Faculteit der Aard- en Levenswetenschappen, Vrije Universiteit

# Household Energy in Mozambique:

A study on the socioeconomic and cultural determinants of stove and fuel transitions

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Connecting People's Capacities

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## List of Acronyms

| | |
|---|---|
| ACS | Advanced Cookstoves |
| CVM | Contingent Valuation Method |
| DGIS | Dutch Ministry of Foreign Affairs |
| ECN | Energy Research Center for the Netherlands |
| GHG | Greenhouse Gases |
| IAP | Indoor Air Pollution |
| ICS | Improved Cookstoves |
| LPG | Liquefied Petroleum Gas |
| SNV | Dutch Development Organization |
| TCS | Traditional Cookstoves |
| WTP | Willingness to Pay |

## PREFACE

This study was conducted under the RENEW-IS Academy program which is a research collaboration forged by the Vrije Universiteit, Energy Research Center for the Netherlands (ECN) and the Dutch Ministry of Foreign Affairs (DGIS) to explore and research the household energy situation in East- and Southern Africa. The project aims to research energy access and development cooperation through three themes: 1) the enterprise perspective, 2) the household perspective, and 3) the innovation systems perspective. The theme of this research is closely linked to the second theme as it also looks into household decision making and behavioral determinants for fuel switching. SNV, a Dutch development organization—although not directly part of the RENEW program—has a Renewable Energy Program that also looks into household energy use and therefore served as a base for conducting the research for this thesis in Mozambique.

# ACKNOWLEDGEMENTS

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## ABSTRACT

The purpose of this research was to investigate the different household factors that a play a role in determining cookstove adoption and the switch from firewood and charcoal to LPG or other modern fuels. Household energy transition theory presents the energy ladder model that depicts income as the sole driver of fuel switching. Under household factors there are economic, non-economic, and cultural and behavioral factors that influence stove and fuel use. Income, household size, and food preferences are for example all variables that could play a role in determining household energy use. A combined cross-sectional and case study design frame—containing both quantitative and qualitative methods of data collection— was conducted in order to fully capture the complexities of technology adoption and fuel transitions. First, a household survey was conducted to find more about household behavior; a focus group was then conducted to verify the survey results and get more detailed information on household energy choice. The results show that the majority of households use a combination of charcoal and modern fuels; while the other households mainly uses only charcoal. Additionally, results show that technology adoption in the study site is mainly hampered by affordability, availability and accessibility factors. A multiple regression analysis was conducted to find the different factors that could determine willingness to pay for improved cookstoves. The conclusion states that household drivers were not the only responsible  factors for cookstove adoption and fuel switching, but that external factors, relating to energy supply, played a decisive role too.

# 1. INTRODUCTION

Throughout the development of human history, food—as a basis for sustenance—and cooking—as a step in food preparation—have played an integral part of peoples' daily lives, on a social, as well as economic and cultural level. Cooking practices, which vary in technique and technology used, to prepare food, are present in all societies, cultures, and sub-cultures. The difference between these aforementioned societies is that some have transitioned towards modern cooking practices whereas others have continued in their traditional ways. The latter refers mainly to developing countries, where vast majorities of the population still depend on traditional biomass for cooking. Yet, although the use of three-stone fires might seem archaic to the developed world, the reality of the developing world proves otherwise—since 2.5 billion people worldwide still depend on traditional cooking fuels such as firewood and charcoal to prepare their daily sustenance (IEA, 2006).

The main issues associated with the production and combustion of traditional fuels are its effects on human welfare and the environment. Human welfare, which considers amongst others, social and economic factors looks at people's overall wellbeing—which in turn is measured by these aforementioned factors. Indoor air pollution, caused by the combustion of biomass and the use of inefficient stoves, has effects on health, which in turn has economic consequences. The environment is also affected as increased demand for wood and charcoal leads to increased deforestation. Households that suffer from energy poverty usually also are the main recipients of the negative externalities caused by the use of traditional fuels.

In order to help ameliorate the situation of those living in energy poverty, Barnes et al. (1994) suggests two demand-side alternatives that can help resolve or alleviate the negative effects associated with the use of traditional fuels. The first is to foster enabling conditions towards a modern fuel adoption. In other words, to create incentives that will motivate households to skip the transitions steps in the energy ladder and instead jump to modern fuels. The second way in which to reduce environmental pressure and health effects is through improved stove technology. By introducing improved cookstoves (ICS) to low-income markets, households are able to escape some of the evils associated with traditional fuels and traditional stoves. This second approach is central to this report as it explores the benefits ICS can provide poor households.

Introducing improved stove technologies to Mozambique would certainly play a positive role in human welfare and environmental gains as three-quarters of the population still heavily relies on biomass to fulfill their vital domestic needs of lighting, heating and cooking. The country's fastest growing cities: Maputo, Beira and Nampula have been facing difficulties meeting their basic energy needs. Between 2000 and 2010, the growth rate to urban areas has increased by 4.8% (FAOSTAT, 2012) raising the demand for fuel from neighboring provinces such as Gaza, to fuel Maputo's charcoal supply. The increased demand for biomass has in turn led to increased deforestation as charcoal production has been said to increase by 160% in the African continent from 1992 to 2007 (NL Agency, 2010).

The people who are especially affected by the country's critical biomass situation form the 'Bottom of the Pyramid' (BoP)—meaning that they are at the bottom of the world economic pyramid with a annual per capita income of $ 1,500 (Prahalad, 2005). Even though the media portrays this group as unable to take part of the market economy due to their limited income, Prahalad (2005) views them as 'resilient and creative entrepreneurs and value-conscious consumers'. This means that the BoP can actively and rationally make choices in relation to their energy expenditure that will help their socioeconomic situation; for example through the use of ICS. Hiemstra-van der Horst & Hovorka (2008) stress this as the importance of consumer choice—in the sense that consumers are not a homogeneous group and that conscious decisions over fuel and stove purchases are part of active household and individual decision-making processes.

Even though low-income consumers are actively involved in their household's decisions, there are social, economic and cultural forces that drive certain energy use patterns or that hinder them. According to the energy ladder model, income drives fuel choice—where higher-income households will use modern fuels, such as LPG or electricity, whereas low-income households will more often use firewood and charcoal (Hosier & Dowd, 1987). Nonetheless, this assertion has been contested by many, arguing that its explanation for household energy transition is too simplistic. Factors such as culture, education and country contexts have later on also joined the household energy discourse that tries to understand energy transition patterns.

Despite the fact that the benefits of improved and modern stoves—over their traditional counterparts—are widely reported, they often fail to reach the population that need to be aware of its benefits the most. Women from low-income levels, which are the main beneficiaries of ICS, need to be made aware of the added benefits of using such technologies. Cash income saved due to reduced fuel consumption and avoided health costs are two advantages that directly affect women (Schlag & Zuzarte, 2008). Reduced deforestation, climate change mitigation and long-term sustainability are also advantages of employing ICS; yet affect the household in a less direct way than socioeconomic and health benefits.

Therefore, by establishing that household decisions are shaped by various economic, social and cultural factors and that ICS provide a clear benefit to households, the issue regarding the prevalence of biomass—as predominant fuel—and traditional stoves is questioned. The following overarching research question has thus been developed,

*"How do households' socioeconomic and cultural profiles hinder the transition from traditional to improved stoves and fuels?"*

To answer this research question the following sub-questions need to be answered first:

1. What is the household energy situation of Maputo's peri-urban areas?
2. To what extent can social, economic, and cultural factors act as determinants for stove adoption or fuel switching?
3. What is the household willingness to pay for ICS?
4. What solutions can be implemented to viably introduce ICS in Maputo's peri-urban areas?

The aim of this research is thus to explore energy transitions at the household level alongside possible driving forces of energy switching and adoption and evaluating possible solutions for the introduction of ICS to Mozambique's urban markets. Through a better understanding of household energy-use patterns, better policies can be shaped and possibly even interventions can be conducted that will lead a changeover to improved cooking solutions. As a consequence, this can be seen as a process leading towards poverty alleviation and not poverty aggravation.

Apart to contributing to the overall household energy literature, this research also provides an innovative approach towards the study and research of household energy. Literature on household energy transition is ample yet specific studies on WTP and ICS is limited and often targeted at rural areas. This study, apart from including a WTP element in the methodology and having an urban focus, also provides a qualitative section which provides insights on the prevalence of certain fuel patterns. The combination of different data collection methods allows the study to take on an integrated approach including both quantitative and qualitative data.

Finally, this report is divided in 6 Chapters with various sub-chapters and sub-sections. Chapter 2, Background and Literature Review, provides background information on the Mozambican energy situation, followed by household energy theory, stove programs and adoption and finishes with previous energy studies using WTP in their methodologies. Chapter 4, methodology, starts with presenting the approach taken to conduct this research and then closely looks into the data collection methods; namely: exploratory research, household questionnaires, and focus group interview. Chapter 4 presents the results from the data collection steps and Chapter 5, the discussion chapter, analyses the findings and links them back to the literature. Finally Chapter 6 ends with conclusions and recommendations.

# 2. BACKGROUND & LITERATURE REVIEW

## 2.1 Energy & Mozambique

Mozambique is a country of 23 million inhabitants situated in southern Africa (Figure 1). After gaining their independence from Portugal in 1975, Mozambique fell into a grueling 15-year civil war—leaving most of the country in a state of complete devastation and extreme poverty. As of today, Mozambique remains one of the poorest countries in the world with 60% of the population living under the poverty line—or less than $1.25 per day. In the UNDP (2011) list of human development Mozambique ranks # 184 from 187—making it the 4th poorest countries in the world.


Figure 1 Map of Mozambique

The dependence of firewood and charcoal[1] for fulfilling energy needs spans the majority of sub-Saharan Africa. According to the report launched by the International Energy Agency (2006), 76% of the population or 575 million people in sub-Saharan Africa still depend on

[1] From now on if firewood and charcoal are mentioned together it will be referred to as biomass.

biomass as their primary fuel for cooking—from these, 162 million live in urban areas. The overall trend suggests that although biomass is predominant in both rural and urban households, the latter's dependence on charcoal is greater whereas the former depends mostly on collected firewood.

The majority of the Mozambican population, namely 70%, depends on biomass—creating a demand of 14.8 million tons of wood per year (Cuvilas et al., 2010). The differences between urban and rural areas differ only in the fact that the latter depends entirely on biomass whereas 70-80% of the urban populations use it as primary source of fuel meaning that alternative fuel sources are also used (Brower & Falcao, 2004). A combination of charcoal with an advanced fuel such as LPG or electricity is the predominant pattern in Maputo, the capital city, where the average urban household consumption of charcoal is 2.99 kg per day, with an annual amount of $0.82m^3$ per capita—compared to $1.0m^3$ in rural areas. The daily amount spent on charcoal was found to be between $0.76 and $1.06 (BEST Mozambique, 2012).

According to Brower & Falcao (2004), the urban population of Maputo consumes a combination of fuels. From the study's 240 respondents, the most popular combination of fuel is charcoal and gas and/or electricity with 57 responses or accounting for 23.8%; followed by charcoal and paraffin with 18.3% and only charcoal by 11.7%. However, 62% uses a type of biomass, so either firewood or charcoal, plus gas/and or electricity and/or paraffin.

## 2.2 Household Energy Transition

Now that Mozambique's energy situation has been presented, a shift will be made in order to present household energy theory. The study of household energy-use patterns and behaviors sparked a great interest after the world's oil crisis in the 1970s. In the developed countries, research was placed on oil dependency whereas in developing country the focus was placed on biomass consumption (Bailis et al., 2009). The idea of perceived energy scarcity after the oil crisis helped instigate research in developing countries were the effect of household fuelwood use would be studied alongside its effects on the environment, human welfare and secured supply (Kowsari & Zerriffi, 2011). The knowledge that has come out from these studies have helped create a better understanding of the household energy situation, therefore helping shape better policy and as a result improve the livelihoods of billions of rural and urban people.

### *2.2.1 Energy Ladder*

The hierarchy of cooking fuels and household fuel transition is often explained using the 'energy ladder' model. This model which resembles a ladder (Figure 2) contains three rungs that represent three categories of fuels—namely, primitive, transition, and advanced fuels.

These fuels  are also ranked in increasing order of importance—starting with 'primitive fuels' such as animal dung and firewood at the bottom; continuing with 'transition fuels' like charcoal and kerosene in the middle; and ending with 'advanced fuels' such as gas and electricity on top. The assumption behind this model is that as a household's socioeconomic status increases, they will rationally choose for an energy carrier that is more advanced and therefore able to better fits their energy service needs (Hosier, 2004). In other words, as a household's income increases, dirtier fuels such as firewood will completely be abandoned and substituted first for transition fuels such as charcoal and kerosene and ultimately with cleaner fuels namely, liquefied petroleum gas (LPG) and electricity. This transition in which one fuel is completely replaced by another is often referred to as fuel switching (Heltberg, 2004).

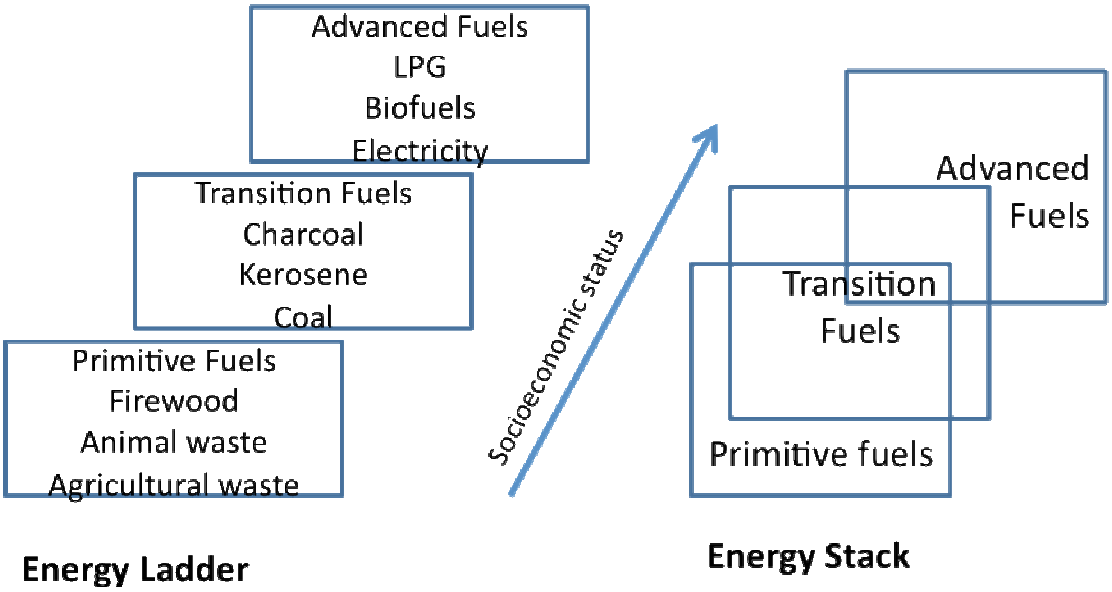


Figure 2 The Energy Ladder. *Source: Adapted from Schlag & Zuzarte (2008)*

As previously mentioned these fuels are placed in a sort of hierarchy, meaning that some fuels are considered to have more disadvantages than others and therefore some fuels are considered superior to others. Therefore, it assumes that as households climb up the energy ladder, a full switch is done to a fuel that has more advantages while still taking into consideration the household's economy,

In their study, Hosier & Dowd (1987) argue that income is an important determinant for the type of fuel used in a household. The authors claim that consumers will choose the most advanced fuel accessible with their socioeconomic profile; replacing lower quality fuels with higher quality ones. This study corroborates the energy ladder model when stating that as income rises, households switch to a fuel better suited for their socioeconomic status. Additionally, although the transition to cleaner fuels is depicted as an "evolutionary process”, both in the energy ladder model and in Hosier & Dowd (1987), the authors present that a more rapid progression towards cleaner fuels can be achieved through “active policy”.

*2.2.2 Energy Stacking*

The energy ladder model, however, has received many criticisms—some that are delineated in Hosier (2004). The criticisms mentioned by Hosier (2004) are that the intricate interactions that characterize energy transitions are not well accounted for in the energy ladder model. The ‘value-laden’ nature of the model is also criticized as it depicts societies in a certain ‘stage’ of development whereas the notion of a linear shift to modernity has been disproved. The lack of longitudinal studies that look at the differences within families is also not studied. Finally, cultural factors such as household dynamics and power relations are also not explained in the energy ladder model.

As a consequence to these criticisms, alternative models have risen (Foley, 1995; Masera et al., 2000). An important finding shared by studies (Masera et al., 2000; Brouwer & Falcao, 2004; Heltberg, 2004; Ouedraogo, 2006; Hiemstra-van der Horst, 2008; Mekonnen & Kolhin, 2008) is that household cooking patterns are far more complex than those depicted in the energy ladder model—which shows a linear transition from traditional to modern fuels in relation to increased income. Although it is not explicitly stated in all the studies, the overall trend does at least imply that energy transitions are not usually linear, unidirectional or even that households completely abandon one fuel and substitute it for another. Therefore, Masera et al. (2000), put forward an alternative model that proposes to look at multiple cooking strategies.

Masera et al.’s (2000) multiple fuel model states that there are various interacting economic, social and cultural factors that explain—or rather, determine—household energy use patterns. Therefore, a linear transition to cleaner fuels is hardly achieved but rather, households become involved in ‘fuel stacking’. Fuel stacking is the term used to describe multiple fuel use patterns (Masera et al., 2000) and it means that various cooking fuels are used at the same time albeit for different purposes. As a result, rather than fuels being abandoned and substituted for cleaner ones a combination of fuels is used. For example, Masera et al. (2000) states that improved cookstoves, such as the Lorena stove, are unfit for cooking traditional dishes such as tortillas, therefore, people revert back to their traditional cooking practices for such specific dishes.

