Greening the Charcoal Chain

Substituting for Charcoal as a Household Cooking Fuel in Dar es Salaam

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Abstract

One of the United Republic of Tanzania's most prized resources, forest land, is being threatened by the industry of charcoal. Deforestation caused by the charcoal industry is a problem that developing countries around the world and particularly in Africa are facing. This study will focus on this problem as it affects the city of Dar es Salaam, the countries largest consumer of charcoal. A large number of citizens, 69% (Malimbwi 2001), use charcoal to cook with, increasing deforestation, adding to their health problems and emitting detrimental greenhouse gases.

The process of producing and using charcoal is not sustainable and many organizations are looking into ways of making the charcoal chain more sustainable. Many options exist; however, this study will focus on decreasing charcoal consumption in the city of Dar es Salaam. Using the results of a survey of 235 targeted households in the city, this report seeks to explain what kinds of people use certain fuels, why they use those fuels, their way of cooking with the fuel, and their willingness to switch to other fuels.

The results of the survey are used in two cost-benefit analyses (CBAs). A household CBA will determine which fuel is the most cost effective, taking daily cost, initial investment cost, health risk avoided and time savings into account. The results of the household CBA will be used in a social planner CBA to determine if investing in a fuel substitution campaign will benefit the society as a whole. The social planner CBA will consider environmental benefits as well as the costs and benefits used in the household CBA.

Finally, we conclude that investing in an extensive LPG marketing campaign to target 30% of charcoal users is not only feasible but beneficial to society. This measure will decrease consumption of charcoal and make the industry more sustainable. Forestland, a precious resource, will have a better chance of surviving and being of continued use to the citizens of Tanzania.

1. Introduction

The continent of Africa is dealing with the growing problem of deforestation and desertification. This problem has become pressing in Tanzania. The forests outside the country's largest city, Dar es Salaam, are rich in biodiversity and keep the delicate local climate in balance. Though these forests have great environmental value they are also used to support the charcoal industry that fuels the stoves of most citizens of Dar es Salaam. This has been a growing problem as these forests shrink and the rarest trees are cut to make charcoal. Under the protection of the government these forests should not be a target for charcoal makers. However, the trees in these forests are the best trees to make charcoal from and the protection, though written in law, is not strictly enforced by the ill equipped forest service.

1.1 The Problem: Deforestation, Health Effects, and Greenhouse Gases

Using charcoal as a cooking fuel attributes to many environmental problems, such as deforestation, negative health effects, and an increase in greenhouse gas emissions. This report was commissioned because of the huge impact charcoal production and use has on Tanzania's natural forests, however, we will not ignore its other effects. Here we will discuss the consequences of producing and cooking with charcoal.

The foremost cause of deforestation in Tanzania is the production of charcoal. While this is a country wide problem, this study draws much of its data about charcoal production from the coastal forests, outside of Dar es Salaam, according to TaTEDO, the country's largest consumer of charcoal. The Pugu and Kazimzumbwi Forest Reserves within the coastal forests are receiving the brunt of the city's charcoal industry and by decreasing the number of charcoal users the hope is that these forests will be saved.

Country wide the forests have reduced from 44.3 million ha in 1961 to 33.5 million ha in 1998 (Ministry of Natural Resources & Tourism 2001). The Division of Forestry and Beekeeping estimates that the country loses between 130,000 and 500,000 ha of forest land annually, against only 25,000 ha planted. In the Coastal Forests the loss is even higher than the national average. Because of the value of older hardwood trees we see an 87% decrease in natural forest between the years of 1987 and 2005 (PREM 2007a), as these trees are selected for charcoal production.

Changes in land usage, such as natural forests to grassland or bushland, as is the case in the Pugu and Kazimsumbwi Forest Reserves, can severely affect the local watersheds and hydrological activities in the area. Deforestation causes soil erosion which clogs rivers and removes fertile soil, as well as increases bushland growth which can prevent the germination of young trees. Extreme weather patterns are also the result of deforestation. Flooding and drought become common in areas where forests are lost. Though research is lacking regarding the specific hydrological effects of deforestation in the Pugu and Kazimsumbwi Forest Reserves it is safe to assume that many of the extreme climatic changes taking place in the area are a result of said deforestation (PREM 2007a).

In addition, to the climatic changes caused by deforestation, the production of charcoal is a major contributor to greenhouse gases. Inefficient earth-mound kilns (the majority of charcoal kilns) cause emissions of carbon dioxide (CO2) and methane (CH4). Use of inefficient cooking stoves (used by 51% of the population (Malimbwi 2001)) wastes a considerable amount of energy and causes incomplete combustion that creates methane. Compared to CO2, methane has a very high global warming potential (around 25 times more than CO2). In this way cooking with charcoal adds to global warming in a way that using fossil fuels does not (WHO 2006).

Environmental degradation is not the only effect charcoal has on Tanzania. The health effects of cooking with charcoal can be quite severe. Worldwide, cooking with biomass (charcoal and firewood) is responsible for 1.5 million deaths. Exposure to smoke from burning biomass can cause lung cancer, tuberculosis and cataracts. Globally, 2.7% of all diseases are caused by cooking with biomass; in Tanzania the number is even higher at 4.4% (WHO 2007).

It is obvious that the production and use of charcoal will continue to be a major threat to the welfare of Tanzanians', unless something is done to stop its consumption. The intention of this study is to bring Tanzania closer to a solution that will protect the health and forests of its citizens.

1.2 Purpose of this Study

The desecration of Tanzania's prized forests has come to the attention of many organizations including the government of Tanzania, the World Bank, WWF, and many other NGOs. Poverty Reduction and Environmental Management (PREM) has worked in conjunction with many of these organizations to identify the links in the charcoal chain. This study has been charged with filling one of the gaps of information in the chain. In Dar es Salaam the household sector consumes 69% of all charcoal (Malimbwi 2001). Because it is the largest sector consuming charcoal it is important to understand why people use charcoal, why they do not use other fuels, and whether or not it is possible to get a significant portion of households to switch. This study will focus on this gap and has addressed these issues with a survey of households in the city.

In addition to addressing the reasons for fuel usage we have performed a cost-benefit analysis to address the question of which fuel is the least expensive fuel to use for cooking. We have approached the CBA from two angles; from the household point of view, calculating the specific cost and benefit of each fuel to the household; and then from the social planner's point of view, calculating the costs and benefits with the addition of the cost to the environment. These analyses will allow decision makers to look at the charcoal issue from two perspectives that have been missing from previous studies.

This study will target the household sector in an attempt to find ways to discontinue the use of charcoal and perhaps increase the use of a substitute fuel. The driving questions of this study are: *is it possible for people to stop using charcoal? If so, what should they switch to? Do the benefits to society and the environment of people switching away from charcoal outweigh the costs?* Through the use of a household survey this study shows why people switch from one fuel source to another, why they do not switch, what the

perceptions of citizens of Dar es Salaam are regarding different sources of cooking fuel, and if they are based on fact, as well as what the organizations listed above can do to make switching fuels more likely to happen. Through a cost-benefit-analysis this report also demonstrates the effects on society and the environment of people switching away from charcoal.

Addressing the problem of deforestation due to charcoal production is complex and there are aspects of the issue that will not be considered extensively here. It is recognized that any decrease in charcoal consumption will greatly affect the lives of charcoal producers; this study does not discuss the possibilities for alternative livelihoods though that is a topic that others are considering. Also, though we recognize the affect the use of fossil fuels has on the climate, we consider LPG to be a great step up from using charcoal and regard it as a viable alternative. There are renewable fuels that exist and, with further study and great effort, can be used as a fuel in Tanzania. However, due to a lack of infrastructure the development and consumption of these fuels will not happen for some time. This study puts forth improvements on the current situation for the short term. Many other options exist to make the charcoal chain more sustainable, such as production forests as well as efficient stoves. However, this report will concentrate on decreasing the consumption of charcoal by switching to alternative fuels.

1.3 Literature Review

Using biomass as a cooking fuel is not unique to Tanzania, nor are the damaging effects of this practice. Poor developing countries across the world use fuel wood (charcoal and firewood) as their predominant cooking fuel source which has led to environmental degradation around the world and brought the issue to the policy agenda's of many countries and the attention of many NGOs. Many options for minimizing the impact of fuel wood consumption and production have been put forth and considered in different countries. In this section different studies and findings will be examined regarding one of those options, fuel substitution.

There have been many studies focusing on the energy sources used by people around the world and the theory of the "energy ladder" has been put forth. People work their way up the "energy ladder" from traditional fuels such as firewood to charcoal and from charcoal to more modern fuels such as liquid petroleum gas (LPG) and electricity. This move up the ladder is linked to rises in income (Arnold et al 2005). A study in Bangalore, India tried to determine if the steps of the "energy ladder" can be altered or influenced by outside actors (Reddy 1994). The conclusion to the analysis was that it is possible through policy intervention to aid the move from one fuel to the next. The study also noted that the transition from firewood to charcoal is a bit faster and easier than the move from charcoal to more modern fuels. Because of these issues the authors advocate subsidies, taxes and financing.

