UPPSATSER FRÅN KULTURGEOGRAFISKA INSTITUTIONEN

June 2010

Socio-cultural dimensions in household cooking energy choice

Implications for energy transition in Catembe, Mozambique

Boris Atanassov

Master's Thesis in Geography, 30 credits
Supervisor: Peter Kinlund
Department of Human Geography, Stockholm University
www.humangeo.su.se

Acknowledgments

This thesis is dedicated to all those who have supported my studies throughout the years: my parents, family, teachers, professors, tutors and colleagues.

It has been an honour and pleasure to be part of the Globalization, Environment and Social Change Master's programme at Stockholm University. This thesis grasps the multi-disciplinary nature of the programme, as it encompass the dynamic field of household energy research. Special thanks to my supervisors, Peter Kinlund and Karin Holmgren for guiding me through the process.

This study would not be possible without the support of the Stockholm Environment Institute. I thank Francis Johnson, Fiona Lambe, Takeshi Takama, Anders Arvidson and Patricia Tella for introducing me to the field of household energy, and giving me the opportunity to conduct this study.

In Mozambique, I would like to first and foremost thank the 402 households of Catembe who participate in my survey; as well as the interview and focus group participants that formed the basis for this study. A special thanks to the municipal administration office of Catembe for hosting me during the field work; as well as providing transportation to and from all the field sites. My gratitude to the traditional leaders of Catembe, whom blessed this study and facilitated access to the communities. In Maputo, special thanks to the staff of GTZ Probec and the University of Eduardo Mondlane, whom shared their experience and knowledge of household energy research in the country. I would also like to acknowledge and thank the Swedish embassy for providing conference space and hosting the focus group discussions.

Finally, a special thank you to my enumerator team: Anibal Munguamba, Carlos Mohinla, Jeremias Massochua, Sergio Essufo, and Simiao Chirindza. Your professionalism, enthusiasm and hard work has contributed towards this final manifestation of our effort. It has been a pleasure working with you.

Abstract

Atanassov, Boris (2010). *Socio-cultural dimensions in households energy choice: Implications for energy transition in Catembe, Mozambique*.

Human Geography, advanced level, master thesis for master exam in Human Geography, 30 ECTS credits.

Supervisor: Peter Kinlund
Language: English

This thesis investigates the theoretical dimension of fuel transition in developing countries; and assesses the role of socio-cultural factors as determinants of fuel choice at household level. Past research has focused on income as a determining factor for fuel transition, as depicted by the energy ladder model, and the more development oriented energy leapfrogging model. This thesis challenges this notion by providing empirical evidence from Catembe, Mozambique; suggesting that socio-cultural factors are just as important determinants for household energy transition. By applying psycho-anthropologic research techniques, a series of qualitative and quantitative results from 402 households in Catembe, provide a framework for understanding the core factors responsible for household cooking energy choice. It was determined that factors such as taste preferences, cooking practices, local cuisine, kitchen type, gender relations and fuel preferences are culturally determined, and significantly influence on the adoption of modern cooking technologies. To demonstrate the importance for considering such factors, the introduction of an ethanol cook-stove is simulated and evaluated in terms of its applicability to user needs and preferences in Catembe. Results show that despite meeting developmental objectives, the stove falls short in conforming to the culinary traditional of intended beneficiaries.

Key words: Energy ladder, Energy leapfrogging, Energy transition, Household energy, Mozambique, Socio-cultural factors, Technology transfer, Traditional biomass fuels.

Table of Contents

List of Tables

List of Figures

Acronyms and Abbreviations

CO^2……..	Carbon dioxide
GHG…….	Green house gas
IAP……...	Indoor air pollution
LPG……..	Liquid Petroleum Gas
MDG……	Millennium development goal
MGI……..	Millennium Gelfuel Initiative
Mt…….	Mozambique Metical
MWH……...	Megawatt hours
PIC……...	Products of incomplete combustion
$PM_{2.5}$.....	Particulate matter (diameter of 2.5 microns)
PM_{10}……	Particulate matter (diameter of 10 microns)
SEI……...	Stockholm Environment Institute
UNDP……...	United Nations Development Programme
US$ …….	United States dollar
WHO……	World Health Organization

1 Introduction

The transition from traditional biomass fuels to modern, safe and efficient energy sources has the potential to increase the welfare of over 2.5 billion people whom continue to rely on inefficient biomass fuel such as firewood, charcoal, animal dung and agricultural residue for their cooking energy needs (IEA, 2006). Together with the laborious task of using these fuels, the health and environmental impacts are immense. Indoor air pollution, emitted from the combustion of traditional fuels is believed to be responsible for over 1.6 million annual deaths (WHO, 2000). While the impacts to climate change and deforestation continue to be reported upon as serious environmental threats (Bond *et al.* 2008; Clancy, 2008; Schlag & Zuzarte, 2008).

Energy transition is therefore of up most necessity, if such problems are to be mitigated. The transition is often depicted by the energy ladder model, which proposes for a gradual shift to modern fuels, as households' income increases (Barnes *et al.* 1996; Leach 1992; Macht *et al.* 2007). Acknowledging this trend, development organizations and policy makers opt for a fast pace move 'up the energy ladder', beyond natural progression of energy development, and introduce modern energy alternatives to those that cannot otherwise afford them. This is usually achieved through subsidisation and stove promotion campaigns. This development objective is usually referred to as 'leapfrogging', whereby developing countries are urged to adopt technologies developed abroad, as to avoid many of the environmental problems associated with natural developmental progression (Lenssen and Flavin 1996; Goldemberg 1998).

Despite the many benefits that would be gained from replacing traditional fuels with modern alternatives; there are numerous examples where improved stove programmes fail to penetrate the markets of the developing world and gain widespread use (Barnes et al. 1993; Budds *et al.* 2001; Masera *et al*, 2000; Schlag & Zuzarte, 2008).

As a means to understand why so many improved, safe and efficient stoves fail to be accepted by households in developing countries, this study aims to reassess and evaluate the models which have classically shaped energy development thinking. It is argued that stove programmes often focus too much attention on the efficiency of the technologies and the economics of supply and demand (Jebra & Iniyan, 2006). This study proposes for an additional determinant of fuel transition – socio-cultural factors. Acknowledging the socio-cultural characteristics of communities; modern stoves can be designed as to cater for the people's needs, preferences and cooking practices. Such stoves will inevitably have a higher acceptance rate, as opposed to technologies designed abroad without taking the local socio-cultural contexts into account.

This research follows, and builds upon a study carried out by the Stockholm Environment Institute (SEI) during September 2009. The institute carried out a household economic analysis of clean cooking stoves and energy in Mozambique; with the aim of assessing the potential for introducing ethanol fuelled cook-stoves in the country. By administering a choice experiment to households in Catembe, a peri-urban district of the capital, the study was able to assess the demand for the proposed technology. It was concluded that despite some enthusiasm, the results point to a low level of willingness of many households to transition from traditional fuels, to this

modern alternative. It was further noted that there seemed to be a 'cultural attachment' to charcoal which influenced on the results (Takama *et al*. 2010). It is therefore the aim of this thesis, to build on this study by assessing the socio-cultural factors driving household energy decision making. Acknowledgement of such factors may also provide understanding to why energy transition has been so slow in much of Africa; despite the ongoing efforts to introduce modern alternatives.

The thesis proposes for an alternative approach to the study of household energy. It introduces the incorporation of psycho-anthropological research techniques and in-depth socio-cultural research models as a tool for understanding household dynamics in energy choice. A multi-method research approach was chosen; it combines quantitative and qualitative data as a means to deliver an all rounded understanding of household energy dynamics in the region of Catembe. A structured household questionnaire formed the base of the study by correlating socio-economic characteristics with energy data for 402 households. A perception mapping survey was administered in parallel, as to quantify the revealed preference for different fuels, stoves and their characteristics. When analysed, the data illustrated the broad trends of household energy practices and preferences in the region. Quantitative data alone, is however not sufficient in explaining the socio-cultural significance for fuel choice. Such insights were gathered through group interviews with selected household cooks and ethnographic observation of the cooking practices in the region. Both the quantitative data and qualitative data were synthesised with the aid of a focus group discussion and selected interviews with energy experts and policy-makers in Mozambique.

2 Research Objectives

1. To empirically examine the core factors responsible for household cooking energy choices in Catembe;
2. To empirically assess the classic energy transition theories, based on household energy trends from Catembe;
3. To demonstrate the importance of considering socio-cultural factors, by evaluating the applicability of the proposed ethanol cook-stove, with reference to the socio-cultural insights gained from the study.

3 Central concepts and definitions

As a means to avoid ambiguity, this brief section clarifies the definition of concepts, as used in the thesis.

Socio-cultural factors: These are the traditions, social norms, customary practices and socially developed preferences which determine household fuel choice. For cooking energy choice, factors such as taste preferences, cooking practices, local cuisine, kitchen type, gender relations and cultural attachments; all influence choice of fuel used.

Product Specific Factors: These are the characteristics which make a stove desirable to households. Factors include functionality, convenience, durability, and even aesthetic appearance. The preference for some factors may be culturally determined

Socio-Economic Factors: These are the factors such as gender, age, education, income level, and household size. Such factors are often determinants of fuel choice at household level.

Solid Biomass fuels: These are fuels which are derived from plant materials and/or animal waste. Such fuels are burned in their solid form, as opposed to other biomass products such as ethanol and biogas.

Fuelwood: referrers to wood related products which are used to generate energy when burned. It includes fire-wood, charcoal, and various woody pallets.

Culinary activities: all activities related to the preparation and cooking of food. In this study, the term generally refers to culturally determined cooking practices and norms.

3-stone stove: This is the most rudimentary form of cooking, whereby three large stones are placed in a triangular pattern on the floor. These stones act as the stove, over which a pot is placed. Households generally use firewood, charcoal or agricultural waste as fuel when using the 3-stone method.

Clean energy: This term is used to refer to modern fuels with significantly low levels of smoke emission, and reduced environmental implications.

Fuel Switching: The process by which a household ceases to use a customary fuel and adopts another fuel-type as a replacement. The term generally signifies the adoption of a modern fuel source.

Multiple fuel use: The practice of using more than one fuel type as to satisfy daily cooking needs. This often occurs when households prefer to cook different meals with different stove types.

Gender roles: A set of social norms which are considered appropriate for a specific gender group. These are usually culturally determined and guide the behaviour of households. Cooking for example, is a gender role given to female members in the study site.

4 Background to the study

4.1 Household energy in developing countries

Access to safe, efficient and reliable energy sources is a key ingredient for development; however the welfare of around 2.5 billion people world wide is continuously challenged by the dependence on inefficient biomass fuels for their daily cooking energy needs. The situation is most severe in sub-Saharan Africa, where 76 % of the regions population make use of biomass fuels as their primary source of energy (IEA 2006).

The most prevalent traditional fuels used for cooking and heating are woodfuels, in the form of firewood and charcoal. In the event that such fuels are unavailable, households generally revert to agricultural residue and/or animal waste. In the rural landscape of many developing countries, firewood is the predominant source of energy used. This is a direct result of its low cost (available for free in most cases) as well as the lack of availability of alternatives. Charcoal is growing in popularity in many rural areas; however it is most widely used in the urban centres. Charcoal is generally preferred by households as it emits less smoke, has higher energy content than firewood, and is easier to transport and store (Schlag & Zuzarte, 2009). Over the years, researchers, development practitioners and policy-makers have increasingly become aware of the many social, environmental and economic implications associated with the use of such fuels. The following briefly discusses the major concerns.

4.1.1 Environmental considerations associated with traditional biomass use:

The World Energy Assessment of the United Nations Development Programme (UNDP) analyses the environmental impacts of traditional biomass use under two main categories: Those impacts arising out of the production and harvesting of biomass and those impacts resulting from the combustion of the traditional biomass fuels (UNDP 2000). The following introduces both categories.

Over the past few decades there have been debates whether the use of traditional biomass fuels are a leading cause of deforestation or not. In the mid 1970, it was widely recognised that biomass fuels were leading to depletion of forest resources, however by the mid 1980's, this premise was contested on the grounds that other activities such as land clearance for agricultural expansion and timber harvesting were primarily responsible for deforestation (Arnold *et al*. 2006). Furthermore, it was argued that fuelwood collection in rural areas was largely in the form of dead wood or twig wood, without cutting the entire tree (Chidumayo, 1997). Recent studies however point to an increasing concern for deforestation, arising from the ever so growing charcoal industry, which fuels the urban energy needs of many of the world's developing countries. There is growing evidence on the impact of charcoal production in and around urban centres in many sub-Saharan African countries. Forest depletion is also severe at production sites,

which at times are managed outside licensing agreements and national laws (Clancy, 2008; Hiemstra-van der Horst & Hovorka, 2008). With the depletion of forest cover, one can also attribute further environmental consequences such as carbon stock depletion, erosion, desertification, decreased soil moisture and quality, albedo and decreased biodiversity (Clancy, 2008; Schlag & Zuzarte, 2008).

The next set of environmental problems arise out of the combustion of fuelwood, either in the process of production (charcoal) or final consumption by households. The burning of solid biomass fuels is thought to impact climate warming significantly. In addition to emitting considerable levels of Carbon dioxide (CO_2), the release of products of incomplete combustion (PIC's) such as carbon monoxide, methane, and particulate matter further influence on climate change (Bond *et al*. 2008; Schlag & Zuzarte, 2008; WHO, 2006). In recent years it has come to attention that the release of black carbon, or better known as soot from the combustion of solid biomass, appear to be just as serious contributor to climate change as are GHG's. However, because black carbon stays in the atmosphere from a few days to a few weeks, the reduction of solid biomass burning may well be a short term solution to the global warming phenomena (Ramanathan & Carmichael, 2008; Bond *et al*., 2008).

4.1.2 Health impacts associated with traditional fuel use:

The World Health Organization (WHO, 2006) brands the cooking with solid biomass fuels as one of the major causes to global ill health. In the year 2000 it was estimated that Indoor Air Pollution (IAP) was responsible for more than 1.6 million annual deaths and 2.7% of the global burden of disease (WHO, 2006:12). There are various substances in biomass smoke that can damage health such as: Nitrogen oxide, Carbon monoxide, Sulphur oxides and various carcinogens such as formaldehyde and benzene (Bruce *et al*. 2000; Budds *et al*. 2001). Furthermore, the burning of solid biomass fuels also releases small particles into the air, which obstruct airways and lungs and impair immune response. The particles range from a diameter of 2.5 microns ($PM_{2.5}$) up to 10 microns (PM_{10}). The finer the particle, the more damage they can infer, as they penetrate deeper into the lungs (WHO, 2006).

Budds *et al*. (2001: 2) describe the problem of IAP as being strongly poverty related, on the basis that it is the poor whom rely on lower grade fuels, and often do not have the necessary infrastructure for a well ventilated cooking space. Those most affected are generally women in low income households, whom spend long hours indoors and are primarily responsible for cooking. Young children are also susceptible to health risks associated with IAP, as they are often close to their mothers as they cook and their immune systems are not fully developed to withstand the toxic effects of smoke (Bruce *et al*., 2000; Budds *et al*, 2001; Smith, 2006; WHO, 2006). The most notable health impacts associated with IAP include: Acute respiratory infections, Chronic obstructive lung disease and lung cancer (Budds *et al*., 2001; Bruce, 2000; WHO, 2006). Also associated with high levels of smoke exposure is the increased susceptibility to Tuberculosis, Cataract and Asthma (WHO, 2006). "The health impacts from IAP have repercussions on the productivity of the poor, which in turn negatively affect both their livelihoods and quality of life" (Budds *et al*. 2001: 2).

In addition to smoke related health problems, using inefficient and cumbersome stoves may result in a variety of user injuries. Burns, scalds and other injuries can occur through contact with hot surfaces or flames. There is also a preoccupation with safety of children, whom are present near open flames (Johnson & Bryden, 2006). Furthermore, "fuelwood collectors often have to travel long distances between the forest and the village, carrying heavy loads on their heads and can suffer from pains and even heart palpitations. There is also the risk of injury from axes, tree stumps, snake bites and poisonous insects" (PREDAS, 2009: 22).

Health problems associated with smoke are also not restricted to the household. Ambient air pollution, resulting from a high concentration of biomass stove users in a given region, can have regional level health impacts. Pollutants may disperse over entire neighbourhoods, impacting on air quality (PREDAS, 2009). During a study to evaluate the impact of cooking fuel smoke on health amongst women in Mozambique, Ellegård (1996) observed that even modern fuel users in low-income districts of Maputo were exposed to high concentrations of particulate pollutants. It is suggested that these higher than normal levels are attributed to a high background level of ambient particulate in Maputo. It is thought that this pollution originates mainly from domestic cooking (solid biomass fuels) in the city, as there was very limited traffic and industrial activity at that time.

4.1.3 Social issues associated with traditional biomass fuels:

There is a distinct gender dimension in the household energy sector in much of the developing world. Malhotra *et al*. (2004) discuss that women and men do not bare the burden of environmental and health factors associated with biomass use, to the same extent. Women in many countries are responsible for the collection, transportation, processing and storing of fuels, as well as the cooking activities; while men typically make decisions of a financial nature (Malhotra *et al*. 2004; Schlag & Zuzarte, 2008; WHO, 2006). It is thus possible to deduce that the health burdens associated with traditional biomass cooking are disproportionately felt by women. "Because of their customary involvement in cooking, women's exposure is much higher than men's" (Bruce *et al*. 2000: 1080).

The time associated with the preparation of food using inefficient cooking technologies as well as the collection and processing of fuelwood is also of a significant concern. "In rural communities that rely almost exclusively on solid biomass for cooking fuel, the burden of firewood collection falls primarily on women and, to a lesser extent, young girls. Women gather firewood on foot, often walking long distances with heavy loads"(Schlag & Zuzarte, 2008: 9). This time spent collecting fuelwood represents an opportunity cost that could potentially be spent on income generation and/or education activities (Schlag & Zuzarte, 2008; Joon *et al*., 2009).

4.2 Modern cooking fuels and the MDG's

The dependence of traditional biomass is seen as being intrinsically linked to poverty, both as a result off, as well as a cause to (Karekezi, 2002). Although there is no Millennium Development Goal (MGD) specifically related to energy; access to modern energy sources have the potential to address many of the MDG's and alleviate some hardships associated with poverty (Arvidson & Nordström, 2005; Schlag & Zuzarte, 2008; WHO 2006). Table 1 illustrated the various ways that improved energy sources can contribute towards the achievement of the MDG's.

According to Schlag & Zuzarte (2008; 4) "Modern cooking fuels are considered to be those that have a high energy density, high combustion efficiency and a high heat-transfer efficiency with sufficient heat-control characteristics. Biogas and LPG are commonly used gaseous fuels, and ethanol, kerosene and Jatropha are the more familiar liquid cooking fuels". For the purpose of this paper, the focus will be on the ethanol cook-stove, as designed by Swedish manufacturer Dometic AB, and proposed for energy development by Project Gaia (Project Gaia, 2010). Appendix VII includes a detailed description of the proposed ethanol fuelled cook-stove.

With the expansion of the biofuels industry throughout the developing world; ethanol that is currently produced for blending into transportation fuels, has the potential to benefit household demands for modern energy sources. Ethanol can be produced from a wide range of crops such as sugarcane, cassava, sweet sorghum, maize and wheat; enabling for the applicability in a variety of geographical settings (Schlag and Zuzarte, 2008). In the past few years, various initiatives have lead to the introduction of ethanol as household cooking fuels. The Millennium Gelfuel Initiative (MGI) pioneered by the World Bank in 2000 aimed to introduce ethanol as a clean, renewable and low-cost household cooking fuel in various African countries (Utria, 2004). Similarly, Project Gaia has been involved in a public-private partnership in Ethiopia to develop a local market for the ethanol fuelled cook-stoves. The stoves are manufactured locally under the licence of Dometic AB (Lambe, 2008). Project Gaia is also tapping into Brazil's ethanol production to introduce the stoves into the household cooking market. A pilot test of the ethanol cook-stoves produced positive results in the Minas Gerais state of Brazil; a region battling deforestation as a result of fuelwood production (Couto & Murren, 2009).

Table 1: Contribution of improved household energy in achieving the MDG's

Millennium Development Goals	Contribution of improved household energy practices
Goal 1: Eradicate extreme poverty and hunger	• Saving time spent being ill or having to care for sick children will cut health care expenses and increase earning capacities. • Where fuels are purchased, increasing fuel efficiency and thus cutting down on the quantity of fuel needed will ease constraints on already tight household budgets. • Improved household energy technologies and practices will open up opportunities for income generation. • Access to electricity will provide a source of light for economic activities in the evening and a source of energy for operating, for example, a sewing-machine or refrigerator.
Goal 2: Achieve universal primary education	• With less time lost in collecting fuel and due to ill health, children will have more time available for school attendance and homework. • Better lighting will allow children to study outside of daylight hours and without putting their eyesight at risk.
Goal 3: Promote gender equality and empower women	• Alleviating the drudgery of fuel collection and reducing cooking time will free women's time for productive endeavours, education and child care. • Reducing the time and distance that women and girls need to travel to collect fuel will reduce the risk of assault and injury, particularly in conflict situations. • Involving women in household energy decisions will promote gender equality and raise women's prestige.
Goal 4: Reduce child mortality	• Reducing indoor air pollution will prevent child morbidity and mortality from pneumonia. • Protecting the developing embryo from indoor air pollution can help avert stillbirth, perinatal mortality and low birth weight. • Getting rid of open fires and kerosene wick lamps in the home can prevent infants and toddlers being burned and scalded.
Goal 5: Improve maternal health	• Curbing indoor air pollution will alleviate chronic respiratory problems among women. • A less polluted home can improve the health of new mothers who spend time close to the fire after having given birth. • A more accessible source of fuel can reduce women's labour burdens and associated health risks, such as prolapse due to carrying heavy loads.
Goal 6: Combat HIV/AIDS, malaria and other diseases	• Lowering levels of indoor air pollution levels can help prevent 1.6 million deaths from tuberculosis annually.
Goal 7: Ensure environmental sustainability	• Where biomass is scarce, easing the reliance on wood for fuel through more efficient cooking practices will lessen pressures on forests. • Moving up the energy ladder and using improved stoves can increase energy efficiency and decrease greenhouse gas emissions.
Goal 8: Develop a global partnership for development	• Recognition in development agendas and by partnerships of the fundamental role that household energy plays in economic and social development will help achieve the Millennium Development Goals by 2015.

Adopted from: WHO (2006: 17)

4.3 Mozambique – Country analysis

4.3.1 Country context

Located in the south-eastern part of Africa, Mozambique is a country recovering from a 17 year long civil war since the brink of its independence in 1975. Such devastation currently places Mozambique as the fifth least developed nation in the world with a GDP per capita of 1,242 (PPP US$), and where 69.4 percent of the 20.5 million people reside below the national poverty line (UNDP, 2007) . Since the mid 90´s, the country has taken stark measures to promote investment and build up the economy; however despite such efforts, basic developmental challenges remain largely unresolved. Only 32% of the population uses improved sanitation, 43% of the population has access to improved water source and over 44% of the population remain undernourished (UNDP, 2007).

4.3.2 Energy Profile

The Mozambican national portal to statistics and country information highlights that the countries´ natural resources include hydro-electricity, natural gas, coal reserves and wood, amongst various minerals and marine resources (Government of Mozambique, 2009). This indicates that the nation is abundant in energy resources. One of the countries flag-ships, is the Cahora Bassa hydro-electric dam, generating the 14,500,378 MWh of electricity, from a total of 14,736,911 MWh produced country wide. The dam also enables Mozambique to be a major energy exporter, channelling out around 80 % of electricity produced, to neighbouring countries such as South Africa, Botswana, Swaziland, Zimbabwe and Namibia (Ministerio de Energia, 2005: 10).