Another possible explanation for household energy patterns is Foley’s (1995:17) ‘energy demand’ ladder stating that, ‘the demand for energy is derived from that for the services it provides or makes possible’. In other words, fuel choice is determined by the purpose of the appliance. When income increases, the need for different appliance expands, broadening energy needs as well. Figure 3, for example, shows how an increase in income corresponds to a more diversified use of appliances and fuels. The most basic form of energy—or the traditional/vital form of energy—is used for cooking, heating and lighting. As income rises and those vital necessities have been filled, households start to buy basic appliances and make use of refrigeration, which requires electricity; meanwhile biomass is still to fulfill the vital needs.

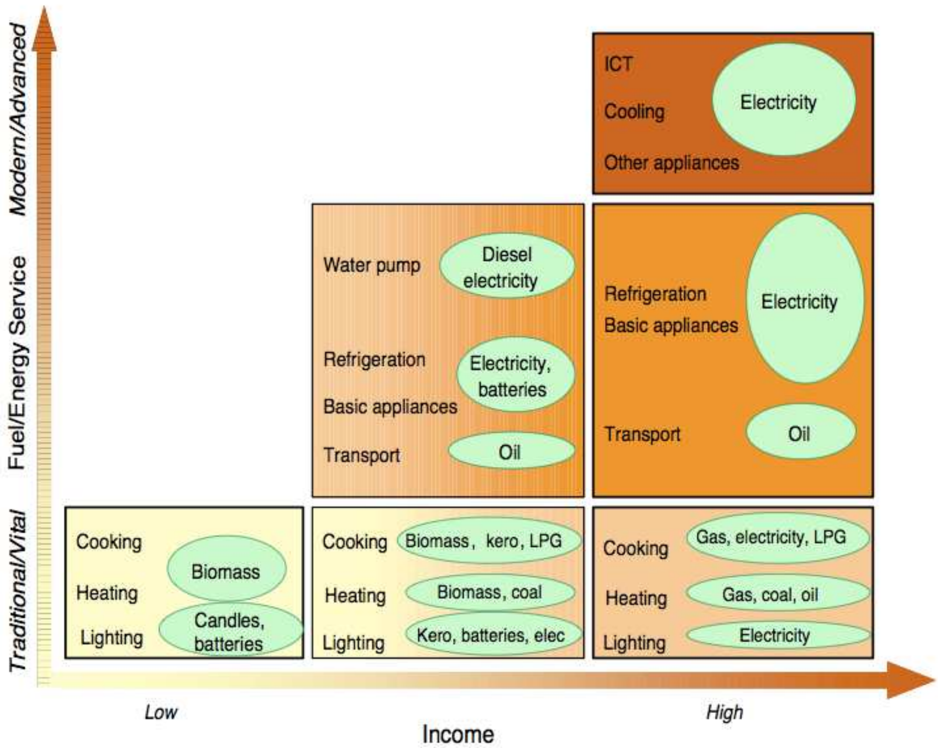


Figure 3 Foley's Energy Demand Ladder Model. *Source: Hosier (2004:425)*

### *2.2.3 Determinants of Energy Choice*

The previous section looked into the theory behind household energy transition to better understand the steps households take when acquiring cleaner fuels and new cooking practices; this section will look at determinants of energy choice. Over the years, studies have continued to focus on household energy transitions and the socioeconomic determinants that induce fuel switching (Brouwer & Falcao, 2004; Heltberg, 2004; Ouedraogo, 2006; Hiemstra-van der Horst & Hovorka, 2008; Mekonnen & Kolhin, 2008; van der Kroon et al., 2011). The previous studies evaluate how households' social, economic, and cultural backgrounds affect or even control fuel choice and use. Therefore, this section looks specifically at the factors that play a role in determining household cooking. Kowsari and Zerriffi's (2011) division of determining factors is rather clear and therefore will be used as a model to structure this section, which will be divided in two sub-sections (Figure 4): endogenous and exogenous factors. Within these sections, categories will be used to further distinguish the factors. Yet the main focus will lie on endogenous factors, as they will help answer the research question. Exogenous factors will be briefly discussed, as they are also important but lie outside the boundaries of this study.

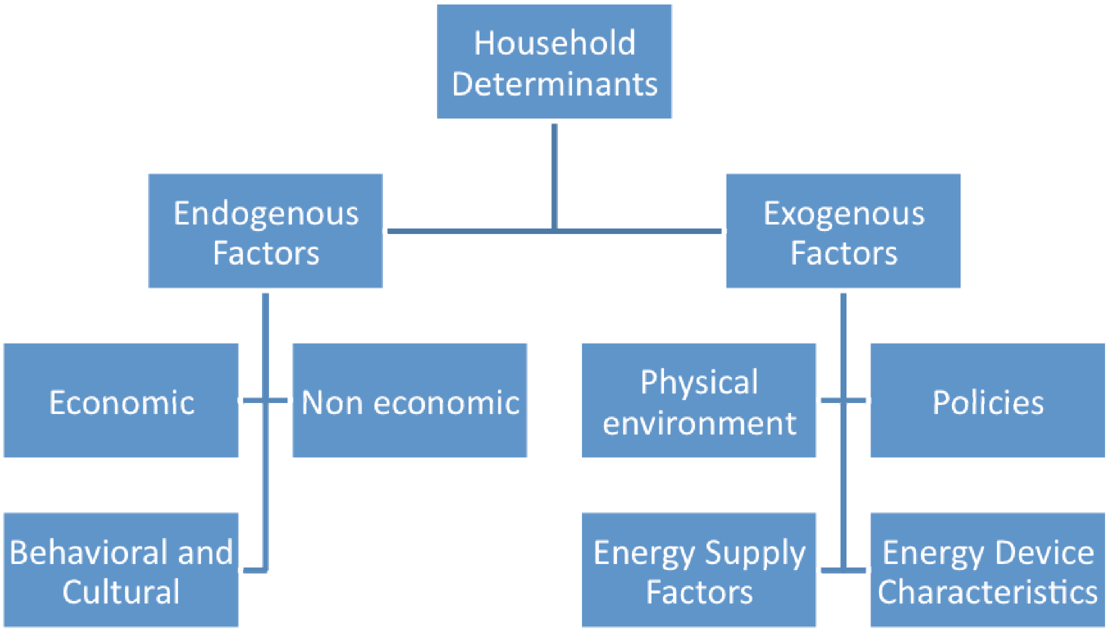


Figure 4 Types of Household Determinants

*Endogenous Factors*

Endogenous factors are those that pertain to the household level—or the so-called 'household characteristics'. The different factors will be subdivided into three sub-categories: economic, non-economic, and behavioral and cultural characteristics.

*Economic Characteristics*

Household income and other indicators such as household expenditure—used to describe a household's economic situation—are two of the most common factors used to explain fuel switching (Brouwer & Falcao, 2004; Heltberg, 2004; Ouedraogo, 2006; Hiemstra-van der Horst, 2008; Mekonnen & Kolhin, 2008). Capital is described as one of the contributing factors for fuel switching but not specifically or necessarily the most important one. The overall trend found on the effect of household economies on fuel switching shows that poorer households do consume more firewood than richer households and that richer households consume more LPG or electricity than poorer ones. However, it does not fully validate the energy ladder model as it also states that more fuels are added to the energy mix when income increases rather than having households fully switch to cleaner fuels and abandoning their previous, more traditional fuels. This is what in the previous section was referred to as the multiple fuel model.

*Non-economic Characteristics*

Household's social characteristics such as household education—which also measure human capital—is positively correlated with modern fuel consumption according to studies (Heltberg, 2004; Ouedraogo, 2006; Rao & Reddy, 2007; Mekonnen & Kolhin, 2008). Age and household size and composition, for example, also fall under the social category. The trend shows that as a household's education level rises, the usage of biomass as the main fuel of choice is more likely to decrease. Mekonnen & Kolhin (2008), stress that as education increases so does the chance of using electricity or kerosene as main source of fuel. This comes to show that through education households possibly become more aware of the advantages of using cleaner fuels or at least learn of the disadvantages of biomass.

Lack of awareness and education, therefore, can lead to prolonged biomass use as primary fuel (Schlag & Zuzarte, 2008). Households are often not aware of the negative externalities that arise from biomass use and the benefits that accompany modern fuels. Awareness campaigns and public education both therefore play a decisive role in promoting the switch to alternative cooking methods.

*Behavioral and Cultural Characteristics*

Behavioral and cultural characteristics affecting household fuel choice are important to consider yet often excluded in investigations. Nonetheless, there are some studies that look into cultural factors such as food preparation and traditional customs, either to explain the prevalence of biomass as preferred fuel of choice or to account for the low adoption rates of cleaner fuels (Masera et al., 2000; Israel, 2002; Gupta & Kolhin, 2006; Ouedraogo, 2006; Joon, et al., 2009; Victor, 2011). The distinct flavor attained by foods cooked with either charcoal or firewood is by many considered to be better than the taste of food cooked with gas or electricity. When cooking traditional foods such as bread (Chapatti) in India (Joon et al., 2009) and tortillas in Mexico (Masera et al., 2000), interviewees preferred the taste these foods acquired when cooked with biomass rather than LPG. This shows that income is not the sole driver of energy transitions and that some deeply rooted cultural traditions—specific to each household or even to each person—play a crucial role too.

Another cultural factor that can hamper energy transition is the patriarchal system (El Tayeb Muneer & Mukhtar Mohamed, 2003; Schlag & Zuzarte, 2008). In patriarchal societies, men are always heads of households and therefore responsible for making financial decisions therein—positioning them at a higher social stance. Although El Tayeb Muneer & Mukhtar Mohamed (2003) and Schlag & Zuzarte (2008) both agree that women are responsible for household chores which include cooking, they diverge in stating who is responsible for making small purchases such as food and fuel. The latter study states that women do not control any financial part of the household economy and therefore depend on the head of the household to allow certain purchases, whereas the former study claims that women are in charge of a small part of the household income—that which is related to cooking. This divergence in findings could have negative repercussions on stove dissemination programs because the recommendations for the first study would be to target women as fuels and cooking fall under their department whereas the second study would recommend targeting men as they are responsible of the household finances. Therefore experts might target the wrong group depending on which study they base their opinions from.

*Exogenous factors*

Other important factors determining fuel choice are the exogenous factors. These factors are those that lie outside the household domain and are considered external conditions that have an effect on fuel choice. As these factors lie outside the scope of this research, only a brief mentioning of each of the main driving forces will be presented.

The first exogenous factor is physical environment meaning the specific country context and how, it location for example, affects energy use patterns. Urbanization for example has been shown to play a positive effect on modern fuel adoption (Hosier & Dowd, 1987). Climate also falls under this category as countries that have a higher temperature variability tend to use more biomass—as it is also used for heating (Schlag & Zuzarte, 2008).

The second exogenous factor is energy policies and regulations which refers to both government and market interventions or involvement that have a direct or indirect effect on energy use patterns. The case of Senegal's butanisation program is an example where modern fuel adoption was sparked through government intervention (Schlag & Zuzarte, 2008). The government implemented a project in the 1970's that provided subsidies for LPG fuel cylinders and taxed petroleum products. Through this, the government was able to incentivize fuel switching as the cost of switching was less than staying with biomass. As of today the subsidies have been eliminated yet the market is continuing to grow, albeit at a slower pace.

The third factor is energy supply factors which relates to availability, affordability, accessibility and reliability of fuels (Kowsari & Zerriffi, 2011). There are several important factors falling under 'energy supply factors' that determine fuel switching. The price of traditional fuels compared to modern fuels is considered an important driving force for fuel switching (Mekonnen & Kolhin, 2008; Schlag & Zuzarte, 2008). Fuel costs—which can be influenced by high transport costs, national policy and other factors—can encourage or discourage biomass use. As charcoal and firewood are accessible, available and affordable in urban and rural areas, a switch to modern fuels is not encouraged as a need for an alternative is not felt.  Another important factor according to Heltberg (2004) and Ouedraogo (2006) is electrification– as soon as people have access to electricity, the use of biomass as main fuel choice decreases. Electricity, as infrastructure are less developed in rural areas, therefore play a greater role in determining accessibility (Schlag & Zuzarte, 2008).

Finally, determining factors can also deal with characteristics that are specific to each device—or the ‘energy device characteristics’. Under this category, technical factors such as stove cost, stove design and adapted cookware are studied Schlag & Zuzarte, 2008). Device characteristics also refer to the acceptability of the stoves; about this Aguilar (1990) states that stoves need to be adapted to the use and not the user to the stove. Additionally, ICS need to be produced locally with local products and fit the user’s needs. In their study, Masera et al. (2000) found that often switching to LPG does not only involve an investment in the stove but also in the cookware as many of the utensils used in traditional stoves are incompatible with LPG stoves.

### *2.2.4 Household Energy Transition & the Multiple Determinants of Energy Choice*

From the previous literature we can observe that the transition from primitive to modern fuels is far more complex than depicted in the energy ladder model. First, there are theories other than the energy ladder model that assert that fuel use patterns are not explained solely through income. Second, determinants of energy choice—divided in two overarching categories—are responsible for shaping household energy use. Third, the transition to cleaner fuels is not always directional as it is also not always a full switch to a cleaner fuel but often a partial switch, or as Masera et al. (2000) would put it, a use of ‘multiple cooking strategies’. These “push and pull” factors that are determined by endogenous and exogenous factors make households move back and forward on the energy ladder.

It is important to note however that there are some gaps in the literature that should be looked into further. The present literature is still very much geared towards income and affordability—therefore studies measuring factors other than economic capital must be further researched. For example, cultural and behavioral factors are often ignored and little is actually understood of individual choices that continue the use of biomass (Foell, 2011). Studies on consumer choice, therefore, would add greatly to the study of household energy transitions as it would provide deeper insights on how women feel about using certain fuels and their actual struggles. Studies that merge endogenous and exogenous factors are also missing, as studies often focus on either one or the other but often do not link them. The problem with this strict divide is that household and country contexts are not seen as complementary units that interact and affect the other but as separate factors. This can ultimately lead to wrong interpretations of fuel transition obstacles.

## 2.3 Cookstove Technologies

Having presented the theory behind household energy, which looks into at household energy transition and behavior and also at the different determinants for fuel switching, we move onto stoves as without stoves the act of cooking could not be done. This section will first introduce the link between fuels and stoves and clarify some stove terminology; after this has been presented the section will then dive into the topic of stove dissemination and adoption programs and finalize with the effects of stoves and fuels.

Making a clear distinction between fuels and stoves is a challenge; therefore the UNDP (2004) 'energy chain' model will be used to help illustrate the relation between them. The 'energy chain' depicted in Figure 5 shows the different categories present in the energy chain. In this chain, biomass, natural gas and solar—to just name a few—are considered 'sources' of energy; electricity and biofuels are 'carriers' and stoves are the 'end-use equipment'; this is all comes together to provide the ultimate 'service' which in this case is cooking. In other words, 'sources' are considered raw forms of energy whereas 'carriers' are already processed forms thereof—the 'end-use equipment' is the appliance which requires either form of energy to operate.

This energy chain shows how all processes are interrelated and therefore dependent on each other. Nonetheless, as the focus of this report is first on ICS and second on fuels, a larger focus will be placed on the health and environmental impacts caused by the 'end-use equipment' rather than on the 'sources' or 'carriers'. However, it should be made clear that as these elements are all complementary it is nearly impossible to disaggregate them. Therefore, a mention to traditional stoves' negative impacts also comes accompanied with the assumption that biomass combustion also plays a role in exacerbating these effects.

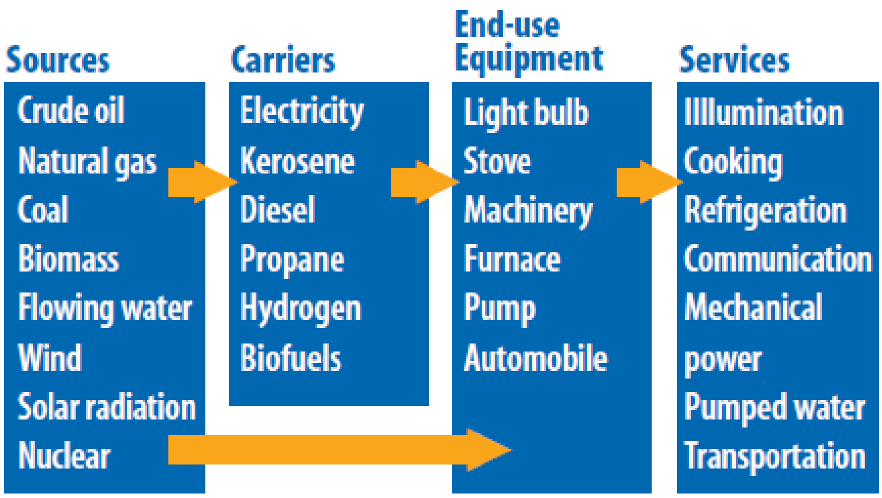


Figure 5 The Energy Chain *Source: UNDP 2004*

Continuing onto cookstove definitions, a clear differentiation between stoves has to be presented before discussing other stove matters. Below, a definition of each category of cookstoves and some examples:

- Traditional Cookstoves (TCS): the most rudimentary types of stoves are the Three-Stone stove and the U-shaped fire—seen most frequently in rural areas. The metallic charcoal, more common in urban areas, is also considered a traditional stove because as the two previously mentioned, it produces a lot of smoke, consumes a lot of fuel and is energy inefficient—using only 5-10% of the energy (Barnes et al., 1994).
- Improved Cookstove (ICS): ICS are considered one step up from TCS. They often locally developed, contain some energy and fuel saving, and produce less smoke. The ICS under study in this research is the POCA stove which is further described in Box 1. The Kenyan Jiko and the Mozambican POCA (Figure 6) are also two examples of ICS.
- Advanced Cookstove (ACS): ACS are often manufactured in developed countries with more sophisticated technologies. Stoves as the StoveTec and EnviroFit would fall under this category.
- Modern Stove: Any stove associated with modern fuels such as LPG and electricity are considered modern stoves.