Another study, focusing on East Africa, presents and argument that is not against subsidies, but does demonstrate reasons to be wary of too much government involvement. This study, by Bhagavan, focuses on how government management of the power sector in east African countries has led to an overly bureaucratic regime that can

not make a quick decision (2003). Tanzania's government run system is used as an example of a country that should commercialize its power sector. The confusion that Bahgavan portrays as inherent in any power sector run by the government does not inspire confidence in its ability to replace charcoal as the cooking fuel for the majority of citizens in Dar es Salaam. Though commercialization and a free market may be the solution for the power sector, it is possible that to control the consumption of charcoal it may be beneficial to have aid from the government to ensure that increases in income are followed by a move up the energy ladder.

Whether or not the move along the fuel ladder is done through the free market or has help from the outside, the impetus that propels people from one fuel to another is not entirely based on rises income. Other factors that play a large part are availability, the importation structure of the substitute fuel, and the perception people have of the fuel's safety, cleanliness, and ease of use (Dang 1993). In an article focusing on Sub-Saharan Africa, Himraj Dang writes that the idea of fuel substitution is noble but if the infrastructure for that fuel is not present, its use will not be taken up widely by the population. Cooking is a necessary, daily activity and fuel must be available at all times in order for people to feel comfortable using it. The UN Millennium Project has highlighted the availability problem as a focus of any energy strategies in developing countries (UNDP and GTZ 2005).

While the Millenium Development Goals (MDGs) do not specifically address energy, it is understood that addressing the dependence on fuel wood is necessary for alleviation of poverty. "The goals are quantified targets for addressing extreme poverty in its many dimensions while promoting gender equality, education, health, and environmental sustainability. Although the provision of adequate, affordable and reliable energy services is not one of the goals, it is a prerequisite if the MDGs are to be achieved" (UNDP and GTZ 2005). The fuel wood issue disproportionately affects women because they are responsible for gathering the fuel, food preparation and cooking (UNDP and GTZ 2005). Though in urban areas women do not spend time gathering the fuel as they do in rural areas, cooking with charcoal requires much more time and effort than cooking with modern fuels. In this way women must focus much of their day on food preparation and can not spend it doing more lucrative activities such as harvesting plants to sell, making crafts, or even learning to read (Stockholm Environment Institute, 1999).

Fuel substitution by more modern fuels has been the focus of studies in Ghana where a large promotional campaign resulted in doubling the number of LPG users (UNDP 2004), in Ethiopia where deforestation has become a focus of the government and the production of electricity is being promoted (Schramm 1987), in India where LPG is being promoted while dealing with problems of accessibility and affordability (D'Sa and Murthy 2004) and in many more developing countries. Each country has a story and a few of the issues highlighted in those stories have been described here. At this point there is no sure way to solve the fuel wood problem, but it is clear that improvements can be made. This is the first study to focus on the demand side of charcoal consumption in Dar es Salaam, targeting the largest consumers, households. By learning from the successes and failures of fuel substitution around the world, Tanzania can save its diminishing forests and improve the lives of its citizens.

1.4 Structure of Report

In this report the problem has already been stated (1.1), the purpose of the study (1.2)has been laid out, and the literature used to form the basis for this study had been discussed (1.3). In Chapter 2 the research methods used will be elaborated upon. The purpose, design, and implementation of the survey that has formed the bulk of our research will be described along with the process used to perform the household and social planner CBAs. Then, in Chapter 3 the positions of the different stakeholders will be laid out and analyzed. In Chapter 4 the results of the survey are presented beginning with the profiles of different fuel users, their preferences and what they think about the health, safety, and environmental risks of cooking with those fuels. Then, reasons people have for switching or not switching to the modern fuels, LPG and electricity, are presented. Next, in Chapter 5 the results of the survey are used along with other numbers to create two cost-benefit analyses. These numbers used are described in detail as are the results. Finally, in Chapter 6 conclusions are made and recommendations are given.

2. Research Methods

To prepare this report a literature review was undertaken, stakeholder interviews were performed and most importantly a household survey of different fuel users was designed and carried out. The literature review and stakeholder interviews are discussed in detail in Chapter 1 and Chapter 3, respectively. This chapter will detail the purpose, design and implementation of the survey as well as the methods used in the cost-benefit analysis.

2.1 Purpose of the Survey

The previously described literature review was the foundation for the formation of the survey. The stakeholder interviews further influenced the survey with the informal interviews conducted with different fuel customers being the most informative. The information gathered in this way was used to form a survey that would measure what type of fuel citizens use, how much they spend per month on this fuel, how much time they spend cooking with it, how much time it takes to buy it, where they buy it, as well as why they use it and would they ever consider switching to another fuel. The survey then aim's to discover what perceptions people have of LPG and electricity, whether or not they would switch to either fuel, if they think that the alternatives are too expensive and if the initial investment cost prevents him/her from switching would he/she take a loan.

The results of the questions about cost and time were then used in a cost-benefit analysis. Much confusion exists about whether or not charcoal is truly the least expensive fuel (apart from firewood). Many people also confuse the energy per kilojoules compared to cost of each fuel with the amount and cost of the fuel that is actually required. It is possible that for each kilo joule of charcoal burned another fuel could burn the same amount at a lower cost but if this is not transferred to the consumer then this type of measurement is useless. What matters is that a person can spend a certain amount of money and cook a certain amount of food for a certain price. If one fuel has higher heat and gives off more energy but a person has to cook on it for hours it could end up being far more expensive than charcoal which has a lower energy content. Therefore, the aim of the survey was to find the true cost to the consumer of each fuel.

Secondly, the survey had the purpose of determining the reasons for the use of certain types of fuel. Research showed that two significant alternatives exist in Dar es Salaam for charcoal. Not many people use these fuels and the assumption has been that the reason for the lack of use is cost. Some believe that it is the cost of continued use of the fuel (Sumbi 2007) while others believe that it is the initial investment cost (Hoogeveen 2007) of the fuel that is a deterrent. The survey tried to determine what overall perceptions people have of these two fuel sources, LPG and electricity. It surveyed their thoughts and knowledge of costs, but also their perceptions on general use such as safety, cleanliness, availability, and timeliness.

2.2 Survey Design and Implementation

The targets of the survey were charcoal, firewood, kerosene, LPG, and electricity users. These cooking fuel sources are the most common fuels in the city, though LPG does not have a wide customer base yet, its usage rate has remained constant for the past few years and recent changes in government taxes are likely to help increase its market share (Tanzania Association of Oil Marketing Companies 2001). Because certain fuel users were being targeted the survey was broken up into fuel use sections, each section to be answered by those who use the fuel. The survey was presented by enumerators in face-to-face interviews to 235 respondents. Respondents could select two fuels and answer the corresponding questions. The survey then directed them to skip the questions for other fuels and continue on to the "switching section". This section was aimed at discovering how many people have switched from one fuel to another in the past five years and why. Finally, the last section of the survey targeted those respondents that do not use LPG and or electricity.

Questions were formed with the goal of finding out what people thought of both fuels and whether or not they found the initial investment cost for each too expensive. The survey was 15 pages long (including a section asking personal details) but only took approximately 20 minutes to answer, as much of the survey could be skipped by each respondent.

Questions were written in a closed format for easier coding if all possible responses could be identified. Other questions were left open-ended when the response could be unpredictable. It turns out that the open ended questions were quite easy to code as most respondents had similar ideas; however, it was difficult to know what these answers would be before the survey.

The survey was written in English and translated into Swahili by the enumerator, then the respondents answers were translated back into English to be written down. The enumerators were 5 students from the University of Dar es Salaam. Pre-testing was done for one day. Changes were made, and then the survey took 5 additional days to administer. The enumerators were asked to spread out evenly across the city to get a diverse group of respondents. We got a higher number of respondents from Kinondoni, the most populated municipality. The surveying went well even though torrential rains slowed down the enumerators during the first two days.

2.3 Cost-Benefit Analysis

To find out, which cooking fuel is the most cost-efficient alternative to charcoal, a cost-benefit analysis (CBA) was conducted. The analysis approaches the problem from two levels: the household level and the social planner level.

The aim of the household CBA is to find out which of the five commonly used cooking fuels in Dar es Salaam is the best energy source for a household when it takes into account the initial investment cost, the daily cost of cooking, the benefits of time saved and human health risk avoided. The goal of the household CBA is to find the most cost-efficient cooking fuel to use.

The outcome of the household CBA is then used in the social planner CBA. In this analysis the aim is to find out whether it would be beneficial for the society as a whole to make households switch from charcoal to the best alternative. The social planner CBA includes the same cost and benefit elements as the household CBA. In addition, it also includes the cost of an awareness raising campaign and environmental benefits from avoided deforestation and greenhouse gas emissions. The goal of the social planner CBA is to maximize social welfare.

The numbers for the initial investment cost and daily cost, as well as the time spent cooking with each fuel are derived from the results of our survey. A literature review was conducted to find out the value for time saved, health benefits and environmental benefits. In most cases, it was not possible to find value information derived directly from Tanzania. To value these benefits we have used benefit transfer from valuation studies conducted in other developing countries and in developed countries. The values were converted to Tanzania by using the differences in per capita GDP.