Despite the potential for energy security, the Human development report highlights that 18.6 Million people are without access to electricity countrywide (UNDP, 2007: 305). This accounts for about 90 percent of the population. To satisfy household energy needs, Mozambicans largely depend on traditional biomass such as firewood and charcoal for cooking and heating, as demonstrated by Figure 1. Kerosene and fire wood is predominantly used for lighting; this is demonstrated by Figure 2. In the capital Maputo, around 75% of the population rely on charcoal and firewood for their cooking energy needs. Charcoal is by far the most prominent fuel and it is used by 63 % of the city population (Ministerio de Energia, 2005: 34). As a means to estimate the household expenditure on charcoal, a baseline survey was carried out on the 14th of September 2009 (Appendix I). The results show that an average family of 5 requires around 70 kg of charcoal monthly. A 70 kg sack of charcoal is sold at the local market for an average of 480 Mt (17 US$). This figure is equivalent to a third of the national minimum wage (1480 Mt, equivalent to 53 US$), (Meusalario, 2010).

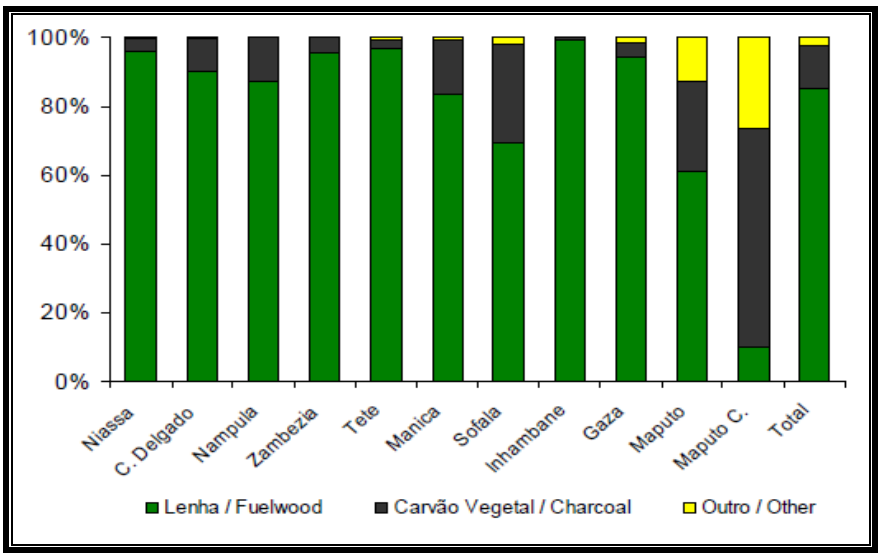

Figure 1: Household energy use for cooking in Mozambique
Source: Ministerio de Energia, 2005, Estatistica de Energia, pp. 34

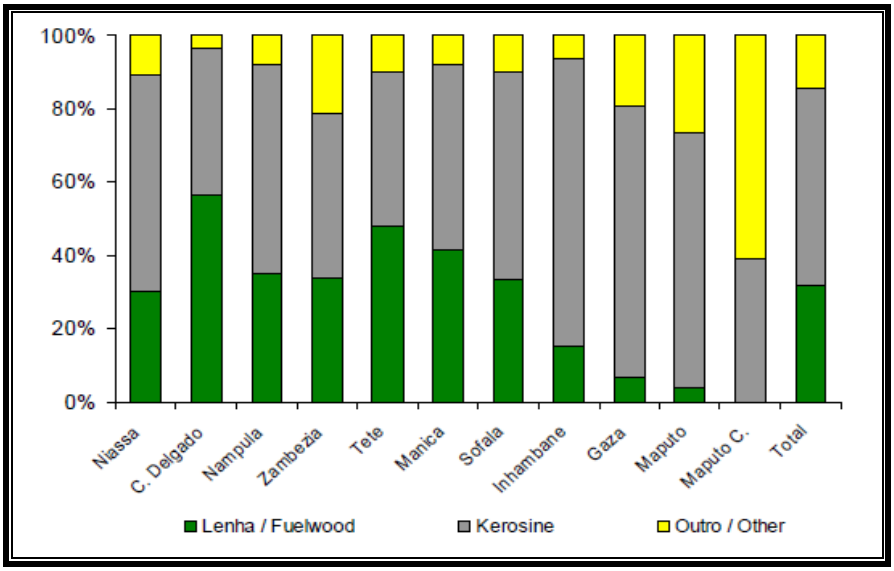

Figure 2: Household Energy use for lighting
Source: Ministerio de Energia, 2005, Estatistica de Energia, pp. 34

4.3.3 Policy Background

As a large majority of the population directly depend on traditional biomass for their energy needs, the National Energy Policy dedicates section 3.6 to the promotion of sustainable use of the country's biomass resources. The policy calls for a gradual reduction in traditional biomass consumption and advocates environmental sustainability through reforestation programmes and the promotion of more efficient and environmentally considerate means to produce and consume biomass products (Governo de Moçambique, 2000). Furthermore, the national strategy on climate change and adaptation focuses on deforestation as a result of fuelwood extraction. According to the document, 18 million cubic meters of forest are explored annually for biomass collection, with no clear sustainability measures in place. Obstacles highlighted include the lack of community level involvement, weak institutional capacity in protecting and controlling forest areas, lack of demarcations on protected regions, as well as the lack of a clear strategy for forest management (MICOA, 2005).

The government of Mozambique has recently introduced its Biofuels Policy and Strategy with the core aims of ridding the country of its dependence on fossil fuel imports, promoting socio-economic development, and contributing to the global initiative of green house gas reduction (Governo de Moçambique, 2009). Mozambique is considered as one of the African countries with the largest biofuels production potential, with the capacity to produce around 7 Exajoules of biofuels sustainably–a figure that assures full energy independence, with surplus to supply international markets (WWF, 2008). Furthermore, the policy promotes the use of gelfuel as a means to reduce the mass use of firewood and charcoal. The policy document also prioritises the introduction of gelfuel stoves as part of the national biofuels development programme. The focus on gelfuel, in contrast to liquid fuels, can be understood to be influenced by the Millennium Gelfuel Initiative, pioneered by the World Bank´s Regional Program for Traditional Energy Sector (RPTES), (Utria, 2004). Mozambique is therefore an ideal candidate for introducing the proposed ethanol cook stove, as there is a growing national biofuels market, and a policy support for the initiative. The challenge therefore is to understand the socio-cultural factors which will either enable for the acceptance of this fuel, or impede its popularity.

4.3.4 Socio-Cultural Context

Mozambique is a country of social and cultural diversity, shaped by various phases in its history. The country is made up of 16 ethnic groups, most of which are of Bantu origin (Ndege 2007: 3). Traditional societies maintain age old practices and traditions; however have been influenced by various external interactions. The north-eastern part of the country has a strong Arab influence dating back to the 12th century trading relations. This region is dominated by Swahili people with predominantly Islamic religious affiliations. With the arrival of the Portuguese in 1498, western influences prevailed for over 5 centuries of colonial occupation. The spread of Christianity, western education and the market economy are amongst the most evident influences (Ndege, 2007: 21-28).

It can be said that the most notable indigenous traditions and practices are retained in the rural landscape of Mozambique. Communities are based in a kinship system, where homesteads mark the rural territory. Typical homesteads comprise of one open space in which the family resides. The social space is outside in the courtyard where children play and visitors are welcomed. It is in this open-air social setting that cooking usually takes place. Culinary duties in the traditional societies are largely gender-specific. Women do most of the cooking; as well engage in subsistence agricultural activities. Millet, cassava, maize, rice, fruits and nuts are the staple diets of many (Ndege, 2007).

According to Ndege (2007; 85) the traditional socialization process is of paramount significance to Mozambican communities. It is the process through which children acquire knowledge, skills and suppositions which enable them to participate actively in society. Cooking for example is learned by girls from a very young age by actively participation and watching their mothers, grandmothers and other female members engage in culinary activities. Similarly drawing water from rivers and collecting firewood is predominantly expected of girls to do. Boys on the other hand are introduced to herding practices, hunting and warfare games (Ndege, 2007). Contrary to the associated custom of female subjugation in many African countries (Onunwa, 2005); Ndege (2007) asserts that in Mozambique, traditional social relations often favour women's rights in many communities. "Traditional Mozambican society accorded women rights over property that they accumulated, In fact, among the matrilineal Chewa, women had a lot of power pertaining to the control of land as well as household resources. Men had fewer rights and could be dismissed and sent away by the wife." (Ndege, 2007: 88).

It is illusive to talk about a pure traditional African society in modern day Mozambique. Influences from Islam, Christianity, colonialism, the modern economy, western education and urbanization have lead to some form of social change (Ndege, 2007: 89). According to Lubkemann (2008), the most drastic disruption to Mozambican traditional culture happened as a result of the two decade long civil war, post independence. This conflict displaced millions of people from their homes and devastated entire social structures. Many people from the rural areas (where armed conflict was most prevalent) took shelter into the major cities such as Maputo, Beira, Nampula, Tete, and Quilimane. These cities were however not built to support the mass influx of displaced communities, resulting in what is today a large peri-uraban makeup of informal settlements. It is in such places where one can clearly see the mixing of urban-rural traditions, customs and practices (Jenkins, 2000; Lunkemann, 2008; Ndege, 2007).

In the urban centres, pressures from modern day economy have modified traditional lifestyles. Children have opportunities to go to school, being less exposed to the traditional socialization processes, as well as gaining other influences. Women have to become increasingly involved in the economy, as to provide additional income to the household. Laborious household tasks become more and more difficult to perform. Raising income level of households also influence on their lifestyle. In many cases, western values are adopted, and household practices conform more to the western ideal (Ndege, 2007).

An article about the impact of colonialism and independence on the culinary habits of Mozambicans (Sitoe, 2010), highlights the tension between tradition and modernity. It is noted that certain values attached to national cuisine are lost, with relations to the

perception that western cuisine is superior. For example, it is often perceived that foods prepared with oil (fried), are of more value then the traditional stews, which are generally associated with the idea of poverty (Sitoe, 2010). The author however, does not discount the cultural value of traditional dishes, and suggests that families often incorporate elements of traditional meals, in their dietary regimes. This observation points to the notion that cultural norms prevail, as external influences shift society towards change.

5 Literature Review – Theoretical Background

It is argued by donor organizations, policy makers and the development community that in order to avoid the problems associated with traditional biomass use, there needs to be a radical shift from such fuels to modern alternatives. However, even if modern alternatives are introduced and accepted, this paper argues that a full transition as propagated by energy ladder model is rarely possible in many developing countries. There are specific cultural needs which are met by traditional sources of energy. These will be discussed in more detail in the following sections.

5.1 Household Energy Transition

Since the early 70's, the development community, governments and stove programme designers have devised plans to curb the problems associate with traditional biomass use in developing countries. Energy transition through a system of fuel switching from elementary fuels such as woodfuels and crop residue, to modern fuels such as bio-ethanol, LPG or electricity has been seen as the prevailing solution.

"The costs of traditional use of woodfuels have been growing – to the householder, in cash or collection time, and to society in inefficient energy use, deforestation, and local and global harm to health and the environment. Modern, efficient stoves can alleviate some of these problems; programs to design and disseminate them would seem a worthwhile pursuit for development activity" (Barnes, 1993: 119).

Studies focusing on energy transition often link factors such as income, access to electricity, household size, and scarcity of forest resources as determinants of fuel switching. Campbell *et al.* (2003) establish that higher income households in urban Zimbabwe have the tendency to transition to modern cooking fuel sources such as kerosene and electricity, as opposed to using woodfuels as their primary energy source like the majority of lower income residents. Similarly, Ouedraogo (2006) determined that as household income increases in Burkina Faso, households' firewood use systematically decreases. Forest resource scarcity in turn also leads to fuel switching, as households may no longer have access to nearby resources for fuelwood collection. Therefore, the increase of fuelwood collection time is also a determinant for fuel switching (Heltberg *et al.* 2000). According to Campbell *et al* (2003), Davis (1998) and

Ouedraogo (2006) access to electricity also plays an important role in shifting the reliance on traditional fuels, however according to Madubansi and Shackleton (2007) this trend was not visible with the introduction of electricity into a rural region of South Africa.

Two main models make up the contents of the classic energy transition theory; the energy ladder model and the leapfrogging model. Both will be discussed in the subsequent section with reference to various critiques to these models.

5.1.1 The Energy Ladder Model:

The energy ladder model suggests that as income increase, households adopt more modern cooking fuels. This linear process is illustrated in Figure 3; whereby households cease to use traditional biomass fuels and adopt modern alternatives as their affluence level increases (Barnes *et al*. 1996; Leach 1992; Macht *et al*. 2007). The model thus proposes income as determinant factor for fuel choice, and thus the rationale for transitioning up the energy ladder. Furthermore Masera *et al*. (2000: 2084) point out that "the energy ladder assumes that more expensive technologies are locally and internationally perceived to signify higher status, and that families desire to move up the energy ladder not just to achieve greater fuel efficiency or less direct pollutions exposure, but to demonstrate an increase in socio-economic status."

Essentially there are three steps in the energy ladder; the first phase is defined as a universal reliance on biomass in the form of wood, dung and agricultural residues. The second phase is characterised by a fuel switch to fuels such as kerosene and coal. These are often refereed to as transition fuels. The third and final phase is the adoption of modern cooking fuels such as LPG, natural gas, electricity or other 'clean' sources of energy (Heltberg 2004: 870).

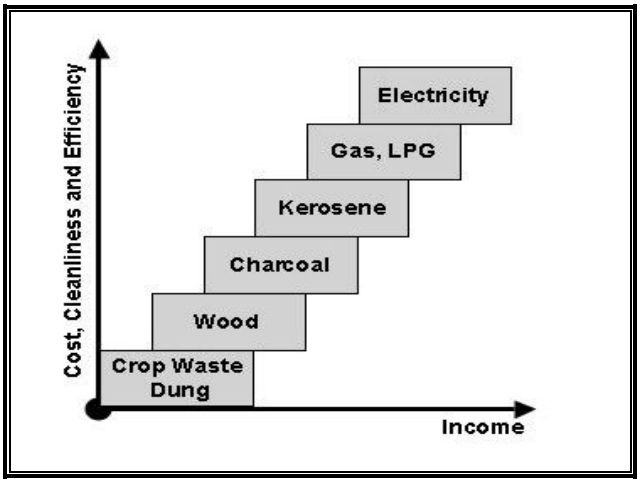

Figure 3: Schematic representation of the energy ladder model
Adopted from: *Holder and Smith (2000)*

Over the past few years, this model has been criticized on various grounds. Jebra and Iniyan (2006) criticise the energy ladder model on the basis that it focuses too rigidly on economic processes as determinants of fuel choice; with no concern for certain social, cultural and behavioural processes as determinants of energy choice. For example, according to the energy ladder hypothesis, fuelwood is seen as an inferior economic good, often associated with a necessity rather than a choice. It can be seen as "fuel of the poor" (1990; Leach, 1992). However, Hiemstra-van der Horst & Hovorka, (2008) illustrate that in Maun, Botswana fuelwood is not restricted to low income strata, in fact it is widely used by all income groups, due to consumer preferences and lifestyle considerations; as opposed to income restrictiveness.

The second criticism of the energy ladder model is on the basis that in many developing countries fuel shift is not a linear process from one fuel to another more modern source. Heltberg (2004: 871) studied fuel-switching in 8 developing countries and concludes that the "uptake of a new cooking fuel far from always displaces traditional fuels". He draws on evidence that multiple fuel use is widespread in the study regions. In Guatemala for example, it was estimated that households predominantly rely on both firewood and LPG (26% and 16% respectively), while in rural parts of South Africa 34% of households use both firewood and kerosene for their cooking needs. Similar observations can be found in other parts of South Africa (Davis, 1998), Botswana (Hiemstra-van der Horst & Hovorka, 2008), in many Sahelian countries (PREDAS, 2009) and in rural India (Joon *et al*, 2009).

Masera *et al*. (2000) provide an alternate to the energy ladder model´s linear fuel switch process, by introducing the "multiple fuel" model. The model asserts that "rural households do not 'switch fuels', but more generally follow a multiple fuel or 'fuel stacking' strategy by which new cooking technologies and fuels are added, but even the most traditional systems are rarely abandoned (…) The specific fuel-mix choice and the relative consumption of each fuel is governed by the characteristics of the fuels and end use devices; specific aspects related to fuel availability; and the local cultural and social context that determines household preferences regarding cooking fuels and lifestyles" (Masera *et al*. 2000: 2084-2085).

5.1.2 The Leapfrogging Model

In development studies, leapfrogging theory suggests that developing countries may learn from the experiences of developed nations, and tunnel through technological generations to adopt most recent technologies and avoid various environmentally degrading stages of the Kuznets curve (McGranahan, 2007; Munasinghe 1999). Doing so, it is suggested that developing countries can avoid repeating the environmentally destructive experience of today's developed world and build for a more sustainable future.

For household energy development, leapfrogging proposes the introduction of modern sources of energy to households in a fast and cost effective manner, as a means to counter environmental degradation associated with traditional energy sources (Lenssen & Flavin, 1996; Goldemberg, 1998). This 'north-south' transfer of technology is often

achieved through a system of stove distribution programmes, stove subsidies and promotional campaigns. Much emphasis is placed on making the technology affordable for the poor to use; as it is they whom rely mostly on biomass fuels (Goldember, 1998). It is therefore proposed that the energy ladder model be replaced with a two step approach – from traditional fuels, straight to advanced energy sources. This will thus avoid some of the environmental and health problems associated with transitional fuels such as coal and kerosene.

In leapfrogging, the introduction of foreign developed technologies is proposed because of the belief that many developing countries have constrained capabilities to create and disseminate local innovations. Murphy (2001) categorises such limitations as being technical, organizational and institutional. Technically, technologies can be difficult to manufacture, keep cost efficient, safe and of good quality (durable). Organizationally, countries may lack the resources to effectively disseminate technologies. There may often be an aid dependency for such initiatives to occur. Institutionally, technological adoption may be constrained by social structures in place. Gender-based roles and community resource allocation traditions may for example allocate a low priority for improved cooking technologies, which primarily affect women (Murphy, 2001). It is therefore believed that by creating technologies abroad, one can bypass such constraints.

In critique to the model, Murphy (2001) asserts that leapfrogging is a misconception because in the majority of instances, modern cooking technologies are developed abroad and disseminated in developing countries in a top-down approach. Although such technologies are popular in some parts of the world, they often fall short of meeting specific social, cultural, and economic conditions that exist in local community contexts.

"It is argued that technological absorption cannot occur without the proper social, cultural, political, and economic institutions to support adoption, dissemination, and appropriate contextual innovation. Institutions in this sense are not only the agencies, property rights regimes, rules, values, or norms existing in a given context. They also include people's daily patterns of behaviour. These patterns – such as who collects fuel, when and how they do it, or how the energy is consumed – are embedded in rural lifestyles and the cognitive processes that influence the behaviour of people. For technologies to be absorbed, they must first be connected to these patterns." (Murphy 2001: 187)

5.2 Technology transfer, diffusion and adoption

In continuation to the suggestions of the leapfrogging model; "technology transfer includes both the movement of technology from the site of origin to the site of use, and issues concerning the ultimate acceptance and use of the technology by end users" (Choi, 2009: 50). User acceptance is thus a determinant of technological transfer success, and can be measured by adoption rate.

According to Barnes *et al*. (1993) the adoption of a technology occurs if the benefits to the household exceed the cost of the proposed technology. In the case of cooking

technologies, benefits such as financial gains from energy savings, as well as time savings as a result of faster cooking time can promote adoption of the technology. According to Amacher *et al.*(1993) household adoption of new technologies also depends on household perception towards the risks associated with current technologies, as well as the households' expectation of the possible gains from the proposed innovation. The awareness of environmental and health risks associated with traditional biomass use, may thus be a determining factor for the adoption of modern cooking technologies.

For technological transfer to be most effective, it should reach and improve the livelihoods of as many people as possible. The process by which this is achieved is refereed to as diffusion. According to Rogers (2003) diffusion is the process by which technological innovations are communicated and spread amongst members of a social system. According to Choi (2009), the process of diffusion occurs through a variety of communication channels such as mass media, interpersonal channels or interactive channels (such as the internet). There are various models which describe this process; perhaps the best known work is by Swedish geographer, Hägerstrand (1967) whom models diffusion of innovations as a special process. A description of these models is beyond the scope of this thesis; however it is worth noting that Hägerstrand (1967) incorporates the notion of cultural influences within the modelling process as well as the notion of individual 'resistance' to innovations, based on social and cultural grounds. This he refers to as the "human landscape feature" (Hägerstrand, 1967: 9).

5.3 Socio-cultural consideration

When not considering socio-cultural aspect, it may inevitably lead to project failure in the long run. There are various examples of stove programmes that have been unsustainable due to not considering the local social and cultural setting of intended beneficiary communities. One such example comes from Jaracuaro, rural Mexico where the large majority of people depend on fuelwood for cooking. It was decided to introduce modern LPG stoves; however it was soon noticed that communities did not abandon fuelwood use, as a result of a cultural incompatibility of the new stoves. It was discerned that the new stoves were not adequate for the cooking of the popular *tortilla*. Since tortillas are customarily prepared over open wood fire, it was reported that the tortillas prepared over a gas flame were distasteful. Furthermore it was also noticed that the design of the LPG stove did not allow for the large enough surface, necessary for efficiently cooking *tortillas* (Masera *et al*. 2000).

There are also cases where a stove developed and designed for use in one developing country, is unsuitable for another. The *jiko* stove of Kenya is a ceramic stove suitable for more efficient burning of charcoal. The design of the stove was largely a bottom up initiative and production was carried out by local artisans, enabling for its wide spread acceptance and popularity in Kenya (Budds *et al*. 2001:30). When the same *jiko* stove was introduced in neighbouring Tanzania, it proved to be unpopular amongst households as it failed to meet consumer preferences. This demonstrates the culture-specific context in which stoves should be designed. Only after design modifications to suit the Tanzanian local needs, was the stove later adopted (Barnes *et al*. 1993: 127;

Budds *et al*. 2001:30). Unfortunately the authors do not elaborate upon the specific cultural reasons for the misfit of the *jiko* stove in Tanzania. This strengthens the need for more in-depth research into specific socio-cultural dynamics within household energy choice.

Household cooking interventions may also be in the form of household modification and awareness raising campaigns. Budds *et al*. (2001) points to the connection between ineffective household ventilation and IAP. It is assumed that an intervention in housing design can alleviate some of the health conditions associated with IAP. Interventions include enlarging windows, raising roof heights and adding ventilation points. However ideal such interventions might seem from a foreign perspective, there are situations where cultural barriers restrict such modifications. In Kenya and India, it was determined that people did not like the smoke emitted by their stoves when used indoors, however it was observed that households were reluctant to open windows or cook outside due to cultural needs for privacy. There were even reports that smoke emitted from cooking was also used to repeal insects and preserve thatch roves in the houses (Budds *et al*, 2001; Barnes *et al*. 1993).

Gender considerations are vital social aspect to consider in stove programme design. The needs of men and women are different when it comes to household energy. According to Malhotra *et al*. (2004: 158), "A technology that aims at benefiting women in the cooking energy sector must meet the following criteria: The device must retain all the features that the women value in their traditional cooking systems; The new device should serve all the uses the current device is being put to; The women should be able to look after the regular operation and maintenance themselves; and the device should be aesthetically appealing." If modern stoves fail to meet these criteria, they might run the risk of not being used by women – the primary beneficiary of improved stoves.