**BOX 1**. The POCA Stove

The POCA stove (Figure 6) is an improved charcoal stove fabricated in Mozambique and will be used as the reference 'improved stove' for this study. The POCA stove is build from ceramic and consumes 33% less fuel than the standard metallic charcoal stove. The average lifespan of the POCA is 3 years and costs between US $8-12.

The main findings of ProBEC's study (Tamai Chidamba, 2010) were the following: half of the respondents use a combination of LPG and charcoal. The money saved from fuel is often used to buy household goods and rarely for small informal business investments. Consumers confirm POCA's fuel saving and time saving capacity (95% and 94% respectively). Additionally, 80% of respondents claim that it emits less smoke. Some of the disadvantages respondents stated from the POCA was that the material was weak and therefore prone to breakage and because it has no legs, cooking had to be done either bending over the fire or sitting down—a practice which is not accustomed in Maputo.


Figure 6 The POCA Stove

*2.3.1 Stove Programs and Adoption*

Interest in household energy started to develop in the 1970's and was mainly triggered by the perceived connectedness between deforestation and household biomass use (Bailis et al., 2009). During this period, the world energy crisis was also taking place, creating raised awareness on the subject of household energy (Barnes et al., 1994). Donor organizations, with the help of stove producers, therefore started investigating how to reduce biomass demand and develop better alternatives to help alleviate the pressure on the environment, or in other words: forests.

Many stove programs have been implemented throughout the years—the majority, however, has not proved to be successful or sustainable after the withdrawal of donor funds (Bailis et al., 2009; Venkataraman et al., 2010)). Reasons for project failure are many as each site encounters distinct problems. However, the main assumptions that can be drawn from the literature conclude that the needs of target populations were not thoroughly studied beforehand and that failure to test the stoves also added to the causes of stove program failure (Adkins et al., 2011). Stove programs were often transferred from area to area presuming that one specific stove would also work and serve the needs of people in another area without testing it beforehand. The main critique towards stove programs was that 'experts' assumed stove models to have a universal fit—a 'one-size-fits-all' model. The realities in the communities however hold that 'traditional modes of cooking serve a number of socio-cultural and practical functions' which were often ignored by experts (El Tayeb Muneer & Mukhtar Mohamed, 2003:261).

Program failure could also be attributed to cultural reasons, as the stoves being introduced were often not compatible to traditional customs. Masera et al. (2000) found that LPG stoves were not fit for cooking tortillas which traditionally was prepared over an open fire. El Tayeb Muneer & Mukhtar Mohamed (2003) blame low cookstove adoption to wrongful targeting—meaning that men were targeted for cookstove demonstrations and training courses whereas the women were mainly responsible for all kitchen and household tasks.

For stove programs to be more successful and for adoption rates to be higher, a series of studies need to be conducted to analyze consumer behavior and preferences before the stove is introduced to the field. Programs need to target areas where there is an actual fuel shortage; stoves need to be produced locally and at affordable prices, stoves need to live up to the reduced consumption that they advertise; and stove design needs to be compatible with cultural preferences. The last requirement—stove design—is of the essence as it will only lead a changeover to ICS when they are 'appropriate' and when they fit the needs of the user in a way that local products and labor are used and that it respects local traditions (Troncoso et al., 2007).

### *2.3.2 Effects of Stoves & Fuels*

#### <u>*Environmental Effects*</u>

Certain practices associated with the use of biomass and cooking are considered to pose a threat to the environment. These practices can surge from the production and harvesting of biomass or from the combustion of traditional fuels. Firewood does not pose an immediate threat to the environment, as deadwood and woodcut are the main sources collected and used for cooking (IEA, 2006; Cuvilas et al., 2010; Sawe, 2012). Charcoal production, on the other, hand poses a strong and immediate threat to the environment (Cuvilas et al., 2010). According to experts, it takes 7-10 kg of firewood to produce 1 kg of charcoal (BEST Mozambique, 2012). Therefore, the combined effort of high charcoal demand—whose production is harmful for the environment—and inefficient TCS—which requires a larger supply of fuel—aggravates local deforestation which also leads to land degradation, desertification, decreased biodiversity, among other problems (WHO, 2006; Cuvilas et al., 2010).

The combustion of biomass alongside the use of inefficient technologies such as TCS also has negative effects on the environment as it creates byproducts of incomplete combustion (Ezzati et al. 2000). Methane, carbon monoxide, and higher hydrocarbons—all powerful GHG—are all products of incomplete combustion (WHO, 2006; GACC, 2011)). "When combining the emissions of $CO_2$ and other GHG in a single index, wood, crop residues and dung score much higher than fossil fuels, such as kerosene and liquefied petroleum gas (LPG)" (WHO, 2006:23). The link to cookstoves is that whereas an ICS or ACS would require 1-2 kg to cook one meal, a TCS due to its low efficiency would require double the amount (R. Mirira, personal communication, May 14, 2012)—this in turn aggravates the effect on the environment.

Therefore, using ICS is beneficial for the environment as the overall amount of wood or charcoal needed to cook an average meal is reduced by up to 50%. This results from stoves that are heat retaining and efficient. If stove programs are implemented at a national level, ICS can help reduce the supply and demand of biomass—leading to decreased deforestation (Manibog, 1984).

*Socioeconomic and Health Effects*

One of the largest threats posed by biomass combustion is to human health, which has a direct effect on human welfare. Indoor air pollution (IAP) resulting from biomass fuel combustion is ranked 4$^{th}$ in the World Health Organization (WHO) top-10 list of global health risks—responsible for 1.5 million premature deaths per year (IEA, 2006). The severity of the damages to health caused by IAP depends on three indicators: source of pollution, pollutant dispersion, and time spent indoors (IEA, 2006). The first deals with fuel and stove type, which in this case is biomass and TCS. The second indicator deals with the type of house and how well ventilated it is. And the third looks at the time different household members spend indoors cooking or in direct contact with smoke. In other words, using primitive fuels as animal waste will have a higher negative effect than charcoal, which is considered a cleaner fuel. However, it also depends on where the cooking takes place; cooking outdoors and in well ventilated areas can greatly reduce the risk of respiratory disease whereas cooking in an enclosed place can exacerbate the problem. Ultimately it is the women and children who are primarily affected by IAP as they are in constant contact with biomass combustion smoke from being involved with cooking or, in the case of children, being around the fire while its burning.

According to WHO (2006), there is strong evidence indicating that IAP produces acute infections of the lower respiratory tract in children aged 0-4—where those exposed being 2.3 times more likely to suffer from such infections than children that are not exposed to IAP (WHO, 2006). Women are also more likely to suffer from chronic obstructive pulmonary disease and lung cancer—their relative risk being 3.2 and 1.9 respectively (WHO, 2006). As ICS reduce the total amount of fuel consumed it also reduces health effects. There are also specific types of ICS that have chimneys so that the smoke produced is funneled and released outside the house and not inside the kitchen helping alleviate some of the harms of IAP.

ICS use also has benefits at the household level as reduced fuel consumption from ICS reduces households' expenditure on fuel purchases. This obviously depends on whether firewood was collected or bought in which case rural areas—or where firewood is mostly collected—would not benefit. Urban areas on the other hand can greatly benefit from fuel purchase reductions. In a case in urban Rwanda, households were able to save $113 over an 18-month period with their ICS (Barnes et al., 1994). Cooking time is also reduced with ICS as they are better at retaining heat, therefore cooking becomes faster, this allows women more time to perform other household tasks.

## 2.4 Previous studies on 'Willingness to Pay'

Much research has been done on household energy transition, however, research centered on WTP of household energy and ICS is less abundant. Although there is much research on household fuels and the economic determinants that hamper its transition to cleaner fuels, focus on the device itself, the ICS, its market potential and WTP is lacking.

Adkins et al. (2010) is the only study to my knowledge that incorporates WTP for ICS in their methodology. The authors performed a study in which WTP for four different ICS and ACS—namely the StoveTec and the Ugastove in Uganda and the StoveTec, EnviroFit and Advent stove in Tanzania—was investigated. Nonetheless, the only stove that would be comparable to the stove used in this study—the POCA stove—is the Ugastove as the other stoves are considered ACS and not ICS. The study had two major components: a technical and a user-survey component—WTP being included in the latter component of the study. The aim of the study was to test stove preference, performance and usability. Ultimately, however, the study also stresses, 'a combined use of quantitative stove tests in combination with qualitative surveys in efforts to determine suitability of cookstoves for household use in a given community' (Adkins et al., 2010:172). The technical part of the study, investigating aspects such as biomass consumption and cooking time of the above-mentioned stoves compared to the three-stone fire, will not be discussed as it covers areas which were not tackled in this research. The focus will be on the user survey administered in this study.

Both study sites–Uganda and Tanzania–have a very similar methodology[2]. Households were chosen at random from an existing database provided by the Millennium Villages Project. In Uganda 24 households were surveyed whereas 30 in Tanzania. The survey, which included qualitative and quantitative elements regarding stove acceptability, comprises two sections (1) stove preferences and (2) cooking practices—WTP being part of the former.

The first section investigated stove design, ease of use and price. The four questions asked related to stove ranking, evaluation of each stove type, time/effort for tending, and WTP. The second section looked deeper into cooking practices and the equipment used for cooking. The topics covered were: pot size, cooking with multiple fires, and effect of ownership of manufactured stove(s) on use of three-stone fire.

Adkins et al. (2010) conducted a closed-ended, double-bounded dichotomous choice contingent valuation. The authors proceeded with conducting the WTP in the following manner; respondents were asked 'whether they would purchase the improved stoves at three prices representing a) 0-25% subsidy, b) roughly 50% subsidy, and c) roughly 65-75% subsidy' (Adkins et al., 2010:174). In other words, respondents were first asked whether they were WTP $17.50, then asked whether they would be WTP $10 and finally whether they would be WTP $5 for the different stoves. In both study sites, the retail price of the StoveTec, Ugastove and Advent stove ranged between $17-24, yet with a more conservative estimate of $20-22; the retail price of the Envirofit was $35. The main finding was that around 60% of respondents would pay $10 for the StoveTec (in both study sites) and the Envirofit (in Tanzania). WTP for both the Ugastove and the Advent stove was very low. Figure 7 shows in more detail the WTP for both study sites.

[2] Changes in methodology were that ICS tests in Uganda were on the StoveTec and Ugastove only, whereas in Tanzania a larger variety–StoveTec, Envirofit and Advent stove–was used; this was mainly due to availability of ICS in the local market. Both study sites did, however, compare the different ICS to the three-stone fire. The second difference is that in Tanzania and Uganda most often food cooked was tested, whereas in Tanzania the food that took the longest to cook was also tested.


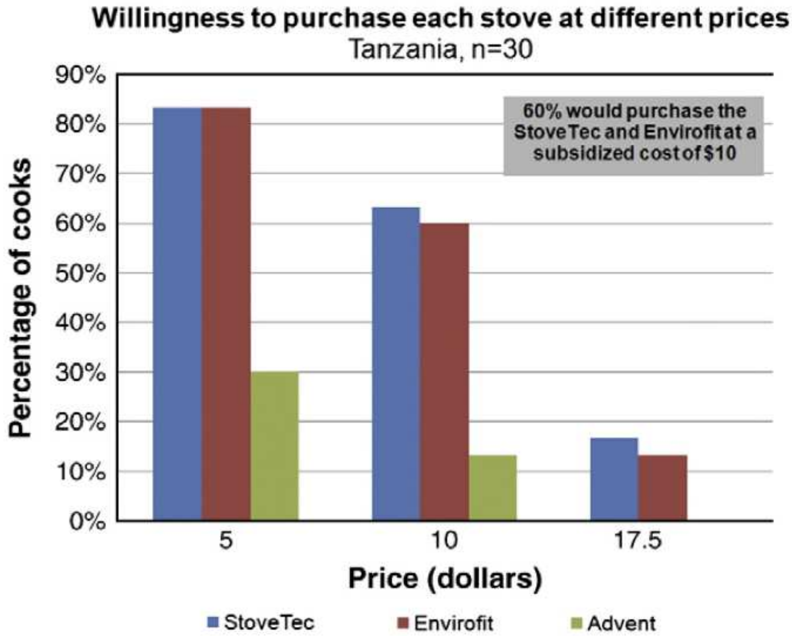


Figure 7 WTP graphs for the different ICS in Uganda (top) and Tanzania (bottom) *Source: Adkins et al. (2011:178 & 183)*

From Adkins et al. (2010) we can conclude that WTP for ICS is rather low and that a subsidy program would have to run alongside the dissemination of stoves, as consumers either cannot afford their retail price or are not willing to make that investment. Even though the authors say that the results have a 'potential for scaling up' as savings of fuel were verified and the villagers were interested and WTP for ICS/ACS, the stainability of the stove programs was not mentioned, even though without subsidies, these stove programs would be unsuccessful.

One of the main strong points of Adkins et al. (2010) is that stoves were actually introduced in the villages, therefore giving people time to get familiarized with the various stoves and in the end be able to give a more accurate and educated estimation on WTP. Another strong point of the article is that it is very complete in terms of data collection. Data was collected in both quantitative and qualitative form, stoves were tested in the field and people's perceptions and behaviors were also tested. One weak point is that the cultural aspect behind stove acceptance was left out. Although there was some inclusion of 'cooking practices'—which can be seen as part of the local culture—further and deeper enquiries on cultural issues were not included.

# 3. METHODOLOGY

## 3.1 The General Approach

From the Literature Review we can observe that the study of household energy contains elements that are easily measurable—as types and prices of fuel—yet also contains elements that are more difficultly quantifiable as they involve the study of human behaviors and reasons for fuel transition. The aspect of household energy that deals with fuel types, prices and—amongst others—frequencies, are easily measureable and quantifiable; however, the aspects that deal with human action and behavior are not as easily quantifiable and therefore require an interpretative approach. As the expected answers from the research questions presented in the introduction are more than descriptive, the approach to analyzing the results cannot also be one-dimensional. Therefore, different approaches will be taken to tackle the questions appropriately and to ensure their validity. Figure 8 shows a schematic overview of the different steps taken in order to answer the research questions.

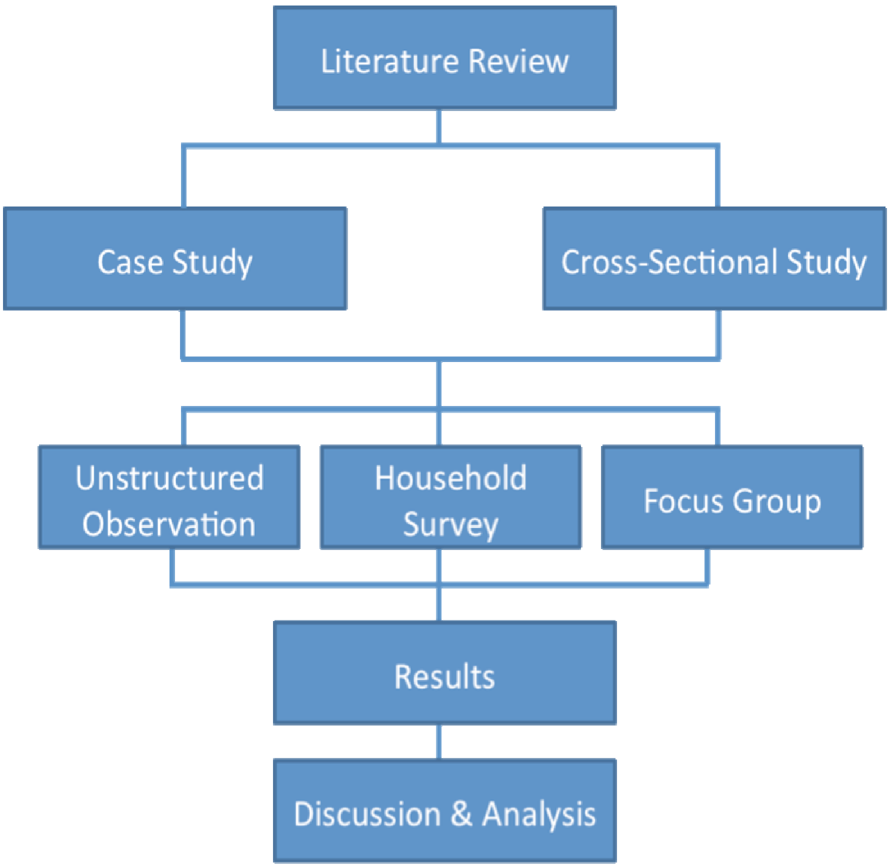


Figure 8 Methodology Approach

## 3.2 Design Frame and Methods

This research takes on a mixed design frame containing case study and cross-sectional study elements as well as a variety of data-collection tools. Mafalala, a Maputo neighborhood, is the case under observation for this research. Through this case study approach, detailed knowledge of households' energy use is explored and with this, the complexities of fuel-use captured. One of the strengths of using a case study approach is the utilization of a variety of research methods and being able to use triangulation as a way to justify the results (Johansson, 2003). The second design frame used in the methodology is cross-sectional, as the households are investigated in one point in time and compared to each other.

Additionally, in order to capture the complexities of household energy use patterns, three data-collection methods were used: unstructured observation—which falls under the exploratory part of the research—household surveys, and a focus group. The different research methods will be presented in chronological order—therefore beginning with exploratory research, followed by the household questionnaire and ending with the focus-group interviews.

### *3.2.1 Study Site: Mafalala*

Mafalala is a neighborhood of 20,000 inhabitants located in Maputo's peri-urban areas. The neighborhood is divided into blocks, as seen in Figure 9. The neighborhood houses middle/low- and low-income families and was chosen to conduct research for a number of reasons. First, the neighborhood houses people that form part of the BoP—therefore our target group. Second, it displays a variety of cultures and ethnic backgrounds including languages such as the Ronga and Shangaana. Third, it is easily accessible from the city as it is less than 5km away from the center—or a mere 10-minute bus ride. And fourth, previous contacts were already established in the area—facilitating the research and allowing the focus groups to be performed there as well.

