Economic Cooperation and Development
SDGs	Sustainable Development Goals

SNM	Strategic Niche Management
TIS	Technological Innovation Systems
TM	Transition Management
TPES	Total Primary Energy Supply
UN	United Nations
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNSD	United Nations Statistics Division
USD	United States Dollar
	(Currency of the United States of America)
WB	World Bank Group
WHO	World Health Organization
WID	Women in Development
SADC	Southern African Development Community
CEDAW	Convention on the Elimination of all Forms of Discrimination Against Women
SDGEA	Solemn Declaration on Gender Equality in Africa

UNITS OF MEASUREMENTS

Ktoe	Kilotons of oil equivalent
m^2	Metre square
MW	Megawatt
Tcf	Trillion cubic feet
TJ	Terajoule

GLOSSARY

Gender

Gender is defined as "a social structure that labels and legitimises particular behaviours, roles and responsibilities as 'feminine' or 'masculine,' which in turn works to 'script' and bound social action in various ways" (Petrova and Simcock, 2019: 3). So, gender is viewed as a social structure based on a sex/gender binary, in which women and men are positioned as opposites, which means that gender is regarded as the socially constructed relations that distinguish women from men based on their household roles.

Gendered innovations

Gendered innovations are viewed as an approach that 'integrates sex and gender analysis into all phases of basic and applied research to stimulate new knowledge and technologies' (Schiebinger, 2014: 1). Gendered innovation occurs at a range of levels, but this study focuses on the household's level, in all dimensions, including sources, services and devices.

Head of household

Refers to the person responsible for the household or indicated by the remaining members as the one. In each household, one was consistently identified, and the household head must be a person residing there who may or may not be present at the time of data collection, provided that the absence was less than six months (INE, 2019).

Female-headed household

Refers to a woman in charge of managing the family, because of the absence of adult-male or in a case of the presence of adult-male, the woman is the breadwinner (Musango, 2022: 2).

Energy transition

Energy transition happens when fundamental changes emerge within an energy system, driven by social issues that influence the energy choices of the system's actors (Cherp et al., 2018; Geels, 2002).

Gendered energy transitions

Within this study, gendered energy transition is used to describe the process of shifting from an incumbent regime that fails to address problematic social aspects that accentuate gender asymmetries to one that perceives structures and manages gender aspects and relations and, as a result, promotes sustainable development. Further, it perceives women's need for energy as the central point of energy policy planning at the household level (Clancy et al., 2019; Lieu, Sorman et al., 2020).

Energy services

Energy services refer to the end use of energy that households require for subsistence needs, convenience, comfort and cleanliness, conspicuous consumption and social signalling, viz. cooking, lighting, cleaning, water heating and space heating (Sovacool, 2011a).

Solid fuels or biomass

The term 'solid fuels' describes the traditional energy sources that households utilise to meet some of their energy requirements. According to Mahumane and Mulder (2016), these often include charcoal and firewood in Mozambique.

Clean fuels

According to the World Health Organization (2020), clean fuels attain the fine particulate matter ($PM_{2.5}$) and carbon monoxide air pollution levels recommended in its Guidelines for Air Quality and Selected Pollutants, respectively. In this study, clean fuels include, but are not limited to, electricity and liquefied petroleum gas (LPG).

Developing countries

The United Nations (2022) uses three categories of development amongst nations, including developed countries, countries in transition and developing countries. The World Bank classifies the economies, amongst others, according to their income, ranging from low-, lower-middle-, upper-middle, and high-income economies (World Bank, 2022). So, according to this categorisation, and considering the Human Development Index from Mozambique (UNDP, 2019), the country qualifies as a developing country with low income.

City of Maputo

In this study, the city of Maputo refers to the capital of Maputo province, the capital of Mozambique, which comprises three distinct areas: urban, suburban and peri-urban.

Urban

In the Mozambican case, urban areas are where the elite or upper- and middle-class households reside and are the city's most developed areas. They are territorially organised and have a high concentration of trade and some industries (Araújo, 2003).

Suburban

Suburban areas are the most populated areas surrounding the urban areas. These comprise unplanned neighbourhoods and often encompass middle- and low-income households (Araújo, 2003).

Peri-urban

Peri-urban areas are areas in expansion located along the outer layer of the city. These areas result from the expansion of the urban areas located between consolidated urban and rural areas (Araújo, 2003).

CHAPTER 1: INTRODUCTION

1.1. Introduction

Energy is one of the most important cross-cutting issues in all spheres of society due to its role in economic development since the industrial revolution (Bashmakov, 2007; Foxon, 2008; Oparaocha & Dutta, 2011). Also, a large body of data exists concerning its negative anthropogenic impact on the environment, particularly regarding the combustion of fossil fuels, has been reported (Biesiot & Noorman, 1999; IPCC, 2014; Rosales Carreón & Worrell, 2018). In recent years, there have been papers describing fossil fuel combustion for energy production as the main driver of the increase in greenhouse gases, which contribute to climate change and global warming and their adverse effect on society and the planet. Furthermore, the effects of climate change and global warming are even more severe in developing countries due to inadequate adaptation measures (Adger et al., 2003; Amoo & Layi Fagbenle, 2020; Artacho, 2020; Baatz, 2013; IPCC, 2014).

Clancy et al. (2019) suggest expanding access to clean energy and gender equality is pivotal for social development agendas. In parallel, it is necessary to consider the sustainability aspects of delivering clean energy sources to households (Oparaocha & Dutta, 2011). This approach has been on the agenda of the Sustainable Development Goals (SDGs), defined by the United Nations (UN), especially SDG 7, which calls for universal access to energy for all, and SDG 5, which demands gender equality (UNDP, 2019). However, the well-known phenomenon of exponential population growth (UN-Habitat, 2016) contributes to increased energy demand worldwide, especially in urban areas (IEA, 2021a), where the growth is often at an alarming rate. UN-Habitat (2016) estimates that nearly 43% of the world's population lived in urban areas in 1990. In 2018, this stood at 55% (UNDESA, 2019), and it is expected to continue rising to 70% by 2050 (IEA, 2021a). Hence, virtually all urban areas will absorb the expected growth in population worldwide (IEA, 2021a; UNDESA, 2019), making these environments the central intervention point to promote sustainability practices.

Data has been presented in the literature (Baynes & Musango, 2018; Grubler, 2012; IEA, 2021a; Madlener & Sunak, 2011; Rosales Carreón & Worrell, 2018) that suggests that, worldwide, urban settlements are the areas with the highest in- and outflows of materials and resources. According to the IEA (2021a), urban areas account for 75% of total global energy consumption and 70% of global CO_2 emissions. The industrial, transportation, residential and commercial sectors are the primary energy end users, accounting for 29%, 29%, 21% and 8% of the total energy consumption in 2018, respectively (IEA, 2020a). Considering the urbanisation trend and the mass movement of people from rural areas to urban centres, identifying strategies and actions to enable the sustainable development of these settings is of the utmost importance.

Multiple studies have been developed to understand and present viable solutions to reduce the negative effect of urbanisation on the environment. Some of these have focused on understanding urban energy systems through the energy transition (Baynes & Musango, 2018; Chabrol, 2016; Grubler et al., 2012; Keirstead, Jennings & Sivakumar, 2012; Rosales Carreón & Worrell, 2018). Of the many frameworks, the low carbon energy transition pathways have been studied the most extensively (Balmer & Hancock, 2017; Chabrol, 2016; Foxon, 2008; Foxon, Hammond & Pearson, 2010; Geels & Schot, 2007; Rosales Carreón & Worrell, 2018; Verbong & Geels, 2007; Van den Bergh & Bruinsma, 2008). These frameworks address society's challenges by transitioning to clean and renewable energy.

It should be noted that, as society evolves, many social issues unfold, and science examines their role and interactions for social development and their challenges to human beings. Among them, gender-related concerns unquestionably dominate the social, political and economic development agendas. In this regard, governments are increasingly called upon to adopt social inclusion measures in the design of their policies while promoting sustainable development. The energy sector is not exempted due to its cross-cutting characteristics and importance for achieving sustainable development and gender equality. A close look at the energy sector revealed that women comprise the social groups that suffer the most from problems deriving from a lack of access to clean energy (UNDP, 2019; WHO, 2020). However, according to Johnson, Gerber and Muhoza (2019), taking gender-related aspects into account during the decision-making process in the energy sector improves economic growth. Hence, understanding the role of gender is pivotal to promoting energy transition, especially in developing countries, where much of the population still does not have access to energy.

Although the relationship between energy sources and services has been studied extensively (Fell, 2017; Jansen & Seebregts, 2010; Kalt et al., 2019; Kaygusuz, 2011; Morley, 2018; Reddy, 2015; Sovacool, 2011a, 2011b), less attention has been paid to the link between energy sources, services, devices and gender to explain the persistent reliance on biomass in urban developing contexts. For instance, Jansen and Seebregts (2010) looked at how to effectively manage demand side management to ensure the security of energy service. Also, Kalt et al. (2019) and Kayguz (2011) focused on the need to look at energy services in the context of well-being, disregarding the energy sources used to meet end user needs. This study takes a holistic perspective, considering the energy sources, services, and devices and focusing on urban households' contexts. In the household environment, the socially constructed perception of gender influences how women and men interact with energy sources, energy services, and energy devices (Listo, 2018; Mechlenborg & Gram-Hanssen, 2020; Nastasia, Nastasia & Kartoshkina, 2009; Schiebinger, 2014; Schiebinger & Schraudner, 2011). This interaction influences how energy services are allocated amongst them, ultimately resulting in the current situation in which women are responsible for the household's energy services that use solid fuels, thereby affecting their well-being.

In developing countries, a long-standing problem has been the persistent dependence on solid fuels by urban households, in tandem with the lack of a contextual, theoretical framework for the urban energy transition. To address this gap, Batinge, Musango and Brent (2019) propose a modified framework focusing on unmet electricity markets, such as those in sub-Saharan Africa. However, their framework does not include gender, a significant enabling factor in energy transition (Clancy et al., 2019). There is vast evidence that gender-sound policies and frameworks are pivotal in ensuring a transition to clean and sustainable energy sources (Cecelski & Matinga, 2014; Clancy & Mohlakoana, 2020; Clancy et al., 2019; Modi et al., 2005; Pachauri et al., 2012). Despite this large body of studies, women's strategic energy needs are often overlooked when policies are designed, and they are yet to benefit from their outcomes fully.

Therefore, accelerating urban households' access to modern and clean energy sources in developing countries requires a gender-sensitive approach. This study focuses on understanding the existing energy transition framework, followed by analysing the gender role and the factors that drive fuel choice decisions within urban households. This then provides the foundation for this study, which aimed to provide a theoretical framework for gendered energy transition and, using Mozambican households as a case study, suggested transition pathways based on an induction and deduction approach, informed by the systematic integrative literature review, exploratory interviews and survey.

This study provides theoretical, empirical, policy and practical, and sustainable development goals contributions, namely:

a) ***Theoretical contribution***: it suggests a novel gendered theoretical framework to address biomass dependence in urban households in developing countries. The study contributes to the body of knowledge on gendered energy transition at a household level by considering gender issues in the transition process.
b) ***Empirical contribution***: it provides tools for location-specific approaches to assess gender roles and the factors that drive fuel choice decisions to understand the gendered energy transition in Mozambique. An evidence-based approach informed the transition pathways to phase out solid fuels in Mozambican urban households.
c) ***Policy and practical contribution***: the Mozambique government has passed a policy on the transition from biomass to LPG and electricity. Hence, based on the evidence-based methodology, this study supports policy regarding such a transition. Also, it suggests the necessary risk assessment to enable the transition pathways.
d) ***Contribution to Sustainable Development Goals***: the application of this study's recommendations can contribute significantly to households' well-being since they are directly related to SDG 7 and SDG 5.

1.2. Arguments for a gendered theoretical framework in energy transition studies

Introducing gender mainstreaming into energy social science research is pivotal for promoting energy transition. The historic and economic context has influenced energy transition pathways since the United Kingdom experienced the first modern energy transition in the early 1700s. There was a shift from organic fuels to a coal-based economy (Allen, 2012; Chabrol, 2016; Solomon & Krishna, 2011). In 1990, Eastern Europe experienced a transformational moment in its socio-political and economic spheres, which motivated many investigators to discuss the transition within this economy (Nastasia et al., 2009). Hence, the scope of their investigation was limited to that context and, to some extent, to other developed and emerging economies (Batinge et al., 2019).

Many investigators within the energy transition discipline have recently focused on moving away from a fossil fuel-based economy to low-carbon energy carriers and technologies, or so-called sustainable change (Allen, 2012; Geels, 2002, 2004; Gismondi, 2018; Sovacool, 2016). They have widened their ground of study by deeply analysing past energy transitions. To this end, they present models to predict future energy transition pathways, determine the key factors driving change within the energy systems, and how lessons can be taken from this to better understand future energy transitions. However, these studies have failed to recognise that developing countries need a different approach since they rely on solid biomass as their primary energy carrier (Brouwer & Falcão, 2004; Karimu, Mensah & Adu, 2016). In fact, biomass consumption is increasing in sub-Saharan Africa, primarily due to population growth (IEA, 2019a). According to the IEA report, nearly 80% of sub-Saharan Africa still uses this energy carrier to meet their cooking needs (IEA, 2019a). Adopting traditional energy carriers is responsible for forest degradation and severely impacts the health of the poor (Cecelski & Matinga, 2014). In Africa, household air pollution (HAP) is responsible for causing the premature death of an estimated 500 000 people annually (IEA, 2019a), and, across the globe, it puts at risk the health of 2.8 billion people (WHO, 2020).

In developing economies, indoor air pollution affects women and children the most (Cecelski & Matinga, 2014; McCarron et al., 2020). Not only are the energy carriers decidedly dirty (Atanassov et al., 2012; Cecelski & Matinga, 2014; WHO, 2020) and the technologies largely traditional (Batinge et al., 2019), but, more importantly, the technologies are inefficient (Brouwer & Falcão, 2004; Clancy et al., 2019; IEA, 2019a; Oparaocha & Dutta, 2011). It is worth noting that inefficient technologies deliver the same services but require households to spend longer than they would otherwise spend when adopting modern energy technologies (Clancy et al., 2019). Also, it refers to the calorific value that modern energy fuels possess compared to traditional ones. For instance, in Mozambique, the equivalent amount of energy attained in charcoal costs up to three-time what the household would have spent if they used LPG (Castán Broto et al., 2018). Therefore, moving away from traditional biomass dependence to modern energy carriers and technologies is fundamental for sustainable development. As stated previously, problems deriving from the lack of access to clean energy affect most women and children in the developing world (UNDP, 2019; WHO, 2020).

It is worth noticing that Mozambique is one of the six countries with the highest clean access deficit (IEA et al., 2019), and only 5% of the population in Mozambique has access to clean energy sources (IEA et al., 2019). The country estimates to achieve 50% grid connection coverage by 2023 (De Fatima, Arthur & Cockerill, 2019). However, the annual expansion rate is arguably too low to reach this goal unless there is a dramatic change in the country's energy system (De Fatima et al., 2019; Ibraimo, Robinson & Annegarn, 2017; Salazar, Castán Broto & Adams, 2017; Uamusse et al., 2019). So far, only 29% of the population is connected to the national grid (IEA, 2019a).

It is generally accepted that, with the growth rate of the population and increased need for energy access, over 30% of the global population will not have access to clean cooking solutions by 2023, and the bulk of these people reside in sub-Saharan Africa (IEA, 2019a; IEA et al., 2019). According to Ali (2021), only 61% of households have access to electricity, representing the lowest coverage compared to other regions across the globe. In Mozambique, the typical energy carriers that electrified households often rely on include electricity, LPG, kerosene, charcoal and fuelwood (Mahumane & Mulder, 2016). However, non-electrified households mostly rely on kerosene, charcoal and firewood. There are several reasons for the lack of access to modern energy sources in many low-income countries. Some of these are identified by Bouille et al. (2012) as (i) diminished financial resources, which contribute to limited or non-existent infrastructure; (ii) asymmetries of income allocation; (iii) government that is powerless or unwilling to implement policies to expedite access to modern energy sources; (iv) unjust deployment of modern energy sources; and (v) lack of adequate institutions, rules and regulations to enable fostering modern energy access.

There are myriad ways in which society can go about promoting clean cooking. These include electricity and LPG (Rahut, Behera & Ali, 2016; Rosenthal et al., 2018). LPG has been identified as an alternative to scaling up clean cooking in developing countries (IEA, 2019a; Rosenthal et al., 2018; Van Leeuwen, Evans & Hyseni, 2007; WHO, 2020). Also, to assure positive outcomes with clean fuel cooking policies, it is imperative to address fuel availability (Rosenthal et al., 2018). In Mozambique, fuel availability has been advantageous since the natural gas discovery in the Rovuma basin in 2010 (Mahumane & Mulder, 2016). The discovery placed the country in the sight of the international community as one of the world's largest gas reserves, attracting interest from sizeable multinational gas corporations (De Gregorio & Xiong, 2013; Salimo, Buur & Macuane, 2020). The gas discoveries are estimated at over 100 trillion cubic feet (tcf) (Xiong & Melina, 2014). In addition, Sasol Petroleum Temane produces natural gas in Inhambane province, which holds proven gas reserves of 2.6 tcf. The most recent discovery represents a significant challenge to the Mozambican government to optimise the exploitation of this resource to catalyse the country's economic development and improve the living conditions of its citizens.

There is robust evidence that many scholars are becoming aware of the link between gender, energy and poverty that influences the evolution of society (Clancy et al., 2007; Listo, 2018; Petrova & Simcock, 2019). This phenomenon led researchers to investigate the gender-energy-poverty nexus (Cecelski & Matinga, 2014; Clancy & Mohlakoana, 2020; Clancy et al., 2007; Oparaocha & Dutta, 2011; Pachauri et al., 2012; Pasqualetti & Sovacool, 2012; Petrova & Simcock, 2019). Consequently, this theme became the centre of debate in much social discourse across the globe and has been on the agenda of several international organisations. This trend led to the foundation in 1995 of ENERGIA, an international network on gender and sustainable energy. So, some widely known empirical evidence needs to be highlighted, including:

a) Energy consumption is responsible for climate change (Adger et al., 2003; IPCC, 2014; Rosales Carreón & Worrell, 2018). Worldwide, many people are still denied access to clean and modern forms of energy (IEA, 2020a; WHO, 2020).
b) Over 13% of the global population without access to clean energy sources, the 'energy-poor', are in developing countries (IEA et al., 2019), and it is in sub-Saharan Africa that the bulk (80%) are located (IEA, 2019a).
c) To meet their energy needs, the 'energy-poor' rely on traditional biomass, often collected unsustainably and represents a hazard to families (Baumert et al., 2016; Ihalainen et al., 2020; Sedano et al., 2016).
d) The lack of access to modern and clean energy sources has a disproportionate influence on women (Clancy et al., 2019; Danielsen, 2012; Oparaocha & Dutta, 2011; Rivas &

Cornwall, 2015), which simultaneously works against SDG 5 and SDG 7 (Musango et al., 2020).

Meeting women's energy needs is paramount for reaching sustainable development (Clancy et al., 2019). A gendered energy transition is an approach that could lessen the asymmetries between the access by men and women to clean fuels for their differentiated daily routines. Data scarcity relating to gender and energy consumption in urban developing environments, particularly in Mozambique, makes it difficult to provide an integrative and thorough assessment. Hence, the rationale for this study is to undertake a bottom-up analysis of the local energy system. It will explain how the transition from traditional energy carriers to modern energy access could be triggered within urban households in Mozambique. This was done by considering the specific attributes of the Mozambican economy, particularly those regarding household income levels and the energy carriers they rely on to meet their energy needs, explicitly considering the gender role. The study intended to analyse the factors that drive the existing energy consumption patterns by looking at gender roles within households.

This research urges a gendered energy transition in developing countries to phase out traditional energy dependence for five fundamental reasons. *Primarily*, and notwithstanding the support from several international agencies and institutions, donors and bilateral organisms, there is now much evidence supporting the hypothesis that Mozambique's likelihood of reaching universal access to modern energy by 2030 is fading (Castán Broto et al., 2020; De Fatima et al., 2019; UNDP, 201). Therefore, integrating mainstream gender into the national energy strategy is pivotal for accelerating modern energy access, which is argued to be one of the factors determining the speed of transition (Clancy & Mohlakoana, 2020; Clancy et al., 2019; Musango et al., 2020; Otero-Hermida & Lorenzo, 2020).

The *second* argument is that energy transition and security are global issues (Pasqualetti & Sovacool, 2012) and that, in developing countries, energy insecurity is one of the driving forces of energy poverty (Musango et al., 2020). While developed countries have adaptation mechanisms available in the event of a threat to fuel supply, developing countries suffer due to their dependence on external supply and lack of adaptation mechanisms (Pasqualetti & Sovacool, 2012). At the household level, energy security is fundamental to satisfying the energy services people require for subsistence needs, convenience, comfort and cleanliness, conspicuous consumption and social signalling (Sovacool, 2011a). These services are often met in poor economies through reliance on dirty and unsustainable fuels (Castán Broto et al., 2020; Salazar et al., 2017).

Third, energy poverty is gendered because it affects women disproportionally (Cecelski & Matinga, 2014; Ihalainen, Schure & Sola, 2020; McCarron et al., 2020; Oparaocha & Dutta, 2011; WHO, 2020). So, even though energy poverty affects many households, its consequences manifest differently among household members. Its manifestations range from social exclusion to severe health problems and the incapability to live life to the fullest (Petrova & Simcock, 2019). Several researchers conclude that the negative implications of traditional fuel dependence are unequal amongst genders, and women – among the householder members –suffer the most (Cecelski & Matinga, 2014; Clancy et al., 2007; Oparaocha & Dutta, 2011). Hence, this study argues that promoting modern energy access is gendered because women and men interact differently with energy sources, technologies, and services. For instance, a study conducted by Clancy et al. (2019) in Nepal and Kenya indicated that while men are interested in energy sources to feed refrigerators and audio-visual appliances, women prioritise energy carriers and technologies for cooking and heating. Central to such difference is the understanding that these gendered differences are driven by social, cultural, economic, and political contexts (Feenstra & Özerol, 2021) and impact women living conditions at different levels.

Furthermore, although the gender and energy nexus studies have focused mainly on developing countries (Feenstra & Özerol, 2021), researchers are currently investigating its manifestation in developed countries. In this regard, there is the work from (Clancy et al., 2017), in which the authors discuss a gendered perspective to address the increased imbalance between women and men and several societal areas, including energy access in the European Union. Building on Clancy et al.(2017), Robinson (2019) assessed gender and energy poverty in England, considering a socio-spatial analysis and found that in England, energy poverty is not gender-neutral and requires a gendered-sensitive perspective to address the negative impact it has on women. Hence, acknowledging that women and men place different emphasis on the sources and technologies to meet their energy needs – either for their routine activities or strategic requirements and are affected differently by energy poverty – prompts a gender-sensitive approach to energy transition (Clancy & Mohlakoana, 2020; Clancy et al., 2019). This study builds its argument on these facts. It seeks to provide a theoretical framework and energy transition pathways that are gender sensitive and simultaneously address the global agenda to promote sustainable development.

The *fourth* argument is that, despite the existence of guidelines that are gender comprehensive, there is a significant gap between policy recommendations and the outcomes deriving from their implementation. This can be better understood through the work of Clancy and Mohlakoana (2020), in which they claim that evidence of gendered policy efficacy remains scarce, despite the abundance of policy instruments available. Likewise, in Mozambique, the reality remains detached from the targets expected to be reached according to these instruments. This assessment emphasises the need for gender audits(Clancy & Mohlakoana, 2020) and a theoretical framework for energy transition built upon mainstreaming gender.

Lastly, women have been neglected in the decision-making process from both a national or international perspective (by fairly participating in policy design) (Clancy & Roehr, 2003; Clancy et al., 2019) and at the household level (by having the ability to choose their preferred energy sources) (Fingleton-Smith, 2018; Nwaka, Uma & Ike, 2020; Oparaocha & Dutta, 2011). This situation leads to two potential impacts. On the one hand, it has a macroeconomic impact as women's participation in the decision-making process has the potential to influence how society evolves and shapes their development pathways (Castro Lopes et al., 2021). On the other hand, women's participation in household decision-making through their empowerment could also work as energy transition enablers due to their ability to choose their preferred fuels. Hence, the global commitment to eradicating gender inequalities is pivotal to promoting social fairness and allows women to contribute to social development. So, this study argues that enabling energy transition also requires the involvement of all, especially women at the household level, due to their role in providing the household's energy services.

1.3. The need for a localised and context-specific approach

Montgomery (2008) says deforestation and forest degradation have reached unprecedented levels in Africa. This situation is negatively influencing the livelihoods of rural households. Similarly, as indicated by the IEA (2019a), IEA et al. (2019) and UNDP (2019), the likelihood that this trend will continue in Mozambique in the coming years is high unless changes are introduced to redefine energy consumption patterns. Their projections are based on urban population growth. This is substantiated by Mahumane and Mulder (2016) and Sedano et al. (2016). The latter also argues that the increase in forest degradation stems from increased demand for charcoal by urban households. Kissinger, Herold and De Sy (2012) conducted a study in developing countries and distinguished drivers for deforestation and forest degradation to determine the main drivers of this phenomenon. The authors concluded that factors contributing to deforestation are: (i) commercial and subsistence agriculture, (ii) mining, (iii) infrastructure extension, and (iv) urban growth.

However, agriculture is the main contributor (Jayathilake et al., 2021; Kissinger et al., 2012) and, according to the Food and Agriculture Organization and the United Nations Environment Programme, it accounts for nearly 73% of the total rate of deforestation worldwide (FAO & UNEP, 2020). On the other hand, the latter study found that (i) timber logging, (ii) uncontrolled fires, (iii) livestock grazing, and (iv) fuelwood harvesting and charcoal production are the main drivers of forest degradation. In Africa, the increased dependence on charcoal in rural and urban settlements tends to trigger slower adoption of cleaner energy sources (IEA, 2019a; Sedano et al., 2016). Although wood fuel consumption is considered a minor contributor to forest degradation worldwide, it represents the foremost driver in sub-Saharan Africa. The effect of forest degradation due to the demand for charcoal and wood fuel in urban areas in Mozambique has received considerable attention (Baumert et al., 2016; Jones, Ryan & Fisher, 2016; Sedano et al., 2016, 2020a, 2020b; Silva et al., 2019; Zorrilla-Miras et al., 2018).

It has been suggested by Hosonuma et al. (2012) that deforestation stems from the demand for fuel and charcoal by both rural and urban households. Also, it is generally accepted that a lack of awareness of the potential damage caused by the unsustainable collecting and consuming of biomass causes several adverse social effects (FAO & UNEP, 2020; Sedano et al., 2020a; Silva et al., 2019). This effect is on the environment, the climate system, the economy, and society. Within this spectrum, a global commitment has been made to address challenges such as poverty, infrastructure, innovation and environmental sustainability. These goals were called the Millennium Development Goals (MDGs), which Mozambique adopted in September 2000. The

MDGs indicated, among others, that by 2015, all signatories should ensure that 75% of poor urban residents have access to modern energy services for their basic needs (UNDP, 2015), which Mozambique failed to accomplish. However, the MDGs have been brought into the SDGs, and this study's goals are aligned with SDG 7, which calls for universal access to modern energy by 2030 and, to a lesser extent, SDG 5, standing for gender equality.

Several structural disparities from the social and cultural spheres condemn women to be vulnerable to energy poverty. These vulnerabilities expose women to many social problems, including: 'exclusion from the economy; time-consuming and unpaid reproductive, caring or domestic roles; susceptibility to negative physiological and mental health impacts; lack of social protection during a life course; and coping and helping others to cope' (Robinson, 2019:225). In fact, Clancy and Mohlakoana (2020) argue that understanding the difference between women and men in meeting their energy needs is fundamental for policy design that addresses the challenges embodied in households' energy requirements and can contribute to the adequate distribution of resources. The Mozambican Government is a signatory to the SDGs and acknowledges the need to identify mechanisms to promote modern energy carriers and gender equality. The Mozambican Energy Strategy acknowledges the need to actively identify, promote and disseminate the adoption of modern energy carriers and technologies. It established that, by 2025, all households should have access to electricity, either on or off the grid (Ministério da Energia, 2011).

Mahumane and Mulder (2016), based on the integrated Energy Outlook for Mozambique, suggest that it is unlikely that the Mozambican Government, through its Electricity Utility (*Electricidade de Moçambique* – EDM), will reach 100% electricity coverage by 2025. Also, they predict that many households will still be deprived of access to modern energy fuels by 2030. This view is corroborated by the IEA (2019b) and the UNDP (2019). The UNDP (2019) states that, despite improvements in increasing access to modern energy carriers, the net progress is fading due to population growth, especially in sub-Saharan Africa. In fact, recent predictions by the IEA (2020b) argue that COVID-19 is also to blame for the decreased rate of coverage of electrification in sub-Saharan Africa.

Reaching universal access by 2030 in Mozambique is a formidable task (Maria de Fatima & Cockerill, 2019) and requires great structural change within the energy systems actors (Gregory & Sovacool, 2019; Maria de Fatima & Cockerill, 2019; Salazar et al., 2017; Salite et al., 2021; Uamusse et al., 2019). Suppose universal access is to be reached by 2030. In that case, there is a need to improve the interaction among businesses, governments, institutions and households in ways that they act in a united front with complementary goals that cumulatively concur with energy system transformation. Moreover, the 2019 report from the Africa SDG Index and Dashboards indicates that Mozambique is one of the countries with the lowest score among Southern African countries (UNDP, 2019). From this perspective, to make progress and respond to the commitments made at the UN summit, there is a need to implement actions to improve the current scenario. The work conducted by the IEA (2019a), Abdelnour, Pemberton-Pigott and Deichmann (2020) and the FAO and UNEP (2020) suggests prioritising clean cooking. This study agrees with this and implies that other SDGs could correlate positively by scaling up clean cooking.

1.4. Gaps in the mainstream literature on energy transition

From the plethora of published documents on energy transition frameworks, the literature search identified one leading school of thought, the '*founding theoretical framework*', named by Köhler et al. (2019). This school of thought include four frameworks, strategic niche management, the multi-level perspective, transition management and technological innovation systems, proposed by Kemp, Schot and Hoogma (1998), Geels (2002), Loorbach (2007) and Bergek et al. (2008), respectively. They, therefore, currently have stimulated the interest and attention of all stakeholders in the energy industry. These scholars built their theories considering the common ground of the co-evolutionary nature of the system dynamics. Although these theories come from the same school, they bear distinct boundaries in their philosophies, which are not necessarily excluding but complementary. The degree to which low-carbon energy transition has been discussed in academia is profound, not only in policies but also in action courses, funding programs and agreements, which differ substantially from the debate in developing countries. There is not only a lack of profound academic debate and studies in developing countries, but there is no substantial change in their energy systems.

The debate on energy transition frameworks is ongoing, and most theories are being re-shaped to address some of the criticisms they have faced individually or collectively. The multi-level perspective, the most prominent energy transition framework, has been the subject of several criticisms. Some of these criticisms have been extensively debated in Genus & Coles (2008); Smith, Vob & Grin (2010); Cherp et al. (2019); and Kanger (2021). For instance, among these criticisms, the lack of policy dimension has been one of the common issues. The policy dimension, which manifests in the government's role in enabling energy transition, is corroborated by Loorbach & Meadowcroft (2012) in developed countries but has also been an advocate as the *sine qua non* condition in developing countries (Clancy et al., 2019). The government's role lies in the global and local agendas for sustainable development, and they have the power and authority to design policies and strategies that bind all energy stakeholders. Hence, this study discussion focuses on government leadership that delivers inclusive policies to enable the gendered transition.

Also, the multi-level perspective extensively values bottom-up change, in which niche innovation is the co-centric environment to change the incumbent regime. This emphasis in developing countries, such as Mozambique, could be biased. Not only because the economy is primarily services centred and depends on the importation of most commodities but also because the ability for niches to flourish is also linked to financial capabilities, which are often lacking in developing countries (Sovacool & Gregory, 2019). This shortcoming is also verified in other frameworks such as strategic niche management and technological innovation system. So, for contexts such as Mozambique, already mature technologies from developed regimes have the potential to leapfrog the niche stage with proper landscape support. Hence, the transition framework needs to encapsulate this feature so that the transition to modern energy can occur.

Within this view, the transition theories are argued to be western-oriented (Castán Broto et al., 2018). Thus, Köhler et al. (2019) concluded that most of these studies focused on Northern European countries. However, the Netherlands, the United Kingdom, and the United States of America dominate (Batinge, Musango & Brent, 2019). This dominance could be linked to their CO_2 emissions limitation under the Paris agreement 2015 and the Kyoto Protocol before that, possibly due to research funding inequalities. Hence, researchers shaped their studies by focusing on a specific conceptual area and utilising their geographical area to explore and develop theories.

It could also be because many transition studies are related to shifting from fossil-driven economies to low-carbon or sustainable economies. These countries depend highly on carbon-intensive energy technologies, which are harming the environment (IPCC, 2014). Conversely, the scenario is different in developing countries as their dependence on fossil-based energy carriers is relatively lower. Additionally, energy access is no longer a matter of debate in these countries within the energy transition context. There is usually total coverage, either via on or off-grid electrification.

Considering this, Batinge, Musango and Brent (2019) identified some limitations in the mainstream energy transition literature. The authors investigated how the existing energy transition framework can be applied in Africa. The conclusion was that the existing energy transition framework failed to address the nature of the African country's energy sector. To address the limitation, the authors suggest a modified framework. The authors built their theory upon the multi-level perspective of the technological transition. Despite the progress made with the modified energy transition, some aspects are yet to be addressed. This study argues for the explicit inclusion of gender roles within the theoretical framework of the energy transition for urban developing contexts. To this end, the study builds its argument on the existing transition frameworks, emphasising the modified transition framework.

1.5. Statement of the problem

The use of biomass is increasing in sub-Saharan Africa and continues to rise. This trend undermines SDG 7, which demands affordable, reliable, sustainable and modern energy by 2030. Moreover, traditional biomass is responsible for the premature deaths of women and children due to HAP caused by its combustion. This situation further jeopardises the achievement of SDG 5, which promotes gender equality. Hence there is a need to know how households can transition to clean energy while considering gender roles is relevant because it allows the definition of energy policies that align with women's and men's strategic energy requirements. So, the gendered theoretical framework for energy transitions and the required pathways to enable the transition can inform the sustainable energy transition in Mozambique to improve access to modern energy services for urban environments.

1.6. Research objectives

This study aimed to examine the gender role in the energy transition to foster modern and clean energy access in Mozambican urban households. The research goal was achieved through the following objectives:

i. To develop a theoretical framework for gendered urban households energy transition;
ii. To assess gendered energy profiles and energy services in urban households in Mozambique; and
iii. To examine pathways to gendered urban energy transitions in Mozambique at the households level.

1.7. Research questions

The research objectives were addressed according to the following research questions:

Research questions for objective 1:

i. How effectively are the existing energy transition frameworks addressing energy-related issues in developing countries?
ii. Which are the steps toward a gendered transition framework in urban households in developing countries? and
iii. What are the interventions for the energy transition in developing countries?

Research questions for objective 2:

i. What households reside in urban areas, using Maputo as a case study?
ii. Which are the current energy sources, services and devices utilised by Maputo households?
iii. What factors influence fuel choice decisions for Maputo households? and
iv. How do gender roles influence the current energy consumption patterns for Maputo households?

Research questions for objective 3:

i. What are the present energy transition pathways, their motivations, and how are they related to the developing world?
ii. Which gendered energy transition pathways exist, and what themes do they address?

iii. How can this study build the past and present empirical literature to provide new typologies of the pathway forward to address urban developing households persistent dependence on solid fuels? and

iv. Which are the key risks for implementing gendered energy transition in urban developing environments?

1.8. Importance of the research problem

The present study is fundamental to understanding how gender roles influence the current energy system at the household level in Maputo city, thereby identifying the leverage intervention points to foster access to modern and clean energy for all by 2030. In tandem with this, there is a global scenario in which society faces environmental and ecological problems that endanger our generation and future generations. Moreover, the adversity resulting from global warming affects all, especially developing countries, because they lack adaptation and resilience mechanisms. In this context, the involvement and engagement of all nations, regardless of their level of development, are crucial. In this way, the present study concerns several stakeholders, and their interaction is depicted in Figure *1.1*.

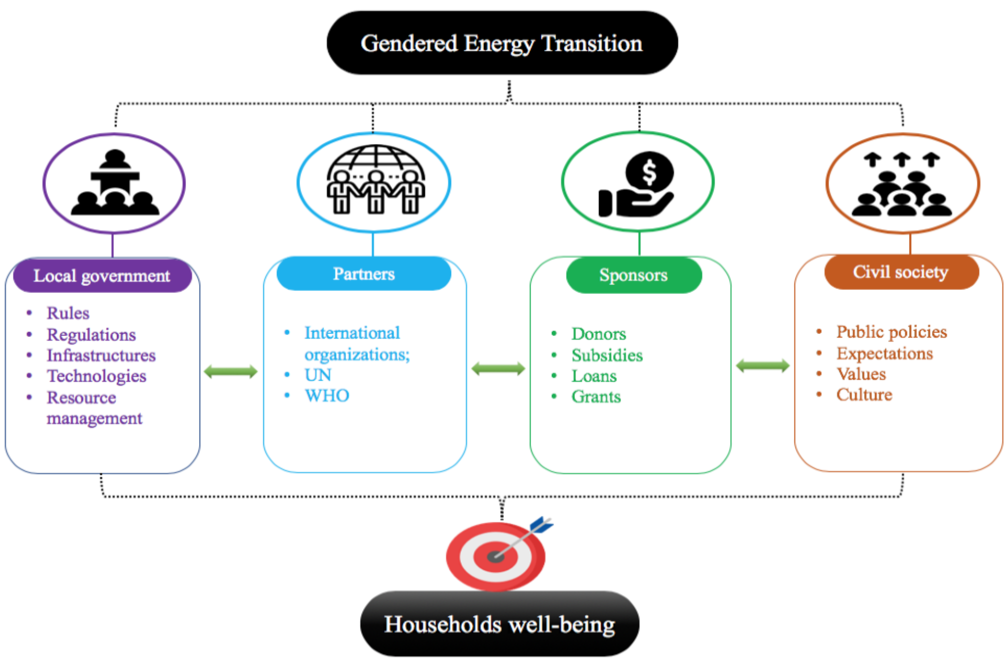


Figure 1.1: Study interest groups
Source: Own visualisation

1.9. Scope of study

The scope of this study was limited to urban households in Maputo city. Thus, it does not focus on the whole of Mozambique, nor all urban or rural settlements across the country. However, although the city of Maputo differs from other larger cities across the country because of its relative development, it bears some fundamental similarities in terms of the consumption patterns, buildings structures, and layers of the urban areas, such as urban, peri-urban and suburban (Castán Broto, Arthur & Guibrunet, 2020; INE, 2021). The study focused on households' energy needs and the phenomena driving their choice of fuel to meet the energy services they require. The literature review and the survey showed that energy transition is dynamic and requires location-specific assessment due to the differentiated socio-cultural, political, economic and resource availability circumstances. The study does not provide a panacea to the diverse nature of current energy systems at local, national, and international levels. Instead, the study suggests a different yet complementary approach to changing the urban developing energy regime. So, generalisation to the developed world context was considered unreasonable. Although the study recognises that the underlying factors that drive solid fuel dependence are similar to many other sub-Saharan African countries, it recommends caution in its replication because of the location-specific situation.

1.10. Study layout

This study is presented in seven chapters. The introduction is presented in Chapter 1. The chapter presented the arguments for a gendered theoretical framework for the energy transition in urban developing environments, the problem, and the main objectives that constitute the pillars of this study. Chapter 2 provides a detailed description of energy transition theory through a critical literature review. The outlook of the Mozambican energy sector on gendered energy transition is presented in Chapter 3. In this chapter, the study shows why a localised and contextual approach is fundamental in developing world environments. Then, Chapter 4 discusses the research methodology and provides detailed information on the research paradigm, design, and methods. Chapter 5, the study presents the findings of the research. The chapter is divided into two main sections, results and discussion. The gendered energy transition pathways of urban Mozambican households that result from the deductive-inductive approach are presented in Chapter 6. Lastly, Chapter 7 presents the conclusions, a summary of the contribution and recommendations for solving the research problem. The chapter also shows the study's contribution and makes proposals for future research.

CHAPTER 2: GENDERED ENERGY TRANSITION - A LITERATURE REVIEW

2.1. Introduction

This chapter undertakes a critical literature review, combined with an integrative systematic literature review on gendered energy transition, to address the first objective of the research: *to develop a theoretical framework for a gendered energy transition for urban households*. This assessment required examining how the gender role is perceived within the energy sector and how it determines the household's energy consumption patterns. This analysis is crucial to encapsulate the potential and fragilities embedded within the existing energy policies. Therefore, the critical review provides the study's theoretical background, which consists of the concepts of gender, gendered innovations, gendered transition, and gendered energy transition pathways. In gendered innovations, the aim is to provide what the mainstreaming scholar on innovation envisages to tackle and address innovation issues affecting the developing world. The chapter also focuses on the contribution of technological development to fostering novelty uptake within urban households in developing countries. Furthermore, sub-section 2.7 presents this research's theoretical contribution to academia, resulting in a novel, gendered theoretical framework to address biomass dependence. Then the chapter outlines the theoretical framework for the gendered energy transition. Also, it opens a discussion on the energy transition pathways. The chapter closes with a summary that overviews the topics discussed. The following section discusses energy transition theory and frameworks.

2.2. Energy transition theory

The first research question that the first objective of this study aimed to address was: *how effectively are the existing energy transition frameworks addressing energy-related issues in developing countries?* To address this research question, the study started by investigating the theory of energy transition, which enabled identifying different scholars discussing energy transition frameworks. It was found that the literature on energy transition has stimulated the interest and attention of all stakeholders in the energy sector. This stimulus has been driven by the significant social challenges faced in the 21st century, including energy justice, poverty, resource depletion, and climate change. So, energy transition theory has drawn the attention of many researchers seeking to present the industry with a globally adaptable method to describe drivers and pathways for energy transition. Transition theory frameworks have evolved through history, and their concepts, analogies and application have been subject to refinement, adaptation and redefinitions. Energy transition responds to the pressing global issue of achieving universal access to modern forms of energy for all, as stated in SDG 7 and to counteract climate change. Energy transition represents the way society can navigate to attain this goal. Researchers have provided solid groundwork on the transition theory, how it manifests across different economic sectors, and how energy systems have evolved since the industrial revolution.

A system can transition when fundamental changes are experienced in it. These changes depend on how individuals position themselves according to their values and behaviours (Grin, Rotmans & Schot, 2011). This perspective makes transition timing unpredictable since the system faces non-linear behaviour. Furthermore, when there is order and stability, the change is slow, and it is fast when chaos and instability influence the system (Loorbach, Frantzeskaki & Lijni es Huffenreuter, 2015; Sinclair et al., 2015). Following this analogy, Rauws and De Roo (2011) explored energy transition in the *peri*-urban areas and concluded that the velocity, intensity, and result changes cause vary as the system evolves.

The transition literature includes the concept of transformation in its analysis. Although the elements of a transformation are still debated, the term is a critical concept to be considered, especially when discussing transition theory. The two are sometimes used interchangeably (Sinclair et al., 2015). This study finds them similar, and many scholars share the same view (Bartholdsen et al., 2019; Lawrenz et al., 2018; Lieu, Sorman et al., 2020; Sinclair et al., 2015). Since transition is directly related to the behavioural aspect of the individuals who comprise the system, its occurrence is very unpredictable, mainly because the system could influence the behaviour of the actors. Therefore, the resulting outcome is often uncertain, hence the importance of the context under which the transition occurs.

The term energy transition is explored differently, following the different perspectives that the authors emphasise. These different emphasis results from the complexity surrounding the theory of transition (Cherp et al., 2018). For instance, on the one hand, some use the terminology ‘energy transition' (Grubb, Hourcade & Neuhoff, 2015; Han, Wu & Zhang, 2018; O'Connor, 2010; Grubler, 2012). Grin, Rotmans and Schot (2011), Solomon and Krishna (2011) and Kim (2019), on the other hand, use the term to discuss 'sustainable transition', and others widen it to 'low-carbon transition' (Ediger, 2019; Geels et al., 2017; Rogge & Johnstone, 2017). These different approaches result from the diverse scope, purposes, and methods of energy transition studies (Cherp et al., 2018).

The transition could be defined as a shift away from a non-desirable or flawed system experienced through a long-term change resulting from transforming the existing system's structure, practice and culture. Researchers seeking to describe this phenomenon do it in ways that fit their application to the context and circumstances on which the research is based. However, a common denominator among them is the structural change of the energy system to a more desirable situation from a social, economic and environmental point of view. O'Connor (2010:8) defines an energy transition as '[a] particularly significant set of changes to the patterns of energy use in society, potentially affecting resources, carriers, converters, and services'. Similarly, Grubler, Wilson and Nemet (2016:18) define energy transition as 'a change in the state of an energy system'. This study focuses on these definitions rather than most contemporary academics on energy transition. This means that the concept focuses more on the process than the drivers, fuel sources or expected outcomes, as many authors prefer. This is mainly when the definition indicates that the energy transition is shifting from fossil-based to low-carbon economies. Castán Broto et al. (2018) discuss that the transition often increases CO_2 emissions in certain economies, particularly in post-colonial contexts, due to the use of fossil-based energy carriers.

As previously stated, the founding theoretical framework includes four ramifications: strategic niche management, the multi-level perspective, transition management and technological innovation systems (Köhler et al., 2019; Markard, Raven & Truffer, 2012). However, the study also focuses on three other transition frameworks: the meta-theoretical model of Cherp et al. (2018), the framework for the unmet electricity markets of Batinge, Musango and Brent (2019), and the regime life-cycle framework of Kanger (2021). These authors developed these frameworks to address some issues deriving from the application of the work done by mainstream energy transition researchers, especially the multi-level perspective. Therefore, in line with the first research question of the objective in perspective, the following subsections present and discuss the existing energy transition frameworks and evaluate their effectiveness in addressing developing countries' energy-related issues.

2.3. The founding theoretical frameworks

2.3.1. Strategic niche management

The fundamental goal of Strategic Niche Management (SNM) is to provide an 'umbrella' for the breakthrough technical artefacts to mature and compete with the existing regime (Kemp, Schot & Hoogma, 1998; Witkamp, Raven & Royakkers, 2011). The critical debates of SNM stem from the need to comprehend and administer niches strategically so that radically sustainable novelties are adequately disseminated. Even more, the radical artefacts should generate a more significant market within the dominant socio-technical regimes (Schot & Geels, 2008; Witkamp, Raven & Royakkers, 2011) and eventually become a feasible substitute for the pre-existing socio-technical regime. For the novelties to surpass all social barriers, there is a need to involve the market players, government, traders and end users in the decision-making process (Lieu, Sorman, et al., 2020). Thus, synergies from each are capitalised on to bring about system transformation (Foxon, Hammond & Pearson, 2010). This approach could potentially eliminate what Munro, Van Der Horst and Healy (2017) described as 'winners and losers' situations resulting from the energy transition from solid fuels to clean energy access.

As discussed by Kemp, Schot and Hoogma (1998), SNM makes it possible to avert the challenges that radical innovation encounters by mastering the processes and interactions in a niche internal process. These niche internal processes have been widely discussed (Geels, 2002; Kemp, Schot & Hoogma, 1998; Schot & Geels, 2008; Witkamp, Raven & Royakkers, 2011). The first process is the need to align expectations regarding future developments, hence the envisioning emphasis described by Schot and Geels (2008). The envisioning approach involves articulating end users' needs with supportive institutions allowing guidance, attracting attention, and giving legitimacy to the niche. Secondly, niche management enables the enlargement of social networks, though this is argued to be a long process (Markard & Truffer, 2008; Smith, Stirling & Berkhout, 2005).

The SNM approach has been criticised for emphasising only the early phases of development (Geels, 2019; Kanger, 2021). Also, a critique has been raised on limiting regime changes to niche innovation than changes from within the regime, which, though at a slow pace, could result in radical innovation (Genus & Coles, 2008) or could guide niche innovations (Penna & Geels, 2015). The excessive emphasis on niche innovations in the Mozambican case is detrimental, not just because the economy is mainly services-based (De Brito, 2009) but also because of the limited research and development capabilities and support scheme (Gregory & Sovacool, 2019). Although the essence of SNM is arguable reflexive and value experiments and learning processes (Schot & Geels, 2008), which is pivotal for system transformation, it possesses fundamental limitations for a linear implementation in urban developing environments such as Mozambique. This limitation stems from their focus on just sustainable transition, implying in *lato sensu*, low-carbon transition, but also because they lack a contextual approach (Kumar, Höffken & Pols, 2021).

So, to address this issue, this study suggests leapfrogging following Batinge, Musango and Brent's (2019) recommendation for developing countries. Hence with a different approach than their focus on renewable energy for the energy services, but considering mature, efficient and clean energy sources and technologies adopted in other mature regimes, mostly from developed countries, such as electricity and LPG as an alternative for biomass dependence. In developing contexts, the use of such novelties, which are often modern and clean energy technologies and carriers, could potentially free women and children from time-consuming activities.

2.3.2. Multi-level perspective

The Multi-Level Perspective (MPL) is a framework that describes the long-term technological transition that occurs in a system. The MLP bases its premises on describing and analysing how systems are interconnected to change the regime, hence the co-evolutionary concept of technological transition (Cherp et al., 2018; Geels, 2002, 2010; Geels & Schot, 2007; Köhler et al., 2019; Markard & Truffer, 2008). Moreover, the MLP framework describes the relationship between society and technology that results in the so-called sociotechnical transition. The co-evolutionary patterns under which the MLP falls imply an interaction within and between the three levels that comprise the framework (Geels, 2002; Rip & Kemp, 1998). These levels encompass the sociotechnical landscape (macro-level), sociotechnical regimes (meso-level), and niche innovations (micro-level).

The first level is the *socio-technical landscape*, representing an independent exogenous environment that constitutes the global or national domain and is composed of rigid elements that do not change easily (Geels, 2002, 2018; Sinclair et al., 2015; Smith, Voß & Grin, 2010). However, it can exert pressure on both the regime and niches to promote niche innovations, thereby triggering changes in the regime (Markard & Truffer, 2008; Schot & Geels, 2008). Geels (2018) argues thatwo groups of factors constitute this level. The first includes slow-changing trends, such as socioeconomic development, change in deep-seated cultural values, political regime change and population growth. The second group includes exogenous or unpredictable events, such as conflicts, global catastrophes, political disturbances, and financial constraints. Both factors influence regimes and niches, though to a different degree.

The second level is the *socio-technical regime*, which is the dominant institutional structuring that enables relevant social functions to be fulfilled at a given time (Frantzeskaki & de Haan, 2009; Geels, 2002; Köhler et al., 2019; Smith, Voß & Grin, 2010). Thus, the regime represents the traditional way a particular economy meets its energy needs. Regimes are argued to be stable and resilient domains in which structures, goods, lifestyles, social values, end user behaviours, practices, beliefs, rules, and principles are highly established so that they create path dependency (Cherp et al., 2018; Markard & Truffer, 2008; Mekhdiev et al., 2018; Smith, Voß & Grin, 2010). The regime uses technological lock-in as a defence mechanism if the pressure from the external landscape allows niche innovation to threaten its stability.

The third level is *technological niches*, representing the spheres in which radical innovations are created, which function as ‘sheltering zones’ for the novelties to mature (Geels, 2002; Smith, Voß & Grin, 2010). Niches’ main feature is that they do not have rigid boundaries. Moreover, the actors, networks, and institutions are somewhat unstable and less established than those of the socio-technical regimes (Byrne et al., 2011; Castán Broto et al., 2018). The novelties pioneered by niches do not enter regimes quickly because regimes are resilient and established spaces. Hence, the system functions in ways that react to the current technology, and if not pressured, the novelties will not progress from their niche level (Cherp et al., 2018; Geels, 2002).

The MLP provides the energy social science field with an entire scope of analysis of the co-evolutionary nature of the technological transition. It also provides a starting point for analysing the transition from a broad perspective and adapting to several situations, especially those in developing countries. Therefore, several authors (Batinge, Musango & Brent, 2019; Cherp et al., 2018; Kanger, 2021) have built upon the MPL to discuss further how the energy transition can be attained. Despite its remarkable influence within the energy transition discourse, the MLP has been subject to several criticisms (Genus & Coles, 2008; Kanger, 2021; Smith, Stirling & Berkhout, 2005; Smith, Voß & Grin, 2010).

One of the key criticisms that the MLP has been widely subjected to is neglecting the role of actors and agency (Genus & Coles, 2008; Smith, Stirling & Berkhout, 2005). Although Geels (2011: 29) clarified it by stating that '*MLP is shot through with agency, because the trajectories and multi-level alignments are always enacted by social groups*', the issue remained somehow unclear (Fischer & Newig, 2016; Levidow & Upham, 2017). Which inspired the work of De Haan and Rotmans (2018), who attempted to explicitly define who are the actors and the agency that not just the MLP refers to but also other founding transition frameworks. Different categories fit actors' roles for energy transition within the energy system and are malleable through time (Fischer & Newig, 2016). According to De Haan and Rotmans (2018), there are actors with power (agency) and those with limited capacity to exert change in the undesirable energy system (path dependent). Therefore, building on De Haan and Roytmans (2018), this study looks at actors as those with agency and act toward a transformative change of the incumbent regime. These actors are at all societal levels (government, civil society, and market). Hence, they are not just at the household level but are also at the governmental arena and market players with decision power to positively influence the current regime change, which is biomass-dependent.

Furthermore, the question raised by Köhler et al. (2019: 6) '*do transitions always take multiple decades*?' is of tremendous relevance in the case of developing countries. The relevance stems from one of the core arguments of the co-evolutionary and systemic transition approach of the

MLP, referencing that transition does not come easily and takes a long occur (Geels, 2002). However, several authors have suggested accelerating energy transition to phase-out, not just carbon-intensive regimes but also solving unmet electricity markets in developing countries. For instance, Gorissen et al. (2018) suggest several phases, including replicating innovative approaches from one system to another, to accelerate its uptake by end users. In Mozambique, especially at the household level, technological replication would benefit the current energy consumption patterns, thereby accelerating the transition pace.

Edmondson, Kern and Rogge (2019) also suggested applying a policy mix enacted by an entity with an agency that can meaningfully control resource flow to foster the energy transition. Also, Batinge, Musango, and Bent (2019) discuss expediting energy transition in developing countries, leapfrogging to renewables. As discussed in the SNM, in the case of Mozambique, accelerating the energy transition in urban households is paramount due to the environmental and health-related issues that the biomass regime cause to women. In this regard, this study values the MLP framework. However, it suggests re-alignment to the developing world contexts considering the gender dimension at the center of the energy transition. The interaction of the three levels of the MLP framework enables identifying the leverage points for intervention, considering aspects such as fuel availability (LPG and electricity as potential clean fuels), culture (gender role) and affordability (how prices influence household's energy choice).

2.3.3. Transition management

The Transition Management (TM) framework is based on applying the term 'management' from a systemic standpoint and, in this case, the energy system. In a complex social system, such as the energy system, TM serves as a valuable tool that potentially dictates the pace, trajectory, and change magnitude in the existing regime (Kemp, Rotmans & Loorbach, 2007; Loorbach, 2010; Loorbach, Frantzeskaki & Lijni es Huffenreuter, 2015). However, attaining the desired outcomes is a challenging process and requires a multidimensional approach so that the combination and interaction of the system's actors are aligned to induce change. The model advocated by TM scientists refers to more significant government intervention (Loorbach, 2010) and its ability to design sustainable energy policies as the driving force for changing the energy regime (Schot & Geels, 2008). This perspective is defended by Foxon, Hammond and Pearson (2010) when describing the avenues leading to change in the energy system and introducing the perspective of government leadership.

According to Witkamp, Raven and Royakkers (2011), TM is similar to the underlying SNM. Both advocate the need for shared expectations and highlight the role of experiments and the power of the learning process. However, TM is the entrance point of shared long-term vision in what Schot and Geels (2008) define as a '*transition arena*,' composed of technological niche, socio-technical regimes, and external social actors. By doing so, TM stimulates changes in the incumbent regimes through niche experimentations and opportunities (Kemp, Rotmans & Loorbach, 2007; Loorbach, Frantzeskaki & Lijnis Huffenreuter, 2015; Witkamp, Raven & Royakkers, 2011). Hence, the managerial framework provides the necessary instruments to connect gendered innovation within a niche and possesses a fundamental starting point for deploying gender-sound energy technologies.

Loorbach (2010) argues that transition management happens according to a cyclical motion. The cyclical feature of the framework does not imply that there are starting points and endpoints (Loorbach, 2010). Instead, the events and features act interchangeably as they reinforce one another differently, and the system's outputs vary according to the context in which they occur (Frantzeskaki et al., 2012). The managerial aptitudes of the governance institution enable the provision of means, capabilities and networks to face the uncertainty and complexities that characterise social structures (Edmondson, Kern & Rogge, 2019; Meadowcroft, 2009). Four elements work as enabling factors: (i) *the arena* (this constitutes spaces where niche and regime actors interact); (ii) *the agenda* (this responds to the questions, what is envisioned as an ideal energy system and which pathways can lead to the transition vision?); (ii) *the experiments* (these constitute artefacts resulting from innovation and their capabilities, allowing learning processes); and (iv) *the monitoring* (this represents an ongoing process, whereby the system's actors are monitored at all levels, including their aptitude to embrace change) (Frantzeskaki, Loorbach & Meadowcroft, 2012; Kemp et al., 2007; Loorbach, 2010; Loorbach et al., 2015). Figure *2.1* illustrates the TM model.

Figure 2.1: Transition management cycle
Source: Adapted from (Kelly, Ellis & Flannery, 2018; Loorbach, 2010; Loorbach & Rotmans, 2010)

Despite its contribution to the body of knowledge within the founding theoretical framework, there have been several criticisms of the TM framework. These include, but are not limited to, its arguable top-down nature (Shove & Walker, 2007) and lack of explicit narrative on a policy role. Also, it looks at government as facilitators, not agents of change, influencing internal regime change (Köhler et al., 2019). The allegation of the top-down approach has been extensively clarified (Loorbach, 2010; Loorbach, Frantzeskaki & Lijnis Huffenreuter, 2015; Loorbach & Meadowcroft, 2012; Loorbach & Rotmans, 201)). Regarding the government role, Edmondson, Kern and Rogge (2019) used the socio-technical systems to discuss policy mix to foster sustainable energy transitions. Also, Foxon, Hammond and Pearson (2010) provide the pathways that could be adopted for a sustainable transition. This study seeks to add the aspect of the transition agenda by adding a gendered energy transition agenda. This agenda refers to developing, implementing, evaluating and monitoring gendered-oriented energy transition goals in developing countries. Such an agenda allows for addressing biomass dependence among urban households.

Like the MLP, TM focuses on managing the energy transition of multiple systems that faces diverse development stages (Kanger, 2021). This calls for cautionary tales brought to attention by Shove and Walker (2007) on how to manage energy transition within neoliberal capitalism and its nuances that contribute to the regime's lock-ins and path-dependence (Mekhdiev et al., 2018) to a completely different panorama. This could explain why Geels (2002) recognises that regime change takes time, even decades, to occur, which could work against the need to accelerate energy transition at the Mozambican household level. Therefore, this study suggests localized and contextual specific energy transitions to address this issue. Hence, its application requires not just implementation of the transition management theory, though adjusted, in ways that the interaction between the state, markets and society are balanced to set a proper tone for the transition direction. Furthermore, building upon the TM, the transition to modern energy sources such as natural gas or electricity in Mozambique will require harmonised and integrative institutional and financial management systems.