Despite the recognition of the importance of incorporating socio-cultural factors in the study of household energy and the outline of examples where such factors impede the acceptance of modern cooking technologies; the bulk of literature on this topic, falls short of extensively assessing and evaluating these factors (Barnes *et al*, 1996; Campbell *et al*, 2003; Joon *et al*, 2009; Schlag & Zuzarte, 2008). In order to accurately represent household energy dynamics in developing countries; models and theories on energy transition should incorporate user-related preferences which determine current fuel choice. By doing so, it will be possible to more accurately forecast user acceptance rate of modern alternatives, as well as to allow for possible technological modification as to increase adoption rates. The following section introduces alternative approaches to the study of household energy, with specific focus on methods for the evaluation of socio-cultural factors as determinants of fuel choice.

5.4 Approaches to analysing socio-cultural factors in household energy

5.4.1 What needs to be studied

"It is incumbent on development organizations to recognise that technologies should be appropriate to people's needs, rather than trying to change people's behaviour to suit the technological option" (Bates, 2001:1). Budds *et al*. (2001; i) asserts that "Many initiatives have been designed according to the priorities of the implementers, or assumed priorities of the intended beneficiaries, with little perception from users. As with other development projects, many initiatives have failed through failing to meet user's needs, which include both practical and socio-cultural factors." It is therefore important to consider and assess consumer needs and preferences, both towards the current energy sources used, as well as to the new technologies introduced. Understanding the reasons why households choose certain fuels will ultimately provide a framework for assessing whether newly developed technologies correspond to the selection criteria of fuel choice by consumers in target regions.

5.4.2 Previous research methodology in household energy studies

Research in household energy studies has predominantly been economic oriented, focusing on aspects such as market demand assessments, market willingness to pay, forecasting models and a variety of methods linking demographic and economic factors (Jebaraj & Iniyan, 2006). Such methods are useful for illustrating the scale and pattern of household energy use, however fail to describe just why these patterns are so. When introducing a new cooking technology to a beneficiary community, besides analysing for a demand forecast, it is also necessary to know the acceptance rate for the proposed energy intervention. It is illusive to forecast market share by simply accounting for those that can or cannot afford the cooking technology. There are various other considerations that determine technological absorption in developing countries.

To best understand user acceptance of modern cooking technologies, field testing is the most effective research means. According to Barnes *et al*. (1993: 126) "the important reason for field testing is to arrive at a design that will be acceptable to the prospective consumers and producers. Regional requirements, different styles of cooking in various countries, and consumer preferences predict different stove designs (…) To help assess consumer needs and preferences, field tests can be supplemented by surveys, consumer panels, and other techniques to determine existing patterns of stove use, the most important criteria people use when purchasing new stoves, who in the household makes the decisions to purchase a new stove, and whether income and fuel saving will provide adequate incentive for stove adoption."

Joon *et al* (2009) analysed household energy consumption patterns and socio-cultural dimensions in a case study approach from rural India. It was the aim of the research to assess the potential for the conversion to cleaner fuels. The researchers adopted a

stratified sampling technique comprising of 250 household respondents. The methods used include door to door surveys in the form of semi-structured questionnaires, which collected data on socio-economic, demographic and housing characteristics. The following questions were asked: type of fuel used, quantity of fuel usage, methods of procurement, spending pattern of households on fuel resources, type of stove in use, availability of chimneys, kitchen characteristics, cooking practices and the cooks preference for a particular fuel. The authors point to various socio-cultural factors which explain why a complete conversion to cleaner fuels has not yet occurred in the study village. It was concluded that taste preferences and culinary practices played an important role in fuel choice. "People frequently use LPG stoves for preparing tea and for cooking vegetables, whereas traditional stoves for preparing bread due to their belief that bread becomes crispier and tasty if cooked with *chulah* (traditional woodfuel stove)" (Joon *et al*., 2009: 1511). Following an extensive literature review, this article by Joon *et al*. (2009) most closely resembles the research topic of this thesis. It is titled "Household energy consumption pattern and socio-cultural dimensions associated with it: A case study of rural Haryana, India". Despite the suggestions of the title, the authors fall short of providing an in-depth account of these socio-cultural dimensions. The reason for which may be due to their predominant reliance on quantitative research methodology, as opposed to the more descriptive qualitative surveying techniques.

Similarly, Brower and Falcão (2004) adopt a quantitative methodology aimed at understanding woodfuel consumption patterns in Maputo, Mozambique. This was achieved by inquiring households about their consumption behaviour as well as their socio-economic characteristics such as the gender of the head of the household, its size and composition, and its total income. Similarly, Coughlin (2007) conducted a survey of 180 household cooks in Maputo, as a means to learn about people's patterns in purchasing and using charcoal, as well as their cooking practices and culinary traditions. Such results offer valuable insight into the prevailing energy use practice, and thus enable for the design of interventions which will compliment the needs and preferences of target populations. There is however a need for a more qualitative understanding of the decision making process for energy choice at household level. The next section proposes for the incorporation of psycho-anthropologic research methodology within household energy studies.

5.4.3 Incorporating psycho-anthropologic techniques to the study of household energy

Lutzenhiser (1992) elaborates on the importance and application of a culture model in energy research. It is argued that the traditional economic perspective in demand assessment focuses on the individual as a rational actor that aims to maximise profit through calculating the costs and benefits of a certain product. According to Lutzenhiser (1992: 52) such a focus often leads to "conceptual blind spots" in energy analysis, as it does not reflect the critical social and psychological processes behind the decision. The origins of particular tastes and preferences are not accounted for. Economic rationality is not enough to explain decision making. There are examples where cooking energy decisions are not congruent with economic rationality; it is in such cases that psycho-anthropologic techniques should be implemented to study household energy behaviour.

According to Budds *et al* (2001: 30) the most important barriers to user adoption of cooking technologies are the 4 A's: Acceptability, Access, Availability, and Affordability. This paper shall focus on Acceptability. A stove is accepted if it is compatible with user needs that can range from cultural needs such as specific cooking methods for traditional cuisine, to individual priorities such as convenience and attractiveness of the stoves (Barnes *et al*, 1993; Budds *et al*, 2001). In order to design a stove which will successfully be adopted by users, one therefore needs to understand what these social and cultural needs are.

Tian (2000) discusses the importance of applying a psycho-anthropological approach to the study of consumer behaviour. The approach focuses on the influence of culture and society on household's decision-making. The incorporation of an anthropological approach stems from the notion that between 25% and 50% of individual behaviour is culturally determined (Gannon 1994: 348). According to Tian (2000) the primary technique which anthropologists use to study culture is participant-observation, which requires the researcher to dedicate a substantial time and live among the people in study. The data is in the form of a recording of observed behaviours, better known at ethnography. Other techniques used by anthropologists include structured and unstructured interviews; hypothetical situations; the analysis of critical events; social networks; myths; folklore; life histories; and historical reconstruction. Although the anthropological approach is ideal to study collective decision making, or preference of a certain society (social group), its weakness is that it is less applicable at explaining the consumer behaviour differences among members of the same cultural group (costa, 1995; Tian, 2000). This is why Tian (2000) incorporates a psychological element to the study of consumer behaviourism. Factors such as individual lifestyles, purchasing patterns, family size, taste preferences, education level and income level should be studies, as they all influence decisions on a personal manner.

Lutzenhiser (1992) similarly incorporates a psychological and anthropological model to understand household energy consumption. This model is referred to as 'the cultural model'. According to Lutzenhiser (1992: 57) the cultural approach offers three applications in energy research, namely; descriptive, explanatory and predictive. These can also be represented in research stages. The first stage - the descriptive - focuses on describing cultures in terms of demographic categories such as age, income, occupation, ethnicity etc. It is a mapping of life-styles. The exploratory stage (second) involves a detailed analysis of uniformities and variations between households within certain cultural groups; for example, amongst young educated women, middle aged housewives and working men. Such groupings may be viewed as sub-cultures. Analysis of intra-cultural groupings allows researchers to determine where the social barriers to the introduction of new technologies are, and how to target these market segments by taking into consideration social differences and similarities within and amongst social groups. Also researchers can find unseen opportunities for technological improvements. This can be done by ethnographic field studies. The third phase is the predictive stage, which allows researchers to apply knowledge of culturally distinct consumer groups to forecasting energy use or choice. It aids in estimating the probability of success of introduction of various energy alternatives. Two approaches may be used: simulation modelling and demand forecasting. This model ultimately allows one to create or modify technologies to fit the culturally accepted standards of beneficiary communities.

6 Methodology and Approach

When considering the potential introduction of the ethanol cook-stove, as produced by Dometic AB (Project Gaia 2010), developers need to consider if this stove is applicable to the context of Mozambique. Despite acclaimed success of acceptance in Ethiopia and Brazil (Project Gaia 2010), the socio-cultural context of these two countries may vary significantly from communities in Mozambique. It is therefore the aim of this research, to formulate a methodology that aids in assessing the conditions for acceptance in the context of Catembe, Mozambique.

Three questions lead to the formulation of the research methodology:

1. What are the current household energy trends and preferences in the study region?
2. What are the core factors responsible for these household energy trends?
3. In what way can these factors impact on the acceptance of the proposed ethanol cook-stove?

6.1 Study site – Geographical profile

This study took place at the Municipal district of Catembe, located less than a kilometre to the south from the city centre of Maputo. Despite being part of Maputo, the inconvenience of crossing the bay with a ferry has shielded the region from large scale urbanization – preserving a unique blend of urban, peri-urban and largely rural characteristics. It is in Catembe that one can truly capture the essence of the diversity which makes up Mozambique. It is in this context that the study reveals cultural characteristics of household energy use. Figure 3 pinpoints the geographic position of Catembe, situated in the southern most part of the country.

Catembe has an estimated population of 21 000 inhabitants, whereby 85 % are dedicated to agricultural activities, and 10 % to the fishing industry. Others are employed in the service sector, often crossing daily to the city centre for work. (Administração do Distrito Municipal da Catembe, 2009). Four neighbourhoods were covered by the survey team, namely; Chali, Guachene, Incassane and Inguide. Each neighbourhood offers a different setting, with Guachene and Incassane as commercial centres inhabited by mostly lower and middle income people; Chali as the more affluent area; and Inguide with its distinct rural aspect of straw and thatch housing. These regions are marked in Figure 4, and are located within a surface area of 174 km². In all four neighbourhoods tree cover was sparse, with remaining fruit bearing trees such as Mango, Cashew and Mafura.

The neighbourhood of Guachene, as illustrate in Figure A, Appendix II, is the gateway to the municipality. This is where the port of Catembe is located, which serves as the link to the Maputo city centre. This territory is marked by a series of wealthier households located on the beachfront and a large number of lower income settlements within the inland. Apart from the beach side estates, the majority of houses in the region

are small in size (1-2 rooms) and constructed from cement bricks with corrugated iron roofs. Despite the congested living space, the large majority of houses have a yard-area where cooking and socialization generally takes place.

Incassane (Figure B, Appendix II) is characterised as a military neighbourhood, which was build to house Portuguese soldiers during the colonial era. Today it continues to serve as a home for many Mozambican soldiers. The neighbourhood has expanded to house some of Catembe's middle and lower income households, which either reside within the colonial houses or newly build houses similar to the ones in Guachene. Outside of the original military quarters, there is little visibility of formal urban planning.

The neighbourhood of Chali is known to house some of Catembe's wealthiest households (Figure C, Appendix II). These estates can be seen along the coast-line of the region. The municipal administration office of Catembe is also located in Chali. Like in Guachene, the inland is characterised by less affluent households which reside within one or two bedroom houses. The inland is also shared by farming estates of 5 to 10 hector land plots. The coastal region of Chali faces severe erosion problems. This can be attributed to the flooding conditions in the past, as well as the removal of vegetation cover on the seaside slopes. Such problems are controlled by wealthier households in the form of barricades and replanting of vegetation; however continue to threaten the property of those less affluent.

Inguide is a largely rural neighbourhood, housing much of Catembe's lower income population (see Figure D, Appendix II). Thatch reed houses called *Palhota's* are a common site in this region. Such houses often comprise of a one room living space, which is primarily used for sleeping. The living space extends outside to the yard area, where socializing and cooking generally takes place. Houses in the region are at dispersed locations, displaying little signs of formal planning. *Palhota's* are generally associated with poverty and are the least expensive means of housing. The houses are often susceptible to destruction from strong winds, heavy rainfall and fires. Cooking practices of those living in such housing, often take this threat into account, thereby placing the stove outside on a sandy area to avoid accidental fires. The land around the *Palhota* (the yard area) is usually cleared from all vegetation, leaving a sandy surface. This is to facilitate cleaning; to remove shelter for unwanted insects and animals; as well as to prevent fires from reaching the thatch houses. It is this removal of vegetation which may be sparking much of the erosion in the region.

Figure 3: Geographical position of Municipal District of Catembe
Adopted from: Google Earth, 2009

Figure 4: Satellite image of the Municipal District of Catembe;
Source: *Google Earth, 2009*

The study site was chosen for four main reasons:

1. Due to its distinctive setting, moderate population size and defined territory. It is thus appropriate for both, an ethnographic study (restrictive to smaller sample size) as well as the more representative demographic survey necessary to capture household energy trends (requires larger sample).
2. It may be said that Catembe is representative of the country at large, due to its urban, peri-urban and rural characteristics. This distinction is facilitated due to the division of such regions in the forms of neighbourhoods. This study however does not propose that the socio-cultural characteristics of Catembe are representative of the entire country. The cultural context of Catembe may well be specific to the region.
3. Due to its isolated character (divided by a bay from the city centre of Maputo), the rich traditional culture is preserved in the region. The different neighbourhoods are governed by traditional leaders, as well as government-based administrators. Modern influences are most prevalent in higher income neighbourhoods, making for an interesting comparison.
4. There were reports that firewood and charcoal production are causing deforestation in the region. This trend was noticed during a field visit to the periphery of Catembe. Figure 5 shows satellite imagery of an area located just 4 kilometres from the Inguide settlement. It is clear that this region has been stripped off much of its trees. This becomes more evident, if one compares the site with another site (Figure 6) located 10 Kilometres from the Settlement of Inguide, and only 6 Kilometres from the site in Figure 5. This trend was visible throughout the region, whereby deforestation was noticed to spread on an average radius of 7 Kilometres from settlements.

Figure 5: Satellite imagery of an area located 4 km from nearest settlement;
Adopted from: Google Earth, 2009

Figure 6: Satellite imagery of area located 10 km for the nearest settlement;
Adopted from: Google Earth, 2009

On site field work in Catembe took place from the 16th of September 2009 to the 2nd of October 2009. A total of 402 households participated from the entire Catembe region. To ensure for a statistically sound representation of respondents with mutually non-exclusive socio-economic strata, a stratified random sampling technique was adopted. The person who was interviewed was the person who generally did the cooking and was over the age of 14. All households responded to the socio-economic questionnaire, 115 of these households responded to the environment and health perception survey, and 45 households carried out the perception mapping questionnaire of fuel preferences. The lower response for the perception mapping questionnaire was because it was time consuming, and thus restricted to fewer respondents. Complete surveys were administered within an average time of 30 minutes.

The surveys were administered by a team of six enumerators, comprising of students from the University of Eduardo Mondlane, public servants from the local administration office and myself. The requirement for the enumerators included previous experience in conducting surveys as well as to speak Portuguese and one of the other local languages (Ronga or Shangana). Surveys were administered orally by enumerators, due to the low literacy levels in the region. The surveys were printed in Portuguese, however translated orally by enumerators when necessary (into local languages). Prior to the study, on the 18th of September 2009, the enumerators participated in a one day workshop, to become acquainted with the research objectives, as well as to learn and practice the necessary surveying techniques. On the 19th of September 2009 the survey team carried out a pilot study, as a means to validate the questionnaires and modify any inconsistencies in the design of the survey.

The municipal administrative centre of Catembe was used as the base for coordinating the study. In addition to being the meeting point for the enumerator team, office space was also provided for the safekeeping of equipment and survey material. The administration also provided transportation to and from the different neighbourhoods visited by the enumerators. Permission for surveying the region was granted by the Municipal administrator in the form of a credential document which was carried by all enumerators, as proof of their intentions. Furthermore, permission was also asked from neighbourhood level administrators as well as the community level traditional leaders. The leaders also aided in the sampling of households, as in most cases there were no urban blue prints available.

The following challenges were encountered during the field study:

- Due to no formal urban planning in some neighbourhoods, it was difficult to implement sampling techniques. It required assistance from traditional leaders which were well familiar with the terrain. The process was time consuming.
- Weather conditions made it difficult to work. High temperatures frequently exhausted enumerators, while rain made it near impossible to work.
- During periods with rain, many households would be working in the fields, and therefore were unavailable to answer. Furthermore, in Catembe, it is a cultural norm to welcome guests in the yard. When there was rain, households were reluctant in inviting enumerators inside the house.
- For this reason care was taken not to base the field work during the rainy season (November to April).
- The national general elections which were held on the 28th of October 2009, also posed some challenges to the field work. Despite occurring three weeks after the conclusion of the survey, electoral campaigns that were held many weeks leading to the elections might have influenced on respondents answers. There is a possibility that some households might have indivertibly associated the survey with a political affair. For this reason, it was important that enumerators did not wear the colour of clothing associated with any of the political parties, nor make any political remarks prior or during the survey.
- The team of enumerators comprised only of men. This selection was not intentional. Two female surveyors that were initially recruited were later unable to participate in the survey due to work commitments.
- Female respondents may have been more ‘open’ and at ease if enumerators were also female.

6.2 Methodology and Design

This research adopts a case study approach, focusing on household cooking energy use dynamics in the Municipality of Catembe. As a research strategy, case studies aim to bring depth to particular phenomena by studying the relationships and processes that define the case (Denscombe, 2003). It is therefore the aim to provide an in depth and holistic account of the cultural and social factors determining household cooking energy choice, and their implication on the introduction of modern energy alternatives. In order

to provide an in depth account, the research relies on multi-method data collection, often referred to as triangulations. Besides allowing for an understanding of the relationship in a more rounded and complete way, it also allows for the validity of data to be tested, as findings from one method are checked against another (Bryman, 2001; Denscombe, 2003).

6.2.1 Quantitative Techniques

Baseline Survey

On 14th of September 2009, baseline data was collected from four large markets in the Maputo region, including the municipality of Catembe. The following information was collected:

- Number and characteristics of different charcoal stoves available in the markets.
- Price of different variants of charcoal stoves
- Different charcoal quantities available for sale to consumers – ranging from small piles to a large 70 kg sack.
- Prices of different quantities available to the consumer and price ratio amongst the different quantities
- Price of firewood sold at the markets
- Price of LPG sold at the markets, as well as different cylinder varieties available to consumers.
- Quantity of fuel sold daily by market vendors.
- Availability of alternative fuels in the different markets.

A total of nine vendors were visited in the four markets. The data was written on a paper pad, and later tabulated electronically on Microsoft Excel. No electronic equipment was used during the survey, due to safety reasons.

The purpose of the market baseline study was to gather information on current fuel types sold at the markets, as well as the prices for each alternative. Such information provided the grounds for the design of the questionnaire, as well as the perception mapping survey that was later implemented in Catembe. The results from the study also served to determine 'access', 'availability' and 'affordability' of alternative fuels in the markets. These are three of the four criteria for fuel transition up the energy ladder, as propagated by Budds *et al*. (2001). In the event that the three criteria are met, focus shall be on 'acceptability' (forth criteria) as the determinant for whether the energy ladder trend is followed or not in Catembe. Assessing 'acceptability' will thus fall under the socio-cultural factors responsible for fuel choice.

One limitation of this survey was the lack of a scale to whey and verify the different quantities of fuel sold; instead the quantities stated by the vendors were registered. It is possible that vendors would elevate the number, so as to sell the pile for a larger price. It was notices that when charcoal was sold in small quantise (stacked inside a two litre tin can), the quantities generally varied. In some instance, vendors would indent the tin container, as to lessen the volume of the can and thus add less charcoal.

The baseline market study is not discussed extensively in the results sections because the focus shall be kept on the social and cultural determinants for fuel choice. The data from the market study is however available for reference in Appendix I.

Structured Household Questionnaire

A structured household questionnaire was administered to 402 households in the four neighbourhoods of Catembe; Guachene, Chali, Incassane and Inguide. In order to ensure for a statistically sound representation of respondents, a stratified random sampling technique was implemented. Respondents therefore were within mutually non exclusive socio-economic stratum, in terms of age, income, education and gender. The survey period was from the 16th of September 2009 to the 2nd of October 2009, and administered by a team of six enumerators.

The structured household questionnaire was designed to collect socio-economic information as well as the household fuel use and expenditure characteristics. Questions were close-ended, designed to gather pre-coded data, as a means to facilitate data entry and analysis of the large sample size. Questions were printed in Portuguese and were asked orally by the enumerators, either in Portuguese or translated into one of the local languages (Ronga or Shangana). The expected outcome was a statistically representative data set on household energy practices. The weakness of such an approach is lack of opportunity for respondents to express true feeling about their household energy practices. Issues out of the scope of the questionnaire were thus not covered, or elaborated upon.

The structured household questionnaire was divided into four sections, namely:

Section A: Identification
Section B: Socio-economic data of household
Section C: Stove related information
Section D: Fuel and usage information

The full questionnaire is attached in appendix III

The aim of the questionnaire was to gather information on current household energy trends and practices, as well as to correlate such data with socio-economic sub-groupings within the community. According to the classic energy transition theory, factors such as income; education level; household size; access to electricity; as well as scarcity of forestry resources, lead to fuel switching (Campbell *et al*. 2003; Heltberg *et al*. 2000; Oudraogo, 2006). It is therefore such factors that were evaluated, as a means to validate or disprove the notion of the energy ladder in the district of Catembe.

Perception Mapping Questionnaire

The perception mapping questionnaire was administered in conjunction with the structured household questionnaire, however only to a limited number of respondents (generally the first respondent of the day, per enumerator). The total sample size was 45 respondents, which can be linked to the structured household questionnaire, as a result

of a coding system. The limited sample size was because the perception mapping questionnaire was time consuming, both to explain to respondents as well as for them to answer.

The Perception mapping questionnaire gathered ordinal data on respondent's revealed preference for cooking fuels, in terms of the following different attributes:

- Preference in terms of price of fuel
- Preference in terms of ease of acquiring the fuels (from the market or forest)
- Preference in ease of storage of fuel
- Preference in size of fuel
- Preference in lighting the fuels (starting the fire to cook)
- Preference in terms of time to cook the meal
- Preference related to smoke level
- Preference related to safety of stove (Risk associated with stove)

Five different fuel types (woodfire, charcoal, kerosene, LPG and electricity) were ranked on a scale from one to five. One indicating most preferable fuel whilst five indicating least preferable fuel (see Figure 7). During the pilot study, the enumerator team encountered difficulties to explain the ranking method to respondents; it was then decided to draw the ordinal scale on paper and illustratively explain the ranking procedures. Alternatively respondents were asked to answer on an eliminatory basis, as to facilitate the process. The most preferable fuel was asked first, the least preferable was asked second, and the same is done with the remaining three fuel choices (pair-wise comparison).