The discount rate used in the analysis is 3%, which is in the range of commonly used values for social discount rates based on social time preference. Sensitivity analysis is conducted by altering the discount rate from 3% to 0% and 10% to find out if the discount rate has an effect on the outcome of the CBA. The time period used in both the household CBA and social planner CBA is 10 years. In addition, the analysis is done for a time period of 25 years to see if this changes the outcome.

3. Stakeholder Views on Charcoal in Dar es Salaam

It is important to understand where the stakeholders of charcoal use and production stand in Dar es Salaam. These stakeholders include different NGOs that are working to solve the problem of deforestation, the government, the charcoal producers, the end users, as well as producers of alternative fuels. In this chapter each view will be examined and discussed. As the NGOs have written the most about the subject their views will be explored in greater detail. The views of other stakeholders have been gathered from different sources including personal interviews, business reports, and reports produced by NGOs.

3.1 NGOs (TaTEDO, WWF, PREM, World Bank)

These four NGOs have varying views about the charcoal industry and what must be done to solve the problem of deforestation. TaTEDO, Tanzania Traditional Energy and Environment Organization is a local NGO based in Dar es Salaam. It has been dealing with the issue of charcoal for many years and has produced many studies regarding its use and production. The main focus of TaTEDO has been the inefficiency of charcoal production and consumption. They have studied the charcoal kilns as well as the stoves used by citizens to cook with charcoal and have been looking for ways to make both more efficient (TaTEDO 2004). Though they recognize fuel substitution as an option they are not optimistic that it is possible (Sanga 2005).

WWF believes that not enough work has been done on the charcoal chain itself. They feel that they are lacking certain important information that prohibits them from acting now (Sumbi 2007). This seems to be an oversight on their part as there have been many studies about the charcoal chain from production to consumption. In fact, an extensive report exists on the subject, titled, *Charcoal Potential in Southern Africa: Final Report for Tanzania* (Malimbwi 2001). In an interview, the Forest Program Officer, Peter Sumbi, mentioned almost every possible solution for the deforestation problem but also stated that it was too early to do anything about the issue. Though he offered many innovative solutions to the problem, he stated that he felt that electricity and LPG are too expensive to be viable alternatives for charcoal. However, he offered no numbers to substantiate this view (Sumbi 2007).

WWF is lagging behind TaTEDO and the other organizations, only having just formed a study group to do a literature review of the charcoal chain. Other than having produced a few educational booklets regarding the subject they have not been instrumental in finding a solution to the charcoal problem. Their sudden interest in the subject may be fruitful. A workshop is planned for July 2007, where interested parties will share their findings, and a National Framework will be the goal. At this point WWF is considering all options and has a lack of priorities.

PREM has completed several studies regarding the charcoal chain, however, gaps remain (PREM 2007a). Many options are being examined by PREM, such as promotion of production forests, promotion of efficient stoves, payments for environmental services

(PES)[1], as well as formalization of the charcoal market (PREM 2007). However, further research is needed on many of these options before being put into practice. This study will focus on the minimization of the consumption of charcoal in the city, rather than on sustaining its production.

The World Bank is also interested in this subject. They understand the large part the charcoal industry plays in the economy as well as in the daily lives of citizens. They are considering production forests on the supply side as well as options to minimize the use of charcoal on the demand side. At this point they are looking into what is the best alternative for charcoal, as well as the best way to introduce this alternative. A representative of the World Bank cited a recent success South Africa has had with electricity as an alternative to biomass fuels. The South African power companies have lowered their standards, which brings down the cost of electricity and allows customers to have just enough power for a few appliances (Hoogeveen 2007). Hans Hoogeveen of the World Bank feels that largest hurdle to Tanzanians switching to another fuel, such as LPG or electricity, is the high initial investment cost. Hoogeveen also stated that the World Bank lacks a cohesive view on the charcoal problem depending on which department is dealing with the issue.

3.2 The Government

The government recognizes that the high rate of deforestation due to charcoal production is something that needs to be addressed but it has had difficulty finding the right solutions. In 2006, the government banned the production of charcoal which only caused the price to rise, in the end hurting the poor consumers. Pressured by many different stakeholders they have made a few rash decisions. Recently the LPG company Oryx was successful in getting the import duty on LPG as well as the VAT abolished. In a speech to the National Assembly the Minister of Finance[2] said, "The amendments made include, exemption of VAT on Liquefied Petroleum Gas (LPG) and its cylinders with the aim of encouraging people to use gas instead of charcoal and firewood so as to protect the environment. The impact of this measure is expected to be noticed in the medium to long term time frame" (Meghji 2007). This is an interesting development and a positive development in the promotion of alternative fuels.

3.3 Charcoal Producers and Consumers

Producing charcoal has a low over-head cost, in fact it could be considered zero-cost. Most producers gather the wood free of charge, use their own labour, and use minimal tools for the harvest. Because there are so few costs to the production of charcoal and there is a large population willing to buy the product, this line of work is very popular.

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[1] "The critical foundation of the PES is on compensating resource owners such as landowners for the environmental services their land generates" (PREM 2006). This would theoretically keep them from degrading the land with unsustainable practices.

[2] This speech was given on 14 June 2007, after the data for this study had been gathered. Because the data was gathered before the taxes were abolished the price for LPG is currently less than what we have reported here.

Also the lack of alternative jobs keeps people producing charcoal even when they recognize the lack of sustainability in the process (PREM 2007a).

Charcoal is consumed by households and commercial enterprises almost exclusively in urban and peri-urban areas. Dar es Salaam consumes half of all charcoal produced in the country and the number of consumers there is growing. There is a belief that improvement of economic circumstances will lead people up the fuel ladder to fossil fuels or electricity, however, there is no evidence that consumption is slowing down in Dar es Salaam (PREM 2007a). This study aims to find out why people are not moving to other fuels. Many studies claim that the reason for not moving "up the ladder" is solely income driven (Arnold 2006, Dang 1993, D'Sa and Murthy 2004, Hosier 1993, Reddy 1993). This study aims check the validity of that belief.

3.4 Producers of Alternative Fuels (Oryx, TANESCO)

The leading producer and distributor of LPG in Tanzania is Oryx, a company based on the continent of Africa. They have been trying to promote their product as a substitute for fuel wood across the continent. Wema Muhama, a representative of Oryx feels that even if citizens of Dar es Salaam can afford LPG they do not know enough about it to invest in it. Many are scared of using LPG due to its history of explosion, not realizing that the containers and form of the product have become much safer, and no longer carry a serious risk. One suggestion has been for the government to begin regulating the safety of LPG canisters, in this way Oryx could market these safety regulations to the public, citing the government as a watchdog. Mr. Muhama stated that the company believes that the market will grow but he does not have faith in the ability of LPG to replace charcoal (Muhama 2007).

TANESCO, Tanzania Electric Supply Company Limited, is owned by the United Republic of Tanzania. It produces electricity though hydropower as well as diesel power stations, for 11 percent of the country. The rest of the countries 34 million citizens are left without power (TANESCO 2007). The company has the highest tariffs in East Africa (Malimbwi 2001, 57) which makes electricity unattainable for the majority of citizens. Rather than prices going down they have been rising and many citizens have switched from cooking with electricity to charcoal.

3.5 Stakeholder Conclusions

In this chapter we have presented the different views of the stakeholders involved. To see their views at a glance please study Table 3.1.

Table 3.1 Stakeholder views

Stakeholder	Position
NGOs	All at different stages regarding the charcoal chain. Make no common recommendations.
The Government	Aware of the problem. Does not think actions through.
Charcoal Producers and Consumers	Producers want to find a way to sustainably continue their line of work. Consumers want a safe, cheap, and reliable fuel.
Producers of Alternative Fuels	Want help to make their products attractive to consumers.

4. Survey results

With a survey that was 15 pages in length, the data collected is quite extensive. In designing the survey we tried to ask all of the questions that might be relevant to our research questions: *is it possible for people to stop using charcoal? If so, what should they switch to? Do the benefits to society and the environment, of people switching away from charcoal outweigh the costs?* In this section we have compiled and analysed the results of the questionnaire using SPSS. Some of the questions asked did not reveal any interesting findings while others did. Here we have included the results that say something about the cooking habits the people of Dar es Salaam, the fuels they use, why they use them, and what makes them switch from one fuel to another.

In this chapter we will illustrate the profiles of the different households using each fuel, the willingness of charcoal users to switch fuels, the ideas that people have about LPG and electricity, and the willingness of people to take aid the switch from charcoal to LPG or electricity.

4.1 Demographics of Different Fuel Users

In this section we will examine the demographics of our respondents including the fuels they use, their family size, income, and education levels. We will look at how the income and education levels of the different cooking fuel users differ from each other. Regression analysis and crosstabulation were performed in SPSS to find out if the income and education level have a significant effect on the fuel source used in the household.

4.1.1 Fuel Source and Family Size

The survey had 235 respondents of targeted fuel users. The respondents were targeted to be representative of Dar es Salaam as a whole. They were targeted based on three criteria: *fuel source*, *income* and *family size*. Table 2.1 shows the percentage of users from each fuel source we surveyed compared to the percentage of users in the city.