### *3.2.2 Unstructured Observation (Exploratory Research)*

The first data-collection method was unstructured observation and was conducted on May 14, 15 and 17—to get a more thorough understanding of the city of Maputo and its people, as well as the stove and charcoal markets, and the neighborhood of Mafalala. Key informant interviews (KII) were also conducted in two occasions—the first with a biomass expert and the second with a Mafalala housewife.  The main findings from the KII were: (1) the prevalence of charcoal in the country for a vast array of social, economic, and cultural reasons; and (2) Maputo does not have a developed ICS market and therefore ICS are not present in households. Although the exploratory research phase was not highly structured or well documented—some notes and pictures were taken—having taken the time to explore the different areas instead of diving straight into data collection positively influenced questionnaire design and ultimately the development of this report.

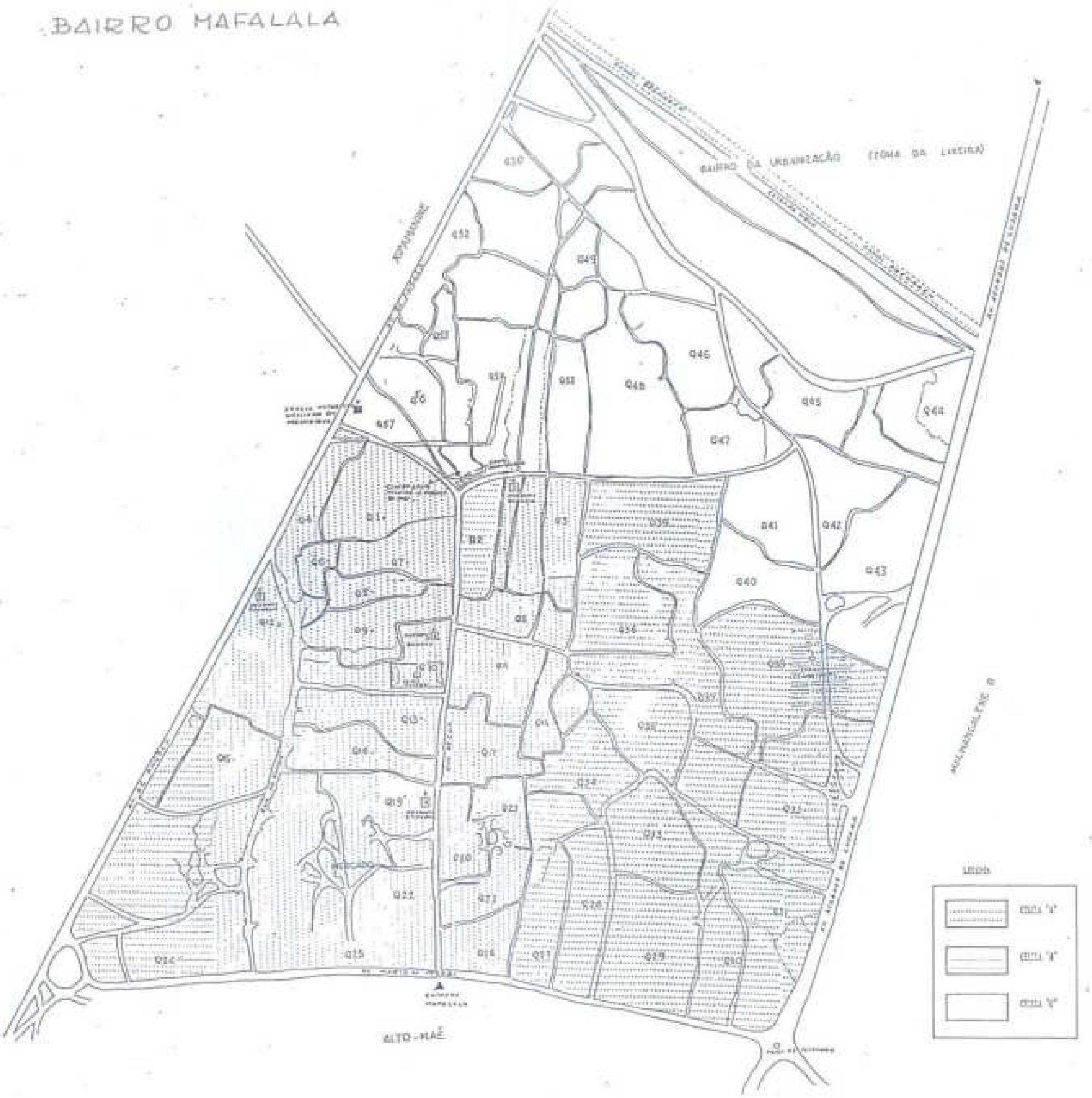


Figure 9 Map of Mafalala

*3.2.3 Household survey*

The quantitative part of the research was conducted through a structured household questionnaire performed in Mafalala between May 23rd and June 4th, 2012. A 6-step approach, which can be visualized in Figure 10, was used to design and carry out the survey.


Figure 10 Steps in Survey Design

<u>*Sample Design and Survey Mode*</u>

Official information on neighborhood demographics is lacking, therefore, a detailed explanation of the neighborhood dynamics is difficult to present. The only point that can be said with certainty is that Mafalala inhabitants are usually in part of the middle/low and low-income strata of society.

A map of Mafalala was provided by the neighborhood Secretary and was used as a guide to conduct research. Every morning each team visited a different block. The houses within these blocks as well as the blocks were chosen at random.

Sample size for this study is 70 observations. The unit of sampling is the household as members of the same household will always have the same fuel consumption patterns. As we found that each household has an average of 7 people, this means that some basic fuel and stove information for 490 people was documented. Nonetheless, this is still not a large enough sample for our data to be representative. The response rate was very high, although records were not kept on the amount of people that refused to answer; an estimate of less than 5 people throughout the entire surveying period seems plausible.

Surveys were conducted in person in the neighborhood of Mafalala for two consecutive weeks. The questionnaires were administered in two teams—each team with one of the people responsible for designing the survey (Kleijn or Risseeuw) plus a Mozambican translator. Due to some scheduling issues with one of the translators, surveys could only be conducted from 8:30am – 12:00pm each day, limiting the responses to 6-9 households per day.

*Survey Materials*

The survey, which can be seen in full in Annex I, was divided into six sections.

1. Fuel Information
2. Stove Information
3. Awareness Questions
4. WTP/ICS
5. Cooking Information
6. Household Characteristics

The survey was designed to cover several aspects of household energy use and ultimately see the relationship between WTP for ICS and several socioeconomic and cultural variables. The first two sections looked into respondents' current energy practices. Fuel types were identified and frequency of use measured. Information on stove types was inquired as well as price, reason for use and period of use. Health and Environment questions, asked in the third section—previous to the WTP—to test respondents' knowledge on the harms of cooking with charcoal. Section four, the WTP section, first started with some awareness questions to test whether respondents knew of the advantages of cooking with ICS. Then continued by giving a short description of Maputo's charcoal dependence, followed by a description of the advantages of the POCA Stove. Finally, respondents were asked whether they were interested in purchasing the stove and what their maximum WTP would be. If respondents were not interested in purchasing the Poca Stove, a follow-up question asked the reason why. The last two sections looked into cooking behavior and demographic characteristics.

The survey had a combination of open- and closed-ended questions. Questions on respondents' ideal fuel type and the reason why was left open to also receive some qualitative information. These answers were then categorized and finally quantified, albeit with little success. The question on WTP however, was open-ended—asking respondents to state their maximum WTP. Additionally, a payment card was not shown—a practice otherwise common to Contingent Valuation studies.

*Execution of Survey*

The first draft of the household questionnaire was pretested on May 21, 2012. The purpose of conducting pretests was to ensure that participants were able to respond to the questions without a large level of difficulty. After the pretest, questions were modified and rephrased to ensure clarity. The second draft of the household questionnaire was conducted on May 23, 2012. This survey was much easier to administer and for respondents to reply—taking between 20-30 minutes to complete. Although some minor changes were made between the second draft and the final draft the changes were trivial and therefore not mentioned. The responses from the second draft were entered as data for this report.

During the surveying period various ethical considerations were taken to respect the inhabitants of Mafalala. Peoples' consent was always asked before starting a survey. When participants seemed hesitant about participating they were reassured by the interviewers, however, if hesitation persisted interviewees were kindly thanked for their time and interviewers continued onto a different household. This however did not occur often, as most households were eager to participate and very hospitable–offering chairs and once even receiving some fresh 'coconut bread'. In relation to the data collected, great care was taken in entering the data to excel and avoiding any mistakes. The data was not in any sense fabricated or falsified.

*Data Preparation and Data Analysis*

Data was entered into an Excel file after each day of surveying. After all responses were entered, data was verified. There were two outliers in the 'WTP in installments' question were respondents claimed to be willing to increase their WTP to MT 4,000. The average including these two numbers was MT 600 and without them it dropped to MT 500, therefore the responses were deleted allowing for a more conservative and accurate number.

Results from the data collected in the questionnaires were analyzed using SPSS—although data was first entered to Excel. Basic calculations to describe the numerical data were first performed; followed by more in depth analysis to estimate statistical relationships between variables and predicting outcomes from variables.

The descriptive and derived statistics were analyzed first to generate the main survey results. In this step, socio-economic data from the households (Survey Section 6), information on fuels and stoves (Survey Section 1 & 2) were combined, as well as the cooking and cultural considerations (Survey Section 5). Data was simplified, organized and calculated. This section dealt primarily with reporting the general results of the survey.

SPSS was also used to perform inferential statistics. Apart from conducting a multiple regression analysis (MRA)—to predict the outcome of the WTP by using various predictor variables—correlations between variables were examined. Using Pearson's correlation coefficient led to insights about the relationships between the variables. Independent t-tests were used throughout the analysis to check for differences between groups in regards to WTP and other variables. These methods were used to explore significant relationships between variables to later justify including them in the MRA.

Through MRA, "an outcome is predicted by a linear combination of two or more predictor variables" (Field, 2005:738). This means that we try to predict people's WTP from a range of socioeconomic variables. The variables used to derive the MRA are presented next and also presented in Table 1. The reasoning behind including these variables was also previously presented in Section 3.1.4 where the determinants for energy choice, according to literature, are listed and explained. Cultural variables were not included in the regression equation because they were difficult to measure and harder to quantify. The model used for the MRA was the following:

$$Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + .... + \varepsilon_i$$

In the above model, Y is the outcome variable which for this research is WTP for ICS. The $\alpha$, $\beta_1$ and $\beta_2$ are all parameters; $\alpha$ represents the constant, the $\beta_1$ and $\beta_2$ are coefficients for the predictors $x_1$and $x_2$. Therefore, $x_1$and $x_2$ represent the predictor variables, which are stated below and range between 5 and 8 variables as the MRA was run 3 times with a different combination set everytime. Finally, the $\varepsilon$ represents the residual between predicted and observed value for the outcome variable (Field, 2005).

*Measurement and description of variables:*

*Willingness to Pay (WTP)*: is the dependent variable and is measured as a continuous variable. Respondents were asked to state their highest WTP for the POCA Stove.

*Sex:* we expect women to have a higher WTP than men as they are the main beneficiaries of ICS. Sex was measured in the following way: 0 = female; 1 = male.

*Age*: we expect age to have a negative effect on WTP (Ouedraogo, 2006). In other words, older people have a lower WTP. Age is measured as a continuous variable.

*Income:* we expect income to have a positive effect on WTP as literature shows that as income increases, so does fuel of choice (Hosier & Dowd, 1987). Income was originally measured in five categories: MT <2,500; 2,500-5,000; 5,000-10,000; 10,000-30,000; and >30,000. The reason behind using an income scale was because of ethical considerations. However, for the MRA, the income categories were transformed to a numerical scale by taking the average of each category.

*Education*: we expect education to have a positive effect on WTP meaning that households with higher levels of completed education are expected to have a higher WTP for ICS (Heltberg, 2004). Education was measured in categories and included in the MRA as an ordinal scale where 0 = no formal education; 1 = primary education; 2 = secondary education; 3 = higher education.

*Household size:* we expect household size to have a positive effect on WTP (Mekonnen & Kolhin, 2008). Household size was measured on a numerical scale in which respondents were asked to state the total amount of people living in their household including themselves.

*Cooking Time:* measures the total amount of time spent per day on cooking. It is assumed that this variable would have a positive influence on WTP– with women with higher cooking times to have higher WTP. We measure cooking time in hours.

*Charcoal Fuel Spending:* shows the monthly amount spent on charcoal by each household. It is assumed that households with a higher spending would also have a higher WTP for ICS. We measure fuel spending in amount of Meticais per month.

*Charcoal Stove Spending:* illustrates the amount spent by the households on the charcoal stove in use. It is hypothesized that households paying higher amounts for their current charcoal stove will also have a higher WTP for the ICS. We measure charcoal stove spending in amount of Meticais per stove.

*Fuel_Combination*: measures the types of fuels present in a household. Households using primitive fuels (wood and charcoal) and only charcoal are estimated to have a higher WTP than households that use charcoal plus an advanced fuel (LPG and/or electricity). We measure fuel combination as a set of dummy variables where: Combo_Low is respondents using charcoal and firewood; Combo_Med is respondents using only charcoal.

Table 1 Variable Specification

| **Demographic variables:** | **Measurement** |
|---|---|
| Sex | Sex of respondent<br>0 = female<br>1 = male |
| Age | Age of respondent in years |
| Income | During the questionnaire income was asked through categories. These categories were transformed to become continuous variables<br>< MT 2,500 = 1,250<br>MT 2,500 – 5,000 = 3,750<br>MT 5,000 – 10,000 = 7,500<br>MT 10,000 – 30,000 = 20,000<br>> MT 30,000 = 40,000 |
| Education | Included as an ordinal scale.<br>0 = No formal education<br>1 = Primary education<br>2 = Secondary education<br>3 = Higher education |
| Household Size | Number of people residing with respondent including respondent |

| | |
|---|---|
| **Other Variables:** | |
| Cooking Time | Cooking time in hours |
| Charcoal Fuel Spending | Monthly spending on charcoal in Meticais (MT) |
| Charcoal Stove Spending | Money spent on current charcoal stove in Meticais (MT) |
| Fuel_Combination | Dummy;<br>Combo_Low (Charcoal & wood),<br>Combo_Med (Only Charcoal), |

*3.2.4 Focus Group*

The focus group interview was mainly organized to complement and strengthen the findings from the survey. As an extensive set of quantitative data was collected through the survey method, a qualitative method was needed to complete and enhance the robustness of the data. This type of data collection provides deeper insights into peoples' feelings and ideas. Additionally, the diversity of answers that come from discussions created by the 'social interactions' between participants is one of the advantages of conducting focus-group interviews (Rabiee, 2004).

A focus group was conducted in an informal locale in the neighborhood of Mafalala on June 19, 2012. There were a total of nine participants—six women and three men—plus the moderator, Beatriz Ibata. Four of the six women that participated had previously taken part of the survey. Due to two non-attendees, two other women that were not familiar with the study were asked to join in order to maximize participation. One of the men present at the focus group was the neighborhood Secretary who specifically asked whether he could attend. The other two men were neighborhood association members who also showed interest in the study and asked to join.

The rationale behind the women's 'selection process' for the focus-group interviews was mainly judged by their performance during the household questionnaire. Knowledge on the different survey topics and strongly voiced opinions were two factors looked for in future participants. Those providing extensive answers, even for simple questions, were requested to participate in a further interview. From the eight women whose contacts were saved four attended. We therefore decided to ask two other women to join. The name, age and household fuel use of the participants are the following (Table 2):

Table 2 Participants Mafalala Focus Group

| Name | Fuel Used at home | Age |
|---|---|---|
| Woman 1 | Charcoal | 69 |
| Woman 2 | Charcoal & LPG | 38 |
| Woman 3 | Charcaol | 45 |
| Woman 4 | Charcoal | 53 |
| Woman 5 | Charcoal & LPG | 48 |
| Woman 6 | Charcoal & LPG | 40 |
| Man 1 | Charcoal & LPG | NA |
| Man 2 | Mafalala Secretary | NA |
| Man 3 | unknown | NA |

The interview was structured and had a total of 15 questions—the complete list of questions from the Focus Group can be found in Annex II. Although the focus group was delayed by 45 minutes, once it started it took the respondents one hour to answer and discuss the different questions. The questions were divided into four themes: (1) Fuel and Stoves, (2) Awareness, (3) ICS, (4) Household/Cultural Information. Only the questions from themes 1,3 & 4 will be discussed—for results on the awareness section refer to Kleijn (2012).

The questions asked in the first theme, 'Fuel and Stoves', followed the following rationale. The respondents were asked to state the advantages and disadvantages of cooking with charcoal, electricity and LPG. The major barriers for stove adoption were also asked as well as any cultural reasons for fuel stacking rather than fuel switching. The third theme, ICS, only dealt with one question: the reasons for their interest in ICS. The final theme dealt mainly with culture related questions asking who should be targeted if stove programs were to be launched—women as they are responsible for household chores or men because they control household finances. A status question related to stoves was also asked under this theme.

The overall group seemed comfortable discussing the topic at hand. Most times there was consensus among the respondents. Questions with highest level of agreeability were: the affordability of LPG cylinders and targeting both men and women for stove dissemination programs. In a few occasions debates arose on topics such as the prevalence of charcoal and the affordability of LPG.

*Data Analysis*

The interviews—conducted in Portuguese—were recorded using a personal laptop then summarized in English[3]. Ritchie & Spencer's (1994) 5-step approach toward data analysis—which will be explained next—will be used as a guide to structure and interpret the focus-group transcripts. Figure 11 shows a visual representation of the different steps taken, followed by a brief description of each.