2.3.4. Technological innovation systems

Technological Innovation Systems (TIS) are the heart of energy transitions because, without them, society would live in a rudimentary fashion (Arapostathis & Pearson, 2019; Binz & Truffer, 2017; Grubler, Wilson & Nemet, 2016; Jacobsson & Bergek, 2004). The TIS concept calls for a redefinition of factors, such as actors, networks and institutions (Carlsson et al., 2002; Markard, 2020), and the relationships among them dictate the success of a technology-specific innovation system (Binz & Truffer, 2017; Jacobsson & Bergek, 2004; Markard & Truffer, 2008; Smith et al., 2010). In fact, according to Markard (2020: 2), technological innovation systems are defined as 'a set of networks of actors and institutions that jointly interact in a specific technological field and contribute to the generation, diffusion and utilization of variants of technology and/or product'. Indeed, innovation systems are embedded in the social structures that we live in (Carlsson & Stankiewicz, 1991; Carlsson et al., 2002; Tigabu, Berkhout & Van Beukering, 2015). Although change does not happen easily, and actors' goals and expectations often are divergent (Bergek et al., 2008) due to their complex nature (Berkhout & Van Beukering, 2015; Carlsson et al., 2002; Gosens, Lu & Coenen, 2015; Tigabu, Markard, 2020), providing direction through the implementation of TM, SNM and MLP frameworks will enable technological change.

At a household level, inefficient and rudimentary artefacts dominate the sectoral regime. Despite the increased deployment of renewables in Mozambique (Castán Broto et al., 2018), modern energy access is not following the same pace. According to these authors, innovation and technology are pivotal in introducing off-grid modern energy access since infrastructural development is a significant challenge because of the country's financial constraints. It also provides a sphere for men and women to participate in the decision-making process, so the innovation is gender sound and benefits both sexes equally (Lee & Pollitzer, 2016; Łapniewska, 2019). This technology change is fundamental in the context of developing countries (Ambole et al., 2019; Tigabu, Berkhout & Van Beukering, 2015). Hence, expediting a system of innovation within these countries could potentially deliver two great dividends: first, economic growth and sustainable development, and second, gender equality.

The complex nature of poverty, unemployment, demographic change and climate change requires an innovative solution for social inclusion. So, TIS need to shape social innovations, which include the development of new technologies, approaches, philosophies and organisations to solve social problems (Levidow & Upham, 2017; Lindberg et al., 2016; Warnecke, 2017; Witkamp et al., 2011). Markard and Truffer (2008) imply that, by merging the fundamentals from the MLP with those found in an innovation systems theory, the result is the TIS. Moreover, their conceptual differences are becoming minimal (Weber & Truffer, 2017). The work presented by Jacobsson and Johnson (2000) combined innovation systems and technological systems. The authors claim that, when studying the different ways to supply energy, the technical systems comprise the specific technology resulting from the innovation system. Later, Jacobsson and Bergek (2004) concluded that innovation has successfully influenced the uptake of renewable energy technologies in Germany, Sweden and the Netherlands. Since gender is a social problem, social innovation emphasises the need to bring gender issues into the discussion (Warnecke, 2017) and address them in ways that ensure social justice. This is, therefore, one of the aspects that this study aims to address by explicitly demarcating the system's actors at the household level. The study looked at households' socially perceptions of gender and its consequences on the chore allocations to inform TIS on the leverage points of intervention to promote gendered innovations.

Furthermore, like SNM, the TIS emphasizes systems innovation in its early stages of development (Kanger, 2021), disregarding the need to stabilise the current system (Köhler et al., 2019). This was previously discussed in the SNM subsection. Hence, the aspect that still needs to be highlighted as the core-centric of this motivation is lessons from other clean and modern energy systems. These modern practices need to be replicated in the Mozambican energy system at the household level. Consequently, it could accelerate the uptake of innovative technologies such as LPG and electricity. In this respect, this study values the TIS approach to emphasize the need to focus on a specific technology (Markard, Hekkert & Jacobsson, 2015).

2.4. Modified transition frameworks

2.4.1. Meta-theoretical framework

Mainstream energy transition models have been the subject of cautionary criticisms (Berkhout, Smith & Stirling, 2004; Grubb, Hourcade & Neuhoff, 2015; Kanger, 2021; Markard & Truffer, 2008; Meadowcroft, 2009; Shove & Walker, 2010; Smith, Stirling & Berkhout, 2005; Smith, Voß & Grin, 2010;). Cherp et al. (2018) explored ways to present an integrated framework, which they named the meta-theoretical framework, to address some of these criticisms. The model focuses on economic growth, radical technological innovation and engagement by institutions and government at a national level to expedite energy transition. The researchers built their study on the argument that while the transition framework is vast, it mostly addresses techno-economic and socio-technical aspects, neglecting the policy role (Meadowcroft, 2009; Clancy et al., 2019) and minimising government influence over past energy transitions (Berkhout, Smith & Stirling, 2004; Smith, Voß & Grin, 2010; Grubler, 2012).

Cherp et al. (2018) model incorporate three dimensions to define an energy transition pathway on a national base due to their complementarity. The first is the *techno-economic system*, which constitutes energy flows resulting from energy markets' exploration, exploitation, transformation, transmission, distribution and final consumption. The techno-economics aspects of energy transition seek to understand how the long-term scenarios resulting from systems actors' interaction affect supply and demand and how the equilibrium can be reached (Cherp et al., 2018). Secondly, the model includes the *socio-technical systems*, in which the systems aspect is related to the embedded technology that sustains the energy flow (Köhler et al., 2019; Markard & Truffer, 2008; Smith et al., 2010). According to Cherp et al. (2018), the transition framework developed in the scholarly tradition, including strategic niche management, the multi-level perspective, transition management and technological innovation systems, corresponds to the meta-theoretical framework's sociotechnical perspective because they share similarities in their scope of analysing.

Lastly, the model emphasises *political actions*, which enforce laws, regulations and institutional influence over the energy transition process.

Similar to SNM and TIS, the meta-theoretical framework focuses on one system, which explicitly represents an opportunity to discuss and integrate policy from a practical perspective. The intuitional role is even more prominent when it involves social issues, such as promoting gender equality (Lindberg et al., 2016; Warnecke, 2017). As per the SDGs, these issues require all countries to provide strategies to address modern energy by 2030. Moreover, from a national point of view, the state offers these strategies, including design policies, instruments and action plans. Even though the meta-theoretical framework suggests policy action to be taken into consideration, it fails to provide a framework that addresses third-world countries' problems of a prevailing lack of access to clean energy. Therefore, it is fundamental to provide a framework that objectively encompasses policy actions meant to address the issues related to access to modern forms of energy that are also gender sound.

2.4.2. Energy transition framework for urban households

The foundations and scenario building of the mainstreaming energy transition frameworks are centred on developed countries where access to modern and clean energy sources is no longer debated. Instead, energy transition debates in these countries are mainly driven by the climate change paradox. The climate change paradox refers to the fact that while society needs energy resources to develop and meet its needs (Gismondi, 2018; Grubb, Hourcade & Neuhoff, 2015), the consumption of these energy resources is responsible for the greenhouse effect and consequent global warming (Amoo & Layi Fagbenle, 2020). Furthermore, there is a lack of evidence that these frameworks can be replicated in developing countries. Hence, because these frameworks neglect to address markets where universal access to energy is yet to be achieved, Batinge, Musango and Brent (2019) provide a modified framework built upon the MLP of technological transition.

Traditional artefacts are still embedded within the structure of energy systems in developing countries. So, even with the rapid phasing-out of traditional technologies, the transition does not result in the complete abandonment of 'old habits'. Instead, the systems maintain these technologies as an alternative (Batinge, Musango & Brent, 2019). Many investigators corroborated this (Castán Broto, Arthur & Guibrunet, 2020; Kaygusuz, 2011; Sovacool, 2011a) and framed the fuel stacking phenomenon. This phenomenon happens when households can afford and have access to modern fuel and do not eliminate their previous energy sources and technologies. The modified framework emphasises the progress made by Geels (2018), which includes landscape events' capability to directly support niche innovation, not just limiting its support to regime actors.

In developing economies, niches are fertile and concur with the fast maturation of new technologies to become a new regime that is more sustainable and desired (Lee & Pollitzer, 2016; Schiebinger & Schraudner, 2011; Warnecke, 2017). From the gender perspective, this assumption is valid and corroborates the essence of the gendered innovation framework. If the landscape, represented by the government, enforces gendered energy policies to foster gendered technologies at the niche level, meaningful energy transition could be attained. Batinge, Musango and Brent's (2019) contributions are fundamental for developing African contexts. However, the framework focuses on the transition to renewable energy as a unique, sustainable pathway that will be feasible in Africa. It neglects the potential for a shift to conventional modern energy sources that could reduce solid fuel consumption. For instance, despite natural gas being a fossil-based energy source, it is a modern and 'relatively' clean energy source (Coelho et al., 2018; Rosenthal et al., 2018) that could resolve many problematic issues affecting poor urban households in developing countries.

2.4.3. Regime life-cycle framework

Energy transition science is constantly evolving, and scientists are seeking to provide integrated, assertive and ground-breaking models so that the next energy transition will be attained and sustainable development will be the new regime across the whole spectrum of society. The article from Kanger (2021) proves that reaching full harmonisation of the topic is evidently out of reach, at least in the foreseeable future. Kanger (2021) suggested a life-cycle regime transition framework built upon the MLP. Ever since the MLP was developed, it has evolved and been redefined to encapsulate and address some of the gaps that have been pointed out by several researchers (Berkhout, Smith & Stirling, 2004; Grubb, Hourcade & Neuhoff, 2015; Meadowcroft, 2009; Shove & Walker, 2010; Smith, Stirling & Berkhout, 2005). The technology life-cycle assessment serves to illustrate that technological innovation often experiences four different phases in a system:

'formative, growth, mature and decline' (Markard, 2020: 6). A similar view has been discussed by Sovacool et al. (Sovacool, Lovell & Ting, 2018).

The technological innovation life-cycle within the energy systems allows decision-makers such as institutions and governments (for policy planning), industry (for technology forecasting) and donors and/or government partners (for funding and investments) to have a better understanding of how the systems operate and identify the leverage points for regime change (Huenteler et al., 2016). The regime life-cycle suggests a multi-dimensional assessment of how technology and economic developments influence the regime throughout its life-cycle (Kanger, 2021). This study concurs with these statements as they open contextual and localised energy transition analysis debates. This approach is necessary because regime changes in developing countries are often delayed. The end users are stuck with energy carriers and technology that are inefficient and undermine their health and social well-being.

In developing countries, market players, end users, the private sector, non-governmental organisations and civil society have little participation in the decision-making process to influence change in the energy system. The state usually dictates the development pathways (Castán Broto et al., 2018). Hence, this study encourages a central coordination approach led by the government. However, it also urges a holistic perspective, as suggested by Foxon (2018). This holistic perspective needs to include all stakeholders from the Mozambican energy system, emphasising civil society and market players. Despite taking different approaches to describing drivers and pathways towards systemic structural changes to attain a transition to sustainability, these frameworks all include some consensus. Some of these characterise energy transition as a complex and multidisciplinary process. Furthermore, they concur on the co-evolutionary perspective on which transition theory is premised. Also, all these frameworks acknowledge four critical phenomena in the energy transition process, namely:

a) *Path dependent:* due to systems being built according to structural features, actors and their beliefs and values (Mekhdiev et al., 2018);
b) *Non-linear:* as per its tendency to depend on the local context and historical conditions (Markard & Truffer, 2008);

c) *Lock-in:* related to the fact that increasing returns in certain technologies lead to positive feedback, causing inertia in energy systems (Klitkou et al., 2015); and
d) *Policy role:* this potentially enables a successful transition by implementing rules and regulations aligned with the system's required changes.

This study builds its arguments on the insights from the aforementioned transition frameworks, emphasising the MPL, the meta-theoretical framework and the framework for urban households to build a theoretical framework for urban households in developing world contexts, informed by the mainstreaming gendered energy transition. Figure *2.2* depicts how the literature review guided the study.

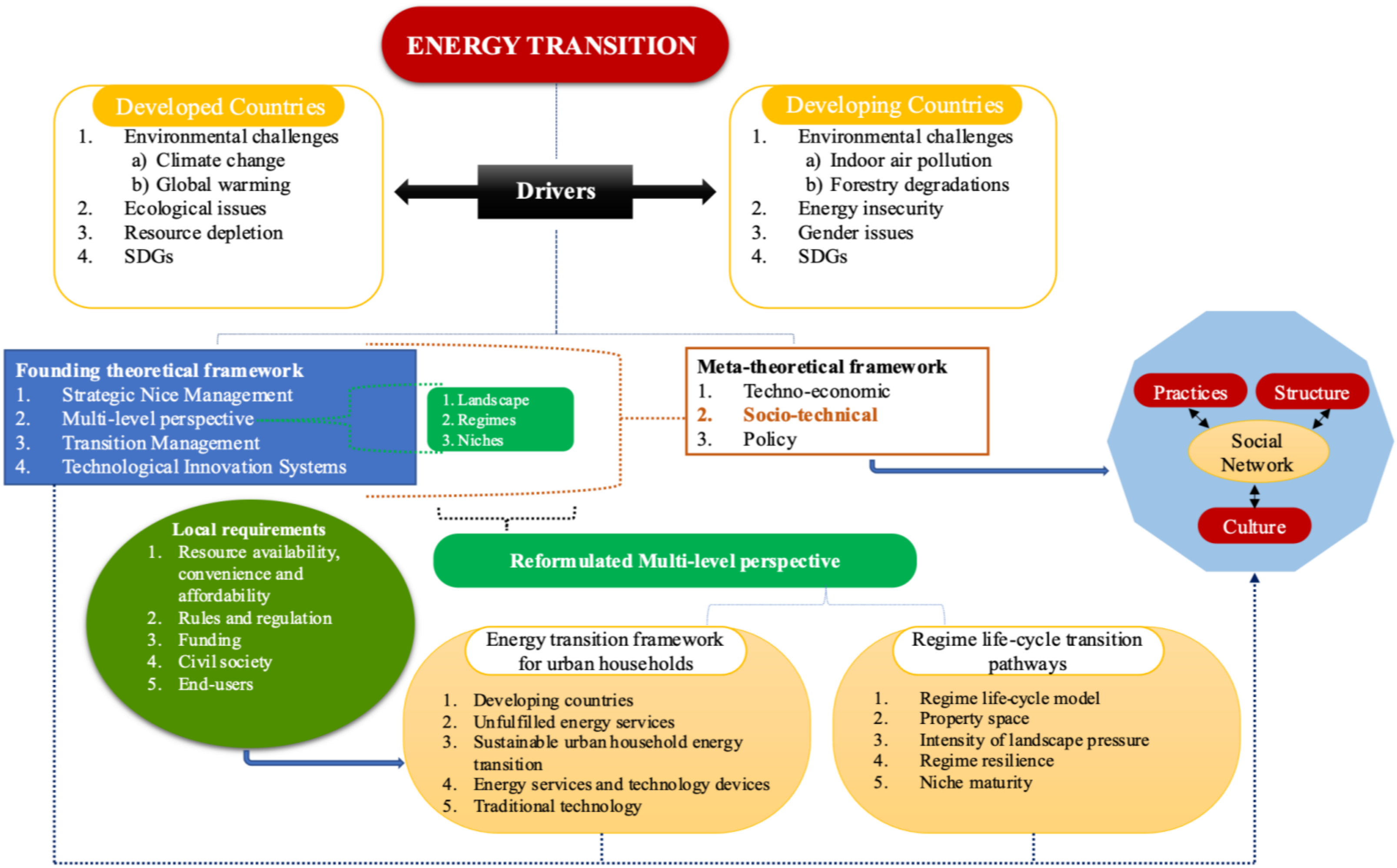


Figure 2.2: Theoretical framework design
Source: Own visualisation

2.5. Towards a theoretical framework for a gendered energy transition

This subsection aims to address the second research question of the first research objective - *which are the steps toward a gendered transition framework in urban households in developing countries*? Gendered energy transition refers to shifting from a problematic energy regime to one that perceives, structures and manages gender relations fairly. This study urges this shift because gender asymmetries are responsible for causing human suffering that manifests in different contexts. It should be noted that the concept of transition has only been used in developing countries (Nastasia et al., 2009). This means that energy transition terminology is a universal modern subject becoming a trend in several social areas due to its relevance for sustainable economic development and social well-being. Notwithstanding the universal aspect of transition, its application falls short in addressing one of the most prominent social concepts in the discourse of several international bodies – the gender issue. The discussion of gendered transition is vital for understanding how society navigates its transformations in pursuing a welfare society considering gender roles and relations. This approach is necessary to uncover the hindering aspects that impede social transformation by equally addressing women's and men's needs.

Studies incorporating gendered identities are lacking (Nastasia et al., 2009). Even in contexts where policies are set out to address gender inequality, governments are interested in them only insofar as they are suitable for their international image. However, their materialisation, influence and potential gains are yet to be achieved, which is evident from the studies of Clancy and Mohlakoana (2020) and Otero-Hermida and Lorenzo (2020). Thus, researchers have become increasingly interested in incorporating gender into national energy policy (Clancy & Mohlakoana, 2020; Fathallah & Pyakurel, 2020; Van Der Merwe et al., 2020). With the changes in regimes across the globe, women often migrate from one patriarchal regime to another with similarly unaddressed issues (Nastasia et al., 2009). This has been verified in all social spheres, ranging from social and economic to political. Rees and Chinkin (2015) indicated that the political field is even more alarming. Political agreements that result in regime change often tend to dismiss gender mainstreaming, especially that related to women's rights.

The UN Security Council Resolution 1325 discusses women, peace and security issues, built upon the Beijing Platform for Action and the Convention on the Elimination of All Forms of

Discrimination against Women. The framework provides a global platform that acknowledges the need to pay special attention to and provide policies that promote gender equality and eradicate discrimination, which often manifests in our social and cultural environments. So, women's meaningful participation in decision-making is called upon to bring balance to the current energy regime, which is male-oriented and has a snowball effect that perpetuates the problems affecting women in particular (Rees & Chinkin, 2015).

From this view, this study implies that women's meaningful participation in decision-making is necessary to understand how their needs are perceived and managed to provide a gender-sound transition. To this end, it looked at the household dimension and studied women's roles and relations and how they positively/negatively influence the required transition. The investigation required perceiving women and men as equal and investigating their needs and expectations and how they are addressed within the household. In parallel, the study also looks at the national level. This implied investigating policies in place to foster access to clean energy. Figure *2.3* depicts the factors potentially facilitating the shift to modern and clean energy carriers and technologies in urban development contexts. The following section discusses gender concepts and the definition of gender used in this research.

Figure 2.3: Diagram for phasing out traditional energy carriers
Source: Own visualisation

2.5.1. Concept of gender

The call for distinctive use of the terms '*women*' and '*men*' to indicate how they contribute to and benefit from economic development dates to the early 1970s (Rathgeber, 1990). It was developed in the women in development (WID) approach, designed to provide an inclusive platform for women to benefit from economic development and encourage women's engagement in training, employment and other social areas (Rathgeber, 1990). Although the late 1960s were marked by the resurgence of feminist movements (Jaquette, 2017), the global awareness of this among researchers, policymakers, and international agencies began only in the 1970s (Rivas & Cornwall, 2015). This period marks the beginning of the term '*gender*' in global movements, which reached a summit with the Convention on the Elimination of All Forms of Discrimination against Women held in New York in 1979. This period coincides with the terminology '*gender equality*' and '*gender empowerment*', claimed by the feminist movement to include women's rights in universal development goals (Rivas & Cornwall, 2015). Since then, the debates in the social and political arena have only increased. With the Fourth World Conference on Women, which took place in Beijing in 1995, named the Beijing Platform for Action and the ENERGIA network, the distinction was emphasised even more strongly. With this framework, gender mainstreaming became a mandate for all UN signatory countries to eradicate gender inequalities. As Clancy and Mohlakoana (2020) discussed, the framework enables an adequate emphasis on policy formulation and implementation to respond to women's and men's needs and prioritise accordingly.

The feminist movement of the 1970s and the success of WID (Jaquette, 2017) influenced the creation of the gender and development (GAD) approach in the 1980s, which addressed some criticisms that WID received from other feminist and gender researchers (Jaquette, 2017). The objections originated because WID focused on integrating women into the pre-existent development agenda (Rathgeber, 1990) rather than on the structural causes of women's oppression (Jaquette, 2017). Furthermore, it did not focus on other non-economic aspects that create imbalances, especially those based on gender identity (Rivas & Cornwall, 2015). The GAD approach proposed a holistic perspective to address these inequities. To this end, it looks at gender mainstreaming rather than women alone, and men come along in the process (Jaquette, 2017) because they possess the potential to contribute to social fairness when they are on the same page with the issues that gender mainstreaming addresses (Rathgeber, 1990). Furthermore, the approach challenges women to engage in any social sphere and contribute to changing the regime. It seeks to understand how gender issues are perceived, structured and managed and how society allocates specific roles, responsibilities and expectations based on gender identity.

The WID and GAD approaches have provided a feminist platform and influenced researchers to become more sensitive to gender issues, which influenced the foundation in 1995 of ENERGIA, an international network on gender and sustainable energy (Listo, 2018). This platform has contributed to solid research based on gender that addresses the gender-energy nexus (Cecelski & Matinga, 2014; Clancy & Mohlakoana, 2020; Clancy et al., 2019; Pachauri et al., 2012). These researchers provide a background for gender-related issues by tackling the relevant energy-related matters that are gendered in ways that affect their needs and expectations differently, hence the need to provide a gender-aware energy policy to address the inequalities. They went even further by auditing the outcomes of gender-sound policies in any given economy. The audit was performed in three countries, and the authors inferred a positive effect. However, the implementation is far from reaching the expected outcomes, especially in national policy. At the same time, the pace is faster in energy-sector organisations, and the materialisation of the results is attained rapidly (Clancy & Mohlakoana, 2020). Moreover, promoting gender equality emerges as a critical issue for the United Nations SDGs, with SDG 5 being created because it acknowledges that women and girls are the most marginalised and vulnerable social group (Łapniewska, 2019; Listo, 2018; UNDP, 2015).

Similarly, the global report of the WHO (2020) indicates that women and children suffer the most from health problems related to biomass consumption. Also, they spend long hours preparing meals and heating their homes, to the detriment of economic activities or going to school. Even worse, they are responsible for collecting the biomass required for the mentioned services (Rosenthal et al., 2018; UNDP, 2019). In this view, the study conducted by Kaygusuz (2011) highlights the need for special attention to be paid to women and girls when discussing energy-related issues. In light of this, the current study highlights the gender aspect of the energy transition to elucidate how women and men position themselves concerning fuel choice decisions within urban households. To do so, it is fundamental to define what this study perceives as gender.

The gender concept is ambiguous, to some extent, according to gendered energy transition scholars (Johnson et al., 2019; Łapniewska, 2019; Listo, 2018). Observations by Listo (2018) suggest that a clear distinction between gender and women is lacking among feminist scholars. Therefore, to provide a proper theme for discussion, the study looks at how the term '*gender*' came to be part of the social debate among scholars. It has been suggested that adopting the term '*gender*' took place at two different moments (Rivas & Cornwall, 2015). The first was in the 1950s, when sexologists referred to '*gender dysphoria*' as a conflict between an individual's gender identity and her/his biological sex. In this domain, individuals could transform or transition to suit the physical appearance of their perception of gender.

The second use of the term guided the feminist movements in the 1970s and inspired recent approaches that tend to be more integrative. According to this use, sex is the basis of gender identity. While gender is malleable, sex is fixed (Rivas & Cornwall, 2015). As Sims et al. (2010:156) indicate, 'sex refers to biological distinctions between males and females, while gender refers to cultural understandings of what it means to be a man or a woman'. This study looks at gender similarly to Clancy and Roehr (2003) and Lieu et al. (2020). Gender is a social structure based on a gender binary in which women and men are oppositely positioned, which means that gender is regarded as the socially constructed relations that distinguish women from men based on their roles within the household.

Gender is then defined as "a social structure that labels and legitimises particular behaviours, roles and responsibilities as 'feminine' or 'masculine,' which in turn works to 'script' and bound social action in various ways" (Petrova & Simcock, 2019:3). This definition was utilised to discuss the main goal of this research, which is gendered energy transition in urban households. The study uses this definition to uncover and address issues that corroborate male supremacy and sexism (Rivas & Cornwall, 2015) and address patriarchal society characteristics under which many developing countries still function, impeding social justice (Nastasia et al., 2009). It has been suggested that energy policies are gender-blind because men are often in charge of designing energy policies and technologies (Clancy et al., 2007). Additionally, the observations of Clancy et al. (2019) and Nwaka, Uma and Ike (2020) also imply that, at the household level, men are also in charge of the fuel type adopted by households.

2.5.2. Household energy services

Households' energy demands are to obtain the energy services required for their welfare. The discussion of energy security unveiled the need to highlight the term energy services, especially when discussing energy access and justice. It is noteworthy that the term energy services is not a novelty in the energy literature. According to Fell (2017), it dates back to 1955, when energy services were first mentioned in an article debating nuclear services. However, it was only in early 1990 that the term 'energy services' gained momentum and became a new trend in energy-related articles (Fell, 2017). Due to inconsistencies in the application and interpretation of the word, several energy researchers have attempted to provide a fully harmonised definition of the concept (Day, Walker & Simcock, 2016; Fell, 2017; Kaygusuz, 2011; Modi et al., 2005; Sovacool, 2011a). Nevertheless, according to Kalt et al. (2019), a complete harmonisation is arguably unreachable, primarily due to different contexts in which the term has been utilised. Regardless, there is a standard agreement that it is not energy *per se* that individuals demand. Instead, it is the services that derive from the use of diverse energy carriers that matter for the end users (Fell, 2017; Haas et al., 2008; Kalt et al., 2019; Kaygusuz, 2011; Modi et al., 2005; Parag, 2014; Sovacool, 2011b).

Fell (2017) presents exhaustive research demonstrating the various usage of the term energy services in the literature. Also, after scrutinising several energy services taxonomies, Fell (2017:137) came up with a definition of energy services as 'those functions performed using energy which is means to obtain or facilitate desired end services or states'. The relevance of a unified understanding of what energy services mean stems from the consequences of the ambiguity when designing energy policies, ranging from emission reduction and demand-side management to modern energy access (Fell, 2017; Morley, 2018). Indeed, the conclusion of Haas et al. (2008) urges clarity on locating the level of energy services that improve human well-being. Moreover, Fell (2017) argues that the positive outcomes deriving from strategies and investigation in the energy sector can be ascribed to the clarity that the concept offers to define what needs to be addressed, which Morley (2018) refers to as 'what energy is for'. Hence, according to Kalt et al. (2019), energy services provide basic human needs that enhance well-being by enabling individuals' benefits. Furthermore, Kaygusuz (2011) indicates that access to modern energy services can promote the life of the poor by providing them with electric lights that allow them to extend the day and engage in several social activities.

In low-income homes in Africa, cooking and space heating are the leading energy services that consume the most available fuel. On the other hand, the picture is different in high- and middle-income households, as they require multiple services and fuel types. Moreover, upper-class homes tend to have more luxurious items and consume much more energy than the other two classes (Sovacool, 2011b). The studies conducted by Kaygusuz (2011) and Sovacool (2011a) conclude that biomass is still the common denominator for all income levels. However, households tend to add other fuel alternatives that are cleaner as their income increases. Moreover, they do not abandon their previous fuel types. Instead, they use multiple alternatives, which the literature refers to as the fuel stacking phenomenon (Ihalainen et al., 2020; Jones et al., 2016; Rosenthal et al., 2018).

Thus, Sovacool (2011b) concluded that the same energy carrier might be utilised to meet different end uses. For instance, while a low-income household uses wood for cooking and heating, the upper-income household might use it for grilling or a luxurious fireplace. The extent to which the energy security of a population in a defined area is assessed depends mainly on how it fulfils its energy services (Parag, 2014; Sovacool, 2011b). So, this understanding enables policy designers to focus on energy carriers that provide satisfaction for end users. Moreover, different income levels imply different types of exposure to energy security vulnerabilities. For instance, while high-income households only foresee a price fluctuation risk, lower-income households face several risks. These include, but are not limited to, (i) depletion of energy sources, (ii) prohibitive connection costs, (iii) women and children spending much of their time preparing meals, heating their houses, and collecting biomass to the detriment of other productive activities, and (iv) lack of suitable technology to meet the needs of the household, especially for cooking (Pasqualetti & Sovacool, 2012).

2.5.3. Gendered innovations framework

An urgent global goal is to provide modern energy access to all citizens by 2030. This goal requires the design and deployment of clean energy technologies, which have been proven to be a significant challenge. These challenges are often linked to the energy sector's complexities, weak governance systems, and lack of financial resources (Gregory & Sovacool, 2019; Tawney et al., 2015). Innovations play a vital role in deploying the technologies that are the practical artefacts working as enablers to achieve modern access to all. The discussion by Tawney et al. (2015) infers that limited attention is being given to the design and deployment of energy innovation to foster the transition to modern energy access for developing countries.

Furthermore, the existing innovation frameworks arguably lack a gender perspective and fail to address the complexity of the socially constructed structures embedded within households and differentiated gender roles (Ambole et al., 2019; Kingiri, 2013). The mainstream energy transition framework considers technological innovation the fundamental aspect that enables the energy transition (Cherp et al., 2018; Geels, 2004; Markard & Truffer, 2008; Smith et al., 2010). So, innovation undoubtedly plays a crucial role in deploying gender-sound technologies. Innovation is defined as the process of 'creating improvements over current practice, achieved through the exploitation of advances in knowledge, and resulting in new goods and services, and new ways of supplying existing goods and services' (Lee & Pollitzer, 2016:2). This definition clearly shows how innovation plays a vital role in an energy transition since it refers to the artefacts serving as practical energy transition enablers (Łapniewska, 2019).

Technological innovations are significant when discussing gendered energy transition because the technical artefacts must resolve the social problem of dependence on solid fuel. Moreover, because women are the primary energy managers at the household level in many countries (Łapniewska, 2019), the innovation should consider the requirements and needs of the end user, which in this case is predominately women. The assumption that household members have the same 'power' over fuel choices or other choices involving their needs is erroneous (Johnson et al., 2019). Thus, to address this potential constraint that may result in unequal benefits from new technologies and services, it is crucial to understand the driving factors that dictate household fuel choice. To respond to this matter, many investigators have turned to gendered innovations (Hwangbo, Park & Lee, 2019; Schiebinger, 2014; Schiebinger & Schraudner, 2011; Van der Merwe et al., 2020). Different gender experts have presented this argument in fields ranging from energy to health science and agriculture (Kingiri, 2013; Lieu, Sorman et al., 2020; Schiebinger & Schraudner, 2011). From the energy sector, this study highlights the work by Van der Merwe et al. (2020) and Hwangbo et al. (2019). Van der Merwe et al. (2020) look at innovation from a contextual dimension. They argue for gender innovation to improve the security of energy services that stem from innovative actions within households.

Hwangbo et al. (2019), on the other hand, urge innovation from a holistic perspective, including laws, regulations and institutions. From their perspective, gendered innovation should be at the centre of debate in governmental planning, research funding and development projects that address women's needs (Hwangbo et al., 2019). Gender experts from the energy sector have already been discussed throughout this study. However, it is noticeable that these researchers emphasise the need to approach mainstreaming gender as a strategy to address social issues that hinder women's participation in productive activities. Gendered innovation is also viewed as a tool that reduces the burden associated with women's socially allocated household chores, which are often time-consuming.

From the field of health science, this study examines the research by Schiebinger and Schraudner (2011) and Sims et al. (2010). They urge that gendered innovation be analysed as an interdisciplinary subject involving science, health science and engineering. Their debate calls for international coordination and collaboration among the different disciplines because better outcomes can be achieved. Such enhanced creativity would have the potential for innovative observation, new inquiries and possibilities for different exploratory studies, such as gendered research on innovation. For example, the lack of sex and gender sensitivity in health science has resulted in unnecessary death and suffering for humans. Schiebinger and Schraudner (2011) found that a balanced engagement between women and men in communally managed water facilities led to improved access to a reliable water supply in Africa. Moreover, the prior assumption that men are more prone to cardiovascular diseases has led to the death of many women in several developed countries.

The lack of a gendered perspective induced medical criteria and treatments to dismiss the symptoms that manifest in women, which led to inadequate treatment for women. However, gendered innovations, in which women are considered to study subjects, have led to several scientific breakthroughs, including identifying the symptoms differently and conducting treatments accordingly (Schiebinger & Schraudner, 2011). Furthermore, a similar situation has been found with osteoporosis, in which gender neutrality negatively affects women's health. Because osteoporosis traditionally involves postmenopausal women, recent discoveries have placed men within the risk group, so gendered innovations include men in the diagnosis (Schiebinger & Schraudner, 2011). Gendered innovation aims to better the living condition of women and men worldwide. Many researchers discuss innovation from a technological point of view (Cherp et al., 2018; Geels, 2004; Markard & Truffer, 2008; Markard et al., 2012; Smith et al., 2010). However, their approach of focusing on private individuals rather than the entire society (Warnecke, 2017) has put into question the framework's efficacy in delivering a broader goal of social well-being. Hence, researchers have looked at innovation from a social perspective (Lindberg et al., 2016; Warnecke, 2017).

Women have a limited influence within the energy value chain, including in production, distribution and utilisation (Łapniewska, 2019). In contrast, the industry is male-dominated, and women's needs are often marginalised throughout the value chain (Lee & Pollitzer, 2016). From this view, innovation policies call for the distinction of the biological and sociocultural viewpoints on the role of women and men in promoting socioeconomic growth via scientific breakthroughs and technology (Łapniewska, 2019). Similarly, Johnson et al. (2019) conclude that generic sociocultural practices and norms dictate the imbalances in the benefits for men and women resulting from adopting new technologies and services. Moreover, an emphasis on individual needs and preferences is critical, as men and women have different expectations of new products and services.

The Organisation for Economic Cooperation and Development (OECD) campaign to promote inclusive innovation is a definite starting point to address this issue (Lee & Pollitzer, 2016). Another would involve women and men equally in the innovation decision-making process and include women in the energy value chain (Łapniewska, 2019). Hence, there is a need to identify the energy services households need and then look at how they structure women's roles to provide evidence of gendered attributions and distinctions. Considering the gender role, technologies should address, for instance, time-consuming activities by providing labour-saving energy technologies. This would enable households (mainly women) to engage in other productive ventures to generate income to support their families (Listo, 2018). Moreover, modern energy carriers and technologies such as LPG, solar panels, or solar water heaters can improve households' health by removing polluting elements (Listo, 2018). The following section discusses gender roles in fuel choice from a global perspective.

2.5.4. Gender role in fuel choice decisions

The discussion of gender roles in promoting economic development has been part of social debates in many countries across the globe, especially those that are signatories of the UNDP. Some of the UNDP programmes provide a framework for its signatories to reduce gender disparities in education and political representation (Cecelski & Matinga, 2014). However, some nations have gone beyond social discourse and included this issue in their development agendas. Studies on gender mainstreaming at the local level are scarce (Otero-Hermida & Lorenzo, 2020). So, discussing gender roles is no longer a myth in any social or economic debate. However, whether these policy instruments have been effective in producing the expected outcomes is still unclear.

Regardless, some aspects within the energy sector are yet to be discussed thoroughly and understood, one of which is the gender role in promoting the fuel switch. Because women are fundamental in implementing innovative technologies and inclusive solutions (Blackden & Wodon, 2006; Feenstra & Özerol, 2021; Johnson et al., 2019, 2020; Lieu, Sorman et al., 2020; Nastasia et al., 2009), their inclusion in the social science discourse is paramount. A clear distinction in gender roles is imperative to design suitable policies and strategies to promote the adoption of modern energy carriers by urban households. It hence is of interest to the study to uncover the patterns embedded within urban households that influence fuel choice. The study intends to understand if the fuel choice decision is female or male-oriented, what are the driving forces, what influences their choices, and if the outcome of this choice influences the transition from traditional to modern energy sources.

Researchers have increasingly become interested in understanding the households' day-to-day choices and decisions that affect living conditions. They have concluded that household members have different roles, expectations and power concerning energy sources and services (Castán Broto et al., 2020; Munro et al., 2017; Sovacool, 2011a). Also, they suggest that women often lack a voice in fuel choice decisions. In developing countries, collecting firewood and preparing meals, among other laborious activities such as providing domestic water for households, is usually left to women and girls (Fell, 2017; Munro et al., 2017; Sovacool, 2011a). Several reasons for this situation include the lack of financial resources to use modern energy carriers and the lack of control over fuel choice. As stated by Rahut et al. (2016), when the household is male-headed, the fuel choice decision lies with men. Not surprisingly, even in a household that uses modern energy, male household members decide when or how much to buy (Fell, 2017). Hence, these household members often marginalise the relevance of energy resources for women's and girls' time management and completing their daily routines.

Cecelski and Matinga (2014) discussed that access to clean cooking energy is a gender issue. According to a study conducted by these authors, women, for instance, prefer LPG for cooking when choosing between 'dirty' energy carriers and clean and modern forms of energy. Understanding whether decision-making is male or female-oriented within urban households is of the utmost importance. This is crucial because it represents an opportunity to inform policymakers and society how to understand these interactions better and produce policies and implementation plans that effectively transform the residential sector energy to ensure meeting the Sustainable Energy for All (SEforAll) initiative.

2.5.5. Factors determining households' fuel choice in Mozambique

In developed nations, households have access to modern energy carriers to meet their wide range of energy services, often through modern energy technologies (Sovacool, 2011a), which arguably give rise to damaging environmental externalities (Jansen & Seebregts, 2010). On the other hand, households in the least developed countries have a limited range of energy services, often delivered through inefficient and rudimentary energy technologies (Kaygusuz, 2011; Sovacool, 2011a; Castán Broto et al., 2020). This challenges transition management scholars to debate transition frameworks by considering the end users' scope, context and development status to adequately address the issues they face. Cooking and heating are the primary energy services for the bulk of poor households in developing nations, accounting for 90% of the total energy demanded by families (Pachauri et al., 2012). The ability to exercise the fuel choice decision is still a privilege in households in developing countries. In developed countries, where a smart grid is not a novelty, consumers are privileged to choose between the existing fuel alternatives, allowing them to access those that fit their needs and capabilities

According to Rahut et al. (2016), privileged location, income level, education level and gender role determine the household's likelihood of adopting modern energy sources instead of dirty fuels. Hence, urban, affluent, well-educated and female-headed families are highly likely to use clean energy carriers. This goes hand in hand with Cecelski and Matinga's (2014) arguments, which indicate that, regardless of the stigma, the often prohibitive prices and supply deficiencies, women prefer clean energy sources such as LPG to charcoal and fuelwood. Furthermore, if they have the option, they will choose gas. So, supposing that women are willing to change to modern energy carriers, addressing the factors impeding the fostering of this transition is imperative. Therefore, it is necessary to identify the impeding factors and inform policymakers and market players to act and provide proper tools in terms of norms, regulations and innovative technologies, considering the reactions and tendencies of each social group (Johnson et al., 2019).

Uncovering the underlying factors influencing fuel choice in Mozambican urban households requires understanding their energy services. To this end, the study clarifies that energy is a means, not an end *per se. U*ltimately, people are interested in the services delivered by energy rather than fuel (Fell, 2017; Kalt et al., 2019; Sovacool, 2011a;). Hence, the demand for energy services is what drives energy consumption. Thus, how society meets its energy service requirements affects our health, environment, wealth and social relations (Byrne et al., 2011). Households' primary energy services are usually categorised into six (6) groups: lighting, cooking, cooling, space heating, water heating and refrigeration (Fell, 2017). However, households rely on different energy carriers and technologies according to their income level (Sovacool, 2011b). In extreme poverty, families are deprived of energy services. While cooling and luxury practices are part of energy service requirements in middle- and high-income households, the energy services are confined to fewer elements in low-income households, primarily cooking and heating (Sovacool, 2011a).

2.6. A theoretical framework for gendered urban households' energy transition

Defining a theoretical framework for the gendered energy transition in developing countries, especially in a post-colonial context (Bennett et al., 2017; Castán Broto et al., 2018), is a formidable task. Not only because the social, political and economic roles are yet fully understood but also because there is already an inevitable aspect to consider, which is climate change, even though there are still universal access challenges to address. Even though there is a vast volume of literature on energy transition, little attention has been paid to the gender aspect on which success depends, especially at the household level.

The existing transition framework emphasises full electricity markets (Batinge et al., 2019). An opposite situation is found in developing countries, where energy access is still out of reach for many households. This section addresses the third research question of the study's first objective - *what are the interventions for the energy transition in developing countries*? Thus, it suggests a novel theoretical framework for the gendered energy transition in urban developing contexts, considering the key intervention informed by the discussion of the existing energy transition frameworks. Figure *2.4* depicts a graphical representation of the theoretical framework on which this study is grounded.

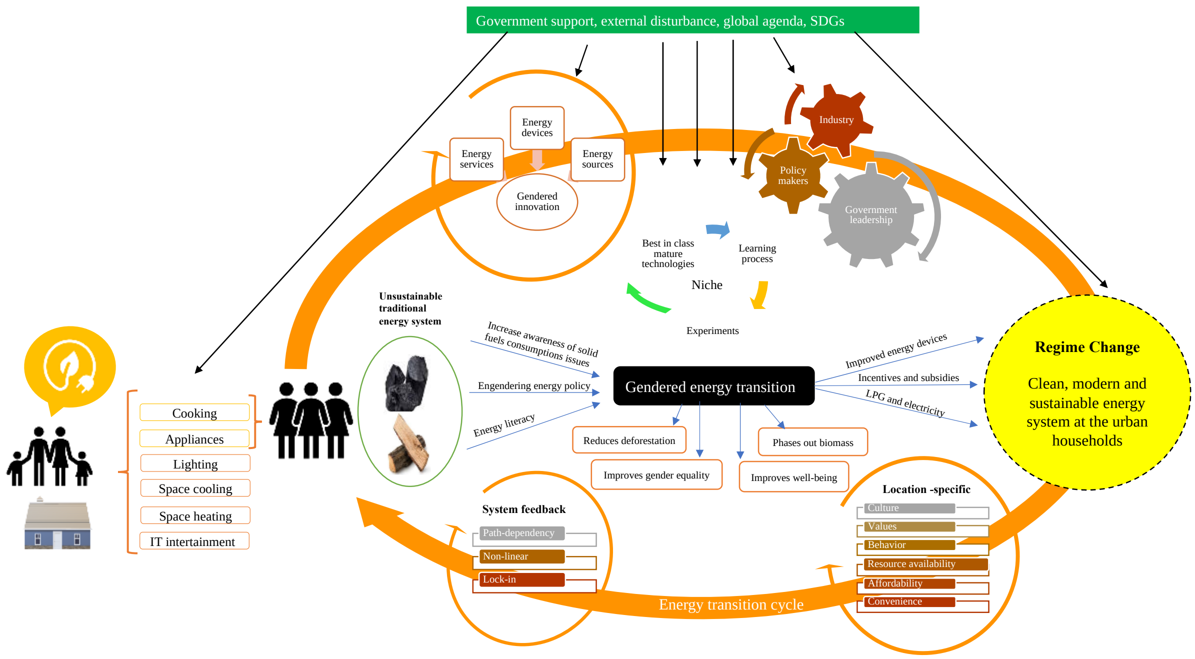


Figure 2.4: Illustrative framework for gendered energy transition using an example of LPG and electricity adoption by urban households
Source: Own visualisation

The framework takes, as an example, a metropolitan area in Mozambique. The illustration of the key ideas suggests the co-evolutionary nature of the energy system components (Edmondson et al., 2019; Geels, 2002), emphasising gender and energy technologies. In addition, the framework follows Kanger's (2021) perspective. The transition unfolds in a cyclical manner (Kanger, 2021), which means that the system's actors operate in a symbiotic manner, although from within their boundaries, motivations and expectations (Cherp et al., 2018; Edmondson et al., 2019; Smith et al., 2005). The cycle does not have any precise starting point or a definite end. Furthermore, in developing contexts, the transition requires a reflexive (Edmondson et al., 2019) government that introduces regulatory measures and strategies to transform the regime's dependence on solid fuels.

For instance, the inclusion of mainstreaming gender in policy (Musango et al., 2020; Otero-Hermida & Lorenzo, 2020; Schiebinger, 2014; Schiebinger & Schraudner, 2011), with proper support from modern energy technologies and incentives (Bouille et al., 2012; Coelho et al., 2018; Usmani, Steele & Jeuland, 2017), may lead to the increased adoption of modern fuels by households. In parallel, other supporting schemes in the global agenda, including increased awareness of the problems caused by indoor air pollution due to solid fuel combustion (Coelho et al., 2018; Mohlakoane & Annecke, 2008, 2009), may also motivate households to search for alternatives fuels, such as LGP and electricity. Similarly, subsidising the upfront investment cost for households to acquire gas cylinders and cooking stoves may also influence households' fuel shift (Mohlakoana & Annecke, 2009). That is to say, the strategies of the system's actors may vary and occur in a different dimensions of the system's components.

This illustration also validates the niche's role as a breakthrough technological innovations arena (Hwangbo et al., 2019; Kemp et al., 1998) and a place for implementing mature modern energy technologies from developed regimes, such as the use of LPG and electricity as cooking fuels, along with their respective devices. Hence, the framework suggests gendered innovations (Muza & Debnath, 2020; Pueyo & Maestre, 2019; Schiebinger, 2014) in ways that the technologies are implemented to introduce labour-saving yet efficient energy sources and devices to enable fuel savings. This model also refers to the potential benefits of system transformation at the household level. These benefits include reducing deforestation caused by the demand for solid fuel in urban areas and promoting gender equality and women's overall well-being. The theoretical framework for gendered energy transition is discussed in more detail in the following subsections.

2.6.1. Existence of traditional technology

Following the framework of Batinge et al. (2019), the proposed theoretical framework for gendered urban household energy transition considers the existence of traditional practices. This study argues that households will be open to change with the awareness of the damage caused by traditional energy sources and the respective technologies (Coelho et al., 2018; Karimu et al., 2016). The chances are even higher when economic incentives are implemented (Usmani et al., 2017). In Mozambican urban households, traditional energy carriers endure in all social groups. These households are argued to be regime dominated by the use of traditional biomass. The uptake of household appliances is gendered (Muza & Debnath, 2020). Hence, the use of traditional technologies decreases because, through landscape support, gender-friendly technologies gain rapid uptake in niches and replace the existing regime.

2.6.2. Lessons from existing sustainable regimes

One of the new elements that this study brings to the discussion is that developing countries could have the opportunity to learn from 'best-in-class' technological transitions. This approach enables developing countries to learn from their counterparts and advanced countries that have mastered the uptake of specific sustainable technologies. The study argues that there is an opportunity to adopt other regimes' ready-to-use technologies and implement them in 'fertile niches' of the existing regime in urban developing contexts. With this approach, the readiness of the technologies enables them to gain momentum and thrive in the current biomass-dependent regime, which constitutes a leapfrogging strategy. This can be attained through the pressure arising from elements in the sociotechnical landscape, including governing strategies to support gendered innovation. However, these ready-to-use technologies require an understanding of the local context to evaluate their readiness for adoption, considering factors such as affordability, accessibility and convenience.

2.6.3. Gendered innovations

Among the prominent energy transition frameworks, such as transition management, strategic niche management, a multi-level perspective and technological innovation systems, technological innovation represents the common denominator. This study argues that innovations are one of the most crucial aspects of an energy transition in any given context (Binz & Truffer, 2017; Markard & Truffer, 2008; Smith et al., 2010). Considering the socio-cultural factors that dictate how urban households in developing countries operate, energy transition approaches should be informed by the socio-cultural values of the target groups to determine the appropriateness of the technologies for those who use them. In many countries, women are the primary energy managers at the household level (Sims et al., 2010). The assumption that household members have the same 'power' over fuel choices or other choices involving their needs is erroneous (Johnson et al., 2019). In fact, household chores are markedly gender-dependent in Mozambique (Castán Broto et al., 2020). Thus, several researchers have urged gendered innovations (Feenstra & Özerol, 2021; Grünewald & Diakonova, 2020; Hwangbo et al., 2019; Lee & Pollitzer, 2016; Schiebinger, 2014; Schiebinger & Schraudner, 2011; Sims et al., 2010) to bring the industry closer to women's strategic energy needs.

Different gender experts have presented gendered innovation, including specialists from the energy sector, health sciences and agricultural sectors (Schiebinger & Schraudner, 2011; Sims et al., 2010). Gendered innovations are viewed as an approach that 'integrate[s] sex and gender analysis into all phases of basic and applied research to stimulate new knowledge and technologies' (Schiebinger, 2014:1). Gendered innovation occurs at the household levels, in all dimensions, including sources, services and devices. Since women are often in charge of cooking (Grünewald & Diakonova, 2020; Lieu, Sorman et al., 2020), providing superior energy sources and technologies, such as LPG and electricity (Van der Merwe et al., 2020), and efficient cooking devices (Karimu et al., 2016) can improve their health, social relations and engagement in other activities. Arguably, women are fundamental for implementing innovative technologies and inclusive solutions to change the existing detrimental regimes (Johnson et al., 2019; Lieu, Sorman et al., 2020; Van der Merwe et al., 2020). Understanding the patterns influencing fuel choices in urban households is essential to promote clean energy access by 2030 (Sustainable Development Goal 7) and mainly to achieve gender equality (Sustainable Development Goal 5).

2.6.4. Low-carbon energy transition

Despite a rapid increase in low-carbon energy transition literature, little attention has been paid to the contexts in which transition results in a high carbon-intensive economy (Castán Broto et al., 2018). In developing countries, increases in household income often result in increased uptake of fossil fuel-based energy sources and increased demand for energy (Castán Broto et al., 2018, 2020), which Smil (2010) indicates to have been the case in past energy transitions, especially in developed countries. Many people have yet to experience the benefits of the past energy transition (Grubler, 2012). In Mozambique, where biomass is the primary cooking fuel, natural gas is an alternative for providing modern energy carriers (Mahumane & Mulder, 2019). However, because natural gas is a fossil fuel, its exploitation, distribution and consumption will most likely increase carbon dioxide emissions. Nonetheless, this research argues that, although an energy transition from biomass to natural gas most likely will result in high carbon emissions, it is expected to contribute to the overarching goal of sustainability in the long run. On the other hand, it could potentially phase out biomass consumption and its adverse effects.

The UN argues that reaching sustainable development goals requires all access to modern energy forms (UNDP, 2015). Grieshop, Marshall and Kandlikar (2011) mentioned that biomass consumption results in a more significant environmental footprint than natural gas. The reduced biomass consumption could enhance forestry preservation and promote its ability to capture carbon, which has been supported by the REDD+ mechanism (Kissinger et al., 2012; Mahumane & Mulder, 2019). Thus, low-carbon energy transition in developing countries has the potential to achieve the overarching goal of sustainability in the long run because it could potentially phase out biomass consumption and its adverse effects.

2.6.5. Policies for a gendered energy transition

The argument for gender-sensitive policies stems from the meta-theoretical framework (Cherp et al., 2018). Hence this study's emphasis is on the role of policy in intervening in energy systems to change undesirable regimes. A central issue in policy is how the coevolution of laws, rules and regulatory mechanisms may prompt a reconfiguration of the energy system. The existing literature discusses several strategies to accelerate the energy transition, some of which include subsidies (Mohlakoana & Annecke, 2009), financial incentives (Hwangbo et al., 2019; Usmani et al., 2017) and public policy (Bergek et al., 2008; Edmondson et al., 2019; Kalt et al., 2019; Lieu, Sorman et al., 2020). This study argues that public policy has an integrated reach and that, in developing contexts, its influences are more significant due to most citizens' vulnerability. More precisely, Ingold, Stadelmann-Steffen and Kammermann (2019) look at the transition from a citizen perspective and assert that individual factors drive the overall transition towards energy sustainability.

Hence, it is necessary to develop a policy strategy to increase awareness from a gender perspective (Musango et al., 2020), energy literacy (Cotton et al., 2021; Rosenthal et al., 2018; Van Den Broek, 2019) and women empowerment (Castro Lopes et al., 2021). This approach could allow women to decide on their preferred fuel sources actively. Furthermore, policies are fundamental to expedite the 'best-in-class' mature technologies from modern regimes. Parallel to that, the framework considers the fundamentals of the multi-level perspective by incorporating radical innovation that is gendered at the niche level. However, there is a need to manage the market mechanisms and other exogenous forces that influence competition between new and existing technologies. Gender-sensitive policies play a vital role in adopting and implementing sustainable energy technologies. Moreover, the dividends are even higher when the policies are designed to target the fuel choice for cooking in developing countries.

2.7. Literature on energy transition pathways

The dialogue on energy transition pathways in academia is a relatively new concept. It was first mentioned by Geels and Schot (2007), whose focus was influenced by the multi-level perspective transition framework based on the sociotechnical transition of the energy system. Thus, the literature on energy transition pathways is still relatively new and under great exploration in the social science discipline. The following subsection addresses two research questions of the third research objective.

2.7.1. Mainstream literature on energy transition pathways

To respond to the question of '*what the present energy transition pathways are, their motivations and how they relate to the developing world context*s', the literature review shows an increasing trend in the discussion of the topic. However, like the energy transition framework debates, there is no similar argument regarding the Developing countries. The examination of the literature also revealed that the driver of the discussion is mainly oriented towards reducing carbon dioxide emissions, and discussion on transition pathways in contexts where access is yet to be fully deployed is lacking. Further, the debate on transition pathways that consider gender dynamics in energy systems also is scarce. This study urges this approach because gender roles are a pivotal pillar in developing countries to enable energy consumption patterns that are not harmful to the less fortunate.

Defining energy transition pathways in developing countries like Mozambique is not straightforward (Iizuka, 2015). For this study, the definition of energy transition pathways was inspired by Foxon et al. (2010) and Silver and Marvin (2018). They consider energy pathways as guidelines driven by the needs and expectations of the up-, mid- and downstream energy system actors with which to formulate a sustainable and socially fair energy future that advises the current decision-making process. That is to say, despite the acknowledgement in the Developing countries of the need to move towards sustainability, the debates on the strategies to achieve these unequivocal, essential goals need to have a common target: social justice.

According to Table 2.1, it is fair to say that there is no consensus on defining the pathways toward energy transition. Instead, the debate is open and gives room for understanding the limits and opportunities of each proposed path and its applicability in different contexts.

Table 2.1: Reviewed literature filtered to meet the research topic and objectives

Order	Article title	Source	Typology of transition pathways	Scope	Limitation
1	Typology of sociotechnical transition pathways	(Geels & Schot, 2007),	1. Transformation 2. Reconfiguration 3. Technological substitution 4. De-alignment and re-alignment	Sociotechnical transitions built upon the multi-level perspective	Limited attention to unmet electricity markets Lacks gender perspective
2	Developing transition pathways for a low carbon electricity system in the UK	(Foxon et al., 2010)	1. Market rule 2. Central coordination 3. Thousand flowers (civil society and governance)	Low carbon transition, a case study in the UK, built upon the multi-level perspective	It is based on developed countries, and, despite the emphasis on civil society roles, it lacks a gender narrative
3	The structure of uncertainty in future low carbon pathways	(Hughes, Strachan & Gross, 2013)	1. Government actors 2. Market actors 3. Civil society	Discusses the role of the three different actors and their relationship with technological innovation in shifting from a carbon-intensive economy to low carbon energy system	Lacks developing world context and gender dynamic perspective
4	Exploring energy pathways for the low-carbon transformation in India – a model-based analysis	(Lawrenz et al., 2018)	1. Renewable (solar) 2. Market design 3. Implementation of environmental norms 4. Rural electrification	Debates low carbon transition, considering renewables such as solar and recommends rural electrification.	Lacks the civil society dimension, particularly the role of gender
5	Examining urban Africa's low carbon and energy transition pathways	(Silver & Marvin, 2018)	1. Address the relations and tensions across formal and informal practices of energy systems. 2. Recognise the limits of urban government and governance 3. Develop an understanding of what forms of intermediary capacity can be created in different urban contexts 4. Better understanding of contested and multiple transition pathways	Low carbon transition in African urban environments. The approach focuses on combining insights from the multi-level perspective and urban governance.	Emphasises low carbon transition even in contexts where carbon emissions are still under acceptable levels. Further, it lacks gender role analysis, which is critical in enabling regime shifts in the developing world.
6	An overview of energy planning in Iran and transition pathways towards sustainable electricity supply sector	(Aryanpur et al., 2019)	1. The link between science and policy 2. Equip decision makers with technical skills 3. Improve sustainability performance in the energy system 4. Optimise modelling expertise	Designed to reduce fossil-based energy sources and suggests renewable energy transition, aligned with the need to provide technical expertise in decision-makers.	Based on the context where access is no longer under debate and does not address gender roles

Table 2.1 (Continued)

Order	Article title	Source	Typology of transition pathways	Scope	Limitation
7	Pathways for Germany's low-carbon energy transformation towards 2050	(Bartholdsen et al., 2019)	1. Different phase-out policies 2. Carbon and resource price developments 3. Efficiency improvements	Focuses on the adoption of renewable energy such as wind and solar to reduce CO_2 emissions in Germany	Lacks gender lens and applicability in a context where CO_2 emissions are not the main driver to change the energy system
8	Pathways for sustainable energy transition	(Chen et al., 2019)	1. New technologies 2. Environmental Sciences 3. Economics 4. Management	Emphasises the need for an interdisciplinary approach (integration) for the transition toward sustainable energy	The pathways lack social dimension, acceptance of the new technologies and gender dynamics as an enabling factor
9	Energy transition pathways to a low-carbon Europe in 2050: The degree of cooperation and the level of decentralization	(Del Granado et al., 2020)	Diversification Direct vision Localisation National champion	Driven by climate change mitigation and focusing on the European continent	It lacks a developing world context, and the gender dimension of energy transitions
10	Three sides to every story: Gender perspectives in the energy transition pathways in Canada, Kenya, and Spain	(Lieu, Sorman et al., 2020a)	1. On-stream pathways 2. Off-stream pathways 3. Transformative pathways	Discusses clean energy transition, built upon arguments from niche innovations and gender perspective to disrupt the male-dominant pathways	Discusses transition towards low carbon emission despite the arguably un-met electricity market encompassing the bulk of the developing world, particularly sub-Saharan Africa.
11	Rethinking the multi-level perspective for energy transitions: From regime life-cycle to explanatory typology of transition pathways	(Kanger, 2021)	1. The intensity of landscape pressure 2. Regime resilience 3. Niche maturity	Building on the multi-level perspective (Geels, 2011) and transition pathways (Geels & Schot, 2007), the author identified 16 different typologies of transitions resulting from various degrees of landscape pressure and niches' and regimes' reactions.	Based on the developing world context, it does not explicitly discuss gender dynamics and their role in regime transformation

Despite the different emphases of the approaches considered by mainstream researchers, the majority acknowledges the vital role of three pivotal actors: governance, market authors, and civil society. This triangle offers a starting point to analyse transition pathways from a holistic perspective, as their interaction shapes the future energy system. This study builds its argument on these actors. It emphasises the gender role as one factor that requires a deeper understanding, as its manifestation in urban households influences the current energy pattern.

2.7.2. Gendered literature on energy transition pathways

The second research question of the third objective of the study is: *which gendered energy transition pathways exist and what themes they address*? The present subsection discusses the gendered literature on energy transition to address this query. So, it should be noted that the existing energy regime in developing countries is under increasing pressure by the SDG goals and the guidelines in the Paris Agreement to reach universal access by 2023. The other driving forces are the natural course of social and economic development. The energy system is challenged to deliver the required energy to drive the industrial, transport, commercial and household sectors and ensure energy security and affordability. These driving forces are referred to as the energy trilemma. Despite its variations in the literature, they tackle a similar issue (Gent & Tomei, 2017; Heffron, McCauley & Sovacool, 2015; Jing et al., 2021; World Energy Council, 2020). Figure 2.5 depicts how this study visualises the trilemma, considering the research goal.