Table 4.1 Fuel source

Fuel Source	**Our Survey**	**Dar es Salaam***
Charcoal	54%	54%
Kerosene	11%	26%
Firewood	7%	12%
Electricity	14%	5%
LPG	14%	1%

*Dar es Salaam percentages from 2002 Census

We sampled the same percentage of charcoal users as there are in the city. The survey under sampled kerosene and firewood users and over sampled electricity and LPG users. This was a conscious choice because a large enough sample for each fuel was needed in order to draw any conclusions from the responses. Habits of users could not be determined with a smaller numbers of respondents and because the habits of charcoal, LPG, and electricity users would be most important to our conclusions we spent more time gathering these responses.

Second to the fuel source we targeted different family sizes. Table 2.2 shows the comparison of the percentages of different family sizes in the city to the percentages of family sizes sampled in our survey. The survey under sampled the smallest and the largest families and got an even sampling of the medium sized families. With the average sized family in the city being around 4, our average family is close to the same (Census 2002).

Table 4.2 Family size

Family Size	Our Survey	Dar es Salaam*
1-2	13%	24%
3-4	40%	30%
5-7	38%	33%
8+	9%	13%

*Dar es Salaam percentages from 2002 Census

4.1.2 Income

In addition, to targeting different fuel users and family sizes we targeted households with different incomes. Due to the over sampling of LPG and electricity users the higher income households are over sampled, because those fuel users tend to have higher incomes than the rest of the fuel users. There was an even sampling of medium income households.

Figure 4.1 presents the monthly income of the head of household in US dollars for each fuel source with the corresponding amount in Tanzanian shillings[3] presented in brackets.

[3] For this study we have used an exchange rate of 1,295 Tanzanian Shillings to 1 US dollar.

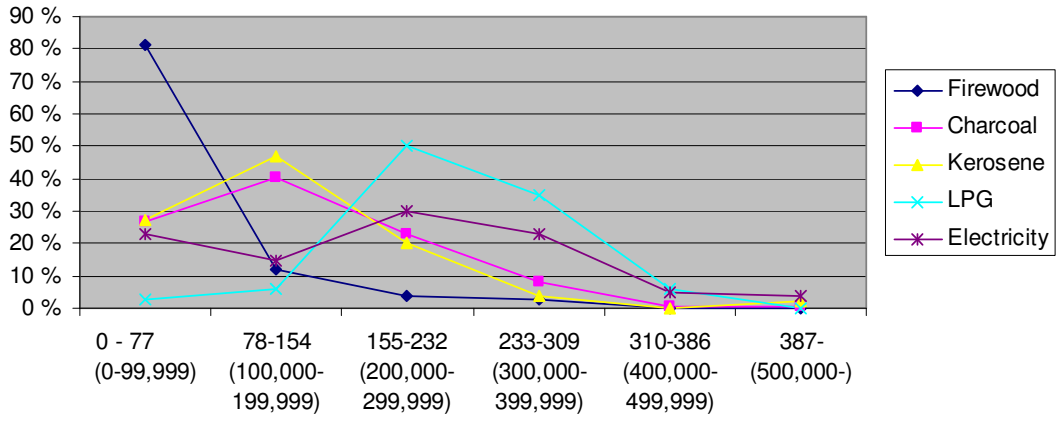

Figure 4.1 Income of the head of household in US dollars (n=235).

Firewood users have the lowest income level, with over 80% of the households having an income less than $77 (100,000 Tsh) per month. Charcoal and kerosene seems to be used mainly in families with lower middle income. LPG users have the highest income level, with over 90% of the households earning over $155 (200,000 Tsh) per month. Electricity users appear to have higher income levels than firewood, charcoal and kerosene users, but electricity is also used more often than LPG in lower income families.

By looking at figure 4.1 it appears that the two variables, cooking fuel used and income, are related to each other. To find out if fuel source is indeed dependent on the income level a cross tabulation and (ordinal) regression analysis were performed. The fuel source was treated as the dependent variable and income the independent variable.

A statistical hypothesis test was conducted in SPSS by using the cross tabs procedure and Chi-Square to find out whether or not these two variables are dependent on each other. The output of the analysis shows that the value of Chi-Square is quite large (104.33) and has a small significance level ($p < 0.001$). These numbers indicate that it is very unlikely that the two variables would be independent of each other. In addition, the correlation coefficient (Cramers's V) is 0.4, which indicates a statistically significant dependency between the two variables. It can thus be concluded that the cooking fuel used in the household can be partially explained by the income of the head of household.

4.1.3 Education

Figure 4.2 presents the breakdown of cooking fuels used in Dar es Salaam by the highest level of education attained. The education level follows the same pattern as income, and it can be concluded that these correlate with each other. Firewood users have, by far, the lowest education level, with nearly 80% having no education at all or having completed only primary school. Charcoal and kerosene users have similar educational profiles, most people having completed at least secondary school. It is interesting to note that 13% of charcoal users have a university degree. LPG users have the highest level of education.

All of the LPG users have completed at least secondary school and half of them have a university degree. Electricity users appear to have a higher education than firewood and charcoal users, but it is more evenly distributed than LPG users, lower educational levels are found among electricity users unlike LPG users.

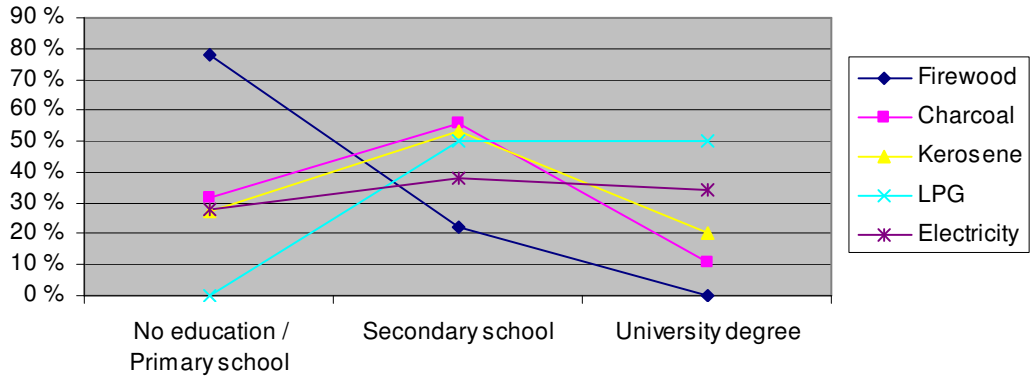

Figure 4.2 Highest level of education attained (n=235).

The education level follows the level of income relatively closely. As can be seen in figure 4.2, it appears that the level of education has an effect of the cooking fuel used in the household. This relationship was tested with a Chi-Square test in SPSS. According to the results, the Chi-Square has a relatively large value (70.28) and a small significance level ($p < 0.001$). In addition, the value (0.4) of the correlation coefficient (Cramers's V) indicates a statistically significant dependency between the two variables. These results indicate that the level of education has an effect on the fuel source used in the household.

4.2 Profile of Different Fuel Users

In this section we will profile the users of firewood, charcoal, kerosene, LPG and electricity, in more detail. In addition to income level, we will also discuss the family sizes as well as, kinds of equipment used for cooking, how often and where the fuel is purchased and how long they spend cooking each day. Furthermore, the respondents were asked to indicate their main reasons for using the fuel(s) they currently cook with. The respondents were given a predefined set of alternatives from which they could choose as many reasons as they thought were important. They were also asked to indicate which one of the stated reasons was the most important for them. This section will analyze the responses received for the questions listed.

Firewood

Firewood is used mainly in low income households. Family sizes are also larger than the average families in Dar es Salaam. Around half of the households using firewood have over 5 members in the family, and nearly 20% have more than 8 people. Half of the firewood users collect the firewood themselves, while other households buy it from the street or store nearby. Nearly 80% of the households use a *mafiga,* which means that they use three stones to create a fireplace for cooking, instead of buying a firewood stove.

Table 4.3 presents the reasons the firewood users have for cooking with it. The low cost of firewood is the most common reason, cited by 89% of the respondents. One third indicated that the easy availability of firewood is important to them.

Table 4.3 Reasons for using firewood for cooking

Reasons for using firewood (n=27)	%
Inexpensive	89
Easy to purchase	33
Easy to use	19
Traditionally used in the household	19
Low initial investment cost	15
Gives high heat/cooks fast	15

Other reasons for using firewood include that it is traditionally used in the household and they are used to it and find it easy to use. Low initial cost was also indicated by 15% of the respondents. A rather surprising reason given by 15% of the respondents is that firewood cooks fast. When compared to kerosene, LPG and electricity users, the firewood users spend on average 2 hours more time cooking every day. Some respondents reported that they spend as many as 7 hours cooking each day.

Charcoal

Charcoal users are mainly lower middle income families. The average family size of charcoal using households corresponds with the average family size in Dar es Salaam: 44% have 3-4 people in the household and 43% have 5-7 people.

Around 80% of the surveyed households used a traditional inefficient charcoal stove instead of the improved more efficient stove. This number contradicts what TaTEDO has reported for the percentage of urban households using the improved charcoal stove. “Recent information has shown that more than 45 percent of the urban households in Dar es Salaam are now using improved charcoal stoves” (Sawe, 2005). It is not clear why there is a 25% discrepancy between our numbers and those of TaTEDO, though it should be noted that their organization does focus on the promotion of efficient stoves and they might therefore, have biased numbers.