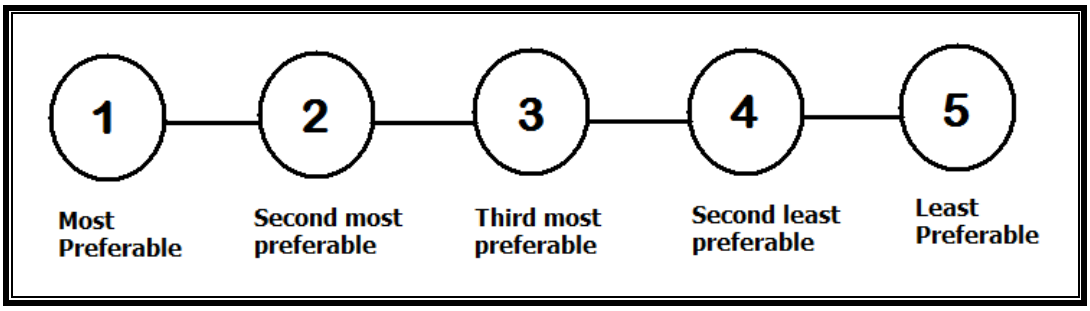

Figure 7: Example of illustrative explanation of ordinal scale ranking as shown to respondents

The purpose of the perception mapping questionnaire was to collect empirical, quantitative data on respondent's revealed preference for household cooking fuels, as well as the product-specific factors that make them desirable/ undesirable to the households. Such analysis offers insight into how to design modern stoves, as to best suit community level preferences. This survey also offers the opportunity to determine if some preferences are culturally determined, by looking at the standard deviation of the mean preferences registered. The smaller the deviation is in preference ranking amongst different household, the greater the likelihood of a cultural influence. Preference analysis is mentioned as one of the prevailing quantitative research methodologies used in psycho-anthropological research, as discussed in section 5.4.3.

The full version of the perception mapping questionnaire is attached in Appendix IV.

Health and Environment Perception Survey

115 households were administered a questionnaire revealing respondents perception of health and environmental impacts associated with firewood and charcoal as cooking fuel. Respondents were asked to answer between three categories: 'yes', 'no' or 'unsure'. If respondents were to answer 'yes', they were asked to provide examples of health or environmental impacts. The following questions were asked:

1. In your opinion, does cooking with firewood affect your health? If yes, How?
2. Does cooking with charcoal affect your health? If yes, How?
3. Does the use of firewood and/or charcoal affect the environment? If yes, How?

The results gained through this questionnaire are important, if one is to consider the marketing of the ethanol stove as a 'health-promoting', 'environmentally-friendly' cooking technology. If households do not perceive health or environmental concerns with current cooking technologies, then it will be more difficult to persuade them to fuel-switch to modern alternatives.

It must be noted that answers are subjective to different interpretations of the meaning of health and environment by respondents. Health may be associated with a medical disorder that requires hospital care, or alternatively a simple cough from inhaled smoke. Similarly, environment might mean climate change for one, and lack of shade as a result of a cut down tree, for another. Both terms are relative to the individual, and thus may pose a challenge for the reliability of results. The enumerators were instructed not to influence respondents' answers by suggesting examples of health or environmental conditions.

6.2.2 Qualitative techniques

Group Interview with Household Cooks

On the 8th of October 2009, a semi-structured group interview was administered to four households from the Catembe region. The interview took place at the local administration office, where the four households were seated inside a conference room. It should be noted that this formal setting might have impacted on the comfort level of respondents. The following households participated:

- Vincente (male): low-income shoe-factory worker, family of 3
- Atalia (female): middle income house wife, family of 6
- Argentina (female): Low income, domestic worker , family of 4
- Cecilia (female): Middle income, retired worker and farmer, lives alone.

The following questions lead the discussions:

1. What is your name, and what type of stove do you use at home to cook food?
2. Why did you buy that stove?
3. Do you know what an ethanol cook-stove is?
4. Who makes the decisions in the house for which stove and fuel-type to buy?
5. Who buys the fuel?
6. Where do you cook your meals – inside or outside the house?
7. What problems do you experience when there is smoke emitted from the stove?
8. What do you think about using electricity to cook?
9. What do you think about using a gas stove to cook?
10. Which fuel types do you think are dangerous?
11. Which fuel type is least dangerous?
12. Which is the cheapest fuel type?
13. Do you think the use of firewood and charcoal impacts on the environment?
14. Are there any cultural reasons for choosing your current stove?

The group interview lasted 60 minutes and was conducted in Portuguese. Transcripts were later translated to English. Households responded to most questions with short answers, however during some instances there was discussion. Consensus amongst respondents was high, showing a general attitude towards household energy use in the region. During the first few questions, the female respondents waited for the male respondent to answer first, however this was not noticed as the interview continued to progress.

Focus Group with Experts and Policy-Makers

On the 18th of November 2009, a focus group comprising of energy research specialists, policy-makers, and biofuels investors was held at the Swedish Embassy in Maputo, Mozambique. Table 2 lists the participants, and their respective backgrounds. The aim of the focus group was to discuss the results gathered from the field work; to verify the results with expert opinion; as well as explore the attitudes, perceptions and feeling of the experts on household energy dynamics in Mozambique. The duration of the discussions was two hours, including a thirty minute break, as well as a brief introduction to the research topic. The language of discussion was largely in Portuguese, as all respondents were able to understand and communicate efficiently. It may however have impacted on the quality of discussion for respondents who are not fluent in the language. In some cased the use of English aided in further clarification. The discussion was tape-recorded, and later transcribed and translated into English in a 23 page document. The discussion was guided by four leading themes:

1. Current trends and practices in household energy in Mozambique.
2. Health and environmental impacts associated with traditional biomass fuels.
3. Opportunities and challenges for introducing ethanol as a cooking fuel in the Mozambican context.
4. Measures necessary for the promotion of modern cooking technologies in Mozambique

Planning and conduction of the focus group was steered by the "Guidelines for preparing and conducting focus group discussions" devised by the Stockholm Environment Institute (SEI, 2002). The following aspects were covered:

- Recruiting process for participants
- Preparations before focus group begins
- Introducing the theme
- Devising appropriate opening question, introductory questions, transition questions and ending questions
- Moderating and guiding the discussion efficiently
- Note taking during the discussion

Participants were invited three weeks prior to the event, via e-mail. Of the 15 people invite, 9 were present. The date of the focus group was chosen, as not to coincide with the national presidential and parliamentary elections held on the 28th of October 2009. It was assumed that policy-makers might be reluctant to participate two weeks prior or two weeks post the elections, due to possible involvement in the electoral campaigns.

Table 2: list of participants in focus group session

	Name	Organization	Background
1.	Amino Ussene Naran	Physics Department, University of Eduardo Mondlane	Expert on indoor air pollution and ambient air pollution, as well as climate change
2.	Anna Lerner	GTZ – ProBEC	Biofuels specialist
3.	Artigo Pascoal Chitombelo	Ministry of Energy, Mozambique	Biomass and bio energy policy-maker
4.	Boris Atanassov	Student	Focus Group Moderator
5.	Eoin Sinnott	Aquila Consultoria e Solucoes, Ltd.	Alternative and renewable energy specialist
6.	Helton Xavier	Directorate for studies and planification, Ministry of Energy	Policy-maker – household energy
7.	Imaculada dos Santos	GTZ – ProBEC	Biomass energy specialist
8.	Monika Branks	Eco-Energia de Mozambique	Investor in biofuels industry – Ethanol production
9.	Per Carstedt	Eco-Energia de Mozambique	Investor in biofuels industry – Ethanol production
10.	Rodrigues Manjate	Department of Chemical Engineering, University of Eduardo Mondlane	Household cooking energy specialist and improved stove programme designer

Semi-Structured Interviews with Experts

One-to-one interviews, with a semi-structured format were held on two occasions:

1. Jose Mucavele : 11 November 2009

Jose Mucavele is a respected musician and delegate at the ministry of Culture and Education in Mozambique. The interview was aimed at collecting valuable insight into the cultural aspects related to traditional biomass use, as well as the means of introducing modern fuel alternatives in the current socio-cultural setting.

2. Dr Almeida Sitoe: 13 November 2009

Dr. Almeida Sitoe is a professor and acclaimed researcher from the Faculty of Agronomy and Forestry at Eduardo Mondlane University in Mozambique. The aim of the interview was to collect insight into the importance of traditional biomass for Mozambican communities, as well as the impact this is having on the countries forestry resources.

Both interviews were conducted on a formal basis, in the offices of the respective respondents. Prior to the interviews, a brief introduction to the research question was given, as a means to encourage direction to the answers. The interviews were both conducted in Portuguese, and later transcribed into English. Notes were taken on paper during the interview, and immediately after the interview, were made more comprehensive. Duration of each interview varied between 30-40 minutes. Time was restricted due to the busy schedule of informants. Both interviews served to confirm results gathered during the survey in Catembe, as well as explain some of the quantitative trends notices during data entry. Such trends will be discussed in detail in the next two sections, as well as the insights provided by the interviewed experts. Care was taken not to enforce interviewee bias effect, especially when introducing the research theme. This was done by not stating strong opinions about the topic, and keeping an objective stance during the proceedings of the interview.

Ethnographic Observations

As a means to provide a holistic account of household energy in Catembe, with insights into local culture and lifestyles, ethnographic research methodology was adopted throughout the duration of the field work. A participant as observer technique was used, whereby the research objective was known to those observed, as opposed to covert observation. The majority of ethnographic accounts occurred during and shortly after the survey was administered; however, a more in-depth account of cooking practices and norms was gained from six different households selected to represent the different socio-economic strata in Catembe.

Households were shadowed as they engaged in cooking practices, with focus on the following observational guidelines:

- Type of house and household's income level
- Type of stove used to prepare food

- Other stove types/ cooking fuels that are available to the household
- Who is cooking? Is there anyone else involved?
- Where is the cooking taking place? Inside or Outside?
- How is the fire lit/ how is the stove started?
- What is being cooked and how?
- Is there any preparation to the food prior to it being cooked?
- What types of cooking utensils are used? What are the pot sizes/ shapes?
- Is there smoke? How does the cook react to the smoke?
- What else is happening, while the food is cooking?
- Does the household engage in other activities while cooking?
- How long is the cooking time?
- Where is the meal eaten?
- How is the fire put off?

In order not to disrupt the naturalness of the setting, field notes were only taken after the observation period.

Additionally, during the administration of the survey, the enumerator team was instructed to record a list of observations, related to household cooking. This normally happened if the survey took place while households were engaged in cooking activities. Of the entire sample, 64 observational accounts were recorded. On limited occasions, cooking practices were recorded via video and photographed; however due to the possibility of this interfering with the natural behaviour of households, such observations will be treated separately.

It was also the objective of this research to determine which fuels are used during traditional ceremonies and social events. Such observation took place on two occasions; the first was on the 16 of October 2009, whereby the community commemorated world food day at the pavilion of the central administration office of Catembe. The other ceremony was in a traditional style and occurred on the 24th of October 2009, whereby the community celebrated the union of a couple in the Nguide neighbourhood.

6.3 Ethical principles

Great care was taken, not to misrepresent any information acquired from the field work, nor to manipulate data for the outcome of the study. During the workshop on the 18th of September 2009, the enumerator team was introduced to research ethics as well as how to minimise researcher bias. Prior to the field work, permission for research was asked from all responsible authorities in Catembe. This included traditional leaders, whom further acted as gatekeepers to the neighbourhoods visited.

In respect with formal requirements, the enumerators were asked to wear long pants during the field work. This was most necessary when working from the municipal administration office; the base for the study. It was advised that in Catembe it is a cultural norm to welcome guests in the yard. The enumerator team thus conducted all surveys in the yards of respondents, unless otherwise requested by respondent. For this reason, surveys were not conducted during adverse weather conditions.

Prior to the survey, respondents were informed about the objective of the research, the possibility of publicising the data and the duration of the survey. Respondents were than asked if they are willing to participate. Enumerators were instructed not to force participation, nor to invade the privacy of households when they seem unwilling to participate.

It was also advised that some people in Mozambique do not appreciate to be photographed or filmed. There is a superstition that a photograph robs one's identity. For this reason, permission was asked whenever a photograph or video footage was taken. In various instance, permission was denied.

7 Results

7.1 Sample population characteristics

Table 3 displays the socio-economic characteristics of the sample population of Catembe. The total number of households surveyed was 402, representing 2% of Catembe´s populations (20,000 inhabitants). Due to the stratified random sampling technique adopted, it can be said with a certain level of confidence that the sampled households are representative of the Catembe population. Such a sampling technique considers households of diverse socio-economic backgrounds, and ensures their consistent representation in the results. It should be noted that 88% of respondents were female. Such a disproportion is due to the nature of this study; whereby the persons whom are generally involved in cooking, were surveyed.

Literature tells us that income is the main determinant for fuel choice. For this reason, households were divided into three income categories: low income, stable income (middle) and high income. This categorization is open to the possibility of sample bias, as income stratification was categorised by the subjective judgement of the enumerators. This was done on ethical grounds, as not to offend households by asking their income level. The following guidelines were used by the enumerators to judge income level:

- Type of transportation ownership (car, motorcycle, bicycle, non, etc.)
- Electrical appliances owned by household
- House type, size and location (neighbourhood as indication)
- Furniture type
- Household occupation

The ownership of a car, a house with 3 bedrooms or more, and a well furnished interior was generally a sign of a high income household of Catembe. Low income households generally resided within thatch reed houses, or non renovated brick house with limited living space. Location and neighbourhood also indicated income level of respondents. Beach-side residents were generally of a higher income group, as opposed to those living in the more crowded interior. According to this classification, the data indicates

that 48% of respondents are within a low income stratum; 46% of middle income, and 5% of a high income group. This proportion corresponds to the general socio-economic characteristic of the region; with a high incidence of poverty (Administração do Distrito Municipal da Catembe, 2009).

Literature also points to household size, electricity connection and availability of forestry resources as determinants of fuel choice. The average number of people living in one household is 6, and the maximum in the sample being 14. This indicated that families need stoves which support cooking for large family sizes, and consequently large pot sizes. In terms of electricity connection, 83% of the sampled population is connected to the national grid. This figure is significant when quantifying electric stove users in the region (the top of the energy ladder). With regards to the availability of forestry resources, it was determined that 41% of the households collect own firewood at least once a month. This may indicate the availability of forests in the region, and thus impact significantly on modern fuel absorption rates.

Table 3: Socio-economic data from survey

Stratum	Sub-stratum	Households	Percentage
Gender	Male	50	12%
	Female	352	88%
Age	Below 25 Yrs	146	36%
	From 26 to 35	94	23%
	From 36 to 45	101	25%
	Above 46	61	15%
Education Level	No formal	28	7%
	Primary level	199	50%
	Secondary level	173	43%
	Higher education	2	0%
Income	Low	194	48%
	Middle	186	46%
	High	22	5%
Number of People living in One Household	Average	6	___
	Highest	14	___
	Lowest	1	___
Type of House	Modern brick	112	28%
	Old brick house	199	50%
	Straw/Grass hut	90	22%
Electricity Connection	Yes	333	83%
	No	69	17%
Collection/ production of Own Fuelwood (at least once a month)	Firewood	165	41%
	Charcoal	13	3%

7.2 Household energy profile for Catembe

This section shows the analysis of current fuel use patterns in Catembe, with emphasis on stove ownership and expenditure on fuels. The multiple fuel use hypothesis will also be elaborated upon, based on the results gathered from the survey.

Figure 8 shows the existing fuel usage pattern amongst all households sampled. Appendix V further includes detailed tables on fuel usage patterns from the survey. A total of 759 stoves are currently being used by 402 households, indicating multiple fuel use amongst the sampled population. There is a clear preference for traditional biomass fuels, which are used by 76% of the population. Charcoal is by far the most popular fuel, used by 78% of households, however only a small percentage of these households rely solely on it (15%). Firewood is the second most popular fuel and is used by 65% of households; the large majority of which use a three-stone method to burn the fuel. It is noticed that 25% of households rely exclusively on firewood. This figure may correspond to the poverty level in the region, as well as availability of forestry resources from which households may gather 'free wood'.

Modern fuels, as described by the energy transition theory, constitute the lowest ownership rates. Electricity is used for cooking by 26% of the households, a figure which is interesting in relations to the fact that 83% of all households have electricity connection at home. LPG is only used by 19% of the population, despite the availability of the fuel in the market place of the region. In both cases, modern fuel users seldom rely exclusively on these fuels. Section 8.1 will further discuss and correlate these trends according to the different income stratum of the sample.

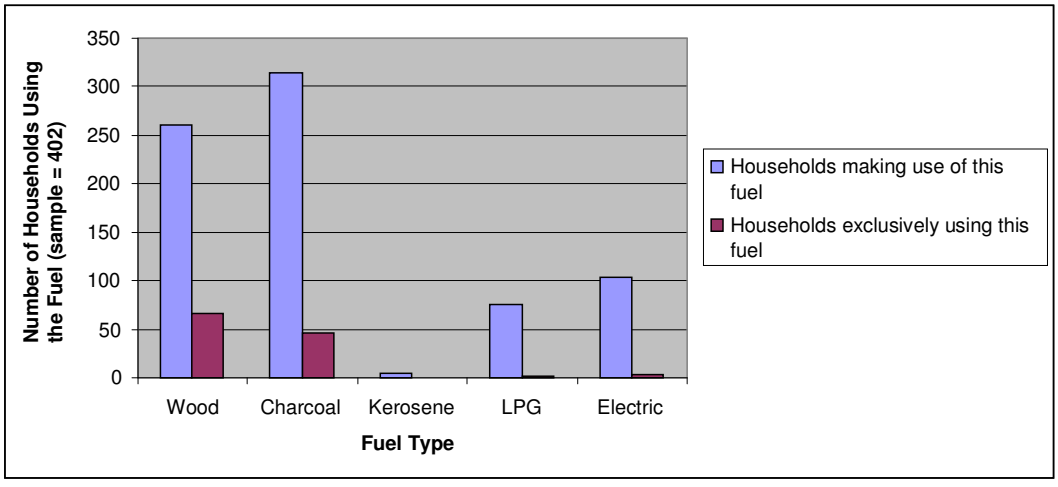

Figure 8: Distribution of currently used stoves in Catembe

As noted, multiple stove ownership is a trend in Catembe, whereby households rarely make use of just one fuel type to cook. On average, households make use of three different fuel types, at least once a month. Figure 9 illustrates the probability rate of households owning a certain type of fuel, as stove ownership incidence increases. From the figure, it can be noted that if households had to have one stove, nearly 60% of the time it will be a fire-wood stove. This suggests that firewood is the most essential fuel source for the population. Perhaps this figure is related to the high poverty incidence in Catembe, whereby those that cannot afford more than one stove, fall back on firewood. However when one looks at multiple stove ownership, Charcoal is the most probable fuel choice. If households were to only have two stoves, there is nearly 47% probability that it will be a charcoal stove; 32% probability that it will be fire-wood, 11% probability that it will be electric, 9% LPG, and no probability that it will be kerosene. These figures become more even as additional stoves are owned; however charcoal remains the most probable choice in all cases.

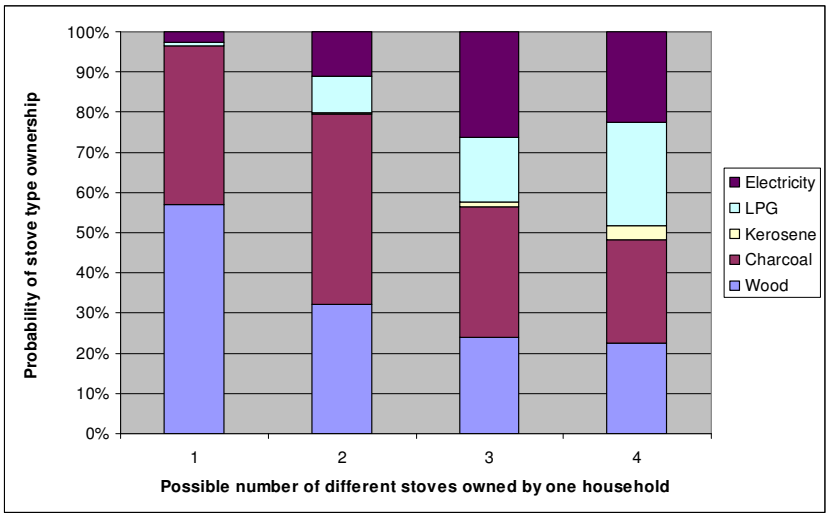

Figure 9: probability of stove type, in event of multiple stove ownership

Figure 10 shows the average monthly household expenditure on the different fuel types, as stated by respondents. It must be noted that the values given by households indicate their personal expenditure, and it is often influenced by the number of different types of fuel used, and family size. It therefore does not indicate the real monthly cost of the respective fuels for all households in the region. Furthermore, the price given for electricity could potentially include the entire electric bill, and not only the portion used for cooking energy. With this in mind, one can see that there is a clear perception of which the cheapest fuel is and which the most expensively perceived fuel is. Both fire-wood (when bought) and charcoal are perceived to be nearly twice as cheap as electricity or LPG. Affordability might thus be a reason for the lower usage of modern fuels in Catembe.

As a means to verify if affordability is the reason why electricity and LPG are not widely used by households in Catembe, respondents were asked which fuels they would use, if they were to become ‘rich’. Figure 11 shows the percentage of households that

choose a certain fuel, if money was not a concern. The clear majority either chose LPG and/or electricity; 62% and 71% respectively. This suggests that modern fuels would probably be adopted as household income increase. Firewood on the other hand, was only chosen by 4% of respondents, clearly supporting the energy ladder hypothesis. It is however interesting to note that, irrespective of financial security, nearly half of the respondents maintained that they will use charcoal as a cooking fuel. This figure suggests that there are additional factors, aside from affordability which support the popularity of charcoal in Catembe, and possibly Mozambique at large. The subsequent sections aim to discern such factors, with special focus on socio-cultural dynamics.