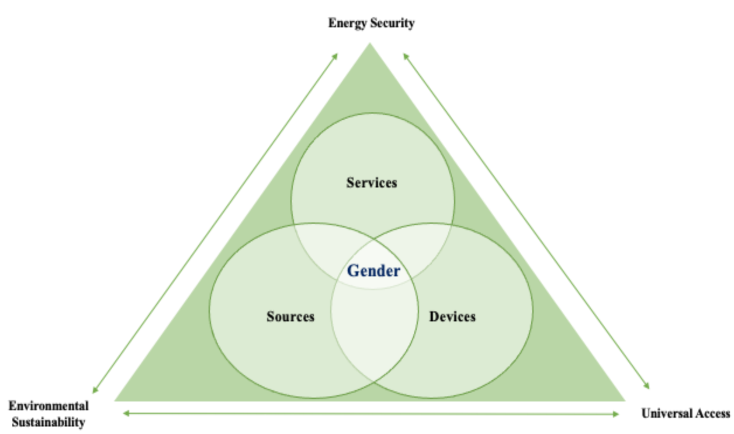


Figure 2.5: Gendered energy trilemma at the household level

Source: Adapted from World Energy Council (2020)

Researchers have proposed many frameworks, road maps and pathways to encourage the transition, which often calls for bottom-up, socially inclusive and multisectoral approaches to facilitate the energy transition. Nevertheless, the literature on energy transition pathways in developing countries is scarce, and even fewer are those that consider transition pathways from a gender lens. The literature review enabled the identification of alternative pathways suggested by Lieu, Sorman et al. (2020). Their discussion focuses on a gendered perspective for energy transition pathways. They argue that the male-dominant nature of the mainstream pathways lacks a gender perspective, which hinders a sustainable energy transition. Therefore, they model alternative pathways to address these issues and consider three different approaches, as depicted in Figure 2.6.

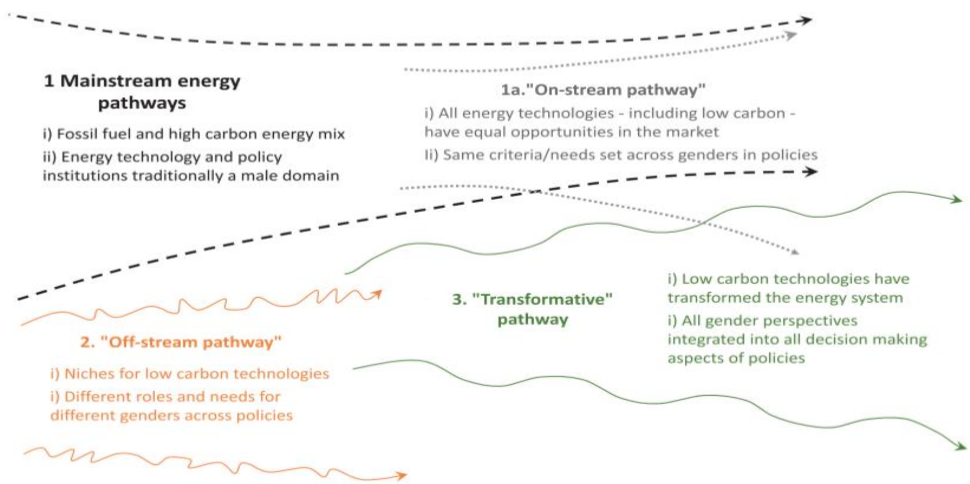


Figure 2.6: Framework for energy transition pathways from a gendered perspective

Source: Lieu, Sorman et al. (2020)

Despite the novel nature of the gendered energy transition pathways, the study argues that there is a need for further discussion of the framework. This study extends its insights to contexts where the transition is not necessarily towards carbon reduction or the adoption of renewable energy sources but also the adoption of carbon-intensive, clean and modern energy. The study aims to demystify the developed countries' approach to a just transition toward low carbon emissions and opens a doorway to discussing the transition in contexts where it may increase carbon emissions. However, there are far more favourable outcomes, such as environmental preservation, health improvement, women's empowerment, engagement in more productive activities and participation in decision-making processes in all social spheres.

2.7.3. Towards gendered urban energy transitions in Mozambique

The study used a critical social assessment to convey the transition pathways towards improving the current energy system at the household level in Mozambique, considering gender dimensions. The discussion of pathways for an energy transition from a gender perspective required a combination of empirical evidence from the analysis of the data collected for this work during the survey and the findings from the critical and integrative literature review to substantiate the proposed approach. The pathways proposed by the study for the energy transition by Mozambican urban households are a result of the combination of the alternative transition pathways from a gender perspective by Lieu, Sorman et al. (2020), and the transition pathways proposed by Foxon et al. (2010). The proposed pathways are based on three co-centric aspects to transform the energy system from these perspectives. These include the role of central coordination (*government*), market rules (*industry and technological innovation*) and civil society (*community*) (Foxon, 2013; Foxon et al., 2010; Hughes et al., 2013; Iizuka, 2015).

There is a significant asymmetry amongst Mozambican urban households. These asymmetries range from income level, the spectrum of the neighbourhoods in which they reside, their lifestyles and their interactions with the energy system. Hence, the definition of the Mozambican energy transition pathways urges a shift from the incumbent biomass regime to clean, modern and sustainable energy systems. The study by no means intends to provide a panacea for the diverse nature of the current energy systems at the local, national and international levels. Instead, the study suggests a different yet complementary approach to changing the urban energy regime. However, considering the gendered approach is not sufficient for enabling the desired transition. The study followed the insights from the modified transition framework developed by Batinge, Musango and Brent (2019) to develop the transition pathways, which emphasise the developing world context.

2.7.4. Risks of the gendered energy transition pathways

Assessing the risks of implementing the energy transition pathway is a fundamental tool for anticipating potential barriers and identifying solutions. The fourth research question required assessing the third objective - *which are the key risks for implementing gendered energy transition in urban developing environments*? Through the literature review, this section addresses this question partially, which will be complemented in Chapter 6, where the survey results inform this risk assessment. Foxon's (2013) research provides the transition pathways and risk assessment for each pathway to a low-carbon electricity future in the United Kingdom.

The risk assessment is based on five factors, namely environmental, social, economic, policy and technological, and considers two different moments, the first taking place at implementation, and the second is the effect or consequence arising from the implementation of the transitions pathways (Lieu, Hanger-Kopp et al., 2020). Hence, this study looked only at the implementation risks, as the risks arising from the implementation are considered marginal due to the proposed nature of the transition and its effect on social welfare and the environment. Therefore, building upon the insights from the risk assessment of low-carbon transition pathways, the following section discusses the risk assessment for the gendered energy transition pathways in Mozambican urban settings. Although the contextual factors are distinctive, there are no clear boundaries in practice. In fact, in most cases, they overlap.

a) Environmental

In developed countries, risk assessment in the environmental context is considered marginal (Lieu, Hanger-Kopp et al., 2020) because the transition pathways are driven towards low-carbon emission, which implies positive outcomes due to environmental conservation. In contrast, the energy transition towards discourse in the developing world needs a cautionary evaluation due to what Iizuka (2015) refers to as the catching-up driving force. Also, the often prohibitive cost associated with the deployment narrative on renewable energy (Lieu, Hanger-Kopp et al., 2020) and energy security aspects (Musango et al., 2020). The key risks in the environmental context are related to poor indoor air quality. This can be experienced if niche innovation does not disrupt the incumbent regime and households continue to rely on biomass to meet their energy needs. The key risks are related to the loss of biodiversity (Artacho, 2020; Gismondi, 2018) due to biomass collection used to supply the demand for wood and charcoal in urban areas (Baumert et al., 2016; Selemane, 2009). Another risk is forest degradation (Kissinger et al., 2012; Sedano et al., 2016) and land-use change (Zorrilla-Miras et al., 2018). There is also a risk of releasing carbon into the atmosphere due to deforestation (Spijker et al., 2020). Lastly, transition pathways in the developing world may increase CO_2 emissions due to adopting modern energy carriers. In the Mozambican case, this could imply an increased domestic consumption of LPG by urban households for their cooking needs.

b) Social

The social context is deeply embedded in this study's goals. The social dimension of the risks of implementing the transition pathways is related to the fulfilment of the basic needs for social well-being that is lacking in many developing world households. These include, but are not limited to, access to modern and clean energy sources, gender equality and overall welfare. Despite the abundance of discourse on the social risks of low-carbon energy transition pathways in rich countries, this debate is scarce in the developing world. This study argues that a reason for this could be the overreaching benefits in comparison to the pitfalls. Nevertheless, this study argues that risks arise from implementing each theme. For instance, the high cost of modern and clean energy carriers, technologies and devices can negatively affect vulnerable families if no support mechanisms exist.

According to Fell et al. (2020), increased electricity costs have different but adverse effects on vulnerable families. This study concurs and adds that this situation could negatively affect the household income distribution according to their subsistence needs. They may withdraw from some of the energy services they need to cope. There is also a risk that vulnerable families cannot afford domestic appliances compatible with modern energy carriers. The other dimension for risk assessment in the social context is the potential for increasing asymmetries between high-, middle- and low-income households, as the vulnerable group lacks the financial capability to adapt to the demands of the new regime. Furthermore, the proposed energy transition pathways have a tremendous social effect on health issues resulting from exposure to smoke from solid fuel combustion and the associated premature death and morbidity, which can be a risk or an improvement, considering the chosen pathway (McCarron et al., 2020; WHO, 2020).

c) Economic

Economic risk assessment requires special attention to be paid to discussing the transition in the developing world. Economic risk refers to the country's infrastructural development to sustain the system and resource exploitation. Given the global nature of the energy sector, this often requires the government to lobby large-scale energy companies (Gregory & Sovacool, 2019). However, due to the uncertainties experienced in the early transformation phase, large-scale companies look at this new innovative requirement as high risk, which often impedes or increases financing costs, which are then allocated to the end user if not managed adequately (Lieu, Hanger-Kopp et al., 2020). Economic risk can also come from the end user perspective, implying they do not have the purchasing power to access modern, clean, sustainable energy carriers.

In the developing world, biomass production and trade are often associated with income generation by all actors in the value chain, which will contribute to their well-being and poverty alleviation (Ihalainen et al., 2020; Jones et al., 2016; Smith et al., 2019; Zorrilla-Miras et al., 2018). Hence, the regime change will probably put at risk the advantages that biomass consumption by urban households brings to these vulnerable groups. Also, there is a risk of the loss of financial autonomy that biomass production and commercialisation offer to women operating in the sector (Jones et al., 2016). Furthermore, in the current context, where COVID-19 hinders economic development prospects and projects, energy transition is facing even higher constraints and financial barriers. This situation forces shifts in priorities at the level of government, donors and end users as the effects of the pandemic are spread to all social classes. However, despite the harmful effects of the pandemic, Artacho (2020) argues that there is no possible 'lockdown' for the climate and environmental crises that the world faces.

d) Policy

The materialisation of the proposed transition pathways is grounded in robust, aligned and socially inclusive policies to guide the energy system actors. Hence, analysing the critical risks that the system may face during the implementation stage is of the utmost importance. The policy context refers to government regulatory instruments and institutions designed and implemented countrywide. Policy and political context are often connected (Lieu, Hanger-Kopp et al., 2020). According to Spijker (2020), politics is often the driving force for policy support for the energy transition.

The literature on energy transition emphasises the policy's role in enabling energy transition (Cherp et al., 2018). It indicates that governments are under even greater pressure under the Paris Agreement targets in developed contexts because they are held accountable for their performance. In the developing world, the role is more significant, as per the universal access and their national obligation to deliver services for the well-being of their citizens. This includes access to modern, clean and sustainable energy carriers and the promotion of gender equality. However, some risks could hinder reaching the expected outcomes for the designed pathways. As indicated in the social and economic context, the energy transition can lead to job and income loss. Bertheau et al. (2020) suggest rigorous planning and coordination prevent this situation. Hence, if the policy and regulatory instruments are not attuned adequately to positive coordination among the different government levels, it may jeopardise the required energy transition.

There is also a risk that the goals of the international energy players are mismatched with the national goals. This is because the developed world and the international agencies are emphasising low-carbon technologies while, at the same time, developing countries are lingering to get universal access, regardless of whether it is to carbon-intensive sources. LPG is a vital cleaner fuel that promotes the achievement of climate goals and supports sustainable development at the household level (Rosenthal et al., 2018). From 2017 until the present (the third trimester of 2021), the northernmost districts of Cabo Delgado province have been attacked by extremist groups (Santos, 2021). The area is the location of international projects exploring natural gas in the Rovuma basin. There is no official information about the insurgents' real agenda and origin (Heyen-Dubé & Rands, 2021). If any accurate information exists, it is kept under lock and key by the Mozambican government.

Nevertheless, given the severity of the situation, in which an unknown number of people have lost their lives and thousands of people are displaced (Santos, 2021), the Mozambican government has found itself forced to accept help from the SADC (Southern African Development Community). The SADC intervention was due to the inability of the national armed forces to control and retake areas proclaimed by the insurgents as taken. This situation puts at risk the implementation of any energy transition in the country. Thus, there is an urgent need for the government to devise measures conducive to mitigating these problems. In addition to having a tremendous negative social impact, the situation leads to an increase in the country's financial risk, which increases the cost and capital of investment and scares potential investors from investing in Mozambique.

e) Technological

The Mozambican economy is largely service driven. The industrial sector is in its infancy (Francisco, 2010), which means it relies mainly on imports. This situation puts the country at significant risk for niche innovation, making it nearly impossible for incubators to thrive and reach massive production. Furthermore, technological breakthroughs are challenged because of the country's underdeveloped industrial sector. The deployment of renewable energy sources and technologies is significantly low, despite support from international development agencies (Tigabu et al., 2015). Lack of technological awareness has been discussed as a critical risk factor for regime change (Bertheau et al., 2020). The poor urban environment, where women have low levels of education and lack access to information regarding issues related to biomass consumption, represents a greater risk of adopting modern and clean energy vectors. However, to mitigate this risk, there is a need to increase awareness of the adverse health effects of exposure to solid fuel combustion and the potential benefits the transition will offer them (Jewitt et al., 2020; Rosenthal et al., 2018).

2.8. Summary

This chapter addressed the first research objective: *to develop a theoretical framework for a gendered energy transition for urban households*. Therefore, it informed the *state of the art* of mainstream energy transition scholars and built the argument for this study and its contribution to the body of knowledge on gendered energy transition at the household level. The chapter provided a critical literature review combined with a systematic and integrative review of the literature on energy transition theory. In this respect, the chapter discussed energy transition frameworks such as transition management, strategic niche management, the multi-level perspective, and technological innovation systems and found that they all do not explicitly discuss mainstreaming gender. It then bridged the transition framework to mainstreaming the gender discussion, provided a definition of gender, and delimited what the study considered urban households in the Mozambican context.

The study identified gender-related concepts that are pivotal to the debate while discussing the energy transition from a gender lens. This included gendered innovation, the gender role in fuel choice decisions, energy services and security at the household level. The chapter then presented the arguments for a gendered energy transition at the urban household level, considering a context-specific assessment. To this end, the chapter presented a novel theoretical framework informed by mainstreaming gender to enable access to clean energy such as LPG and electricity by the urban household in Mozambique. Chapter 3 of this research provides a context analysis in which the Mozambican energy sector's outlook on gendered energy transition is brought into perspective.

CHAPTER 3: MOZAMBICAN ENERGY SECTOR OUTLOOK ON GENDERED ENERGY TRANSITION

3.1. Introduction

This chapter provides the foundation to address the research questions under the second research objective. This study's second objective was *to assess gendered energy profiles and energy services in urban households in Mozambique*. In this chapter, the study provides an overview of the country's economic status and its remarkable periods of evolution. It furthermore provides a discussion of factors that shape household fuel choice, followed by an analysis of the status of mainstreaming gender within the energy sector. In doing so, the study intends to uncover the gender role in promoting fuel switching. Finally, the section presents a summary and conclusions.

3.2. Economic and social context of Mozambique

Mozambique is a low-income country in sub-Saharan Africa, with around 30 million inhabitants, of which 52% are women, and 33,4% of the population live in urban areas (INE, 2020). The country is continuously at the bottom of the pyramid regarding the international economic development standards, such as GDP, GDP per capita, and the human development index (HDI), making it one of the weakest economies in the world. In 2018, the GDP per capita was US$499 per person (The World Bank, 2020), and the country's HDI was positioned at number 180 out of 189 countries and territories. The average life expectancy at birth is 60 years, and nearly 55% of the population lives in poverty, which is an increase from 2015, when 46% of the people were living in extreme poverty (The World Bank, 2020; UNDP, 2019).

Mozambique borders South Africa, eSwatini, Zimbabwe, Zambia, Malawi and Tanzania. The country lies on the Indian Ocean for 2 500 kilometres in the east. Mozambique's total area of 802,590 km^2 is divided between land and water, making the country the 34th largest country in the world in territorial area. Figure *3.1* shows a map of Mozambique and highlights its location globally and on the African continent. Portugal colonised Mozambique, which thus inherited Portuguese as its official language.

Figure 3.1: Map of Mozambique

Source: https://geology.com/world/mozambique-satellite-image.shtml

The country has ten (10) provinces, namely Maputo (capital city), Gaza, Inhambane, Sofala, Manica, Tete, Zambézia, Nampula, Cabo Delgado and Niassa. Maputo, the capital city, is located on the western shore of Maputo Bay, at the Southern end of the country, and represents the pivotal arena of decision-making in all economic, political and social spheres of government. Four relevant periods mark the country's pathway toward economic development (De Brito, 2009). The first, from 1895 to 1975, represents the Portuguese colonial rule that subjugated the country. During the colonial era, the country's economy experienced two different stages. In both, the economy was service-oriented.

In the *first* period, the existing industry was mainly agro-industrial, and nearly all the production was for export. All decisions came from Portugal during this phase and were made according to their interests. This was because Mozambique was considered an overseas province, and Portugal was the capital. During this period, all economic development strategies were shaped to benefit the coloniser, and most of the revenue generated was invested in Portugal. The *second* period was marked by a need to promote the migration of the Portuguese population to the so-called overseas provinces. This phenomenon obliged the colonial state to develop a local industry of consumer and intermediate goods. During this period, the Cahora Bassa Dam was built and completed. Moreover, despite the commencement of coal exploration, this extractive industry was still in its infancy. Also, although natural gas was discovered in Pande and Temane in 1960, it was only in 2004 that its production and export began. The *third* significant period happened after the proclamation of independence in 1975. Two years later, the nation succumbed to a civil war that lasted for sixteen years (1977 to 1992). There were two main parties, *Frente de Libertação de Moçambique* (FRELIMO) and *Resistência Nacional de Moçambique* (RENAMO), which fought each other to gain control of and rule the country. Not surprisingly, the economy collapsed during and immediately after the civil war (Castán Broto et al., 2018; De Brito, 2009). The war decimated lives, the industry was sabotaged, and the infrastructure inherited from colonialism was destroyed, including nearly all the transmission lines from the Cahora Bassa hydropower plant (Mahumane & Mulder, 2016).

Moreover, the rural exodus reached unprecedented rates, and the cities were packed with people seeking protection (Castán Broto et al., 2018). They remained in the cities even after the civil war, and the country lived permanently on foreign aid (De Brito, 2009). The end of the hostilities marked the beginning of the democratic era, which is the last period – marked by the establishment of the income economy, which started after the peace agreement between the opposing parties in 1992. One of the most significant changes in this era was the shift from Marxist ideology, which was embraced immediately after independence, to a capitalist ideology. As a result, Mozambique experienced an economic recovery based on the development of the extractive industry, accompanied by an increased rate of electrification (Castán Broto et al., 2018). It is essential to note the paradoxical aspect of the Mozambican economy.

On the one hand, excluding aluminium, energy products such as gas and electricity are the most substantial contributor to the country's exports. On the other hand, Mozambique has a deficit in supplying internal demand and reverts to Eskom to import electricity from South Africa. At the same time, Mozambique exports electricity to South Africa (Mahumane & Mulder, 2016). Another aspect worth mentioning is that, despite increased electrification in Mozambican households, biomass consumption remained a significant share of the TPES throughout the four periods.

The Government of Mozambique acknowledges that promoting gender equality is fundamental for sustainable development. This can be verified by regional and international instruments that advocate promoting gender equality. These instruments include, but are not limited to: (i) the Convention on the Elimination of all Forms of Discrimination Against Women (CEDAW); (ii) the Solemn Declaration on Gender Equality in Africa (SDGEA); (iii) the Beijing Declaration and Platform for Action; (iv) the Southern African Development Community (SADC) Declaration on Gender and Development; (v) the Protocol to the African Charter on Human and People's Rights on the Rights of Women in Africa; and (vi) the SADC Protocol on Gender and Development.

Figure *3.2* illustrates the timeline in which the government of Mozambique has rectified these instruments since 1993.

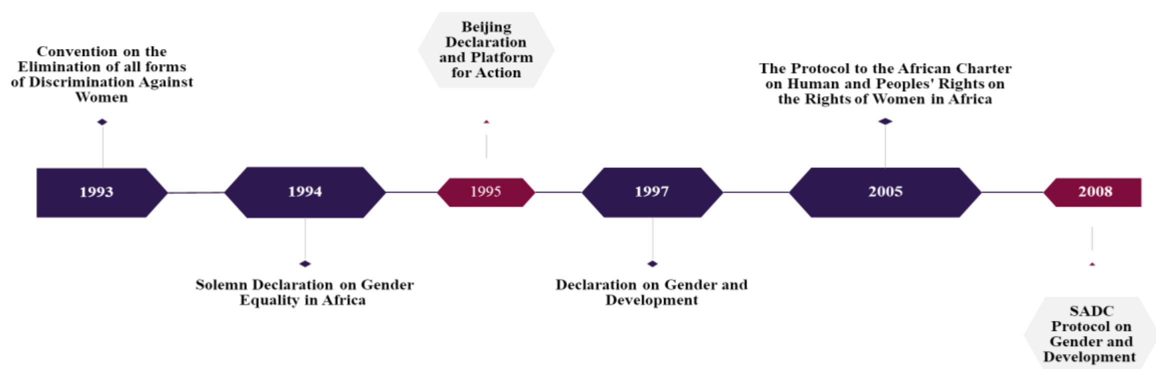


Figure 3.2: Timeline of the gender-oriented instruments rectified by the Mozambican Government
Source: Own visualisation

Not only does Mozambique have ratified instruments that mandate the signatory countries to act and enforce policies that enable gender equality, but the state also has an institutional and legal framework that is favourable for gender equality. Some of these are part of the country's executive structures, including (i) the Government's Five-Year Programme (2015 to 2019); and (ii) the Action Plan for Poverty Reduction, known as PARP (*Plano de Acção para Redução da Pobreza*). These frameworks reiterate that promoting gender equality is fundamental to sustainable development. Furthermore, Mozambique has gender strategies in critical areas for the country's socioeconomic development, such as education, health, agriculture, energy and mineral resources, and public service (Ministério da Energia, 2011).

3.3. Female opportunities in the Mozambican context

In sub-Saharan Africa, gender debates are closely related to female empowerment (Castro Lopes et al., 2021), including access to education, land ownership, employment, and income generation. In Mozambique, girls have lower school attendance (Jaén-Sánchez et al., 2020) amid unintended pregnancy (Muleva et al., 2022), allocation of time-consuming chores (Oparaocha & Dutta, 2011) and poverty (UNDP, 2019). Furthermore, as previously shown, Mozambican households are predominantly male-headed (INE, 2020), and in urban areas, men (62,5%) represent the gender with a higher employment rate INE (2021). However, according to Gradín & Tarp (2019), women often perform unpaid activities and mainly work in the agricultural sector, though primarily rudimentary. Castro Lopes et al. (2021) found a direct relationship between female empowerment and the probability of participating in decision-making. The authors found that education is the most critical feature. In this perspective, women's empowerment is a vector that could not only allow them to decide about the fuel choice but also to actively advocate the advantages of energy transition and the benefits it brings to sustainable development. Women empowerment is multidimensional and involves context and location-specific.

3.4. Outlook of the Mozambican energy sector

Mozambique is argued to have a vast potential for power generation. With different untapped energy sources, such as coal, gas, wind and solar, it is also emerging as one of Africa's leading energy producers (Mahumane & Mulder, 2019). Moreover, hydropower accounts for 61% of the country's installed capacity, approximately 2,200 MW (Uamusse et al., 2019), representing the leading source of electricity generation – a renewable energy source. Moreover, projections of the natural gas reserves indicate that their exploitation in Africa, including in Mozambique, is expected to last for 900 years before complete depletion (Hafner et a., 2018; Uamusse et al., 2019). Despite the availability of diverse energy sources, the country still fails to provide access to modern energy forms to its population. Surprisingly, Mozambique exports a significant amount of its electricity production to South Africa, Zimbabwe and Botswana (EDM, 2018; Mahumane & Mulder, 2019). There is a long-term agreement with South Africa's electricity entity Eskom. Under this agreement, Mozambique will export 1,500 MW of its production to South Africa, representing 70% of its capacity, until 2027 (Uamusse et al., 2019).

However, the contract will terminate in 2029 (EDM, 2018; Mahumane & Mulder, 2019). Nearly all its coal and natural gas production is also exported. Natural gas is transferred via pipeline to South Africa. Moreover, exportation is the leading destination for the bulk of its natural gas from the Rovuma basin (Hafner et al., 2018; IEA, 2019a). This is one of the motivations for this study, which hopes to design a theoretical framework and pathways for the gendered energy transition, considering the opportunities that natural gas offers to change the current energy system. Therefore, this study investigates possible pathways that enable change, considering the core issues surrounding the two dimensions that threaten energy security: the affordability and accessibility of modern energy sources.

Currently, the electricity provided by the national electricity utility fails to be consistent and affordable because of the constant blackouts, and the supply is expensive, considering the purchasing power of the bulk of the population (Castán Broto et al., 2018). There is a need to highlight the debate on resource affordability in the Mozambican case. Mozambican electricity prices are relatively low, and the government supports most of the investment in transmission and distribution lines (Gregory & Sovacool, 2019). This brings to light the paradox of the government's energy strategy. As mentioned before, most of the beneficiaries of electricity are urban households, and most of the population living in rural areas does not benefit from this policy. Moreover, despite the ongoing production of natural gas by Sasol, a South African company, the gas is exported via pipeline to South Africa because of the lack of gas industry. Conversely, Mozambique imports all its domestic needs for LPG, which derives from oil – a sub-product of the oil refinery. Hence, the external dependency is influenced by the foreign country's stability since, if any disturbances occur, it may affect the final product price. Consequently, due to its reliance on external supply, Mozambique may suffer the negative consequences of this resource's affordability, availability and convenience.

Researchers have become increasingly interested in the concept of energy security to provide the meaning of the concept and how it can serve as a tool to measure and promote energy transition (Jansen & Seebregts, 2010; Månsson et al., 2014; Novikau, 2019; Parag, 2014; Pasqualetti & Sovacool, 2012; Sovacool, 2011a). Hence, the long-standing problem of limited emphasis on developing world contexts prevails (Musango et al., 2020a) since many of these countries focus on foreign countries' dependence on a supply of energy from a given economy (Novikau, 2019). Mozambique has limited dependence on imported energy, except for oil products, where the country is positioned on the exporter side. However, a risk of fuel available exists mainly for those who have adopted LPG. The potential lack of fuel availability challenges the country to provide energy security strategies to balance its net exportation and domestic demands. The government is yet to produce these strategies and establish the scope for a definition of energy security.

A transition to a different energy source that differs from that on which the regime depends should be accompanied by clear support from the energy system. This is pivotal because, as Gillessen et al. (2019) discussed, the transformation of energy systems affects energy security. Moreover, shifting from traditional biomass to modern energy carriers is expected to change the country's energy system in Mozambican. Hence, to ensure energy security, the new sources must be capable of supplying the system's needs. This will also ensure that the sources are sustainable and according to the end users' values and expectations. The Mozambican energy sector depends heavily on biomass, followed by oil and hydropower (see Figure *3.3*). Moreover, regardless of the introduction of natural gas in early 2005, its share has remained marginal until now, and biomass remains the dominant energy source.

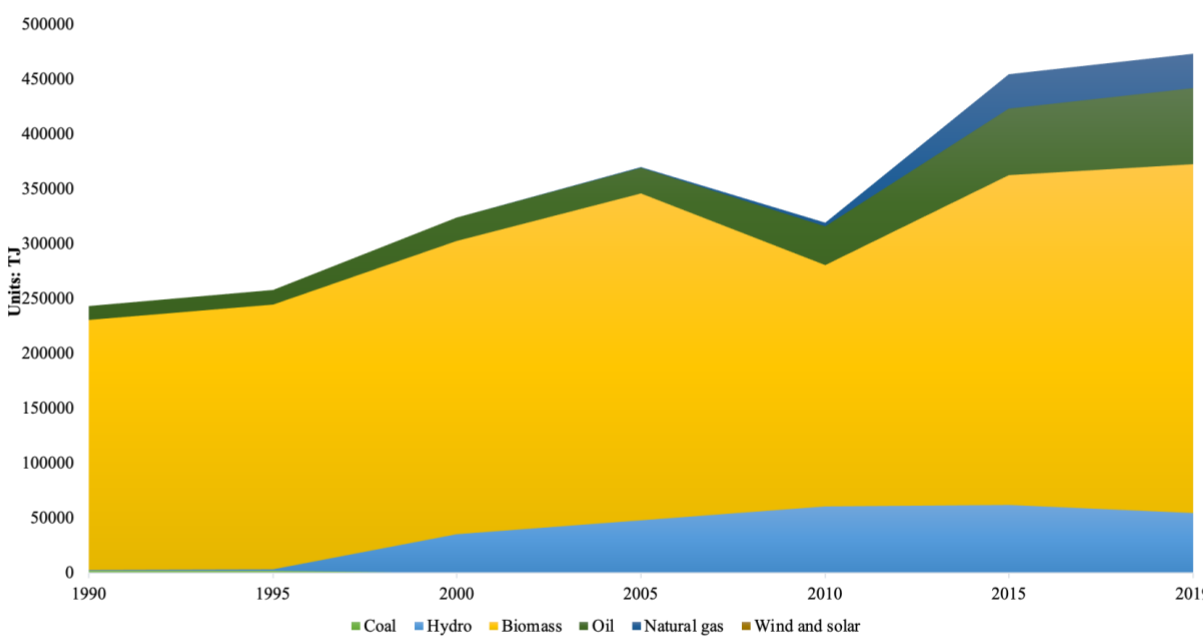


Figure 3.3: Total primary energy supply by source, Mozambique 1990-2019
Source: Adapted from IEA

It should be noted that, although the IEA (2020a) mentions 'biofuels and waste' in its designation of Mozambique's energy profile, this designation is for standardisation purposes, meaning that e IEA uses this designation for all countries. The International Energy Agency defines biofuels as 'liquid fuels deriving from biomass or waste feedstock' (IEA, 2019a:265). However, in Mozambique, the production of biofuels, in its literal form, is nearly non-existent (Fundira & Henley, 2017). Hence, the study refers to biofuels and waste as biomass or solid fuels. The arguments for this normalisation are based on the literature on the Mozambican energy profile (Arthur, Bond & Willson, 2012; Castán Broto et al., 2018, 2020; Mahumane & Mulder, 2016; Salazar et al., 2017; Silva et al., 2019; Uamusse et al., 2019). Despite its alarming dependence on traditional biomass, the Mozambican energy sector has evolved significantly since its independence, proclaimed on 25 June 1975 (Arthur et al., 2012; Mahumane & Mulder, 2016; Salite et al., 2021). Before Portugal colonised the country, access to modern energy carriers was limited to the wealthy and assimilated. However, the government has invested significantly in infrastructure to provide access to modern energy carriers such as electricity and gas (Castán Broto et al., 2018; Mahumane & Mulder, 2016, 2019).

According to Figure *3.4*, biomass accounted for 67% of Mozambique's total primary energy supply in 2019, as in the rest of Africa and other developing economies. Mozambique has one of the larger hydropower capacities in Africa, with 2,200 MW (Mahumane & Mulder, 2016; Uamusse et al., 2019). Nevertheless, the benefits of this venture fall short of the expectations of Mozambican citizens, who wish to have their homes electrified and use the electricity produced by the Cahora Bassa Hydroelectricity Company. Not only that, but Mozambique also exports the bulk of its gas from Temane and Pande and similarly to the hydropower situation, the benefits are yet to reach the Mozambican population.

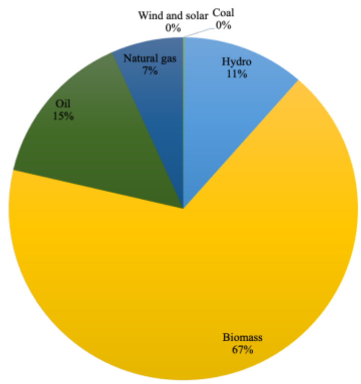


Figure 3.4: Total primary energy supply by source, Mozambique 2018
Source: Adapted from IEA (2021b)

More recently, with the construction of the gas to electricity power station at Ressano Garcia in Maputo Province, some of its production has been consumed locally in the form of electricity. Hence, its prices are highly prohibitive and have forced the national electricity utility to increase electricity tariffs. This brings concerns about affordability and the extension of the electricity grid to those who lack access to the national grid (Gregory & Sovacool, 2019). As a result, this prevents many Mozambican households that live under the poverty line from having access to clean energy carriers. Figure *3.5* illustrates the differences between Mozambican total energy consumption by source and that of the rest of the world. For instance, while biomass represents only 10% of the world's total energy consumption, in Mozambique, it represents 66% of the country's total energy consumed in 2019. On the other hand, despite the existence and exploitation of coal, its share in the country's consumption is nearly non-existent because nearly all the coal production is exported.

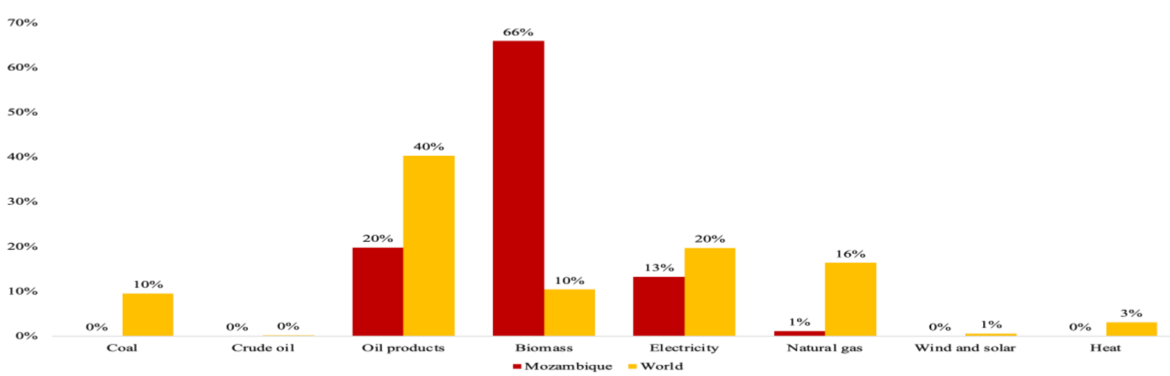


Figure 3.5: Total final consumption by source – Mozambique and the world in 2019
Source: Adapted from IEA (2021b)

Figure *3.6* shows that, in general, the energy consumption of countries registered an increasing trend from 1990 to the year 2019. This growth is directly attributed to population growth and economic development, although other specific factors may have influenced the trend. It can be seen that, over the period in question, the residential, industrial and transport sectors stood out, although the residential sector was the absolute leader. The residential sector leadership makes the sector important from the point of view of energy strategies and policies and deserving of in-depth analysis. This analysis enables an understanding of the factors influencing consumption levels to optimise consumption and ensure sustainable energy use within the sector.

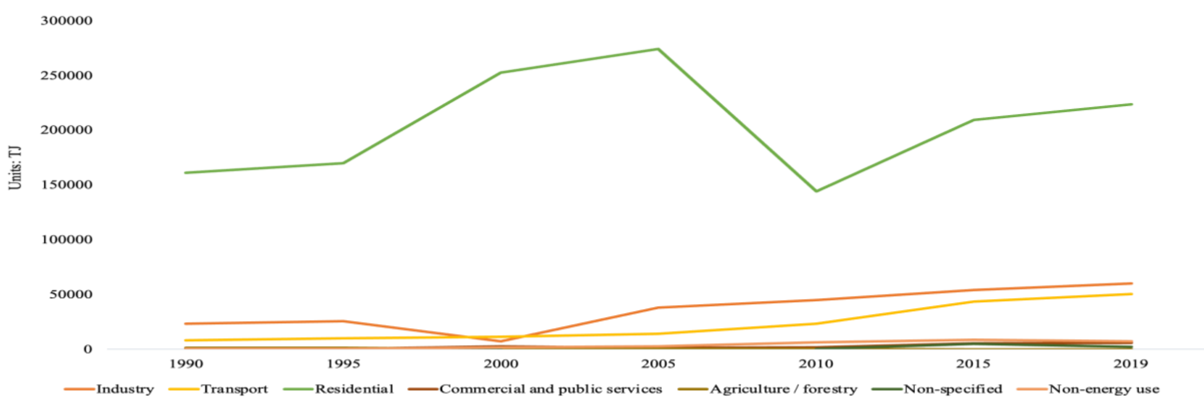


Figure 3.6: Total final consumption by sector, 1990 to 2019
Source: Adapted from IEA (2021b)

Figure *3.7* shows that the residential sector is responsible for consuming 64% of the total Mozambican final energy, followed by the industry and transport sectors, with 17% and 14% in 2019, respectively.

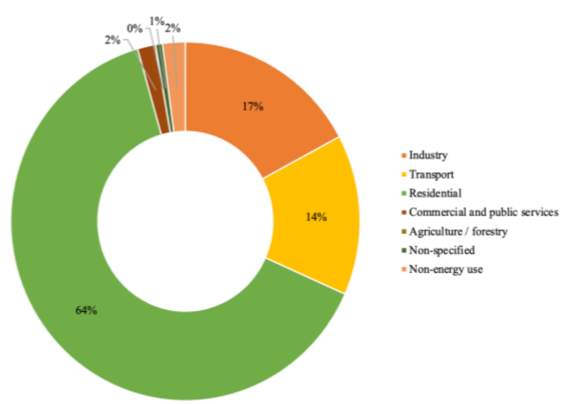


Figure 3.7: Total final consumption by sector in 2019
Source: Adapted from IEA (2021b)

As stated before, aside from the current gas production in Panda and Temane, the gas discovery in the Rovuma Basin, estimated at over 180 tcf, makes Mozambique newly rich in hydrocarbons. However, since the areas were leased to international investors, agreements were made between the government and the investors. Some of these include exporting gas production to Asian and European markets. A small portion will be left in the country that will be channelled to electricity production and processing into liquid fuels and fertilisers. This small proportion is expected to improve the living conditions of those who rely on biomass to meet their energy needs. This study also intended to provide a strategy to boost the massive adoption of this energy source, which is cleaner than traditional biomass.

Nevertheless, it is critical to note that abundance in natural resources is not an automatic assurance of social and economic development. Indeed, according to Cockx and Francken (2014), studies have shown that resource-rich developing countries have performed worse compared to resource-poor countries. There are some examples in Africa to take lessons from. These include bad experiences in countries such as Angola, Equatorial Guinea and the Democratic Republic of Congo. The abundance of natural resources brought management problems, institutions and dependence on oil resources. Selemane's (2009) observation indicates that countries rich in natural resources remain extremely poor, even after long years of exploitation. This situation of abundant natural resources, along with slow economic growth and extreme poverty, is known as the 'paradox of abundance' (Nwonwu, 2016). In other words, the 'natural resource curse' was coined by Auty in 1994 (Cockx & Francken, 2014). Thus, these observations pose enormous challenges for Mozambique, especially in ensuring that gas revenues contribute to the well-being of all citizens of current and future generations. This manifests in the citizens' ability to reap the benefits of having these modern resources to improve access to clean energy.

3.5. Energy patterns of the Mozambican residential sector

In Mozambique, the residential sector is the most significant final energy consumer, accounting for 64% of the country's total energy consumption (IEA, 2021b). However, the bulk of the energy results from biomass combustion. The findings of Pablo-Romero, Pozo-Barajas and Yñiguez (2017) suggest that developed countries, including eastern and southern Asian countries, are called to reduce the energy consumption of their residential sectors substantially. Their study does not intend to exclude developing countries from this quest. Instead, they acknowledge that energy consumption in developing countries is growing rapidly, despite residents still lacking basic needs, such as access to clean energy carriers.

The conceptual framework of energy access demands a paradigm shift in the Mozambican energy sector, electrification acceleration, and an increase in LPG consumption as keys to clean energy access. According to Figure *3.8*, while the residential sector is the more substantial energy consumer, the sector consumes only 11% of the electricity available in Mozambique, which means that electricity is not yet widely distributed countrywide, leaving the sector to depend on biomass. Moreover, the bulk of the electricity generated by the country is destined for industry. Hence, the industry is the second largest energy consumer in the economy.

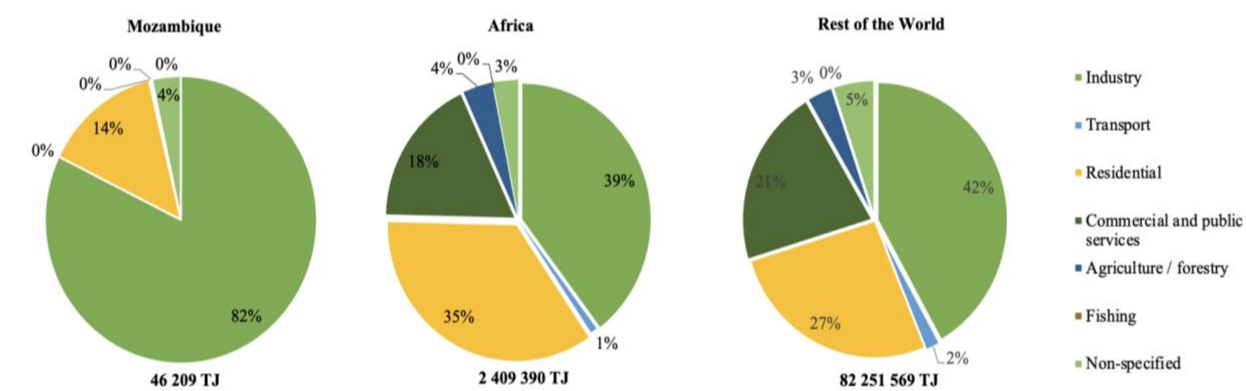


Figure 3.8: Final electricity consumption by sector, Mozambique, Africa and the rest of the world, 2019
Source: Adapted from IEA (2021b)

According to the IEA (2019b), about 40% of Mozambicans have access to electricity, including both on-grid and off-grid systems. Also, several off-grid renewable initiatives focus primarily on rural electrification. For instance, a recent estimate of solar PV's installed capacity is 2,2MW (Castán Broto et al., 2018). These figures corroborate the statements by Brouwer and Falcão (2004), Castán Broto et al. (2018), Cuvilas, Jirjis and Lucas (2010), the IEA (2019a), and Mahumane and Mulder (2016, 2019), which indicate that the bulk of Mozambicans relies on traditional biomass to meet their energy needs. If dependence on biomass persists, the Mozambican development aspiration may be jeopardised since energy is positively related to economic development. In fact, if the poor are marginalised, they will succumb to even deeper poverty and deprivation (Pachauri et al., 2012). Some factors impede the widespread use of clean energy. According to Bouille et al. (2012), these include but are not limited to a lack of financial resources, income asymmetries, and uneven distribution of natural resources.

However, some prerequisites are widely known and have been discussed intensely by scholars from diverse disciplines that facilitate modern energy access. The starting point is fuel availability, affordability and convenience (Coelho et al., 2018; Pachauri et al., 2012). The Mozambican household environment has been the subject of several studies, including those by Arthur et al. (2012), Mahumane and Mulder (2016) and Castán Broto et al. (2018, 2020). These studies provide an excellent outlook on the Mozambican household energy patterns, and they all conclude that Mozambican families depend on multiple fuels to meet their energy needs. Mahumane and Mulder (2016) say that household fuel alternatives can be distinguished in electrified and non-electrified households. Electrified households often rely on electricity, LPG, kerosene, charcoal and fuelwood, while non-electrified households tend to adopt kerosene, charcoal and fuelwood.

These findings concur with Castán Broto et al. (2020), who indicated that even the more affluent households still use charcoal as their energy alternative to meet their energy needs. Risseeuw's (2012) study reveals that the fuel switch to modern and clean energy carriers in Mozambique is related to internal household arrangements and external factors such as affordability, availability and accessibility. Arthur, Zahran and Bucini (2010) and Leach (1992) concur and state that a household's ability to purchase energy appliances influences their fuel choice. Although Leach (1992) is categorical in affirming that an increase in income is a determinant for energy transition, Castán Broto et al. (2020) revealed lower confidence levels in determining households' fuel choices. Neighbourhood characteristics and cultural values stood out in their study(Castán Broto et al., 2020). They also found that, as a household's income increases, so do its energy consumption and fuel alternatives.

Observations by Sovacool (2011b) made when the author investigated households' energy ladders concur with this argument and say that households tend to have multiple energy sources as their income increases. Families use this mechanism to increase their energy security. What is observed is that the systems still have these technologies as an alternative. This corroborates the findings of

Kaygusuz (2011), which postulate that when households' income increases, they do not eliminate the energy sources that are regarded as traditional. Instead, they tend to expand their fuel choice and technologies by having multiple alternatives (Cheng & Urpelainen, 2014; Jewitt, Atagher & Clifford, 2020). So, the energy ladder theory does not reflect what is observed empirically because households rarely move along the ladder; instead, they are found to stack fuel (Cheng & Urpelainen, 2014; Ihalainen et al., 2020; Rosenthal et al., 2018).

There is also an important finding from Arthur et al. (2010). They indicated that the unit cost of traditional energy is high compared to their competitive modern forms, such as LPG and electricity. This finding appeals to the poverty-alleviation mechanism for poor urban households. Castán Broto et al. (2020) conclude that, despite this apparent advantage, families, even when electrified, still adopt alternative and often traditional fuels for some of their daily energy needs. Several factors contribute to this slow transition. For instance, Clancy and Mohlakoana (2020) identify a lack of gender-sensitive policies, which is the case in Mozambique. Leach (1992) also argues for a clear definition of government strategies for the targeted groups and monitoring and evaluating the efficacy of the policy to minimise risks.

There are significant factors, such as culture and lifestyle, that have been studied extensively (Sovacool & Griffiths, 2020), which influence the use of solid fuels by poor urban households (Castán Broto et al., 2020; Haque, Lemanski & De Groot, 2021; Johnson et al., 2019; Musango et al., 2020). The provision of modern energy carriers to the poor is not just a matter of expanding grid connection or providing more dispatching points for LPG. Even more critical is households' financial capabilities to absorb the upfront connection cost. There are recurring electricity supply costs in grid connection cases (Pachauri et al., 2012) and the cost to acquire stoves and LPG cylinders and refilling costs (Castán Broto et al., 2018; Mohlakoana & Annecke, 2009). Another significant concern that has been debated is the stigma that poor households usually attach to LPG and tend to associate its consumption with domestic accidents (Mohlakoana & Annecke, 2009).

Moreover, in the Mozambican case, LPG distribution points are often limited to fuel stations and small-scale distributors, usually far from the end users (Castán Broto et al., 2018). This situation has been impeding accelerated LGP uptake. According to the survey conducted by Castán Broto et al. (2018), only 22,5% of the surveyed households used LPG for some of their energy needs, especially for cooking, although not exclusively. The majority claim to use more than just one fuel alternative, which includes biomass and charcoal (Castán Broto et al., 2018). In this regard, this study argued the need to understand the current fuel type that is being utilised by households, how fuel switching is triggered, and what sustains the fuel switching. For instance, even in a situation where households can afford to use electricity for the energy services they need, they may face fuel deprivations because transmission and distribution lines from the national utility are yet to cover the whole country (Castán Broto et al., 2018; Gregory & Sovacool, 2019; Mahumane & Mulder, 2019). Access to LPG is also limited because the supply is concentrated in the south and major cities in other parts of the country (Castán Broto et al., 2018). In addition, the electricity rate and LPG price are still highly prohibitive (Castán Broto et al., 2018; Mahumane & Mulder, 2016). A significant number of the Mozambican population live below the poverty line and cannot cope with the high upfront investment cost and recurring costs (Castán Broto et al., 2018, 2020).

The consumption of LPG is still confined to urban areas (Castán Broto et al., 2020) and is subjected to several issues, such as dependence on the importation, price fluctuations and availability. Despite this, civil society has recently raised concerns about the government's capability to regulate the market players as piracy allegations relating to LPG suppliers increase. The extract from the Mozambican *Noticias* Journal (14 August 2021, p. 2) discusses LPG consumption in Mozambique. It implies that gas cylinders have been tampered with, and the indicated weight does not match the contents, forcing families to spend more money and, in some cases, to return to solid fuels (see Figure 3.9).

Tema de Fundo

Será que teremos que voltar à lenha?

DENTRE as várias reclamações apresentadas, nos últimos tempos, pelos moçambicanos, há uma que é comum: o gás de cozinha já não dura tanto quanto antes.

Esta situação fez com que os consumidores procurassem diversas maneiras de manifestar o seu desagrado contra os provedores deste produto, uma vez que desconfiavam que eles andavam a adulterar o peso das botijas.

É que muitas famílias que usam o produto há décadas sempre se guiaram na máxima de que uma botija está para aguentar pelo menos um mês. Vai daí que surgiu a ideia de que vale mais investir no uso do gás do que da lenha, afinal este sistema saía muito mais barato. Acontece, porém, que nos últimos tempos o cenário alterou completamente, ao ponto de, por exemplo, uma botija de gás de 11 quilogramas somente ser usada apenas uma semana. Ou seja, para aguentar um mês passaram a ser necessárias quatro botijas. Isto equivale a dizer que mantiveram-se as mesmas botijas, manteve-se o preço, mas a quantidade do gás existente nestes recipientes deixa muito a desejar. É que o mesmo parece evaporar-se somente por carregar a botija do posto de revenda para casa.

A situação do gás está a obrigar muitas famílias a inventarem soluções, chegando algumas a usar, simultaneamente, gás, carvão vegetal, lenha e os fogões eléctricos. É que o penoso "sumiço" do gás nas botijas não está nada bom para ninguém.

E porque ninguém mais aguentava puxar os cordões à bolsa para adquirir quatro botijas por mês, eis que o choro geral irrompeu, com muita gente a ampliar a sua desolação nas redes sociais.

Foi diante de tanto clamor dos consumidores que o Instituto Nacional de Normalização e Qualidade (INOQ) decidiu pôr mãos à obra. E foi à rua para compreender a razão de tanto choro, sobretudo de gente que dizia haver algo estranho com as botijas de gás. Eis que, inspeccionados uns tantos recipientes, o INNOQ detectou o problema: hás muitas botijas de gás que aparecem com o peso adulterado. Ou seja, essas não são devida e suficientemente enchidas.

A constatação desta instituição governamental que lida com pesos, medidas e qualidade não causou espanto para os pacatos consumidores, afinal passaram de uma para quatro botijas ao mês. Só isso depreendia que algo não estava bem aqui. Faltava apenas a confirmação destas suspeitas.

Mas se o choro de muitos consumidores levou o INNOQ a fazer um trabalho de fundo que permitiu detectar anomalias, a questão que agora se coloca é: quem será responsabilizado por estas falhas gravosas que lesam o pacato cidadão? Quem garantirá que, doravante, o consumidor do gás não mais precisará comprar quatro botijas para poder aguentar-se durante os 30 dias? Quem será penalizado pelos transtornos de vária ordem, incluindo os prejuízos de ordem financeira, que sempre recaem sobre o consumidor? Será esta uma estratégia para desencorajar o consumo do gás ou simplesmente os provedores deste serviço apenas andam a ludibriar o Estado, o Governo e todo um povo. Sim! Todo o povo, porque estas anomalias foram detectadas em todo o país.

Bom mesmo é que o INNOQ decidiu intervir. Agora, verdade seja dita, todos aguardam por uma solução, que passa por corrigir-se as graves falhas constatadas nas botijas de gás, que obrigam o consumidor a comprar quatro botijas por mês.

Figure 3.9: Do we have to go back to wood?
Source: *Noticias Journal*, 14 August 2021, p. 2

3.6. Summary

This chapter provided an outlook on the Mozambican energy sector, emphasising transition. The analysis of the Mozambican economy, combined with its energy sector, indicates that there is a long way for Mozambique to go to reach the intended development goal and provide modern energy carriers to its population. Nevertheless, the existing energy resources, combined with the growing institutional capacity and successful transition examples, make it possible for the country to keep up the pace and deliver both dividends, economic growth and change to modern energy carriers. It was found that, as in other developing countries, Mozambican households depend significantly on charcoal and fuelwood for their energy needs and that cooking needs are met mainly by using charcoal in urban households. Not only do urban households use charcoal as their energy carrier, but they also use it interchangeably with LPG. Hence, LPG is becoming more of an alternative, despite the relatively low pace of its introduction. The literature also indicates a growing awareness of gender roles in the energy sector. Several actors concur that the mainstreaming of gender is a factor in massive transition, especially in developing countries such as Mozambique. Chapter 4 discusses the research methodology.

CHAPTER 4: RESEARCH METHODOLOGY

4.1. Introduction

This chapter provides the methodology to respond to the stated research objectives to address the gaps in the mainstream energy transition frameworks. The research implemented a mixed-methods approach. The mixed-methods combines a quantitative approach, defended by positivism and a qualitative approach, preferred by interpretivism. The third objective of the research valued the deductive-inductive approach as part of developing the gendered energy transition pathways informed by the critical literature review and the case study. The method adopted serves as a guide to provide a theoretical framework and a map to design the pathways for the gendered energy transition in urban developing households. This chapter firstly gives a brief introduction to the research methodology. It then presents the research design to substantiate the approaches that were considered to respond to the research objectives. Thirdly, it presents the research paradigms followed by the study, followed by the methods that were defined according to each of the stated research objectives. The last three sections of the chapter discuss the limitations of the adopted methodology and the ethical implications and provide a summary of the chapter.

4.2. Research design

This research adopted a mixed-methods approach, encapsulating qualitative and quantitative research approaches. Mixed methods enable the researcher to understand and deepen the explanation of the reality under study (Axinn & Pearce, 2009; Chen, 1997; Morgan, 2007; Shannon-Baker, 2016; Tashakkori & Teddlie, 1998; Van Velzen, 2018). This method enabled studying the existing energy transition frameworks and their application and relation to the Mozambican context. This approach enabled the use of the descriptive process to understand Mozambican urban households' energy needs, services and appliances and how they currently meet their needs. The method was also used to understand better the complex realities surrounding households' interactions with energy systems. It involved developing a case study and conducting a survey to discover their values, representations, beliefs, opinions and behaviours.

From a critical realism standpoint, knowledge can be attained through the 'retroduction' approach (Fletcher, 2017; Sorrell, 2018; Sovacool, Axsen & Sorrell, 2018; Zachariadis, Scott & Barrett, 2013). Retroduction is used to theorise on the cause-and-effect mechanism in an interaction between urban households and the energy system in Mozambique and to produce inferences on the outcomes that result from the traditional dependence on biomass. The retroduction approach enables researchers to engage in a more responsive and dynamic mode of inquiry into social reality (Zachariadis et al., 2013). In fact, retroduction differs from induction, deduction and abduction. The differences manifest in ways that value the researcher's ability to abstract (Sorrell, 2018). The ability of the abstract was fundamental in this study because it allowed absorbing information from the researcher's senses and bridged the theoretical foundation for the energy transition in urban developing contexts to the survey's results and vice-versa. So, by giving the gendered perspective, interpretation, and contextualised inference of the qualitative and quantitative data and making connections to the global agenda of universal access to modern energy by 2030, the study developed the energy transition framework at the household level.

Furthermore, retroduction allowed examining the current energy system and questioning whether it is social fair at the urban household level. The examination was based on what the current energy consumption pattern represents from a broad household spectrum, including household income, gender of the households, energy sources, services, and devices, to name a few. So, retroduction allowed the study to develop innovative venues that society, especially Mozambican urban households, could navigate towards energy transition informed by the literature and location-specific assessment. So, this research was inspired by the philosophy of the critical realism paradigm to determine the methods that were utilised to meet the stated objective goals. The retroductive approach was used throughout the study as a data analysis instrument. Figure *4.1* visualises how the mixed-methods approach was used and how the research process flows. The figure illustrates that the study follows a critical realism approach to address the three stated objectives. The different methodological approaches were implemented to look at the study problem from a pluralistic point of view to provide a holistic vision of the problem and produce proper inferences on the social reality.

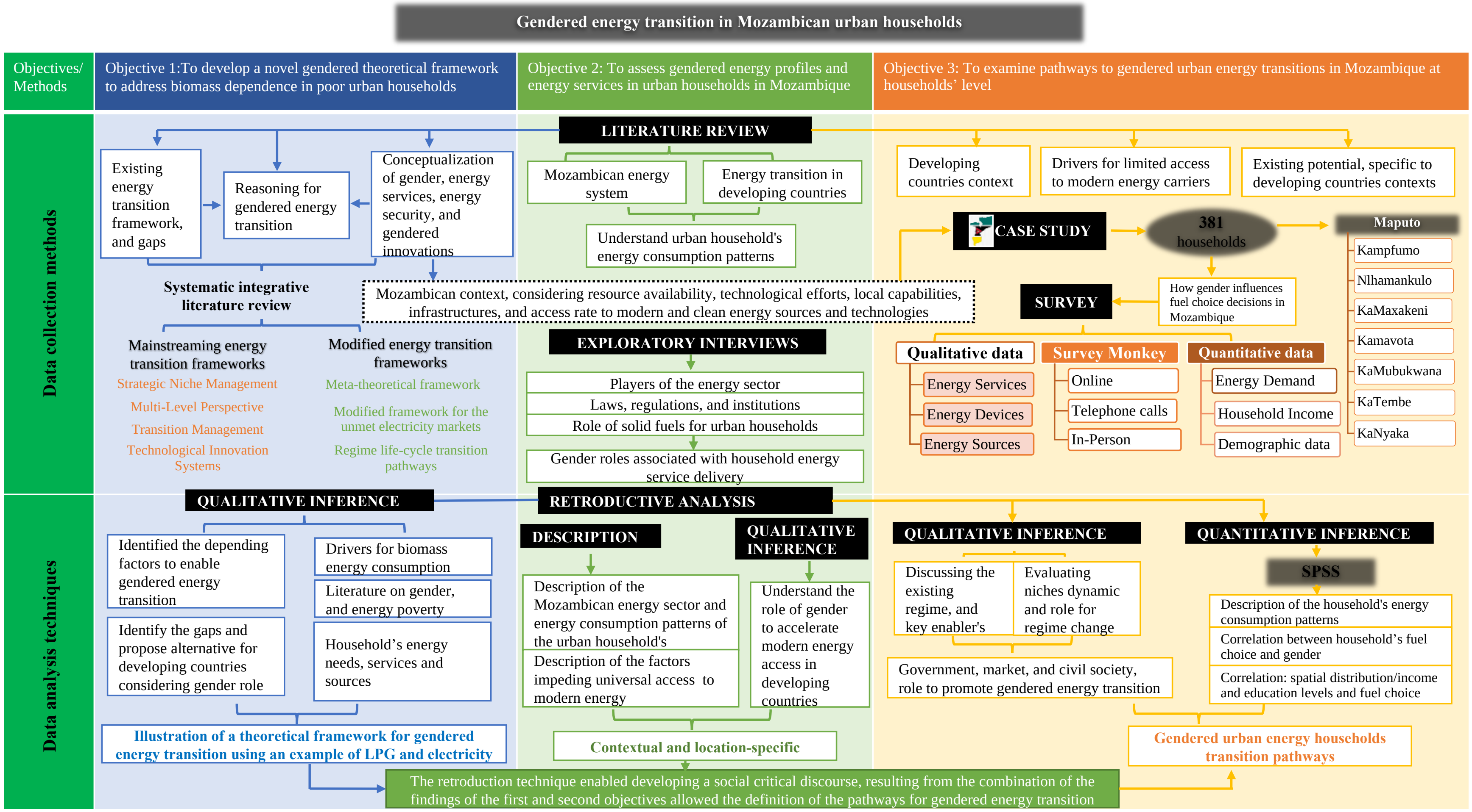


Figure 4.1: Research design and approach
Source: Own visualisation

4.3. Research paradigm

There are three prominent research paradigms in the energy social science context: positivism, interpretivism and critical realism (Sovacool et al., 2018). On the one hand, the positivism paradigm has been utilised since the 19th century and has its foundation in empirical knowledge, by which reality is understood through observation (Kim, 2003; Mingers, 2006). On the other hand, interpretivism argues that there are multiple realities, and the reality depends on the individual's beliefs, experience and understanding (Schwandt, 1998). The positivism paradigm has been criticised for its empirical perspective, which fails to provide a sense of reality beyond observable factors (Grunhut, 2019; Mingers, 2006).