According to the results of the survey, the low cost of charcoal is the most important reason for using it. Table 4.4 shows all the reasons the respondents mentioned. In addition to the low cost of charcoal, its easy availability is seen as an important reason for over half of the respondents. Around 65% of the charcoal users buy the fuel more often than once a week. They buy it in small bags from a charcoal dealer that can usually be found only a few minutes away.

Only 10% of the respondents indicated that taste of food cooked with charcoal is important to them. While other studies from around the world (Food and Agriculture Organization of the United Nations 1993) have pointed out the importance of the

traditional taste of food cooked with charcoal, our findings for Dar es Salaam[4] do not support this. Only 10% of the charcoal users indicated that taste is a reason for using charcoal. When asked what the *most important reason* (not shown in graph) for cooking with charcoal only 2.2% responded because the food tastes better and only 3.7 percent said because it is traditionally used in the household. Another PREM study reports that important reasons for not switching from charcoal to another fuel source are a bad taste (8%) and a traditional preference for charcoal (9%) (Massey and Di Prima 2005). This former PREM report, focused on commercial enterprises and it is possible that this discrepancy in responses is due to the fact that many commercial establishments specialize in cooking over a grill, while most households do not cook the same foods or cook their foods in the same way. For these reasons it can be assumed that the charcoal taste is more important to restaurants than to households.

Other reasons mentioned include that charcoal is easy and safe to use and is traditionally used in the household. Most of the charcoal users have been using it for a long time and are accustomed to it. When the respondents were asked if they would continue using charcoal for the next five years, over 80% said they would. The main reason given was that it was the only fuel that they could afford.

While many charcoal users believe that it is the only fuel that they can afford we compared their incomes with those who use LPG and found that 30% of charcoal users have the same income profile as LPG users. This finding suggests that people are not aware of the benefits of alternative fuels such as LPG. In section 4.4 we will illustrate the perceptions charcoal users have of LPG and electricity.

Table 4.4 Reasons for using charcoal for cooking

Reasons for using charcoal (n=134)	**%**
Inexpensive	71
Easy to purchase	52
Easy to use	28
Safe to use	20
Low initial investment cost	12
Traditionally used in the household	12
Food tastes better	10
No negative health effects	6
Gives high heat/cooks fast	5
No electricity available	3
Clean to cook with	2

[4] Most of the studies published about charcoal consumption in Tanzania, and specifically Dar es Salaam, do not mention taste as an important reason for cooking with charcoal. However, in interviews with representatives from WWF, The World Bank, and PREM the issue was discussed (due to the fact that it is an issue in other parts of the world). Based on the responses to our survey as well as the lack of attention other studies in Tanzania have given

Kerosene

Kerosene is a fuel used mainly in small lower middle income families. Approximately 22% of the households have only 1-2 people and 50% have 3-4 people. In large families (8+) kerosene is rarely used and it is not the main fuel source but rather a supplement to charcoal or firewood. This could be due to the fact that kerosene stoves are generally smaller in size.

Table 4.5 shows the reasons the kerosene users gave for cooking with the fuel. The most important reasons to use kerosene include that it is easy to use and it cooks fast. Other reasons are the low cost of kerosene and the stove as well as easy availability. Kerosene can be bought from petrol stations and shops that are located all over the city.

Table 4.5 Reasons for using kerosene for cooking

Reasons for using kerosene (n=51)	*%*
Easy to use	71
Gives high heat/cooks fast	48
Easy to purchase	27
Inexpensive	23
Low initial investment cost	21
Clean to cook with	6
Safe to use	2

Kerosene is not a viable alternative to charcoal due to its characteristics. Even though it is an inexpensive fuel to use and cooks fast it lacks the capacity to fulfil the needs of larger families. The kerosene stoves are generally smaller in size than charcoal stoves and due to this the fuel is used mainly to quickly heat water or cook small things instead of preparing three meals a day for the whole family.

LPG

LPG is mainly used in families that have higher income and education levels compared to users of other fuels. The family sizes of LPG using households correspond with the average family sizes in Dar es Salaam. Most of the households have 3-4 (31%) or 5-7 (47%) people. The most common equipment used for cooking with LPG is the smallest cylinder (6 kg), which is used in 36% of the households. Around 25% of the households use a larger 15 kg cylinder. Most of the families purchase gas from an Oryx agent (86%) once or twice a month (75%) depending on the size of the cylinder.

Table 4.6 presents the reasons that the users of LPG have for cooking with it. The most important reason is that it is fast to cook with. On average the respondents reported cooking with LPG around 2 hours every day. This is considerably lower than the time spent on average cooking with charcoal and firewood (around 4 hours).

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to the issue, we assume that there are differences in the way Tanzanians cook with charcoal and therefore taste is not a significant factor.

Over 50% of the respondents think that LPG is inexpensive. According to some of the surveyed households they have been able to save money by switching to LPG from charcoal. Our survey results do not fully support this view, because charcoal has a slightly lower average monthly cost than LPG, as reported by the users of each fuel. However, it is possible that since the LPG users have a higher income level than charcoal users they are less concerned about how much money they spend each month on cooking fuels. The poorer families using charcoal spend a considerable portion of their monthly income on charcoal and are more likely to use the fuel more scarcely. Other reasons that were important for many LPG users include that it is easy to use and clean to cook with.

Table 4.6 Reasons for using LPG for cooking

Reasons for using LPG (n=36)	*%*
Gives high heat/cooks fast	61
Inexpensive	53
Clean to cook with	47
Easy to use	42
Easy to purchase	22
No negative health effects	14
Safe to use	8
Low initial investment cost	8

Electricity

Electricity is used in households with middle or high income levels. The family sizes are quite evenly spread: 23% have 1-2 people, 35% have 3-4 people and 31% have 5-7 people in the family. Electricity is also used more often in larger families compared to kerosene and LPG. Most of the households use a prepaid *luku* (76%) instead of a monthly bill. They usually purchase more credit once a month. The *luku* users thought that it gives them a convenient way to control their electricity cost.

Table 4.7 presents the reasons for using electricity. The most often cited reason was that electricity is easy to use. The second most often cited reason was that it is clean to cook with. It is also seen as fast to cook with. Other reasons mentioned include its easy availability and safety of use. In addition, 26% think that it is important that electricity has no negative health effects. Very few people mentioned that cost as good reason for using electricity. This corresponds with what is known about the high costs of electricity. Though many people professed a desire to use electricity it is just too expensive for them to consider.

We also asked the respondents about the reliability of electricity. According to the electricity users they need to use another cooking fuel quite often due to a power shortage. Around 31% of the respondents indicated that this happens a few times each month and 14% thought that power shortages occur a few times per week.

Even though electricity is fast, clean and easy to cook with, its high cost[5] makes it unattainable for most of the people in Dar es Salaam. In addition, the electricity network does not cover the whole city and the power supply is very unreliable.

Table 4.7 Reasons for using electricity for cooking

Reasons for using electricity (n=54)	%
Easy to use	70
Clean to cook with	59
Gives high heat/cooks fast	48
Easy to purchase	28
Safe to use	26
No negative health effects	26
Traditionally used in the household	9
Food tastes better	4
Inexpensive	2
Low initial investment cost	2

4.3 Perceptions of cooking fuels

To find out what the users of each fuel think about its health and safety effects, they were asked if they think that the fuel they currently use has any negative health effects and (in a separate question) if they think that it is safe to use. In addition, the charcoal users were asked whether or not they thought that charcoal production has any negative effects on the natural environment in Tanzania. If they said they thought there are negative health effects, safety risks or environmental impacts, they were asked to specify what those effects are.

In Figure 4.3 the percentage of users of each fuel that think there are negative health effects to cooking with the fuel, are shown. Approximately half of the firewood and charcoal users, and over 40 % of kerosene users, indicated they had experienced negative health effects when cooking with the fuel. Most common effects mentioned were chest ache and coughing as well as eye problems. Only a few percent of the LPG and electricity users thought there were negative health effects to cooking with the fuel. And in these cases they were more concerned about the safety of the equipment and the negative health effects caused by electric shocks or gas leaks.

[5] The high cost of electricity is discussed extensively in Chapter 5.

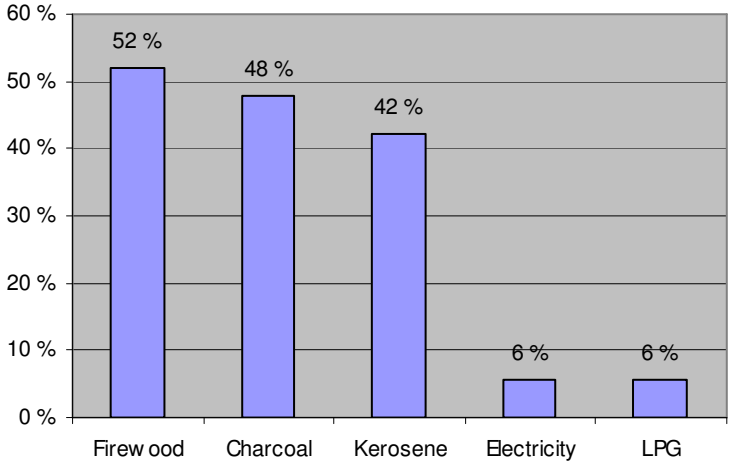

Figure 4.3 Percentage of users of each fuel that think there are negative health effects to cooking with the fuel.(n=235).