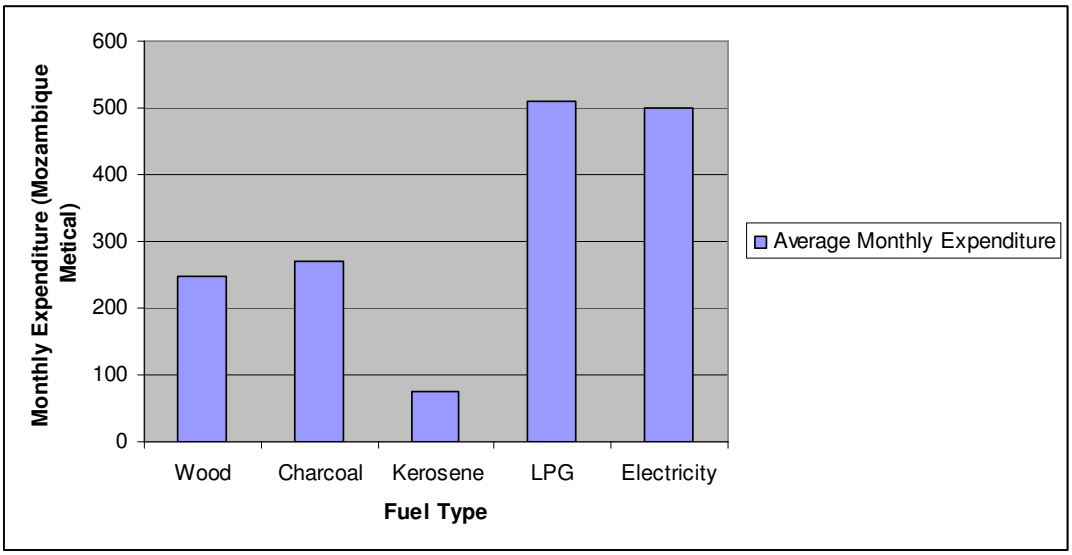

Figure 10: Average monthly expenditure per fuel type, as stated by households

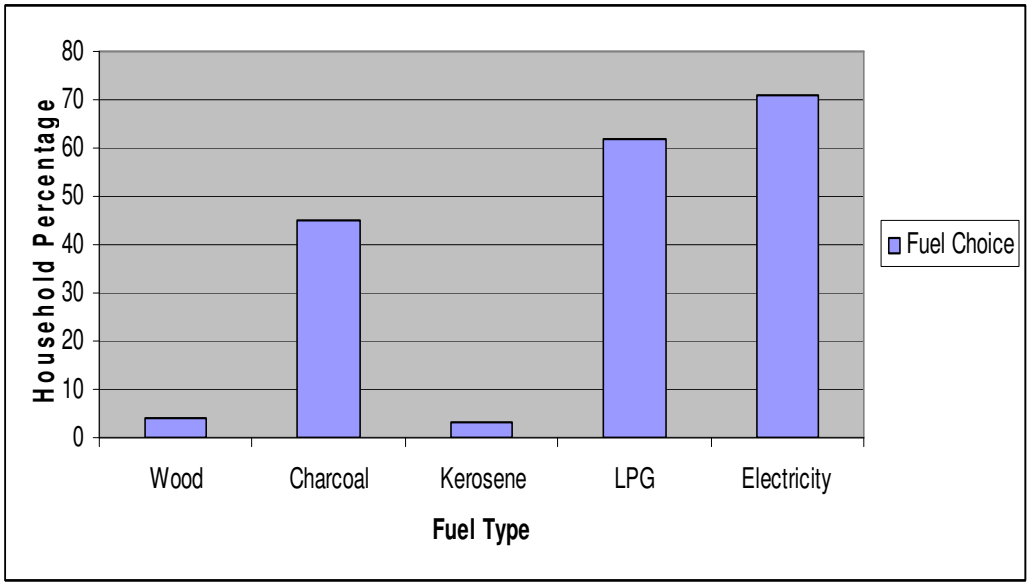

Figure 11: Household fuel choice if they were to become 'rich' (wish-list approach)

7.3 Perception Mapping Survey

Results from the perception mapping survey, demonstrate the general trend of fuel preferences in Catembe, according to the following fuel attributes: price, accessibility, storage facilitation, size, ease of lighting, time of cooking, Smoke level and safety level.

Figure 12 illustrates the general perception of households, in terms of preferred fuel according to price. There is a clear ranking of fuels, whereby firewood is perceived by the majority as the most desirable fuel in terms of price, followed by charcoal, kerosene, LPG and finally electricity as the least desirable fuel in terms of cost. The standard deviation between electricity and LPG, is however too close to make a generalization about which of the two fuels is least preferred.

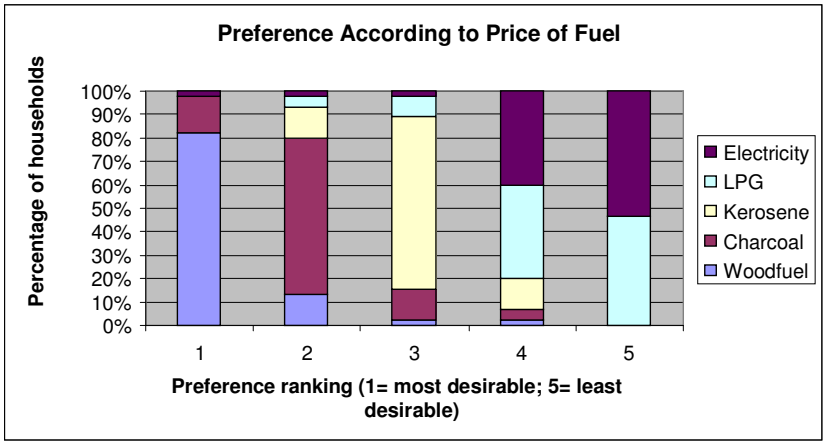

Figure 12: Household fuel preference according to price

Figure 13 illustrated preference according to accessibility of fuel, whereby it is noted that firewood is perceived as most accessible, followed by charcoal, electricity, kerosene and LPG as least accessible fuel for households in Catembe.

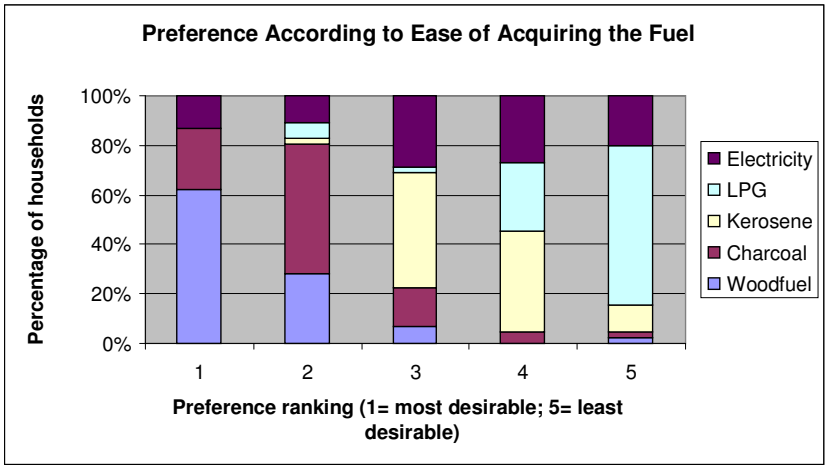

Figure 13: Household fuel preference according to accessibility

Figure 14, demonstrates which fuels are preferred in terms of ease of storage. The standard deviation amongst the results was low, indicating mixed perception amongst respondents; however the trend shows that electricity is most preferable, as it requires no storage, while firewood is least preferable, possibly due to its bulky nature. Charcoal is seen as the second most desirable fuel in terms of ease of storage.

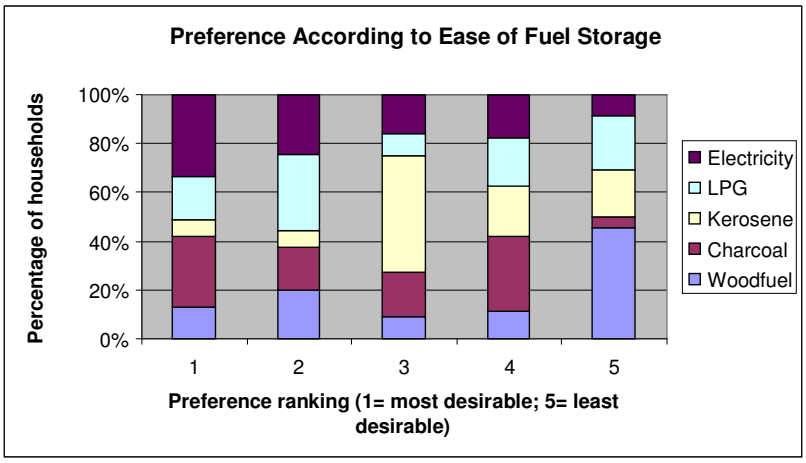

Figure 14: Household fuel preference according to ease of storage

When it comes to preference in size and weight of fuels; Figure 15 shows similar trends as figure 14, whereby electricity is clearly preferred, whilst firewood is perceived as most undesirable fuel in terms of size. This trend can be associated with the laborious task of carrying the wood from the collection site to the home. Charcoal again, is second most preferable fuel.

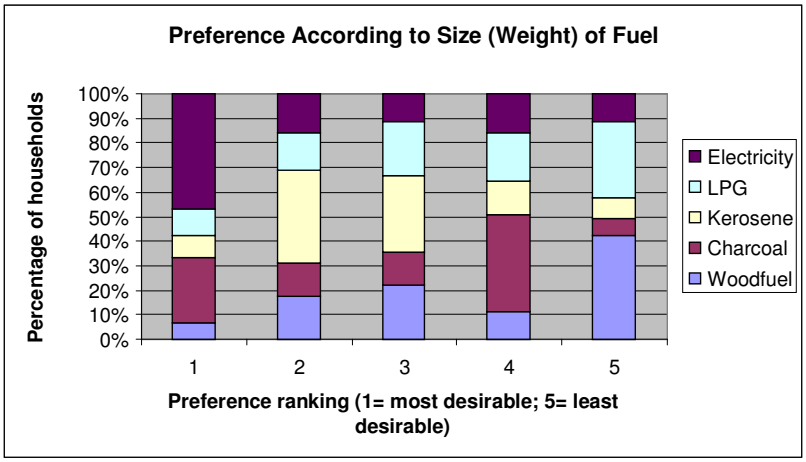

Figure 15: Household fuel preference according to Size

Literature often points to opportunity cost as a determinant for the use of modern cooking technologies. Time and effort saved on cooking could for example be used in income generating activities. Figure 16 shows household preference for fuels according to the ease of starting the stove to cook. The modern fuels are clearly perceived as being most desirable, whereas firewood and charcoal are least desirable. It is worth noting that charcoal is by far the least desired fuel in terms of lighting the fire.

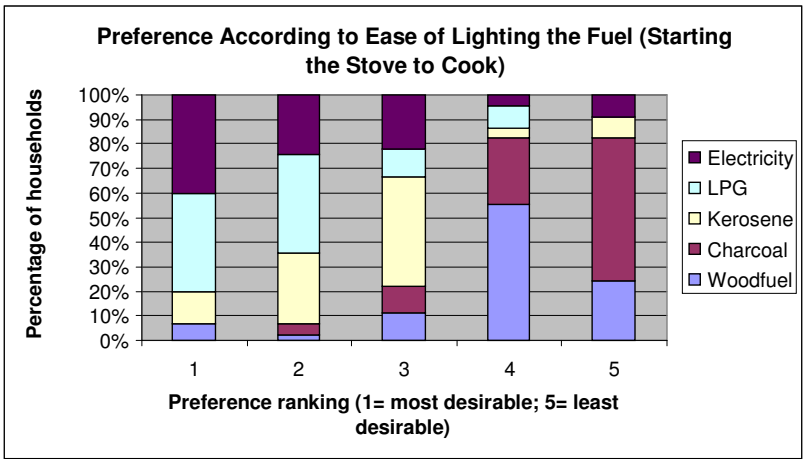

Figure 16: Household fuel preference according to ease of lighting the fuel

Continuing with time, as an attribute, figure 17 illustrates household preference according to the time it takes to cook a meal. LPG is significantly most popular when it comes to cooking time. Charcoal on the other had, is perceived as second most time saving fuel in terms of cooking activity, as opposed to the negative perception it received in terms of lighting the fire (Figure 16). It is interesting to note that significantly more people perceive that cooking with electricity is time consuming.

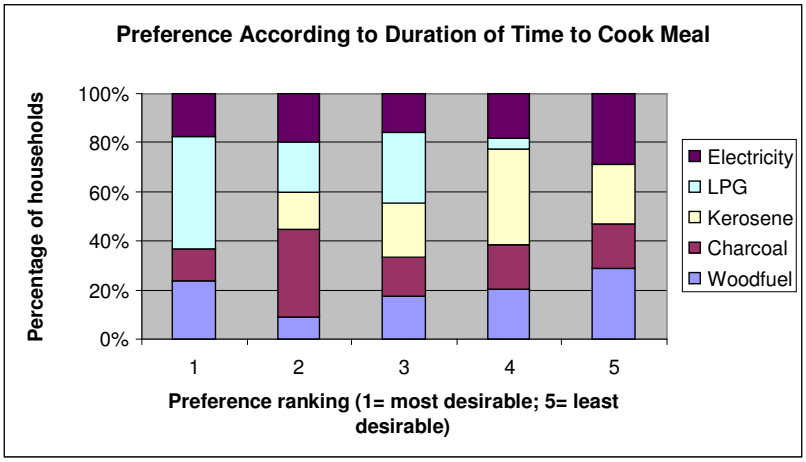

Figure 17: Household fuel preference according to duration of time to cook meal

Because Indoor Air Pollution (IAP) is considered as one of the most serious problems associated with traditional biomass cooking; it was necessary to determine if households perceived this problem in Catembe. Figure 18 suggests that households clearly prefer fuels with lower levels of smoke. Electricity is seen as most desirable, followed by LPG and interestingly enough, charcoal in the third place. Although charcoal is generally considered a smoke emitting fuel, households attach a neutral feeling to it, and even perceive kerosene as less desirable in terms of smoke. Firewood on the other hand is most widely perceived as least desirable according to its smoke emissions factor.

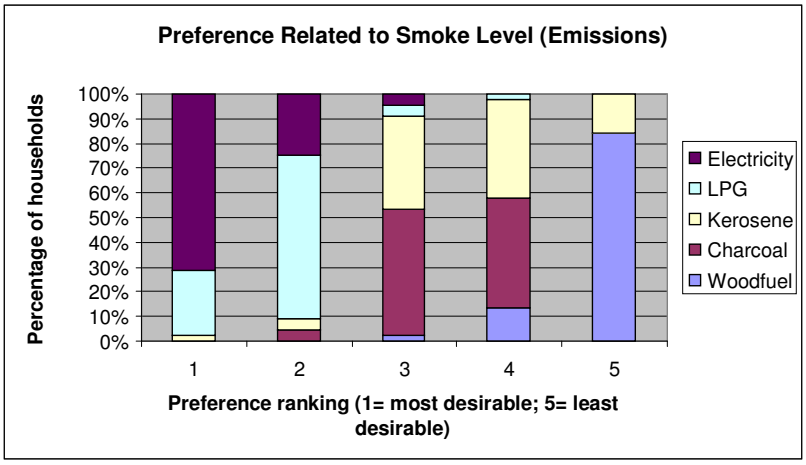

Figure 18: Household fuel preference according to smoke emission

In terms of the safety associated with each fuel, Figure 19 demonstrates that the majority of households perceive charcoal as being the safest fuel, followed by electricity, kerosene, firewood and finally LPG as the least safest alternative. It is worth noting that as much as 51% of respondents felt that LPG is the least safest fuel. The reason for this consensus is revealed in the results of the group interview in section 6.6.

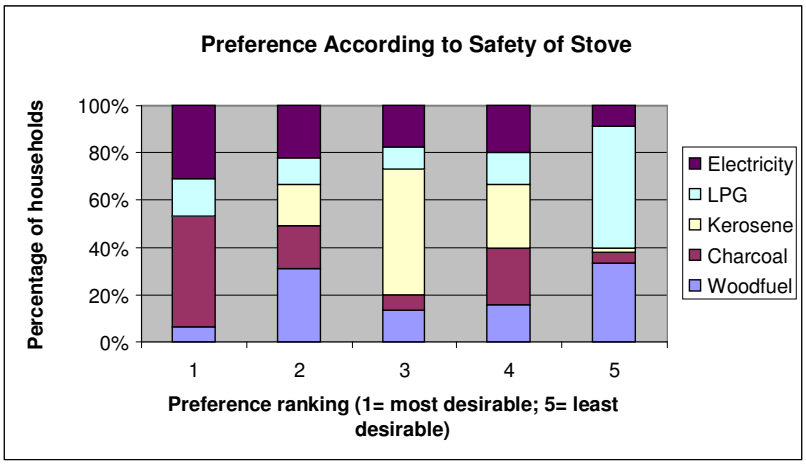

Figure 19: Household fuel preference according to safety

7.4 Health and environment awareness

Are consumers willing to pay for greener and healthier technologies? Do they understand the threats associated with solid biomass use? These are some of the questions that stove programme designers and policy-makes should answer prior to introducing modern energy alternative. It is possible that households will not adopt modern cooking technologies if they see no harm in what they are already using. For this reason, an environmental and health perception questionnaire was administered to 115 household in Catembe. The questionnaire aims to determine the awareness level of the population in terms of health impacts associated with firewood and charcoal, as well as environmental impacts associated with both fuels.

Figure 20 shows the results from the questionnaire, after respondents were asked if firewood and charcoal affect health. Each fuel was asked separately, as to see the difference in perception. 63% of respondents believed that firewood affects health in some way or another (See reasons stated by respondents in Appendix VI), however 37% were either unsure of any health impacts, or simple disproved the association. What is most noticeable however is that as much as 73% of respondents either denied or were unsure of health impacts associated with charcoal use. This figure highlights that charcoal is not perceived as a health impacting fuel. Modern fuels such as the ethanol stove, which is marketed as being smoke-free, might be seen as beneficial amongst firewood users, however might not be as appreciated by charcoal stove users.

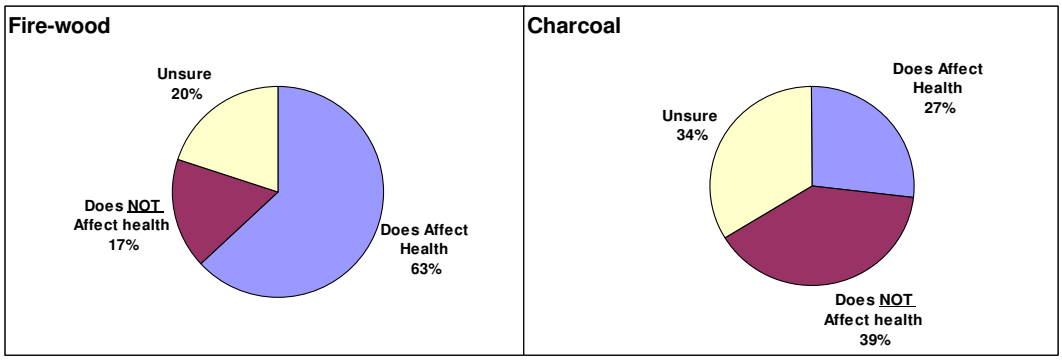

Figure 20: Household perception to whether cooking with fire-wood or charcoal affects health

Respondents where then asked if they think that producing and using charcoal and firewood is bad for the environment. Figure 21 illustrates the answers given by respondents. 54% of the respondents believed that it did affect the environment (see Appendix VI for reasons stated by respondents), however the other half did not attribute any harm from biomass use. It is worth noting that 31% of households were unsure on what to answer. This gap indicates that through education and environmental awareness campaigns, it may be possible to promote modern stoves in Catembe.

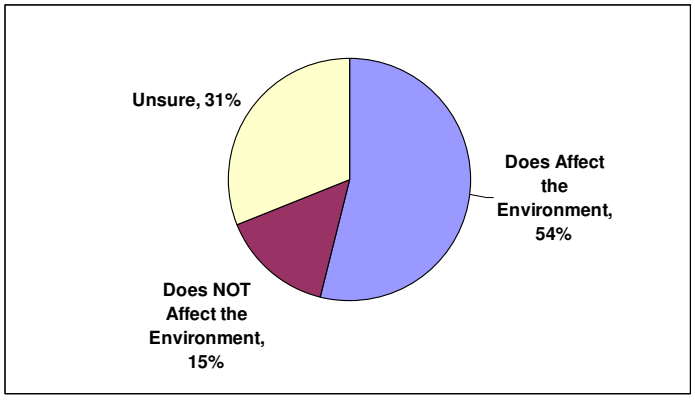

Figure 21: Household perception to whether using fire-wood and charcoal is bad for the environment.

7.5 Group Interview

The group interview held on the 8th of October 2009 amongst four households of different socio-economic backgrounds, revealed insights into household cooking energy preferences, practices and cultural influences. There was a general trend of consensus, as households deliberated on the topics of discussion. The following highlights the general insights given by respondents.

The discussion revealed that the respondents relied primarily on charcoal for their cooking needs. It was labelled as an affordable, easy to find and reliable fuel, with the capacity to provide long lasting cooking time. In addition, respondents agreed that cooking with charcoal gives a pleasant taste to the food. Both taste preferences and suitability to cook traditional slow brewing stews, were labelled as the main cultural reasons for choosing charcoal. LPG is considered as the second most popular fuel, offering an efficient solution to cooking, especially when households are constrained by time. A full time worker explains, “I sometimes use a gas stove because it is practical. When I return late from work, it is quick to prepare a meal. With charcoal it takes time to start the fire”. Electricity was considered to be the ideal source for cooking, however none of the respondents made use of electric stoves due to the price factor. One respondent mentioned the preoccupation of receiving a shock from electric stoves.

Smoke was not brought up as a determining factor for fuel choice. All respondents confirmed to cooking outside the house when using fire wood and charcoal. In the event of rain, they would cook inside with the charcoal stove. Health problems in relation to smoke were mentioned to occur when respondents cooked indoors. Headache and eye irritation were attributed to indoor use of charcoal stoves. One respondent mentioned the inconvenience of washing cooking pots after they are blackened from smoke from wood fuel use.

The risk factor was extensively discussed, whereby LPG took centre stage as a fuel source with the risk of explosion. Respondents made it clear that great care needs to be taken when cooking with gas. This may be a reason for the relatively low percentage of LPG users, as revealed by the survey. Charcoal and firewood were perceived as fire

hazards, however the solution being that households choose to cook outside; generally on a sandy area to avoid ignition from sparks.

When respondents were asked about environmental impacts associated with firewood and charcoal use, all but one respondent were unaware of the consequences. The respondent mentioned deforestation as the major environmental problem. “Cutting trees for fuel has diminished tree cover in the region, the trees are finishing.”

7.6 Expert opinions

Interview with Dr. Almeida Sitoe, Department of Forestry and Agronomy at Eduardo Mondlane University:

The one-to-one interview with Dr. Almeida Sitoe from the department of Forestry and Agronomy of the Eduardo Mondlane University was centred on production and consumption of fuelwood, and the importance of such fuels for the livelihoods of people.

According to Dr. Almeida Sitoe, people in Mozambique have a cultural attachment to cooking with charcoal. “The government promotes electricity use for household cooking. In the last ten years for example, there has been a large increase in grid connections, however people still choose not to use electricity for cooking purposes. Studies even show that charcoal is at times much more expensive then if electricity would have been used.”

This mass reliance on fuel wood is to a large extent a cause of deforestation, however Dr Sitoe highlights that it is the urban centres which are cause of concern, especially when one considers the extensive charcoal market. “In rural areas, the populations tend to collect dead wood or cut branches from the trees, and not whole trees, as they tend to do for retail in urban centres.”

When it was asked whether communities realise the environmental impact of large scale biomass consumption, Dr Sitoe responded as follows: “For rural people, trees are not just a means for fuel wood. They provide fruits, shade, medicinal properties and even aesthetic purposes. Village members in an area cleared of trees from fuelwood production once told me that now they suffer from strong winds, as a result of the deforestation, as well as a lack of fruits to collect. They now resort to buying fruits from the market”.

The remainder of the interview was to a large extent focused on government related initiatives to curb deforestation as a result of fuel wood production and consumption. According to Dr. Sitoe, “Government does not want to be too strict on restricting fuel wood productions, due to poverty concerns. Many people sustain a livelihood from selling charcoal and firewood. It is a large sector of the informal economy. Only ten percent of producers are actually licensed. Two options are thus available for government; either to find other means for producers to earn income, or to promote alternatives in the market so that the business of fuel wood production is not in high

demand." When it was asked for the most effective means of promoting alternative cooking technologies, Dr Sitoe stated that first and foremost, "people need to be educated on the benefits of the alternative" and the "initial cost of buying the stove must be considered" furthermore, it was added that "It is much easier to introduce alternatives in urban areas, as the distribution of energy sources and dissemination of information occurs at faster rates. In rural areas, people live in dispersed locations, and have the option of collecting firewood – which is a free source of energy".

Interview with José Mucavele: renowned musician and cultural advocate for the Ministry of Culture and Education in Mozambique:

The interview was directed towards understanding cultural aspects attached to household use of traditional fuels, as well as discussing the options available and most appropriate means to influencing households to adopt modern cooking technologies.