The interpretivism paradigm has also been criticised for its limited replication of the findings in ways that the knowledge gained through research cannot be transferred to other contexts (Kim, 2003; Mingers, 2006). So, to address the gaps that social science researchers encounter in the two mentioned paradigms, Roy Bhaskar created a new research paradigm, defined as critical (Golob & Makarovič, 2019; Grunhut, 2019). Critical realism 'invites critical and meta-critical explorations as to why, and under what conditions, human beings generate false or otherwise inadequate accounts of their practices' (Bhaskar, 2020:115).

Several social science researchers from different disciplines have adopted critical realism as a methodology for their research endeavours (Fletcher, 2017; Hoddy, 2019; Mirzaei Rafe et al., 2019; Sorrell, 2018; Sovacool et al., 2018; Zachariadis et al., 2013). For instance, Zachariadis et al. (2013) conducted a study using critical realism to investigate the information system in the financial sector. From their philosophical approach, the authors could understand and explain the outcome of implementing information systems on firm performance. They were also capable of validating and generalising their results. There is also a study by Fletcher (2017) in which the author utilises critical realism to conduct social research in the agriculture sector. The author sought to understand how policy change influences women's welfare in the Canadian farming sector. Critical realism posed a tremendous advantage for the study because it enabled the author to explain critically the causes and effects of the policy change in the agriculture sector from a gendered perspective. The author built her arguments through critical engagement with participants' knowledge and experience in her study, which combines the positivism and interpretivism research paradigms. Not only did the approach enable an understanding of whether the policy change had a disproportional effect on women, but it also allowed the author to suggest a solution to social change that promotes social justice.

The study by Fletcher (2017) represents an extraordinary example of how critical realism can be determinant in understanding social reality from a gendered perspective and how policy influences social justice and the promotion of gender equality. It is based on the argument that this research utilised critical realism as the research paradigm. Several studies have proven the negative effect of using traditional energy carriers, which have implications for the health of the poor and the environment. There is limited research on how gender roles influence fuel choice within urban households in developing country contexts.

So, critical realism offers a tool to investigate and explain the social drivers of the existing regime, which is held responsible for the burden that traditional biomass consumption places on women and children. This understanding served as a guide to provide the transition framework and pathways for a gendered energy transition in urban households in developing countries. The ontological approach of this research is critical realism. The study first acknowledges that traditional biomass consumption in the developing world disproportionately affects women and children. However, the transition to modern and clean energy carriers provides an opportunity to promote sustainable development and reduce gender inequality in developing countries.

The epistemology that guided this study aimed to convey 'our knowledge of reality' (Fletcher, 1017; 182). According to Sovacool et al. (2019), retroduction generates knowledge. Retroduction is an approach used to create theories about social actors and causal mechanisms that combine to generate our knowledge of reality (Zachariadis et al., 2013). In this perspective, the principles of causation and validation underpin the process of knowledge generation (Fletcher, 2017; Zachariadis et al., 2013). This study's epistemology differs from those guiding positivism (*prediction*) and interpretivism (*interpretation*) (Sovacool et al., 2019). This study values explanation, which characterizes critical realism (Sorrel, 2018). This approach is fundamental because it brings up the essence of the study, which is to provide a gender-sound transition framework to understand and explain how socially constructed values influence gender roles in the fuel choice decision and how this affects the household members. Even more, through this approach, it is possible to make recommendations for the fundamental path to enable social justice, particularly gender equality, and access to modern forms of energy.

4.4. Research methods

This section presents the study's methods to meet the stated objectives. The section illustrates the methods for each of the three objectives, including the research instruments, data collection, and analysis processes.

4.4.1. Objective 1: To develop a theoretical framework for a gendered energy transition for urban households

The research instruments utilised to collect the required data to respond to the research's first objective were a systematic integrative literature review of gendered energy services and the design of the theoretical framework for the gendered energy transition in urban developing environments. The integrative literature review is a method for dynamic topics that enables the construction of new knowledge (Torraco, 2016). This method was based on Musango et al. (2020), who rationalised its application in social science research on energy. However, the inference mode that the study adopted emphasised the retroductive approach. Retroduction focuses on describing *the social reality* the study is concerned with, *why* inadequate human practices are followed, and *how* they affect social well-being. This enabled the study to engage in a more responsive and dynamic method to examine social reality (Zachariadis et al., 2013) and propose a solution to the undesirable social reality.

a) Systematic integrative literature review

The literature search was performed mainly on Scopus and was executed using the keywords of the study. The study used Boolean operators, snowballing or pearl-growing search technique. However, it was extended to the Google Scholar platform to cover the relevant grey literature. The search was performed for all concepts covered in the objective, individually and in combination, using Scopus's advanced research techniques. This included searches for the terms 'energy transition', 'urban energy transition', and 'gendered energy transition'. Then the amplitude was narrowed by limiting the subject areas, titles and keywords that matched the area of interest and selecting 30 sources (see Table *4.1*).

Table 4.1: Reviewed literature according to the filters on Scopus as in December 2020

Topics	Scopus results	Filtered results, limited to subject area, source title and keywords	Selected sources
Energy transition	361,970	111	18
Urban energy transition	1,716	132	9
Gendered energy transition	18	6	3
Total	363,704	249	30

The results show a plethora of publications related to the term 'energy transitions', which were distributed over several research areas. However, when the search was limited to the exact words and titles, social science covered a more significant number of publications, and the *Energy Research and Social Science* journal had gained impetus in the last decades. When limiting the search to 'gendered energy transition' and synonyms, 18 publications were found. However, the results dropped to only one article when limited to exact terms. The systematic, integrated review discovered that most of the research on gender and energy transition had been conducted by European researchers and that African researchers represented only 6% of the total (see Figure *4.2*). This is quite alarming because it is mainly in Africa, where issues relating to gender inequality and the transition to modern and clean energy sources are problematic.

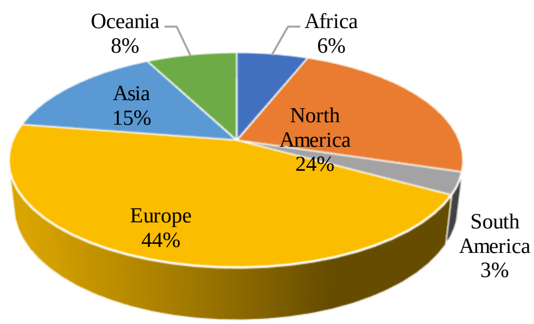


Figure 4.2: Demographics results of documents mentioning gender AND energy AND transition, excluding articles on medicine

The second search was undertaken to widen the search and to include other terms that are linked to the topic. This was executed through a combination of terms such as 'gender', 'energy services', ‘energy transition’, ‘innovation’, ‘traditional energy’, ‘energy access’, ‘energy poverty’ and ‘urban households’. Restricting the search by journal was undesirable since gender and energy are cross-cutting issues. Using the Boolean operator ‘AND’, combined with the snowballing or pearl-growing search technique in which the search is limited to subject area, source titles and keywords, 50 sources were discovered (see Table 4.2). This approach allowed the formulation of a definition of gender and linked it with the energy transition debate in the developing world context. The investigation allowed for the understanding of how gender relates to other energy-related aspects, such as energy access, energy poverty and innovation.

Table 4.2: Reviewed literature according to the filters on Scopus search as in December 2020

Term	Boolean operator	Search combination	Scopus result	Filtered results	Selected sources
‘Gender’	AND	‘Energy transition’	45	40	10
		‘Energy services’	502	287	10
		‘Technological innovation’	5 164	57	5
		‘Energy access’	562	102	5
		‘Energy poverty’	732	138	8
		‘Urban households’	32,636	623	12
Total			39,641	1,247	50

From the physical library, relevant publications relating to energy transition theory were revised. In parallel, the search was widened to the internet to include synonyms of the main terms. The search was performed using a combination of the Boolean operators ‘AND’ and ‘OR’, limiting the search scope to the social sciences and energy subject area. The search was then limited to source titles and keywords and their relevance. The study found that some of the results overlapped with those of the previous search. So it was necessary to exclude those that had already been obtained. The results were narrowed down by relevance to the topic. The process yielded 26 sources that were thoroughly reviewed. The process was executed as follows:

- *Gender* AND *energy services* OR *energy needs* resulted in 1,525 documents, which were narrowed down to nine documents.
- *Gender* AND *urban households* OR *poor urban households* OR *poor urban settlements* resulted in 41 documents, which were narrowed down to six documents.
- *Gender* AND *energy poverty* OR *biomass energy consumption* OR *traditional energy sources* OR *traditional energy carriers* resulted in 300 documents, which were narrowed down to 11 documents.

As mentioned earlier, the possible search bias deriving from the use of articles mainly from developed countries was mitigated with the search on the grey literature discussing developing world contexts. A wide range of sources was encountered using Google Scholar and the snowballing or pearl-growing search technique. After filtering the titles and abstracts for significance, 40 sources with a high number of citations were considered relevant.

Finally, to validate that all relevant publications were reviewed thoroughly, the last search was performed on 2 February 2021. This search was only conducted in the *Energy Research and Social Science* journal due to its relevance and extended publications relating to gender and energy transition. In this phase, the search started by looking for publications in 2021 that used the term 'energy transition'. The results showed a total of 34 documents. However, when limited to matching the keywords 'energy transition' OR 'energy transitions', the results dropped to 15 documents, and only two were considered relevant. The second approach was to look at publications on the topic 'gender and energy transition'. Only two documents were found, and one was considered relevant.

The selection of the literature was guided towards understanding the *state of the art* of energy transition topics within the social science energy research field to understand how the theory and existing framework respond to the issues of gender and energy access in developing countries. The study reviewed the mainstreaming energy transition researchers, such as Rip and Kemp (1998), for strategic niche management, Geels (2002) for the multi-level perspective, Loorbach (2010) for transition management, and Bergek et al. (2008) for technological innovation systems. The search for other frameworks aimed at addressing some gaps that the mainstreaming energy transition scholars failed to address. As a result, it was found three other transition frameworks, namely the meta-theoretical framework of Cherp et al. (2018), the modified transition framework for the unmet electricity market of Batinge et al. (2019), and a framework on regime life cycle transition by Kanger (2021). However, except for the model of Batinge, Musango and Brent (2019), all other models were neutral in the context of developing countries. Moreover, none of the mentioned frameworks discusses energy transition from a gender perspective. This was identified as a significant gap in the existing energy transition theory.

The central argument of this study was constructed from a combination of data from Scopus, Google Scholar and the snowballing or pearl-growing technique. This combination resulted in numerous publications and allowed for identifying peer-reviewed journals, articles, books, book chapters, web pages, global reports and other publications. The study also focused the search on the most prominent gender and energy researchers, and identified documents with evidence-based research results from a global, African and Mozambican context, as in Clancy et al. (2007), the GENS Team, particularly Musango et al. (2020), and Castán de Broto et al. (2020), respectively. These documents were then revised, as relevant for this study, by filtering them according to titles and abstracts. The total number of documents was 150, as summarised in Figure 4.3.

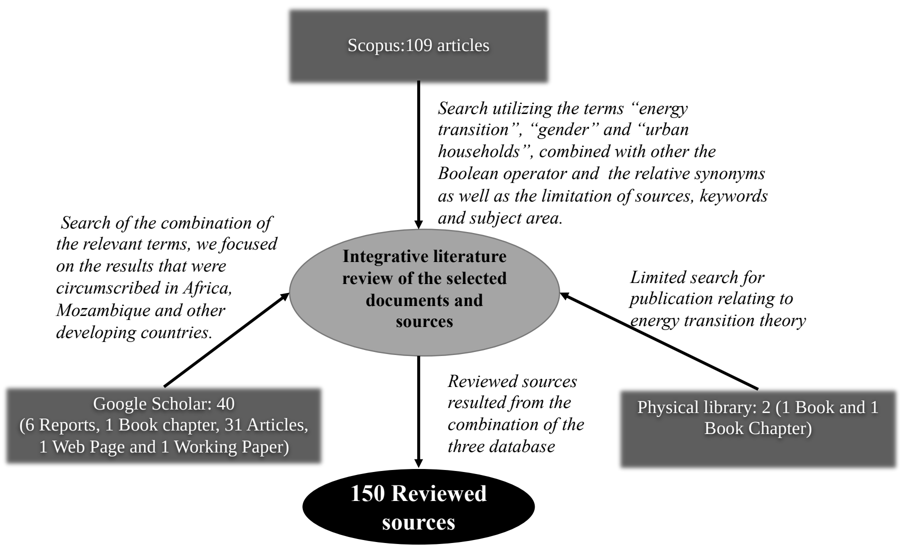


Figure 4.3: Literature selection criteria for the first objective of the research

b) Retroduction data analysis for the first objective of the research

Through a retroductive approach, the scope of this study was first addressed by investigating the Mozambican energy system, followed by a search of the scope of the existing energy transition frameworks. The gaps in the mainstreaming literature on energy transition were then identified, allowing for the construction of arguments for a gendered theoretical framework to enable energy transition in urban developing environments. The development of these topics required discussing the following questions: (i) What are households' energy needs in general? (ii) What are the energy services that they require? (iii) What is the current fuel type that is being utilised to meet their needs? and (v) What are the leverage points for transitioning from biomass to alternative fuels?

c) The theoretical framework for a gendered energy transition for urban households

The goal of the first stated research objective was *to develop a theoretical framework for a gendered energy transition for urban households*. This framework was designed by combining the foundation of the modified transitional framework with the unmet electricity market, built upon the multi-level perspective, the meta-theoretical framework that emphasises policy action as a transitional enabler, and the regime cycle transition. Then, the theoretical framework for a gendered energy transition by urban households was developed, considering the existence of traditional technologies, lessons from the existing regime, gendered innovations, low-carbon energy transition and the role of policy. The interactions and processes of these considerations were explained and then illustrated graphically, as in section 2.7 in Chapter 2.

4.4.2. Objective 2: To assess gendered energy profiles and energy services in urban households in Mozambique

The study utilised a critical literature review and exploratory interviews to collect data to meet the second research objective: *to assess gendered energy profiles and energy services in urban households in Mozambique*. The data analysis used a retroduction approach, thus focusing on a description of the social reality the study aimed to address. This included understanding *why* inadequate human practices are happening and *how* they affect social well-being. The following sub-topics provide the detailed processes for each adopted data collection and analysis approach.

a) Critical literature review

This research's second objective was to understand Mozambican households' energy services. Hence, by understanding the energy services required by the households, it was possible to draw parallels between energy services, devices and sources and the gender role in the households. To address this objective, several sub-topics were considered. These include studying the gender concept and how it relates to the present study and discussing why it is pivotal to focus on the gender role in the energy transition context.

The critical literature review highlighted how the socially constructed perceptions of gender in households dictate the transition's speed, depth and direction. It also enabled analysing of gendered innovations and how they can expedite the energy transition in developing countries. Furthermore, the literature review enabled a review of the concepts of energy security and energy services and how they relate to gender. This analysis was fundamental because it revealed that energy security is essential for households to meet the energy services required to ensure their well-being. It is critical to improving women's conditions in poor urban settlements. The literature review also focused on Mozambique to provide an outlook on its energy sector. The main finding was that, as in sub-Saharan African countries, Mozambican households rely heavily on traditional biomass – not only in rural areas but also in urban environments. The work from Castán Broto et al. (2018) provides a meaningful discussion on charcoal still being adopted by more affluent households in urban areas, regardless of its negative implications for the environment and household health.

From the literature review, it was possible to describe the reasons for a household's fuel choice decision and draw on the possible outcomes that a transition to modern energy can generate. These potential outcomes involve the construction of social well-being resulting from an equitable distribution of resources among all citizens, potentially leading to social justice. The critical literature review was carried out through (i) Internet databases such as Google and Google Scholar and online data from the Stellenbosch University Library; (ii) books from bookstores and the physical Stellenbosch University Library; and (iii) peer-reviewed journals from Science Direct and grey literature. Furthermore, to cover the studies related to gender in the energy sector, the research adopted snowballing and advanced research techniques using SCOPUS. This was done using keywords such as '*gender*', '*energy transitions*', '*energy services*' and '*urban areas*' to filter the results. This process was executed with different combinations of keywords and was used to understand the state of the art of energy transition framework.

To address the study's second objective, namely, *to assess gendered energy profiles and energy services in urban households in Mozambique*, the study first undertook a critical literature review using advanced Scopus techniques and the topics illustrated in Table 4.3. The search process allowed for several documents to be retrieved, and some of them did not match the scope of the objective. Therefore, the results were filtered to match the subject area by using the Boolean operators ‘AND’ and ‘OR’, combined with the snowballing or pearl-growing search techniques. The results were then limited to sources’ titles and keywords related to the main works that encapsulated the research objective, including Mozambique, urban areas, solid fuels, urban households, gender and energy transitions. Several sources that informed the first objective of the research overlapped with the literature search for the second objective and were also utilised during the literature review. The Scopus database gave rise to 90 documents that were analysed comprehensively. This search technique allowed for understanding the Mozambican economy and development contexts and relating this to its energy sector outlook. The peer-reviewed journals enabled navigating the local, national and international contexts and comparing the Mozambican energy systems and that of other countries, especially in sub-Saharan Africa.

Table 4.3: Literature reviewed according to the filters on the Scopus search as in August 2021

Topics	Scopus results	Filtered results	Selected sources
Mozambique ‘AND’ energy	386	27	20
Gender ‘AND’ energy	12,394	1,922	19
Energy services ‘AND’ urban households	446	332	11
Charcoal and urban areas	413	308	8
Gendered innovations	320	201	1
Energy transition ‘AND’ urban households	241	189	5
Urban, ‘OR’ urbanisation, ‘OR’ urban areas, ‘AND’ energy, ‘AND’ Mozambique	43	30	18
Gender, innovations and sustainable transitions	13	10	8
Total	14,256	3,019	90

To cover all the relevant literature that discusses the Mozambican energy system, it was fundamental to extend the search to other databases and include the databases mentioned earlier, such as Google, Google Scholar, online data from the online library, books and grey literature. This search produced a plethora of documents, and to match the documents with the topic, the search was limited to matching the keyword, subject areas and the abstract. Also, as demonstrated in Table 4.4, which summarises this search technique, several reports and web pages also contributed to obtaining relevant data on the Mozambique energy sector, particularly concerning urban households’ energy consumption patterns. Particular emphasis was put on reports and web pages by the International Energy Agency. The overall assessment verified that the Mozambican energy system is still in its infancy regarding access to modern and clean energy sources at the urban household level. It also revealed that charcoal and wood are still part of urban households' fuel alternatives.

Table 4.4: Reviewed literature extended to another database, excluding Scopus, as in August 2021

Topics	Scopus results
Peer-reviewed journals	12
Reports	15
Books	8
Books chapter	3
Web pages	15
Total	53

Figure 4.4 depicts the literature selection criteria used by the study to inform the second objective. The critical literature review resulted in a total of 143 reviewed documents. However, some sources overlapped with those utilised to address the first research objective. Hence, their content was relevant to address some of the topics discussed in the second objective. For instance, the study discussed energy transition in the first objective, which was also a point of discussion for the second objective, emphasising the Mozambican context. Hence, some of the sources were utilised for both research objectives.

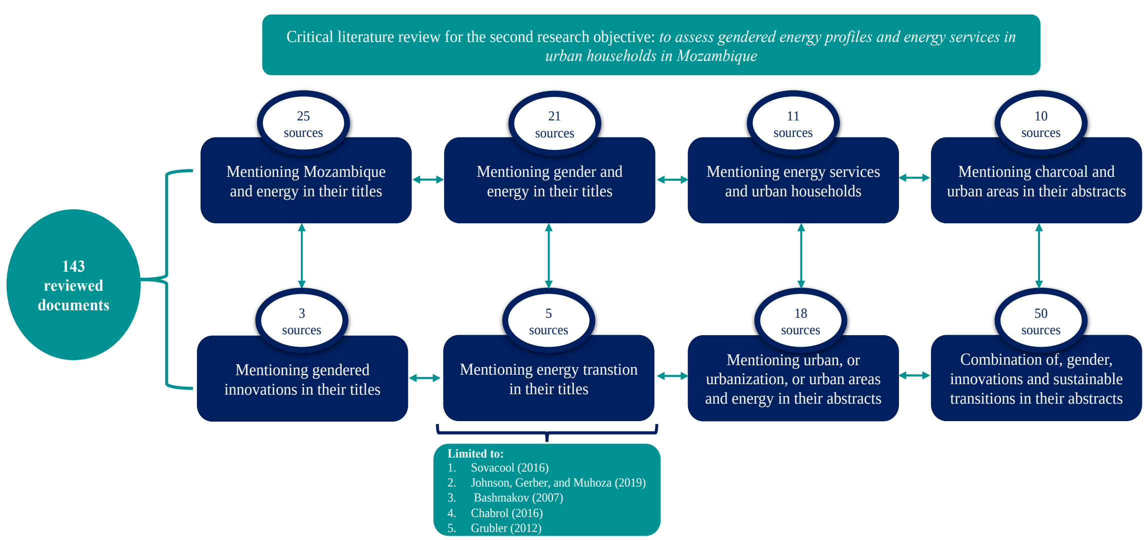


Figure 4.4: Literature selection criteria for the second research objective

b) Case study selection

This research considered the case of Mozambique. However, it is circumscribed only in urban households in Maputo, the country's capital city. Mozambique is on the verge of becoming one of the largest natural gas producers (Salimo et al., 2020). However, the country is rated as one of the poorest economies in the world, and solid fuels are the most relevant fuels at the household level. Moreover, the country does not have a domestic natural gas consumption approach (Salimo et al., 2020). Recently, there has been broad interest in the Mozambican energy system (Castán Broto et al., 2020; Gregory & Sovacool, 2019; Jones et al., 2016; Mahumane & Mulder, 2016; Salimo et al., 2020; Uamusse et al., 2019). Still, the country has a low electricity coverage rate and faces several risks, including insufficient funds and debilitating infrastructural and managerial issues (Gregory & Sovacool, 2019). Castán Broto et al. (2020) state that even high-income households rely heavily on solid fuels. Mozambique exports a significant amount of electricity to its neighbouring countries, including South Africa (Gregory & Sovacool, 2019; Uamusse et al., 2019). This paradoxical situation makes the country's energy situation atypical and deserves special attention.

Mozambican urban households' features possess some differences from those in rural areas. According to the household budget survey published by INE (2021), the average monthly income of Mozambican households revealed that between 2019/20, in urban areas, the households earned 12,972 MT per month (equivalent to 199.7 USD as of 13 August 2021), while in rural areas, the households earn 6,813 MT. The second more significant destination of the household's income is housing, water, electricity, gas, and other fuels, with 25,2% (urban areas) and 24,2% (rural areas), surpassed only by food products. There is a more economically active population in rural areas (91,2%) than in urban areas (79%). There are also other differences, between urban and rural areas, including infrastructural development, especially the grid connection, which is lacking in rural areas (Gregory & Sovacool, 2019). Furthermore, there is a massive conversion of different cultures in urban areas due to rural exodus. The rural exodus is responsible for the fast rate of urbanisation and increased energy poverty in urban areas. Mahumane and Mulder (2022) described this phenomenon as the 'urbanisation of energy poverty'. Also, on average, fuel poverty is high in urban than in rural areas (Roberts, Vera-Toscano & Phimister, 2015).

Like many developing countries, urban spaces in Mozambique comprise three different realities – urban, suburban, and peri-urban areas (Araújo, 1999). In an article published in 2003, Araújo suggested an urban spaces organisational model, as illustrated in Figure *4.5*, and discussed their peculiarity in the Mozambican scenario as follows:

i. Urban areas, so-called '*Cidade de Cimento*', are territorially organised and have paved streets, electric lighting, a water supply network, and sanitation services. Construction, in general, is vertical. They have a high trade concentration and some industries and generally comprise middle to high-income households (Araújo, 2003).

ii. Suburban areas are known as '*Cidade de Caniço*', constituting unplanned neighbourhoods with a high density of land occupation, making circulation complex. They have a deficient or non-existent network to supply electricity and drinking water. There is an absence of or deplorable telecommunication network, a lack of basic sanitation, predominantly horizontal construction, and an abundance of low-cost or precarious construction material. There also is a lack of services, poor commercial networks, industrial units, and severe environmental problems (Araújo, 2003).

iii. Peri-urban areas result from the expansion of urban areas located between consolidated urban and rural areas. There is plenty of land for construction, a completely horizontal structure, alternating durable and precarious construction material, and electricity and water supply networks are deficient or non-existent. There is a lack of essential sanitation services, difficulty in road traffic due to the lack of adequate roads and the persistence of rural activities, and the population consists of peasants residing there for a long time, immigrants from other rural areas, and immigrants from the urban areas (Araújo, 2003).

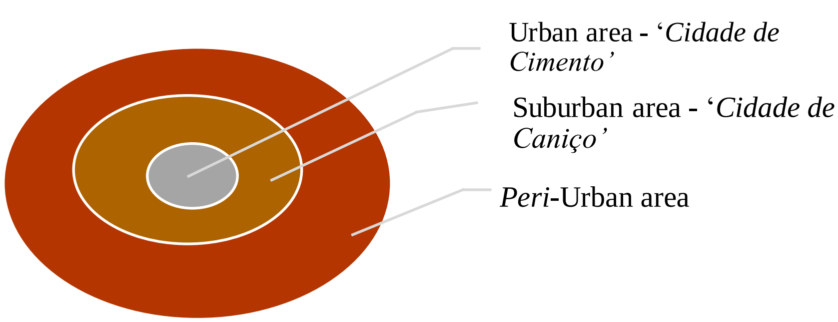


Figure 4.5: Organisational model of urban spaces in Mozambique
Source: Adapted from Araújo (2003)

The reason underlining the selection of urban areas was based on the results of many studies that suggest that households from urban areas are more likely to adopt modern energy carriers in comparison to households in rural areas (Karimu et al., 2016; Kojima, 2011; Mohlakoana & Annecke, 2009; Troncoso & Soares da Silva, 2017; Vahlne, 2017). Also, studies relating to energy access and security in poor urban environments are scarce (Musango et al., 2020). For this study's sake, urban areas comprise urban, suburban and peri-urban areas. Considering the stratification of urban areas in Mozambique (Araújo, 2003), it is fair to conclude that the Mozambican urban regions comprise high-, middle- and low-income households. Families often depend on energy services and carriers in these areas, according to the illustration provided in Figure *4.6*. The figure indicates that, as the household's income increases, so does its fuel mix. Nevertheless, they continue consuming traditional energy carriers.

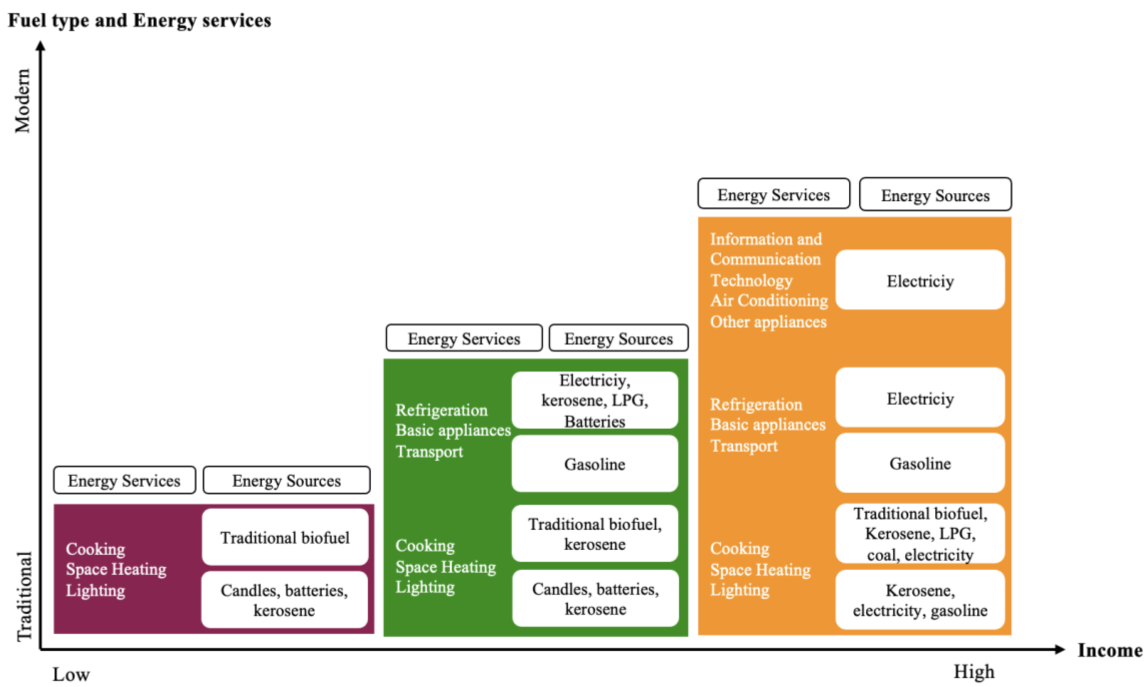


Figure 4.6: Energy services and fuels according to household income
Source: Adapted from IEA (2002)

Using a case study was fundamental for understanding the local context, which helped differentiate households' energy consumption patterns according to their neighbourhood and household income level. This stratification is of great significance because it enabled a deeper understanding of the findings of Castán Broto et al. (2020). These authors analysed why high-income Mozambican families continue to rely on charcoal. With the case study, it was then possible to compare the attributes and structures of high-, middle- and low-income households, which dictate the current fuel-type consumption pattern. Also, it was possible to navigate the networks and interactions of household members and explain the underlying reasons for traditional biomass consumption. This involved incorporating middle- and lower-income families that were not addressed (Castán Broto et al., 2020).

c) Survey of gendered energy services

Surveys are a very common approach, especially in social science research (Sovacool et al., 2018). Their main advantage is that the researchers can assess thoughts, requirements and attitudes (Hox & Boeije, 2005). Surveys enabled the gathering of primary data and information from urban households in Maputo city. This study used a survey because it allows for researching a large population and provides an opportunity for generalisation (Sovacool et al., 2019). The research problem affects urban Mozambican households and other developing urban households, especially in sub-Saharan Africa. So, the study conclusions can be generalised and provide evidence-base to make fundamental recommendations for changing their current energy systems. Surveys allow the gathering of reliable data due to the anonymity of the respondents. The anonymity increases the probability of data accuracy, in opposite to interviews. In interviews, respondents may be uncomfortable and risky in case of sensitive questions (Secor, 2010). Therefore, respondents may tend to convey inaccurate data to hide or portray a more pleasant image or vice-versa.

The data collection process considered the risks inherent in a random approach. To reduce this risk, data collection took a non-linear approach, i.e., data collection at wide-ranging schedules, including weekends. Furthermore, the study had the help of the heads of the neighbourhoods and blocks, which helped identify the families where the data would be collected. These families were made aware of the nature and context of the data to be collected. Nevertheless, in many cases, this approach proved to be the only possible one, as some households were unwilling to provide data without the knowledge of local authorities. Furthermore, in some cases where the consent of household heads was necessary, the interview was postponed if they were absent. It should also be noted that participation was voluntary and guided in terms of informed consent. Moreover, because the survey occurred during the pandemic period, where social distancing measures were in place, this favoured the study because, in some cases, it was found that many adults (some working remotely and others due to loss of work). This context and approach contributed to reducing the risk of interviewing only households where the sample was towards households with, e.g., a) a stay-at-home parent, b) unemployed people, and c) youth staying home.

The city of Maputo comprises seven municipal districts, namely KaMpfumo, Nlhamankulu, KaMaxakeni, KaMavota, KaMubukwana, KaTembe and KaNyaka. According to the last census, there are more than 235 750 households in these areas (INE, 2019). Different social groups live in these areas, including high-, middle- and lower-income families. For the design of the sample, the study considered all the municipal districts in the city. These municipal districts encapsulate the urban, suburban and peri-urban areas indicated by Araújo (2003) to manifest in Mozambican urban environments. The sample size was calculated using equation (3.1) (Daniel, 2005:142) and considered the total number of households in seven municipal districts with 62 neighbourhoods. The study assessed 235 750 households, with a margin of error of 5%, a confidence level of 95%, and a likely proportion of 50%. The recommended sample size thus was 384 households, as illustrated in Figure *4.7*. This sample size corresponds with Sovacool, Axsen and Sorrell's (2018) recommendation of the population size in analysis considering the margin of error, level of confidence, and population size.

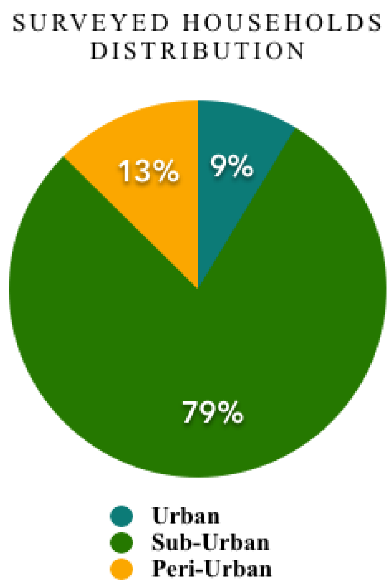
$$n = \frac{N\ x\ X}{X+N-1} \tag{3.1}$$

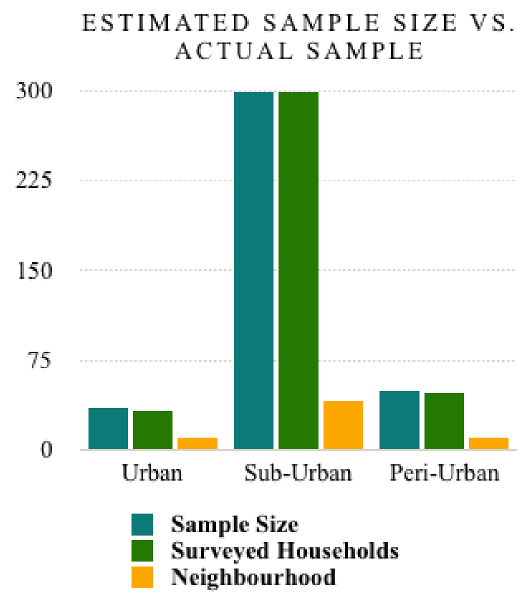
and

$$X = \frac{(Z_{\propto/2})^2 x\ p\ x\ (1-p)}{(MOE)^2},$$

Where:
N = population size;
n = sample size;
MOE = margin of error, in this case, 5%;
Z = critical value of the normal distribution; since the confidence level is 95%, α is 0.05, and the critical value is 1.96; and
P = sample proportion, 50%.

The metropolitan area, referred to as '*Cidade de Cimento*' or urban area, is home to the most affluent households (Castán Broto et al., 2018). Figure 4.7 shows that about 9% of neighbourhoods with this classification were located in the municipal district of KaMpfumo. The so-called '*Cidade* *de Caniço*', or suburban area, was stratified next. This area represented the bulk of the surveyed households and accounted for 300 households, corresponding to 79% of the surveyed households. Lastly, the study also stratified peri-urban areas located between the consolidated urban and rural regions and accounted for 48 families. These are all located in the municipal districts of KaTembe and KaNyaka, with a minor representation from KaMavota.





SUMMARY BY GEOGRAPHICAL AREA

Geographical Area	Number of Household	Neighbourhood	Sample Size	Surveyed Households
Urban	21,457	11	35	33
Sub-Urban	184,130	41	300	300
***Peri*-Urban**	30,163	10	49	48
Total	**235,750**	**62**	**384**	**381**

Figure 4.7: Selected sample according to the geographical area and neighbourhood

Table B1 in Appendix B provides detailed data on the population and sample size according to the geographical area and municipal districts, which enabled the determination of the equivalent proportion that matches each municipal district. Despite the calculation results, there was a slight difference between the estimated sample and the actual survey due to some limitations in the data collection process. This limitation influenced the sample from the urban and peri-urban areas. In suburban regions, where the bulk of the sample was located, the sample corresponded to the actual survey. So, in KaMpfumo, there were 33 surveyed households instead of 35 households. In KaNyaka, one out of the three neighbourhoods were not observed, and the total number of settings dropped from 63 to 62. Hence, due to the minor representation of KaNyaka, only one household out of the three could not be surveyed. As a result, 381 out of the expected 384 families were studied, corresponding to 99% of the projected sample size. The survey relied on a questionnaire designed by the GENS team, of which I am part. The team consists of researchers from different countries in Africa and Europe. The questionnaire was built upon the model developed by Smit, Musango and Brent (2019), based on the Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism (MuSIASEM) framework, which was published by Kovacic et al. (2019).

The questionnaire designed by the GENS team focused primarily on informal settlements, so it required an adaptation to widen the focus group and include formal settlements. Appendix C illustrates the structure and the question that was administrated to the households. A Portuguese version was implemented for the data collection due to the targeted country's official language. The questionnaires were designed to provide information on the following aspects:

1. Who is the head of the household, their gender, education level, type of work, income level, and size of the household?
2. What are the households' energy, services and devices needs in general?
3. How much do they spend on their basic needs, especially on their energy requirements?
4. What current fuel type is being utilised to meet their energy needs?
5. What role does gender play during the decision-making process for fuel choice?
6. Which are the potential fuel types? and
7. What are the leverage points for the transition from biomass to alternative fuels?

The gender assertion in identifying heads of the households was essential to analyse whether the household fuel choice decision is related to the gender of the household head. This was possible by combining the household's response to the household head gender and fuel type and comparing male-headed with female-headed. This was important to determine if there is any relationship between the genders of the heads with the fuel type they adopt. The same philosophy was used to link the education level of the head of the household and their fuel choices. The gender role in the fuel choice decision was determined by assessing who often uses a set of fuel types, including, but not limited to, paraffin, wood, LPG, candles, charcoal and electricity, and comparing their response with those who decide on and pay for the energy sources and devices that they use.

This assessment made it possible to define who is paying for the devices often assigned to women. Moreover, this research should understand traditional biomass or wood fuel as charcoal and firewood. As discussed by Brouwer and Falcão (2004) and Cuvilas et al. (2010), these represent the primary solid fuels used by Mozambican households. The households were also asked about their preferred fuel type for meeting their needs. This was necessary to complement their responses on their satisfaction level regarding their current energy mix. This assessment was pivotal in identifying the leverage points for the transition from biomass to alternative fuels. In Mozambique, LPG presents an alternative for switching from charcoal and firewood, especially for cooking. Furthermore, the data from this query was determined for developing the transition pathways for urban Mozambican households. Households were also asked about the most affected household members when insufficient energy. This assessment proved critical, especially to emphasise that issues related to energy access affect women disproportionally.

d) Process of data collection under COVID-19

The use of structured questionnaires requires defining the sample size and collecting the responses from an appropriate and relevant population group. This could have been executed through postal surveys and internet systems, including email and web surveys (Phellas et al., 2012). However, for the purposes of this study, a postal research survey was found challenging because the urban areas of Mozambique encompass informal settlements where few houses have postal addresses. Internet users were also ruled out because internet and electronic device access is still limited to more affluent citizens (INE, 2020). However, the data collection process for this study coincided with the global pandemic of COVID-19. From April until June 2020, the Mozambican Government decreed a level three state of emergency. Therefore, the data collection process was adjusted to respond to the situation while simultaneously reaching the designated sample size to overcome this problem. To this end, the techniques were modified from merely face-to-face interviews to a mixed approach, which included SurveyMonkey, telephone calls and controlled face-to-face meetings. The face-to-face interviews were administered in neighbourhoods where SurveyMonkey and telephone calls did not reach the desired sample. These interviews followed the Mozambican

Government's instructions of keeping two metres between the interviewer and interviewee and the mandatory use of masks.

The ethics evaluation committee substantiated this in the research protocol for in-person data collection under COVID-19. The survey involved five students from the Statistics Course in the Department of Informatics and Mathematics at Eduardo Mondlane University. The co-researchers engaged in this process were given a training section and selected according to their performance. These undergraduate students were identified through contacts provided by fellow postgraduate students who also collected data for their studies. This process started by converting the questionnaire into the SurveyMonkey format, which required breaking down most of the questions and adjusting the options to drive the respondents to a valid response. After this process, a pilot survey was conducted with some randomly selected participants, fellow postgraduate students and the Mozambican National Institute of Statistics employees. This process enabled identifying difficulties and weaknesses in the online questionnaire and then addressing them adequately.

The results of the pilot study made it possible to improve some of the questions. For instance, the questions about the amount of money the households spent on several needs were improved to include more options to select from. Likewise, the question relating to the type of house that the household resides in had to include a new option of a conventional house with an outside bathroom, a category not incorporated into the INE household's typology. The description of the gathered data provided a profile of Mozambican urban households, their energy patterns, their interactions with the energy system, the role of gender in fuel choice, and the energy devices adapted to meet their energy needs. Following the general households' consumption patterns description, a P-value indicator was used to understand the variables influencing the fuel choice decision. For example, to understand the roles of the household members, they were asked to indicate the people who primarily utilised certain energy services in the household.

Secondly, it was possible to determine that women and girls prioritise cooking and washing, while general household services are often gender-neutral. Furthermore, it was possible to verify that the process of allocating chores is often a result of household habits, values and culture rather than a particular logic of chore allocation. The study also intended to examine the link between fuel type and the household member who utilises the fuel most. This examination, combined with the previous assertion, was instrumental in understanding one of the critical problems that this research intended to address: the relationship between gender and household fuel type. The data was collected in person and virtually via the SurveyMonkey application. However, only 20 questionnaires were answered virtually, and most respondents did not answer all the questions, which required immediate re-adjustment to favour in-person and telephone call interviews.

The data was loaded into IBM SPSS Statistics version 26. The study utilised descriptive statistics, cross-tabulation, the p-value and the binary logistic regression model. The descriptive analysis was performed using the pivotal table in Excel, and SPSS software was used for cross tabulation, p-value and binary logistic regression model. It should be noted that, although the p-value and binary logistic regression models analyse the relationship between a dependent variable and other independent variables, the study favoured both to increase the confidence of the inferences made in the surveyed households. Further, the study utilised logistic regression because the dependent variables were arranged in categories, while in linear regression, they are continuous. In logistic regression, the output is expressed as the probability of occurrence of the predicted values of the dichotomic variable.

In this regard, the study intended to understand which factors significantly influence fuel choice decisions, considering factors such as household size, neighbourhood category, age of the interviewees, sector of activity of the household head, gender and education level of the household head, and household income. This statistical tool enabled summarising the collected information, triangulating it with several other data, and doing a co-relational analysis of the critical energy elements at the household level, as depicted in Figure *4.8*.

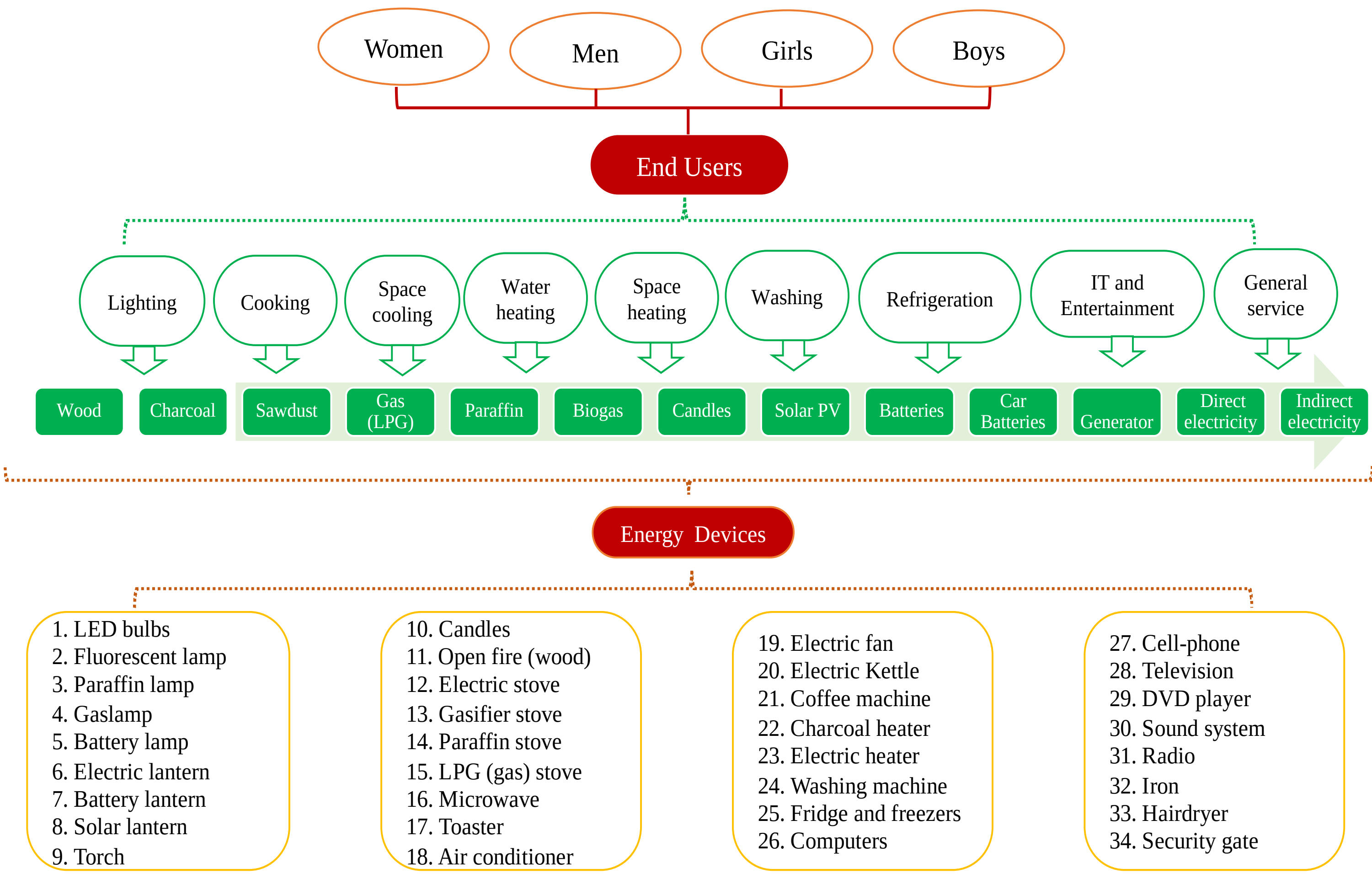


Figure 4.8: List of energy devices, fuel types, energy services and household members
Source: Own visualisation

The collected data show that the most productive fuels, such as electricity, are often utilised for information technology and entertainment (IT and entertainment), often male-oriented energy services. In contrast, inefficient or traditional energy carriers, such as fuelwood and charcoal, are often used for the most time-consuming activities, usually allocated to women, and in the Mozambican case, for cooking and washing. Furthermore, to understand the decision-making process regarding energy devices, the study used a triangulation of the responses provided to the question relating to (i) the devices for different energy services in the household; (ii) the person who uses the energy device; and (iii) the person who buys the energy device. The responses revealed that the decision on the energy device is linked to the fuel type and that the gender of the household head is also connected to the fuel type. A comparison of the study findings was made with those of other researchers. Figure 4.9 depicts how the variables were matched to convey this data.

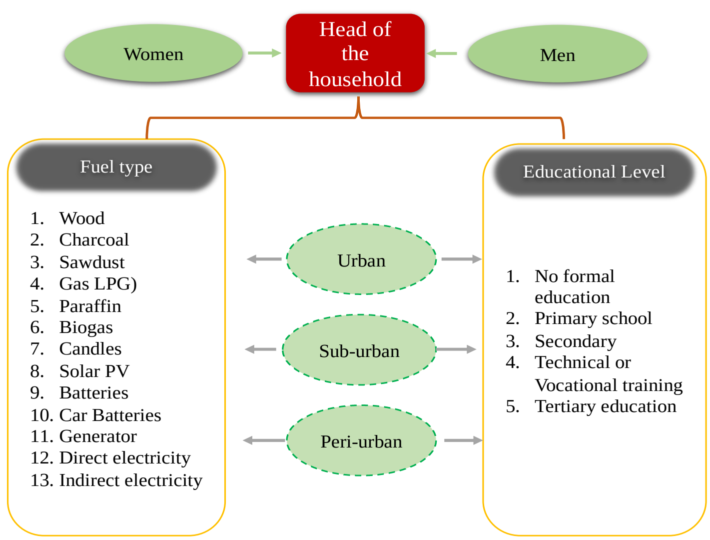


Figure 4.9: Relationship between survey variables
Source: Own visualisation

The study also determined the relationship between a household's income levels and its energy source. This was possible through a descriptive analysis of the survey findings relating to household income and the energy services they use for their needs, combined with the neighbourhood segregation for the selected sample, including the urban, suburban and peri-urban areas. The findings show similarities to some of the conclusions of Castán Broto et al. (2018), in which charcoal is still one of the typical energy sources, even among high-income households.

Furthermore, the energy mix was even high in peri-urban areas due to the inhabitants' mixed character. A detailed analysis of the survey and interviews is found in Chapter 5.

e) Exploratory interviews

Since a critical literature review on its own does not favour the construction of an elaborate novel element in the academic world (Sovacool et al., 2018), the research combined this approach with other complementary strategies to pursue a new perspective on the transition framework. The study chose the exploratory interview technique because it provides an informational platform (Zachariadis et al., 2013) and is more flexible than questionnaires (Phellas, Bloch & Seale, 2012). The informational aspect of the exploratory interviews was found to determine an understanding of the social context. The study could establish how local institutions and organisations perceive gender and energy with this instrument. As Clancy and Mohlakoana (2020) pointed out, this assessment confirms how gender issues have been embodied in the country's energy policy. Exploratory interviews also served to understand how energy programmes are budgeted for, considering the different emphases of men and women in their energy requirements. The exploratory discussions provided complementary information on how the Mozambican energy sector operates and how gender is perceived and empowered as an energy transition enabler.

The selection of the participants for the exploratory interviews aimed to complement the data collected via literature review and the survey. In this view, the study aimed to understand the existing supporting scheme from the government to foster modern energy uptake within urban households in Mozambique. Therefore, it was necessary to identify the leading institutions that oversee the Mozambican energy sector, so the Ministry of Mineral Resource and Energy was identified. Then, the study aimed to understand the entities that implement government strategies that impact the consumers (households) directly, so this allowed identifying the national utility company – Electricidade de Mocambique, the National Energy Found and the National Hydrocarbons Company. This group of entities were also confirmed to be most relevant in policy design and implementation agencies with the question that the interviews were asked, namely 'Are there any other institutions to contact'—their responses coincided by and large. However, the study collected only three responses, as the National Energy Fund considered the line of questioning inapplicable to them, as they only work with access to solar energy in remote areas, which was outside the scope of this study.

The interviews followed the structure presented in Appendix A. The interviewees were asked to select their preferred language between English and Portuguese, as shown in Appendices A.1 and A.2, respectively. The interviews were structured in a way that started with a brief description of the nature of the interview and the interviewee's role in that institution. It then looked at the linkage between the institutions and the energy sector. After that, the questions were presented as guided by the existing structure. Despite the initial intention of conducting in-person interviews, this was impossible due to the COVID-19 pandemic. The researcher, therefore, performed two online interviews with key informants from the national utility company and the Ministry of Mineral Resources and Energy. At the same time, the National Hydrocarbons Company responded to the questions via e-mail. The data was recorded using a voice-recording device, and notes were also taken to allow for a connection between the answers provided and to ask for further clarification when needed.

The Ministry of Mineral Resources and Energy is responsible for designing the national energy strategy. From this institution, the exploratory data was conducted with one representative, appointed formally, upon the submission of the letter requestion the interview, which was accompanied by the interview script, and the interview was conducted online using Google Met, which allowed recording the section. Its views and prospects are relevant to the objectives of this study in ways that the provided information allowed a deeper understanding of how the state is working towards ensuring universal access by 2030. It became clear that the country would fail to reach this goal if no action was implemented at the current pace.

A similar analysis led to the selection of *Electricidade de Moçambique*, the national energy entity responsible for on-grid electrification, which operates as a monopoly (Gregory & Sovacool, 2019). in this institution, there were two moments for data collection. The first was online via Google Meet. The purpose was to explain the scope of this data and the objective of the exploratory interview. Then after this section, they requested the interview script, responded to the questions and sent them via e-mail. The inputs by the national energy entity clarified the country's prospects of promoting universal access and the road map guiding this entity to meet SDG 7. However, regardless of the effort made so far and the funding from several international agencies and institutions, the likelihood of reaching universal access by 2030 is fading. Several constraints contribute to these shortcomings, including insufficient investment and other barriers, such as reaching remote rural areas, which is arguably not cost-effective. The selection of *Electricidade de Moçambique* for the exploratory conversation was of relevance because they oversee the definition of areas within the energy sector in which there is a fundamental investment to promote universal access in the country.

Although the scope of this work did not match the area of intervention of the National Energy Fund, it still provided insights that brought clarity to their activities and role in contributing toward universal access by 2030. The interviews with the key person of the National Energy Fund unveiled several challenges that the institution faces, ensuring that those households that have been electrified with solar systems remain electrified in the long run. Their previous assessment found that the maintenance of the installed system was failing, and households ended up without access.

Finally, the National Hydrocarbons Company is a public company operating in the hydrocarbon sector. This institution responded to the interview script and sent their responses via e-mail. They were selected because Mozambique is endowed with significant natural gas. However, its consumption is limited to large cities, and as argued previously, the country strives to ensure stable prices, and the demand often surpasses the capacity. Hence, the selection of this institution was fundamental because it enabled an understanding of how the government and private sector position themselves to ensure universal access and increase the share of natural gas in the country's energy profile. However, there is no specific target that the government has set to increase access to LPG by poor urban households. Instead, the policy is set in ways that rely on market mechanisms. So ultimately, the government's role is limited regarding the need to foster LPG adoption by Mozambican households. This approach is further discussed in Chapter 6, which discusses the Mozambican energy transition pathways.

f) Retroduction data analysis for the second research objective

The second objective was to assess gendered energy profiles and energy services in urban households in Mozambique, resulting in the gathering of qualitative data. This data was retrieved from the literature review and the exploratory interviews. As mentioned previously, the study adopted a descriptive approach to understanding the state of the art in the energy sector, emphasising the energy transition debates. The retroductive analysis made it possible to explain *why* households still depend heavily on traditional biomass. Also, it enabled the drawing of insights from the debates, actions and agendas at the local and international levels that address gendered energy issues. These debates are about environmental and health problems linked to the use of traditional biomass. Furthermore, retroductive analysis also served to uncover the social injustice that hinders the promotion of gender equality and works against sustainable development goals. These goals include ensuring universal access to modern energy by 2030 and promoting gender equality, as established in SDGs 7 and 5.

4.4.3. Objective 3: To examine pathways to gendered urban energy transitions in Mozambique at the household level

The third objective of this research, *to examine pathways to gendered urban energy transitions in Mozambique at the household level*, was achieved utilising a critical literature review and a survey for data collection. The data analysis provided the actions required for a gendered urban transition in Mozambican urban households. The study also used the retroductive approach, focusing on the '*and, so what?*' question. The following sections on this sub-topic describe how the study went about during data collection for and analysis of the last objective.

a) Critical literature review

The primary motivation of this objective was the lack of a framework to inform developing countries on gender-sensitive typologies of energy transition pathways to transform the current problematic energy system, which is biomass driven. The study searched for the mainstreaming gender and energy scholars' debate to address this gap and evaluated their recommendations to ensure modern energy access by 2030. The integrative literature review adoption was appropriate to understand the status of gender and energy research (Torraco, 2016), which, combined with the retroductive approach, allowed building arguments for the relevance of this study. Therefore, informing the development of the conceptual framework for gendered energy transition pathways. The study adopted literature searching in physical libraries and two internet databases, Scopus and Google Scholar, to cover all relevant publications, including peer-reviewed journals, reports, books, book chapters, web pages and working papers. The data collection process occurred in five distinctive stages.

The *first stage* of the integrative literature review was a revision of the focus on the most relevant authors for this study, including, Skutsch and Batchelor (2003) and Musango et al. (2020). They discussed energy and gender issues from a global and sub-Saharan Africa. The study also searched for literature that discusses gender and energy transition in other developing countries beyond sub-Saharan Africa and identified the work of Khalid and Razem (2022). The revision of this source resulted in a similar finding. They also recognised a lack of gender sensitivity in the current energy system, and women are the social group most affected by energy poverty consequences. To conclude this stage, the study searched for literature that discusses energy transition pathways, from a global and gendered perspective, based on their publication frequency, which resulted in the revision of two journals, Foxon, Hammond and Pearson (2010) and Lieu, Sorman, et al. (2020).

In the *second stage*, the study used the Scopus database to identify studies under the range of the theme in the discussion. The search was conducted using the Boolean operator ‘AND’ to search for ‘energy’ AND ‘transition’ AND ‘pathways’ and found 14 099 sources. Then the search was limited to the subject area of ‘energy’. The results showed that the research on this topic started in 1960, and 1533 documents are available. However, when analysing the documents' themes before 2007, it was found that their context and scope did not match this study's interest, so they were ruled out. According to the Scopus search, although it was between 2006 and 2007 when the theme gained impetus, it was in 2007 when the first article that provided the typology of transition pathways was first published, written by Geels and Schot (2007). Since then, several authors have discussed the energy transition pathways. In 2010, Foxon, Hammond and Pearson (Foxon, Hammond & Pearson, 2010) provided a different perspective on the typologies of energy transition pathways for low-carbon emission targets. The work from Geels et al. (2016) was also conducted in 2016, which reformulated the 2007 framework from Geels and Schot (2007). Lastly, the Scopus search retrieved the only document that discusses the gendered energy transition pathway, published in 2020 by Lieu et al. (2020).

The *third stage* aimed to widen the search to include other known and unknown literature. To substantiate the gap and identify other similar studies. In this stage, the search was conducted to match other keywords' households', developing countries', 'Africa', 'gender' and 'urban areas'. This was performed using the Boolean operator 'AND' to search for documents relating to the topic 'energy transition pathways' and the mentioned keywords, which delivered 247 documents. These sources were narrowed down to 56 documents that were considered relevant to the discussion. The summary of this process is described in Table 4.5.