Figure 4.4 presents the percentage of users for each cooking fuel that think there are safety risks. Approximately 45% of the LPG users said they thought there is a risk to cooking with LPG. Most common reason given for this was that the container might explode. Over 30% of kerosene users think that there is a safety risk with using kerosene, mainly because of a risk of fire or explosion. Around 25% think that there is a safety risk to cooking with electricity, because of the possibility of electric shocks. Interestingly most of the firewood and charcoal users think that there no safety risks with using the fuel, even though cooking with firewood is mostly done on open fire.

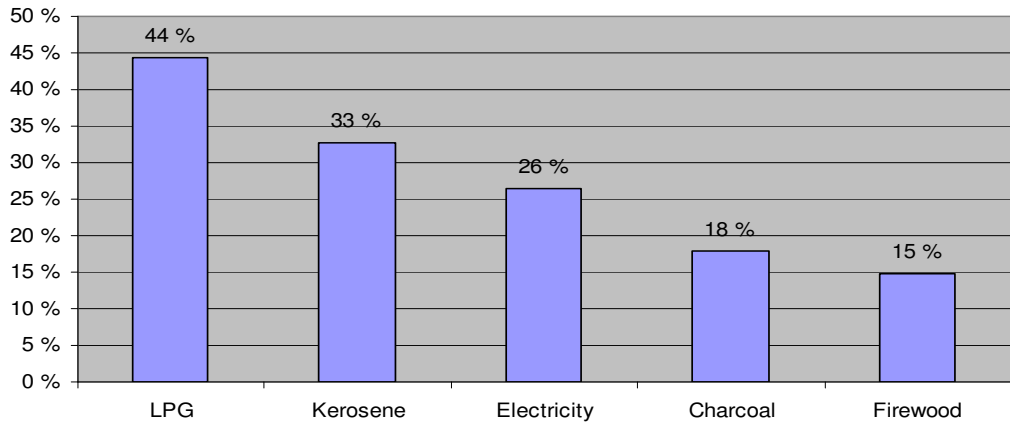

Figure 4.4 Percentage of users of each fuel that think there are safety risks to cooking with the fuel (n=235).

Charcoal users were asked if they thought that charcoal production causes any negative environmental effects to the natural environment in Tanzania. Figure 4.5 shows that 77% of the users indicated they thought there were negative environmental effects from charcoal production. Of the respondents 12% said that they did not think charcoal production causes negative environmental effects and 11% were not sure.

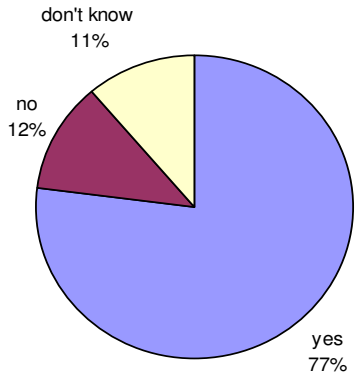

Figure 4.5 Percentage of charcoal users that think there are negative effects from charcoal production.(n=134)

The charcoal users that think that there are negative environmental effects from charcoal production were asked to indicate what they thought these effects were. This question was asked in an open-ended way, however, the responses received were easily coded. In Figure 4.6 the most often given environmental effects are presented; 73% mentioned that charcoal production causes deforestation, 26% mentioned drought, 9% air pollution and 4% soil erosion.

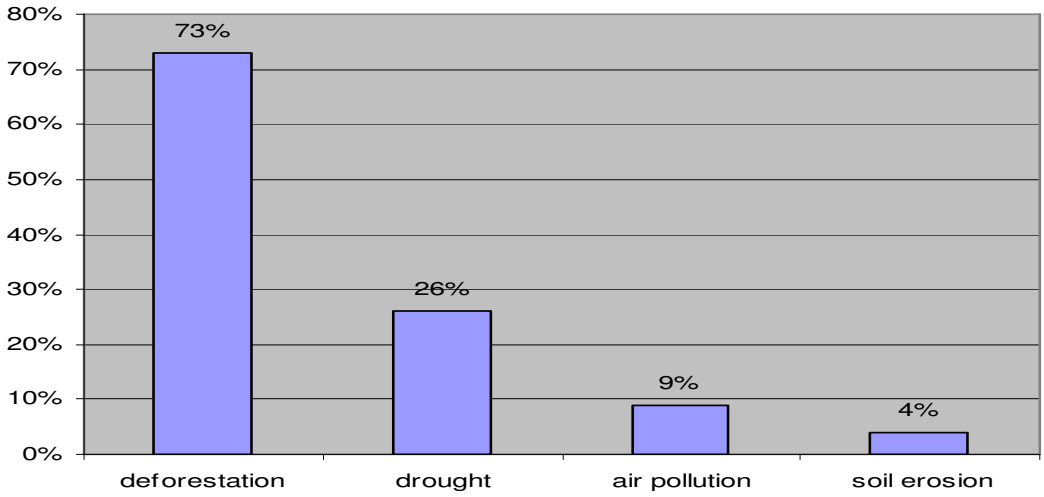

Figure 4.6 Negative environmental effects of charcoal production most often given by charcoal users (n=134).

4.4 Switching

After finding out about who uses what fuel, why, and what they think about it, the second portion of the survey was dedicated to finding out about what respondents thought of the two modern fuel alternatives, LPG and electricity. Before writing the

survey it became clear that kerosene did not have the capabilities of replacing charcoal, because of this, we did not spend time finding out the willingness of people to switch to that fuel. The following section will show how many people are willing to consider switching to LPG and electricity, why or why not, and also whether or not they would accept financial aid in their quest to switch.

Willingness to Switch to LPG:

The majority of charcoal users surveyed would not consider switching cooking fuels to LPG, as is seen in Table 4.6.

Table 4.8 Will charcoal users consider switching to LPG?

	Percent
Yes	44%
No	56%
Total (n=133)	100%

The profiles (using income and education) of two sets of respondents, those who said yes they would consider switching to LPG and those who said no, do not show any significant differences. One might assume that those who said no would be less educated and correspondingly poorer. However, this is not the case; the two groups have similar profiles. This finding can lead us to the conclusion that price is not a significant reason for not using LPG, instead there is something else preventing households from switching. Below we see the graphs showing reasons why charcoal users would switch (Figure 4.7) and why they would not switch (Figure 4.9).

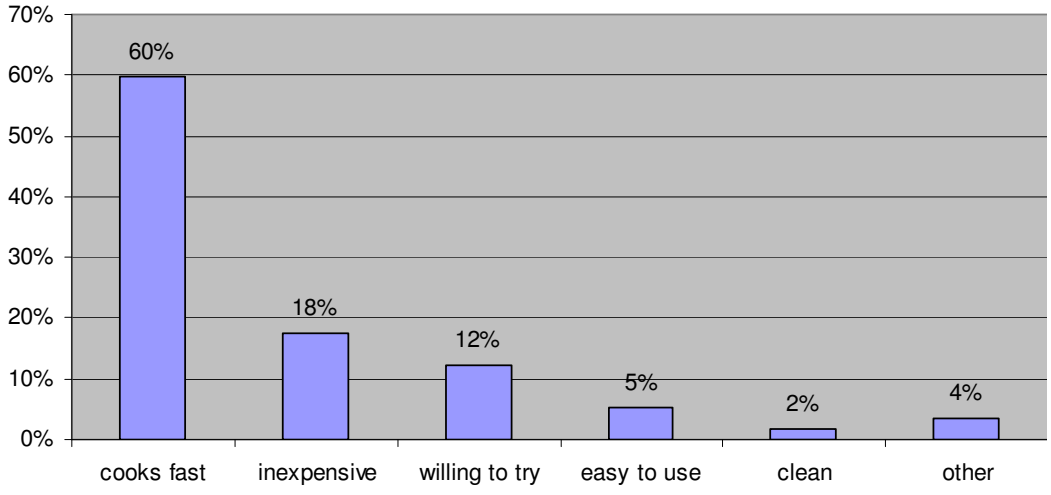

Figure 4.7 Reasons charcoal users are willing to switch to LPG (n=59).

Figure 4.7 illustrates that the most important reason to switch to LPG is the fast cooking time. Cooking with LPG instead of firewood or charcoal can cut cooking time by about 2 hours. Below in Figure 4.8, we show the average amount of time respondents spend cooking with their respective fuels. It is clear that charcoal requires quite a bit of time.

Kerosene appears to cook the fastest, however, we have learned that one of the reasons for this small amount of time is that people use it for breakfast food, reheating things that have previously been cooked, and boiling water.