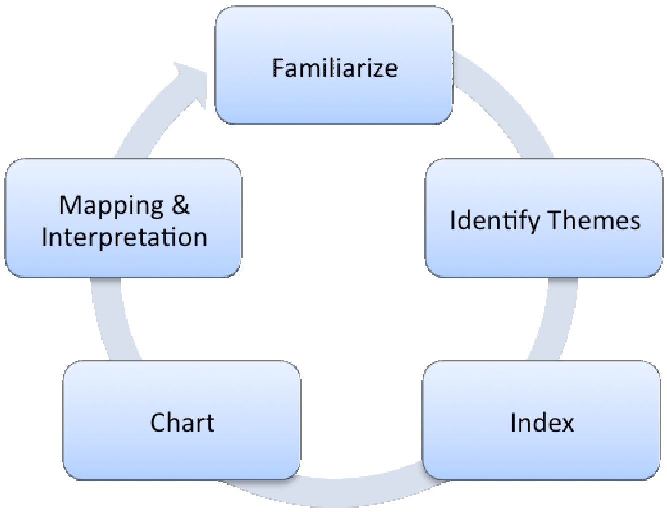


Figure 11 Focus group 5-step data analysis approach

Although Ritchie & Spencer (1994) approach data analysis as five separate stages they also clarify that the process is not linear and rather 'highly interconnected'. Therefore, there is somewhat of an order yet stages overlap and complement one another throughout the cycle.

The 'familiarization' stage is rather straightforward and literally means becoming familiarized with the data. This can be done through repeated listening of the interview itself or reading over the transcripts numerous times. During the second step, 'identifying a thematic framework', themes start to emerge and descriptions of these serve as a basis to explain the different ideas and concepts that arose in the interview. The next two steps, 'indexing and charting', are related to data management. 'Indexing' refers to the actual sorting and comparison of data in which 'within' and 'between' cases are examined. 'Charting' on the other hand, refers to the organizing the data under the themes that have emerged.

[3] The reason behind using a summary and not the official transcript is discussed in the limitations section.

‘Mapping and interpretation’, the final step, is where the relationships and links arise. Sense is made out of the data and links between themes are constructed as well as analyzed and explored. This 5$^{th}$-step also contains a set of sub-steps that help organize and categorize the key findings of the discussion. For the sake of clarity the seven sub-steps will be listed and described in short:

1. Words: study the words used and determine whether they fit their actual meaning.
2. Context: study the context in which ideas and thoughts are presented.
3. Internal Consistency: study changes of opinion within and between participants.
4. Frequency and extensiveness of comments: measure how often a comment is made and the number of participants that share the same view.
5. Intensity of comments: study the degree of feeling associated with each answer.
6. Specificity of comments: evaluate responses that make links to personal experiences rather than hypothetical situations.
7. Big ideas: highlight and discuss recurring trends and ideas.

## 3.3 Limitations, barriers and research pitfalls

Every research has a set of institutional, financial and time-constraint barriers that prevent the data collection and analysis stages from running as expected. Some limitations encountered in this research were minor yet some can be seen as major obstacles that hindered the development of the research.

The language barrier during the entire research was minor, yet during the data collection stage it played a more significant role; especially when combined with the financial barrier encountered during this same stage. Lack of financial support from SNV meant that only one enumerator could be hired to conduct surveys and only for a period of 4 days as this was what the budget allotted for. Although support was given from the Mozambican intern working at SNV this was not enough to conduct the desired amount of surveys. Therefore, speaking the language would have resulted in a larger sample, as instead of working in pairs we would have worked individually. This leads to one of the major limitations which is that the sample size is too small to be representative of the neighborhood, meaning that the results cannot be used as an accurate representation of the actual energy situation in Mafalala or Maputo.

Another major limitation—this one during the data analysis stage—was that the person in charge of transcribing the focus group interview failed to deliver the results on the date that had previously been agreed on. Therefore, a ‘self-translated’ summary of the interview was written and used instead of the transcript as basis for the analysis. This of course limited the depth in which data could be analyzed as only the main points were extracted from the interview and detail-rich information was left out because of time and language constraints.

Finding cultural variables to insert in the MRA was not possible which can also be seen as a major limitation of this research as one of the aims was to find cultural determinants that could influence WTP. Identifying cultural variables was already a challenge meaning that finding these and further quantifying them in order to include in a model was often difficult or not possible. Therefore, the cultural determinants were established mainly through the focus group results, which in turn were also compromised due to lack of complete data (ie. The transcript)

# 4. RESULTS

The results from both the survey and the focus group will be presented in this chapter. Section 5.1, which is subdivided according to the themes in the questionnaire, presents the survey results and ends with the MRA findings. Section 5.2 will present the focus group results with an integrated discussion.

## 4.1 Survey Results

The household questionnaire results will be presented in five parts; (1) Sample population characteristics, (2) Fuel and Stove Information, (3) Willingness to pay for ICS, (4) Cooking Practices and Cultural Considerations, and (5) Multiple Regression Analysis. These themes have been arranged to provide a clearer structure which will also be followed in the Discussion Chapter.

*Sample Population Characteristics*

The main findings from the sample population are illustrated in Table 3. From the 20,000 inhabitants living in Mafalala, 70 households were surveyed. Because every household has an average of 7 members, we can estimate that 2.45% of the population's energy behaviors can be accounted for.

Women were the predominant surveyed group—representing 80% of the sample. Women were specifically targeted for two reasons: first because their knowledge on household cooking practices and fuels was far more superior to those of men; and second, women were predominantly present in the mornings—when the surveys were conducted—whereas men were busy with work.

The level of education proved to be a significant determinant of fuel switching according to literature—predicting that households with a higher level of education would be less likely to use traditional fuels. Therefore, the highest level of schooling completed by any household member was asked to the respondent. Around two-thirds of the sampled population completed secondary schooling. Figure 12 also shows that in 25% of the households, a family member had completed higher education.

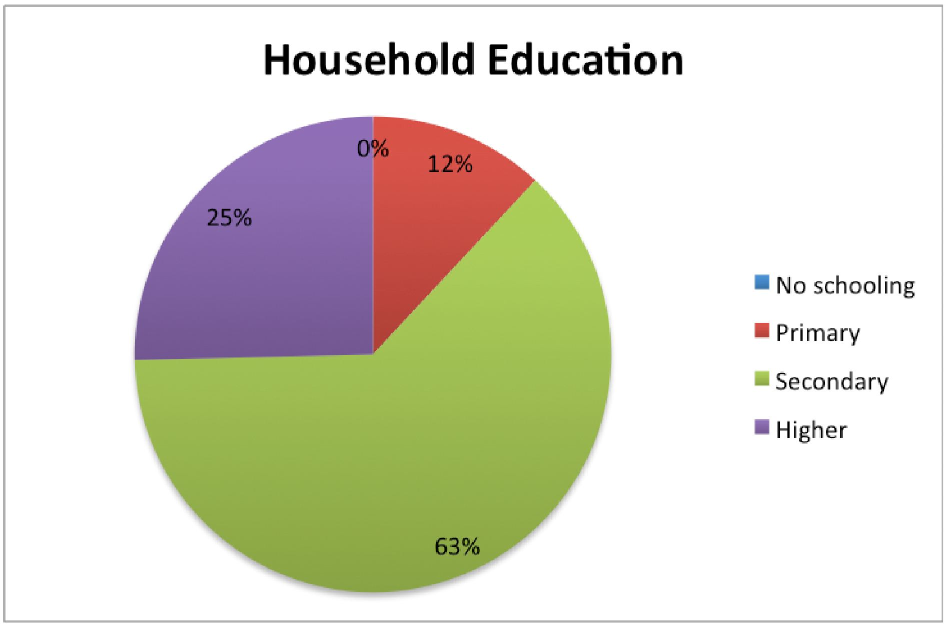

Figure 12 Household Education

The household income results shown in Figure 13 illustrate that 18 households, accounting for 28% of the sample, earn less than MT 2,500 ($91) per month and that 39% earn between MT 2,500 and MT 5,000. This means that that 67% of respondents have an average monthly income of less than MT 5,000, which is equivalent to $182. With household sizes averaging at 7 members (SD=4), living under the poverty line is a sad reality for many of these households.

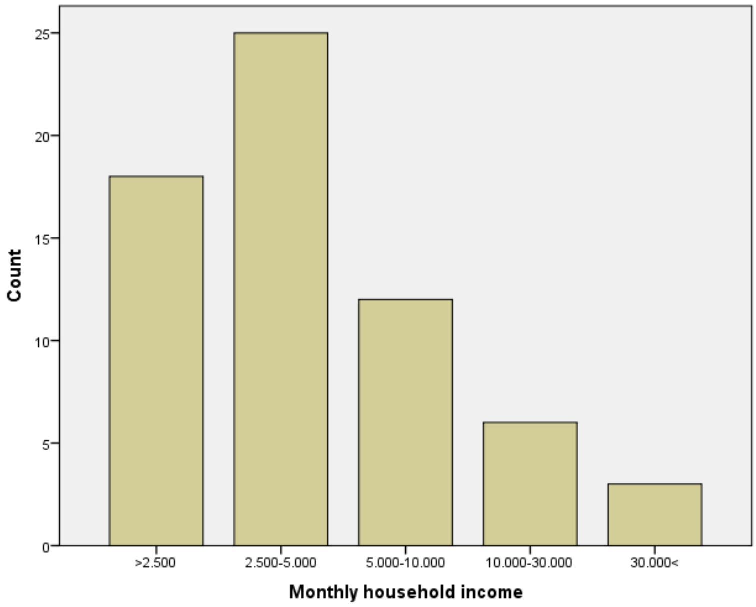

Figure 13 Monthly Household Income

Although participants' stated income was very low, participants were also asked whether they had a television, radio, mobile phone and fridge. The purpose of this question was to evaluate the number of valuable assets households acquired throughout the years and through this, verifying their stated income. The most common appliance to have was a mobile (N=65), followed by television (N=64). 51 respondents had a fridge and a radio. This proves that people have been able to meet their basic energy needs of cooking, heating and lighting and have adopted more advanced technologies and appliances that require electricity. This confirms Foley's energy demand ladder which will be discussed further in the following sections.

Electricity and dwelling type, two factors also seen to influence fuel choice were measured as follows. Respondents were asked whether they had electricity or not–in which 94% of the sample responded yes. The interviewers, however, judged the dwelling type by using some basic guidelines. Precarious houses mainly consisted of iron-sheet walls and metal-sheet roofs; modest houses had old-brick walls, dirt floors and metal-sheet roofs; and modern houses were made of new-brick walls, concrete floors yet mainly also had metal-sheet roofs. Respectively, 48%, 21%, and 15% of the sample lived in modest, modern and precarious houses.

Table 3 Socioeconomic characteristics of sample population

| **Group** | **Sub-group** | **Households (*N=70*)** | **Percentage (%)** |
|---|---|---|---|
| Gender | Female | 55 | 80% |
| | Male | 14 | 20% |
| Place of Birth | Urban | 52 | 75% |
| | Rural | 17 | 25% |
| | (blank) | 1 | |
| Age | Average | 38 | |
| | Max. | 82 | |
| | Min. | 18 | |
| Household size | Average | 7 | – |
| | Highest | 26 | – |
| | Lowest | 2 | – |
| Electricity | Yes | 65 | 94% |
| | No | 4 | 6% |
| Dwelling Type | Precarious | 15 | 22% |
| | Modest | 33 | 48% |
| | Modern | 21 | 30% |

*Fuel and Stove Information*

A key finding about household fuels was the presence of charcoal in 99% of the households. The results show that 70% use it as first choice, 26% as second, and 3% as third. On average, households spent MT 775 on charcoal per month. Additionally, from the 70 households interviewed 29% use LPG and 1% use firewood as their primary fuel. Monthly spending on LPG was MT 815 and for firewood undetermined because households often collect rather than purchase it. None of the respondents used electricity as first option yet did as either second or third choice. Nonetheless, electricity still ranked more important than firewood, being present in 17% of the households whereas firewood only in 11%. Therefore, charcoal ranked first as most common fuel—followed by LPG, electricity, and lastly firewood.

Another important finding was the combination of fuels used, which can be explained more easily by first referring to Figure 14. As can be noted, most households use a combination of charcoal with an alternative fuel yet 40% still only use charcoal to fulfill their household cooking needs. This graph shows that around half the population (49%) still uses a combination of the so-called 'traditional' and 'transition' fuels, yet the other half (51%) already employs advanced fuels such as LPG and electricity, albeit still in combination with charcoal. Only 1% of households use LPG alone. Figure 15 shows a simplified version of Figure 14 where seven categories were reduced to three. The 'low' level, uses only traditional fuels (firewood and charcoal); the 'intermediate or transition' level, uses only charcoal; and the 'transition & advanced' level, uses charcoal and an advanced fuel (LPG and/or electricity).

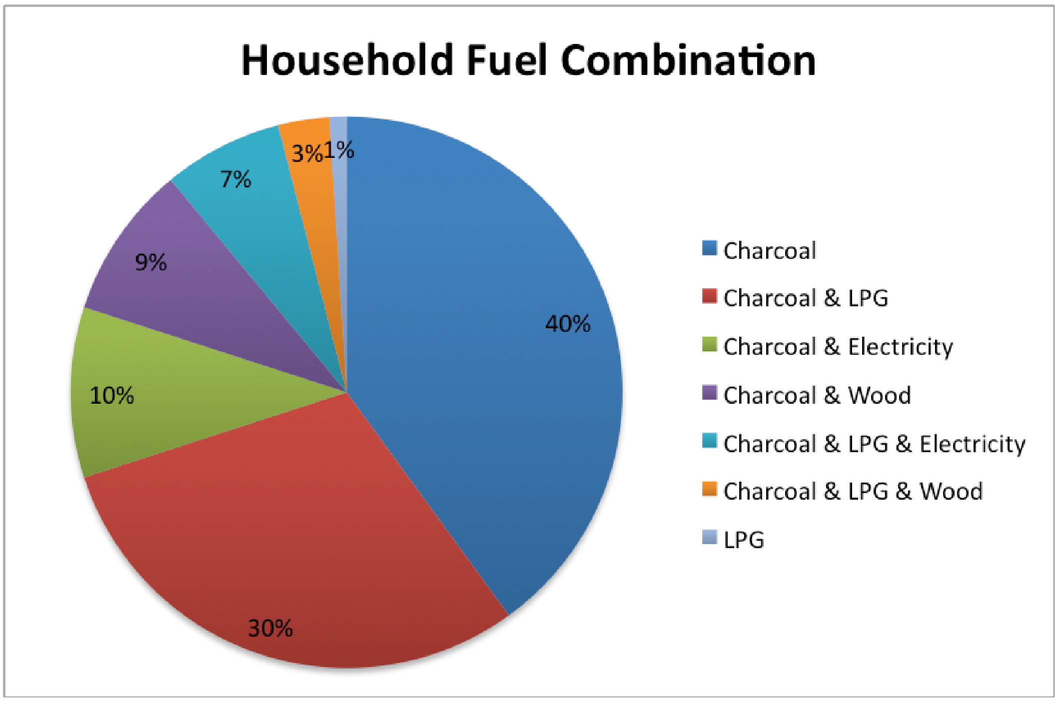


Figure 14 Combinations of Household Fuels

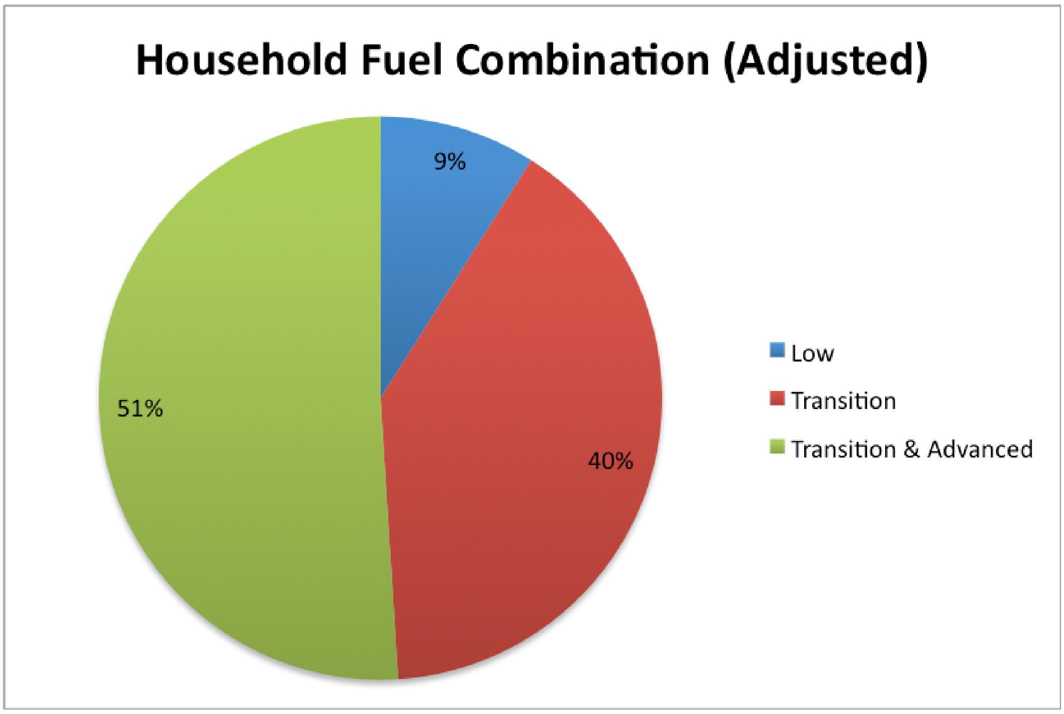


Figure 15 Combinations of Household Fuels (Adjusted)

The third key finding was participants' stated ideal fuel and the continued use of charcoal for cooking. LPG was considered the ideal fuel by 63% of the respondents—charcoal only scored 1% in this field. Nonetheless, when compared to the percentage of respondents that claimed to continue using charcoal regardless of favorable economic conditions, charcoal dominance still prevails—as 84% stated to continue using charcoal regardless of their economic situation.