It was confirmed by Jose Mucavele that fire wood and charcoal are the primary means for household cooking energy in both urban and rural areas of Mozambique. Mucavele gives the following reason for this trend:

- People have been using charcoal and firewood for hundreds and hundreds of years. It is what they know, and what they are comfortable with;
- Charcoal is actually seen as a modern fuel, and it is even used inside building in the city. There is much less smoke with charcoal, and it is relatively cleaner than firewood;
- Food cooked with charcoal is reported to taste better, than when cooked with other means;
- Firewood is often used in traditional ceremonies to make meals for a large number of people;
- Fuelwood maintains heat for a long period of time, thus it is most economical for cooking traditional Mozambican dishes which require long simmering time.

According to Mucavele, it will be possible to motivate people to shift to modern fuels; however it will require much effort from government and social organizations in the promotion of such fuels. The following guidelines were provided by Mucavele:

- People need to be educated about the dangers associated with traditional biomass use, they need to understand the benefits of modern stoves;
- Culture needs to be targeted; perceptions need to change;
- People need to have a guilt conscious when using charcoal and firewood. They should realise that when using traditional biomass, a tree has been cut. This tree that serves many functions such as fruit bearing, shade creating and aesthetic purposes;
- People will have to learn how to use stoves. No point in introducing something that people are afraid to use or just don't know how to.

According to Mucavele, it is important to mobilise different government and non-government actors for the promotion of modern fuels:

- Social organizations should disseminate information on the benefits of modern fuels;
- Government also should promote and support this initiative. Government already has the infrastructure in place to make it possible.
- Traditional leaders are crucial to promote new stoves. They are the authorities closest to the people, and often most respected. They need to accept benefits of the new fuel first, and then promote it to the communities. Demonstration projects should take place;
- Artists are also important. Through theatre, music and other cultural events, a large number of people can gain access to information on the benefits of modern fuels;
- Citizen to citizen information is most important. Students and other advocate groups should spread information on the benefits of using modern fuels, as opposed to traditional biomass;
- Radio is the best means to divulge information in Mozambique.

Jose Mucavele believes that people in Mozambique are willing to accept change, however must first be educated on the benefits of new technologies. According to Mucavele, poverty will not stand as an obstacle to the introduction of modern stoves. "Mozambique has never been rich, however many development projects have been successful. People are always open to ideas and technologies that improve their lives."

Focus group with experts and policy makers:

The focus group comprising of energy experts and policy makers covered a wide range of topics surrounding household energy in Mozambique. For the purpose of the study direction, the focus will be on the significant socio-cultural aspects highlighted during the discussion.

When the idea of introducing ethanol cook-stoves in Mozambique was brought up in the discussion, Rodrigues Manjate, a household energy researcher and expert highlighted the following aspect to consider, "if we study ethanol use at household level in a population typically Muslim, and if we make this study in a typically Christian community, the results will probably be very different. This is because in Muslim communities, alcohol is prohibited; therefore the fuel might be associated with the drink and thus be prohibited in the house. Furthermore, when you have a society where people drink alcohol, the ethanol might be used both ways – as a fuel and as a drink. This may potentially be harmful to health."

The focus group served also to analyse the results gathered during the survey. It was discussed that the popularity of charcoal is culturally driven, due to aspects such as taste, traditional cooking methods and even status. Dr. Amino Ussene Naran, reinforces this by stating: "it is 'chic' to eat charcoal grilled prawns at restaurants in Maputo. It is status. This tendency may lead people to choose charcoal at home. People might think that if they have prawns, they must to be cooked with charcoal; it cannot be with gas or electricity". Per Carstedt, a biofuels investor however is quick to point out that "it is not a case of black or white. It is not a question of ethanol or charcoal. Maybe to grill a chicken, charcoal is the choice, but to cook something else, maybe ethanol is a better choice. In reality fuel options are mixed". The main problem, says Per Carstedt, is to

make ethanol affordable for the people, as to be more attractive then charcoal; “how to integrate external costs, because consumers don’t want to pay for green house effects, consumers don’t want to pay for deforestation. The consumer might not have the capacity to pay for health benefits. How then to make ethanol more attractive to the people?” One of the aspects raised in the discussions, is the fact that charcoal is attractive because it can be bought in small quantities, giving consumers more financial security, as opposed to paying a large once off payment for a gas cylinder or electricity bill. Similarly it was suggested that ethanol can be marketed and sold in small, daily to weekly quantities.

Unawareness of health and environmental consequences of traditional biomass use, amongst some consumers was brought up in the discussions. It raised concern that this might impede the introduction of the ‘environmentally friendly’ and ‘health benefiting’ ethanol stove. Rodrigues Manjate however highlights an example of a study in a village nearby a biofuels plantation, where improved stoves (for more efficient burning of firewood) were introduced. “The results from this study showed that people became aware that there was a firewood shortage in the region, and thus began to use the improved stove, as to save wood. They became aware that they need to manage their firewood consumption. So, in this community, if ethanol is offered as a cooking fuel, then these people will have yet another alternative. Ethanol for cooking purposes has a higher probability for being accepted in this community, as they are already familiar with ethanol. Furthermore, the men in this community have previously worked in South Africa where they have seen ethanol cook stoves”.

Monika Branks highlights that deforestation as a result of wood fuel production is a serious concern, especially since much of it is unlicensed. Rodrigues Manjate agrees, and points to a cultural observation with regards to logging for charcoal. “What we observed, is the following: The producer of charcoal, is not a resident of the place where this charcoal is produced. He is an immigrant. Being an immigrant, he does not have a notion of the regions culture, nor which trees to cut. Every zone in Mozambique has two or three trees that are sacred. You can go from north to south and you will find at least one tree which is sacred to the local population. Here in the south for example, it is the cashew tree. The cashew tree does not serve the purpose of fuelwood. It is a sacred tree! But when a person from Inhambane province comes here for the production of charcoal, he cuts the cashew tree. If you go to the north, you will find a tree called Kogogo. If you walk in the fields, you may even find that there are cloths tied to this tree, marking it as sacred. This tree does not serve for charcoal production to the local community, it is a cultural symbol. But when a person comes from one province to another, he may well cut this tree. Charcoal production is becoming a serious threat, even to culture.”

7.7 Ethnographic Observation

Literature review indicates that ethnography is the most informative research method for understanding social and cultural aspects in energy studies (Lutzenhiser, 1992; Tian, 2000). Table 4 summarises the relevant socio-cultural trends observed during the field work in Catembe. The results highlight the reasons why traditional biomass fuels are

popular amongst households, in terms of how they fit into the social scene of Catembe, and the important part they play in expressing culture and traditions of the local people.

Table 4: General socio-cultural trends associated with traditional biomass use in Catembe

Category of Observation	General Trend in Catembe
House Type	• Either brick house, or traditional reed/ grass huts • 1-2 bedroom houses with no dedicated kitchen space • Traditional grass huts comprised of just one room, usually used for sleeping. • Large yard – used as socialising space • Living space – outside and inside • Guests are usually invited to sit outside in the yard.
Cooking place when traditional fuels are used	• Outside, in the open yard area • On sandy surface, to avoid fire • Sometimes in shaded, separate kitchen in the yard, as to shield from rain or wind.
Primary Stove types	• Three stone firewood – three stones placed on ground to hold the pot over the burning wood. • 1 mouth metal charcoal stove (quality of metal varies) • Two-mouth metal charcoal stove. • Charcoal stove design is similar amongst all observed. Such stoves are widely available in the markets
Other stove types available to the household	• Households generally used firewood or charcoal stoves, however it was noticed that some had LPG and electric stoves inside the homes. • It was observed that households used modern stoves to boil water and quickly heat food. • In one occasion it was observed that household used LPG stove to fry cassava roots, known as *Mandioka*. • Slow cooking food, was prepared over traditional fuels, on most instances.
Person cooking	• In the large majority of observations, it was women who were engaged in cooking activities. • Either the house wife, or daughters were engaged in cooking. • Many times, other households were helping with food preparation.
Cooking as a social activity	• Food is usually prepared by more then one household. • While cooking takes place, different members of the household gather and socialise in the yard (Usually women and children) • Children play in the yard while cooking takes place. • Mothers tend children, as they cook.
Cooking Utensils Used	• Pots varied in size and shape. • Usually large pot sizes were used, as to cook for large family size • Metal kettle is used to boil water for tea or coffee, and is suitable to be placed over wood or charcoal stove. • Large pot to heat water for bathing. • Three stone firewood stove most suitable for large pots • Elongated wooden spoon used to stir the stew. This prevents household from bending over to stir.
Lighting the Fire	• Lighting firewood or charcoal seems to be a laborious task. • The time to light the fire and wait until it is ready to place the pot over is generally from 20-30 minutes

	• Dry grass, reads and leaves are generally used to ignite the fire. • In some cases, paper and cardboard pieces were used, • Some households pour kerosene over charcoal as to encourage flame. • Households generally blow on the flame, as to encourage heat to spread. Alternatively they fan the flame with the lid of the pot or another available device. • Smoke from the process of lighting the fire seems to be most irritable to households. There is considerably less smoke during cooking process.
Adaptation to smoke:	• Households cook outside • Charcoal emits significantly less smoke than firewood • Smoke emitted during lighting of fire seems to be most problematic to households (especially as they blow on the fire) • Some varieties of wood and charcoal emit less smoke then others. • Dry charcoal/firewood emits less smoke
Cuisine	• Most households observed were cooking stews which require slow simmer time. Such stews consist mostly of vegetables, (including edible leafs). • *Matapa* and, *Cacana* were most widely prepared. *Matapa* is primarily consistent of Casava leaves, other vegetables and finely grinded peanuts as well as grated coconut. • It was noticed that the stew was generally prepared in a large pot, as to possibly cater for the large household size. • It may take up to three hours to cook the stews, as they slowly simmer • The stews were generally side-dished with *Shima* (mille-maize porridge) or rice. • In two instances, the *Shima* was prepared over the LPG stove, as it requires fast cooking time. Alternatively it is prepared on the charcoal stove, whereby the heat is heightened by lowering the pot near to the burning coal. Some stoves were adjustable. Cheaper ones were not.
Other activities performed by cook, during cooking time	• Households often perform other household chores while cooking. • It was not unusual for households to clean, wash clothing or tend to children while the food is simmering. • It seems as if the long simmer time for some dishes, allows for households to multi task. • Mothers would often watch over children as they played in the yard.
Methods for putting off the fire	• Firewood would generally be put off by water, or by covering the flame with sand. Firewood can be reused, provided that some parts of the wood were left unburned. • Charcoal is often let to burn out, whereby it is not reused again. In one instance it was noticed that the charcoal was putt off with sand. This was to enable for the fuel to be re-used.
Social events and traditional ceremonies	• Only two events were observed, however in both instances firewood was used to cook meals for the guests. This was irrespective of economic status. • The event organised by Administrative centre of Catembe catered for over 200 people, requiring large pot sizes to cook the large quantities of food. These pots could only be supported by the three-stone method. Additional charcoal stoves were provided for the grilling of chicken and fish. • In the traditional ceremony, based at a household, firewood on a three stone stove method was used; however pot size was not too big. It is not certain if there are other cultural/ spiritual factors responsible for firewood choice.

7.8 Synthesis of data – summary

Table 5 summarises the key finding from both the quantitative and qualitative methods applied. These results will provide a framework for the discussion based on the importance of considering socio-cultural factors in the study of household energy. These insights will also be used to evaluate the hypothetical introduction of the ethanol cook-stove in the context of Catembe.

Table 5: Summary of qualitative and quantitative insights into household energy use in Catembe

Household energy characteristics	Quantitative insights	Qualitative insights
Number of Stoves used	• 759 stoves used by 402 households • 3 stoves used by one household on average	• Multiple fuel use pattern because different stoves perform different function. Different food types may be cooked with different stoves.
Percentage of household using certain fuels	1. Charcoal (78%) 2. Firewood (65%) 3. Electric (26) 4. LPG (19%) 5. Kerosene (1%)	• Charcoal is reported to be affordable, accessible, safe, and emits less smoke than firewood • Charcoal also reported to make food taste better • Charcoal is suitable for preparing traditional stews
Accessibility of fuel	• Firewood and Charcoal are most accessible fuels • LPG is considered least accessible • 83% of households have electricity at home. Only 26% of respondents use it for cooking.	• Firewood is available from nearby forestry resources, while charcoal is sold in all markets and various street corners • LPG is only widely available in the city centre. In Catembe it is only available in one market.
Smoke	• Firewood is least desirable fuel in terms of smoke emitted • Smoke from charcoal is not considered undesirable	• Households cook outside, avoiding many of the problems associated with IAP • When cooking with charcoal inside the house, some households report irritation with smoke
Health Awareness of solid biomass use	• 63% aware that firewood impacts on health • Only 26% aware that charcoal impacts on health	• Smoke level is considerably higher when using firewood • When lighting firewood and charcoal stove, household experience most discomfort, as most smoke is emitted then. • Households generally cook outside, avoiding many IAP problems
Environmental impact awareness of biomass use	• 53% aware • 15% deny impact • 31% unaware	• Low level of awareness possibly due to availability of forestry resources in region • Education level of respondents

		(generally low) may also impact on awareness level.
Preference in size, and weight of fuels	• Electricity and charcoal are most favoured fuels • Wood and LPG are considered least favourable	• Firewood and LPG cylinders are heavy to carry back home. • Charcoal can be bought in small quantities, making it more portable and easy to store. • Charcoal can be bought in small quantities, as many households cannot afford once-off-payments for large quantity.
Time saving	• Households perceive LPG as most favourable in terms of lighting the stove and cooking time • Important for households to have quick start up time. • Charcoal is least preferable when it comes to lighting the fire, but preferable in relations to cooking time of food.	• Charcoal is preferred due to its capacity to either cook meals fast, when pot is placed closer to the burning coal; or alternatively slowly cook traditional meals when pot is placed further from burning coal, or less coal is used. • households working away from home have less time to light charcoal or firewood stoves, thus opt for LPG
Safety Associated with fuels	• Charcoal is perceived by most as the safest fuel type • LPG is largely perceived as least safest fuel	• Households fear the danger of explosion from LPG, and do not trust children around the stove. • Gas leakage is also a concern for many. • Charcoal is perceived safe because of measures taken by households when cooking. Eg. Outside on sandy area.
Stove type in consideration to pot size	• 65% of respondents use firewood as choice of fuel, whereby 3-stone cooking technique is used • Average of 6 people living in a household	• Large household size requires large pot size to cook for all. • Three stone cooking method with firewood is ideal to support large pot sizes, which range up to 20 litres.

8 Discussion

Literature review and expert interviews point to the dangers associated with traditional biomass fuels, ranging from health, through to gender issues and environmental concerns. It has been discerned that in Mozambique, it is the charcoal industry that is cause for much preoccupation. Being the major source of cooking energy for the country's urban centres, the trend is increasingly threatening forestry resources, most prominently in and around the cities. When initiating an online internet search for the words 'charcoal' and 'Mozambique', the first two references highlight this growing preoccupation (Agencia de Informação de Moçambique, 2010; Hanes, 2010). In stressing the problem, both articles point to the realization that the charcoal market sustains the livelihoods of many and is a secure source of income for those involved in the extensive chain of production and retail.

According to Rodrigues Manjate, "When we research the charcoal sector, we realise that there is little or no use in targeting the producers of charcoal in order to reduce production. We should rather target the consumer. We have to go directly to the stoves. We need to find and offer alternatives. We cannot stop the business of charcoal production; we cannot tell the producer to stop producing – what else are they to do? But if we introduce alternatives to charcoal, people will consume less charcoal, leading to the reduced production of the commodity" (Rodrigues Manjate, focus group, Maputo 2009).

The importance of introducing modern cooking energy alternatives, to curb problems associated with traditional biomass is thus of up most essence. But alternatives such as LPG and Electricity are already widely available in the markets. Why then does 75% of the population in the country's capital rely on traditional biomass for their cooking energy needs? The household energy analysis in Catembe, offers insights into this trend, which surpass the economic-oriented assumptions of the energy ladder model and classic energy transition theories.

Research results from Catembe point to realization that income is not the only determining factor for household cooking energy choice. This especially noticed when households were asked in the questionnaire, which fuels they would use if they were to become 'very rich'; amongst the choice of modern alternatives, 45% of households maintained that they will continue to use charcoal. This figure strengthens the significance of the hypothesis that socio-cultural factors are equally important as determinants of energy transition in Mozambique. These and other results from the study challenge the notion of classical energy transition theory which is supported by the energy ladder model, as well as the more drastic 2-step energy leapfrogging model.

8.1 The energy ladder empirically tested

As discussed in section 5.1, the energy ladder model presumes that households transition up the energy ladder, as their income increases. Each step in the ladder represents a more sophisticated, cleaner and efficient choice of fuel. Furthermore, the

energy ladder proposes for a linear transition from one fuel to another, leaving little scope for multiple fuel use (Barnes *et al*. 1996; Leach 1992; Macht *et al*. 2007). The model will thus be challenged on two grounds; that income is not the sole determinant of fuel choice, and that households rarely cease the use of one fuel to adopt another, they rather adopt a multiple fuel use approach.

Figure 22 shows the distribution of fuels used amongst the three income strata in Catembe; low income, stable income (middle), and high income. Income group is treated as the independent variable while fuel choice is the dependent variable. Fuel choice is thus expected to change, as households with similar income levels are grouped. The graph clearly depicts the energy ladder process if one looks at the LPG and firewood usage rates amongst the different income groups. LPG, which is considered a modern fuel, is only used by 3% of lower income households, by 14% of the stable income group, and 22% of the high income group. Therefore the trend depicts an increase in LPG usage, as household income level rises. Correspondingly, firewood usage increases as income decreases (going down the energy ladder). It can therefore be said, that to a certain extent, LPG and Firewood usage trends in Catembe, correspond to the energy ladder model.

The energy ladder hypothesis is however challenged when one looks at the charcoal usage pattern amongst household of all income groups. Charcoal usage remains constant around the 40% mark, irrespective of income strata. Figure 23 shows a linear graph depicting the fuel usage distribution amongst different income strata in Catembe, and compares it to the distribution pattern suggested by the energy ladder model. It is clear that the pattern observed in Catembe deviates from that, as suggested by the classic energy transition models. The following variations are noted:

- High income and middle income household do not abandon the use of firewood, to the rate suggested by the energy ladder model;
- LPG and electricity are not used by a higher proportion of middle and high income households, as suggested by the energy ladder pattern;
- Usage pattern amongst middle and higher income groups does not vary significantly;
- Irrespective of economic status, all groups make use of charcoal at equal proportions (around 40% of households). The energy ladder pattern on the other hand, suggests that middle income household should use a portion of around 20% of charcoal for cooking, whilst higher income groups should only use 5%.
- The lower income fuel usage pattern is the only one which corresponds to the energy ladder model.

From this observation, one can gather that income is not the sole determinant for fuel choice in Catembe, nor do households cease to use traditional fuels as they rise in economic status (especially if one considers charcoal). They rather adopt a multiple fuel use strategy (as discussed in section 7.2). Since both these factors characterise the energy ladder model; findings from the household energy analysis in Catembe can serve to refute the model on both these grounds. By challenging the energy ladder model, one can also challenge the assumptions of the energy leapfrogging model. This is because both models share the principle that households will fuel-switch if the modern technologies are affordable. However data indicates that income level is not the only determinant for fuel choice.

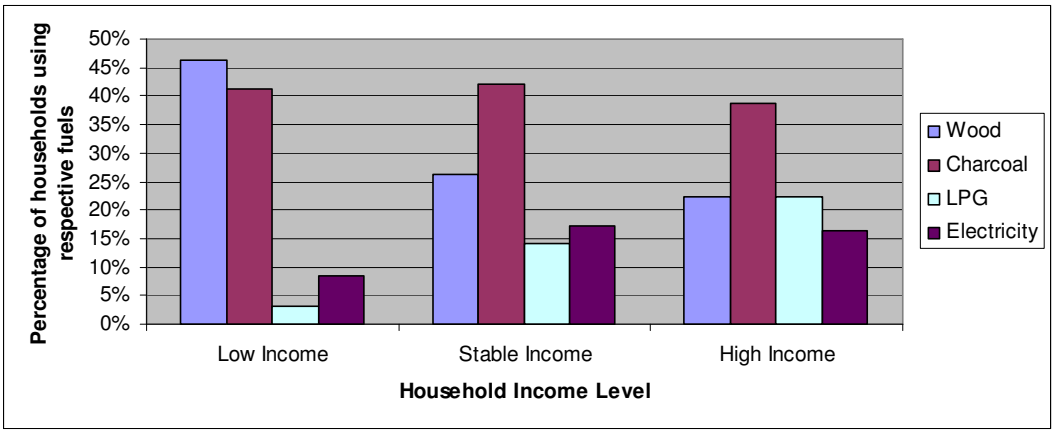

Figure 22: Fuel use distribution amongst different income groups in Catembe

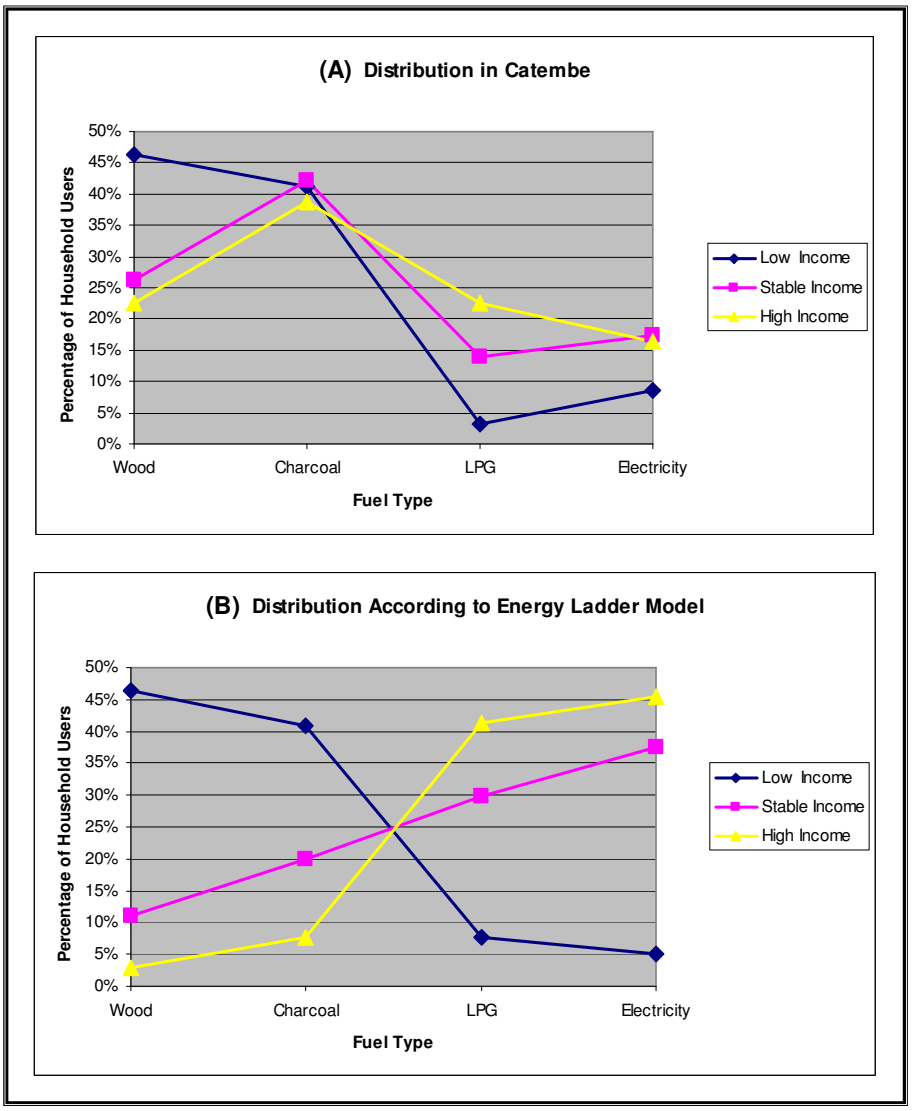

Figure 23: Comparison between fuel distribution amongst different income groups in Catembe (A), vs. fuel distribution as suggested by the energy ladder model (B).