Table 4.5: Reviewed literature according to the filters on Scopus search as of November 2021

Term	Boolean operator	Search combination	Scopus result	Filtered results	Selected sources
'Energy transition pathways'	AND	'Households'	62	51	10
		'Developing countries'	82	74	11
		'Africa'	45	34	14
		'Gender'	12	8	8
		'Urban areas'	46	42	13
Total			247	209	56

Still, in the third stage, the search was oriented to find documents that specifically discussed 'energy' AND 'transition pathways'. The results showed 680 documents. The study used the Boolean operator 'AND' and the snowballing or pearl-growing search technique. With this process, the Scopus results were limited to the 'energy' and 'environmental science' and 'social sciences' subject areas, and the results dropped to 331 documents. These were then limited to source titles and keywords, and the results dropped again to 120. However, only 12 documents were considered relevant after reading their abstracts and matching their content to this study's scope.

As per its cross-cutting nature, the study executed the *fourth stage* to cover other grey literature relevant to this study. This was also fundamental, considering that limited peer-reviewed journals discuss gendered energy transition in urban developing environments (Musango et al., 2020). Hence, Google scholar and Google direct searches were utilized to search for 'energy transition pathways', which yielded several sources ranging from reports, books, book chapters, web pages, and working papers, including peer-reviewed journals. Since the output from google included all sources that mentioned exactly or similar search terms, it was necessary to filter the results to match their content to the scope of the study. This was performed using five search strings:

'households', 'developing countries', 'Africa', 'gender' and 'urban areas', and only 160 were considered potential documents for further analysis. After reviewing their abstracts for relevance, 106 were excluded, and 68 were read in full. This was compliment by physical visitations of libraries, and four books were considered relevant and used for this study discussion.

The *last stage* was classifying all the materials according to a coding schema since the yielded sources were sufficient for the study. The coding schema identified the type of material, and the articles were in ten categories to match the search strings. Overall, the selection criteria resulted in 142 sources, which were found to represent the topic, being reviewed and synthesised to formulate the problem, identify the gap, and gather and analyse data to provide the conceptual framework for energy pathways. Using Mozambique as a case study, a gendered perspective informed the pathway to the shift from solid fuel dependence to modern, clean, and sustainable energy consumption. Figure 4.10 summarises the process that oriented the formulation of the arguments and discussion of the third research objective and provides a robust roadmap informed by a contextual analysis.

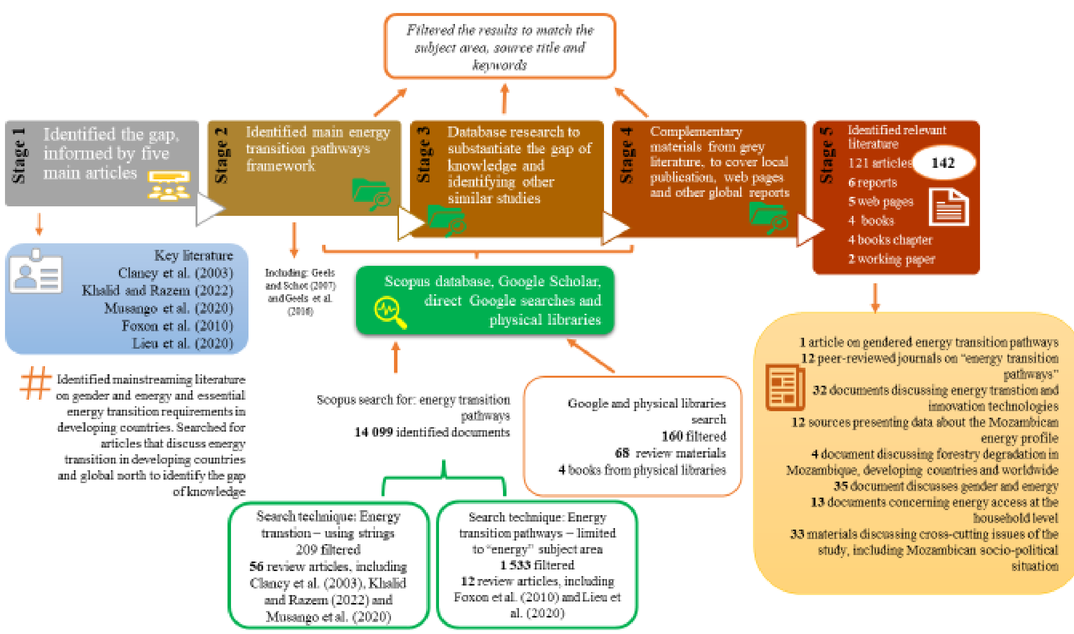


Figure 4.10: Literature selection criteria for the third research objective

b) Theoretical framing informed by the data

Pursuing a literature review, interviews, and surveys allowed the study to gather qualitative and quantitative data. Using a retroductive process, the qualitative data from the first objective was combined with the data collected for the second objective and then critically analysed. The data was critically analysed and combined with the findings that resulted from the survey to produce the pathways for gendered energy transition for Mozambican urban households. This approach allowed using the deductive-inductive approach, through which it was possible to generate inferences of the issues caused by traditional energy consumption by urban households. The process allowed navigating through the casual aspects responsible for the current energy regime. Then, it was possible to develop a hypothesis of how the situation could have been different, considering the potential that it is possible to explore. Furthermore, the data allowed analysing of how Mozambican institutions operate and how gender energy-related issues are perceived and addressed. This data served as input to design the theoretical framework for gendered energy transition, in which the intuition’s roles were emphasised. The gendered innovation is the starting point to enable energy transition in developing urban environments.

4.5. Limitations of data collection

This study utilised a survey-based approach to complement the qualitative data from the literature review and the exploratory interviews. However, due to time and resource constraints, it was impractical to cover all urban households in Mozambique to obtain the required data for analysis. The city of Maputo was therefore chosen as the area in which to conduct the survey. Despite the sample’s representativeness, the conclusion drawn is not based on the whole population. The data collection phase of this study coincided with the outbreak of the global COVID-19 pandemic. The data collection process primarily required physically administering questionnaires at the household level. This process was adjusted to be collected remotely via electronic and digital platforms, such as telephone calls and the SurveyMonkey application. It was possible to test this approach in the pilot study, and the results showed that, because of the length and depth of the questionnaire, the collected data was either incomplete or incoherent.

Thus, the study compiled a data collection protocol taking all the sanitary measures necessary to prevent the spread of COVID-19 because of the survey. After receiving ethics approval, the data was collected mainly face to face and, to a lesser extent, via SurveyMonkey and telephone calls. The major limitation that the study encountered with the use of electronic and digital platforms was the reliability of the data because it was impossible to confirm some of the responses provided visually. Furthermore, with the virtual questionnaire, the respondents did not request explanations or clarification to questions they were unsure which response to provide. This resulted in some respondents submitting incomplete questionnaires and answers that did not match the questions. The study eliminated all responses from SurveyMonkey and only considered responses collected in person or via telephone calls. The study could not complete the sample because two responses from households in Polana Cimento B (KaMpfumo Municipal district) were missing, and one from Ridzene (KaNyaka). In Polana Cimento B, the families were unwilling to reveal their information for fear of data misuse. In Ridzene, contacting residents willing to participate via a telephone call was impossible because in-person interviews were impossible due to its location (an island) and transport limitations. Hence, instead of analysing 384 responses, the study processed and analysed 381 responses, equivalent to 99% of the sample.

4.6. Ethical considerations

The study mapped all potential ethical issues that could result from its development. These were all circumscribed in the interviews and questionnaires. With both methods, the study recognised that the information requested was sensitive because it touched on culturally sensitive values of society, especially in a male-dominated society. So, the approach was first to obtain approval from the surveyed groups, in which they signed the declaration of consent. The consent form was designed in English and Portuguese (see Appendix D). Then the study's objectives were explained to the subjects, and, most importantly, they were reassured that their identities would not be disclosed at any point in the research. The exploratory interviews were recorded. The interviewers were also reassured that access to the records was limited to the researcher and supervisors and served to preserve the accuracy of the conversations. Regardless of the ethical precautions taken by the study, Stellenbosch University mandates that all research has ethics approval. This process was also respected, and the study obtained ethics approval per Appendix E's statement. However, it is essential to note that, although there were imminent possibilities that could have affected the study negatively, they have been resolved through reasonable approaches.

4.7. Summary

This chapter provided the study's methodology adopted to meet the stated research objectives. The research design followed by this study allowed the adoption of a mixed-methods approach, whereby a critical literature review, an integrative literature review, a survey-based analysis and a case study were combined, described and used to infer findings. The chapter presented three primary research paradigms: positivism, interpretivism, and critical realism. Several social sciences regard the latter as the middle term between positivism and interpretivism. This research endorsed the latter and used this approach to understand energy patterns in urban households in Mozambique. This approach enabled the use of appropriate instruments, data collection tools and data analysis techniques, as described in the methodology section. The next chapter presents the results and discussions deriving from the case study.

CHAPTER 5: RESULTS AND DISCUSSIONS

5.1. Introduction

This chapter aims to address the second objective of the research, namely, *to assess gendered energy profiles and energy services in urban households in Mozambique*. The chapter presents and discusses the results of the survey conducted in the city of Maputo. The subsections within the results and discussion sections follow a similar structure. The subsections start with the sampled households' descriptions, followed by an assessment of the relationship between gender and the energy sources, services and devices. Then it presents the factors that determine fuel choice decisions, using SPSS using cross-tabulation, P-value and logistic regression. The subsections presenting the results and discussion are informed by the research questions for the research objective in the analysis. The final part of this chapter summarises the key findings from the data analysis.

5.2. Results

5.2.1. Household profile

The first research question of the second objective that this study aimed to answer concerned the description of the households that constituted urban developing environments. This section presents the results of the survey. There were 235,750 households in Maputo at the time of the study, and the corresponding sample size was 384. Due to some limitations in the data collection process, data was retrieved from 381 households. Figure 5.1 depicts the municipal districts. The figure indicates that most respondents came from KaMubukwana and KaMavota, representing 29% of the sample each.

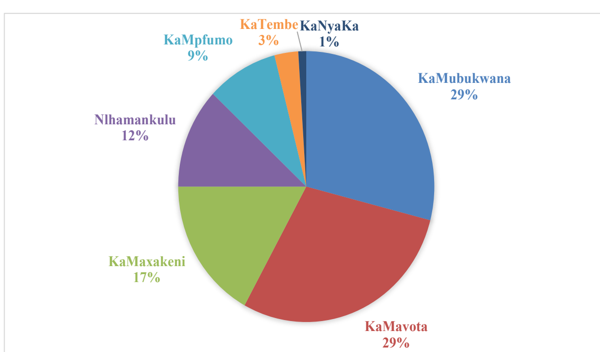


Figure 5.1: Representation of the surveyed households according to municipal districts

Following Araújo's (2003) stratification of Mozambican urban areas, the distribution of households is shown in Figure 5.2. Therefore, suburban areas represent the area with larger interviewed households, corresponding to approximately 78% of the sample.

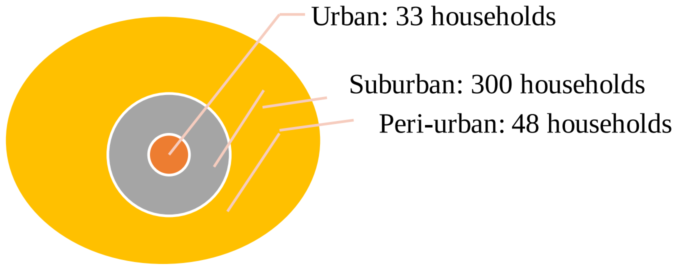


Figure 5.2: Surveyed households according to the classification of the neighbourhoods

The collected data revealed that women were the majority of interviewees, accounting for 54% of the 381 people surveyed (see Figure 5.3).

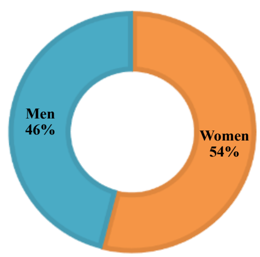


Figure 5.3: Gender of the interviewees

Although most of the interviewees were women, the households were largely male-headed. According to Figure *5.4*, male-headed households account for 66%, and a small percentage of the households preferred not to say who was the head of the family.

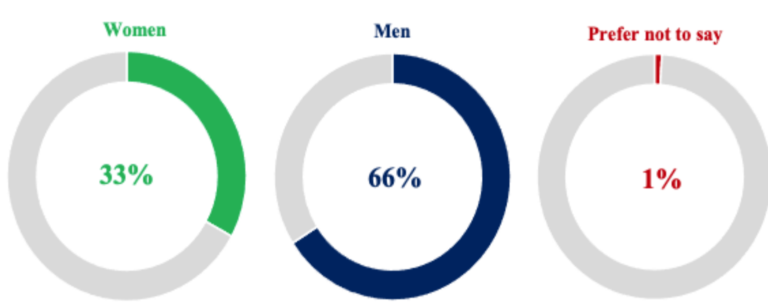


Figure 5.4: Gender of the head of the household

Figure 5.5 shows the absolute frequency of household numbers and their respective percentages. Most of the surveyed households comprised five members, at 17%.

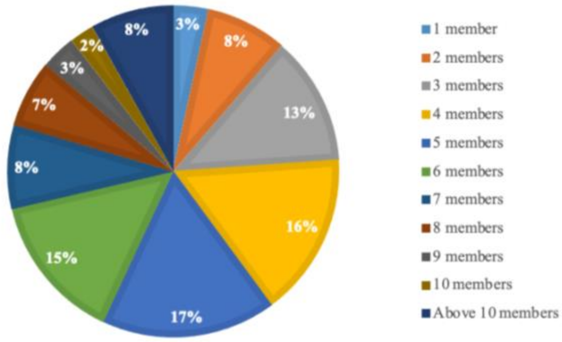


Figure 5.5: Descriptive statistics of household size

A further analysis was conducted on the household size distribution according to the type of neighbourhood in which they live. According to Table 5.1, households in suburban neighbourhoods had more members than in other neighbourhoods, and most households had an average of 5 members (17%). It was also found that 23 households had more than ten members, and most lived under precarious conditions.

Table 5.1: Descriptive statistics of household size according to the type of neighbourhood

Households size	Type of the neighbourhood			Total
	Urban	Suburban	Peri-urban	
1	0	9	4	13
2	6	22	2	30
3	2	37	9	48
4	2	52	7	61
5	4	52	9	65
6	7	42	6	55
7	5	26	0	31
8	2	21	2	25
9	2	10	1	13
10	1	6	2	9
Above 10	1	23	6	31
Total	32	300	48	381

The analysis of the gender of the household head concerning the type of neighbourhood they live in indicated that, by comparison, men represent the most significant proportion of household heads in urban areas, accounting for 70% of the surveyed households in that area. In contrast, more women are the head of households in peri-urban (44%) and suburban (33%) areas. Figure *5.6* demonstrates this data analysis.

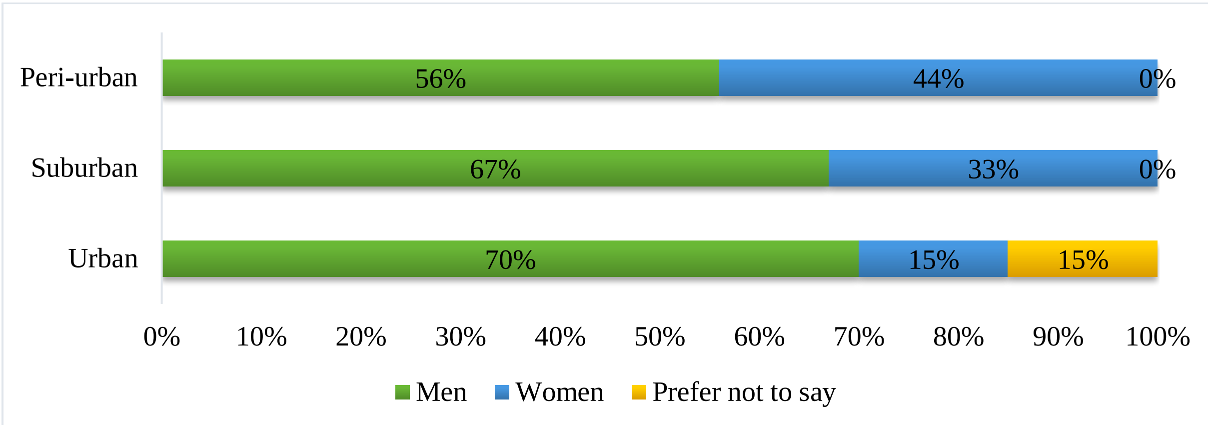
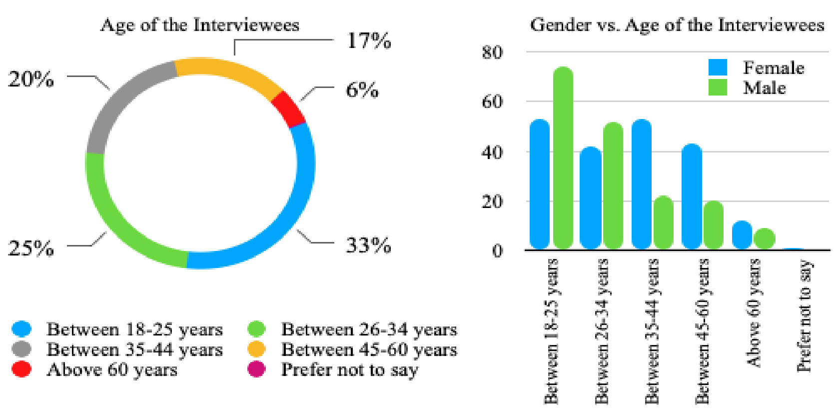


Figure 5.6: Gender of the head of the household per location

The age group analysis revealed that most respondents were between 18 and 25 years of age, at 33%. Also, women were in the majority of the group of 35 to 44 years. According to data in Figure *5.7*, the only gender that did not provide their age was women, although just one woman among 204 female respondents.



Summary by Age and Gender of the Interviewees

Age Group	Frequency	Female	Male
Between 18-25 years	127	53	74
Between 26-34 years	94	42	52
Between 35-44 years	75	53	22
Between 45-60 years	63	43	20
Above 60 years	21	12	9
Prefer not to say	1	1	0
Total	**381**	**204**	**177**

Figure 5.7: Relationship between the age group of the interviewees and gender

The study also looked at other demographic features of the surveyed households to provide the profile of the targeted group. This included analysing their employment status, their work sector, and the type of activity they perform. According to the summarised data in Figure 5.8, self-employed people represented many interviewees, accounting for nearly 50% of the sample. The self-employed interviewees are located primarily in suburban areas.

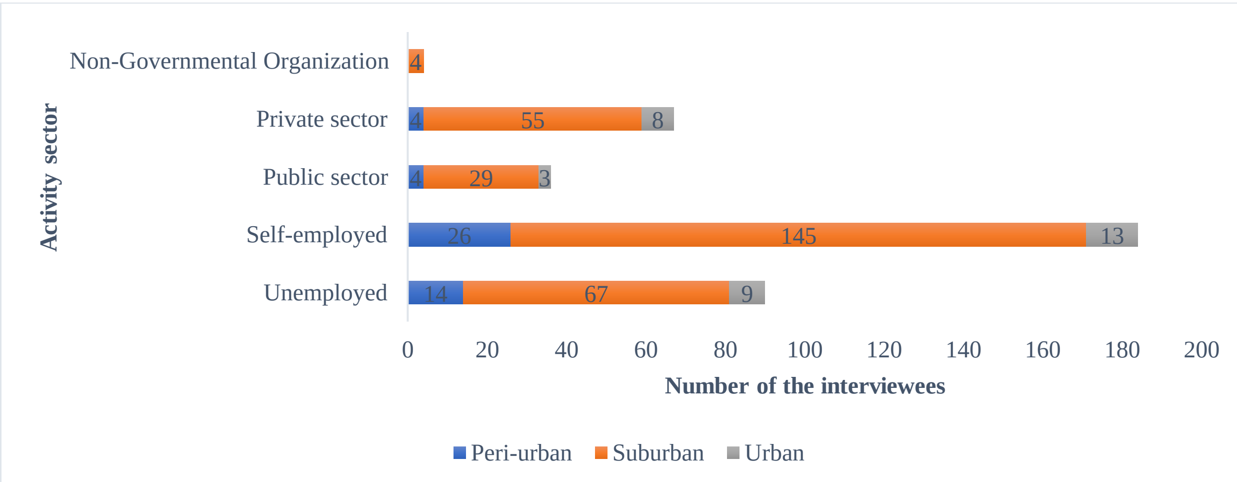


Figure 5.8: Sector of activity of the interviewees vs neighbourhood

The results revealed that most of the surveyed households (51%) reside in an incomplete conventional house without a bathroom and kitchen. Only 3% of the sampled households reside in apartments or flats, and only one household is reported to reside in a mixed house (see Figure 5.9).

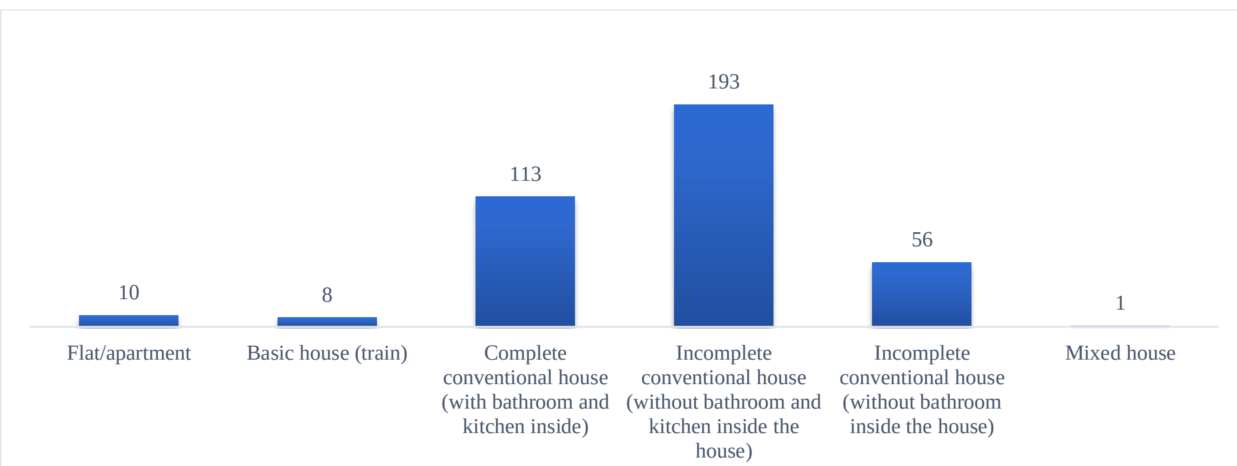


Figure 5.9: Household building type

Table 5.2 demonstrated that 21% of the surveyed households informed that their household income was below 4,000 MT, an equivalent of 63.5 USD per month. Also, 44% of the surveyed households preferred not to say their income, while 33% were from suburban areas. Only one household reported earning more than 100,000 MT, equivalent to 1,586.55 USD. Nearly 4% indicated their income to be between 10,001 Mt and 15,000 MT.

Table 5.2: Households' income according to the area in which they reside

Household Income	***Peri*-Urban**	**Suburban**	**Urban**	**Grand Total**
Below 4,000MT	11	67	3	81
From 4,001MT to 6,000MT	3	37	2	42
From 6,001MT to 8,000MT	0	25	3	28
From 8,001MT to 10,000MT	5	18	3	26
From 10,001MT to 15,000MT	1	12	1	14
From 15,001MT to 20,000MT	2	4	1	7
From 20,001MT to 25,000MT	0	3	0	3
From 25,001MT to 30,000MT	0	2	2	4
From 30,001MT to 40,000MT	0	1	0	1
From 40,001MT to 50,000MT	0	4	0	4
From 50,001MT to 80,000MT	0	2	1	3
Above 100,000MT	0	0	1	1
Prefer not to say	26	125	16	167
Total	**48**	**300**	**33**	**381**

Exchange rate: 1 USD is equivalent to 63.03 MT, as of 13 August 2021

When asked about their monthly expenditures, only three households preferred not to say. So, it was possible to gather data regarding the amount of money they spend monthly for food, travel, medical expenses, personal care, household essentials, education, electricity and other fuels, water, mobile phone and data, rent, savings and other expenses. Figure 5.10 shows that, on average, most households that reported earning less than 4,000 MT spent 22,153 MT per month for the selected essentials needs, and overall, the sampled households spent 23,448 MT monthly. Also, it was found that those who preferred not to say their income did disclose their monthly expenditures, and on average, they spent 33,534 MT. The detailed data are presented in Table F2 in Appendices F.

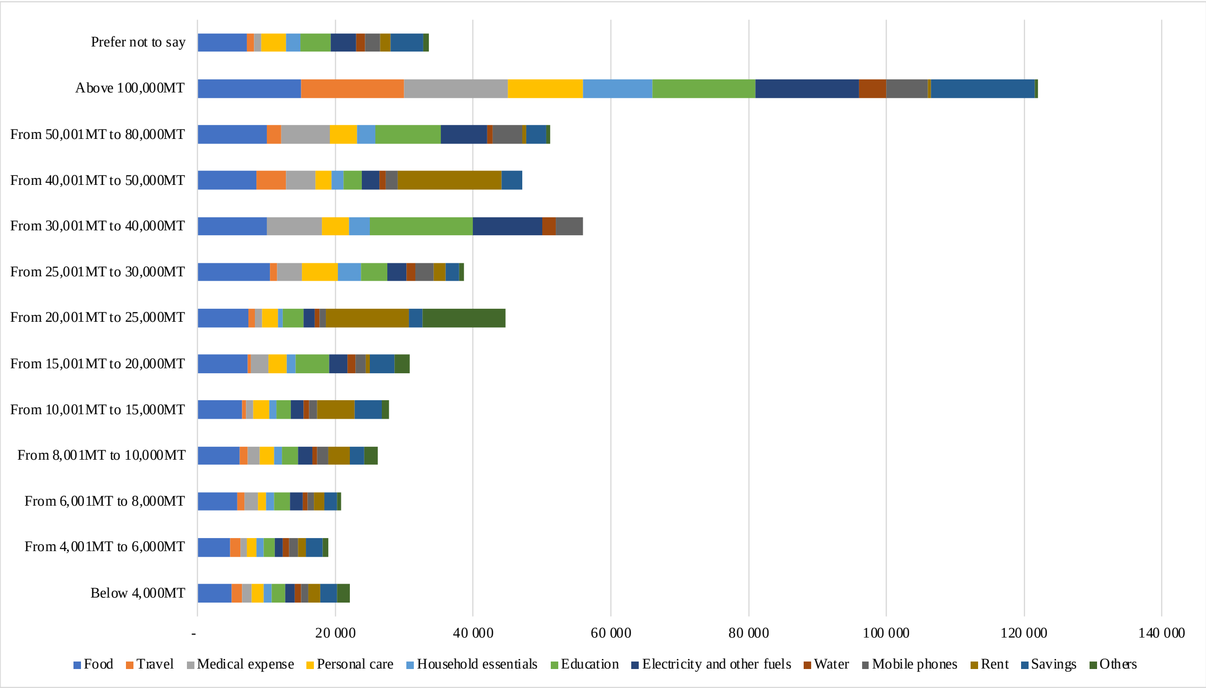


Figure 5.10: Average of the household's monthly expenditure *per* reported household income

According to Figure 5.11, food comprises the most significant expenditure, 25% of their monthly selected expenses. Savings and education represent the second (10%) most significant expenditures of the sampled households. Electricity and other fuels are positioned in number six of the households' expenditures, accounting for 7% of the total expenses.

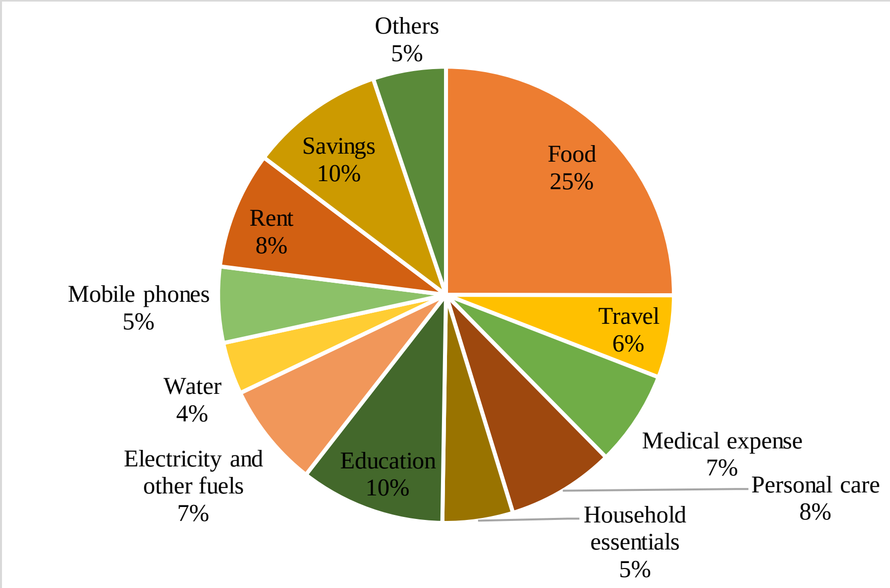


Figure 5.11: Average of household's monthly expenditures

The other component that the survey aimed to understand was the head of the household's education level. The results show that most of the heads of the households had a primary or secondary school education, while only 11% had higher education (see Figure 5.12).

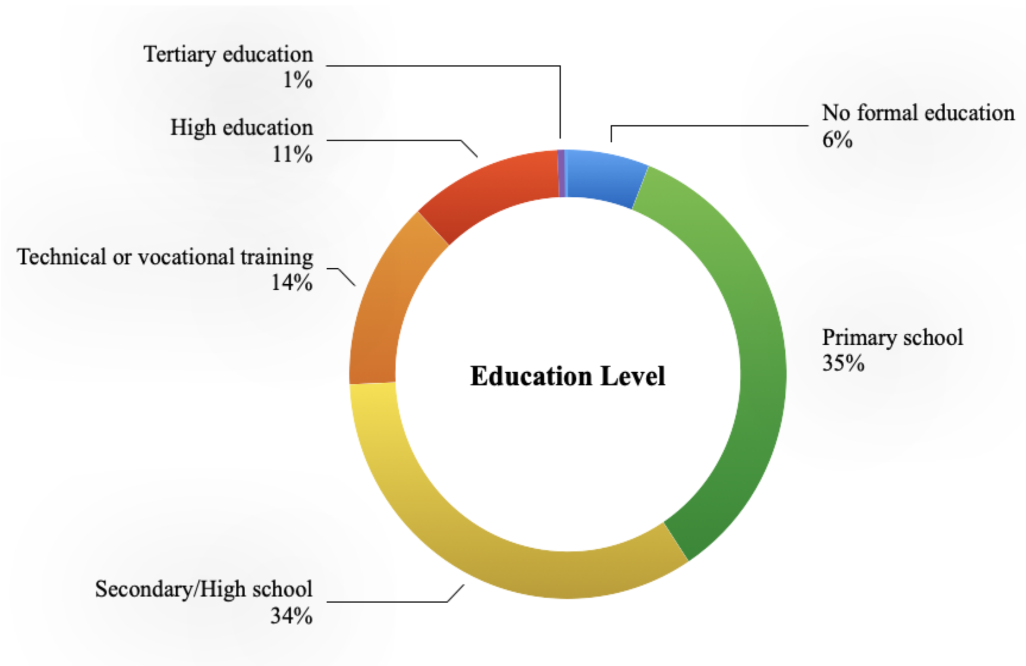


Figure 5.12: Education level of the household heads

The study also analysed the relationship between education level and income. The results in Table 5.3 reveal that most households with low income have no formal education, primary and secondary school. Those with vocational training are primarily in the middle-income range, and high education predominates among those with high income. The results revealed that, on the one hand, most female-headed households have primary education (65 out of 125 households), and of those who declared their income, the bulk (47%) have the lowest income (less than 4,000 MT). On the other hand, most male-headed households have a secondary level of education (96 out of 250 households), and of those who declared their income, the bulk (32%) earn less than 4,000 MT. Also, male-headed households have the bulk of middle to high income, and none of the female-headed households earns more than 30,000 MT.

Table 5.3: Relationship between households' income and educational level

(a) Household and education level

Household income	Educational level							
	No formal education	Primary school	Secondary/High School	Technical or Vocational training	High education	Tertiary education	Other	Total
Below 4,000MT	10%	48%	23%	6%	11%	1%	1%	100%
From 4,001MT to 6,000MT	10%	38%	36%	10%	7%	-	-	100%
From 6,001MT to 8,000MT	-	32%	39%	18%	11%	-	-	100%
From 8,001MT to 10,000MT	-	27%	46%	12%	15%	-	-	100%
From 10,001MT to 15,000MT	-	21%	14%	43%	21%	-	-	100%
From 15,001MT to 20,000MT	-	29%	14%	29%	29%	-	-	100%
From 20,001MT to 25,000MT	-	-	33%	33%	33%	-	-	100%
From 25,001MT to 30,000MT	-	-	-	50%	50%	-	-	100%
From 30,001MT to 40,000MT	-	-	-	100%	-	-	-	100%
From 40,001MT to 50,000MT	-	-	25%	25%	50%	-	-	100%
From 50,001MT to 80,000MT	-	-	-	33%	67%	-	-	100%
Above 100,000MT	-	-	-	-	100%	-	-	100%
Prefer not to say	7%	33%	40%	13%	7%	1%	-	100%
Total	**6,0%**	**34,6%**	**33,6%**	**13,6%**	**11,3%**	**0,5%**	**0,3%**	**100,0%**

(b) Household and education level in male-headed households

Household income	Educational level							
	No formal education	Primary school	Secondary/High School	Technical or Vocational training	High education	Tertiary education	Other	Total
Below 4,000MT	2%	38%	33%	7%	14%	2%	2%	100%
From 4,001MT to 6,000MT	-	28%	44%	16%	12%	-	-	100%
From 6,001MT to 8,000MT	-	18%	53%	24%	6%	-	-	100%
From 8,001MT to 10,000MT	-	18%	47%	18%	18%	-	-	100%
From 10,001MT to 15,000MT	-	15%	15%	46%	23%	-	-	100%
From 15,001MT to 20,000MT	-	-	-	50%	50%	-	-	100%
From 20,001MT to 25,000MT	-	-	33%	33%	33%	-	-	100%
From 25,001MT to 30,000MT	-	-	-	-	100%	-	-	100%
From 30,001MT to 40,000MT	-	-	-	100%	-	-	-	100%
From 40,001MT to 50,000MT	-	-	25%	25%	50%	-	-	100%
From 50,001MT to 80,000MT	-	-	-	33%	67%	-	-	100%
Above 100,000MT	-	-	-	-	100%	-	-	100%
Prefer not to say	3%	30%	42%	16%	8%	1%	-	100%
Total	**2,0%**	**26,4%**	**38,4%**	**18,0%**	**14,0%**	**0,8%**	**0,4%**	**100,0%**

(c) Household and education level in female-headed households

Household income	Educational level							
	No formal education	Primary school	Secondary/High School	Technical or Vocational training	High education	Tertiary education	Other	Total
Below 4,000MT	18%	63%	11%	5%	3%	0%	0%	100%
From 4,001MT to 6,000MT	24%	53%	24%	-	-	-	-	100%
From 6,001MT to 8,000MT	-	55%	18%	9%	18%	-	-	100%
From 8,001MT to 10,000MT	-	44%	44%	-	11%	-	-	100%
From 10,001MT to 15,000MT	-	100%	0%	-	-	-	-	100%
From 15,001MT to 20,000MT	-	67%	33%	-	-	-	-	100%
From 20,001MT to 25,000MT	-	-	-	-	-	-	-	-
From 25,001MT to 30,000MT	-	-	-	100%	-	-	-	100%
From 30,001MT to 40,000MT	-	-	-	-	-	-	-	-
From 40,001MT to 50,000MT	-	-	-	-	-	-	-	-
From 50,001MT to 80,000MT	-	-	-	-	-	-	-	-
Above 100,000MT	-	-	-	-	-	-	-	-
Prefer not to say	14%	43%	39%	2%	2%	0%	-	100%
Total	**13,6%**	**52,0%**	**25,6%**	**4,8%**	**4,0%**	**0,0%**	**0,0%**	**100,0%**

5.2.2. Energy sources, services and devices

The second research question of this study intended to provide a comprehensive assessment of the energy sources, services and devices that households adopted. This subsection presents the results accordingly.

a) Energy sources

In terms of energy sources, the results revealed that direct electricity was by far the predominant source of energy amongst the surveyed households. Only four households had no access to direct electricity, meaning that 99% of the sampled households had access to a grid connection. Table 5.4 shows that four leading energy carriers comprise the Mozambican urban household's energy mix. Due to their minor representation, candles and sawdust as fuel types were considered marginal, therefore, disregarded for further analysis.

Table 5.4: Fuel type utilised by the households

Fuel type	Number of households	Sample	Percentage
Direct electricity	377	381	99%
Charcoal	282	381	74%
LPG	183	381	48%
Wood	94	381	25%
Candles	3	381	1%
Sawdust	3	381	1%

The results revealed that most of the surveyed households (51%) reside in an incomplete conventional house without a bathroom and kitchen, and most adopt direct electricity and charcoal. Also, households residing in flats or apartments do not adopt wood (see Figure 5.13).

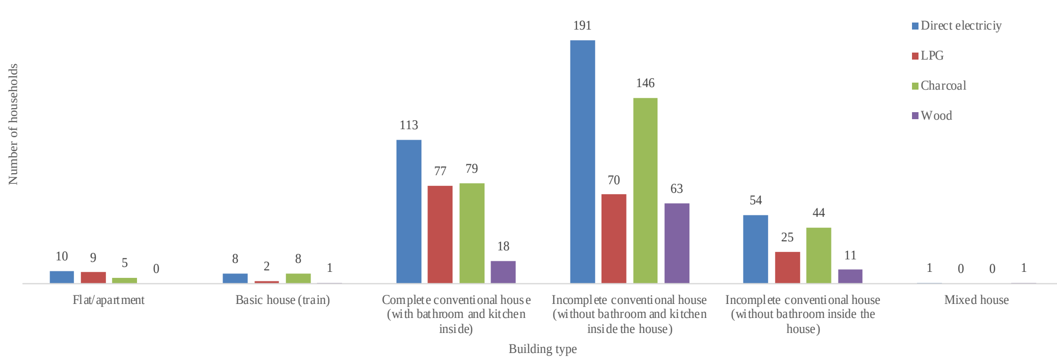


Figure 5.13: Household building type and energy source adopted by the households

The energy consumption patterns were further detailed to illustrate how they relate to the household's location. The illustration presented in Figure 5.14 depicts the fuel type that the households use according to their area. The figure shows that charcoal and electricity use are distributed relatively proportionally in all locations, whereas LPG and wood differ. While LPG is one of the preferable fuels in urban areas (33%), it does not show a similar trend in suburban and peri-urban areas, with a share of 18%. Furthermore, the fuel mix was extended to charcoal and wood in suburban and peri-urban areas.

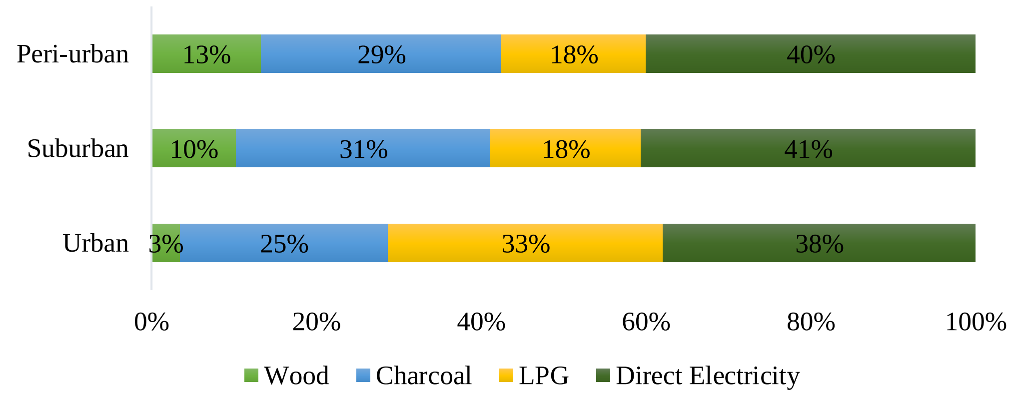


Figure 5.14: Fuel type per type of area in which the household resides

According to Figure *5.15*, about 63% of the surveyed households claimed to have sufficient fuel for their required energy services.

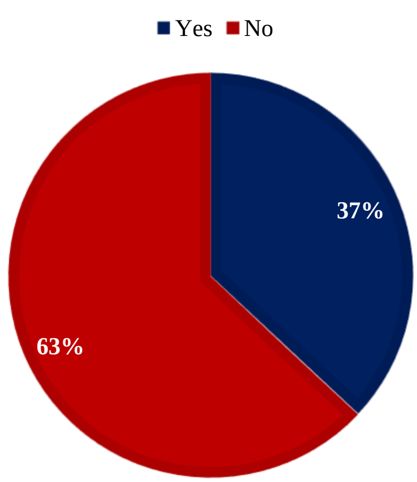


Figure 5.15: Level of energy security

Figure *5.16* shows that among the households adopting direct electricity, 11% claimed to be very dissatisfied with its performance. The fuel that households are mostly dissatisfied with is wood, with a percentage of 41%. Furthermore, charcoal represents the fuel the largest group (63%) claimed to be satisfied with its usage, despite 22% not being happy.

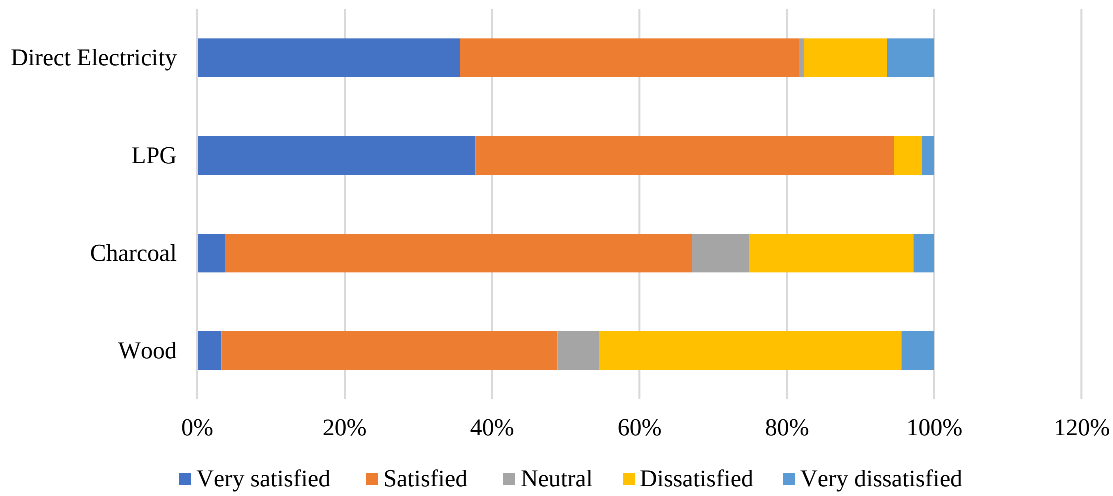


Figure 5.16: Level of satisfaction with the adopted fuels

According to the sampled households' responses, access to energy sources plays a minor role in household fuel choice. According to the results, 50% of the sampled households revealed that fuel preference is associated with their financial capabilities. Table 5.5 provides detailed information on this pattern.

Table 5.5: Reason for fuel choice

Reason for fuel preference	The area in which the household resides			Total
	Urban	Suburban	Peri-urban	
Are the ones that match the appliances	14	92	15	121
Are the ones we can afford	8	161	21	190
Are the ones to which we have access	11	18	2	31
Other	0	29	10	39
Total	33	300	48	381

Further analysis of households' income and the fuel type they adopt revealed that regardless of their income, households adopt multiple fuels. Also, the more affluent households do not adopt wood as part of their energy sources (see Figure 5.17).

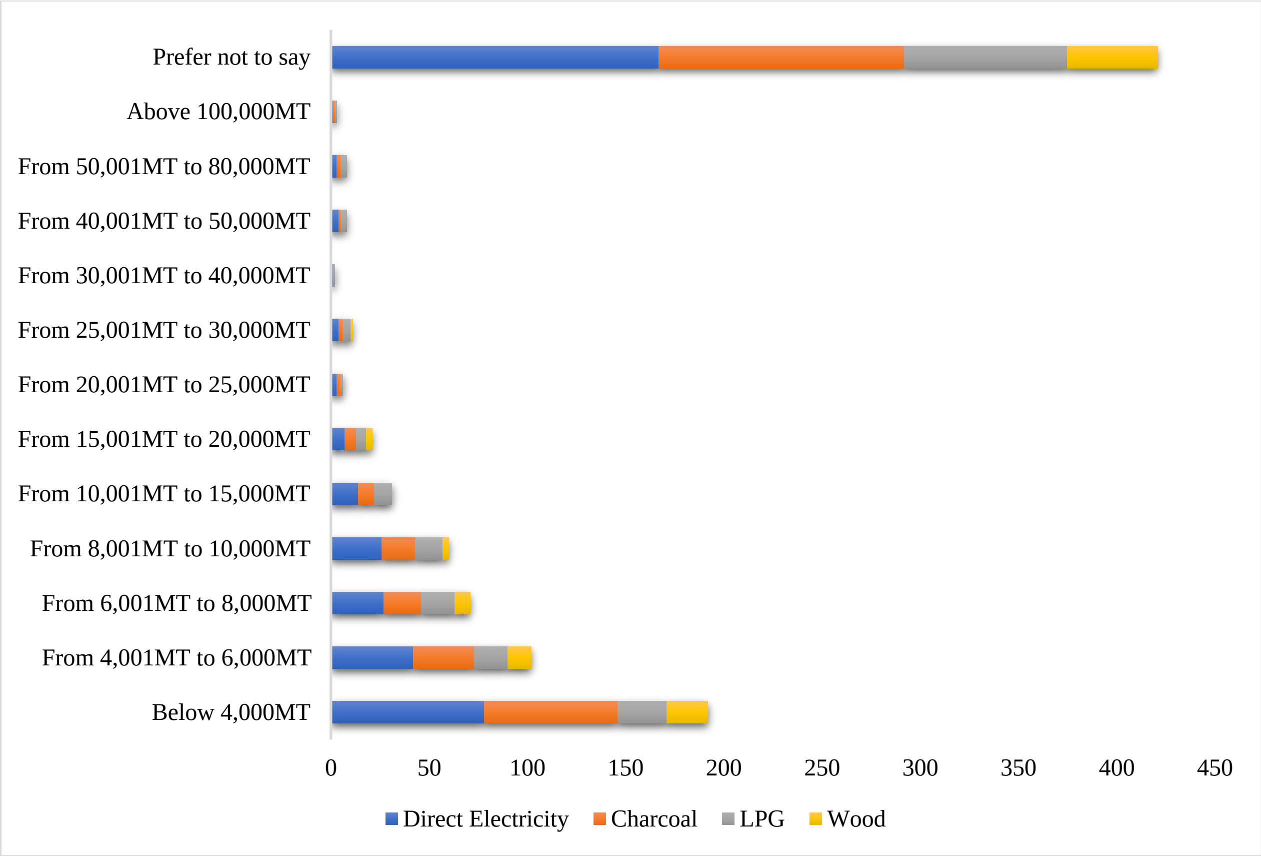


Figure 5.17: Household's income and adopted fuels

Considering this study was conducted during the COVID-19 pandemic, the interviewees were asked how it affected their household income. Only 26% reported that it had not affected their income. According to Figure 5.18, among those affected by the pandemic, 97% said that it negatively affected their household income.

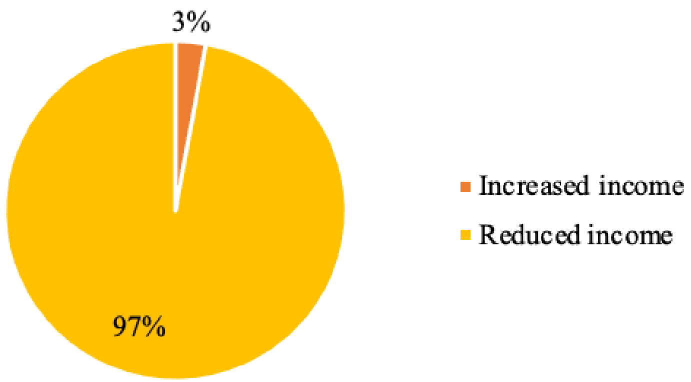


Figure 5.18: Effect of COVID-19 on household income

The study also sought to know which household members were most affected when the energy sources were insufficient for their needs. According to Table 5.6, most households claimed that all family members were affected when there was a lack of fuel for their daily needs.

Table 5.6: Household heads vs household members most affected by insufficient energy sources

Households member	Household head			Total
	Men	Women	Prefer not to say	
Men	76	15	1	92
Women	60	71	1	132
Girls	2	2	0	4
Boys	1	2	0	3
Everyone	111	35	4	150
Total	**250**	**125**	**6**	**381**

b) Energy services

In this section, the study presents the energy services required by households, and the summary is illustrated in Figure 5.19. The results reveal that lighting, cooking, IT and entertainment are the predominant energy services, accounting for 99% of sampled households. Space heating is adopted by only 2% of the sampled households' energy services. Also, a marginal number of households adopt dish and clothes washing, representing only 14% of the surveyed households.

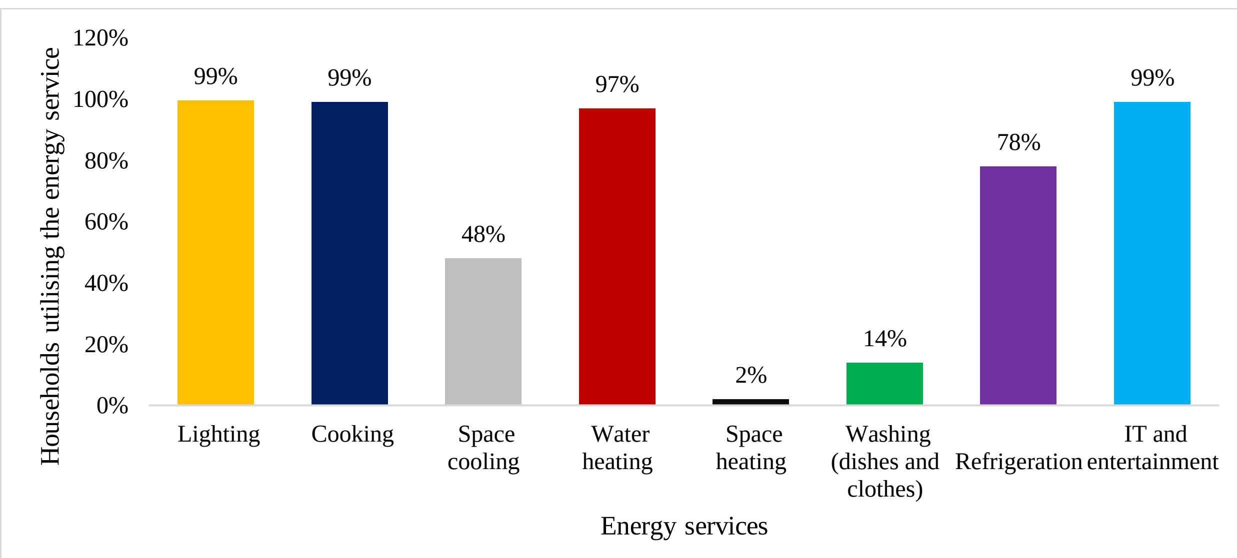


Figure 5.19: Energy services from the sampled households

Table 5.7 depicts the relationship between the location of the households and the energy services they adopt. The results indicate that households in urban areas have 100% coverage of energy services such as lighting, cooking, water heating, refrigeration and IT and entertainment. In suburban and peri-urban areas, refrigeration covers only 77% of the sampled households within those areas. Peri-urban areas have the lowest coverage rate (35%) for space cooling

Table 5.7: Relationship between urban locations and energy services

Energy services	Urban		%	Suburban		%	Peri-urban		%
	Respondents	Sample		Respondents	Sample		Respondents	Sample	
Lighting	33		100%	299		100%	48		100%
Cooking	33		100%	299		100%	48		100%
Space cooling	19		58%	147		49%	17		35%
Water heating	33		100%	297		99%	43		90%
Space heating	1	33	3%	7	300	2%	1	48	2%
Washing	2		6%	52		17%	2		4%
Refrigeration	33		100%	230		77%	37		77%
IT and entertainment	33		100%	297		99%	48		100%

The analysis of the households' energy services and the household head's educational level, depicted in Figure *5.20*, demonstrates that families without formal education and tertiary education do not use energy services such as space heating and washing. Table F4 in Appendix F provides detailed information on the person in charge of energy services.

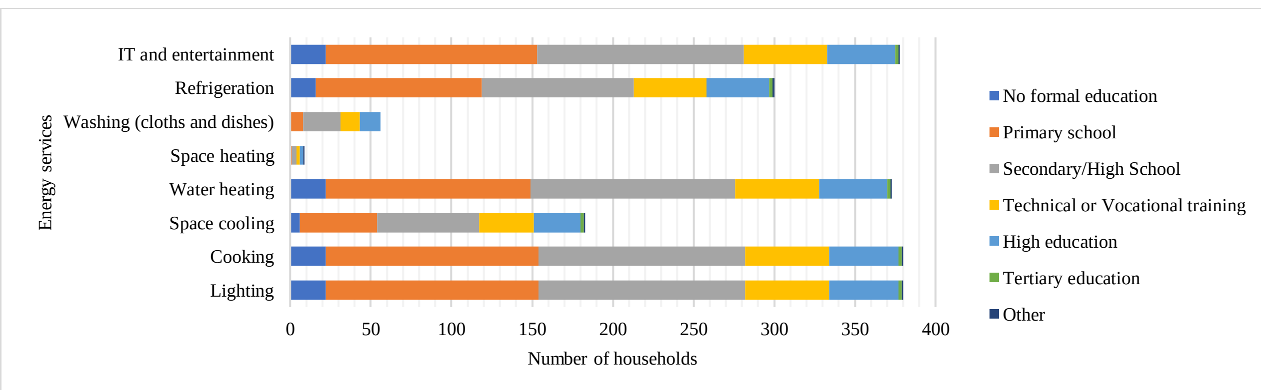


Figure 5.20: Relationship between energy services and educational level of the household's head

Figure *5.21* indicated that the energy services adopted by the sampled households are not linear related to their income. For instance, while households with reported low-income use space heating and washing machines and dishwashers, which are reportedly scarce amongst the households, there are middle to high-income households with no access to these energy services.

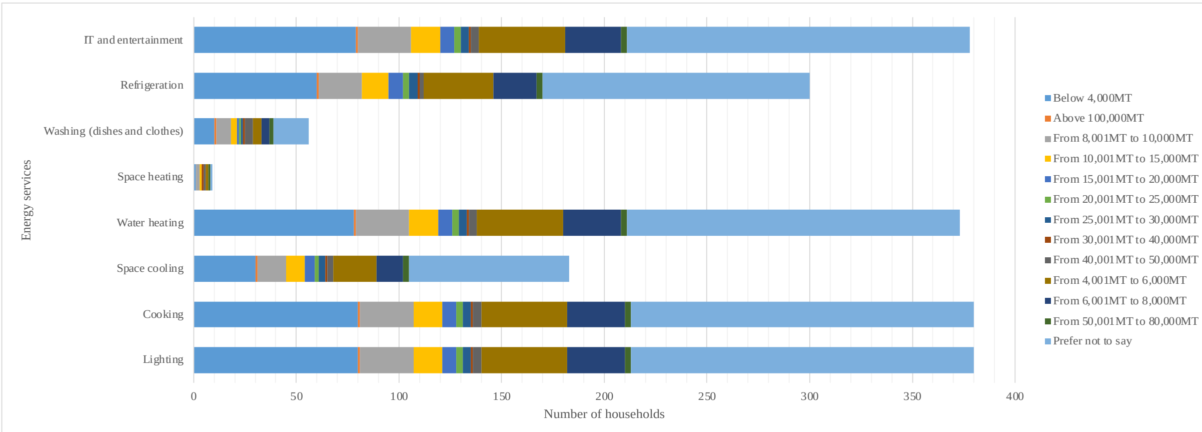


Figure 5.21: Relationship between energy services and household income

A complementary assessment was conducted to analyse the relationship between energy services and the average monthly expenditures for electricity and other fuels. Figure *5.22* indicates that most households spend between 1,000 and 2,000 MT monthly on electricity and other fuel expenditures. There is no linear relationship between the energy services that the households adopt and the amount of money they spend on their energy needs.

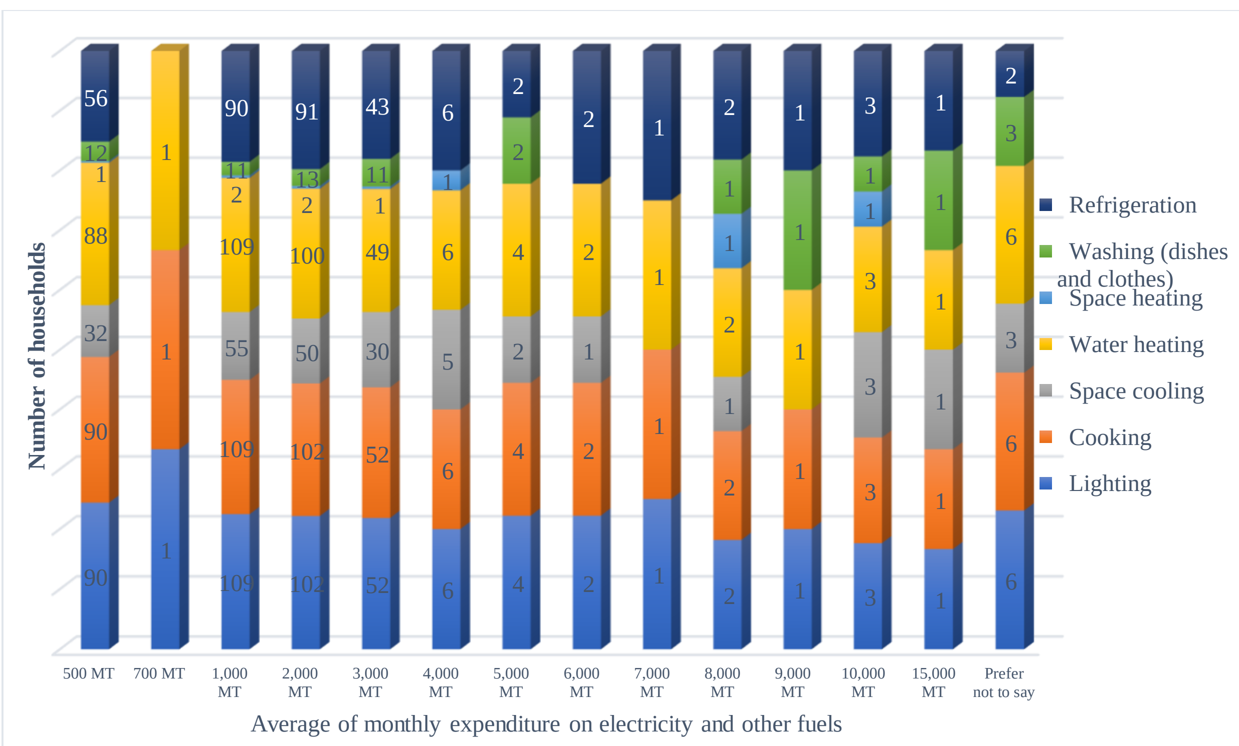


Figure 5.22: Relationship between energy services and monthly household expenses for electricity and other fuels

c) Energy devices

The results showed numerous typologies of energy devices adopted by the surveyed households. According to Figure *5.23*, a total of 23 energy devices were identified. The results also revealed that mobile phones and television sets were the most owned energy devices, with shares of 100% and 95%, respectively. The charcoal stove was among the most owned energy devices used by 81% of households. In contrast, electric and LPG stoves had low representation. None of the surveyed households owned a coffee machine.