During the questionnaire respondents were asked some open questions regarding their choice of fuel and stove. Nonetheless, as the responses were open-ended, quantifying and measuring these results did not provide with the expected answers and therefore left out from this section. Nonetheless, the focus group results are better at exploring this type of qualitative information.

*Willingness to Pay for POCA Stove*

Three major findings can be derived from the WTP section. The first finding in the WTP section was respondents' lack of knowledge of the benefits of the POCA stove. In other words, respondents were not aware of the advantages of ICS. Respondents were asked whether they thought the ICS, (1) reduced fuel use; (2) reduced cooking time; (3) reduced health problems; and (4) reduced environmental problems. In general, knowledge on the advantages of ICS was low—figure 16 shows the results. Reduced fuel use ranked highest, with half the respondents attributing fuel reduction capabilities to the POCA. As can be noted from Figure 16, most respondents answered 'Don't know' on the different characteristics of the stove. This also shows the lack of ICS in the Maputo market and the effect it has on peoples' perception of ICS.

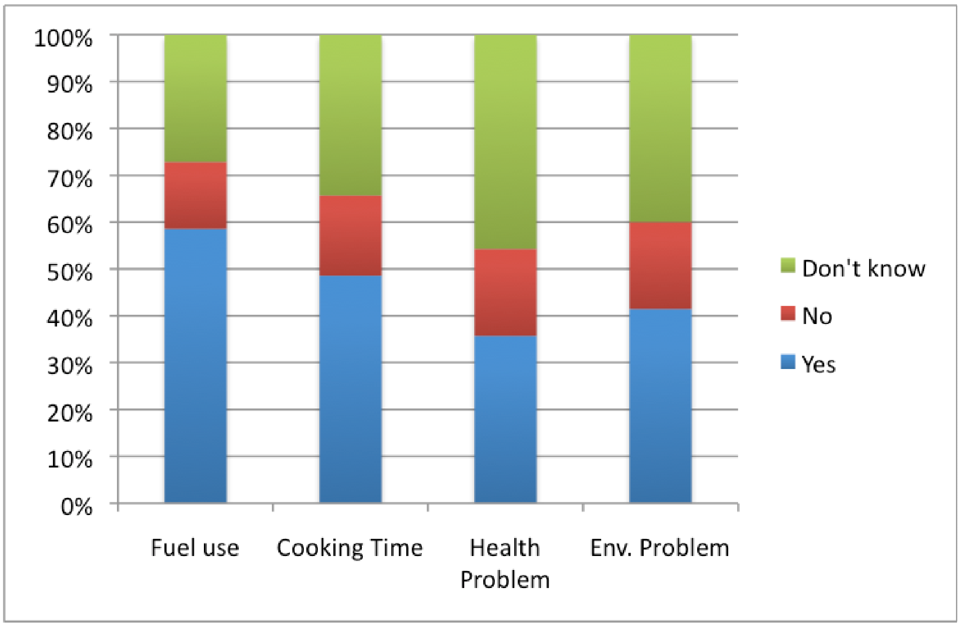


Figure 16 ICS Awareness Questions

The second result finds that the majority of respondents were interested in the POCA stove and that their WTP was considerably similar to the product's retail price. From the 70 sampled, 94% or 66 respondents said that they were interested in buying the POCA stove. The average WTP in a single cash payment was MT 331 (SD=219,5). However, the average WTP increased to MT 499 (SD=355,4) if respondents were given the chance to pay in installments. This represents a 51.5% increase from the first given price.

WTP can be further broken down if looking at WTP according to income categories. Figure 17 shows a positive trend where increasing income also leads to increasing WTP while Table 4 shows the different income categories and their corresponding mean and standard deviation. It can be noted that there is a continuous increase in the average WTP as income increases.

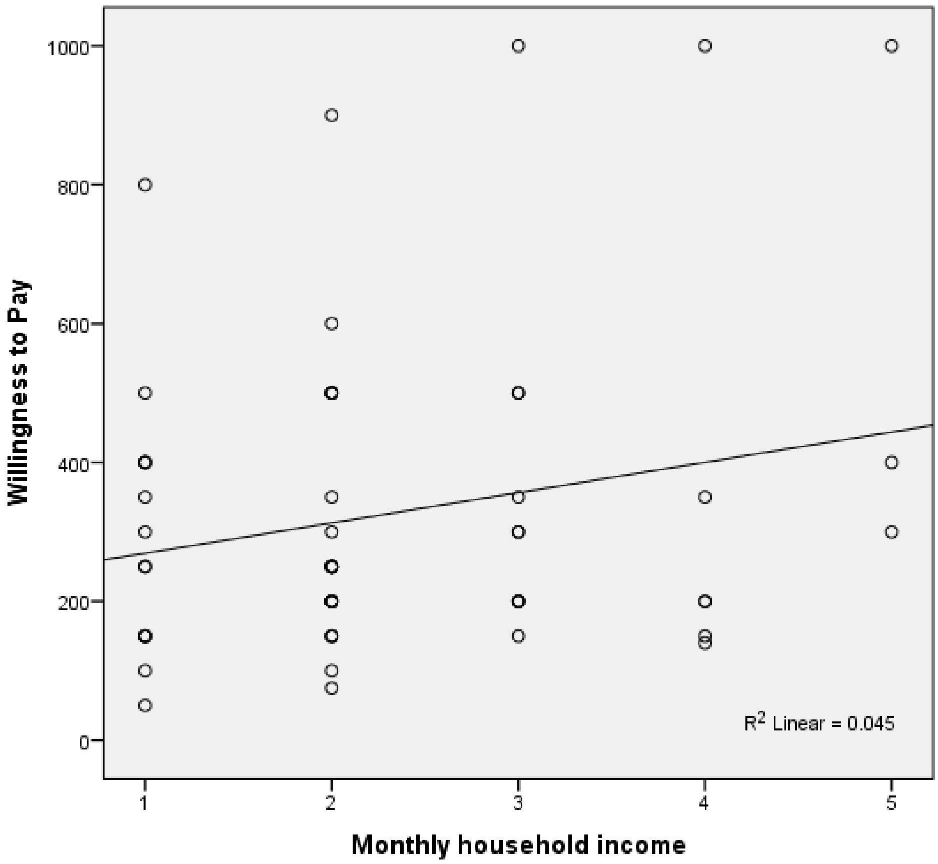


Figure 17 Willingness to Pay and Income Categories

The third finding focuses on stove characteristics and finds that stove material is the most important characteristic respondents are looking for when purchasing a stove. Respondents were asked whether price of stove, fuel spending, number of mouths, stove material, effect on the environment, and production of smoke were either 1=not important, 2=important or 3=very important characteristics they looked for in a stove. The characteristic respondents are most looking for is a stove made of a durable material, followed by stove price and then fuel spending. Effect on the environment and smoke were not considered important.

Table 4 Willingness to Pay divided into Income Categories

| | Mean | SD |
|---|---|---|
| <2,500 | 293 | 193 |
| 2,500 - 5,000 | 299 | 188 |
| 5,000 - 10,000 | 354 | 245 |
| 10,000 - 30,000 | 340 | 332 |
| >30,000 | 567 | 378 |

*Cooking Practices and Cultural Considerations*

From the results and general observation it is safe to conclude that women are responsible for cooking and not men. From 69 responses only 2 were attributed to men. The reason why these men were responsible for cooking was not asked yet heuristic assumptions can be made—for example, the man does not have a wife or other womanly figure living in the household.

The average household consumes 2.6 warm meals per day, spending an average of 2.2 hours cooking. From the meals asked that consumed most fuel, beans–or *feijao* was considered the main one. Additionally, most households boiled water for drinking and other purposes such as taking a hot shower using charcoal.

Household decision-making was also enquired. With this information, cultural determinants such as patriarchy were explored. Even though 68% of the respondents attributed the head of the household to be male, when asked about who made specific decisions on food, fuel purchases and stoves, women came in with a higher ranking. As seen in Figure 18, men mainly had a higher say than women when it came to appliances such as TVs and radios. This shows that although men are considered head of the household, women still have some decision-making power—these results will also later be confirmed in the focus group results.

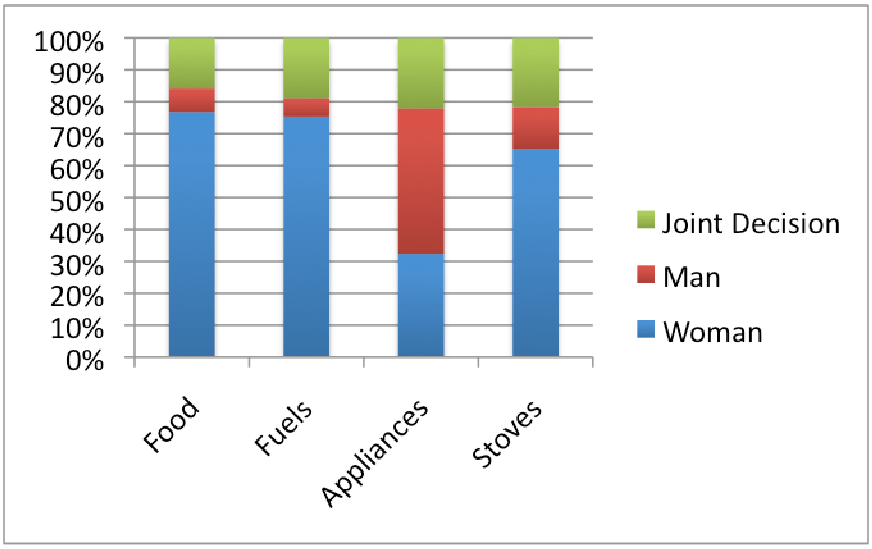


Figure 18 Household Decision Making

*Multiple Regression Analysis*

The variables presented in the methodology were tested to see whether any had a correlation to WTP. Age was the only significant variable (negatively) correlated to WTP. A MRA was then run three times (in Table 5 presented as WTP #1, WTP #2 & WTP #3), to find which combination of variables would result in the highest R Square. The results from the

MRA are shown in detail in Table 5. Age was the only variable that proved to be significant, yet not in WTP #2.

Table 5 Results WTP # 1, 2, 3

| **Dependent Variables** | ***b*** | **SE *b*** | **β** |
|---|---|---|---|
| | | | |
| *Willingness To Pay #1* | | | |
| Sex | -5.44 | 78.56 | -0.01 |
| Age | -4.27*** | 2.18 | -0.28 |
| Income | .000 | .000 | 0.15 |
| Household Size | 2.32 | 7.23 | 0.04 |
| Education | 16.49 | 58 | 0.04 |
| R Square = .14 | | | |
| | | | |
| *Willingness To Pay #2* | | | |
| Sex | 108.14 | 112.83 | 0.16 |
| Age | -1.87 | 3.23 | -0.11 |
| Income | 0 | 0.001 | -0.1 |
| Household Size | 0.89 | 9.21 | 0.02 |
| Education | 26.01 | 78.56 | 0.06 |
| Cooking Time | 60.58 | 45.38 | 0.31 |
| Charcoal Monthly Spending | -0.08 | 0.09 | -0.16 |
| Charcoal Stove Spending | 0.27 | 0.17 | 0.29 |
| R Square = .28 | | | |
| | | | |
| *Willingness To Pay #3* | | | |
| Sex | -11.23 | 80.07 | -0.019 |
| Age | -4.37*** | 2.2 | -0.29 |
| Income | 0 | 0 | 0.21 |
| Household Size | 3.78 | 7.85 | 0.07 |
| Education | 3.83 | 64.22 | 0.01 |
| Charcoal_Low | -116.81 | 123.02 | -0.14 |
| Charcoal_Med | 20.28 | 68.68 | 0.044 |
| R Square = .16 | | | |

*** Significant at 0.1

The first MRA (WTP #1 in Table 5) shows the results of the model when run only with the demographic variables; the R Square being .14. Age was found to have a negative effect on WTP and was also found to be significant at the 10% level. Therefore, age is a possible predictor of WTP where in one unit change in the age of respondents corresponds to a -4.26

unit change in respondents WTP. In other words, the WTP difference between a 25 year-old respondent and a 65 year-old respondent is MT 128.

Although the rest of the demographic variables were not found to be significant some heuristic assumptions can be made of the results. As expected, household size and education have a positive effect on WTP albeit not significant. Although the former represents a small change in WTP (2.32), the latter has a greater effect (16.49) on WTP.

The variables used in WTP #2 yielded the highest R Square: .28, yet none of the variables were found to have a significant effect on the outcome variable WTP. Charcoal stove spending was almost found to be significant at the 10% level and shows that a unit change in a charcoal stove represents a 0.27 unit change in WTP. This was expected, as households spending more on stoves would also potentially be WTP more for an ICS.

The results from WTP #3 yielded a lower R Square than WTP #2 with .16 yet age again showed to be a significant predictor variable. The non-demographic variables, Charcoal_Low and Charcoal_Med, were placed in the model as people in different stages in the energy ladder would be expected to have different WTP for ICS. The results from these variables show that people using only charcoal (Charcoal_Med) have a positive effect on WTP, whereas households using a combination of firewood and charcoal have a negative effect on WTP. This could be explained to the fact that people in the Low Fuel group are mainly part of low-income groups, therefore having limited spending capital and therefore perceive and ICS with less urgency.

## 4.2 Focus Group Results

In order to get 'familiarized' with the data, the focus group recording was listened to a couple of times. Notes were taken during this stage to later simplify the next step which was 'identifying themes'. Nonetheless, identifying themes for the interview was rather straightforward as a set of questions were prepared before the focus group took place. The first theme was fuels, which can be divided into charcoal and alternatives. Under this theme the barriers for clean fuel adoption was also presented. The second theme was fuel and culture. Figure 19 shows an image of the focus group.

The first theme covers charcoal, electricity and LPG. When asked about the advantages and disadvantages of each fuel, respondents tended to agree with each other—there were some disagreements and differences of opinion yet not strong enough to create a very heated debate. Nevertheless, having consensus on various ideas regarding fuels and the fact that new insights were not found also helps corroborate the conclusions of the household questionnaire and from personal observation. Table 6 presents the 'charting' step where a simplified representation of the advantages and disadvantages of charcoal and LPG/Electricity is shown.

Table 6 Fuel Advantages and Disadvantages

| | Advantages | Disadvantages |
|---|---|---|
| Charcoal | Money Savings<br>Backup option<br>Available in nearby markets<br>Available in small amounts<br>Useful in large households<br>Taste of certain dishes | Time to ignite |
| LPG and Electricity | Fast cooking time<br>Clean to use | Perceived high fuel price<br>Initial cost cylinder bottle<br>Safety |

Money savings brought on by charcoal use was the main reason why all participants, except Man #1—who claimed LPG to be the most economic option—used charcoal. Respondents still perceived charcoal to be the cheapest option although in reality LPG is less expensive than charcoal. Charcoal was also often used as a backup option—even for the women who owned LPG stoves. The economic reason for the continued reliance on charcoal was that it was readily available and that it could be purchased in small amounts. Sociological reasons behind continued charcoal use are household size; Woman #6 mentioned how charcoal is not only preferred for roasting chicken but how it was also used in large families. Cultural reasons behind the reliance of charcoal can be attributed to food preferences, other cultural traditions such as weddings, and custom and habit—*'there are things that we traditionally make using charcoal'*, as Woman #5 very simply put it.

The advantages linked to advanced fuels were mainly about time savings. Charcoal's long ignition time was stated as its main disadvantage, therefore respondents often stated to use electricity or LPG to reheat meals at night or to cook meals when in a hurry. Another advantage of clean fuels was that the house remained cleaner than when cooking with charcoal.

Safety became an issue when discussing LPG disadvantages. Two women stated that they were either scared of using LPG or that greater care had to be put in the kitchen when cooking with this fuel. Although some claim food taste to differ considerably depending on the fuel (Woman #6), Man #1 claims all meals to taste the same—unless it is "grilled chicken". The perceived price of LPG and charcoal also became questioned in this part. Man #1 says, *'I think that [cooking with an] LPG stove is more economical, even for cooking meals such as curry which have a long simmering time'.* However, many of the women still perceive LPG and electricity to be more expensive and therefore the best alternative when cooking meals that take a long time to cook, such as beans, is charcoal or firewood.

Market barriers were also discussed with the participants and the following results came up. The main issues arising were availability and affordability. Charcoal is readily available in the neighborhood markets, as well as stoves. The barriers lie with LPG cylinders, refilling and partially with stoves. The main issue, which was confirmed by all respondents, was the initial price of the LPG gas cylinder. Refilling was also an issue yet perceived less importantly than the bottle. It was noted however that charcoal in that case was used as an alternative because if a household did not have MT 600 to refill the gas cylinder, then the alternative would be used which was buying MT 20 worth of charcoal. Woman #1 concluded, '*if smaller bottles were available for sale, more people would buy LPG'*. This shows that paying one lump sum for fuel is still an issue for many households.

Moving into cultural reasons behind partially switching to LPG and not fully switching, respondents claimed charcoal to be 'their tradition'. Man #3 mentioned ceremonies to be a reason for the continued use of charcoal, yet the issue of modernity and development arose when Woman #3 said, 'we have become more civilized, as before we used to cook with firewood'. Stating that cooking with charcoal is 'more civilized' than cooking with firewood asserts various modernity theories where development is expected to follow a predetermined path—in other words, that of the 'West'.

Foley's theory on energy demand also arose in the discussion where Woman #5 said, '*If you have electricity, you use it for other purposes. You need electricity for lighting, the fridge etc. You use electricity for things the things you cannot use using charcoal*.' This also shows how households are rational in their decisions and diversify their energy profile. Households might save LPG for cooking at night or for cooking fast meals whereas charcoal is used during the daytime to save the more 'valued fuel' for other uses.