Literature also points to household size, electricity connection and availability of forestry resources as determinants of fuel choice; and a subsequent transition up the energy ladder (Campbell *et al*. 2003; Heltberg *et al*. 2000; Ouedraogo, 2006). The average number of people living in one household in Catembe is 6, and the maximum in the sample being 14. This indicated that families need stoves which support cooking for large family sizes, and consequently large pot sizes. For this reason, the three stone firewood system is widely used by larger households in the region. This factor may thus impact on fuel switching in the Catembe and also explains the necessity for a multiple fuel use strategy.

In terms of electricity connection, 83% of the sampled population in Catembe are connected to the grid. According to Campbell *et al* (2003), Davis (1998) and Ouedraogo (2006) access to electricity plays an important role in shifting the reliance on traditional fuels. Such a trend has not been witnessed in Catembe, especially since only 26% of households actually use their access to electricity for cooking purposes.

With regards to the availability of forestry resources, it was determined that 41% of the households collect own firewood at least once a month in Catembe. This may indicate that there is an availability of forests in the region. According to Heltberg *et al*. (2000) forest scarcity often leads to fuel switching, as households no longer have the option of collecting fuel. Availability of nearby forestry resources may thus be a reason why fuel switch levels are consistently low in Catembe. Figures 5 and 6 in Section 6.1 clearly indicate the presence of forestry resources in the region of Catembe; however also point to the gradual decline in tree cover as a possible result of firewood collection and charcoal production. If the deforestation rate continues in the region, it may become a necessary pre-condition for fuel-switching.

8.2 Considering socio-cultural factors – an alternative approach

As quoted earlier, “It is incumbent on development organizations to recognise that technologies should be appropriate to people’s needs, rather than trying to change people’s behaviour to suit the technological option” (Bates, 2001:1). Following this proposition, the study has been dedicated to understanding household energy trends, practices and preferences – the socio-cultural determinants of fuel choice. Such considerations ultimately give insight into whether a specific technology will be appropriate for the local needs of the intended beneficiaries or not. Furthermore, knowledge of such determinants will ensure for the design of a stove which has a higher chance of user adoption and long-term sustainable use. If the health and environmental problems associated with traditional biomass consumption are to be curbed, then it is vital for proposed technologies to match and fulfil consumer culinary needs and preferences.

8.2.1 The ethanol cook-stove in Catembe – evaluating applicability

In a hypothetical situation, would the ethanol cook stove be suitable for the socio-cultural setting of Catembe? This should be the first question asked by stove programme designers and policy makers, when introducing technologies in any region. This section will characterise the current design of the ethanol cook-stove, as marketed by Swedish manufacturer, Dometic AB. Extracts from the product's information pamphlet will guide this discussion; whereby the stove will be evaluated according to the socio-cultural insights gained from the study. Figure 24 illustrates the 'CleanCook' stove as proposed by Dometic AB.

Figure 24: The CleanCook ethanol stove by Dometic AB
Adopted from: Dometic AB (2009)

The Dometic CleanCook ethanol stove comes in two models; with one burner or with two burners. The stoves are made from stainless steel and have an aluminium finish. The two burner model has a dimension of (WxDxH) 596 x 326 x 137 mm, and reported to support a maximum weight of 20kg. The fuel canister has a capacity of holding 1.2 litres of ethanol, which is reported to last one day for a family of 5. Cooking time of a full canister is around 4.5 hours on full heat (Dometic AB, 2010). See Appendix VII for more detailed specification and illustrations of the stove models.

The stove is marketed as a safe, clean, time saving and user friendly technology. It is safe due to its patented fuel canister design, whereby the alcohol fuel is absorbed onto a refractory mass, which holds the fuel as if it were solid. According to the marketers, this prevents leakage or spillage. Furthermore the fuel is not pressurised, eliminating the danger of explosion. The stove is branded as clean, because it emits low levels of carbon and soot, directly improving indoor air and health for those previously using traditional fuels. The stove also promises time-savings in the kitchen, as it burns at 1.5kW at full power, promising faster cooking time. Finally, it is marketed as a user

friendly and convenient appliance, with simple user instructions and adjustable heat control capacity (Dometic AB, 2009).

In the light of time savings, environmental protection and health improvement, this stove seems to be an ideal choice for household cooking energy; especially if it hopes to replace the inefficient traditional biomass fuels which are notoriously known for their implications. With such developmental benefits, the stoves have the potential of being subsidised by governments and/or development agencies, possibly making them more affordable to the poor – the intended beneficiaries. But is monetary value, the only reason for current energy choices? It was demonstrated in Section 8.1 that cost is not the only determining factor for household fuel choice. This section evaluates the suitability of the ethanol cook-stove when also considering social and cultural dimensions.

Price, accessibility and poverty

The perception mapping questionnaire highlights that households find firewood and charcoal to be most desirable fuels in terms of price. Dr Almeida Sitoe, however brings up that there are instances when monthly charcoal expenditure surpasses that of modern fuel costs. This trend was observed in the market baseline study carried out in Maputo (not specific to Catembe); whereby a 70Kg sack of charcoal, reported to last a family of five for a month, equated to the average monthly cost of using electricity to cook, as well as the average price for LPG per month. One explanation for why households continue to buy charcoal is the fact that charcoal can be bought in small quantities at most markets and various street corners. LPG and Electricity on the other hand, require a once off large payment. This may pose financial insecurity for most. It is in the case of buying charcoal in small quantities, that households would pay an average of 64% more per month, then if they had bought the large 70 kg sack of charcoal. Therefore, it can be said that although charcoal can be more expensive, it is preferred as there is an option for households to partition the cost in intervals. The start up cost of charcoal is also at economic capacity for most. A charcoal stove ranges from around 50 Meticais (2 US$) for the cheapest one mouth stove to 500 Meticais (17 US$) for a good quality two mouth stove. This cannot be said even for the cheapest LPG or electric stoves. Figure 25 illustrated the typical charcoal stove sold at most market places, and used by the majority of households.

If one follows the sense that some households prefer to buy fuel in smaller quantities in order to partition costs, then the proposed ethanol cook-stove may prove desirable to such people. Since the stove canister has the capacity of holding 1.2 litres of ethanol at a time, then the fuel can be purchased as to suit the family demands in daily quantities. The entry cost for the ethanol stove must also correspond to the household financial capacities. This can either be achieved by government subsidies for the production of the stoves, or perhaps a system of purchasing the stoves on credit. This can only work however, if the fuel is accessible and widely available for households to procure. The perception mapping survey points to the popularity of charcoal as a fuel which is most accessible. LPG on the other hand, is least desirable as it is not available in all market places. This may explain its low level of usage in Catembe.

Figure 25: Typical charcoal stove used by families across Mozambique
Photographer: Boris Atanassov

Housing design and cooking place

When introducing improved cooking technologies, it is important to consider whether housing design permits for the use of such a stoves, as well as whether the cooking place typically used by households is permissive to placing the new technology. Data from Catembe shows that the majority of respondents live in a one or two room house, which typically sleeps a family of 6. It can be gathered, that indoor space is generally used for sleeping and shelter from rain. When introducing the ethanol stove, it must therefore be taken into consideration that perhaps households do not have a space dedicated to place a stove inside the house. In the event that the kitchen space is outside in the yards, it must further be considered whether the ethanol stove can be suitable for such use. Figure 26 illustrates the typical cooking setting for a low income household in Catembe,

Furthermore observation indicates that cooking is a social activity, whereby various people may gather in the yard, while cooking occurs, as a means to socialize or help with the preparation of the food. Stove programme designers should therefore consider if the ethanol cook-stove (or any other improved cooking technology) is applicable for outdoor use. It should withstand elements from the terrain such as sand, wind, direct sunlight and possibly rain. These are some of the elements which the popular charcoal stoves are recognised to withstand.

Figure 26: Low income household cooking on 3-stone firewood stove, outside thatch house.
Photographer: Boris Atanassov

Time Savings – a relative concept

The ethanol stove is marketed as being time efficient in terms of lighting the stove for use, as well as the time it takes to cook food. Such time savings, in comparison to the often laborious task of lighting traditional fuels, can give women the time to engage in other activities, such as income generation or perhaps education.

The perception mapping survey, points to a clear consensus that traditional fuels are least preferable in terms of lighting the stove to cook. It is in this case that households would rather use LPG or electricity. The ethanol stove would thus provide a welcomed relief.

In terms of cooking time, the ethanol cook stove may also provide time-savings due to its high power output in relations to solid biomass fuels. This might not however be desirable to some. Again, the notion that cooking is a social activity might be as a result of long cooking time. Eliminating the need for time spend to cook, might impact on such relations. Furthermore, observations highlight that traditional stews often require long cooking time. Promoting the ethanol stove as a fast cooking device might shy households from using it due to the culinary practices in place.

Multiple fuel use and cuisine

Data shows that households in Catembe rarely just use one fuel type to satisfy cooking energy needs. Some fuels are better suited for some function than others; for example, the charcoal stove is ideal for grilling meet, as well as slowly simmering the traditional stews. The LPG and electric stoves on the other hand, are preferred for quickly boiling water, frying, and preparing side dishes such as rice and *shima*. The value of the 3-stone firewood stove as to support large pot sizes is also important to consider. Figure 27 illustrates a typical 3-stone firewood stove supporting a large sized pot. In sum, this indicates that perhaps the ethanol stove will not substitute traditional fuels - at least in the short term – however might offer utility for households in preparation of certain foods (those currently prepared on gas and electric stoves).

If the ethanol stove is to truly succeed in its developmental objectives, it should replace the function provided by traditional fuels in preparing slow simmering stews. It was observed that stews such as *matapa* and *cacana* may take up to 3 hours to cook. The specifications for the ethanol cook-stove register a 4.5 hour cooking time on a full fuel canister. This is barely sufficient for one meal. Furthermore, it should also be considered whether the ethanol cookstove can withstand the weight and shape of the large pot sizes, available for households to cook in. Specifications point that the cook stove supports a maximum of 20 kg weight. It was observed that households often cook with larger pots, as to cater for the large household size, surpassing the 20kg requirement. Pot sizes also vary in shape, whereby some pots had rounded bottoms. It may be necessary to modify the ethanol stove, as to support such cooking utensils.

Finally, it should be noted that households attribute desirable taste to food cooked with firewood and charcoal. This may stand as an impediment to the acceptance of ethanol cook-stoves.

Figure 27: The 3-stone firewood stove supporting a large sized pot
Photographer: Boris Atanassov

Health benefits and awareness level

The ethanol stove is marketed as to provide relief from the adverse health effects associated with traditional biomass use.

"The CleanCook is a high-performing stove. It provides a significant health benefit to families otherwise dependent on solid fuels – wood, dung, crop residues, charcoal, even coal – by eliminating dangerous smoke and gases from the home. Millions of families around the world are still dependent on these fuels and millions die, mostly women and children, as a result of cooking smoke" (Dometic AB, 2010).

Two factors in the context of Catembe might impact on the adoption rates of the ethanol cookstove. The first factor is the awareness level of households in relations to health impacts associated with biomass fuels. In Section 7.4 it was demonstrated that many households (63%) were aware of health impacts associated witch firewood use. In the case of charcoal, however, only 27% of households agreed that it may be harmful to health. This suggests that perhaps households may not perceive the need to discontinue using charcoal, on grounds of health concerns, and therefore not shift to ethanol. The second factor which may impede the acceptance of the ethanol cook-stove is the trend of cooking outside in open air. Households have already found the solution to IAP, by moving the stove outside the house. The ethanol cook-stove may however offer relief when weather conditions are adverse, such as in the case of rain.

In terms of safety, the study reveals that households attach importance to this factor as a determinant to fuel choice. The perception mapping questionnaire was clear in pointing the negative connotation associated with LPG and safety. This was clarified in the group interview, whereby households most feared the risk of explosion from LPG. It is in this sense that the ethanol stove can be most successfully marketed in Catembe.

"The CleanCook not only burns cleanly but is extremely safe to use. The fuel tank is non-pressurized and holds ethanol fuel in a special absorptive fiber so it cannot spill. The burner flame is adjusted and extinguished by a simple regulator. This stove was developed to address the many safety concerns presented by other stoves." (Dometic AB, 2010)

Environmental awareness

"Cooking with ethanol from sustainably produced energy crops reduces wood-use and deforestation. The CleanCook dramatically reduces greenhouse gas and soot (black carbon) emissions. This means a greatly reduced Global Warming Impact." (Dometic AB 2010)

The same way that health awareness might determine if households see the need to fuel switch, environmental awareness is equally important if deforestation is to be curbed by the introduction of the ethanol cook-stove. The environment perception questionnaire revealed that 54% of respondents believed that fuelwood use affects the environment in some way or another; however the other half did not attribute any harm from biomass use. It is worth noting that 31% of households were unsure on what to answer. This gap indicates that through education and environmental awareness campaigns, it may be

possible to promote the ethanol cook-stove on grounds of environmental protection in Catembe. As suggested by Jose Mucavele in section 7.6, there are various means to divulge such information. Through theatre, music and other cultural events, people can be persuaded to switch to more environmentally friendly alternatives. It is also imperative to recognise the influential role played by traditional leaders at community level in places such as Catembe. It is they that need to accept the benefits of modern fuels first and demonstratively influence others to follow example.

Alcohol taboos

During the focus group discussion, Rodrigues Manjate, a household energy specialist highlighted the following concern; "if we study ethanol use at household level in a population typically Muslim, and if we make this study in a typically Christian community, the results will probably be very different. This is because in Muslim communities, alcohol is prohibited; therefore the fuel might be associated with the drink and thus be prohibited in the house. Furthermore, when you have a society where people drink alcohol, the ethanol might be used both ways – as a fuel and as a drink. This may potentially be harmful to health." (Manjate, focus group, Maputo, 2009)

The religious affiliation of households in Catembe was not studied, however based on insights from Ndege (2000), there are three major groups of religions in Mozambique; Christian, Islamic and traditional religious beliefs. When introducing the ethanol cook stove, programme designers should thus take this diversity into account.
In terms of the preoccupation of using the fuel as a drink, one solution is provided by Obueh (2006: 29) whereby a colorant and a bitter agent can be added to the fuel, as a means to distinguish it from consumable liquids as well as to make it unpalatable. It is proposed that Denatonium Benzoate is added to the fuel, as it will make it bad tasting and physically intolerable to swallow. Care must be taken however, for the chemical not to influence the smell of the burning fuel or the taste of food cooked with it, as this may prove undesirable to households.

Is the ethanol stove applicable for Catembe?

From the discussion above, it can be gathered that there is not a simple 'yes' or 'no' answer to the applicability of the 'CleanCook' ethanol stove. There are however various instances where the stove may prove desirable to households, such as in time-savings; adjustable heat control capabilities; the possibility of buying small quantities of fuel at a time; and safety motives. The study however also points to the necessity for a certain level of technological modification, as to satisfy other user needs and preferences. The capacity for the stove to withstand large and heavy pots is questionable; while the burning time of the fuel on a full canister may be too short for the cooking duration required for traditional meals. It can be proposed that the metal stand on the burner of the stove be modified as to withstand greater weight. It may also be necessary to alter the stand as to support the different pot shapes used by households in Catembe (e.g. rounded bottom). In terms of fuel burning time, the canister could possibly be enlarged as to contain more fuel.

Furthermore, because it is customary to cook outside in the yard, the stove should ideally be suitable for such use. It may be that elements such as sand, light rain and direct sunlight damage the currently proposed stove. This should be evaluated by field testing, and possibly addressed by technological modification. It should also be noted, that in order for the stove to be used on a long term basis; households should be able to service and care for the device themselves. Observation shows that the popular charcoal stove is often repaired by households if damaged. With this said, there may be a safety concern if households repair the ethanol stove themselves.

Finally, the study shows that through educational and promotional campaigns, the CleanCook stove may gain acceptance in Catembe. The number of people that are currently uninformed of the health and environmental risks associated with traditional biomass can potentially be convinced to fuel-switch.

8.3 Theoretical contribution and applicability

Perhaps the most important theoretical contribution of this study is that it highlights the importance that socio-cultural factors play in household energy choice. It has been discerned that economic struggle, unavailability of alternatives and abundance of forestry resources are not the only determining factors for the mass use of traditional biomass fuels. The study shows that household energy choice is a product of active decision making, which involves taste preferences, culinary norms, social relations, and other considerations deeply ingrained in the tradition of society. It is therefore imperative that theoretical models recognize and incorporate such dynamics, as to lead energy programmes into long term sustainability.

Incorporating socio-cultural dimensions may however be restricted to project size. Budds *et al*. (2001: 28) describe the difference between large-scale nation wide initiatives to stove dissemination, and small scale local projects. While large scale projects may achieve a greater quantity of distribution, the success rate of adoption of technology is much lower. Small scale initiatives on the other hand, are often participatory in nature and offer for a bottom up approach to the introduction of the new technology. Barnes *et al.* (1993:137) however warns that small scale projects are often case specific and the lessons learned in one community may not be applicable for another, therefore requiring a repetition of field testing, which in turn is more time consuming in the long run. The socio-cultural insights learned from the study in Catembe, therefore run the risk of being specific to the region. Because Mozambique is a culturally diverse country, it may be necessary to replicate the study in other regions.

For there to be consistency in studying socio-cultural dynamics within household energy sector, Table 6 shows a checklist devised from lessons learned during this study, which can be implemented in other places of interest.

Table 6: Checklist for stove programme designers

Checklist questions	Rationale	Research
What do households currently cook with?	To determine which fuel/stoves the new technology will substitute, and whether there is a need for such substitution.	Survey/ Observation
Which fuel/stove characteristics are most preferable to users?	To evaluate what makes current stoves preferable, and therefore to design a stove that satisfies user needs.	Perception mapping survey
Where does the user currently cook? Can new stove be placed there?	To design a stove that is applicable to cooking surroundings. Possibly for outside use.	Observation/ interviews
Does the stove cater for the average family size in the community?	To determine the pot size necessary for cooking, and whether new technology can withstand size.	Survey
Does the design of the stove fit in the surroundings?	To determine if the stove is culturally and aesthetically pleasing.	Observation
Does the stove support the use of cooking utensils currently available to households?	Households should not be made to change pots, as to correspond to new stove. Stove should correspond to what users already have.	Observation
Does the user value clean energy?	To determine if users are aware of the benefits proposed by new stove. Such awareness is necessary for technological absorption.	Health and environment perception survey
Can traditional cuisine be prepared with the stove?	It is difficult to persuade households to modify cooking techniques of traditional food as to suit new stoves.	Observation
Can the fuel be sold in quantities desired by households?	Many times stoves fail to be used because of inappropriate fuel refill methods	Survey/ interviews
Will stove meet safety needs of users?	There is no use in introducing something which households fear using. LPG is clear example	Perception mapping survey
Does stove meet the specific needs of women?	Since women are mostly responsible for cooking, it is their needs which must be taken into account.	Observation / interviews
Do both men and women understand benefits of stove?	Since in many instances men provide financial means for stove to be purchased, they should be convinced of the benefits.	Interviews/ Perception questionnaire
Does stove perform functions of currently used stoves?	Traditional stoves will probably not be replaced if new stoves cannot perform all the functions.	Observation
Is there a cultural attachment to fuels currently used?	If there are cultural attachments, than it will be more difficult to persuade household to fuel switch.	Interviews
Do households collect own fuel?	Perhaps ‘free’ fuel is difficult to replace. Environmental awareness programmes would probably need to accompany stove distribution.	Survey/ Interview

9 Conclusion

This study highlights the complex decision making process of household energy choice in developing countries. It was shown that economic rationality, based on the energy ladder model is not the only determining factor for fuel choice amongst households. Furthermore, the linear assumption of fuel-switch was disproved on the basis that households in Catembe adopt a multiple fuel use approach. As a household's income increase, there is a higher likelihood of modern fuel adoption; however households seldom cease to use traditional fuels. This trend highlights the dominance of socio-cultural factors as determinants of fuel choice.

It was determined that cuisine, taste preferences, culinary utensils, cooking location, and the act of cooking itself, are all culturally determined in Catembe. Traditional cooking practices with the 3-stone firewood stove and the more popular charcoal stove, are widely used, and satisfy the culinary needs of households. Such fuels however have a multitude of social, health and environmental consequences attached to their production and use. It is therefore of up most importance that society moves towards the use of more sustainable energy alternatives.

If change is to be made, then the most effective means of introducing modern stoves needs to be made. This study proposes designing stoves that appeal to the social-cultural needs of intended beneficiaries. It is much easier to modify the stove design, than it is to modify household cooking practices, as to meet the requirements of the new technology. Introducing culturally acceptable stoves will therefore have a greater likelihood of being accepted and used by households in the long run.

Since this study focuses on Catembe, the results may well be specific to that region. It is recommended that similar studies be carried out in other parts of the country as well as other parts of the world. It will be worthwhile to compare results from predominantly urban areas to those from peri-urban and rural regions.

To verify the arguments raised in this study, it will be interesting to introduce the actual ethanol cook-stoves to selected families in Catembe. This should be done in the form of a pilot study, as to monitor and evaluate the use of the technology amongst households. It would also be worthwhile to modify the design of the stoves, according to the socio-cultural context of Catembe, and compare acceptance rate with the current model.

Finally, while conducting the literature review, it came to attention that there is a lack of up to date and country-wide data on household energy use in Mozambique. It is recommended that such baseline studies be carried out, together with a focus on the socio-cultural characteristics of each study site. This will ultimately create a data bank, which will facilitate stove programme designers in adapting technologies to the needs of people.