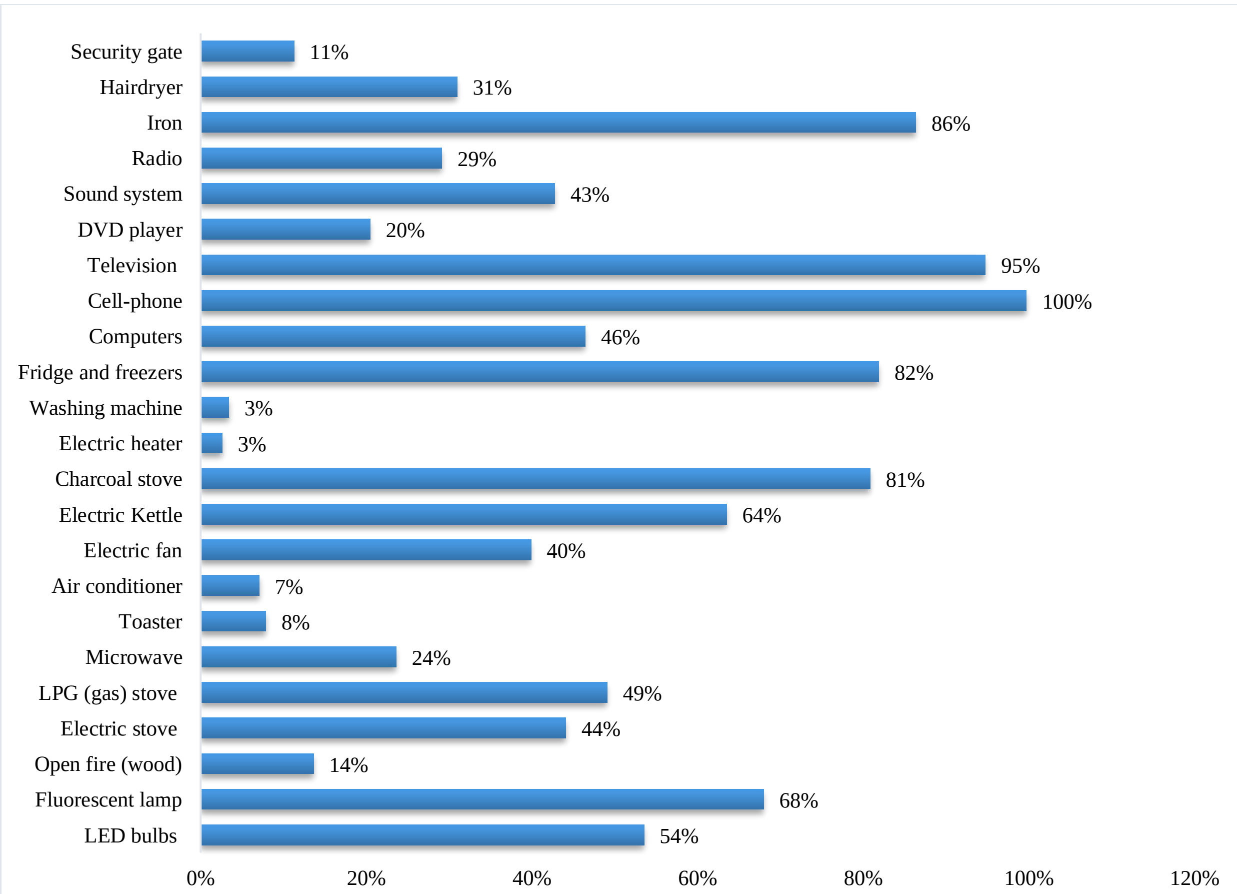


Figure 5.23: Households' energy devices

A complementary analysis of household income and selected energy devices is illustrated in Figure 5.24. The results indicated that regardless of income, the households also adopt charcoal stoves, electric kettles, toasters, microwave LPG (gas) stoves, electric stoves and open fire, except when the device is an open fire. Open fire is mainly used by low-income households, and many prefer not to say their household income.

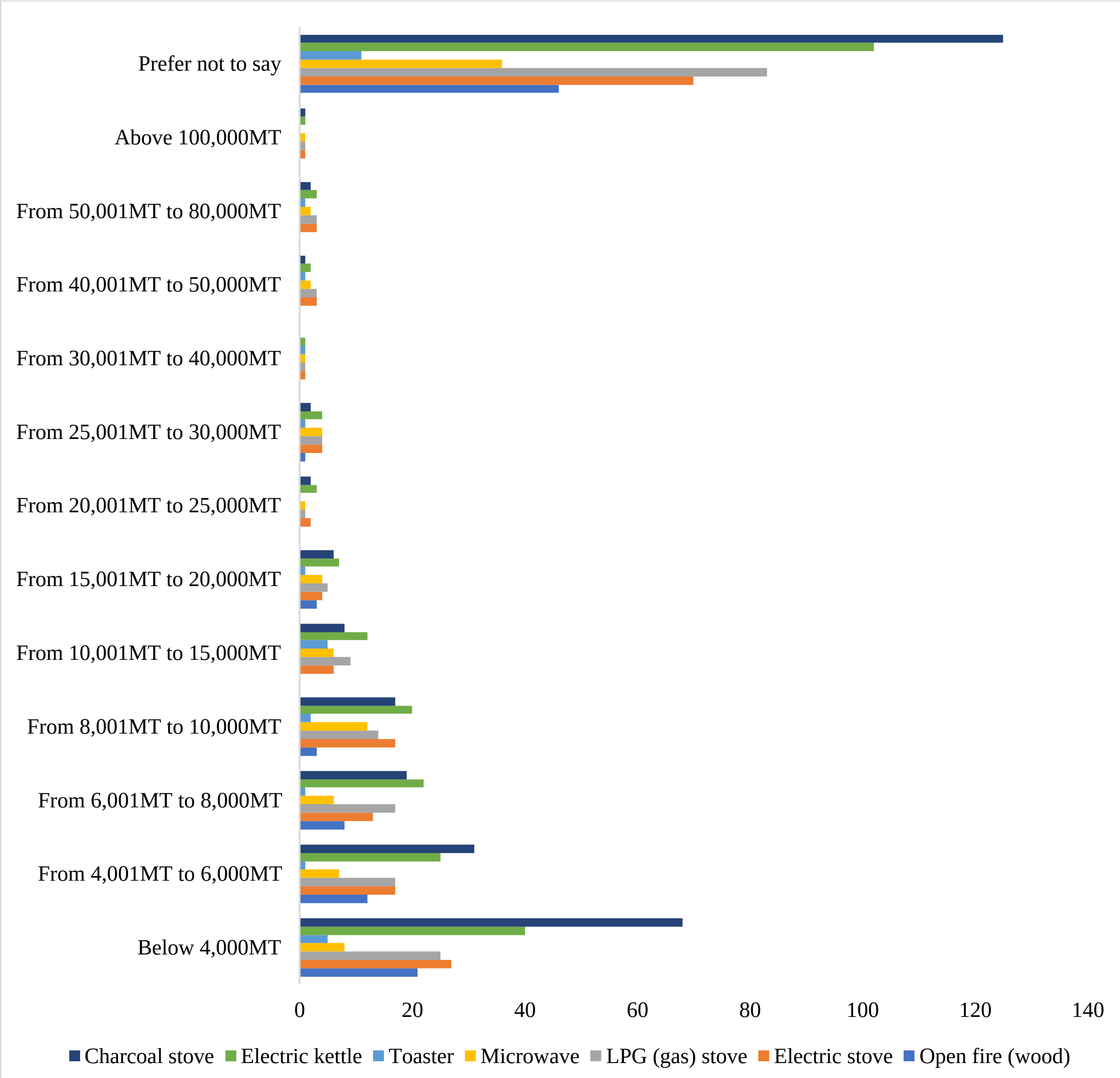


Figure 5.24: Household's income and adopted energy devices

Table 5.8 presents the relationship between energy sources, devices, and services. Electricity is the primary energy input for the energy devices owned by households. The energy services are met through the adoption of multiple fuels. The results revealed that 13% of the sampled households use wood for cooking in open fire devices, and 2% use it for water heating. LPG is mainly used for cooking (40%), and a small proportion is used for water heating, accounting for 8%.

Table 5.8: Relationship between energy sources, services and devices

Energy device	**Energy services**									**Energy source**
	Lighting	Cooking	Space cooling	Water heating	Space heating	Washing (clothes and dishes)	Refrigeration	IT and entertainment	Other services	
LED bulbs	55%	-	-	-	-	-	-	-	-	Electricity
Fluorescent lamp	64%	-	-	-	-	-	-	-	-	Electricity
Open fire (wood)	-	13%	-	2%	-	-	-	-	-	Wood
Electric stove	-	44%	-	0.3%	-	-	-	-	-	Electricity
LPG stove	-	40%	-	8%	-	-	-	-	-	LPG
Microwave	-	15%	-	-	-	-	-	-	6%	Electricity
Toaster	-	3%	-	-	-	-	-	-	3%	Electricity
Air conditioner	-	-	7%	-	-	-	-	-	-	Electricity
Electric fan	-	-	38%	-	-	-	-	-	-	Electricity
Electric kettle	-	1%	-	61%	-	-	-	-	-	Electricity
Charcoal stove	-	61%	-	20%	-	-	-	-	-	Charcoal
Electric heater	-	-	-	-	2%	-	-	-	-	Electricity
Washing machine	-	-	-	-	-	3%	-	-	-	Electricity
Fridge and freezer	-	-	-	-	-	-	81%	-	-	Electricity
Computer	-	-	-	-	-	-	-	36%	-	Electricity
Cell-phone	-	-	-	-	-	-	-	99%	-	Electricity
Television	-	-	-	-	-	-	-	96%	-	Electricity
DVD player	-	-	-	-	-	-	-	21%	-	Electricity
Sound system	-	-	-	-	-	-	-	48%	-	Electricity
Radio	-	-	-	-	-	-	-	25%	-	Electricity
Iron	-	-	-	-	-	-	-	-	87%	Electricity
Hairdryer	-	-	-	-	-	-	-	-	30%	Electricity
Security gate	-	-	-	-	-	-	-	-	11%	Electricity

5.2.3. Factors determining fuel choice decisions

The third research question of this study aimed to identify the factors that influenced energy consumption patterns in urban households in developing countries. The study used binary logistic regression to assess the factors that influenced the fuel choices of the surveyed households. Four fuel types were identified: wood, charcoal, LPG and direct electricity. The analysis was executed on the primary fuel type adopted by the surveyed households, and four models were produced. The model analyses the relationship between one variable (dependent variable) and other variables (independent variables). In this case study, the dependent variable was whether the household adopts certain fuel types, and the independent variables referred to (i) household size; (ii) type of neighbourhood in which they reside; (iii) the age of the interviewees; (iv) household income; (v) education level of the household head; (vi) the gender of the household head; and (vii) activity sector of the household head.

The binary logistic regression was done to discover which factors significantly influence the choice of the type of fuel that the surveyed households adopt since there were four types of fuel, and the use of one does not imply the non-use of the other. Hence the reported multiple fuel alternatives. The analysis was executed on the main fuel type adopted by the surveyed households, and four models were produced. The models used indicators such as constant B and the p-value of the Wald test, and the models revealed that for all fuel types, the Wald test was significantly different from zero, thereby rejecting the null hypothesis of the constant being equal to zero, so the results of the model were statistically significant. When all variables were introduced into the model, the significance of the parameters for the variables was evaluated through the Step, Block and Model tests that presented a meaningful value of 0.000, rejecting the hypothesis that all parameters were null. Knowing that the model presented significant parameters, the study ran the model to evaluate which variables influenced current fuel choice decisions.

a) Wood fuel

At a significance level of 5%, it was possible to determine that household size, the type of neighbourhood and the level of education of the household head were the variables that contributed significantly to the choice of the use of wood (see Table 5.9), complementary data in Appendix F.

Table 5.9: Variables in the equation for wood fuel consumption as the dependent variable

Independent variables	B[1]	S.E.[2]	Wald[3]	df[4]	Sig.[5]	Exp (B)[6]	95% C.I.[7] for Exp(B)	
							Lower	Upper
Household size	**0.147**	**0.047**	**9.607**	**1**	**0.002**	**1.158**	**1.055**	**1.271**
Type of neighbourhood	**1.016**	**0.358**	**8.073**	**1**	**0.004**	**2.763**	**1.371**	**5.569**
Age of the interviewee	-0.088	0.126	0.488	1	0.485	0.916	0.715	1.173
Household income	-0.004	0.028	0.017	1	0.896	0.996	0.942	1.053
Education level of household head	**-0.38**	**0.168**	**5.097**	**1**	**0.024**	**0.684**	**0.492**	**0.951**
Gender of the household head	0.068	0.325	0.044	1	0.835	1.07	0.566	2.022
Sector of activity	0.092	0.143	0.409	1	0.522	1.096	0.828	1.451
Constant	-3.258	1.247	6.825	1	0.009	0.038		

b) Charcoal

Only two variables influenced the decision to use charcoal, namely the household size and the education level of the household head. Table 5.10 summarises the binary logistic regression model developed to deepen the analysis regarding the use of charcoal in the surveyed households. Complementary data can be seen in Appendix F.

Table 5.10: Variables in the equation for charcoal consumption as the dependent variable

Independent variables	B	S.E.	Wald	df	Sig.	Exp (B)	95% C.I. for Exp(B)	
							Lower	Upper
Household size	**0.216**	**0.066**	**10.848**	**1**	**0.001**	**1.241**	**1.091**	**1.411**
Type of neighbourhood	-0.245	0.323	0.577	1	0.448	0.783	0.416	1.473
Age of the interviewee	-0.001	0.128	0	1	0.994	0.999	0.777	1.285
Household income	-0.026	0.027	0.931	1	0.335	0.974	0.923	1.028
Household head education level	**-0.507**	**0.148**	**11.809**	**1**	**0.001**	**0.602**	**0.451**	**0.804**
Gender of household head	-0.335	0.331	1.027	1	0.311	0.715	0.374	1.368
Sector of activity	0.146	0.127	1.328	1	0.249	1.157	0.903	1.484
Constant	2.248	1.263	3.17	1	0.075	9.471		

[1] B = coefficient for the constant (unstandardized regression weight)
[2] S.E = indicates the *standard error* around the coefficient for the constant
[3] Wald = tests the degree of significance of each coefficient of the logistic equation, including the constant.
[4] df= measures the *degrees of freedom* for each variable
[5] Sig. = predict whether or not an independent variable would be *significant* in the model
[6] Exp(B) = exponentiation of the B coefficient (the odds ratios for the predictors)
[7] C.I. = Confidence Interval

c) Liquefied petroleum gas

The binary logistic regression indicated that only two variables influenced LPG utilisation by the surveyed households. The study verified that the type of neighbourhood and education level of household heads were the variables that contributed to the choice of LPG as a fuel alternative, at a significance level of 5% (see Table 5.11). Also, complementary data can be seen in Appendix F.

Table 5.11: Variables in the equation for LPG consumption as the dependent variable

Independent variables	B	S.E.	Wald	df	Sig.	Exp (B)	95% C.I. for Exp(B)	
							Lower	Upper
Household size	0.049	0.044	1.226	1	0.268	1.05	0.963	1.145
Type of the neighbourhood	**-0.735**	**0.326**	**5.083**	**1**	**0.024**	**0.479**	**0.253**	**0.908**
Age of the interviewee	0.021	0.113	0.035	1	0.851	1.021	0.818	1.276
Household income	0.027	0.025	1.139	1	0.286	1.027	0.978	1.078
Household-head education level	**0.75**	**0.147**	**25.845**	**1**	**0**	**2.117**	**1.585**	**2.826**
Gender of the household head	-0.276	0.291	0.9	1	0.343	0.758	0.428	1.343
Sector of activity	0.011	0.121	0.008	1	0.928	1.011	0.798	1.28
Constant	-0.911	1.15	0.627	1	0.429	0.402		

d) Electricity consumption

Regarding direct electricity, the data analysis resulting from the model built in the binary logistic regression showed that at a significance level of 5%, none of the independent variables contributed significantly to the use of electricity in the surveyed households (see Table 5.12), and Appendix F, presents complementary data.

Table 5.12: Variables in the equation for direct electricity consumption as the dependent variable

Independent variables	B	S.E.	Wald	df	Sig.	Exp (B)	95% C.I. for Exp(B)	
							Lower	Upper
Household size	0.196	0.262	0.558	1	0.455	1.216	0.728	2.033
Type of neighbourhood	0.652	1.624	0.161	1	0.688	1.919	0.08	46.273
Age of the interviewee	0.212	0.425	0.249	1	0.618	1.237	0.537	2.847
Household income	0.489	0.521	0.881	1	0.348	1.63	0.588	4.523
Household head education level	1.312	0.812	2.613	1	0.106	3.714	0.757	18.231
Gender of the household head	-1.827	1.333	1.877	1	0.171	0.161	0.012	2.195
Sector of activity	0.152	0.518	0.086	1	0.77	1.164	0.421	3.214
Constant	-0.403	4.468	0.008	1	0.928	0.668		

Table 5.13 summarises the binary logistic regression model used to determine the factors influencing the fuel choice decision in the sampled households. The interviewee's age, household income, gender of the household head and sector of activity did not influence the fuel choice decision in the surveyed households. The factors that influenced the sampled households' fuel choice decision by the level of importance include household heed education level, household size and the type of neighbourhood in which they reside.

Table 5.13: Factors influencing fuel choice decisions within the surveyed households

Independent variables	**Dependent variables**			
	Wood	**Charcoal**	**LPG**	**Direct electricity**
Household size	influences	influences	no influence	no influence
Type of neighbourhood	influences	no influence	influences	no influence
Age of the interviewee	no influence	no influence	no influence	no influence
Household income	no influence	no influence	no influence	no influence
Household head education level	influences	influences	influences	no influence
Gender of the household head	no influence	no influence	no influence	no influence
Sector of activity	no influence	no influence	no influence	no influence

5.2.4. Gender roles in energy consumption patterns

The last research question of this study's second research objective was, 'How do gender roles influence the current energy consumption patterns'? The results were structured to present gender roles in the sampled households' energy sources, services and devices. This assessment was conducted using cross-tabulation and pivotal tables. Table 5.14 depicts the relationship between the gender of the person who uses the energy sources and the municipal district. The results showed that, overall, women predominantly use energy sources. In KaMubukwana and KaTembe Municipal districts, wood is solely used by women. Direct electricity is the energy source that is used by both gender throughout the Municipal districts, and they experience some degree of neutrality. However, it is in KaNyaka, where it is 100% neutral.

Table 5.14: Gender of the person who uses the energy sources the most per municipal district

Municipal District	Gender	Energy source			
		Wood	Charcoal	LPG	Direct electricity
KaMpfumo	Women	67%	64%	59%	39%
	Men	0%	5%	0%	3%
	Neutral	33%	32%	41%	58%
Nlhamankulo	Women	86%	97%	94%	40%
	Men	14%	3%	6%	12%
	Neutral	0%	0%	0%	49%
KaMaxakeni	Women	90%	95%	100%	73%
	Men	10%	5%	0%	26%
	Neutral	0%	0%	0%	2%
KaMavota	Women	84%	90%	80%	13%
	Men	6%	1%	12%	16%
	Neutral	10%	9%	8%	71%
KaMubukwana	Women	100%	95%	94%	67%
	Men	0%	4%	3%	14%
	Neutral	0%	1%	3%	19%
KaTembe	Women	100%	78%	67%	45%
	Men	0%	11%	33%	36%
	Neutral	0%	11%	0%	18%
KaNyaka	Women	50%	0%	0%	0%
	Men	0%	0%	0%	0%
	Neutral	50%	100%	0%	100%

Figure 5.25 shows the relationship between the household building structure and the gender of the household. The results reveal a nearly similar trend between male and female-headed households. However, most incomplete conventional houses, without bathrooms and kitchens inside the house, are male-headed. Also, households residing in apartments do not use wood, regardless of the gender of the household head.

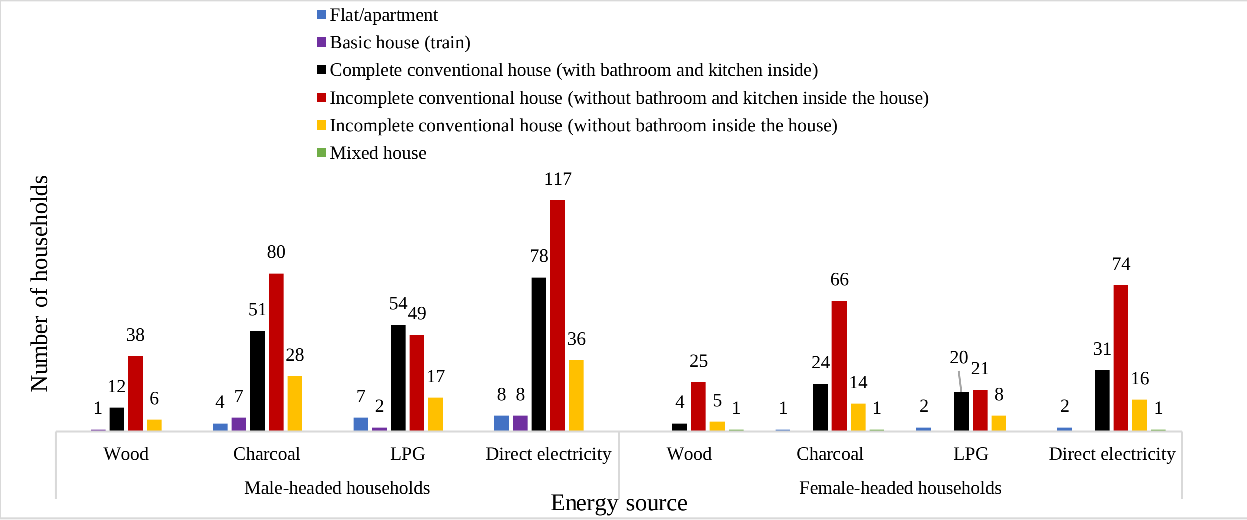


Figure 5.25: Household building type and gender of household head

Figure 5.26 shows that, while women in the sampled households are generally responsible for deciding and using the fuels that households adopt, men are the ones paying for them. Hence, while women's roles in the decision on fuel reduce as the fuel choice becomes cleaners, men's role in paying for the adopted fuels increases as the fuels becomes cleaner. Electricity adoption was relatively gender neutral in the sampled households (see detailed data in Table F2 and Table F3, in Appendix F).

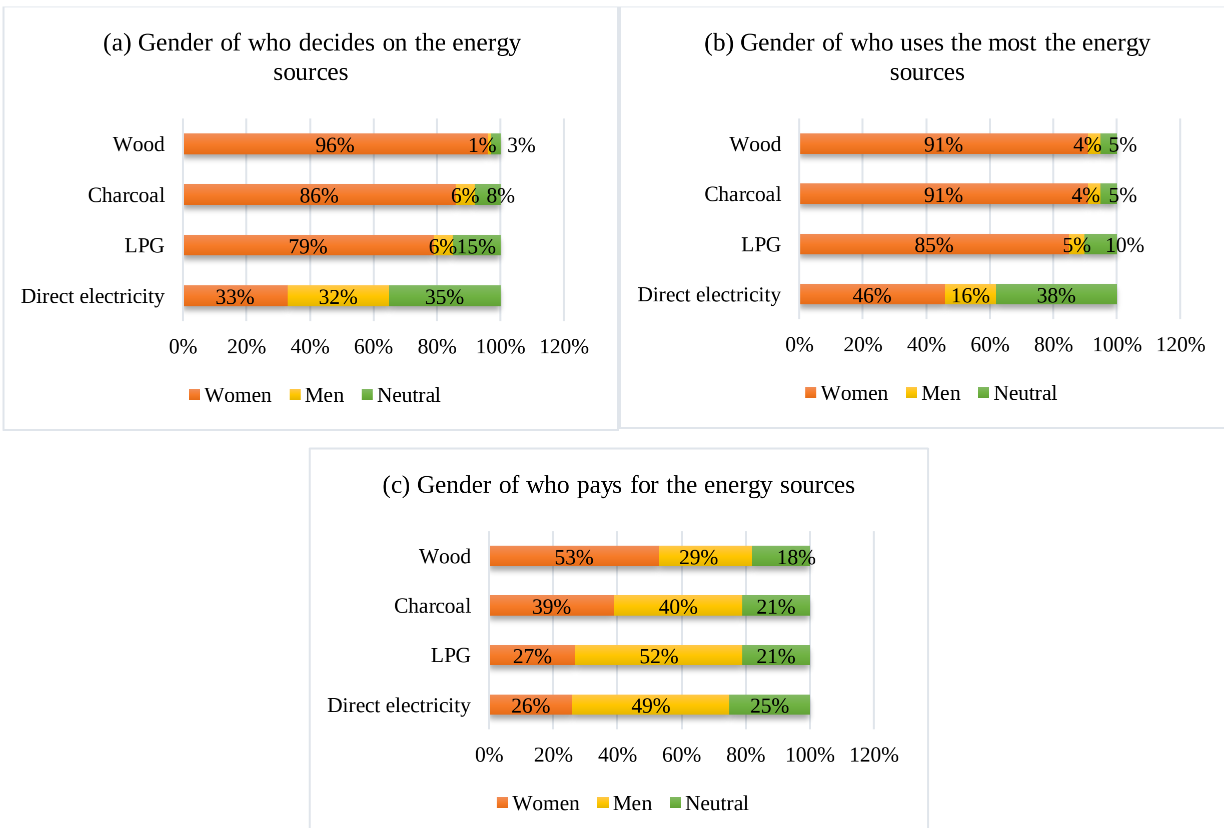


Figure 5.26: Gender of who (a) decides on, (b) uses the most of and (c) pays for the energy source

Figure 5.27 illustrates the analysis of household heads and the gender deciding on the type of fuel adopted by the households. According to the figure, regardless of the gender of the household head, women in the sampled households choose to use solid fuels. For instance, in female-headed households, nearly 100% of choice for wood and charcoal was made by women. In male-headed households, the trend is nearly the same, although men's roles increased slightly. In male-headed households, women's decision power decreased as the fuels became cleaner. Men even surpassed women's roles in the decision about direct electricity.

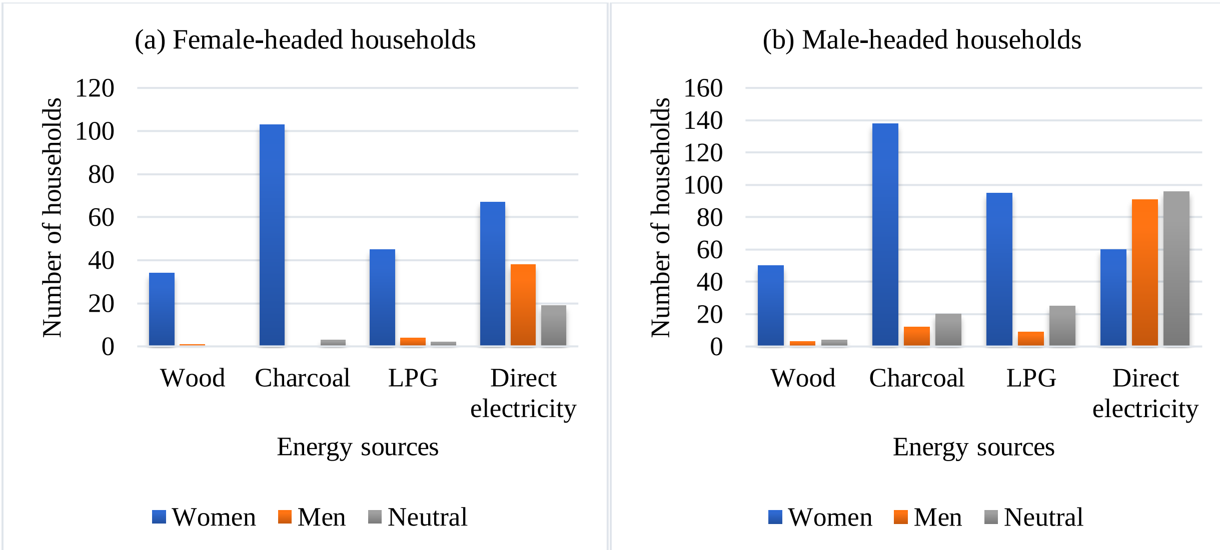


Figure 5.27: Gender of who makes the fuel choice decision, (a) female- and (b) male-headed households

The study then analysed how the gender of the household head relates to the gender of who pays for the energy options. Figure 5.28 shows that the gender of the household head influences the gender of who pays for the fuel. In other words, in the sampled female-headed households, women were generally responsible for paying for the fuel, and charcoal was the most preferred fuel in the households. However, in male-headed households, men are predominately in charge of paying for fuel, and electricity is the most favourable energy source, with wood the least preferred energy source. Furthermore, women's role in buying fuel is minimal in male-headed households.

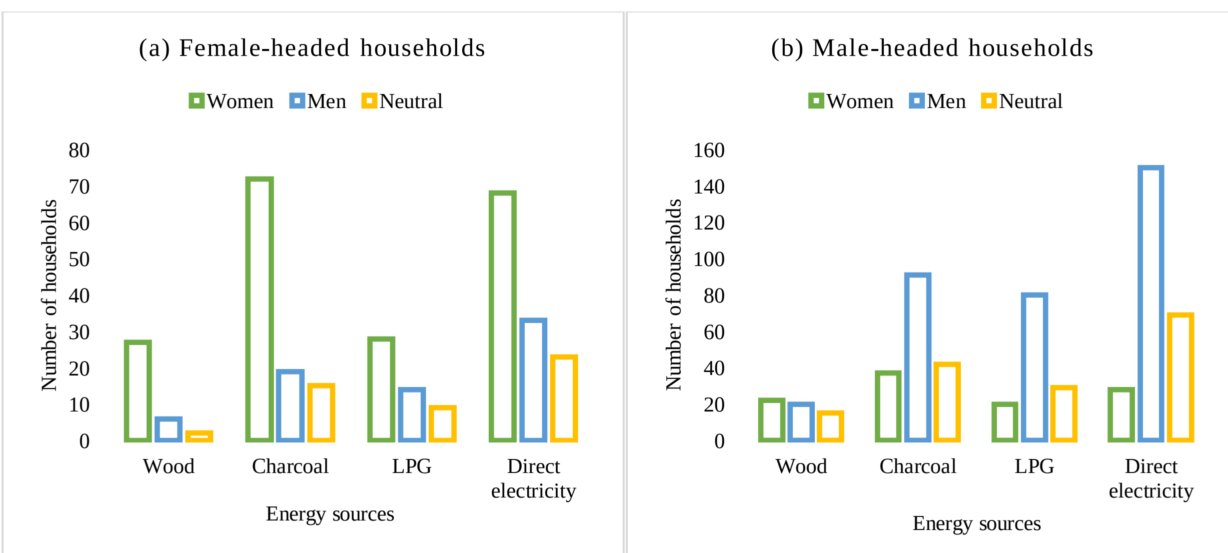


Figure 5.28: Gender of who pays for the fuel, (a) female- and (b) male-headed households

However, according to Figure 5.29, while lighting, cooking, IT and entertainment are absolute needs, space heating, washing and space cooling were not part of all surveyed households. The results indicated that women are responsible for most energy services (45%) of households' requirements.

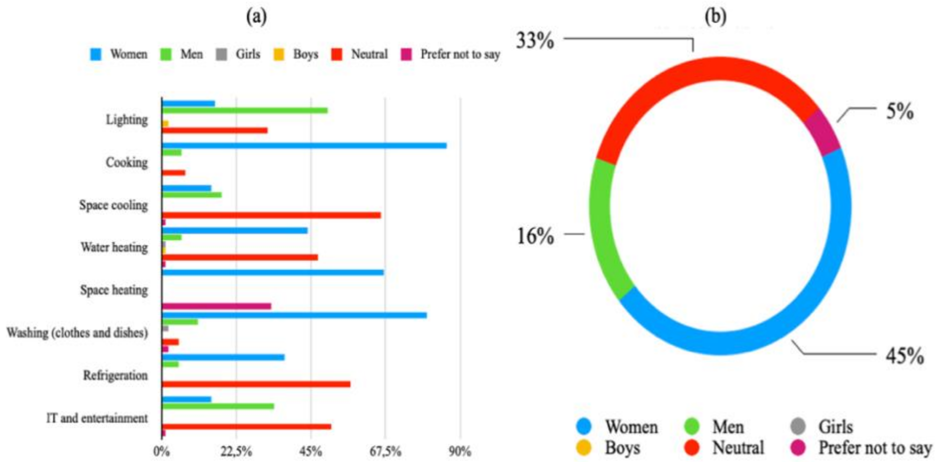


Figure 5.29: Household energy service allocation (a) and summary of energy services allocation (b)

The data analysis of the households' dynamics regarding energy devices showed that, on average, women decide on the devices that the households use (38%). However, the average of those claiming the neutral choice was higher (36%) than those saying that women are in charge. Figure 5.30 demonstrates this pattern and shows that, despite the average use of energy devices being primarily neutral (50%), women still represent a larger group than men, at 33% and 17%, respectively. Hence, men are mainly responsible for buying energy devices.

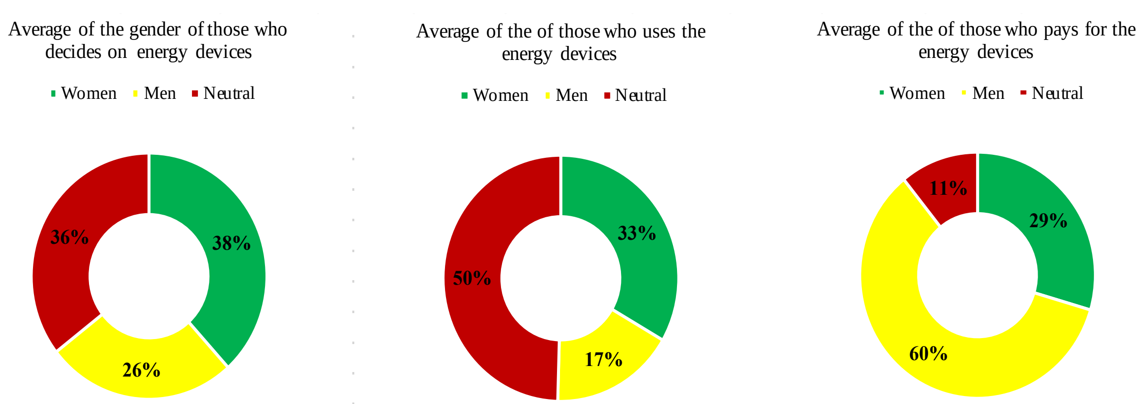


Figure 5.30: Average of the gender in charge of deciding, using and paying for energy devices

Figure 5.31 shows that the energy devices are primarily allocated to women. However, compared to men, they do not have the power to buy the devices. Also, Table F5 in Appendix F gives more detailed data regarding the energy services, women's role in fuel choice and the gender that uses the most energy devices.

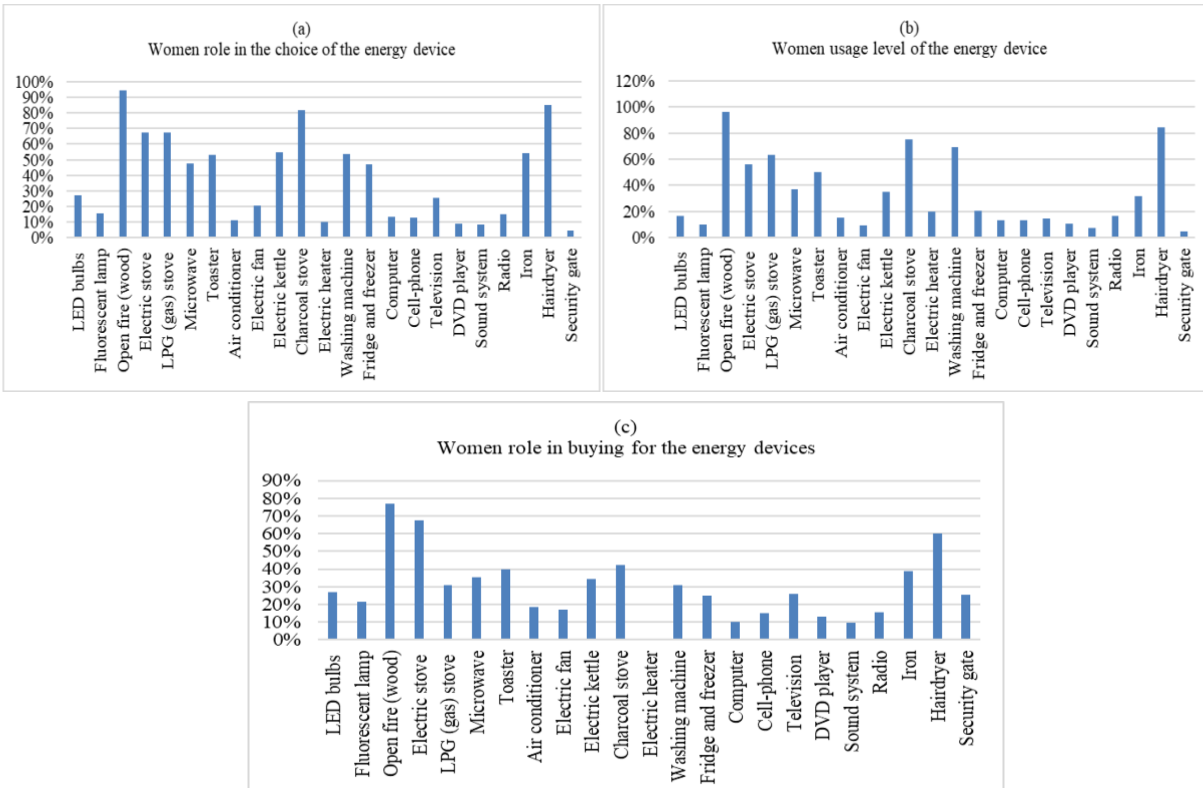


Figure 5.31: Women's role in deciding on (a), using (b) and buying (c) energy devices

According to Figure *5.32*, women decide the most on using the bulk of the selected energy devices, with a larger share of the charcoal stove (almost 250 women out of 300). A similar pattern was verified when analysing the gender who uses the energy device the most. The gender of those buying the energy devices indicated that men are mainly in charge of purchasing these devices except for open fire and electric stoves, where women's role surpasses men's.

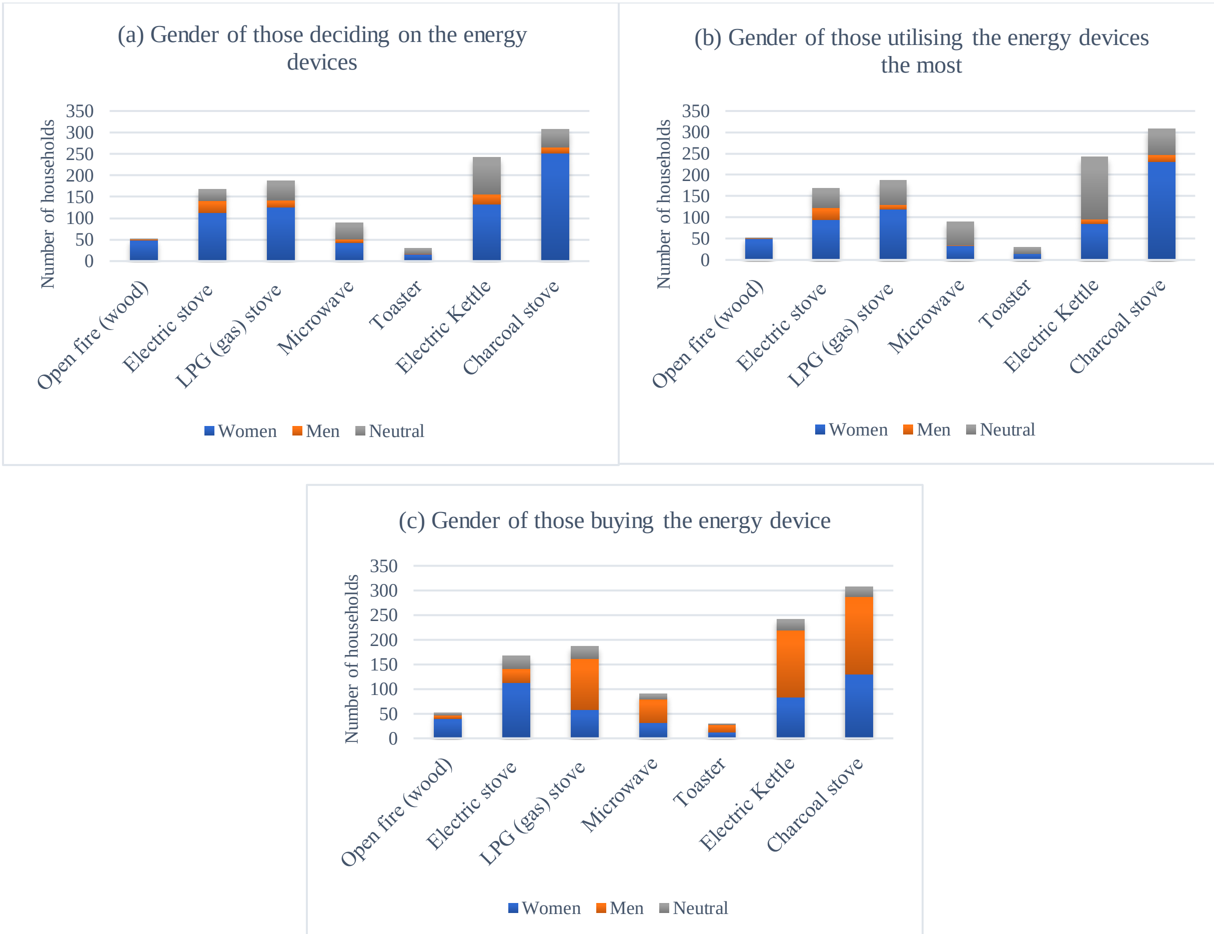


Figure 5.32: Energy devices *vs* gender of those deciding (a) utilising (b) and paying (c) for energy devices

5.3. Discussion

5.3.1. Household profile

To address the second research objective, this study started by responding to the first research question of the objective, which intends *to describe the households that constituted urban developing environments*. The analysis of the results indicates that the suburban areas comprise the bulk of the urban population, which are, in general, low-income households prone to stacking multiple fuels (Cheng & Urpelainen, 2014; Jewitt, Atagher & Clifford, 2020; Masera, Saatkamp & Kammen, 2000). Moreover, most households are male-headed, which corroborates the society's patriarchal nature (Fingleton-Smith, 2018; Nwaka, Uma & Ike, 2020; Oparaocha & Dutta, 2011;), which is the case even in developed countries (Nastasia, Nastasia & Kartoshkina, 2009).

Considering the conclusion by Rahut et al. (2016), this demography poses a risk to clean energy sources in a situation where traditional biomass is the preferred fuel. According to these authors, female-headed households in urban environments with purchasing power and a high level of education are highly likely to adopt clean fuels, especially for cooking purposes. The results also show that most household heads have only a primary school education, which corroborates the results of a study by Armah et al. (2019) conducted in 31 countries in sub-Saharan Africa, including Mozambique. This finding is alarming because, as indicated in previous studies, the lower the household head's education level, the smaller the chances of adopting cleaner energy, such as LPG (Karimu et al., 2016) and electricity (Rahut et al., 2016).

Most sampled households are composed of five members, corroborating the results of the last population census led by the National Institute of Statistics in 2017 (INE, 2019). Furthermore, the bulk (48%) of the interviewees were self-employed. According to the last census, this figure relates to the national statistics, where around 51,8% of the Mozambican population is self-employed(INE, 2019). Also, nearly 24% were unemployed, which goes hand in hand with World Bank data, indicating that 26.45 % of the Mozambican labour force were unemployed per the 2020 reference point (The World Bank, 2020). Also, this could be related to the reported income loss due to the COVID-19 pandemic. It became clear from the interview with EDM that the pandemic reduced the purchasing power of households to buy their energy sources, especially direct electricity, which was aggravated by the already existing employment issue.

A significant number of households (44%) did not disclose their income. However, most households reported earning less than 63,46 USD, approximately 2 USD per day, which corroborates the United Nations Development Programme report, indicating that Mozambique is one of the world's poorest countries (UNDP, 2019). Hence, the data did not sustain or co-relate when analysing other data relating to their monthly expenditure and energy consumed. According to INE (2021), the average expenses of the households in Maputo city corresponds to nearly 20,000 MT (320 USD), although the national average in urban areas is 12,587 MT (198.22 USD). For instance, when asked about their monthly expenses, their reported amount was higher than what they alluded to be their household income. The results revealed that, on average, they spent 23,448 MT per month. This figure is closer to the national household budget report, which indicated that, on average, the households in Maputo city spend 19,664MT. This discrepancy could be due to how the question was framed, as they showed interest in reflecting on how much they spend monthly or because they became more comfortable and willing to answer the questions as the interview progressed.

There is a direct relationship between households' income and the educational level of the household heads. However, when looking at the gender of the household head, the results revealed that most households with high education and high income are male-headed. In female-headed households, even with increased education, their income is within the low- and middle-income range. This might be why the female-headed households adopt less efficient energy sources in the sampled households. This data shows that female-headed households are likely to experience fuel poverty and adopt traditional energy sources as far as their income compared to male-headed households.

Food comprises the most significant expenditure. Savings and education represent the second most significant expenditures of the sampled households. Electricity and other fuels were positioned in number six of the households' expenditures, accounting for 7% of the total expenses. This result is similar to Pemana, Azis and Siong (2015), who conducted a study in Bandung city, Indonesia. Their findings revealed that households the Bandung city households spent nearly 9% of their income on electricity and water. It was impossible to relate the household's electricity and other fuel expenditures to the national data because the national report aggregates rent, water, electricity, gas and other fuels (INE, 2021).

5.3.2. Energy sources, services and devices

a) Energy sources

Addressing the second research question of the second objectivity of this study required *understanding the energy sources, services and devices the sampled households adopted*. The findings indicate that the households adopt multiple *energy sources* composed of direct electricity (99%), charcoal (74%), LPG (48%) and wood (25%). These results validate the fuel-stacking phenomenon (Masera, Saatkamp & Kammen, 2000; Cheng & Urpelainen, 2014; Jewitt, Atagher

& Clifford, 2020) as well as the persistent dependence on traditional fuels (Castán Broto, Arthur & Guibrunet, 2020; Clancy et al., 2019; Musango et al., 2020) despite an increase in household income. This finding invalidates the energy ladder theory, described by Sovacool (2011b), in which households adopt cleaner energy as income increases. However, although the energy ladder theory has been criticised for its biased assumption of a direct relationship between income and energy transition among households, it provided the ground for developing the fuel stacking theory (Musango, 2022). Nevertheless, both theories lack socio-cultural aspects, such as gender roles and household preferences based on values and beliefs.

b) Energy services

Mozambican urban households require several services for their comfort. Building upon the categorisation of services by Sovacool (2011a), the study identified eight groups of energy services currently part of the needs of households. The findings reveal that the energy services that the households need are similar in different areas. The EDM spokesman was asked about the household fuel mix to complement this query. Their response was similar to this study's results, revealing that households often resort to traditional sources such as biomass for cooking, heating and night lighting. Furthermore, some regions still use kerosene, flashlights and candles for lighting. Also, batteries, solar systems and small electrical generators supply electricity.

The heads of households without formal and tertiary education did not use space heating and washing machines. The possible underlying reasons for the low usage of space heating could be the country's geographical location, namely in a tropical region. The low usage of washing machines could be related to the lower rate of washing machine ownership. This technology is still a novelty amongst most households, and due to their financial status, they cannot purchase these devices. Also, the observations revealed that housekeepers often perform these tasks, usually washing by hand. Some households in urban areas reported owning washing machines, but dishwashers were nearly non-existent.

c) Energy devices

In Mozambican, urban households use a myriad of energy devices. A total of 23 energy devices were identified to meet their energy services. The most owned energy device is the charcoal stove, used by 81% of households. In contrast, electric and LPG stoves have low representation, which corroborates the previous consideration that charcoal was the preferred energy source for cooking. The discussions by Kovacic et al. (2019) and Musango et al. (2020) on energy sources in other urban developing environments differ from this study's findings. For instance, this study did not find cases where kerosene stoves and lamps were part of households' energy devices. Although the interview with EDM indicated that kerosene is part of the Mozambican energy mix, it is mainly adopted by rural households and, to a lesser extent, urban households in small cities across the country.

Moreover, a similar conclusion was reached when looking at access to decentralised renewable sources and technologies. Oyewo et al. (2019) and Haque et al. (2021) have advocated faster access by increasing modern and renewable energy sources in poor urban environments. Despite this, none of the surveyed households claimed to have access to indirect electricity via solar panels or owning solar water heaters. It should be noted that according to the interview with MIREME, it was found that under the National Electrification Strategy, FUNAE and EDM encompass two critical actors in the Mozambican energy sector. On the one hand, EDM is responsible for carrying out on-grid electrification. On the other hand, FUNAE is in charge of off-grid electrification and uses renewable energy technologies such as solar, mini-hydro and mini-grids, and domestic solar systems. Furthermore, EDM is also working towards meeting the energy for all goals under UNDP programs named ProEnergia. Also, EDM is promoting renewable energy auction programs and initiatives to connect renewable projects to the grid. So, considering this strategy and the fact that the government and its international partners are founding these projects (according to the MIREME spokesman), there could be an improvement in the upstream energy value chain with alternative energy sources than could improve modern fuel availability.

Traditional fuels are used to meet energy services such as cooking and water heating, which in more affluent households use devices such as LPG (gas) and electric stoves. While electricity is the most versatile energy source, biomass and LPG are mainly for cooking and water heating. Cooking is the most versatile energy service, which can be done on several energy devices, while space heating, washing and refrigeration are limited to one energy device each. Studies investigating the energy, gender and poverty nexus say that solid fuels in the form of wood are mainly used for cooking purposes (Castán Broto et al., 2020; Karimu et al., 2016; McCarron et al., 2020; Nwaka, Uma & Ike, 2020; Rahut et al., 2016), which this study concurs. Although the availability of natural gas could imply its massive adoption in the form of LPG by households, its adoption is still in its infant stage. According to the interview with ENH, it has become clear that there are no specific targets for domestic consumption share. Particularly strategy to address the gendered energy-related issues that could potentially be minimized by LPG massification.

5.3.3. Factors determining fuel choice decisions

The binary logistic regression was done to discover which factors significantly influence the choice of the type of fuel that the surveyed households adopt. Furthermore, this assessment addressed the third research question of the study's second objective.

a) Wood

Nwaka, Uma and Ike (2020) found that female-headed households in the developing world tend to use solid biofuel the most. In this study, the gender of the household head did not influence the use of wood in the surveyed households. Instead, the use of wood was primarily influenced by the type of neighbourhood in which the survey households resided. Also, as stated earlier in the cross-tabulation analysis, in most of the surveyed households, women used wood the most. Nwaka, Uma and Ike (2020) point out that the traditional division of household energy services and chores influences the decision to use wood fuel and their socially constructed stereotypes. In fact, in urban areas, where the household members are relatively well informed and have financial stability, wood fuel represents one of the least preferable options. According to MIREME and EDM interviews, the persistent adoption of wood, despite the abundance of clean fuels such as natural gas, solar energy, hydroelectricity, and geothermal, is linked to the low capacity of households to pay for energy services. Also, the availability of wood fuels and the socio-cultural values in households use wood for cooking certain foods. For instance, they allege that it takes a long time to be prepared, and they cannot afford the use of gas because it is allegedly more expensive than wood.

All interviewees (EDM, MEREME, and ENH) were asked: '*what are the pathways to ensure the transition from biomass dependence to modern energy carriers in urban areas*'. The spokesman showed consensus on the need to foster renewable energies and maximize the use of LPG. Their insight was that households in urban settlements often have access to electricity. Hence, the continued use of solid fuels provides cooking and water heating services (with the survey's findings). So, they recommend using solar water heaters as a renewable alternative for water heating and LPG as clean energy for cooking. Furthermore, they implied that with this approach, it is possible to address the gendered energy-related issues.

b) Charcoal

There is consensus in the literature that charcoal production and use by urban households have driven unprecedented forestry degradation and land-use change in the developing world, especially in sub-Saharan Africa. The negative implication of its adoption is a topic of debate by scholars in several disciplines (Banerjee et al., 2012; Baumert et al., 2016; Castán Broto et al., 2020; Ihalainen et al., 2020; Jones et al., 2016; Sedano et al., 2016; Smith et al., 2019; WHO, 2020). As indicated previously, of 381 surveyed households, 282 reported using charcoal as part of their fuel mix, which accounts for 74% of the surveyed households. Charcoal, thus, is the second most adopted fuel in the surveyed households, surpassed only by electricity consumption.

In the case of charcoal, only two variables influenced the decision to use charcoal: the household size and the education level of the household head. As indicated previously, charcoal represents the preferred energy for cooking in all urban areas in Maputo city. According to Rahut et al. (2016), this is the case in Ethiopia, Malawi, and Tanzania. The cross-tabulation analysis found that, like the surveyed households that use wood, those adopting charcoal are predominantly male-headed. Hence women are those deciding on the use of charcoal and use it the most. The data analysis revealed that, of the 282 households that utilised charcoal, 108 (38%) did not reveal their income, and of those who revealed their income, the bulk (86; 30%) said that their income was between 4 000 MT and 6 000 MT – the lowest reported in the study. In addition, most of the heads of households that used charcoal were either unemployed or self-employed, which is often linked to inconsistent income (McCarron et al., 2020). This leads them to adopt mixed fuel alternatives that allow them to stock and buy small amounts (Musango et al., 2020) that fit into their financial capabilities.

c) Liquefied petroleum gas

The literature on energy transition for urban developing contexts advocates LPG as an alternative clean cooking fuel (Karimu et al., 2016; Lieu, Sorman et al., 2020; Mohlakoane & Annecke, 2008; Rahut et al., 2016). The underlying reason for this advocacy is linked to the positive outcomes that its use could bring to Mozambique. These include, but are not limited to, reduced deforestation, reduced solid fuel consumption, health-related issues, and improved women's well-being, which could ultimately contribute to SDG 7 and SDG 5. Although LPG is relatively carbon-intensive and might increase the country's carbon footprint, this study defends its use as LPG is fundamental for the Mozambican urban household to transition from solid fuel to this modern energy source. LPG is mainly used as cooking fuel. While LPG is one of the preferred fuels in urban areas (33%), it does not show a similar nature in suburban and peri-urban areas, with a share of 18%. Further, instead of household size, which reportedly encourages the use of charcoal, in the case of LPG, it is the type of neighbourhood, which was also the case for wood fuel consumption patterns.

However, in the case of wood fuel, the type of neighbourhood determined how clean the energy sources the households consumed were. In other words, the regression analysis showed that suburban and peri-urban areas were most likely to use wood fuels. In contrast, the situation was reversed in the case of LPG, which means that as urbanisation increases, so does the surveyed households' probability of adopting LPG. This finding validates the relevance of understanding the socio-spatial dimensions of energy transitions at the household level (Castán Broto, Arthur & Guibrunet, 2020; Damari & Kissinger, 2018). Furthermore, according to the interviewees from the critical energy sector, several constraints contribute to current low LPG adoption and limited consumption in middle- and high-income households, including insufficient investment, compared to the current cover rate, lack of energy literacy, and stigma. The literature also reported high upfront costs related to acquiring gas cylinders and stoves (Castán Broto et al., 2018; Mohlakoane & Annecke, 2008; Vahlne, 2017).

The insights from ENH, the national entity managing the hydrocarbon sector, were relevant for analysing Mozambique's LPG consumption patterns. So, it was relevant to understand not only the strategies and policies in place for the massification of LPG adoption but also if the local context informs their actions and that the gendered dimension is captured with their strategies. The information retrieved for the interview with this institution confirmed the issues raised by Salimo, Buur and Macuane (2020), indicating that, among others that Mozambique does not benefit from its abundant natural resources, among which are mainly exported. There is also a lack of national targets or thresholds for domestic consumption. In this view, to address this gap in the Mozambican energy system, it is necessary to change the incumbent regime actors from within (Köhler et al., 2019) by transforming the institutional structuring (Loorbach, 2010). For instance, introducing policy mix strategies (Edmondson, Kern & Rogge, 2019) that are gender sensitive (Hwangbo, Park & Lee, 2019) provide a starting point for the gendered energy transition in Mozambique. However, it is also necessary to introduce evaluating and monitoring mechanisms (Loorbach & Meadowcroft, 2012) informed by gender audit approaches (Clancy & Mohlakoana, 2020).

d) Electricity

Electrification is one of the significant milestones that the Mozambican government struggles to achieve, especially in rural areas. Nearly 30% of the Mozambican population has access to the national electricity grid. In urban areas, 73% of the population is connected to the grid (IEA, 2019a). However, in the selected sample, 99% of the households reported being connected to the grid. Electricity is used mainly for electrical devices, including electric stoves, to a small extent. In the case of the surveyed households, while women were more interested in fuel sources for cooking and water heating, men, on the other hand, emphasised fuel sources for energy services such as IT and entertainment, and refrigeration. This finding corroborates the findings of Clancy and Mohlakoana (2020), who claim that men and women place different emphases on energy for their needs. In fact, this study also provides an evidence-based argument to validate the observations of Nwaka, Uma and Ike (2020). They claimed that the traditional, gendered chore allocation is associated with households' energy consumption patterns.

Like LPG, increased urban household use of electricity undoubtedly is paramount. In the case of the surveyed households, the issue is no more extended to access to electricity (99% were connected to the national grid) but widening the services that could be met using this source. As indicated, in the case where the household owns electronic devices, these are fed with direct electricity generated from the hydropower plants that exist in Mozambique. Hence, the challenge would be increasing households' use of electricity for cooking purposes, which so far happens in only a minimal number of households of the urban elite (Castán Broto et al., 2020). Therefore, this study argues that strategies and policies to improve women's living situations and reduce dependence on solid fuels must be informed by these household energy consumption dynamics. According to Clancy and Mohlakoana (2020), Musango et al. (2020) and Nwaka, Uma and Ike (2020), this involves understanding the gender role regarding fuels and services that are needed in daily activities and the division of labour.

A significant number of households (37%) said that the energy fuels they have access to are insufficient to meet their daily needs. This raises concerns about energy security, as mentioned by Musango et al. (2020). The relevance of addressing this issue is pivotal, as its negative implications disproportionately affect women. Additionally, although 50% of the sampled households revealed that their fuel preference is associated with their financial capabilities, the binary regression analysis showed no direct relationship between income and fuel choice decisions. It should be noted that the possible reason for the insignificance of income level could be that most households did not declare their income. However, the education level of the head of the household represented the primary factor dictating the fuel choice decision. In addition, the location of the household (urban, suburban or peri-urban area) influenced the fuel choice decision by the surveyed households, which is corroborated by Musango (Musango, 2022). None of the variables was significant for the decision of the surveyed households to adopt direct electricity.

Regarding the target group, direct electricity access was not an issue. In fact, according to EDM, the country's electricity production surpasses its internal demand. This is arguable due to the lack of infrastructure for distributing electricity to all Mozambicans (Gregory & Sovacool, 2019). Among others, there is a need to export the electricity produced to sustain the existing infrastructure, despite the bulk of the Mozambicans not being connected to the national grid. As previously discussed, Mozambique exports a significant amount of its hydroelectricity and natural gas to its neighbouring countries (Uamusse et al., 2019; Salimo, Buur & Macuane, 2020; Salite et al., 2021).