When asked about household decision-making, the men present in the focus group agreed that women were responsible for food, fuel and stove purchases. Then, when asked about appliances such as televisions, they agreed that men were in charge of that department. Nonetheless, Woman #5 said that household decisions were mainly joint decisions—that both the man and the woman had a say in the handling of their finances. Guy #1 stated that the only reason why men would disagree on buying a stove is when other goods are perceived to be more important or in greater need in the short-run. Therefore, stove programs should target both in order for both to see the need for improved technologies.

Finally, when asked about promoting ICS, respondents came up with a variety of ideas to initiate a move towards these stoves. Promotion campaigns need to be targeted towards men and women. Kids need to be educated on the advantages of cooking with clean fuels and the disadvantages of biomass. Additionally, public stove demonstrations can further motivate people into seeing the benefits of ICS in comparison to traditional stoves.


Figure 19 Focus Group Mafalala

# 5. DISCUSSION

From the results presented above, various discussion points can be formulated. The discussion will attempt to follow the structure of the results section in order to keep a similar argumentation flow.

## 5.1 Household Survey Discussion

### *Fuel and Stove Discussion*

The fuel and stove results presented above confirm Masera et al. (2000) multiple fuel model and also help add value to the various household energy theories presented in Section 3.1. Masera et al. (2000) propose a multiple fuel model in which households start using a combination of fuels—money permitting—rather than completely switching to advanced fuels. Although the results show that 40% of respondents solely use charcoal as cooking fuel, most respondents use a combination of charcoal and an advanced fuel, or charcoal and wood—although less frequent. Table 7 confirms the fuel-stacking model by showing the relation between (adjusted) fuel combination and income. Income categories are presented as columns in Table 7 and the fuel combination categories as rows. It can be noted that even high-income groups (>5,000) still rely on a combination of firewood and charcoal—placing them under the low fuel combination category. On the other hand, there is 1 respondent who falls under the advanced fuel combination group albeit having a very low income. Although these previous examples fall outside the norm—which generally state that higher income groups use more advanced fuels—it shows that fuel combinations can be present in all income categories.

Table 7 Cross Tabulation between Fuel Combination and Household Income (Number of respondents)

| | Low Income (<2,500) | Middle Income (2,500-5,000) | High Income (>5,000) | Total |
|---|---|---|---|---|
| Low Fuel | 3 | 1 | 2 | 6 |
| Transition Fuel | 14 | 10 | 2 | 26 |
| Transition & Advanced Fuel | 1 | 14 | 17 | 32 |
| Total | 18 | 25 | 21 | |

Although Table 7 shows that it is generally more likely for high-income groups to use advanced fuels, it also proves that different fuel combinations are present throughout the income spectrum. This discredits the energy ladder model that states that as income increases, so does fuel of choice. Table 7 also shows that most households are in either the transition or transition/advanced stages of the energy ladder; with 26 households falling under the former and 32 in the latter. This in turn can provide a variety of insights for household energy theory. The households surveyed have started to make a 'partial switch' from only charcoal to charcoal plus an advanced fuel. This can mean that those households making a partial switch could, in some years, make a full switch towards clean fuels—meaning that they are going through a small transition period between a partial and full switch. The households which are currently in the transition stage could then move into the transition and advanced stage and continue onto a similar path which would ultimately end in advanced fuels only.

This relation between income and fuel use also gives us another insight into Foley's (1995) energy demand ladder which states that as income increases households start using a more diversified energy portfolio. The people under the 'transition & advanced' level could still be using charcoal because they would rather use electricity to run their televisions or only use LPG for heating up foods while charcoal is still used to economize and cook most meals. Foley's model also says that as income increases, energy needs also increase meaning that the basics have been covered and therefore other more advanced needs such as basic appliances, refrigeration and transport, to name a few, enter the picture.

When browsing through the data it becomes apparent that some households that use a combination of fuels also use more energy; further confirming Foley's energy demand ladder model. For example, average households consume around MT 775 worth of charcoal per month. However, it was observed that some households using charcoal and LPG consume MT 775 on charcoal and MT 800 on LPG every month. This can mean either that people become less efficient with their fuel use, or a more plausible idea is that their cooking behaviors start changing. This can mean a more diversified diet, eating more than 2 hot meals per day, reheating meals more often etc. There are a variety of factors that explain why households, as they start using a combination of fuels, start also consuming more fuel.

The last point to be discussed in this section is the prevalence of charcoal and traditional charcoal stoves in the households surveyed. Although the reasons could be cultural, other reasons such as affordability, availability, and acceptability are more plausible reasons for the predominance of charcoal and TCS. The prevalence of charcoal can be partly attributed to household factors yet the prevalence of TCS is attributed, almost to its entirety, to exogenous factors. Charcoal is affordable, available, and acceptable in Mafalala, ICS on the other hand are not available; this explains their absence in the households. Modern fuels, although available, are not entirely reliable meaning that people continue to depend on a multiple fuel model to ensure their cooking energy needs. Additionally, modern fuels such as LPG albeit being cheaper than charcoal, require a one lump sum payment whereas the other allows small quantities to be bought; therefore, charcoal is more affordable on the short term because the methods of payment are compatible to their spending behavior.

The prevalence of charcoal, therefore, can be explained by an intermixed combination of endogenous and exogenous factors. Certain food preferences such as grilling meat or cooking for large amounts of people in celebrations could help explain the prevalence of this fuel. Yet, secured supply and affordable price are also reasons for the continued use of charcoal over other modern fuels.

*WTP Discussion*

The WTP section provides some interesting results for analysis. The first issue that will be tackled is the high market potential for ICS in Mafalala. Most households stated interest in purchasing the POCA if available on the market (94%). This shows that there also is a willingness to change in the area. People did not seem reluctant to acquire improved and new technologies meaning that they have gained at least some sort of acceptability. Nonetheless, the results of this survey are merely stated and not revealed preferences, meaning that people's actual behavior was not tested; therefore not being able to confirm their actual preferences.

The issue of willingness to change can relate back to behavioral and cultural factors such as habit and custom. These cultural factors are particularly strong as they are embedded in people's *ethos*—their fundamental values and beliefs. If respondents would have indicated low interest in the POCA then it can also be seen as resistance towards new and unknown technologies—a resistance targeted towards first world development. However, this study shows that people are at a transition stage where ICS adoption could be a reality given the necessary enabling conditions. Nonetheless, it is important to reiterate that the actual adoption of ICS is still to be researched and this study only presents stated preferences.

The second point of discussion would be to find the necessary enabling conditions to foster the change towards ICS adoption. It is a given that respondents' WTP was MT 330—albeit different if divided into income categories—yet, this was similar to the stoves actual retail price (around MT 350). Financial incentives such as subsidies, taxes, and microfinancing programs could help further trigger a move towards improved technologies. This provides an added motivation to consumers which ultimately also provides environmental, economic and social benefits that are felt by all.

People continue to use charcoal because it is available in small amounts and people have little disposable income to invest in improved technologies. Finding a way to decrease the price of LPG could trigger a move toward modern stove adoption. Additionally, an increase in charcoal prices could fuel a move towards ICS as people perceive the need to save on biomass. Nonetheless, it is also important that economic incentives are felt throughout the country and not only in urban centers. Often the most affected from biomass use are rural peoples; therefore ways to spread the benefits should be analyzed.

When looking at financing incentives however, it is also important to take into account stove 'acceptability'. Providing incentives is one step but making sure that user needs are met is also an important part of the process. The stoves that are introduced have to be able to meet the needs of the people using them. It has often happened that stove dissemination programs have failed because the stoves are not compatible with traditional cooking practices.

The third discussion point links the current study with the findings from Adkins et al. (2011). When comparing the results, it can be observed that the respondents WTP in this study is closer to the product's actual retail price—in other words, the product can be introduced to the market without government or private subsidies. This would mean a product that could potentially make it to the market without external financing. The WTP findings in Adkins et al. (2011) are much more reliant on external financing as the stoves being tested were more advanced and expensive than the one evaluated in this research.

Lack of awareness is the fourth and last issue to be discussed in this section yet important because it shows the need for information on the welfare gains and environmental benefits that accompany ICS use. The switch to a modern LPG stove would require several adaptations at the household level as foods are prepared differently and the utensils also vary. The switch to ICS, on the other hand, would not require many added differences in comparison to the metallic stove and it provides ample improvements both in money and time savings, and in reduced health risks. Even if respondents are not particularly interested in purchasing stoves that have a reduced impact on the environment, the impacts would still be positive as a collective adoption of ICS would reduce the pressure on Mozambique's forests.

*Cooking Practices and Cultural Considerations Discussion*

Analyzing the cultural reasons for cookstove adoption is important, as household decision-making cannot solely be explained through economic reasoning. Cultural considerations, although often difficult to identify, as they are deeply ingrained in people's being, also play a decisive role in the household decision arena.

Cooking with charcoal gives women the opportunity to perform other household chores, as the fire does not have to be closely tended. Therefore, while cooking a meal, the women could be doing laundry or cleaning the house; this ultimately can also be seen as a time saving strategy. Cooking with LPG, on the other hand, requires greater care. This however can be an explanation for the continued use of charcoal instead of LPG but it does not explain the prevalence of traditional stoves over ICS.

Cooking with charcoal—as noted from personal observation and data collection—was a common practice in the whole of Mozambique. People have been using fuelwood as main cooking fuel for centuries meaning that it has become a custom and a habit to cook with this fuel. Nonetheless, this continued use of charcoal can be attributed to the aforementioned 'habit' but it can also be attributed to lack of perceived need for better alternatives. People continue using charcoal and the inefficient TCS because they do not perceive a need to buy more energy efficient stoves such as the POCA. Additionally, ICS are simply not present in the market therefore people are not able to purchase them. Consequently, habit only touches one aspect of it but there are other factors that also need to be present in order to make a move towards improved technologies.

Other cultural elements that were taken into consideration during the research were gender relations and household decision-making. As previously expected, men are in most cases the head of the household. Female head of households can be explained as single-parents who are not married. Referring back to the literature, studies show that cookstove adoption can be low because men, who are also the head of the household, do not see a need for ICS and as women cannot make financial decisions, adoption rate remains low. Nonetheless when respondents were asked about household decision-making, women proved to have a strong say in daily decisions such as buying food and fuels. This shows women do have some decisive power within the household nonetheless, with often little spending capital women might be willing or eager to purchase an ICS yet unable to do so for financial reasons.

## 5.2 Cookstove Adoption Determinants and Strategies for Transition

The previous sub-sections presented the analysis from the household questionnaire and the focus group. This sub-section will tie the analysis from the questionnaire and the focus group into one integrated assessment that discusses the main determinants found in this research and some strategies that could help trigger the transition from traditional stoves and fuels to improved and modern/advanced stoves and fuels.

The first most noted barrier for stove and fuel transition was affordability. Although more than half of the households used a combination of fuels, the complete or partial switch towards LPG has been limited because of several issues. For the people that already use LPG, charcoal is seen as a backup when LPG is either not available or when there is not enough capital to refill the gas cylinder. For those who only use charcoal, a partial switch to LPG has not been possible because of the high investment costs from the cylinder bottle. The prevalence of charcoal therefore can be explained because it is available in small amounts and is able to provide household savings.

In order to deal with the problem of affordability in the various respects, measures need be taken to ease the financial burden consumers at the BOP face. Specific solutions need to be found for different groups of people. In other words, not all consumers face the same problems. For example, people who fall under the 'transition and advanced' fuel category need solutions that will help trigger a full switch towards advanced fuels such as refilling gas bottles on credit and that way they do not need to resort to buying small amounts of charcoal. For those who are only using charcoal, ICS or financing opportunities for the LPG cylinder and the stove could be an option. Figure 20 shows how, even though the target populations have the same problem, the solutions are different. Policy makers have to acknowledge this fact in order to create incentives that will benefit the different groups.

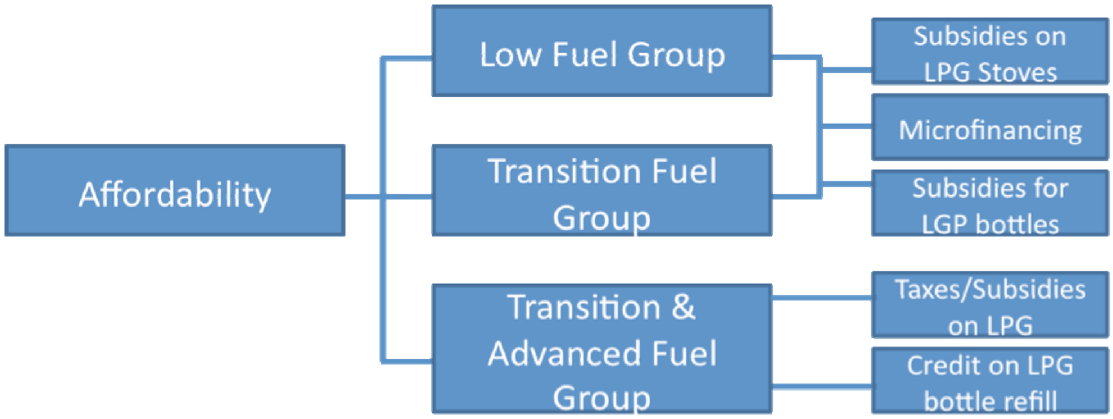

Figure 20 Affordability Solutions for Different Target Populations

The second barrier encountered was fuel and stove availability. Although this barrier could not have been detected from the household surveys and the focus group, the exploratory research phase helped bring it to light. By having visited the stove and fuels markets around Maputo observations could be made about the stoves on offer and the fuels that were available. If ICS are not in the market then people cannot purchase them either, meaning that the biggest obstacle for stove transitions is availability of stoves and not necessarily cultural hindering factors. In order to change the availability situation it is important that stove producers first learn what consumers really need and then start producing stoves that will fill those needs.

The third barrier deals with acceptability, which will also be tied to stove-availability. Prevalence of charcoal can partly be explained through cultural factors such as food preference and habit; nonetheless this does not explain the prevalence of TCS over ICS. The prevalence of traditional stoves is probably due to the lack of alternatives. ICS are rarely available in Maputo—therefore people are not aware of improved solutions and continue to use the metallic stoves that are available throughout the city.

In order to tackle the problem of acceptability a stove dissemination program has to be introduced in Maputo for people to become more familiar with the product. However, before any ICS is introduced in the market it has to be previously tested in households to ensure that it meets the needs of the people. As Bates (cited in Atanasov, 2010:27) quotes, ‘It is incumbent on development organization to recognize that technologies should be appropriate to people’s needs, rather than trying to change people’s behavior to suit the technological option’.

The three barriers noted above—affordability, availability, and acceptability—all fall under Kowsari & Zerriffi’s (2011) energy supply factors and energy device characteristics which are part of the exogenous and not the endogenous factors that affect fuel and cookstove adoption. This finding at least implies that the primary issue for fuel and cookstove adoption in Mafalala is not necessarily attributed to household hindering factors but in the uncertainty and unreliability of the exogenous factors. From the results we find that the method of payment for modern fuels is not compatible with people’s daily expenditures and therefore not affordable; the supply of LPG is inconsistent meaning that it has low availability; the stoves are also not built to satisfy consumer needs therefore decreasing their acceptability. To sum up, Barnes et al. (2005) state how income is not necessarily the hindering factor but that service availability and initial cost of the service are.

General awareness is also needed to educate people on the consequences of biomass use and inform them of the advantages that come through ICS use and modern fuel use. It is important to reiterate this point because through education people will start to learn how the inefficient combustion of biomass has negative repercussions on their health and their household economies. Once people start associating charcoal to health problems and costs, is when the largest transition to either ICS or modern stoves will occur. If people do not see the harm in using biomass then alternative solutions will also not be sought for.

# 6. CONCLUSIONS & RECOMMENDATIONS

The combustion and production of biomass has negative effects on both human welfare and the environment. The introduction of ICS would therefore help ease the effects of both these issues; however, ICS were not found to be present in the study site, Mafalala. In order to identify the different socioeconomic and cultural factors that play a role in household energy transitions an extensive literature review on the different theories of the energy ladder and household determinants was first conducted. Households usually take part in one of two common practices of fuel transition—the first being partial switching and the second full switching. Most studies are found to support the former where households start diversifying their energy profile and not necessarily switching to the alternative or cleaner fuel immediately.

From the literature we can conclude that although income is a determinant for switching, there are many others that also have a decisive role. Other factors that can be included are sociological variables such as education and household size. Also, it is important to not leave out cultural and behavioral factors which are often forgotten and excluded from academic studies. Traditional ceremonies generally include traditional dishes which are also, by custom, cooked in 3-stone fires or use biomass. Habit, male-heads of households, and taste preferences were all found to be cultural elements that could have an influence on fuel of choice. Finally, variables that are present at the country level such as government subsidies or fuel availability could ultimately also have an effect in adopting ICS or switching to cleaner fuels.

The results from the household survey, the focus group, and personal observation conclude that the main reason for the prevalence of TCS are energy supply factors and not necessarily household factors—which were presented as endogenous factors in Section 2.2.3. The Maputo market for ICS is almost nonexistent meaning that households have not been introduced to such technologies. This however, does not mean that household factors do not play a role in fuel switching.

Household fuel transitions in Mafalala corroborated many studies, as practices of fuel stacking were present instead of practices of fuel switching. Although households were only observed in one point in time, there was only one case of sole LPG use. Charcoal, as also mentioned in literature, proved to be the predominant fuel in households.

When looking at determinants for fuel switching, economic, sociological and cultural factors arose as playing a role for the prevalence of charcoal. Income indirectly played a role as households continued their charcoal practices because of its availability in small amounts. This is said to be indirectly related to income because if a solution would be found to purchase small amounts of LPG or electricity then people would be more inclined to making that switch. Household size was also mentioned as a factor helping charcoal remain as the predominant fuel. On the other hand, cultural factors as tradition and habit arose often as reasons for charcoal use.