Reference List

Administração do Distrito Municipal da Catembe, 2009, *Banco de Dados Socio-Economico,* Catembe, Government of Mozambique publication

Agencia de Informação de Moçambique, 2010, *Mozambique: Charcoal Production Must Be Controlled*, (Online source) Available at: http://allafrica.com/stories/200806161361.html, (Accessed: 2010-01-25)

Amacher, G. S., Hyde, W. F. and Rafiq, M., 1993, "Local Adoption of New Forestry Technologies: An Example from Pakistan's Northwest Frontier Province". In *World Development* 21(3): 445-453

Arnold, J. E., Köhlin, G., and Persson, R., 2006, "Woodfuels, Livelihoods, and Policy Interventions: Changing Perspectives", in *World Development,* 34(3): 596-611

Arvidson, A. & Nordström, M. (2005) "The role of energy in meeting the MDGs and the scale of the challenges" in *Renewable Energy for Development*, 18(3): 12

Barnes, F., Openshaw, K., Smith, K., & van der Plas, R., 1993, "The Design and Diffusion of Improved Cooking Stoves", in *The World Bank Research Observer,* 8(2) 119-141

Barnes, D.F. and Floor, W.M., 1996, "Rural energy in developing countries: A Challenge for Economic Development", in *Annual Reviews in Energy and the Environment*, 21(1) 497-530

Bates, E., 2001, "Smoke can seriously damage your health: especially if you live in the developing world", in *The Woman Engineer*, 16 (12), spring 2001

Bond, T., MacCarty, N., Ogle, D., Roden, C., Still, D., 2008, "A laboratory comparison of the global warming impact of five major types of biomass cooking stoves". In *Energy for Sustainable Development,* 7(2): 5-14

Brower, R. and Falcão, M. P., 2004, "Wood fuel consumption in Maputo, Mozambique, in *Biomass and Bioenergy,* 27: 233-245

Bruce, N., Perez-Padilla, R. & Albalak, R., 2000, "Indoor air pollution in developing countries: a major environmental and public health challenge" in *Bulleting of the World Health Organization*, 78(9): 1078-1092

Bryman, A., 2001, *Social Research Methods*, Oxford University Press: Oxford

Budds, J., Biran, A. & Rouse, J. 2001, *What's cooking: a review of the health impacts of indoor air pollution and technical interventions for its reduction.* Leicestershire: Water, Engineering and Development Centre, Loughborough University

Campbell, B.M., Vermeulen, S.J., Mangono, J.J., and Mabugu, R., 2003, "The energy transition in action: Urban domestic fuel choices in a changing Zimbabwe", in *Energy Policy* 31(6): 553-562

Chidumayo, E. N., 1997, "Woodfuel and Deforestation in Southern Africa – a misconceived association", in *Renewable Energy for Development*, 10(2): 12-17

Choi, H. J., 2009, "Technology Transfer Issues and a New Technology Transfer Model", In *The Journal of Technology Studies*, 35(1): 49-57

Clancy, J. S., 2008, "Urban ecological footprint in Africa", in *Afr. J. Ecol.* 46: 463-470

Costa, J. A., 1995. "The social organization of consumer behaviour". In Sherry, J. S (ed.) *Contemporary marketing and consumer behaviour: An anthropological sourcebook*, Thousand Oaks, CA: Sage

Couto, R & Murren, J., 2009, "Tapping the potential of Brazil's Proalcool movement for the household energy sector", in *Boiling Point*, issue 56. pp. 36-38

Coughlin, P. E., 2007, *Baseline survey of Market and Household Cooks,* Econ-Policy Report commissioned by GTZ-ProBec, Mozambique.

Davis, M., 1998. "Rural household energy consumption: The effects of access to electricity – evidence from South Africa." In *Energy Policy* 26(3): 207-217

Denscombe, M., 2003, *The Good Research Guide: for small scale social research projects,* Philadelphia: Open University Press

Dometic AB, 2009, *A New Stove and Fuel for Developing and Emerging Markets*, Power Point Presentation, (Online source) Available at: http://siteresources.worldbank.org/INTENERGY/Resources/335544-1232567547944/5755469-1239633250635/Ted_Orbrink.pdf, (Accessed: 2010-05-05)

Dometic AB, 2010, *Alcohol fuelled stove models*, (Online source) Available at: http://www.dometic.com/3bd0d450-1131-4f8f-8ce7-90e8283815e0.fodoc, (Accessed: 2010-05-05)

Ellegård, A. 1996, "Cooking Fuel Smoke and Respiratory Symptoms among Women in Low-Income Areas of Maputo", in *Environmental Health Perspectives,* 104(9) 980-985

Gannon, M.J., and associates, 1993, *Understanding global cultures: Mataphorical journey through 17 countries*. Thousand Oaks, CA: Sage

Goldemberg, J., 1998, "Leapfrog energy technologies" in *Energy Policy* 26(10) 729-741

Government of Mozambique, 2010, *Country Information,* (Online source) Available at: http://www.portaldogoverno.org.mz/mozambique (Accessed: 2010-02-20)

Governo de Moçambique, 2000, *Estrategia de Energia, 3 de Outubro de 2000*, (Online source) Available at: http://www.portaldogoverno.gov.mz/docs_gov/estrategia/energia/estrat_energia.pdf (Accessed: 2010-02-20)

Governo de Mocambique, 2009, *Politica e Estrategia de Biocombustiveis*, 21 May 2009, Government Gazzete

Hägerstrand, T. 1967, *Innovation Diffusion as a Spatial Process,* Chicago: University of Chicago Press

Hanes, S. 2010, *Charcoal fuels the economy and deforestation of Mozambique* (Online source) Available at: http://www.csmonitor.com/World/Africa/2008/0402/p20s01-woaf.html, (Accessed: 2010-01-25)

Heltberg, R., Arndt, T., Sekhar, N., 2000, "Fuelwood consumption and Forest Degradation: A Household Model for Domestic Energy Substitution in Rural India". In *Land Economics* 76(2): 213-232

Hetlberg, R., 2004, "Fuel switching: evidence from eight developing countries". In *Energy Economics* 26(5) 869-887

Hiemstra-van der Horst, G & Hovorka, A. J., 2008, "Reassessing the energy ladder: Household energy use in Maun, Botswana", in *Energy Policy,* 36(2008) 3333-3344

Holdren, J. P. and Smith K. R., 2000, "Energy, the Environment, and Health". In *The World Energy Assessment: Energy and the Challenge of Sustainability*, ed. Jose Goldemberg, 61-110. UN Development Programme, New York

IEA (International Energy Agency), 2006*,* "Energy for Cooking in Developing CountriesWorld"*,* in *Energy Outlook 2006*. Paris: IEA

Jebaraj, S. and Iniyan, S. 2006, "A review of energy models" in *Renewable and Sustainable Energy Reviews,* 10: 281-311

Jenkins, P., 2000, "City profile: Maputo", in *Cities*, 17(3): 207-218

Johnson, N. G., Bryden, M. 2006, "Direct contact hazaerds of cookstoves: Burns, cuts, and scalds" in *Boiling Point,* 52: 14-15)

Joon V., Chandra A., Bhattacharya M., 2009, "Household energy consumption pattern and socio-cultural dimensions associated with it: A case study of rural Haryana, India" in *Biomass and Bioenergy* issue 33 (2009) pp. 1509-1512

Karekezi, S., 2002, "Poverty and energy in Africa – A brief review" in *Energy Policy,* 30 (2002): 915-919

Lambe, F. 2008, "Development of Local Biofuel Markets: A Case Study from Ethiopia" in *Renewable Energy for Development*, 21(1): 4-5

Leach, G., 1992, "The energy transition", in *Energy Policy* 20(2) 116-123

Lenssen, C. and Flavin, C., 1996, "Sustainable energy for tomorrow's world: The case for an optimistic view of the future", in *Energy Policy* 24(9) 769-781

Lubkemann, S. C., 2008, *Culture in Chaos: An anthropology of the social conditions in war,* Chicago: The University of Chicago Press

Lutzenhiser, L., 1992, "A cultural model of household energy consumption", in *Energy* Vol.17, No. 1, pp. 47-60

Macht, C., Axinn, W. and Ghimire, D., 2007*, Household Energy Consumption: Community Context and the Fuelwood Transition*, Michigan: Populations Studies Centre University of Michigan

Madubansi, M. and Shackleton, C.M., 2007, "Changes in fuelwood use and selection following electrification in the Bushbuckridge Lowveld, South Africa. In *Journal of Environmental Management* 83: 416-426

Malhotra, P; Neudoerffer, C; Dutta, S. 2004, "A Participatory process for designing cooking energy programmes with women" in *Biomass and Bioenergy,* 26 (2004); 147-169

Masera, O., Saatkamp, B., and Kammen, D., 2000, "From Linear Fuel Switching to Multiple Cooking Strategies: A Critique and Alternative to the Energy Ladder Model", in *World Development* 28(12) 2083-2103

McGranahan, G., 2007, "Urban Transitions and the Spatial Displacement of Environmental Burdens"*,* in Marcotullio, P. & McGranahan, G (eds) *Scaling the Urban Environmental Challenge: From local to global and back,* London: Earthscan

Meusalario, 2010, *Salario Minimo em Mocambique*, (Online source) Available at: http://www.meusalario.org/mocambique/main/salario-minimo/, (Accessed: 2009-04-30)

MICOA (Ministerio para a coordincao da accao ambiental), 2005, *Avaliacao da vulnerabilidade as mudancas climaticas e estrategias de adaptacao*. (Online source) Available at: http://www.portaldogoverno.gov.mz/docs_gov/estrategia/agricultura/avaliacao_vulnerab_mud_climat_estrateg_adapt.pdf (Accessed: 2010-02-20)

Ministerio de Energia, 2005, *Estatistica de Energia 2005,* Government publication: DIRECÇÃO NACIONAL DE ESTUDOS E PLANIFICAÇÃO (DEP)

Munasinghe, M., 1999, "Is environmental degradation an inevitable consequence of economic growth: tunneling through the environmental Kuznets curve". In *Ecological Economics* 29 (1999) 89–109

Murphy, J.T., 2001, "Making the energy transition in rural East Africa: Is leapfrogging an alternative? In *Technological Forecasting & Social Change* 68(2001) 173-193

Ndege, G. O., 2007, *Culture and Customs of Mozambique,* Westport: Greenwood Press

Obueh, J., 2006, "Methanol stoves for indoor air pollution reduction in Delta State, Nigeria – addressing the needs of people for clean energy", in *Boiling Point,* 52: 27-29

Onunwa, U. R. 2005, *Tradition, Culture & Underdevelopment of Africa,* Arima Publishing: Suffolk

Ouedraogo, B., 2006,"Household energy preferences for cooking in urban Ouagadougou, Burkina Faso." In *Energy Policy* 34(18): 3787-3795

PREDAS (Programme for the Promotion of Household and Alternative Energy sources in the Sahel), 2009, "Women and household energy in Sahelian countries", in *Boiling Point,* 56: 21-32

Project Gaia, 2010, *General organizational information*, (Online Source) Available at: http://www.projectgaia.com/, (Accessed: 2010-04-17)

Ramanathan, V., and Carmichael, G. 2008, "Global and Regional Climate Change due to Black Carbon", in *Nature Geoscience,* 1(4): 221-227

Rogers, E. M. 2003, *Diffusion of innovation* (5th ed.), New York: Free Press

Schlag, N and Zuzarte, F, 2008, *Market Barriers to Clean Cooking Fuels in Sub-Saharan Africa: A Review of Literature*, working paper, Stockholm Environment Institute.

SEI, 2002, *Guidelines for preparing and conducting focus group discussions,* Unpublished organizational document, Stockholm

Sitoe, T. A. 2010, *Colonização e independência em Moçambique: hábitos alimentares em mudança*, (Online source) Available at: http://www.slowfoodbrasil.com/content/view/307/95/, (Accessed: 2010-02-20)

Smith, K. R. 2006, "Update on the health and climate impacts of household solid fuels" in *Boiling Point*, 52: 3-5

Takama, T., Atanassov, B., Lambe, F., Nilson, L., 2010, *Household Economic Analysis of Clean Cooking Stoves and Energy in Ethiopia, Tanzania and Mozambique*, Stockholm Environment Institute, Stockholm

Tian, R. G. 2000, Understanding Consumer Behavior: The Psycho-Anthropological approach, in *North American Journal of Psychology*, 2(2); 273-280

UNDP, 2000, *World Energy Assessment: Energy and the Challenges of Sustainability.* New York, United Nations Development Programme.

UNDP, 2007, *Human Development Report 2007/2008*, New York: Palgrave MacMillan

Utria, B. E. 2004, "Ethanol and gelfuel: clean renewable cooking fuels for poverty alleviation in Africa" in *Energy for Sustainable Development*, 8(3): 107-114

WHO (World Health Organization), 2006, *Fuel for Life: Household Energy and Health,* Geneva: WHO. Also available online: http://www.who.int/indoorair/publications/fuelforlife.pdf

Wilhite, H., Nakagami, H., Masuda, T., Yamaga, Y., and Haneda, H., 1996, "A cross-cultural analysis of household energy use behaviour in Japan and Norway, in *Energy Policy* 24(9) 795-803

WWF, 2008, Mozambique *consultancy report on biofuel study* (Online source) Available at: (http://www.wwf.se/source.php/1203702/mozambique_biofuel_report_june2008_bio_fuels_draft.pdf (Viewed: 2008-10-09)

Appendices

Appendix I: Market baseline survey results

Charcoal stove types and prices:

Table A: The prices of different types of charcoal stoves in four locations

Stove Type	Vendor 1 (Xipamanini 1)	Vendor 2 (Xipamanini 2)	Vendor 3 (Xipamanini 3)	Vendor 4 (Mercado Janet)
Round weak (Redondo)	50 mt	50 mt	50 mt	100 mt
1 mouth weak	50 mt	85 mt	75 mt	125 mt
1 mouth strong	150 mt	100 mt	90 mt	250 mt
Two mouths weak	-	280 mt	280 mt	-
Two mouths strong	280 – 300 mt	500 mt	340 mt	375 mt

**Prices are all in Mozambique Metical (Mt.); 1 US Dollar is equivalent to 29 Mt.*

Note: stoves are of different quality and size; prices vary from:

- 50 mt to 125 mt for weak (thin metal sheet) 1 mouth stoves
- 90 mt to 250 mt for durable 1 mouth stoves
- 280 mt for weak two mouth stoves
- 280 mt to 500 mt for durable two mouthed stove

Charcoal quantities and prices:

Table B: The prices for different charcoal quantities available at different markets

Quantity	Mercado do Museu	Mercado do Xipamanini	Mercado Janet	Catembe
Tin container +- 2 Liters	**12,50 Mt**	**12 Mt**	**10-15 Mt**	**NA**
Tin container 10 Liters	**Not for sale**	**Not for Sale**	**80 Mt**	**NA**
Tin container 20 Liters	**Not for sale**	**110 Mt**	**140 Mt**	**NA**
Large Sack +- 70 kg	**550 Mt**	**410 Mt**	**480 Mt**	**300 Mt**

**Prices are all in Mozambique Metical (Mt.); 1 US Dollar is equivalent to 29 Mt.*

Note:

- Most common mode of buying charcoal is either in a small tin container of about 2 liters (ideal for one meal) or a large sack of +- 70 Kg which is reported to last for a month for a family of 5.
- Information about weight of containers and sacks varied between vendors – necessary to go back with scale and measure actual weight to determine how many small cans make up large sack.
- Average price for 70 kg sack is 500 mt
- Average price for standard 2 liter tin is 12, 50 mt.

Firewood Prices and Availability

Prices from Xipamanini Market, Maputo

- 25 Mt per Kg for good quality
- 20 Mt per Kg for poorer quality

Prices from out of Maputo – Bilen in Gaza province

- 10 Mt for +/- 1kg (log)

Note: from various markets visited, firewood was only sold in Xipamanini Market, and not too great of quantity compared to charcoal. When I asked vendors about possible places to buy firewood, I was told to look out of the city in the countryside. This is surprising as previous studies on household energy, point to firewood as a major source of energy even in the city area.

No firewood stoves were on sale. Respondents confirmed that the 3-stone mode of cooking was used.

Price of LPG Fuel and Stoves

Three LPG resellers were visited. Prices were standard:

- 450 Mt for a refill cylinder (Change 11 kg cylinder for new full one)
- 1300-1500 Mt when buying a new gas cylinder (filled)

Stoves vary in type and price. They are sold in retail stores and range from 800 to 5000 Mt

Appendix II: Satellite Imagery from the different neighbourhoods in Catembe

Figure A: Satellite image of Guachene neighbourhood
Adopted from: Google Earth (2009)

Figure B: Satellite image of Incassane neighbourhood
Adopted from: Google Earth (2009)

Figure C: Satellite image of Chali neighbourhood
Adopted from: Google Earth (2009)

Figure D: Satellite image of Inguide neighbourhood
Adopted from: Google Earth (2009)

Appendix III: Structured Household Questionnaire in Portuguese

Questionário estruturado para agregado familiar

Data:	Para questões com o simbolo '❑' marca só 1 opção; e para o símbolo 'O' pode marcar mais de 1 opção				
A. Identificação do respondente					
Código do questionário:			Código do intrevistador:		
Nome do entrevistado: Nome do bairro:		❑ HOMEM	❑ Mulher	Estado civil (Faça um circulo) Solteiro(a) / Casado(a) / Viúvo(a)	
B. Estado sócio-economico					
Número de pessoas na familia		Número de crianças a baixo de- 5 anos			
Idade ↓	Educação* ↓ (código)	Profissão ↓	Segunda profissão ↓		
**** código de Educação:*** ***Sem Escola (0);*** ***pRIMARIA (1);*** ***sECONDARIA(2);*** ***UniversIDADE (3)***					

!!! Estado economico da familia (assinale ✔)		❑ [ALTO]		❑ [ESTáVEL]		❑ [BAIXO]		
Tipo de casa (assinale ✔)		❑ [Alvenaria/ moderna]		❑ [Alvenaria/velha]		❑ [Caniço / Chapa]		
Números de quartos na casa (assinale ✔)		❑ [4 ou mais]		❑ [3 ou 2]		❑ [1 ou 0]		
Se a casa e eletrificada (✔)	❑ sim	❑ não	Se sim responda as questões seguintes					
Tipo de eletrificação (✔)	○ [Instalado na rede]		○ [Energia pré-pago]		○ [Solar]	○ [Outro (Indica)]:		
Nr. de dias com electricidade por semana(✔)	❑ 1 dia	❑ 2 dias	❑ 3 dias	❑ 4 dias	❑ 5 dias	❑ 6 dias	❑ 7 dias	
Horas de eletricidade por dia (✔)	❑ [24-20]	❑ [20-15]		❑ [15-10]		❑ [10-5]	❑ [5-0]	
C. Perguntas relacionadas com fogões								
Qual é o tipo de fogão que usa? (✔)	○ três pedras	○ fogão melhorado a lenha	○ fogão a carvão	○ petróleo / querosene	○ Gás	○ Fogão eléctrico	○ eTANOL	
A qunto tempo tens o fogao?	Não tem aplicação							
Voltará a comprar o mesmo fogão no futuro?	Não tem aplicação	❑[sim] ❑[não]	❑[sim] ❑[não]	❑[sim] ❑ [não]	❑[sim] ❑ [não]	❑[sim] ❑ [não]	❑ [sim] ❑ [não]	
D. Perguntas relacionadas com combustíveis usados para cozinhar								
Qual foi o tipo de combustivel que usou no último mês? (✔)	○ Lenha	○ Carvão	○ Petróleo	○ Gás	○Electricidade	○ Etanol		

Quanto dinheiro é gasto mensalmente?						
Se tornar-se muito rico, qual dos combustíveis irá usar mais? (✔)	○	○	○	○	○	○
Qual de estes combustiveis colecionas ou produzes sozinho(a)	○	○	Não tem aplicação	Não tem aplicação	○(gerador)	○
Ja alguma vez oviste a falar do fogao a etanol?	Sim ❑	Nao ❑	aonde:			

Notas de Observação :

Appendix IV: Perception Mapping Questionnaire

Questionário de Perçepção

A. Numero do questionario	Data:	Codico do entrevistador: Nome do Intrevistador:
Nome do entrevistado:		

Compare e indique de 1 a 5 a sua preferencia	Lenha	Carvao	Petroleo-querosene	Gas	Electricidade
Preco : muito barato = 1, ate muito caro =5					
Facilidade de encontrar o combustivel: (muito facil=1, muito dificil= 5)					
Facilidade de armazenamento: (muito facil=1, muito dificil = 5)					
Facilidade para iniciar o fogo: (muito facil=1 , muito dificil= 5)					
Flexibilidade no tamanho: (Muito flexivel=1 , menos flexivel= 5)					
Tempo de cozinha: (pouco tempo=1 , muito tempo= 5)					
Fumaca: (pouco fumo = 1, muito fumo = 5)					
Risco de queimadura: (pouco arriscado 1 , muito arriscado =5)					

Appendix V: Household Energy Profile for Catembe

Table C: Stove types currently used by households

Stove Type	Number of households using	Percentage
3-stone woof-fire	254	63%
Improved wood-fire	7	2%
Charcoal	315	78%
Kerosene	4	1%
LPG	76	19%
Electric	103	26%

Table D: Number of households exclusively using respective fuels

Fuel Type	Number of households exclusively using	Percentage
Fire-wood	66	25%
Charcoal	46	15%
Kerosene	0	0%
LPG	1	1%
Electric	3	3%

Table E: Average monthly household expenditure on fuel type, as stated by respondents:

Fuel type	Meticais	US Dollar ($1 = 28 Mt)
Wood-fire	248,04 Mt	$9
Charcoal	270,45 Mt	$10
Kerosene	75, 00 Mt	$3
LPG	510,69 Mt	$18
Electricity	500,00 Mt	$17

Appendix VI: Health and Environment Perception Questionnaire

Table F: Respondent perception of health problems caused by firewood use

Health Problem (multiple answers per household possible)	Acknowledgement frequency (Number of Households)
Smoke as dangerous for health	36
Cough problems	22
Eye problems	12
Breathing Problems/ weak lungs	12
Sinus	6
Intoxication	4
Burn injuries	1
Tiredness	1
Back strain	1
Danger for children	1

Table G: Respondent perception of health problems cause by charcoal use

Health Problem (multiple answers per respondent possible)	Acknowledgement frequency (Number of Households)
Smoke as dangerous for health	16
Intoxication	3
Breathing problems	3
Cough	2
Sinus	2
Headache	1
Burn injuries	1

Table H: Household perception on environmental problems cause by fuelwood use

Environmental Problems (multiple answers per respondent possible)	Acknowledgement frequency (Number of Households)
Deforestation	32
Erosion	17
Pollution/ poor air quality	16
Green House Gas emission/ Climate change	4
Desertification	3
The cause of fires	3
Lack of oxygen	3
Lack of shade	2
Overall	1
Lack of rain	1
Wildlife habitat destruction	1

Appendix VII: Ethanol cook-stove specifications

Figure E: Specifications of the Dometic CleanCook stove

Dometic CleanCook M 1 / M 2 and A 1 / A 2

1-burner stove / 2-burner stove

CleanCook M 1

CleanCook M 2

	CleanCook M 1 / A 1	CleanCook M 2 / A 2
Materials	All stainless steel burner parts, body of stainless steel, galvanized steel, high quality enamel finish (M 1 / M 2) or aluminum (A 1 / A 2)	
Number of burners	1	2
Bearing weight	Max. 20 kg supported	
Product weight	M1 3.1 kg / M2 5.7 kg	
Fuel canister	Fuel tank empty: 0.59 kg / full: 1.79 kg	
Fuel requirements	Ethanol and/or methanol fuel. Recommended water content of fuel is 10% or less	
Fuel capacity	1.2 liters	1.2 liters per tank
Power on high	1.5 kW power	
Power on low	0.3 kW. Turn down ratio: 1/5	
Cooking time	4.5 hours on high, up to 9 hours on low	
Average cooking capacity	1 liter of fuel per day will provide cooking for a family of five	
Efficiency	Greater than 60%	
Emissions	Negligible soot or carbon. Meets or exceeds World Health Organization (WHO) standards for Carbon Monoxide emissions	
Dimensions (W x D x H)	340 x 290 x 160 mm	596 x 326 x 137 mm
Certification	Aprovecho Research Center (www.aprovecho.org) Benchmark Certification June 2009	

All stainless steel burner parts, body of stainless steel (M1/M2), galvanized steel, high quality enamel finish or aluminum (A1/A2).

Fuel requirements: Ethanol and/or methanol fuel. Recommended water content 10% or less.

1 liter of fuel (one filling) will provide a full day of cooking for a family of five.

Successfully tested in homes in Brazil, South Africa, Ethiopia, Nigeria and elsewhere.

The CleanCook stove is based on tried and true technology in use in Europe and the Americas for 30 years.

Adopted from Dometic AB (2009)