Furthermore, according to the interview with the MIREME spokesman, one of the national strategic objectives is to transform the country into a regional hub in the southern African energy sector. To this end, according to the ENH spokesman, investments in large projects, such as natural gas in Rovuma, are in the course. Moreover, the EDM spokesman also referred to other structuring projects. These include the MPhanda Kuwa Hydroelectric Power Plant, Photovoltaic Plants in Mocuba, Metoro, Cuamba, Mecufi, and Dondo, the Temane gas plant project and its transmission lines, and Mozambique-Malawi, Mozambique-Zambia and Mozambique-Tanzania regional interconnection line projects.

5.3.4. Gender roles in energy consumption patterns

The study conducted by MGCAS (2016), which investigated the gender profile in Mozambique, alluded that several challenges impede gender equality in Mozambique. These challenges include, however not limited to: (i) lack of implementation of national strategies that advocate the protection of women and girl's rights; (ii) socio-culture factors that continue discriminating and excluding women and girls from social, political and economical life; and (iii) up until now poverty and inequality as still women issues. However, it should be noted that the Mozambican national energy strategy states that '*creating conditions that facilitate the access, and utilisation of energy resources for daily activities by women and men, contributing to improving the subsistence conditions of families and communities*' (Ministério da Energia, 2011: 26).

So, the existing policy considers women's and men's daily needs and activities that require access to fuel sources. According to Clancy et al. (2020), this is fundamental in contexts such as those of developing countries, where government interventions are fundamental for the energy transition. However, according to the EDM and ENH spokesman, the mentioned strategies lack implementation, monitoring and evaluation mechanisms, and some are outdated. Furthermore, gender strategies are not in the domain of most of the employees of the institutions responsible for their implementation. This study aimed to understand how gender roles influenced the fuel choice decisions of urban households. Accordingly, it attempted to analyse the roles of women and men in the sources, services and energy devices they adopted.

a) Energy sources

The assessment of how gender influences fuel choice decisions within the sampled households revealed that the type of neighbourhood that constitutes the municipal district influences the gender of those who primarily utilise the energy sources. In KaMpfumo, where the urban households are located, the gender emphasis on energy sources is less prominent than in other municipal districts, namely suburban and peri-urban areas. This finding is consistent with Castán Broto et al. (2020) study, which showed that household dwelling characteristics influence household energy patterns. The data shows that households' energy consumption patterns are deeply gendered. The gendered nature of the households' energy consumption patterns in Maputo corresponds with the conclusions by Clancy et al. (2019), Lieu, Sorman et al. (2020) and Musango et al. (2020). In KaNyaka, for instance, the sampled households revealed that some roles are gender neutral and do not use LPG or wood as fuel alternatives. The lack of LPG adoption could be linked to the fact that this is a small island, and access to the area is only by boat and, to a lesser extent, by small aeroplanes, and LPG supply to the area is nearly non-existent. This finding validates Musango's (Musango, 2022) conclusion, indicating that not every household energy-related aspect is gender centred.

Furthermore, the results indicated that while women's role in the decision on fuel decreases as the fuel becomes cleaner, men's role in paying for the adopted fuels increases as the fuel becomes cleaner. For instance, women's roles are more significant in deciding on wood, charcoal and LPG. In contrast, women's role in electricity use is minimal, and the decision-making is nearly equally divided between men and women. Electricity adoption was primarily gender neutral in the sampled households. Even though women desire clean and modern energy sources (Cecelski & Matinga, 2014), they are often subjected to solid fuels due to their lack of income (2020). Therefore, despite women's decision on the fuel type, men's capabilities or willingness to pay for the energy carriers ultimately dictates the household energy sources for their energy services. This finding is of no surprise when looking at gendered energy studies. These include the work of gender and energy nexus scholars (Clancy et al., 2003, 2019; Oparaocha & Dutta, 2011; Rosenthal et al., 2018). They say women's role in fuel choice decisions in poor urban environments is marginal, and the pattern is even prevalent in male-headed households. According to Nwaka, Uma and Ike (2020), women's lack of income may be the reason for this scenario.

The assessment on how gender utilises the most energy sources showed that, while wood, charcoal and LPG are used most by women, electricity is more balanced and neutral to some degree. In the Maputo case, although women are mainly in charge of fuel choice decisions (mostly solid fuels), the decision directly depends on men's willingness to pay for the fuel. Therefore, for women to truly take responsibility for the energy sources adopted by households, especially those that sustain the energy services allocated to them, they should play a significant role in paying for cleaner energy sources. Also, while women were more interested in fuel sources for cooking and water heating, men emphasised fuel sources for energy services such as IT and entertainment and refrigeration. This finding corroborates the findings of Clancy and Mohlakoana (2020), who claim that men and women place different emphases on the energy required for their needs. This study also provides an evidence-based argument to validate the observations of Nwaka, Uma and Ike (2020). They claim that the traditional, gendered chore allocation is associated with household energy consumption patterns. Also, it confirms that mainstreaming gender scholars claim that if any transition should be successful at the household level, women's needs should be at the heart of the debate.

When asked the underlying reason for their fuel choices, most households mentioned financial capabilities as the main driving force for their selection. This finding is similar to the results presented by Aung et el. (2022) in a study conducted in Myanmar. They found that one of the reasons for using traditional fuels was the associated costs, especially those with high initial investments such as LPG gas cylinders and grid connections. However, although 50% of the sampled households revealed that their fuel preference is associated with their financial capabilities, the binary regression analysis showed no direct relationship between income and fuel choice decisions. By comparison, LPG is households' most satisfactory energy fuel, followed by electricity. Conversely, charcoal and wood are the energy sources with a high level of dissatisfaction among the users. This finding calls for a better understanding of the underlying reason for the continued use of charcoal, despite rising awareness of its harm to the environment and climate (Rahut et al., 2016).

b) Energy services

The study analysed the gender role in the households by looking at the average of their energy services allocation. According to Fell (2017) and Sovacool (2011a), the bulk of household energy services are allocated to women, including cooking and washing, which often represent a health hazard when performed with solid fuels (Rosenthal et al., 2018; Smith & Peel, 2010). According to Clancy et al. (2019) and Khalid & Razem (2022), the underlying reason for this pattern is related to the socially constructed perception of women and men within the household's environment. These perceptions often imply allocating time-consuming energy services such as cooking, water heating and cleaning to women, according to Edwina (2018) and Nwaka, Uma and Ike (2020). And in the sampled households, these are often met by utilising fuels such as wood, charcoal, and LPG. Conversely, men are interested in energy services such as IT and internment (Clancy et al., 2019). This study's results also corroborated this, and electricity is the primary energy input for these services. In fact, it was found in the case of the sampled households that the bulk (45%) of energy services were allocated to women, including cooking and washing. Furthermore, men are the gender that is often responsible for ensuring that lighting services function and, to a lesser extent, they are also in charge of IT and entertainment. However, in terms of the latter, 51% of the household said that these services are not necessarily allocated to a particular gender.

This result corroborates the mainstreaming literature on the energy and gender nexus (Banerjee et al., 2012; Cecelski & Matinga, 2014; Clancy et al., 2003, 2007; Oparaocha & Dutta, 2011a). The survey revealed that the energy services that the households need are similar in different areas. The data from the gender and energy services analysis presented in the previous sections revealed that women often cook and wash clothes and dishes. To better understand this pattern, the data was filtered to discover which energy sources are utilised by households to provide those services. The study also aimed to highlight these patterns and relate the gender decision to the fuel households use to provide energy services traditionally allocated to women. The relationship demonstrates that, by and large, women use most of the energy devices. In contrast, the analysis of the gender that pays for energy devices indicates that, like the gender that pays for energy sources, men are also the gender that pays for most energy devices. Women surpass men's role in purchasing energy devices for open fire cooking and electric stoves.

c) Energy devices

The analysis of energy devices shows that women are responsible for choosing and buying most of the energy-intensive devices, such as open fire, electric stoves, LPG stoves and charcoal stoves. In contrast, men pay for most energy devices. Women surpass men in purchasing energy devices for open-fire cooking and electric stoves. The results show clear-cut roles for men and women in the surveyed households, depending on the neighbourhoods. Therefore, it is possible to infer that household energy consumption patterns are profoundly gendered and require a gender-sensitive approach to address issues associated with access to clean energy sources, services and devices.

These results reveal a disconnection between those buying and those benefiting from the energy devices. In fact, this was also the case in the study conducted by Fingleton-Smit (2018) in Kenya. This situation could result from the male-headed dominance of the households, in which men are in charge of deciding how the households spend their income and defining the household's expenditure priorities. Furthermore, Pemana, Aziz and Siong (2015) concluded that men are the leaders in male-headed households even though women are more educated. Regardless of the awareness of the energy-related issues and benefits that could arise from implementing modern energy devices, the household could still be deprived of these modern technologies if the men are not in accordance. This situation is critical, and more dialogue needs to be conveyed in the society, especially in Maputo city, about the need for more balanced decisions among the household members, not only in the fuel choice but mainly on purchasing power. This could be attained by empowering women by voicing their choices and giving them financial autonomy to materialise their choices regarding the energy devices they adopt for their strategic energy needs.

However, the education level of the head of the household represented the primary factor dictating the fuel choice decision. This finding has been reported in several gender and nexus studies (Clancy et al., 2003, 2007; Feenstra & Özerol, 2021; Longe, 2020; Nwaka, Uma & Ike, 2020).

Also, the observations of Cotton et al. (2021) and Van den Broek (2019) link energy transition to households' energy literacy, which can be obtained from their education level. This perspective is in line with Lopes et al. (2021) findings, in which the authors indicated that empowering women through education increases their likelihood of being included in the decision-making on issues that affects their living conditions. Therefore, if women are empowered, they are more likely to adopt modern and clean energy sources. In addition, the location of the household (urban, suburban or peri-urban) influences the fuel choice decision by the surveyed households, which is corroborated by Castán Broto et al. (2020) and Musango et al. (2020). None of the variables was significant for the surveyed households' decision to adopt direct electricity. This finding is no surprise because 99% of the surveyed households have access to electricity. Its adoption is mostly for electrical appliances and covers energy services, often in the men's domain (IT, entertainment and refrigeration).

Although employment status influences household income directly, which is reportedly a vital indicator of the household's willingness to shift its energy sources (Nwaka, Uma & Ike, 2020), the degree to which it influences has had different perspectives in the literature. While Castán Broto, Arthur and Guibrunet (2020) alluded that income did not influence household fuel choices in Mozambique, Malakar (2018) concluded that it had limited influence on the fuel households adopt in rural India. Conversely, a study conducted in rural Vietnam indicated that households' income level influences their willingness to transition from solid to modern fuels (Vahlne, 2017). A similar conclusion was reached by Rahut et al. (2016). These diverse conclusions reveal that understanding how household income affects energy transition requires consistent and location-specific data analysis. This study, therefore, acknowledges that the transition to clean energy sources requires specific energy sources and devices that can support the new requirements, implying the household's ability to absorb the investment.

5.4. Summary

The objective of this chapter was to present and discuss the findings from the survey conducted in Maputo city. Data from 381 households were examined, considering three different variables: urban, suburban and peri-urban. The data was analysed considering gender, energy sources, services, and devices adopted by households. The last dimension was crossing various demographic and socioeconomic boundaries to determine whether they influence the household's decision on fuel choice. The results invalidated the energy ladder theory and validated the fuel-stacking phenomenon. The results show that households use wood, charcoal, LPG and electricity for their energy requirements. The first three are used mainly for cooking, and electricity is the most versatile energy source. Hence, its adoption for cooking is very limited in elite urban households.

The results also show that, surprisingly, the gender of the household head in the surveyed households did not influence their fuel choice decision. Furthermore, household income did not influence the fuel choice decision. The reason could be the inconsistency in the collected data, as some preferred not to give their income. Also, even the responses to this query showed inconsistencies when the study analysed other factors, such as the amount of energy used and their monthly expenditure. Other factors did not influence the households' fuel choices, including the interviewees' age and the activity sector. The factor that influenced households' fuel choices the most was the educational level of the household head, followed by the household size and the type of neighbourhood they resided. The cross-tabulation analysis found an inverted relationship between the gender who decides on the fuel type and who pays for energy sources. While women are more likely to choose wood charcoal and LPG, men have a decisive role in household electricity use. Although men, on average, are responsible for paying for the appliances and energy sources on which the households rely, women mostly pay for the use of wood. The following section presents Chapter 6, which presents the gendered urban energy households' transition pathways.

CHAPTER 6: GENDERED URBAN ENERGY HOUSEHOLDS TRANSITIONS PATHWAYS

6.1. Introduction

This chapter aims to address research objective 3: *to examine pathways to gendered urban energy transition in Mozambique*. This section uses a deductive-inductive approach, informed by the first and second research objectives. This approach was materialised by responding to the third research question of the last research objective. The goal was to respond to *how this study can build the past and present empirical literature to provide new typologies of the pathway forward to address urban developing households persistent dependence on solid fuels*. The first research objective provided the literature review that established arguments for the need for a theoretical framework for developing urban contexts. The second objective provided a location-specific assessment complemented by the findings from the survey and the exploratory interviews. The next section discusses the current energy regime, followed by a section in which the alternative pathways are presented. Lastly, the section presents the risk assessment of the proposed transition pathways.

6.2. Current energy regime in Mozambican urban environments

The survey results reveal that the Mozambican energy system is complex as in other developing countries. Several factors and actors, acting in different dimensions, dictate the current Mozambican energy system. The critical reports by the IEA (2019a, 2019b), the literature review, the interviews and the survey conducted for this study reveal that the Mozambican urban energy sector is highly dependent on biomass, mainly wood and charcoal. The energy services for which Mozambican urban households require energy are primarily cooking and lighting. The energy sources are often composed of a mix of sources. On the one hand, cooking is often done using wood, charcoal, LPG and electricity. On the other hand, lighting is almost exclusively provided via electricity supplied by the Mozambican national electricity utility, which operates as a monopoly, according to Gregory and Sovacool (2019).

While charcoal is the preferred fuel alternative for cooking in urban areas, electricity as a cooking fuel is limited. When adopted, it is confined to elite households. Furthermore, electricity is the primary energy source for other services such as space cooling, water heating, washing, refrigeration and IT and entertainment. The on-grid electricity in Mozambique is centrally generated, and it derives mainly from hydropower produced at the Cahora Bassa Dam, which is located on the Zambezi River. Other small-scale hydropower plants, such as Mavuzi, Chicamba and Corumana, also provide household electricity (Uamusse et al., 2019). Due to a long-term agreement, the electricity generated by the Cahora Bassa Dam is mainly for export (Gregory & Sovacool, 2019). More than 70% of the generated electricity is exported to South Africa (the largest destination), Zimbabwe, and Botswana (Uamusse et al., 2019).

A similar situation was found concerning natural gas. Despite its exploitation at the Pande-Temane gas project, the first stage of the government and the investors' agreement demanded its exclusive exportation to South Africa via pipeline. Only in 2012 did Mozambique gain access to 50% of the gas along the pipeline. However, the final consumers are private companies (Salimo et al., 2020). The local consumption of natural gas is in the form of LPG, the preferable cooking fuel for middle- and high-income households. The energy strategy plan of the Mozambican government is geared towards universal access by 2030, which is the main driver for regime change at the landscape level. The primary source being emphasised is on-grid electrification, and according to the key informants from the strategic energy sector, the strategy is gender blind. So far, no programme has looked directly at gender-differentiated needs or emphasis on the energy services of urban households; instead, they focus on providing access to electricity.

With the recent increase, as of 2021, in electricity prices, LPG has become one of the drivers of continued dependence on solid fuels. Despite growing civil society complaints about the price increase, little action is seen from the government level. This situation is the consequence of the current energy pathways, which are market-led, and the government has weak power or is unwilling to regulate and supervise the market players. Furthermore, this situation raises concerns about the components of the energy trilemma, resulting in the continued dependence on energy sources with low calorific values (Castán Broto et al., 2018). As a coping mechanism, households adopt fuel sources that can be stored and acquired in small portions according to their financial capabilities.

6.3. Household gendered urban energy transition pathways in Mozambique

Energy transition pathways arise through the dynamic interaction of technological and social factors at and between different levels (Foxon et al., 2010:1204). Therefore, the nature of events (Kanger, 2021) arising from the political, social, cultural, and institutional spectrum (Foxon et al., 2010) would result in different reactions at the niche and regime levels (Geels, 2011), thereby determining the typology of the transition pathway of any given energy system. However, as discussed by Lieu, Sorman et al. (2020), and Musango et al. (2020), energy transition requires a gendered lens since the technical and economic aspects *per se* do not fully address the socially embedded nature of energy transition in developing environments. The study combined the role of agency and interaction between institutions, technology, and infrastructure. The proposed gendered energy transition pathways include business-as-usual, differentiated pathways, and a disruptive pathway led by the market, government, and civil society. Figure 6.1 illustrates the proposed pathways, highlighting gender as the central force. The figure depicts how the alternative gendered transitions framework (Lieu, Sorman et al., 2020) relates to the low-carbon transition pathways (Foxon et al., 2010).

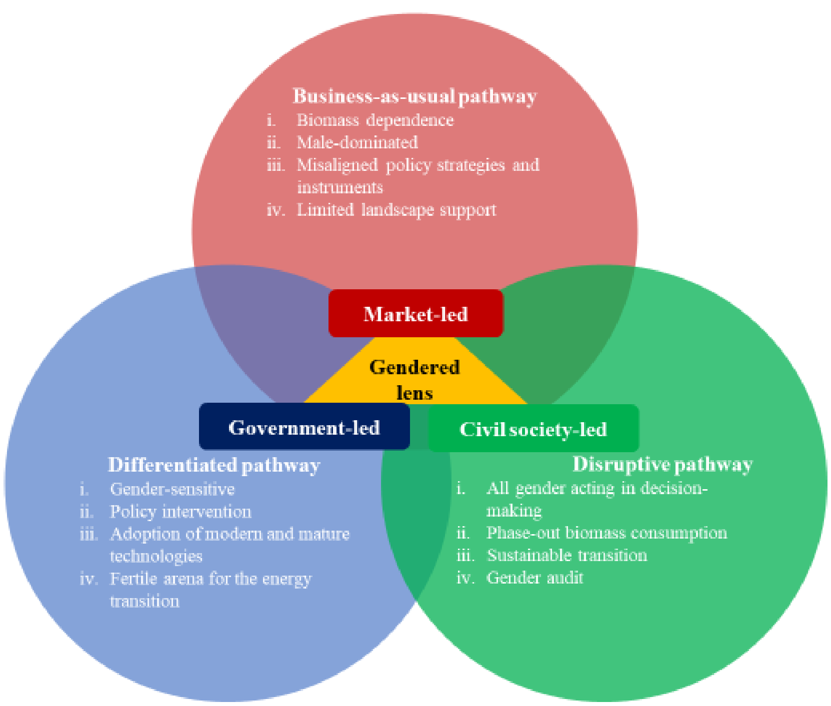


Figure 6.1: Gendered energy transition pathways for Mozambican urban households
Source: Own adaptation based on Foxon (2013) and Lieu, Sorman et al. (2020)

6.3.1. Business-as-usual transition pathway

The business-as-usual transition pathway for Mozambican urban households is based on insights from the on-stream and market-led transition pathways of Lieu, Sorman et al. (2020) and Foxon et al. (2010), respectively. In this pathway, the energy systems evolve with a limited government role (Geels & Schot, 2007). Furthermore, actors at the household level, such as consumers and local communities, do not exert any agency role. The energy system follows path-dependency as energy production and supply chain actors are driven by the profitability of their investments and do not seek alternatives. In this case, the state-owned national electricity utility continues to be the leading energy company. Also, their focus will continue to be on expanding on-grid electrification, which arguably will not resolve the current energy consumption in Mozambican urban households. Because even electrified, urban households still adopt multiple fuels, mainly charcoal, for cooking and water heating. Despite higher lacunae in domestic coverage and consumption, electricity and natural gas will continue to be exported to the neighbouring countries. The following subsections present the elements that constitute this pathway. These elements result from articulating the literature review, the case study and interview data.

a) Biomass dependence

The business-as-usual scenario implies that system transformation's speed and direction follow the current rate (Hughes, Strachan & Gross, 2013; Rikkonen et al., 2021; Silver & Marvin, 2018), and biomass remains a vital energy source in Mozambican households. There is no change in lifestyles and behaviours. Consequently, women will continue to use solid fuels the most, and cooking will still be met via multiple energy sources, mostly charcoal. This situation perpetuates the health-related issues and the disproportional effect solid fuel consumption has on women (Rosenthal et al., 2018; WHO, 2020). In this pathway, actors do not exert any agency role, contradicting De Haan and Rotmans (2018) findings. Furthermore, since the motto remains on-grid electrification, disregarding the essential energy services required by households, clean energy will remain utilised to meet part of the household's energy needs, primarily lighting and IT and entertainment. Therefore, cooking and water heating, energy-intensive services, are met via marginal energy sources such as biomass and charcoal. Also, on this pathway, the additional energy demands arising from urban area expansion are expected to be met via the same household energy mix.

b) Male-dominated

According to the survey results, men ultimately have the decision power to pay for energy sources and devices. These results revealed that the socially constructed perception of the role of men and women in the household sphere dictates the current energy consumption patterns amongst the surveyed households. In this pathway, the decision-making spheres are controlled predominantly by men (Lieu, Sorman, et al., 2020), and policies reinforce the existing regime (Foxon, Hammond & Pearson, 2010; Lieu, Sorman, et al., 2020). Hence, the leading actor at the household level is men. Since they are not affected by biomass-related issues and when the households suffer from energy poverty, they are not as reflexive as required for the regime to change. Instead, the socio-cultural norms contribute to households experiencing path dependence and lock-in inhibiting energy transition. Moreover, there is no differentiated treatment of men and women that emphasises their strategic energy needs.

It was possible to infer that the male-dominance nature of the business-as-usual pathways possesses a significant social risk to women. This risk can be justified by the verified disconnection between the gender who buys devices such as electric stoves and charcoal stoves. The results revealed that in households adopting electric stoves, women were in charge of purchasing the device, whereas men were those buying charcoal stoves. So, men prefer devices supplied by inferior fuels, which represents a risk to women's health when in charge. This perception is primarily influenced by the gender of the household heads, who are responsible for deciding the household's affairs, including their energy sources, services, and devices. Therefore, the negative implication solid fuel consumption has on women, including but not limited to health-related issues and the impossibility of actively participating in productive activities is reproduced.

c) Misaligned policy strategies and instruments

The interviews with the key energy players in the Mozambican energy sector revealed that institutional structuring is still underdeveloped, especially concerning gendered informed energy policy approaches. This situation contradicts the transition management theory framing, which calls for harmonized yet integrative institutional and financial management system. Also, the work from Sovacool and Gregory (2019) implies that the Mozambican government lacks financial robustness to accommodate the necessary improvement in the energy sector value chain. Furthermore, the survey results also validate the lack of adoption of renewable energy sources, such as solar energy and its respective energy devices. Despite their proven benefits to the climate and environment, they are yet to be implemented by the sampled households. This situation could be related not just to energy literacy and awareness (Sayadi & Calatrava-Requena, 2008; Van Den Broek, 2019) but primarily to the lack of policy instruments, as per the insights from the exploratory interviews.

Adopting a policy mix, which encompasses strategies and instrument mix (Edmondson, Kern & Rogge, 2019), is pivotal to shielding niche innovations. Within the socio-technical transition approach, the strategies of the system's actors are fundamental to creating favourable conditions that stimulate change in the energy system (Geels & Schot, 2007; Edmondson, Kern & Rogge, 2019). In the Mozambican case, as the country is a signatory of the United Nations' sustainable development goals, it makes the country legally bound to the agenda of universal access by 2030. However, the current trend puts this goal at risk (Salazar, Castán Broto & Kevin, 2017), and the lack of policy instruments enforces this risk (Maria de Fatima & Cockerill, 2019). The current energy strategies primarily depend on large international companies to mobilise resources and fund the necessary investment to exploit and distribute energy in the economy (Gregory & Sovacool, 2019). The government will still be challenged to provide an energy strategy that values domestic consumption targets and a balanced rate of domestic consumption vs exportation of electricity, natural gas and other energy sources. So, this disconnect is expected to continue in this pathway, and the transition rate will likely not happen within the desired timeline.

d) Limited landscape support

As alluded to in Figure *2.4*, which demonstrates the framework for gendered energy transition, the Mozambican landscape factor includes the SDGs, most precisely SDG 7. The landscape factors are motivated by societal concerns (access to clean energy) and environmental problems (climate change and forestry degradation), which according to Geels (2002), do not change easily. Building on that, and the essence of the multi-level perspective, if there is development in the landscape, it can pressure both regime and niche innovation (Markard & Truffer, 2008) to change the incumbent regime (Köhler et al., 2019). However, the business-as-usual pathway landscape has limited power to pressure niche or regime, and the system experience '*regular change*' (Geels & Schot, 2007). Although Mozambique is the signatories of the SDGs, the government leadership and power to absorb the landscape development is very limited and results in the weak institutional structuring and implementation of strategies.

As indicated, in the business-as-usual pathway landscape, support for the niche is negligible (Barnacle et al., 2013). Hence, niches do not mature enough to dethrone the incumbent regime (Lieu, Sorman, et al., 2020). Because the government sets the policies and strategies for the energy system for the market players to implement, the latter is not part of the policymaking decision that often tends to fall short and continues perpetuating the distance between policy and implementation (Clancy & Mohlakoana, 2020). Due to the minimal government intervention in the energy system and the lack of end users' support in incentives or subsidies, acceptance of the new energy carriers, technologies, and devices for households' energy services is nearly inexistent. Only high-income families (to a large extent) and mid-income families (to a lesser degree) are willing to make any changes of their own accord. Hence, the government's lack of intervention allows the investment cost to be transferred to end users (Foxon, 2013). There is also a continuation of a centralised energy system, where the state-owned companies manage the distribution of on-grid electricity (Gregory & Sovacool, 2019).

6.3.2. Differentiated transition pathway

The second transition pathway is the differentiated pathway. It is inspired by the off-stream pathway of Lieu, Sorman et al. (2020) and the government-led transition pathway of Foxon et al. (2010). The core difference between this pathway and the previous one is that the government is deeply involved in coordinating the energy system's functionalities (Foxon, Hammond & Pearson, 2010) and is gender-sensitive (Lieu, Sorman, et al., 2020). In this pathway, government intervention is not just limited to policy design and planning. Even more, the government acts as an entity with an agency, intending to change the current energy system. These actions are not just motivated by the need to attain sustainable development goals by 2030 but mainly to fulfil their mandate to address energy poverty meaningfully. Furthermore, in this pathway, the government cooperates with international donors, non-governmental organisations, local communities, and energy companies to design action plans to address the issues related to biomass dependence. Also, the strategies are aligned to end-uses needs and address gendered-related energy issues. So, the actors cooperate to address institutional, technological and unfractured barriers that hinder energy transitions at the household level. The following sub-sections present the features that encompass the differentiated transition pathway.

a) Gender-sensitive

The study results indicated that the current energy regime in the urban households in Mozambique is profoundly gendered and that the institutional structures are not as developed as needed and do not adequately address access to clean modern energy at the household dimensions. In fact, the current regime is not gendered sensitive. With that comes several issues already discussed. The gender and energy nexus scholars have produced sufficient evidence of the need for the gender-sensitive energy transition in the developing world, looking at the context-specific. In this view, building upon the leading school of the energy transition and the modified energy transition, this study defends the need for the intended directionality of the energy transition. This directionality addresses gendered energy-related issues, with landscape development perceived and translated by actors to exert the necessary change. The government agency's role manifested in its capability to mobilise and provide financial resources to invest in infrastructure and development. Further, they also fund supporting schemas at the household level, including but not limited to subsidies and incentives.

Due to government leadership, the policies are designed to promote modern, clean and sustainable technologies through niche support. However, they are also intended to reflect the differentiated emphasis women and men place on the household's energy needs and services (Clancy et al., 2019). Musango et al. (2020) indicated that addressing modern and clean energy access in sub-Saharan Africa is gendered, calling for mainstreaming gender in energy policy planning (Clancy & Mohlakoana, 2020). Hence, gender perspective remains scarce in developing countries (Feenstra & Özerol, 2021). In these environments, the inner households' social interactions dismiss women's needs and perpetuate women's and men's unbalanced opportunities (Blackden & Wodon, 2006; Gerber & Muhoza, 2019; Hwangbo, Park & Lee, 2019; Johnson, Mechlenborg & Gram-Hanssen, 2020; Nastasia, Nastasia & Kartoshkina, 2009; Rakow, 1988). In Mozambique, there is room for designing energy policies that capture the country's energy mix, especially one that emphasises the use of LPG amongst urban households. In this pathway, the government is called upon to introduce mainstream gender into the national energy policy by acknowledging that women's emphasis on the household's energy strategic needs differs from men's. In fact, the results indicated that women often use inferior and detrimental fuels. So, mainstreaming gender into the Mozambican energy policy implies a gender-sensitive approach informed by a location-specific assessment of energy consumption at the household level and set energy transition targets and roadmaps for universal access by 2030.

b) Policy intervention

As Usmani et al. (2017) concluded, households respond positively to policy interventions such as government economic incentives. This was the case in Brazil, where government regulations and subsidies increased LPG adoption by households (Coelho et al., 2018). The abundance of natural gas resources offers a leverage point for regime change in the Mozambican case. According to Table 2.1, energy transition scholars have advocated the government role, considering the region (developed and developing countries) or the typology of transition (low carbon transition, renewable energy transition, and modern energy transition). This makes the government's role pivotal for any transition to occur. The government have been the core-centric approach to the transition management framework (Frantzeskaki, Loorbach & Meadowcroft, 2012), accompanied by proper niche management (Schot & Geels, 2008; Witkamp, Raven & Royakkers, 2011). In a developing world, this is fundamental due to several social imbalances and the poverty of most of the population.

The interview results and case study indicated a lack of government leadership in the current energy system at the household level. In Mozambique, the government is expected to design policies that have multifaceted effects on niches or regime actors. Therefore, the magnitude and targeted actors can potentially produce multiple effects in changing the sociotechnical regime

(Edmondson, Kern & Rogge, 2019). In Mozambique, the government is expected to design gender-sound policies that influence the current energy production value chain by valuing clean and sustainable ones. Also, the policy mix must align with the socio-cultural context and positively influence investment decisions targeting gender-related issues. For instance, with the proper instrument, it is possible to address market failure, such as the increase in electricity and LPG price verified in Mozambique since 2021. In combination with this approach, in this pathway, the government is expected to provide balanced net exportation of energy sources to the neighbouring countries and provide domestic consumption thresholds.

c) Adoption of modern and mature technologies

The survey revealed that households depend heavily on traditional energy sources (wood and charcoal) and technologies (open fire and charcoal stoves). There are also other (marginal) households adopting modern and clean energy for the same purpose that those are adopted. Therefore, there is room for opportunity through learning processes and shared visions within the regime for phasing-out these traditional artefacts. Furthermore, unlike the business-as-usual pathway, the government dedicates special attention to protecting and supporting niche innovation to change the incumbent regime. In this regard, Geels and Schot's (2007) landscape support comprises a protective approach in which the new technologies are subsidised and incentivised through special programmes. In Mozambique, this could also imply adopting mature technologies from other developed regimes, which at the household level implies the adoption of LPG. Although LPG is already part of the current energy matrix, its adoption is limited to affluent households. Considering aspects such as affordability (Castán Broto, Arthur & Guibrunet, 2020) and stigma (Mohlakoana & Annecke, 2009) are addressed via incentives, awareness, and energy literacy, its adoption could increase and potentially phasing-out solid fuels.

d) Fertile arena for the energy transition

Since government leadership is the core-centric feature in this pathway, there is a need for a robust institutional structure. These structures include laws, rules, and regulations (Edmondson, Kern & Rogge, 2019), which should act to change the solid fuel dependence regime at the household level. For instance, Allen's (2012) study posits a direct relationship between people willing to adopt new technology and price incentives. Also, Karimu et al. (2016) add that socioeconomic and demographic factors represent the households' fuel choice drivers. Affluent families are prone to adopt modern and clean energy sources and devices. Likewise, well-off households adopt clean energy sources and devices in Mozambique. So, it is fair to infer that it is possible to change the existing regime with supporting schemas that engage market players in meeting households' needs. In this regard, with a proper supporting scheme arising from implementing a gender-sound policy mix, this pathway provides a fertile arena for the energy transition. Hence, valuing the central coordination nature of this pathway.

6.3.3. Disruptive transition pathway

The disruptive transition pathway favours a bottom-up approach, under which civil society leads the transition pathway (2010). This pathway is built upon the insights from the transformative pathway (Lieu, Sorman, et al., 2020) and the civil society-led transition pathways (2010). The disruptive pathway infers a complete and abrupt paradigm shift. However, this study values the cautions of Winskel (2012) and Geels (2018), indicating that change in the energy system does not only come from a disruptive innovation arising from niche innovation. Instead, it results from sequential and gradual performance improvement within the system can also result in the transformation of the energy system. In this pathway, actors are driven by the need to have a socially just society where the needs of all societal groups, especially those related to women's needs, are adequately addressed. Therefore, the civil society, the leading actor, is well organised, energy literate and aware of the issues that biomass consumption causes to the health and well-being of women.

In this regard, all actors mentioned in the previous pathways are aligned and have agency roles, thereby acting towards the transformation of the current energy system. From the policy standpoint, this pathway requires the policy mix to be developed enough in ways that the government role is fulfilled and society experience high levels of democracy and freedom of speech. Consequently, society possesses and exercises its rights, such as the ability to protest and join forces with meaningful local, national and international organisations compromised with sustainable development goals. In this regard, civil society pressures the actors (market operators, consumers, niche and government entities) acting or influencing the energy production and supply chain to seek innovative ideas and provide new and modern technological solutions to enable the energy transition. The following sub-sections present how this pathway is envisioned regarding the key aspects that corroborated its manifestation in Mozambique.

a) All gender acting in decision-making

The survey revealed that women and men have different yet complementary household roles. Additionally, the binary regression analysis showed that the gender of the households did not influence the household's energy sources. However, when looking at especially roles, men ultimately decide because of the purchasing power compared to women. It was found that while women decide about the energy sources and use them the most, men are those paying for them. So, this imbalance is, to some extent, responsible for the current energy consumption pattern. Therefore, if women had the power to buy energy sources for their needs, the situation could be different, as was the case of female-headed households. This power can be attained in myriad ways, including women empowerment, by increasing their education, land ownership, employment, and income generation.

It should be noted that historically, women's roles in society have been marginalised, and their participation in decision-making in all social spheres has been minimal. However, as society evolves and becomes globalised, women have been claiming their inclusion in decision-making and contributing to socioeconomic development. Recently, the discussion has made unprecedented progress, and women empowerment and gender equality have been part of global social debates (Danielsen, 2012; Łapniewska, 2019). Nonetheless, there is a long way to go to achieve the desired improvement, as several deep-rooted sociocultural and behavioural variables hinder this progress, especially in the developing world.

Accelerating regime change through disruptive technological innovation has been discussed in developed (Geels, 2018; Kanger, 2021; Kivimaa & Kern, 2016; Winskel, 2012) and developing contexts (Muza & Debnath, 2020). Therefore, gendered technological innovations are called upon under this pathway. This study argues that these innovations are expected to be easily adopted as consumers are well informed and aware of their advantages. The energy system co-evolves to reach the desired energy transition to enable this acceptance. Moreover, in the Mozambican case, this implies that the market operators provide clean energy sources (electricity and LPG) and technologies (cooking stoves, LPG gas cylinders, and water heating devices) that are accessible, convenient and affordable. These market mechanisms are possible because the government also places proper support on policy design and supporting schemas as well as maintains a dialogue with all relevant stokeholds to monitor and evaluate the progress.

Like many other developing countries, in Mozambique, women and men have different yet complementary household roles. Hence, in Mozambique, women often perform unpaid activities and mainly work in the agricultural sector, though primarily rudimentary (INE, 2021). Also, when looking at specific roles, men ultimately decide on the household affairs, placing them as the household heads. So, this imbalance is, to some extent, responsible for the current energy consumption pattern. Therefore, if women had the power to buy energy sources for their strategic needs, the situation could be different. In Mozambique, this power can be attained in myriad ways, including education, employment, and involvement with activities that generate income. Considering that women's empowerment increases their probability of participating in decision-making, it could work as a vector that allows them to decide about fuel choice and actively advocate the energy transition's advantages.

It should be noted that gender equality is one of the agendas of the United Nations, which possesses a crosscutting feature as it manifests in all societal spheres. Within the household arena, several researchers have focused their work on addressing the gender and energy nexus (Clancy et al., 2007; Feenstra & Özerol, 2021; Khalid & Razem, 2022; Musango et al., 2020). Since civil society leads this pathway, they are expected to be sufficiently organised and aware of the social imbalances caused by gender inequality and pressure government and market actors to change the energy system. Moreover, due to its bottom-up approach, government and market intervention are expected to be aligned to promote the gendered energy transition by assessing end users' needs. Therefore, integrating women's and men's perspectives in the energy transition (Lieu, Sorman, et al., 2020).

b) Phase-out biomass consumption

For this pathway to occur, a '*specific shock*' influences the landscape to exert substantial pressure on the regime (Geels & Schot, 2007; Kanger, 2021). However, two perspectives assist disruptive innovation. The first is that disruptive innovation arises from mature technology that is clean and modern and has been implemented in other developed regimes. This approach would contribute to addressing the perception of sociotechnical transition having to take several decades (Geels, 2019), thereby accelerating modern energy uptake (Gorissen et al., 2018) or even leapfrogging to the sustainable system (Batinge, Musango & Brent, 2019). The second includes disruptive innovation within the existing regime, supported by the landscape and community engagement with industry. Since the survey results indicated that solid fuel consumption in Mozambican urban households is gendered and deeply rooted in socioeconomic and cultural aspects, phasing-out its consumption would require high pressure from the landscape on the regime and niche levels. This could be through implementing a feedback mechanism (Edmondson, Kern & Rogge, 2019) in which civil society actors actively influence policymaking to create a reflexive policy in constant realignment (Geels & Schot, 2007).

It is important to note that landscape development does not automatically induce change at regime and niche levels due to its intrinsically slow change characteristic. Therefore, it is pivotal that actors from different levels, especially decision makers at the government level and the end users at the household level, understand these developments and act (also interact) to implement meaningful influence on the socially unfair regime. So, this requires viewing consumers as active actors. In this perspective, consumers' activeness could manifest not just in inducing a change in the energy system but mostly in changing their behaviours and routines enabled by their energy awareness and literacy. Moreover, within the households, these actors (consumers) can adopt modern energy sources and technologies, and at their prime, informed citizens are willing to use efficient technologies.

c) Sustainable transition

Regime change occurs because of innovative approaches from local government and civil society to disrupt the incumbent regime (Foxon, Hammond & Pearson, 2010; Lieu, Sorman, et al., 2020). The study argues that the market, the government and the civil society in the developing world have a fertile yet challenging arena to introduce the issues relating to universal access to clean, modern and sustainable energy systems at the household level. Considering that the civil society is aware of the sustainable goals and is also energy literate, they possess a significant role in influencing government and civil society to embargo towards sustainable transition in Mozambique. However, there is a need for learning from other successful regimes and developing technologies through the support of niche innovation and infrastructural development to ensure modern energy sources and technologies' affordability, convenience, and reliability. And in the Mozambican case, the issue of affordability arguably hinders energy transition (Castán Broto et al., 2018; Mahumane & Mulder, 2022)

d) Gender audit

Disrupting the existing regime requires designing policies that explicitly look at the gender issues arising from a lack of modern and clean energy at the household level. These policies need to collaborate with market operators and civil society to include all stakeholders. Hence, there is a need for the government to introduce strategies and instruments that are aligned with women's needs and introduce an audit mechanism, as suggested by Clancy and Mohlakoana (2020), to monitor and evaluate the results.

6.4. Risk assessment of the gendered energy transition pathways

This section completes the response started in Chapter 2, subsection 2.7.4, regarding the question: *what are the key risks for implementing gendered energy transition in urban developing environment*? This section provides the risk assessment of the energy transition pathways, informed by the survey results. Amongst the potential risks, social risks are substantially gendered. This can be observed in the business-as-usual pathway where there are continued gender asymmetries, health issues and premature death due to indoor air pollution, exposing women and children to these risks. Potential financial losses also arise from implementing the other two pathways (differentiated and disruptive). This risk is eminent for women because they often operate in the solid fuels value chain. In the event of a transition to modern energy fuels, there is the risk of losing this source of income and reducing their financial autonomy.

In the Maputo case, it is pivotal to address this risk adequately, especially in female-headed households. The loss of income could impede these households from transitioning to not just modern energy but also modern technologies due to their diminished financial capabilities. Furthermore, in the case of energy services, such as I.T and entertainment, which are mele-oriented, no significant risks are expected in either of the pathways. This low risk is because households are often powered by electricity which has a nearly 99% coverage rate in the surveyed households. Overall, most of the social risks are expected to significantly impact women, not just adverse (business-as-usual pathway) but also positive (in both differentiated and disruptive pathways). However, with a proper strategy, they can be addressed accordingly. The relative risks and their degree of influence on each transition pathway are summarised in Table *6.1*. It should be noted that most of the elements representing potential implementation exist in all transition pathways. However, the study differentiates them according to the likelihood of occurrence in each theme.

Table 6.1: Key risks for the gendered energy transition pathways in Mozambican urban environments

Contextual factors/transition pathway	Business-as-usual pathway	Differentiated pathway	Disruptive pathway
Environmental	1. Continued deforestation 2. Land-use change 3. Loss of biodiversity 4. Carbon release due to deforestation and land-use change	1. Deforestation due to biomass production for urban areas 2. Land-use change 3. Loss of biodiversity 4. Carbon release due to deforestation and land-use change	1. Increased carbon dioxide emissions due to the adoption of LPG as cooking fuel 2. Increased consumption of fossil fuels 3. Outdoor air pollution
Social	1. Continued gender asymmetries 2. Indoor air pollution health-related issues affecting women and children 3. Increased mortality due to smoke exposure from biomass combustion	1. Loss of financial autonomy of women operating in the biomass value chain 2. Income loss in families operating in the biomass value chain 3. Increasing energy security asymmetries between affluent and vulnerable households	1. Depreciation of social welfare due to the high cost of modern and clean energy carriers 2. Reduced energy services due to the high price of the domestic appliances compatible with the energy carriers 3. Income loss in families operating in the biomass value chain
Economic	1. Leaving out women's contribution to socioeconomic development 2. Decreased rural income 3. Increased energy poverty in rural families and vulnerable families in urban areas 4. COVID-19 forces change in the government's energy investment priorities	1. Priorities shifting due to adverse impact of COVID-19 2. Job losses in wood and charcoal production 3. Lack of funding to invest in new energy technologies, such as gas cylinders as well as ovens, in the case of LPG adoption for cooking	1. Investment costs of the infrastructural development 2. Uncertainties for investors 3. Increased needs for funding mechanisms 4. Lack of skills for new job requirements 5. Job losses in wood and charcoal production 6. Lack of funding to invest in the new energy technologies
Policy	1. Weak energy policy and regulatory framework 2. Lack of coordination between policymakers and implementors 3. Lack of planning and coordinated action amongst the energy actors	1. Lack of coordination between policymakers and implementors 2. Lack of planning and coordinated action amongst the energy actors	1. Mismatch between goals of international energy players and national goals 2. Lack of coordination between policymakers and implementors 3. Lack of planning and coordinated action amongst the energy actors
Technological	1. Technical capabilities 2. Technological awareness 3. Infrastructural development 4. Underdeveloped industrial sector	1. Technical capabilities 2. Technological awareness 3. Infrastructural development 4. Underdeveloped industrial sector	1. Lack of technological infrastructure for distribution 2. Lack of innovative energy devices for household usage 3. Investment cost of modern and clean household appliances

6.5. Summary

This chapter discussed the last research objective, which was *to examine pathways to gendered urban energy transition in Mozambique*. Therefore, the study combined data from the literature review, the interviews and the survey. At first, the study presents the Mozambican energy regime to suggest the proper transition pathways. Then three pathways were suggested, business-as-usual, differentiate and disruptive. All of them are informed by a gender perspective. The study uses this analysis to inform all energy systems stakeholders, especially policymakers, international donors and civil society, about the possible course to change the current energy system at the household level. Finally, the chapter presented the risk assessment of the suggested pathways. The risk assessment was discussed considering environmental, social, economic, policy and technological factors. Next, the study presents the conclusion and recommendation chapter.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1. Introduction

This chapter presents the conclusions and recommendations of the study by summarising its main contribution and the key research findings concerning the research objectives and questions. The chapter also highlights the limitations of the study, followed by the application of the empirical contributions of the study, and makes suggestions for future research.

Access to modern and clean energy is still lacking in urban developing countries, especially in sub-Saharan Africa. This study aimed to investigate the role of gender in the energy transition in urban households in Mozambique. This study argues that energy transition is a fundamental key to increasing access to modern and clean energy in urban developing environments. Energy transition plays a vital role in improving the livelihoods of households and prompts universal access to modern and clean energy sources by 2030 in Mozambique. The results indicated that men and women have clear-cut roles regarding fuel choices in urban households in developing countries. However, mainstream energy transition scholars have discussed transition frameworks by looking at contexts where access to modern energy sources is no longer the subject of debate.

This study found this to be a significant gap because it is crucial to understand the local energy situation in developing countries. Also, there is a need to introduce mainstream gender into the debate since it is in developing countries such as Mozambique that the lack of access to clean energy disproportionately affects women. Hence, this study argues the need for developing a gendered theoretical framework and pathways for the energy transition to address the persistent dependence on solid fuels in urban households in Mozambican. The assessment valued a contextual and location-specific analysis of the driving forces and identified the leverage points to transform the current energy system.

7.2. Summary of contributions

The contribution of this study can be summarised in terms of two different aspects, the theoretical and empirical, which are detailed in the following sub-sections.

7.2.1. *Theoretical contribution*

Scholars from several disciplines have investigated and developed theories for the energy transition. Hence, their emphasis has been on developed countries, where climate change and resource depletion issues drive energy transition debates. This study contributes to the limited literature on gendered energy transition in urban developing environments. For that, the study focused on understanding the local context to establish a proper energy transition framework, which involves technological innovations, transition management, socio-political aspects, and economic and market readiness to determine how this transition is perceived and implemented at a household level. Therefore, the study developed a novel gendered theoretical framework to address biomass dependence in urban developing households. The model incorporates the existence of traditional technologies, lessons from existing regimes, gendered innovation, low-carbon energy transition, and the role of policy.

The proposed framework highlighted the need for a multidimensional approach that focuses on gender to reduce the asymmetries between women and men interacting with the fuel sources they rely on. These asymmetries are observed in the typology of fuels adopted by the household members, where women often utilise inferior fuels, which harm their health and well-being. While women are more interested and affected by energy use for cooking and water heating, men are intensely interested in energy for IT and entertainment, and lighting. Since cooking is mostly met using solid fuels such as wood and charcoal and IT and entertainment and lighting via direct electricity, solid fuel consumption's negative implications primarily affect women. These differences in the emphasis that men and women have on their strategic energy needs arise from the socially constructed perception of what it means to be women and men within the households, their beliefs, values and cultural factors. These perceptions and socio-cultural values result in a disproportional allocation of household chores, where women are primarily responsible for cooking and cleaning. The goal of the proposed framework is to fulfil the objectives of Sustainable Energy for All and simultaneously promote gender equality by securing the energy services that urban households require. The application of the proposed theoretical framework may vary according to the local context. However, there is a global agenda to eradicate premature deaths caused by respiratory ailments due to exposure to indoor air pollution resulting from the use of traditional biomass. The study contributed to the body of knowledge on gendered energy transition at a household level by addressing gender issues in the energy transition process.

7.2.2. Empirical contribution

Energy transitions can occur in different sectors of the economy. Due to its relevance in the global, national and local energy balances, this study focused on the urban household level in Mozambique. The focus on the urban household level was critical because traditional biomass is hazardous to households and contributes to deforestation and forest degradation in the country. The study suggests pathways for the gendered energy transition in urban households in Mozambique, guided by an evidence-based approach that assesses gender roles and factors that drive fuel choice decisions. The evidence-based approach informed the transition pathways to phase out solid fuels from Mozambican urban households. This study proposed gendered transition pathways that include business-as-usual, differentiated, and disruptive pathways, which are led by the market, government, and civil society, respectively. Hence, despite the leadership of the indicated energy system actors, they are all informed by mainstreaming gender and are part of each identified pathway. However, their level of intervention differs accordingly. The proposed gendered transition pathways could contribute to sustainable development goals. Firstly is increasing access to modern and clean energy sources. Secondly, it contributes to reducing gender inequality. Lastly, it could benefit from eradicating premature deaths caused by respiratory ailments due to exposure to indoor household air pollution resulting from conventional biomass.

This study demonstrates a lack of literature addressing the energy and gender nexus in developing urban households. The study used a systematic integrative literature review complemented by exploratory interviews, a critical literature review and a survey to provide a contextual and location-specific assessment of energy consumption patterns in urban households in Mozambique. This approach made it possible to verify that energy transition in urban developing environments in the country is deeply gendered. With the survey, the study provided an evidence-based argument for the need for gendered energy transition approaches and identified the variables that influence the current energy patterns. This combination of methods complemented one another and made it possible to address the study’s main goal by suggesting how the transition pathways, resulting from a deductive-inductive approach, could be implemented to enable a gendered energy transition in Mozambican urban households. This study developed the risk assessment of the environmental, social, economic, policy and technological factors that could impede the achievement of the proposed pathways. However, the risks at the social dimension can significantly jeopardise energy transition at the household level.

7.3. Key research findings

This study aimed to develop a theoretical and empirical grounding for a gendered energy transition in Mozambican urban households. Therefore, the study had three specific objectives, and the key findings are the following:

7.3.1. To develop a theoretical framework for a gendered energy transition for urban households

The integrative systematic literature review allowed an understanding of the global spectrum of energy transition theory. This assessment revealed that the energy transition theory had received considerable attention worldwide. However, limited research has been done in developing countries, especially in sub-Saharan Africa, where solid fuel consumption has been increasing. Furthermore, there is a lack of literature developed by African researchers. The results also reveal that the energy transition debates are mostly from a multi-level perspective, which focuses on sociotechnical transition, disregarding the policy role. Not only that, but the results also reveal a lack of emphasis on mainstreaming gender in the energy transition debate. In this regard, this study suggests mainstreaming gender in the transition debate. In addition, there is a need to ensure effective implementation of the international instruments that mandate introducing gender-sensitive policies throughout government institutions and include gendered energy policies in energy policy planning and implementation strategies.

7.3.2. To assess gendered energy profiles and energy services in urban households in Mozambique

The second research objective aimed to provide a contextual and location-specific assessment of Mozambican urban households' energy consumption. This process required an analysis and description of households' energy services, how they meet their energy needs, the available energy sources, how the fuel choice is made, and the gender roles. This was performed through a retroductive analysis of the data obtained from the critical literature review, the exploratory interview and the case study conducted in Maputo city. The investigation revealed that Mozambique is one of the poorest countries in the world. The existing energy regime at the household level is mixed, encompassing traditional energy sources, fossil fuels and renewable sources (hydropower). Electrification rates are low, and only 29% of the population has access to electricity, with the majority living in urban areas. Solid fuel consumption represented 66% of the country's total final energy consumption. The case study involved interviewing informants from key energy sectors and surveying 381 households to understand better how the socially constructed perception of gender influences households' energy patterns and the role of women and men in the current energy regime.

The survey results confirm the mainstreaming gender scholars' view that the current household energy consumption patterns are profoundly gendered and that the families are male-headed. It was confirmed that families use multiple fuels for their energy needs, including wood, charcoal, LPG and electricity. The results also invalidated the energy ladder theory and validated the fuel-stacking phenomenon. The crosstabulation analysis revealed that, while electricity is the most versatile energy source and is mainly used to feed households' electrical appliances, cooking is the most versatile energy service, achieved with multiple fuels. However, charcoal was the preferred fuel source for cooking in the surveyed households. Women decide on household energy fuels, use them the most, and are in charge of delivering the bulk of the household's energy services. There is an inverted gender role when analysing the gender responsible for paying for fuel. As the fuel gets dirt, women pay for it, while the cleaner energy sources become, the more men are responsible for paying for the fuel. The study complemented the crosstabulation data analysis technique with the binary logistic regression to understand which variables influence the current fuel choice decisions in the sampled households. The results indicate that the gender of the household head did not influence fuel choice decisions. This finding contradicts a large body of studies, which reported that the gender of the household head influences their fuel choice decision. However, it is essential to note that the role of the gender of the household head in the fuel choice decision was reported mainly in rural households. Furthermore, the results also revealed that the education level of the household head was the most influential variable in their fuel choices, meaning that the higher the educational level of the household head, the cleaner the energy sources they adopted.

7.3.3. To examine pathways to gendered urban energy transitions in Mozambique at the household level

The last objective of this study was to identify the transition pathways that could enable the country to attain the desired transition from its dependence on solid fuels to modern, clean and sustainable energy sources. This objective was addressed through a deductive-inductive approach which enabled designing transition pathways informed by the literature review, the exploratory interviews and the survey results. The study developed transition pathways considering a common goal among the energy system actors, ranging from decision-makers at the policy design level to industry, market players, and civil society. In the transition from the current, undesired scenario, this study proposes a gendered energy transition pathway for urban households that focuses on the local context to enable successful and consistent adherence to modern energy sources and technologies.

Traditional energy consumption is still significant in Mozambican urban households, despite the availability of and access to clean and modern energy sources. Several aspects concur with this feature. They include lack of infrastructure, absorptive capacity, government priorities (Iizuka, 2015), technological development (Lieu, Sorman et al., 2020), awareness of the issues relating to current energy consumption patterns (Musango et al., 2020) and lack of energy literacy (Cotton et al., 2021; Rosenthal et al., 2018; Van Den Broek, 2019). These factors impede the attainment of universal access. The degree to which the existing regimes can be disrupted depends highly on a gendered energy transition policy and regulatory support capacity. Also, there is a need to invest in the required technological infrastructure and the scale of capital turnover.

7.4. Limitations and assumptions of the study

Despite the contribution of this study, it also had some limitations, which are discussed below.

a) The proposed theoretical framework faces limitations, especially in addressing the well-documented fuel-stacking situation because even when households adopt new and clean energy technologies, they still utilise traditional fuels. Some cases are linked to the need to increase their energy security and cultural values.

b) Since government and policy support are the core of support for energy transition, the system may face failures and divergencies when political agendas differ from social ones.
c) The study used the city of Maputo as a sample, which differs substantially from other urban areas across the country.
d) The data collection process occurred during the COVID-19 pandemic, and several households reported being affected by it negatively. This potentially also affected their fuel choices due to reported job losses.
e) Applying the gendered energy transition pathways may result in social issues caused by job losses in households operating in the solid fuels supply chain. Therefore, without a strategic plan for their social inclusion, it may slow the transition pace, and regime change will not occur as desired.

It is important to note that this research was conducted during the global pandemic caused by COVID-19. Its effects are yet to be analysed comprehensively in the national and international spheres. Furthermore, in Mozambique, there is also the situation of insurgents attacking the North of the country. These phenomena challenge the government and civil society to re-adjust their energy transition agendas. In light of this, this study introduces a body of recommendations in the following section. These have a greater emphasis on government intervention to set the Mozambican energy sector’s transition towards a resilient, environmentally friendly regime and consider women’s and men’s differentiated energy needs.

7.5. Recommendations of the study

The discussion in this research reveals that regime change in developing countries faces challenging and complex issues, and several variables risk the likelihood of its accomplishment. In Mozambique, where solid fuels dominate the country’s energy system at the household level, the transition should be implemented using a gendered lens by introducing gender mainstreaming as a policy strategy and integrating clean cooking into the national energy policy. From this approach involving government leadership, meaningful progress can reduce household solid fuel consumption and increase the adoption of clean, modern and sustainable energy carriers. Regime change is challenging, takes time and requires effort by all energy stakeholders. In the Mozambican case, the challenges are exacerbated not only because of the country’s economic situation but also because it lacks sound gender strategies in the energy sector. However, despite these challenges, there is a need to accelerate the transition pace by learning and adopting available mature and clean energy sources technologies. The investigation of the literature, the case study and the information provided in the interviews with the informants from the critical energy sectors allowed recommendations to be made, considering the three main groups involved in the design of the transition pathway, namely government, market, and civil society. The recommendations, therefore, focus on these stakeholders.

7.5.1. Government

a) One of the key variables that affected households' fuel choice decisions in the sampled households was the level of education of the household heads. Since education is a role of the government, this study calls for more significant intervention by the government to ensure the education of its citizens.
b) The government needs to take the lead in implementing transition pathways in urban environments in Mozambique.
c) The current energy strategy is gender blind and excludes energy issues that affect women and children. Hence gender-sensitive rules and regulations are required.
d) There is a need to align the existing policies on gender equality with strategies and implementation plans to address gendered issues.
e) There is a need to design strategies to increase the uptake of modern energy sources, especially regarding fuel availability. The Mozambican government could intervene with price incentives or subsidies.
f) There is an urgent need to mobilise resources to broaden the existing infrastructure according to the typology of energy resources.
g) There is a need to restore social justice by deploying modern energy and technologies that are accessible to all Mozambicans.
h) There is a need to introduce clean cooking into the national energy policy and strategies.

7.5.2. Market

a) Niche innovations can only occur if market players are aligned with the government and civil society needs. Therefore, markets are pivotal for a technological breakthrough, which can be accomplished through constant research and development.

b) Markets need to be aware of the issues women face in their day-to-day energy services and provide solutions that could reduce the burden and time-consuming household chores often allocated to women.

c) The Mozambican market operators have an additional challenge to reduce dependence on external supplies of technologies and devices that households need for their energy services.

7.5.3. Civil society

a) Civil society organisations are called to promote activities to increase awareness of the issues related to the use of solid fuels and the benefits of modern energy sources.

b) There is a need to undertake gender audits on the performance of government policies and the funds allocated by international organisations to improve women's access to modern energy sources.

c) Ordinary citizens are encouraged to be aware of the social problems caused by gender asymmetries, actively reduce these inequalities, and support women's empowerment.

7.6. Recommendations for future research

This research brings new venues to light to foster energy transition in urban developing contexts. These contributions are a starting point and require commitment from all key stakeholders in the Mozambican energy sector. Hence, further research is necessary to address areas that were not covered but are fundamental for the required transformation of the Mozambican energy system. The primary contribution of this research was developing a theoretical framework for gendered energy transition and the respective pathways for Mozambican urban developing environments. However, to make sense of the dynamics of the actors to strategically manage niches to promote novelty in developing contexts such as Mozambique, where the economy is services based, requires further location-specific analysis. This may cast light on the potential of niches and the leveraged points to foster the uptake of new developments by urban households.

The study also provides a tool for decision-makers, government, market operators, donors and civil society to design and implement gender-oriented policies, particularly those that influence the household domain and are in line with SDGs 7 and 5. Hence, looking beyond the frameworks, further investigation is necessary to assess the efficacy of the existing gender policy by undertaking a gender audit. This assessment could enrich the study's findings by pinpointing the specific aspects of the legislative and executive government powers that work against or in favour of the desired energy transition.

This study's area of interest was limited to urban environments. However, the climate and health issues documented in this study are supported by several *gender/energy/poverty* nexuses. Rural households are exposed to the same problems, arguably even more severely. A surprising result of the study was the lack of influence of the gender of the household head on the households' fuel choice decisions, which differs from a large body of data concerning factors that influence decisions on fuel choices, although the bulk of these studies referred to rural areas. Therefore, this study suggests that a future researcher could look at which dynamics amongst rural vs urban households give rise to differences in the household head's role in fuel choice decisions.