To finalize the conclusion, Hiemstra-van der Horst & Hovorka (2008:3342) make a concluding remark that perfectly fits into the discussion of cultural and behavioral determinants for cookstove adoption and fuel switching, '*energy use patterns (…) are not mainly driven by the desperation of poverty or a simple struggle to overcome developmental constraints. Rather they are the product of active decision-making on the part of individual households according to their preferences and broader lifestyle considerations, which, moreover, are diverse rather than uniform*'.

<u>*Recommendations*</u>

*For NGO's & policy makers:*

NGOs and policy makers can work together to provide economic incentives that will promote fuel switching.  Households already perceive LPG as their ideal fuel, yet some initial investment costs might be too high to fuel that change. Therefore, providing subsidies on cylinder bottles or stoves can help ease the initial payment burden for those households who fully rely on charcoal. Senegal's butanization program serves as success example in which subsidies, introduced by the government, were able to create a nationwide switch to LPG—and almost completely in urban areas.

Another recommendation is to create national campaigns on the disadvantages of biomass and the advantages of ICS and modern stoves. This study found that people were not aware of the harms associated with biomass use, therefore outreach programs and education can help spark a deeper understanding of the negative externalities linked to the combustion of primitive fuels and the advantages of clean ones.

*For further research:*

There are two points for further research that will be presented—the first being on stove dissemination target groups. In patriarchal societies men are often responsible for the household's financial decisions, yet some articles do present the women as financially responsible for certain household tasks such as food purchases and cooking. This study shows that women are responsible for some household decisions and therefore should be the main target for dissemination programs; however this could not be the case for all sites.
For that reason, anthropological studies on gender roles and labor divisions on program sites would help identify who needs to be targeted for stove program efforts to be effective and successful.

The second point for further research would be in the prevalence of charcoal. This study found that 84% of the household questionnaire respondents claimed that they would continue to use charcoal even if money were not an issue. Conducting a longitudinal study that looks into household energy use could provide a better insight on household energy transition than a cross-sectional study. A longitudinal study could help answer whether the people who are now using charcoal and LPG will still be using charcoal in the future and whether those household who now only use charcoal move into the LPG and charcoal stage. By doing so, policy makers and NGO's can also see where to target their efforts—whether ICS is the best solution or directly skipping towards LPG adoption or any other advanced fuel.

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# ANNEX I – Household Questionnaire Mozambique

Interviewer:
Date of interview:
Time of interview:
Time at end of interview:
Location:
Questionnaire no.:

**Introduction:**
We are doing research on household fuel patterns and cookstoves, as a part of our master's thesis for the Free University of Amsterdam. Your participation is very important to us and your answers will help provide us with a better understanding of the energy situation in Maputo. The questionnaire will take between 20-30 minutes. The responses are strictly confidential and will only be used for the purpose of this study. Please answer as truthful as possible. If you are ready, let us begin.

**Part 1: Fuel Information**

| | | 1. What fuels does your household use for cooking? [rank in order of use] | 2. How often do you buy a unit of fuel?<br><br>1. Daily<br>2. Weekly<br>3. Monthly<br>4. Other, specify | 3. How much money do you spend each time? | 4. Why do you use this type of fuel? (let respondent answer) | 5. Do you think [fuel] is:<br><br>0. Don't know<br>1. Cheap<br>2. Normal<br>3. Expensive |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1 | Wood | | | | | |
| 2 | Charcoal | | | | | |
| 3 | Gas (LPG) | | | | | |
| 4 | Electricity | | | | | |
| 5 | Kerosene | | | | | |
| 6 | Other | | | | | |

**Part 2: Stove Information**

| 6.<br>What types of stove are you currently using? Rank in order of | 7.<br>Why do you use [stove type]? | 8.<br>How much did you pay for this stove | 9.<br>How long have you had your current stove? |
|---|---|---|---|

| | | | |
|---|---|---|---|
| use<br><br>[see 'Stove Code' box] | | (Mt)? | (specify months or year) |
| | | | |
| | | | |
| | | | |

**Stove Code**

| | | | |
|---|---|---|---|
| **Traditional Stove** | 1. 3 stone, open fire | 2. U shape, surrounded fire | |
| **Charcoal Stove** | 3. Metal stove (1-mouth | 4. Metal stove (2-mouths) | |
| **Improved Cookstove** | 5. Rocket stove (wood) | 6. Ceramic stove (charcoal) | |
| **Modern Stove** | 7. Kerosene stove | 8. LPG Gas cooker | 9. Electric Stove |

10. Describe your **ideal** stove. What fuel would it use? Why? What characteristics would it have?

    …………………………………………………………………………………………………………………………………
    …………………………………………………………………………………………………………………………………
    ……………………………………………………………………………………………

11. If money weren't an issue, would you completely stop using charcoal and switch to either gas or electricity? o(1) Yes o(2) No
12. Why yes? Why not?

    …………………………………………………………………………………………………………………………………
    …………………………………………………………………………………………………………………………………
    ……………………………………………………………………………………………

**Part 3: Awareness Questions**

13. Do you know in what region the charcoal that you are using is being produced?
    o(1) Yes o(2) No [go to **Q13**]
14. If yes, where is it produced? ………………………………………………………………….
15. Do you think using charcoal for cooking affects the environment?
    o(1) Yes o(2) No [go to **Q15**] o(3) Don't know
16. If yes, how does cooking with charcoal affect the environment?
    ……………………………………………………………………………………………………………..
17. Do you think using charcoal for cooking affects the health of your household?
    o(1) Yes o(2) No [go to **Q17**] o(3) Don't know
18. If yes, how does it affect the health of your household?

…………………………………………………………………………………………………………………………………

19. How serious do you think the following social problems are in Mozambique?
    (1 not serious, 2 serious, 3 very serious, 0 Don't know)
    a. Hunger: [……]
    b. Poverty: [……]
    c. Poor health care: [……]
    d. Poor education: [……]
    e. Crime and violence: [……]
20. How serious do you find the following environmental problems in Mozambique? (1 not serious, 2 serious, 3 very serious, 0 Don't know)
    a. Loss of trees: [……]
    b. Quality of drinking water: [……]
    c. Poor soil fertility: [……]
    d. Loss of flora and fauna: [……]
    e. Global climate change [……]
21. Do you think the following health problems are affected by cooking with charcoal?
    a. Headache: o(1) Yes o(2) No o(3) Don't know
    b. Eye irritation: o(1) Yes o(2) No o(3) Don't know
    c. Coughing: o(1) Yes o(2) No o(3) Don't know
    d. Shortness of breath: o(1) Yes o(2) No o(3) Don't know

**Part 4: Willingness to Pay Improved Cookstoves**

22. Do you think improved cookstoves:
    a. Reduce fuel use therefore, money spent?

       o(1) Yes o(2) No o(3) Don't know

    b. Reduce cooking time?

       o(1) Yes o(2) No o(3) Don't know

    c. Reduce health problems

       o(1) Yes o(2) No o(3) Don't know

    d. May reduce environmental problems

       o(1) Yes o(2) No o(3) Don't know

Improved cookstoves are devices that were designed to be more energy efficient – that is, to reduce the total amount of biomass consumed and to reduce cooking time. Production of smoke is also reduced with these devices, therefore having positive effects on health. Most of the population living in Maputo still relies on charcoal as their main fuel used for cooking. The most common stoves used for cooking are very inefficient in terms of heat retention and fuel use. Additionally, the large amounts of smoke they produce causes health problems, such as asthma which predominantly affects women and children as they spend most time in the kitchen.

The following improved cookstove has these characteristics:

- Reduces fuel consumption by half
- Produces little smoke
- Reduces cooking time
- Helps reduce pressure on the environment

23. Considering the characteristics previously mentioned and taking into account your household income, would you be interested in buying this product?

    o(1) Yes **[Go to Q22]** o(2) No **[Go to Q23]**

24. If so, what is the maximum amount you would be willing to pay for this product? Mt ……
25. Why would you not be interested in buying this product?

    ………………………………………………………………………………………………………………………………
    …………………………………………………………………………………………………………

26. How important do you find the following characteristics in a stove? [1 not important, 2 important, 3 very important]

    a. Price of stove [……]
    b. Amount of money spent on fuel per week [……]
    c. Has two burners [……]
    d. Made from durable material [……]
    e. Effect on the environment (less loss of trees) [……]
    f. Low health impact (less smoke produced) [……]

27. Would you be willing to pay more for an improved cookstove if you could pay in installment more interested in buying an improved cookstove if you could pay in installments? o(1) Yes o(2) No [go to **Q27**]

28. If yes, how much more would you be willing to pay? Mt…….

**Part 6: Cooking Information**

29. Who is mainly <u>responsible for cooking</u> in your household?

    o(1) Woman o(2)Man

30. How many <u>hot</u> meals does your household consume per day? ……times/day

31. How much time do you spend cooking per day in your household? ......hours/day
32. Which of the meals cooked in your home consume the most fuel?

    o(1) Beans o(2) Xima o(3) Rice

    o(4) Vegetables o(5) Meat/Fish o(6) Other, specify
33. How often do you boil water in your household? ……times/day
34. With what fuel or appliance do you boil water?

    o(1) Wood o(2) Charcoal o(3) Gas (LPG)

    o(4) Ethanol o(5) Electricity o(6) Kerosene

    o(7) Electric kettle o(8) Other, specify…
35. Where do you cook in the dry season (winter)?

    o(1) Completely outdoors o(2) In a partly covered space

    o(3) Completely indoors
36. Where do you cook in the wet season (summer)?

    o(1) Completely outdoors o(2) In a partly covered space

    o(3) Completely indoors

**Part 7: Household Characteristics**

37. What is your age? ……years old
38. [Observe and note] Gender? o(1) Male o(2) Female
39. Where you born in an urban or rural area? o(1) Urban o(2) Rural
40. What is the size of your household? ……. (number of people)
41. What is the <u>highest level of education</u> completed by any member in your <u>household?</u>

    o(1) No formal schooling o(2) Primary school

    o(3) Secondary school o(4) Higher education
42. What is the <u>main</u> economic activity of your household?

    o(1) Farming o(2) Self-business

    o(3) Formal trade o(4) Informal trade

    o(5) Salaried employment o(6) Casual Labor (part-time)

    o(7) Other, specify
43. Looking back on the past 12 months, what is your household's <u>average income per month?</u> (include pensions, remittances, other sources)

    o(1) Less than 2,500 Mt o(2) 2,500-5,000 Mt o(3) 5,000-10,000 Mt  o(4) 10,000-30,000 Mt

o(5) More than 30,000 Mt

44. Is the house connected to an electricity grid?

o(1) Yes  o(2) No [go to **Q46**]

45. If yes, what is the payment method used? [Go to Q**47**]

o(1) Pre-paid  o(2) Monthly bill o(3) Solar o(4)Other

46. If not, what is the <u>main</u> source of lighting in your dwelling?

o(1) Kerosene/Oil/Gas lamps  o(2) Candles

o(3) Battery flashlight  o(4) No lighting

47. Does your household own any of the following items? [tick box if **yes**]

o(1) Television  o(2) Fridge

o(3) Mobile phone  o(4) Radio

48. Who is the head of your household?

o(1) Woman  o(2)Man

49. Who in your household makes decisions on:

o(1) Woman  o(2) Man  o(3) Joint decision

o(4) No money spent  o(5) Other

a. Buying food: ……
b. Buying fuels used for cooking: ……
c. Buying expensive appliances (tv, fridge): ……
d. Buying a cookstove: ……
e. Buying mobile phone credit: ……

50. [Observe and note] Type of dwelling:

o(1) Precarious o(2) Modest  o(3) Modern

**END!**

Thank you so much for participating in our survey. Your responses will be of great help in our study which looks to find more information on the household energy situation in Maputo. We want to reiterate that your answers will remain strictly confidential and anonymous.

## ANNEX II — Focus Group Questions

State name, stove and fuel(s) you use at home.

FUELS & STOVES

1. What do you think about cooking with charcoal? Advantages & disadvantages
    a. Why does charcoal use prevail in households?
2. What do you think about cooking with electricity? Advantages & disadvantages
3. What do you think about cooking with LPG? Advantages & disadvantages
4. Are you looking for an alternative for the current fuel you are using?
5. What is the biggest barrier for buying an LPG stove?
    a. High investment cost of stove
    b. Lump-sum payment of gas cylinder refill.
6. Why do you think people would still use charcoal if money weren't an issue?
7. Why are you using more than one fuel at the same time? Why don't you fully switch?
8. Are there any cultural reasons behind that? What foods do you always cook using charcoal? Why? Are there any foods that cannot be cooked using LPG/Electricity? (For example, in Mexico tortillas need to be cooked over an open flame, therefore need to be cooked using firewood).

AWARENESS

9. How does charcoal use affect your health?
10. How does charcoal use affect the environment?
11. Which are important environmental issues in Mozambique?

ICS

12. Why would you be interested in ICS?

HH INFO

13. If an alternative would arise (LPG, ICS…) would we have to target women or men? Who makes the financial decisions?
14. Are modern stoves considered 'status symbols?
15. Do you have any other comments, questions, ideas you want to add before we finish the interview?

## ANNEX III – Summary Focus Group Transcript

**Question 1: What do think about cooking with charcoal? Advantages and disadvantages.**

*Advantages:*
Charcoal is economic. A friend (?) buys MT 15 of charcoal and cooks all meals. (woman 1)
The savings it provides, *poupanca*
Multi-purpose use of charcoal, many things can be done with it.

*Disadvantage:*
It takes longer to ignite, igniting time.

*General comments:*
'Charcoal is a base'

**Question 1-B: Why do people continue using charcoal if their ideal fuel is gas?** (06:52)

We can do a lot with charcoal. Cooking with gas is different than with charcoal. The way you roast the chicken…food has better flavor when cooked with charcoal (woman 6)

So you only continue to use charcoal for roasting chicken? (Moderator)

Not only for that, also for *trabalhos de familia,* for families with many people (woman 6)

There are things that we traditionally make using charcoal (woman 5)

**Question 2: What do you think about cooking with electricity? Advantages and disadvantages.** (09:13)

*Advantages:*
I only use electricity to re-heat my food (woman 1)

*Disadvantages:*
Electricity is very expensive

*General comments:*
Electricity is worse [than charcoal] (woman 3)
Once you have an LPG and charcoal stove, electricity becomes expensive. If you have electricity you use it for other purposes. You need electricity for lighting, the fridge etc. You use electricity for things you cannot use with charcoal.

**Question 3: What do you think about cooking with LPG? Advantages and disadvantages.** (11:20)

*Advantages:*
I think that an LPG stove is more economical, even for cooking meals such as currry which have a long simmering time (guy 1)
It is fast, you can use gas when you are in a hurry (woman 2)
Rapidity, heating up food at night, and cleanliness of house (woman 6)

*Disadvantages:*
The taste of some meals (guy 1)
I'm scared of using gas (woman 3)
When the bottle is about to finish it throws a 'different fire' which burns the pans (?) (guy 1)
Issue of safety. You have to be very careful when using gas–you are not going to send a child, who is not used to using gas, to light it. (woman 6)

*General Comments:*
I like cooking with charcoal but when it is night and I want to boil water I use gas (woman 6)

**Question 3-B: What is the biggest barrier for buying an LPG stove? Is it the cost of the stove, the gas cylinder, or the gas cylinder refill?** (16:30)

There is no barrier once you have the stove, the biggest barrier is the 'additional' which is the bottle (gas cylinder). The bottle is very expensive. The refill costs around MT 620

Having a stove is easy then? (Moderator)

Yes, you have diversity of stoves; with one mouth, two mouths (woman 5)

The problem is the initial cost of having to buy the bottle, the monthly lump sum of the refill is also an issue yet not as big as the cost of the bottle. (Moderator)

You can cook for MT 20 with charcoal but you need MT 600 to refill the gas bottle (woman 6)

Here we have also discovered that the only reason for using charcoal is not because the food tastes better but because it is an alternative to gas. (Moderator)

Agreed to buy gas if it where available in smaller bottles

**Question 4: What does the current market have and what does it need?**

There is gas and charcoal availability in the current Mafalala market but not gas stoves. Charcoal stoves are sold in the market.

There should be a larger variety of stoves on the market (woman 1)

**Question 5: Why people do people use a mixture of fuels? Why do people continue to use charcoal?** (25:24)

It is custom, habit. Our tradition is charcoal.

We have become more civilized as before we used to cook with firewood (woman 3)

Party, marriage (guy 3)

Cook certain dishes using gas (rice) and then for beans, *caril de amendoim* (peanut curry) use of charcoal (guy 1)

**Question 6: Are there any meals that can only be cooked using charcoal?** (27:35)

Beans, matapa, chicken sometimes, 'cow head'.

I think meals are good prepared in any type of stove, the difference is in time (guy 1)

**Question 7: Who is responsible for buying food? Fuels? Stoves? If an alternative would arise would the target have to be women or men? Who makes the financial decisions?** (43:03)

Women are responsible for food, fuels and stoves. General consensus was that men and women make a joint decision on matters.

Promote ICS/modern stoves to the women.
'It comes from their pocket' but women make the decision.

It is not that men should not be targeted but more that women are more capable of seeing the benefits of using these stoves. He says that its not that the men are again buying an improved stove it has to do with their priorities at the moment and establishing whether buying a stove is appropriate or not in relation to the conditions at the time. (guy 1)

Promotion in general is needed.

There's households that do not have a man therefore women make all the decisions (woman 3)

**Question 8: Are stoves seen as status symbols?**

A new stove calls for attention, neighbors are going to ask about it, how it works etc.

**Who can be the multipliers in the neighborhood? Woman chief or man?** (48:00)

Joint promotion
Educate kids
Public demonstration of one of the stoves