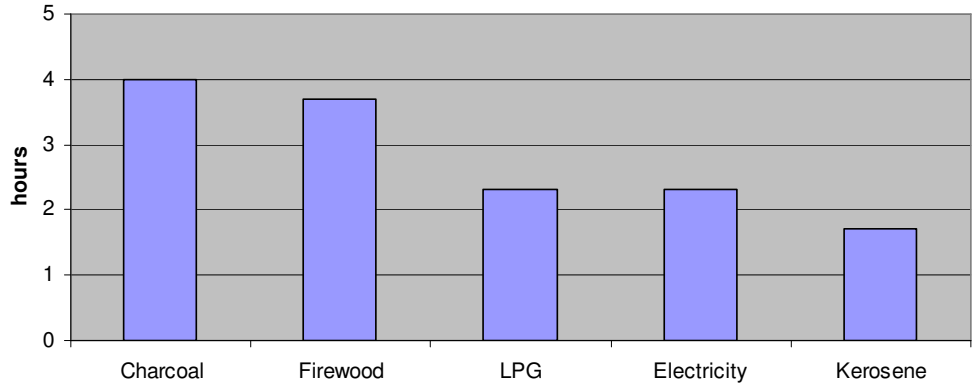

Figure 4.8 Time spent cooking every day with each fuel source.(n=235).

Earlier we reported the reasons respondents gave for cooking with charcoal, and here we have asked why they do not switch to LPG. We found that bad taste and preference for the current fuel are not significant reasons for not switching. As Figure 4.9 demonstrates the reason cited most often for charcoal users not switching to LPG is the perception that it is not safe and specifically that it will explode. In fact, only 1% felt that the taste of food was a reason not to switch and only 6 % stated a preference for charcoal as an important reason not to switch. Though people cite taste and tradition as reasons for using their current fuel it does not appear to play a part in their consideration of other fuels.

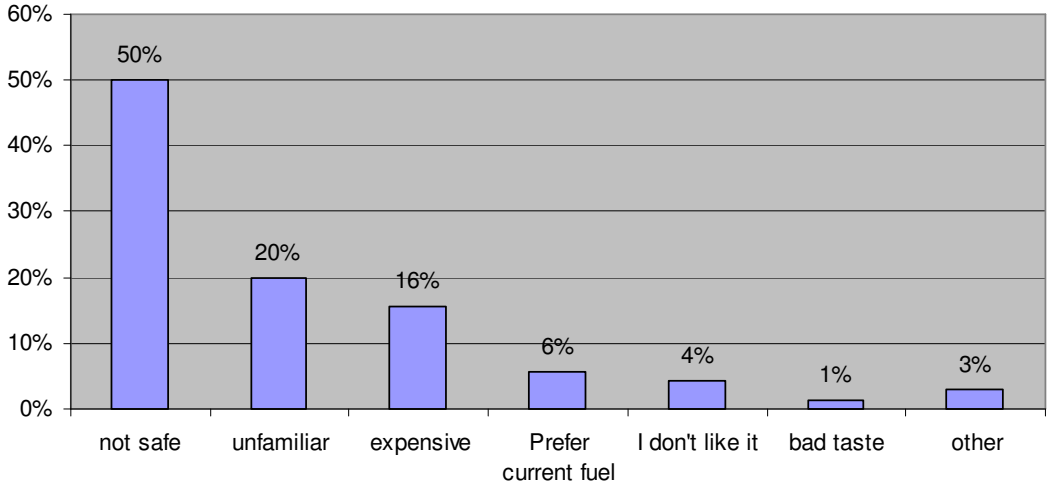

Figure 4.9 Reasons given by charcoal users NOT willing to switch to LPG (n=75).

Many consider the initial investment cost of cooking with LPG to be too high for the citizens of Dar es Salaam (Hoogeveen 2007, Sumbi 2007). Therefore financing for this initial cost could be an option. To see whether or not people would take advantage of

such financing the following question was posed with an explanation: "There are several micro-financing institutions in Dar es Salaam. If they were willing to give you a loan for the amount needed to pay the initial investment cost for LPG with a payback period of 6 months and an interest rate of 10%, would you take advantage of the opportunity?" Figure 4.10 illustrates that a majority would find a loan, with the stated conditions, satisfactory.

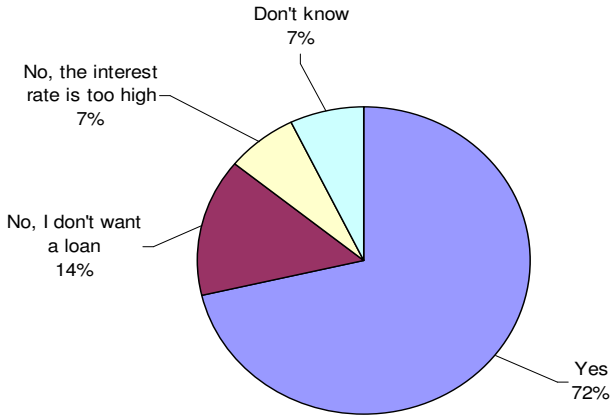

Figure 4.10 The willingness of charcoal users, who would consider switching to LPG but find the initial cost is too high, to take a loan (n=14).

Of those charcoal users who are willing to switch to LPG but the initial investment cost is preventing them 72% are willing to take a loan with the stated conditions. This appears to be a large number and shows that if help were available it would be taken advantage of. These numbers, while promising, can not be reliably broken down because the sample size is too small.

There is a portion of charcoal users who would not find the initial investment cost a deterrent to switching. This group of people, 30% of charcoal users, have the same income profile as LPG users. In section 4.1 we reported the income profiles of each group of fuel users and here we would like to establish that we have identified 30% (as was previously explained on p. 21) of current charcoal users as potential LPG users. These charcoal users were identified as those who would have no need of being financially aided in switching to LPG. To increase the 30% who could switch to LPG we have identified 7% of charcoal users (derived from the 72% in Figure 4.10) that would take a loan to aid with the initial investment cost of LPG. This could mean that with access to micro-financing 37% of charcoal users could switch to LPG[6]. In Chapter

[6] Micro-financing is a complicated issue and is out of the scope of this report. Here we have identified potential targets for aid, but we are unable to delve further into the issue at this time.

5 we examine this group of 30% further to see if targeting them with an LPG marketing campaign would, in fact, be beneficial to society.

Willingness to Switch to Electricity:

When asked about willingness to consider switching to electricity for a cooking source respondents had a more negative view than they did for LPG. Table 4.7 shows that 77% are not willing to consider switching to electricity.

Table 4.9 Will charcoal users consider switching to electricity?

	Percent
Yes	23%
No	77%
Total (n=115)	100%

Figure 4.11 shows the reasons mentioned by the respondents who are willing to switch to electricity. We find once again that the most important reason to switch to electricity is the fact that people recognize its capability to cook much faster than charcoal. The second reason also had a significant response as many people feel that electricity is easy to use.

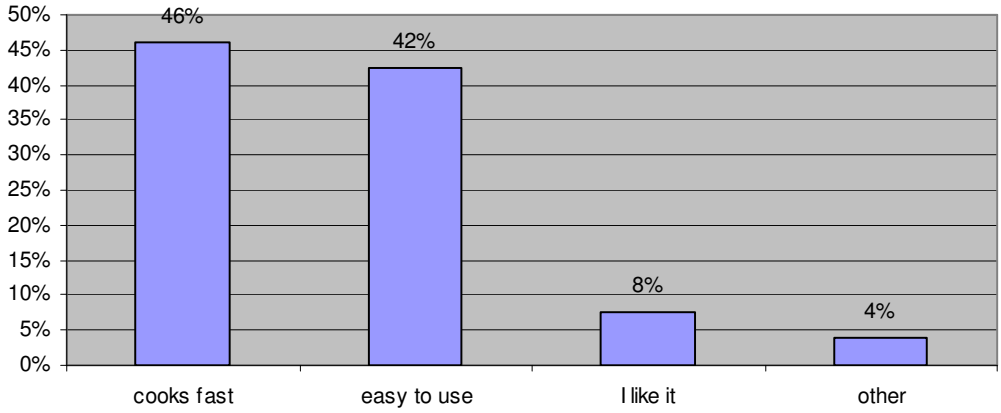

Figure 4.11 Reasons given by charcoal users willing to switch to electricity (n=26)

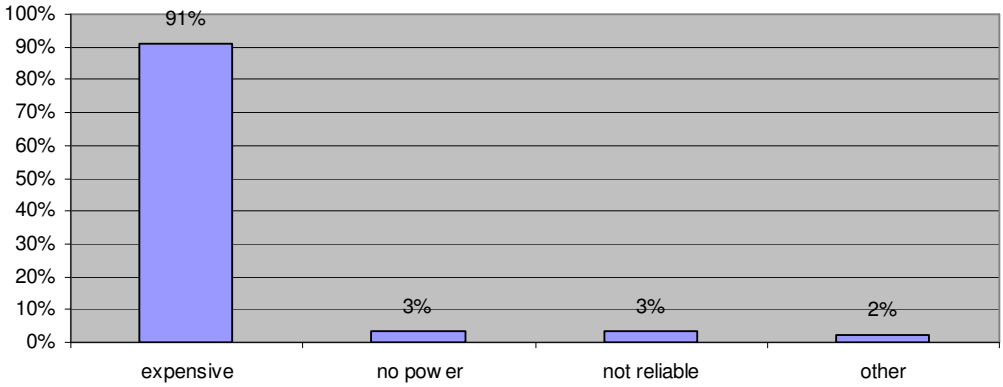

Figure 4.12 Reasons given by charcoal users NOT willing to switch to electricity (n=89).