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9. APPENDICES

Appendix A: Questions for exploratory interviews

Appendix A 1: English version – exploratory interview

Interviewee Name			**Conducted By**		
Interview date		**Interview start time**		**Interview end time**	
Interviewee job position					
Venue					
Description of the interview topic					
These questions are our investigations on gendered energy transition to phase out biomass dependence in urban environments. Please answer the following questions as they apply to you. The responses you provide are confidential and anonymous; also, your right and privacy will be protected.					

Order	**Question**
1	*How do you describe your institution's interactions with the Mozambican energy sector?*
2	*What are the critical responsibilities of your institution in the provision of energy to households?*
3	*Are there any targets set to reach the SDG 7? 'Universal access to modern energy sources by 2030.'*
4	*Can you describe these targets and how are they enforced?*
5	*Are there any targets set to reach the SDG 5, 'gender equality'?*
6	*Can you describe these targets and how are they enforced? – Link them with the provision of modern energy sources.*
7	*Does the government provide a particular budget to ensure the SDG 5 and 7? If yes, can you state your views of the finished results, the challenges, and opportunities?*
8	*Does your institution have any regulatory instruments relating to gender?*
9	*If yes, does it specifically address gender issues that are related to modern energy access?*
10	*How do you describe your performance to attend these goals?*
11	*What is the nature of energy access at the household level?*
12	*Which households are most vulnerable to energy poverty?*
13	*What mix of energy is consumed in these households?*
14	*What influences their choice of energy mix?*
15	*What is the critical energy-intensive service at the household level?*
16	*Are there gender roles associated with household energy service delivery?*
17	*How does your institution envisage energy access from a gender perspective?*
18	*What are the biggest challenges in the Mozambican energy sector, particularly concerning switching from biomass consumption to modern and clean energy sources?*
19	*Are there any targets, supporting schemes or policies regarding phasing out biomass consumption in urban settlements?*
20	*What type of household consumers do these organisations/institutions/initiatives support?*
21	*What are the biggest challenges to improve access to modern and clean energy sources at household level?*
22	*Is the country energy-secure?*
23	*What are the opportunities in the Mozambican energy sector?*
24	*What are the pathways to ensure the transition from biomass dependence to modern energy carriers in urban areas?*
25	*What are you view in general of the gender role to ensure energy transition in the Mozambican Urban settlements?*
26	*Is there anyone else I should talk to?*
27	*May I contact you again if I need more information?*

Appendix A 2: Portuguese version – exploratory interview

Entrevistado			**Conduzido por**		
Data da entrevista		**Hora de Inicio**		**Hora do termino**	
Posicao do Intrevistado					
Local					
Descrição do tópico da entrevista					

Ordem	**Questoes**
1	*Com descreve a interação da sua instituição com o sector energético moçambicano?*
2	*Quais são as responsabilidades crucias da instituição na provisão de energia para os agregados familiares?*
3	*Existe alguma meta em particular para o alcance das metas do desenvolvimento sustentável (SDG 7)? 'acesso universal a fontes modernas de energia até 2030.'*
4	*Pode descrever essa meta e como elas são aplicadas?*
5	*Existe alguma meta em particular para o alcance das metas do desenvolvimento sustentável (SDG 5)? 'igualdade do género'?*
6	*Pode descrever essa meta e como elas são aplicadas? – Ligue com a necessidade de provisão de fontes modernas de energia.*
7	*O Governo estabelece algum financiamento para o alcance do SGG 5 e 7? Se sim, mencione os resultados alcançados, os desafios e as oportunidades?*
8	*A instituição tem algum instrumento regulamentar relacionado com o género?*
9	*Se sim, o instrumento responde especificamente as questões do género relacionadas com o acesso a fonte modernas de energia?*
10	*Como descreve a Vossa prestação em atender a esses objectivos?*
11	*Qual é a natureza do acesso a energia dos agregados familiares?*
12	*Quais são os agregados familiares mais vulneráveis para a pobreza energética?*
13	*Qual é o mix de energia consumido por esses agregados familiares?*
14	*O que influencia a escolha do mix de energia?*
15	*Qual e o serviço critico de uso intensivo de energia a nível dos agregados familiares?*
16	*A entrega dos serviços energéticos estão associados ao papel do género dentro dos agregados familiares?*
17	*Como a instituição prevê o acesso a energia na perspectiva do género?*
18	*Quais são os maiores desafios no sector energético moçambicano, particularmente no que diz respeito a mudança do consumo da biomassa para fontes de energia modernas e limpas?*
19	*Existem metas, mecanismos de apoio para eliminar gradualmente o consumo biomassa nas zonas urbanas?*
20	*Que tipo de agregados familiares essas organizações, instituições, iniciativas apoiam?*
21	*Quais são os principais desafios encontrados para melhorar o acesso a fontes de energia modernas e limpas a nível dos agregados familiares?*
22	*O Pais e seguro em termos de energia?*
23	*Quais são as oportunidades do sector energético moçambicano?*
24	*Quais são os caminhos para garantir a transição da dependência da biomassa para as fontes modernas e limpas de energia?*
25	*Qual a sua análise sobre o papel do género para garantir a transição energética nas zonas urbanas de Moçambique?*
26	*Existe mais alguém com quem devo falar?*
27	*Posso entrar em contacto novamente se precisar de mais informações?*

Appendix B: Detailed sample size

Table B1: Population and sample size per geographical area

Order	Municipal District and Neighbourhoods	Geographical area	Number of households	Sample Size per Neigbouhood and District	Surveyed per Households
	Municipal District of KaMpfumo				
1	Alto Mae A	Urban	1,818	3	3
2	Alto Mae B	Urban	2,366	4	4
3	Central A	Urban	1,997	3	3
4	Central B	Urban	2,364	4	4
5	Central C	Urban	1,754	3	3
6	Coop	Urban	1,233	2	2
7	Malhangalene A	Urban	1,515	2	2
8	Malhangalene B	Urban	2,912	5	5
9	Polana Cimento A	Urban	2,072	3	3
10	Polana Cimento B	Urban	1,688	3	1
11	Sommerschield	Urban	1,738	3	3
Sub-total			**21,457**	**35**	**33**
	Municipal District of Nlhamankulu				
12	Aeroporto A	Sub-urban	2,896	5	5
13	Aeroporto B	Sub-urban	3,485	6	6
14	Chamanculo A	Sub-urban	2,360	4	4
15	Chamanculo B	Sub-urban	2,012	3	3
16	Chamanculo C	Sub-urban	5,130	8	8
17	Chamanculo D	Sub-urban	2,388	4	4
18	Malanga	Sub-urban	2,401	4	4
19	Minkadjuine	Sub-urban	1,476	2	2
20	Unidade 7	Sub-urban	1,664	3	3
21	Xipamanine	Sub-urban	3,217	5	5
22	Munhuana	Sub-urban	1,180	2	2
Sub-total			**28,209**	**46**	**46**
	Municipal District of KaMaxakeni				
23	Mafalala	Sub-urban	3,907	6	6
24	Maxaquene A	Sub-urban	3,900	6	6
24	Maxaquene B	Sub-urban	5,343	9	9
26	Maxaquene C	Sub-urban	3,479	6	6
27	Maxaquene D	Sub-urban	3,904	6	6
28	Polana Canico A	Sub-urban	8,262	13	13
29	Polana Canico B	Sub-urban	8,919	15	15
30	Urbanizacao	Sub-urban	2,960	5	5
Sub-total			**40,674**	**66**	**66**

Order	Municipal District and Neighbourhoods	Geographical area	Number of households	Sample Size per Neigbouhood and District	Surveyed per Households
	Municipal District of KaMavota				
31	Albazine	*Peri-urban*	5,826	9	9
32	Costa do Sol	Sub-urban	7,328	12	12
33	Ferroviario	Sub-urban	10,226	17	17
34	FPLM	Sub-urban	2,192	3	3
35	Hulene-A	Sub-urban	4,904	8	8
36	Hulene-B	Sub-urban	9,603	16	16
37	Mahotas	*Peri*-urban	12,225	20	20
38	Mavalane A	Sub-urban	4,012	7	7
39	Mavalane B	Sub-urban	2,421	4	4
40	3 de Fevereiro	*Peri*-urban	3,548	6	6
41	Laulane	Sub-urban	5,541	9	9
Sub-total			**67,826**	**111**	**111**
	Municipal District of KaMubukwana				
42	Bagamoio	Sub-urban	4,493	7	7
43	George Dimitrov	Sub-urban	8,235	13	13
44	Inhagoia A	Sub-urban	3,117	5	5
45	Inhagoia B	Sub-urban	3,398	6	6
46	Jardim	Sub-urban	2,485	4	4
47	Luis Cabral	Sub-urban	7,580	13	13
48	Magoanine A	Sub-urban	8,739	14	14
49	Malhazine	Sub-urban	1,579	3	3
50	Nsalene	Sub-urban	703	1	1
51	25 de Junho A	Sub-urban	2,600	4	4
52	25 de Junho B	Sub-urban	3,823	6	6
53	Zimpeto	Sub-urban	7,580	12	12
54	Magoanine B	Sub-urban	6,313	10	10
55	Magoanine C	Sub-urban	8,375	14	14
Sub-total			**69,020**	**112**	**112**
	Municipal District of KaTembe				
56	Chali	*Peri*-urban	1,471	2	2
57	Chamissava	*Peri*-urban	1,941	3	3
58	Guachene	*Peri*-urban	1,034	2	2
59	Incassane	*Peri*-urban	1,493	2	2
60	Inguide	*Peri*-urban	1,324	2	2
Sub-total			**7,263**	**11**	**11**
	Municipal District of KaNyaka				
61	Inguane	*Peri*-urban	490	1	1
62	Nhaquene	*Peri*-urban	300	1	1
63	Ridzene	*Peri*-urban	511	1	0
Sub-total			**1,301**	**3**	**2**
Total			**235,750**	**384**	**381**

Appendix C: Questionnaire on gendered energy services in Maputo city

Wellcome to our survey!!

Thank you for participating in our survey. Your feedback is very important for this study.

Survey objective

The present survey aims to collect data referring to energy consumption patterns verified in households in the urban areas of Maputo City. The study seeks to understand whether the patterns currently verified are influenced or not by gender and to analyze the role of gender in reducing the demand for biomass (charcoal and firewood) since its consumption contributes to the increasing degradation of the Mozambican forest. Several factors are analyzed, such as the person in charge of the family, the gender of those responsible for making decisions with an impact on the sources, appliances and functionalities for which energy is required within households. All the Neighborhoods of the 7 Municipal Districts were selected, namely: **Kampfumo, Nlhamankulu, KaMaxakeni, Kamavota, KaMubukwana, Katembe and Kanyaka**. The survey takes approximately 1 hour to complete.

Note: there is a minimal inconvenience of time in filling the online form.

Informed Consent

My name is Adélia Chicombo, and I am a PhD student at Stellenbosch University. I want to invite you to participate in a research project entitled Gendered Energy Transition in Mozambican Urban Households.

Please take some time to read the information presented here, which will explain the details of this project and contact me if you require further explanation or clarification of any aspect of the study. Also, your participation is entirely voluntary, and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part.

Please note that:

- By participating in this study, we do not expect any potential for negative experiences or risk of harm, including discomfort, inconvenience, psychological stress and stigmatisation;
- The results of this study will help several interest groups, such as the Government, civil society, donors, academics about the relevance of understanding gender role in energy transition within households;
- By participating in this study, no payment or compensation of any form is expected;
- Interviews will be recorded, strictly to state what was discussed accurately;
- All the information provided will be confidential, and no names will be indicated in the study results. Individuals will be distinguished by refereeing them with codes, which will be alphabetical and numerical. Only the student and supervisors will have access to the information.
- Feel free not to answer certain questions, this will not have invalidated your participation, and you can remain in the study.

If you have any questions or concerns about the research, please feel free to contact my personal number: +258 84 525 2657, or to my supervisor, Prof. Josephine Musango: + 27 79 906 2034

RIGHTS OF RESEARCH PARTICIPANTS: You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because you participate in this research study. If you have questions regarding your rights as a research participant, contact Ms Maléne Fouché [mfouche@sun.ac.za; 021 808 4622] at the Division for Research Development.

You have the right to receive a copy of the Information and Consent form.

* 1. Do you want to participate in the survey?

◯ Yes

◯ No

* 2. Who is responsible for the data collection?

◯ Participant

◯ Interviewer

3. Data of the Interviewer

[ ]

4. Mode of data collection

◯ Telepfone

◯ Online Link

◯ In-person

Other (specify)

[ ]

* 5. Date of data collection

Date/time

Date		Time		AM/PM
DD/MM/YYYY		hh	mm	-

* 6. Municipal District where you reside

- Kampfumo
- Nlhamankulu
- KaMaxakeni
- Kamavota
- KaMubukwana
- KaTembe
- Kanyaka

7. In what neighbourhood do you reside?

- Alto Mae A
- Alto Mae B
- Central A
- Central B
- Central C
- Coop
- Malhangalene A
- Malhangalene B
- Polana Cimento A
- Polana Cimento B
- Sommerschield
- Aeroporto A
- Aeroporto B
- Chamanculo A
- Chamanculo B
- Chamanculo C
- Chamanculo D
- Malanga
- Minkadjuine
- Unidade 7
- Xipamanine
- Munhuana
- Mafalala
- Maxaquene A
- Maxaquene B
- Maxaquene C
- Maxaquene D
- Polana Canico A
- Polana Canico B
- Urbanizacao
- Albazine
- Costa do Sol
- Ferroviario
- FPLM
- Hulene-A
- Hulene-B
- Mahotas
- Mavalane A
- Mavalane B
- 3 de Fevereiro
- Laulane
- Bagamoio
- George Dimitrov
- Inhagoia A
- Inhagoia B
- Jardim
- Luis Cabral
- Magoanine A
- Malhazine
- Nsalene
- 25 de Junho A
- 25 de Junho B
- Zimpeto
- Magoanine B
- Magoanine C
- Chali
- Chamissava
- Guachene
- Incassane
- Inguide
- Inguane
- Nhaquene
- Ridzene

* 8. What kind of house do you live in?

- ◯ Freestanding
- ◯ Attached

Other (specify)

* 9. Type of structure of the house

- ◯ Complete conventional house (with bathroom and kitchen inside the house)
- ◯ Incomplete conventional house (without bathroom and kitchen inside the house)
- ◯ Incomplete conventional house (without bathroom inside the house)
- ◯ Flat/Apartment
- ◯ Hut
- ◯ Improvised house
- ◯ Mixed house
- ◯ Basic house (train house)
- ◯ Part of commercial building
- ◯ Other (specify)

* 10. How old are you?

- ◯ Between 18 - 25 years
- ◯ Between 26 - 34 years
- ◯ Between 35 - 44 years
- ◯ Between 44 - 60 years
- ◯ Above 60 years
- ◯ I prefer not to say

* 11. Gender of the interviewee?

- ◯ Famale
- ◯ Male
- ◯ I prefer not to say

* 12. Are you the head of the household?

- ◯ Yes
- ◯ No

Other (specify)

* 13. Do you engage in any paid activity??

- ◯ Yes
- ◯ No

Other (specify)

* 14. What sector do you work for?

- ☐ Public
- ☐ Private
- ☐ Non-Governmental Organization
- ☐ Self- employed

Other (specify)

15. What is the industry where you do your main activity?

- ◯ Agriculture, Animal Production, Hunting, Forestry and Fishing
- ◯ Extractive Industries
- ◯ Manufacturing Industries
- ◯ Electricity, Gas, Steam, Hot and Cold Water and Cold Air
- ◯ Water Collection, Treatment and Distribution; Sanitation, Waste Management and Remediation
- ◯ Construction
- ◯ Wholesale and retail trade; Repair of Motor Vehicles and Motorcycles
- ◯ Transport and Storage
- ◯ Accommodation, Catering and Similar
- ◯ Information and Communication Activities
- ◯ Financial and Insurance Activities
- ◯ Real Estate Activities
- ◯ Consulting, Scientific, Technical and Similar Activities
- ◯ Administrative and Support Services Activities
- ◯ Public Administration and Defense; Compulsory Social Security
- ◯ Education
- ◯ Human Health and Social Action Activities
- ◯ Artistic, Performing, Sports and Recreational Activities
- ◯ Other Activities and Services
- ◯ Activities of Household Employing Families and Production Activities of Families for Own Use
- ◯ Activities of International Organizations and other Extra-Territorial Institutions
- ◯ Other (please specify)

* 16. What is the regime of your work?

- ◯ Full-time
- ◯ Part-time
- ◯ Non-Regular

Other (specify)

17. How many days do you work per week, and for how many hours?

	Up to 4 hours	Up to 6 hours	Up to 8 hours	Up to 10 hours	Up to 14 hours	Up to 16 hours	24 hours
1 day	◯	◯	◯	◯	◯	◯	◯
2 days	◯	◯	◯	◯	◯	◯	◯
3 days	◯	◯	◯	◯	◯	◯	◯
4 days	◯	◯	◯	◯	◯	◯	◯
5 days	◯	◯	◯	◯	◯	◯	◯
6 days	◯	◯	◯	◯	◯	◯	◯
7 days	◯	◯	◯	◯	◯	◯	◯

Other (please specify)

* 18. What is your monthly income in meticais?

- ◯ Below 4.000,00Mt
- ◯ Up to 6.000,00Mt
- ◯ Up to 8.000,00Mt
- ◯ Up to 10.000,00Mt
- ◯ Up to 15.000,00Mt
- ◯ Up to 20.000,00Mt
- ◯ Up to 25.000,00Mt
- ◯ Other (specify)
- ◯ Up to 30.000,00Mt
- ◯ Up to 40.000,00Mt
- ◯ Up to 50.000,00Mt
- ◯ Up to 80.000,00Mt
- ◯ Between 81.000,00Mt - 100.000,00Mt
- ◯ Above 100.000,00Mt
- ◯ I prefer not to say

19. Do you own the house you live in?

- ◯ Yes, I am the owner (with title deed)
- ◯ Yes, I am the owner (without title deed)
- ◯ No, I rent it

Other (specify)

20. How often do you get paid?

- ◯ Daily
- ◯ Weekly
- ◯ Monthly
- ◯ Occasionally

Other (specify)

* 21. Who is the head of the household (the person who makes the main decisions relating to the family)?

- ◯ Female
- ◯ Male
- ◯ I prefer not to say

* 22. What is the level of education of the head of the household?

- ◯ No formal education
- ◯ Primary school
- ◯ Secondary/High school
- ◯ Technical or vocational training
- ◯ High education
- ◯ Tertiary education

Other (specify)

* 23. How many people live in the household?

	Female	Male
Babies (0-4 years)		
Children (5-15 years)		
Teenagers (16-18 years)		
Young adults (19-25 years)		
Adults (26 - 59 years)		
Elderly (60 years and above)		

* 24. What is the status of household employment and education?

	Females	Males
Adults employed		
Adults unemployed		
People retired		
People enrolled in full-time education		

25. What is the income status of other employed adults?

	Regime of work	Sector of work	Days of work per week	Hours of work per day	What is the payment periodicity	What is the monthly income in Meticais
Adult 1						
Adult 2						
Adult 3						
Adult 4						

26. What are the other sources of household income?

	Amount received per month	Receiving frequency
Government grants (e.g. social relief, disability, pension, childcare)		
Donations		
Interest on savings		
Rental income		
Personal loans		
Running a small business (for example, spaza shops)		

Other (specify)

27. If you indicated above that you earn income from a small business you run, where is the business located?

- at my home
- at another location

28. What energy fuels (if any) do you use to run your business?

- Wood
- Charcoal
- Sawdust
- Gas (LPG)
- Paraffin
- Biogas
- Candles
- Solar PV
- Batteries
- Car Batteries
- Generator(petrol/diesel)
- Direct Electricity
- Indirect Electricity

Other (specify)

29. Would you say the COVID-19 situation has affected your household income?

- Yes
- No

30. How has the COVID-19 affected your income?

- Increased income
- Reduced income
- Other (please specify)

* 31. How much does the household spend, on average, per month on the following?

	Monthly values
Food	
Travel	
Medical expenses including Insurance (Life, car, medical, etc.)	
Personal care (hair, nails etc.), clothes, leisure	
Household essentials (Toiletries, cleaning products, appliances	
Education	
Electricity or other fuels	
Water	
Rent	
Mobile phone calls and data cost	
Savings	
Other	

* 32. What is the gender of the person responsible for deciding, buying, using, and transporting/collecting household fuels?

	The person who decides which fuels to use	The person who pays for the fuels	The person who mainly uses the fuels	The person who goes to buy or collect the fuels
Wood				
Charcoal				
Sawdust				
Gas (LPG)				
Paraffin				
Biogas				
Candles				
Solar PV				
Batteries				
Car Batteries				
Generator(petrol/diesel)				
Direct Electricity				
Indirect Electricity				
Other				

* 33. How much does the household spend on the energy sources monthly?

	0,00Mt	Below 500,00Mt	Up to 750,00Mt	Up to 1.000,00Mt	Up to 2.000,00Mt	Up to 3.000,00Mt	Up to 5.000,00Mt	Up to 6.000,00Mt	Up to 8.000,00Mt	Up to 10.000,00Mt	Up to 15.000,00Mt	Up to 20.000,00Mt	Ab
Wood													
Charcoal													
Sawdust													
Gas (LPG)													
Paraffin													
Biogas													
Candles													
Solar PV													
Batteries													
Car Batteries													
Generator(petrol/diesel)													
Direct Electricity													
Indirect Electricity													

Other (specify)

* 34. What is your level of satisfaction with the following energy fuels in your house?

	Very Satisfied	Satisfied	Neutral	Dissatisfied	Very dissatisfied
Wood					
Charcoal					
Sawdust					
Gas (LPG)					
Paraffin					
Biogas					
Candles					
Solar PV					
Batteries					
Car Batteries					
Generator(petrol/diesel)					
Direct Electricity					
Indirect Electriciy					

Other (specify)

* 35. Are these energy sources sufficient for the household's needs?

- ◯ Yes
- ◯ No

Other (specify)

* 36. Why do you prefer to use the fuels that you currently use in the household?

- ◯ Are the ones we can afford
- ◯ Are the ones we have access
- ◯ Are the ons that match the appliances we use

other (specify)

* 37. Where do you get these fuels from?

	Go to the Shop to buy	Via digital platforms	Buy from authorized vendors	Delivered at the doorstep	Produce it in the house	Collected from environment	N/A
Wood	◯	◯	◯	◯	◯	◯	◯
Charcoal	◯	◯	◯	◯	◯	◯	◯
Sawdust	◯	◯	◯	◯	◯	◯	◯
Gas (LPG)	◯	◯	◯	◯	◯	◯	◯
Paraffin	◯	◯	◯	◯	◯	◯	◯
Biogas	◯	◯	◯	◯	◯	◯	◯
Candles	◯	◯	◯	◯	◯	◯	◯
Solar PV	◯	◯	◯	◯	◯	◯	◯
Batteries	◯	◯	◯	◯	◯	◯	◯
Car Batteries	◯	◯	◯	◯	◯	◯	◯
Generator(petrol/diesel)	◯	◯	◯	◯	◯	◯	◯
Direct electricity	◯	◯	◯	◯	◯	◯	◯
Direct Electricity	◯	◯	◯	◯	◯	◯	◯
Indirect Electricity	◯	◯	◯	◯	◯	◯	◯

Other (specify)

* 38. What are the energy devices used at the household level? Indicate the persons (gender) who decide, buy, use, and maintain the household energy devices? Tick both if it is neutral.

	Tick if used	The person who decides about the energy device	The person who buys the energy device	The person who uses the energy device	The person who maintains or repairs
LED bulbs					
Fluorescent lamp					
Paraffin lamp					
Gaslamp					
Battery lamp					
Electric lantern					
Battery lantern					
Solar lantern					
Torch					
Candles					
Open fire (wood)					
Electric stove					
Gasifier stove					
Paraffin stove					
LPG (gas) stove					
Microwave					
Toaster					
Air conditioner					
Electric fan					
Electric Kettle					
Coffee machine					
Charcoal heater					
Electric heater					
Washing machine					
Fridge and freezers					
Computers					
Cell-phone					
Television					
DVD player					
Sound system					
Radio					
Iron					
Hairdryer					
Security gate					

Other (specify)

* 39. Who mainly consumes these different household energy services? Who is responsible for the following household energy chores?

	Women	Men	Boys	Girls	Neutral
Lighting	◯	◯	◯	◯	◯
Cooking	◯	◯	◯	◯	◯
Space cooling	◯	◯	◯	◯	◯
Water heating	◯	◯	◯	◯	◯
Space heating	◯	◯	◯	◯	◯
Washing (dishes and clothes)	◯	◯	◯	◯	◯
Refrigeration	◯	◯	◯	◯	◯
IT and entertainment	◯	◯	◯	◯	◯

Other (specify)

* 40. What proportion of energy fuels are used to deliver different energy services?

	Lighting	Cooking	Space cooling	Water heating	Space heating	Washing (dishes and clothes)	Refrigeration	IT and entertainment	General household services
Wood									
Charcoal									
Sawdust									
Gas (LPG)									
Paraffin									
Biogas									
Candles									
Solar PV									
Batteries									
Car Batteries									
Generator(petrol/diesel)									
Direct Electricity									
Indirect Electricity									

Other (specify)

* 41. What are the household energy devices used for different energy services?

	Lighting	Cooking	Space cooling	Water heating	Space heating	Washing (dishes and clothes)	Refrigeration	IT and entertainment	General household services
LED bulbs									
Fluorescent lamp									
Paraffin lamp									
Gaslamp									
Battery lamp									
Electric lantern									
Battery lantern									
Solar lantern									
Torch									
Candles									
Open fire (wood)									
Electric stove									
Gasifier stove									
Paraffin stove									
LPG (gas) stove									
Microwave									
Toaster									
Air conditioner									
Electric fan									
Electric Kettle									
Coffee machine									
Charcoal heater									
Electric heater									
Washing machine									
Fridge and freezers									
Computers									
Cell-phone									
Television									
DVD player									
Sound system									
Radio									
Iron									
Hairdryer									
Security gate									

Other (specify)

* 42. What is your level of satisfaction with the following energy services in your house?

	Very satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
Lighting					
Cooking					
Space cooling					
Water Heating					
Space Heating					
Washing (clothes, dishes)					
Refrigeration					
IT and Entertainment					
General household services					

Other (specify)

43. Who is most affected when you do not have enough energy in the house?

- ◯ Women
- ◯ Men
- ◯ Girls
- ◯ Boys
- ◯ All
- ◯ I prefer not to say
- ◯ Other (please specify)

44. Have you personally designed an alternative energy device?

- ◯ Yes
- ◯ No

45. What energy fuel does the device(s) use?

- ☐ Wood
- ☐ Charcoal
- ☐ Sawdust
- ☐ Gas (LPG)
- ☐ Paraffin
- ☐ Biogas
- ☐ Candles
- ☐ Solar PV
- ☐ Batteries
- ☐ Car Batteries
- ☐ Generator(petrol/diesel)
- ☐ Direct Electricity
- ☐ Indirect Electricity

Other (specify)

46. What household energy services does the device(s) provide?

- ◯ Lighting
- ◯ Cooking
- ◯ Space cooling
- ◯ Water heating
- ◯ Space heating
- ◯ Washing (dishes and clothes)
- ◯ Refrigeration
- ◯ IT and entertainment
- ◯ General household services
- ◯ Other (please specify)

47. Will you be willing to participate in co-designing energy innovations (in a living lab) to provide your energy service needs?

- ◯ Yes
- ◯ No

48. Do you mind answering follow-up questions later?

- ◯ Yes
- ◯ No

49. Personal details

Name

E-mail address

Telephone number

Appendix D: Consent form to participate in research

Appendix D 1: Consent form in English

UNIVERSITEIT•STELLENBOSCH•UNIVERSITY
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STELLENBOSCH UNIVERSITY
CONSENT TO PARTICIPATE IN RESEARCH

Dear Mr(s)_______________________________________

My name is Adelia Chicombo, and I am a PhD student at Stellenbosch University. I want to invite you to participate in a research project entitled Gendered Energy Transition in Mozambican Urban Households.

Please take some time to read the information presented here, which will explain the details of this project and contact me if you require further explanation or clarification of any aspect of the study. Also, your participation is **entirely voluntary,** and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part.

Please note that:

- By participating in this study, we do not expect any potential for negative experiences or risk of harm, including discomfort,
- inconvenience, psychological stress and stigmatisation;
- The results of this study will help several interest groups, such as the Government, civil society, donors, academics, about the
- relevance of understanding gender role in energy transition within households;
- By participating in this study, no payment or compensation of any form is expected;
- Interviews will be recorded, strictly to state what was discussed accurately;
- All the information provided will be confidential, and no names will be indicated in the study results. Individuals will be
- distinguished by refereeing them with codes, which will be alphabetical and numerical. Only the student and supervisors will have
- access to the information.
- Feel free not to answer specific questions, this will not have invalidated your participation, and you can remain in the study.

If you have any questions or concerns about the research, please feel free to contact my number: +258 84 525 2657, or to my supervisor, Prof. Josephine Musango: + 27 79 906 2034

RIGHTS OF RESEARCH PARTICIPANTS: You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because you participate in this research study. If you have questions regarding your rights as a research participant, contact Ms Maléne Fouché [mfouche@sun.ac.za; 021 808 4622] at the Division for Research Development.
You have the right to receive a copy of the Information and Consent form.

If you are willing to participate in this study, please sign the attached Declaration of Consent

DECLARATION BY PARTICIPANT

By signing below, I …………………………………...………………. agree to take part in a research study entitled **Gendered Energy Transition in Mozambican Urban Households**, conducted by Adélia Filosa Francisco Chicombo.

I declare that:

- I have read the attached information leaflet, and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions, and all my questions have been adequately answered.
- I understand that taking part in this study is **voluntary,** and I have not been pressured to participate.
- I may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- I may be asked to leave the study before it has finished if the researcher feels it is in my best interests or if I do not follow the study plan as intended.
- All issues related to privacy and the confidentiality and use of the information I provide have been explained to my satisfaction.

Signed on …………...………...

....

Signature of participant

SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to _________________________ *[He*/she] was encouraged and given ample time to ask me any questions. This conversation was conducted in Portuguese.

______________________________________ ______________

Signature of Investigator **Date**

Appendix D 2: Consent form in Portuguese

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STELLENBOSCH UNIVERSITY
CONSENTIMENTO INFORMADO PARA PARTICIPAR NA PESQUISA

Cara(a) Sr(a)____

Meu nome é Adélia Chicombo, sou Moçambicana e estudante de Doutoramento na Universidade Stellenbosch na Africa do Sul. Gostaria de convidá-lo a participar de um projeto de pesquisa intitulado: Transição Energética baseada no Género nos Agregados Familiares Urbanos de Moçambique.

Reserve um tempo para ler as informações apresentadas aqui, que explicarão os detalhes deste projeto e entre em contato comigo se precisar de mais explicações ou esclarecimentos sobre qualquer aspecto do estudo. Além disso, sua participação é totalmente voluntária e você pode recusar-se a participar. Se você disser não, isso não afetará você de forma alguma. Você também pode se retirar do estudo a qualquer momento, mesmo se concordar em participar.

Por favor, note que:

- Ao participar deste estudo, não esperamos potencial para experiências negativas ou risco de danos, incluindo desconforto, inconveniência, estresse psicológico, e estigmatização;
- Os resultados deste estudo ajudarão vários grupos de interesse, como governo, sociedade civil, doadores, acadêmicos sobre a relevância de entender o papel do gênero na transição energética nas famílias Moçambicanas;
- Ao participar deste estudo, nenhum pagamento ou compensação de qualquer forma é esperado;
- As entrevistas serão gravadas, estritamente para indicar com precisão o que foi discutido;
- Todas as informações fornecidas serão confidenciais e nenhum nome será indicado nos resultados do estudo; os indivíduos serão distinguidos por meio de códigos, que serão alfabéticos e numéricos, apenas a estudante e os supervisores terão acesso às informações.
- Fique à vontade para não responder a certas perguntas, isso não invalidará sua participação e você ainda poderá permanecer no estudo.

Se você tiver alguma dúvida ou preocupação sobre a pesquisa, entre em contato com meu número pessoal: +258 84 525 2657, ou com minha supervisora, Prof. Josephine Musango: + 27 79 906 2034.

DIREITOS OS PARTICIPANTES DE PESQUISA: Você pode retirar seu consentimento a qualquer momento e interromper a participação sem penalidades. Você não está renunciando a nenhuma reclamação legal, direito ou recurso devido à sua participação neste estudo de pesquisa. Se você tiver dúvidas sobre seus direitos como participante da pesquisa, entre em contato com a Sra. Maléne Fouché [mfouche@sun.ac.za; 021 808 4622] na Divisão de Desenvolvimento de Pesquisa.
Você tem o direito de receber uma cópia do formulário do Consentimento Informado

Se você está interessado em participar nessa pesquisa por favor assine a declaração de consentimento em anexo.

DECLARAÇÃO DO PARTICIPANTE

Ao assinar abaixo, Eu ………………………………...………………. concordo em participar no estudo de investigação intitulado: **Transição Energética Baseada no Género nos Agregados Familiares Urbanos de Moçambique, ou simplestemente '*Gendered Energy Transition in Mozambican Urban Households*'** and conducted by Adélia Filosa Francisco Chicombo.

Eu declaro que:

- Li as informações em anexo para os participantes e estão escritas numa língua com a qual sou fluente e confortável.
- Tive a oportunidade de fazer perguntas e todas as minhas perguntas foram respondidas adequadamente
- Entendo que a participação neste estudo é voluntária e não fui pressionado a participar.
- Posso decidir deixar o estudo a qualquer momento e não serei penalizado ou prejudicado de forma alguma.
- Posso ser solicitado a deixar o estudo antes de sua conclusão, se o pesquisador achar que é do meu interesse ou se eu não seguir o plano de estudo, conforme combinado.
- Todas as questões relacionadas à privacidade, confidencialidade e uso das informações que forneço foram explicadas para minha satisfação.

Assinado em …………...………...

....

Assinatura do Participante

Assinatura do Investigador

Eu declaro que expliquei as informações fornecidas neste documento para ________________________ [*Ela*/Ela] foi incentivado e teve tempo suficiente para me fazer qualquer pergunta. Essa conversa foi conduzida em português.

______________________________________ ______________

Assinatura do Investigador **Data**

Appendix E: Ethics Committee approval of research project

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NOTICE OF APPROVAL

REC: Social, Behavioural and Education Research (SBER) - Initial Application Form

4 June 2021

Project number: 14977

Project Title: Gendered Energy Transition in Mozambican Urban Households

Dear Ms AFF Chicombo

Co-investigators:

Your response to stipulations submitted on 21/05/2021 14:38 was reviewed and approved by the REC: Social, Behavioural and Education Research (REC: SBE).

Please note below expiration date of this approved submission:

Ethics approval period:

Protocol approval date (Humanities)	Protocol expiration date (Humanities)
18 March 2021	17 March 2022

GENERAL REC COMMENTS PERTAINING TO THIS PROJECT:

INVESTIGATOR RESPONSIBILITIES

Please take note of the General Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

If the researcher deviates in any way from the proposal approved by the REC: SBE, the researcher must notify the REC of these changes.

Please use your SU project number (14977) on any documents or correspondence with the REC concerning your project.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

CONTINUATION OF PROJECTS AFTER REC APPROVAL PERIOD

You are required to submit a progress report to the REC: SBE before the approval period has expired if a continuation of ethics approval is required. The Committee will then consider the continuation of the project for a further year (if necessary).

Once you have completed your research, you are required to submit a final report to the REC: SBE for review.

Included Documents:

Document Type	File Name	Date	Version
Research Protocol/Proposal	PhD_Proposal_SUN_Adelia_Chicombo	04/04/2020	Lat Version
Investigator CV (PI)	Adélia_Chicombo_CV_2020	04/04/2020	Last Version
Informed Consent Form	Consent_ Form_Portugues	04/05/2020	First Version
Data collection tool	Exploratory_Interview	04/05/2020	First
Data collection tool	Semi_Structured_Interview	04/05/2020	First
Non-disclosure agreement	Confidentiality_Agreement_Co-Researchers	29/09/2020	First
Non-disclosure agreement	Confidentiality_Agreement_Co-Researchers_Translated	30/09/2020	First
Default	Research_Protocol_SUN_EN	16/12/2020	1

Default	Research_Protocol_SUN_Pt	16/12/2020	1
Budget	Fied-Work_Budget	26/04/2021	First
Data collection tool	Questionnaira_SurveyMonkey_Portuguese_Final	26/04/2021	3
Data collection tool	Questionnaire_SurveyMonkey_English_Final	26/04/2021	3
Informed Consent Form	Consent_Form_English_Revised	26/04/2021	2
Default	Manual_Co-Reserchers_Training_Revised	26/04/2021	3
Default	RESPONSE LETTER_Adélia_Chicombo_26_04_2021	26/04/2021	4

If you have any questions or need further help, please contact the REC office at cgraham@sun.ac.za.

Sincerely,

Clarissa Graham

REC Coordinator: Research Ethics Committee: Social, Behavioral and Education Research

National Health Research Ethics Committee (NHREC) registration number: REC-050411-032.
The Research Ethics Committee: Social, Behavioural and Education Research complies with the SA National Health Act No.61 2003 as it pertains to health research. In addition, this committee abides by the ethical norms and principles for research established by the Declaration of Helsinki (2013) and the Department of Health Guidelines for Ethical Research: Principles Structures and Processes (2nd Ed.) 2015. Annually a number of projects may be selected randomly for an external audit.

Principal Investigator Responsibilities

Protection of Human Research Participants

As soon as Research Ethics Committee approval is confirmed by the REC, the principal investigator (PI) is responsible for the following:

Conducting the Research: The PI is responsible for making sure that the research is conducted according to the REC-approved research protocol. The PI is jointly responsible for the conduct of co-investigators and any research staff involved with this research. The PI must ensure that the research is conducted according to the recognised standards of their research field/discipline and according to the principles and standards of ethical research and responsible research conduct.

Participant Enrolment: The PI may not recruit or enrol participants unless the protocol for recruitment is approved by the REC. Recruitment and data collection activities must cease after the expiration date of REC approval. All recruitment materials must be approved by the REC prior to their use.

Informed Consent: The PI is responsible for obtaining and documenting affirmative informed consent using **only** the REC-approved consent documents/process, and for ensuring that no participants are involved in research prior to obtaining their affirmative informed consent. The PI must give all participants copies of the signed informed consent documents, where required. The PI must keep the originals in a secured, REC-approved location for at least five (5) years after the research is complete.

Continuing Review: The REC must review and approve all REC-approved research proposals at intervals appropriate to the degree of risk but not less than once per year. There is **no grace period.** Prior to the date on which the REC approval of the research expires, **it is the PI's responsibility to submit the progress report in a timely fashion to ensure a lapse in REC approval does not occur.** Once REC approval of your research lapses, all research activities must cease, and contact must be made with the REC immediately.

Amendments and Changes: Any planned changes to any aspect of the research (such as research design, procedures, participant population, informed consent document, instruments, surveys or recruiting material, etc.), must be submitted to the REC for review and approval before implementation. Amendments may not be initiated without first obtaining written REC approval. The **only exception** is when it is necessary to eliminate apparent immediate hazards to participants and the REC should be immediately informed of this necessity.

Adverse or Unanticipated Events: Any serious adverse events, participant complaints, and all unanticipated problems that involve risks to participants or others, as well as any research-related injuries, occurring at this institution or at other performance sites must be reported to the REC within **five (5) days** of discovery of the incident. The PI must also report any instances of serious or continuing problems, or non-compliance with the RECs requirements for protecting human research participants.

Research Record Keeping: The PI must keep the following research-related records, at a minimum, in a secure location for a minimum of five years: the REC approved research proposal and all amendments; all informed consent documents; recruiting materials; continuing review reports; adverse or unanticipated events; and all correspondence and approvals from the REC.

Provision of Counselling or emergency support: When a dedicated counsellor or a psychologist provides support to a participant without prior REC review and approval, to the extent permitted by law, such activities will not be recognised as research nor the data used in support of research. Such cases should be indicated in the progress report or final report.

Final reports: When the research is completed (no further participant enrolment, interactions or interventions), the PI must submit a Final Report to the REC to close the study.

On-Site Evaluations, Inspections, or Audits: If the researcher is notified that the research will be reviewed or audited by the sponsor or any other external agency or any internal group, the PI must inform the REC immediately of the impending audit/evaluation.

Appendix F: Survey results

Table F1: Sector of activity and type of interviewees

Order	Sector and type of activity of the interviewees/location	Peri-urban	Suburban	Urban	Grand total
1	**Non-Governmental Organisation**	**0**	**4**	**0**	**4**
1.1	Activity of Families Employing Domestic Personnel and Production Activities of Families for Own Use	0	1	0	1
1.2	Education	0	1	0	1
1.3	Human Health and Social Action Activities	0	2	0	2
2	**Private Sector**	**4**	**55**	**8**	**67**
2.1	Accommodation, Catering and Similar	0	1	0	1
2.2	Activities of International Organisations and other Extra-territorial Institutions	0	1	0	1
2.3	Activity of Families Employing Domestic Personnel and Production Activities of Families for Own Use	0	5	0	5
2.4	Administrative and Support Service Activities	0	0	1	1
2.5	Agriculture, Animal Production, Hunting, Forestry and Fishing	0	2	0	2
2.6	Artistic, Show, Sport and Recreational Activities	0	3	0	3
2.7	Construction	2	2	0	4
2.8	Consulting, Scientific, Technical and Similar Activities	0	1	0	1
2.9	Education	0	1	0	1
2.10	Electricity, Gas, Steam, Hot and Cold Water and Cold Air	0	3	0	3
2.11	Extractive Industries	0	1	0	1
2.12	Financial and Insurance Activities	0	2	1	3
2.13	Human Health and Social Action Activities	0	1	1	2
2.14	Information and Communication Activities	0	2	0	2
2.15	Other Activities and Services	1	17	5	23
2.16	Real Estate Activities	0	2	0	2
2.17	Transport and Storage	0	1	0	1
2.18	Water Collection, Treatment and Distribution, Sanitation, Waste Management and Depollution	0	2	0	2
2.19	Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles	1	8	0	9
3	**Public Sector**	**4**	**29**	**3**	**36**
3.1	Administrative and Support Service Activities	2	1	0	3
3.2	Consulting, Scientific, Technical and Similar Activities	0	2	0	2
3.2	Education	0	15	2	17
3.3	Extractive Industries	0	1	0	1
3.4	Human Health and Social Action Activities	0	2	1	3
3.5	Other Activities and Services	0	2	0	2
3.6	Public Administration and Defence, Mandatory Social Security	2	5	0	7
3.7	Transport and Storage	0	1	0	1
4	**Self-employed**	**26**	**145**	**13**	**184**
4.1	Accommodation, Catering and Similar	0	3	0	3
4.2	Agriculture, Animal Production, Hunting, Forestry and Fishing	0	3	0	3
4.3	Education	0	2	0	2
4.4	Extractive Industries	0	1	0	1
4.5	Financial and Insurance Activities	0	1	0	1
4.6	Human Health and Social Action Activities	0	1	0	1
4.7	Other Activities and Services	13	42	12	67
4.8	Real Estate Activities	0	1	1	2
4.9	Transport and Storage	0	1	0	1
4.10	Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles	13	90	0	103
5	**Unemployed**	**14**	**67**	**9**	**90**
Grand Total		**48**	**300**	**33**	**381**

Table F2: Average of the households monthly expenditure per report household income

Household income	Household expenditure (monthly average)												Total
	Food	Travel	Medical expense	Personal care	Household essentials	Education	Electricity and other fuels	Water	Mobile phones	Rent	Savings	Others	
Below 4,000MT	4,901	1,550	1,368	1,791	1,165	1,975	1,385	848	1,051	1,825	2,419	1,875	22,153
From 4,001MT to 6,000MT	4,762	1,500	864	1,385	1,048	1,657	1,179	929	1,238	1,214	2,395	786	18,954
From 6,001MT to 8,000MT	5,786	1,000	1,958	1,233	1,130	2,333	1,778	741	926	1,500	1,893	500	20,778
From 8,001MT to 10,000MT	6,154	1,056	1,794	2,100	1,192	2,313	2,019	740	1,635	3,083	2,111	2,000	26,197
From 10,001MT to 15,000MT	6,500	500	1,125	2,286	1,071	2,071	1,857	786	1,192	5,375	3,917	1,125	27,805
From 15,001MT to 20,000MT	7,286	500	2,500	2,643	1,286	4,929	2,571	1,167	1,571	500	3,583	2,250	30,786
From 20,001MT to 25,000MT	7,333	1,000	1,000	2,333	667	3,000	1,667	667	1,000	12,000	2,000	12,000	44,667
From 25,001MT to 30,000MT	10,500	1,000	3,667	5,250	3,250	3,875	2,750	1,333	2,667	1,667	2,000	667	38,625
From 30,001MT to 40,000MT	10,000	-	8,000	4,000	3,000	15,000	10,000	2,000	4,000	-	-	-	56,000
From 40,001MT to 50,000MT	8,500	4,333	4,333	2,250	1,750	2,667	2,500	1,000	1,750	15,000	3,000	-	47,083
From 50,001MT to 80,000MT	10,000	2,167	7,000	4,000	2,667	9,500	6,667	833	4,333	500	3,000	500	51,167
Above 100,000MT	15,000	15,000	15,000	11,000	10,000	15,000	15,000	4,000	6,000	500	15,000	500	122,000
Prefer not to say	7,166	990	1,096	3,625	2,067	4,360	3,673	1,361	2,225	1,436	4,739	804	33,543
Average	5,873	1,372	1,580	1,791	1,173	2,412	1,732	865	1,262	1,944	2,239	1,214	**23,458**

Table F3: Relationship between household head and the gender of who decides on the fuel

Energy Source	Head of the household	Gender of who decides about the fuel			Total
		Women	Men	Neutral	
Wood	Women	34	1	0	35
	Men	50	3	4	57
	Prefer not to say	1	0	1	2
Total		**85**	**4**	**5**	**94**
Charcoal	Women	103	0	3	106
	Men	138	12	20	170
	Prefer not to say	2	3	1	6
Total		**243**	**15**	**24**	**282**
LPG	Women	45	4	2	51
	Men	95	9	25	129
	Prefer not to say	2	1	0	3
Total		**142**	**14**	**27**	**183**
Direct electricity	Women	67	38	19	124
	Men	60	91	96	247
	Prefer not to say	2	3	1	6
Total		**129**	**132**	**116**	**377**

Table F 4: Relationship between household head and the gender of who pays for the fuel

Energy source	Head of the household	Gender of who pays for the fuel			Total
		Women	Men	Neutral	
Wood	Women	27	6	2	35
	Men	22	20	15	57
	Preferer not to say	1	1	0	2
Total		**50**	**27**	**17**	**94**
Charcoal	Women	72	19	15	106
	Men	37	91	42	170
	Preferer not to say	2	3	1	6
Total		**111**	**113**	**58**	**282**
LPG	Women	28	14	9	51
	Men	20	80	29	129
	Preferer not to say	1	2	0	3
Total		**49**	**96**	**38**	**183**
Direct electricity	Women	68	33	23	124
	Men	28	150	69	247
	Preferer not to say	2	3	1	6
Total		**98**	**186**	**93**	**377**

Table F 5: Person in charge of the household energy chores

Energy Services	Person in charge of the household energy chores						Total
	Women	Men	Girls	Boys	Neutral	Prefer not to say	
Lighting	61	191	0	6	121	1	380
Percentage	16%	50%	0%	2%	32%	0%	100%
Cooking	326	24	0	1	28	1	380
Percentage	86%	6%	0%	0%	7%	0%	100%
Space cooling	27	33	0	0	121	2	183
Percentage	15%	18%	0%	0%	66%	1%	100%
Water heating	165	23	4	2	177	2	373
Percentage	44%	6%	1%	1%	47%	1%	100%
Space heating	6	0	0	0	0	3	9
Percentage	67%	0%	0%	0%	0%	33%	100%
Washing (clothes and dishes)	45	6	1	0	3	1	56
Percentage	80%	11%	2%	0%	5%	2%	100%
Refrigeration	112	16	1	0	170	1	300
Percentage	37%	5%	0%	0%	57%	0%	100%
IT and entertainment	55	129	1	0	191	2	378
Percentage	15%	34%	0%	0%	51%	1%	100%
Average	**45%**	**16%**	**0%**	**0%**	**33%**	**5%**	**100%**

Table F 6: Energy devices and gender role in the choice, usage, and purchase of the energy device

Energy devices	Gender of who decides on the energy device				Women's role	Gender of who uses the energy device the most				Women's role	Gender of who buys the energy device				Women's role
	Women	Men	Neutral	**Total**		Women	Men	Neutral	**Total**		Women	Men	Neutral	**Total**	
LED bulbs	56	127	21	**204**	27%	34	29	142	**205**	17%	55	123	27	**205**	27%
Fluorescent lamp	41	174	44	**259**	16%	25	20	214	**259**	10%	49	154	26	**229**	21%
Open fire (wood)	49	2	1	**52**	94%	50	1	1	**52**	96%	40	7	5	**52**	77%
Electric stove	113	28	27	**168**	67%	95	28	46	**169**	56%	113	28	27	**168**	67%
LPG (gas) stove	126	16	45	**187**	67%	119	11	57	**187**	64%	58	103	26	**187**	31%
Microwave	43	8	39	**90**	48%	33	1	56	**90**	37%	32	47	11	**90**	36%
Toaster	16	1	13	**30**	53%	15	0	15	**30**	50%	12	16	2	**30**	40%
Air conditioner	3	9	15	**27**	11%	4	1	22	**27**	15%	5	18	4	**27**	19%
Electric fan	31	47	74	**152**	20%	14	23	115	**152**	9%	26	107	19	**152**	17%
Electric Kettle	133	23	86	**242**	55%	85	11	146	**242**	35%	83	136	23	**242**	34%
Charcoal stove	252	14	42	**308**	82%	231	16	61	**308**	75%	130	157	21	**308**	42%
Electric heater	1	2	7	**10**	10%	2	0	8	**10**	20%	0	9	1	**10**	0%
Washing machine	7	1	5	**13**	54%	9	0	4	**13**	69%	4	9	0	**13**	31%
Fridge and freezers	146	26	140	**312**	47%	64	7	241	**312**	21%	77	197	38	**312**	25%
Computers	24	94	59	**177**	14%	23	72	82	**177**	13%	18	135	24	**177**	10%
Cell-phone	49	67	264	**380**	13%	49	56	275	**380**	13%	57	191	132	**380**	15%
Television	93	41	227	**361**	26%	52	40	269	**361**	14%	94	213	54	**361**	26%
DVD player	7	47	24	**78**	9%	8	36	34	**78**	10%	10	66	2	**78**	13%
Sound system	14	111	38	**163**	9%	12	67	85	**164**	7%	16	137	11	**164**	10%
Radio	17	87	7	**111**	15%	18	59	34	**111**	16%	17	87	7	**111**	15%
Iron	179	35	115	**329**	54%	104	19	206	**329**	32%	127	161	41	**329**	39%
Hairdryer	100	9	9	**118**	85%	100	7	11	**118**	85%	71	43	4	**118**	60%
Security gate	2	4	37	**43**	5%	2	41	0	**43**	5%	11	30	2	**43**	26%

Table F 7: Factors influencing the use of wood

Independent variables	Categories	Dependent variable: Gender of who decides on the use of wood			Total
		Women	Men	Neutral	
Gender of the head of the household	Women	34	1	0	35
	Men	50	3	4	57
	Prefer not to say	1	0	1	2
Total		85	4	5	94
Type of neighbourhood	Urban	1	0	2	3
	Suburban	69	3	3	75
	Peri-urban	15	1	0	16
Total		85	4	5	94
Age of the interviewees	18-25 years	23	3	4	30
	26-34 years	22	0	1	23
	35-44 years	15	1	0	16
	45-60 years	22	0	0	22
	Above 60 years	3	0	0	3
Total		85	4	5	94
Educational level of the household head	No formal education	7	0	1	8
	Primary school	40	4	2	46
	Secondary/high school	31	0	0	31
	Technical or vocational training	2	0	0	2
	Higher education	4	0	2	6
	Tertiary education	1	0	0	1
Total		85	4	5	94
Household income	Below 4 000 MT	17	3	1	21
	From 4 001 MT to 6 000 MT	11	0	1	12
	From 6 001 MT to 8 000 MT	8	0	0	8
	From 8 001 MT to 10 000 MT	3	0	0	3
	From 10 001 MT to 20 000 MT	3	0	0	3
	From 20 001 MT to 30 000 MT	1	0	0	1
	Prefer not to say	42	1	3	19
Total		85	4	5	94
Sector of activity	Unemployed	23	0	3	26
	Self-employed	47	0	1	48
	Public sector	7	1	0	8
	Private sector	8	3	1	12
	NGO	0	0	0	0
Total		85	4	5	94
Gender of who uses the fuel the most	Women	81	1	3	85
	Men	0	3	1	4
	Neutral	4	0	1	5
Total		85	4	5	94

Table F 8: Factors influencing the use of charcoal

Independent variables	Categories	Dependent variable: Gender of who decides on the use of charcoal			Total
		Women	Men	Neutral	
Gender of the household head	Women	103	0	3	106
	Men	138	12	20	170
	Prefer not to say	2	3	1	6
Total		243	15	24	282
Type of neighbourhood	Urban	12	3	7	22
	Suburban	199	10	16	225
	Peri-urban	32	2	1	35
Total		243	15	24	282
Age of the interviewees	18-25 years	74	10	5	89
	26-34 years	58	2	8	68
	35-44 years	52	2	5	59
	45-60 years	42	0	5	47
	Above 60 years	17	1	1	19
Total		243	15	24	282
Education level of the household head	No formal education	19	0	2	21
	Primary school	95	3	10	108
	Secondary/high school	88	6	7	101
	Technical or vocational training	25	2	2	29
	Higher education	15	4	3	22
	Tertiary education	1	0	0	1
Total		243	15	24	282
Household income	Below 4 000 MT	58	5	5	68
	From 4 001 MT to 6 000 MT	28	0	3	31
	From 6 001 MT to 8 000 MT	17	0	2	19
	From 8 001 MT to 10 000 MT	14	2	1	17
	From 10 001 MT to 15 000 MT	8	0	0	8
	From 15 001 MT to 20 000 MT	5	0	1	6
	From 20 001 MT to 25 000 MT	2	0	0	2
	From 25 001 MT to 30 000 MT	1	0	1	2
	From 30 001 MT to 50 000 MT	1	0	0	1
	From 50 001 MT to 80 000 MT	1	0	1	2
	Above 100 000 MT	0	0	1	1
	Prefer not to say	108	8	9	125
Total		243	15	24	282
Sector of activity	Unemployed	63	3	5	71
	Self-employed	121	9	11	141
	Public sector	19	3	4	26
	Private sector	37	0	4	41
	NGO	3	0	0	3
Total		243	15	24	282
Gender of who uses the fuel the most	Women	237	4	15	256
	Men	1	10	0	11
	Neutral	5	1	9	15
Total		243	15	24	282

Table F 9: Factors influencing the use of liquefied petroleum gas

Independent variables	**Categories**	**Dependent variable: Gender of who decides on the use of LPG**			**Total**
		Women	**Men**	**Neutral**	
Gender of the head of the household	Women	45	4	2	51
	Men	95	9	25	129
	Prefer not to say	2	1	0	3
Total		142	14	27	183
Type of neighbourhood	Urban	18	2	9	29
	Suburban	111	7	15	133
	Peri-urban	13	5	3	21
Total		142	14	27	183
Age of the interviewees	18-25 years	58	6	4	68
	26-34 years	32	5	9	46
	35-44 years	28	0	8	36
	45-60 years	19	2	5	26
	Above 60 years	4	1	1	6
	Prefer not to say	1	0	0	1
Total		142	14	27	183
Educational level of the household head	No formal education	2	0	1	3
	Primary school	35	3	3	41
	Secondary/high school	51	5	8	64
	Technical or vocational training	31	3	6	40
	Higher education	21	3	9	33
	Tertiary education	1	0	0	1
	Other	1	0	0	1
Total		142	14	27	183
Household income	Below 4 000.00 MT	21	4	1	26
	From 4 001 MT to 6 000 MT	12	1	3	16
	From 6 001 MT to 8 000 MT	14	0	3	17
	From 8 001 MT to 10 000 MT	10	2	2	14
	From 10 001 MT to 15 000 MT	5	0	4	9
	From 15 001 MT to 20 000 MT	2	1	2	5
	From 20 001 MT to 25 000 MT	0	0	1	1
	From 25 001 MT to 30 000 MT	2	1	1	4
	From 30 001 MT to 40 000 MT	1	0	0	1
	From 40 001 MT to 50 000 MT	3	0	0	3
	From 50 001 MT to 80 000 MT	1	1	1	3
	Above 100 000 MT	0	0	1	1
	Prefer not to say	71	4	8	83
Total		142	14	22	183
Sector of activity	Unemployed	43	3	5	51
	Self-employed	67	6	7	80
	Public sector	11	0	6	17
	Private sector	21	5	9	35
Total		142	14	27	183
Gender of who uses the fuel the most	Women	119	10	26	155
	Men	8	2	0	10
	Neutral	15	2	1	38
Total		142	14	27	183

Table F 10: Factors influencing the use of direct electricity

Independent variables	Categories	Dependent variable: Gender of who decides on the use of direct electricity			Total
		Women	Men	Neutral	
Gender of the head of the household	Women	67	38	19	124
	Men	60	91	96	247
	Prefer not to say	2	3	1	6
Total		129	132	116	377
Type of neighbourhood	Urban	14	5	14	33
	Suburban	104	108	84	296
	Peri-urban	11	19	18	48
Total		129	132	116	377
Age of the interviewees	18-25 years	42	45	39	126
	26-34 years	30	30	33	93
	35-44 years	33	22	18	73
	45-60 years	17	23	23	63
	Above 60 years	6	12	3	21
	Prefer not to say	1	0	0	1
Total		129	132	116	377
Educational level of the household head	No formal education	11	8	3	22
	Primary school	40	52	38	130
	Secondary/high school	42	45	40	127
	Technical or vocational training	20	14	18	52
	Higher education	15	12	16	43
	Tertiary education	1	0	1	2
	Other	0	1	0	1
Total		129	132	116	377
Household income	Below 4 000.00 MT	31	34	13	78
	From 4 001 MT to 6 000 MT	17	16	9	42
	From 6 001 MT to 8 000 MT	7	9	11	27
	From 8 001 MT to 10 000 MT	11	8	7	26
	From 10 001 MT to 15 000 MT	2	5	7	14
	From 15 001 MT to 20 000 MT	2	2	3	7
	From 20 001 MT to 25 000 MT	1	0	2	3
	From 25 001 MT to 30 000 MT	2	1	1	4
	From 30 001 MT to 40 000 MT	0	0	1	1
	From 40 001 MT to 50 000 MT	2	1	1	4
	From 50 001 MT to 80 000 MT	1	1	1	3
	Above 100 000 MT	0	0	1	1
	Prefer not to say	53	55	59	78
Total		129	132	116	377
Sector of activity	Unemployed	31	31	29	91
	Self-employed	71	59	51	181
	Public sector	8	14	14	36
	Private sector	17	27	21	65
	NGO	2	1	1	4
Total		129	132	116	377
Gender of who uses the fuel the most	Women	84	7	7	98
	Men	35	106	45	186
	Neutral	10	19	64	93
Total		129	132	116	377