We find in Figure 4.12, that the prevailing reason not to switch to electricity is its cost. This is a change from the view of LPG where only 16% of respondents cited expense as a reason not to switch (Figure 4.9). Electricity has a monthly price of more than double the cost of LPG and charcoal[7]. With expense as the reason for 91% of respondents it is clear that something would have to be done to minimize the cost of cooking with electricity in order to have a significant number of charcoal users switch to that fuel.

The same question was posed regarding the willingness of respondents to take a loan for the initial investment cost of cooking with electricity (this amount to include the hook-up cost). As is illustrated in Figure 4.13, 53% of charcoal users who want to switch but find the initial investment cost too high would take a loan with the stated conditions. This percentage is down from the 72% who are willing to take a loan for LPG (Figure 4.10). This could be because the price difference is so large. It costs approximately $46 (60,000 Tsh) to invest in LPG while it costs approximately $347 (450,000 Tsh) to invest in electricity, which is information that was given to the respondents before they answered this question.

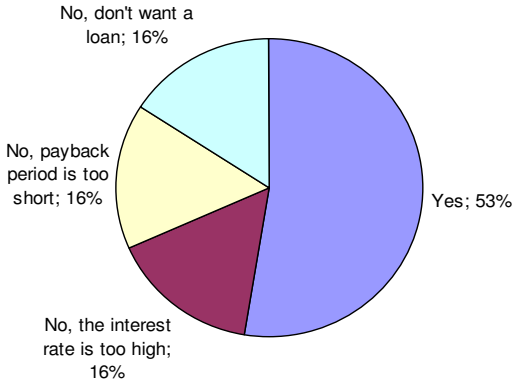

Figure 4.13 The Willingness of Charcoal Users, who would consider switching to electricity but find the initial cost is too high, to take a loan (n=19).

[7] These numbers are discussed further in Chapter 5 (5.1).

Here we have shown that the group of people willing to switch to electricity is not large (23%, Table 4.7). In addition, we have seen that due to the high costs of electricity there is also not a large group of people that have the financial capability to switch to electricity. We are unable to identify a group of charcoal users similar to the 30% we have identified with capability to switch to LPG. In Chapter 5 the differences between electricity and LPG will be examined further.

4.5 Motivation for Switching

We asked respondents if they had switched or added fuels in the past 5 years and if so what had they switched from? While we did get a significant number of respondents who switched (23% or 54 respondents) they had not switched from or to fuels as we had expected. There is no real trend to these responses, and it is therefore difficult to make any conclusions. We were expecting many people to have switched from charcoal to electricity, LPG, or kerosene. Though a percentage of households have switched to LPG (35% of switchers) the fuel that had the second largest percentage of people switching to it was charcoal, with a few even switching to firewood. After further examination we see that this switch to charcoal is due to recent hikes in the prices of electricity and kerosene. A few of these households switched from using firewood to charcoal which is a step up, and none of our respondents had switched from LPG to charcoal.

Of the 35% of households who switched to LPG 53% switched from electricity and 42% switched from charcoal. However, this 35% is only 19 households, which makes any further breakdown unreliable. There is no real trend to the reasons why these groups made the switch. Almost all of the reasons listed were cited but no reason showed itself as the most important reason to switch to LPG though we can speculate that the high price of electricity was a reason for the 53% who used to use it. Because of the assumptions we made before implementing the survey the coded reasons were directed toward respondents who would be switching from charcoal to LPG, electricity, or kerosene. Not the other way around.

Though it is difficult to come to any conclusions about why people switch to LPG we can make some conclusions about why people switch fuels in general. Below (Figure 4.14) we see the reasons cited for switching.

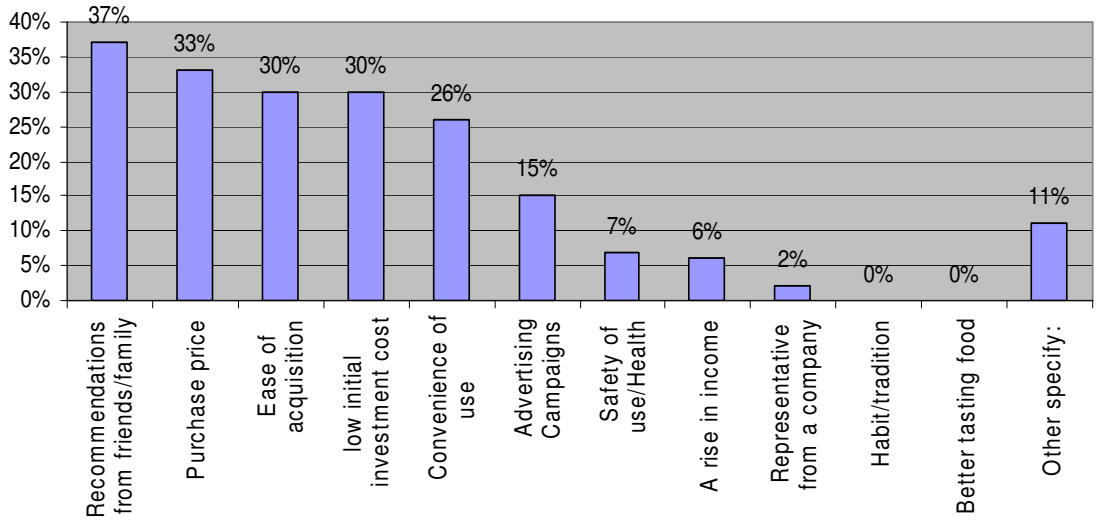

Figure 4.14 Motivation for switching given by the people who had switched their cooking fuel within 5 years (n=19).

Recommendation from family or friends was the most often cited response, which could lead to the assumption that people can be convinced to switch. The second most often cited reason was purchase price, this is in accordance with the fuels that people switched from. In other words, these people have most likely switched from electricity because of its high cost. Based on the results illustrated in this figure (Figure 4.14) we can assume that people can be motivated to switch fuels. In addition, we feel that the 15% of respondents, who cited an advertising campaign as a reason for switching, does show that people could be receptive to further marketing by Oryx.

The fear that people will not switch from the fuel that they are currently using due to the fact that it takes an effort to switch, is a valid fear. Unfortunately, our survey was unable to identify a helpful trend. However, we do feel that the significant number of respondents, 54, who have switched fuels, illustrates that people can and will switch if they feel strongly enough. Further examination of what makes people feel strongly enough to switch, would be beneficial for future charcoal substitution studies.

4.6 Main Findings of the Survey

The analysis of the survey results has given us a profile of the users of different fuels, their preferences and their perceptions. We have analyzed the reasons people have for switching or not switching to LPG and electricity; in addition, to the perceptions people have of alternative fuels. After comparing the results of our survey with the assumptions of others, such as NGOs, we find, and can say with certainty, that initial investment cost as well as taste and traditional use of their current fuel are not nearly as important to the consumer as the safety of their fuels.

By comparing charcoal users to LPG users, we have discovered that approximately 30% of charcoal users have the same income profile as LPG users. This has allowed us to

identify this 30% as a potential target group for a large scale marketing campaign focusing on the safety and time saving properties of LPG. The survey showed us that these are the two most important points to play upon. Safety being the most often cited reason for not using LPG and time savings being the most often cited reason for using LPG.

By examining the responses of households who have switched to another fuel we found that advertising does make an impact and recommendations from friends or family has the most influence on fuel change. This information can be used to illustrate that people are willing to switch fuels if they are presented with good information that convinces them that they are missing out on something by not switching. It is our assumption that 30% of charcoal users are easy targets for fuel substitution campaigns. We will examine this assumption in more detail in Chapter 5. While the 30% of charcoal users that we have identified is not a hard number we feel that the reasons we have stated for people not to switch are solid.

4.7 Uncertainties and Limitations of the Survey

The biggest limitation that reaches each section of the survey is the small sample size; it is not completely representative. Therefore, it is difficult to comfortably generalize about the whole population of Dar es Salaam. However, a representative sample size is nearly impossible to reach, and even the last national Census carried out in Tanzania did not reach this goal (Census 2006). We feel that we did receive a good number of responses to our survey from households with different income levels and family sizes as well as different fuel users to make useful conclusions. Due to the limitations of the small sample, the true size of the group of charcoal users that have the same income profile as LPG users is uncertain. The 30% target group that we use in our CBA is, therefore, a rough estimate.

5. Cost-Benefit Analysis

A cost-benefit analysis (CBA) was conducted on two levels: the household level and the social planner level. The aim of the household CBA is to find out, which cooking fuel is the best alternative when the initial investment cost, daily cooking cost, time spent cooking and health risks are taken into account. The goal for the household CBA is to find the most cost-efficient fuel to use.

Then, the best fuel source, according to the results of the household CBA, is used in the social planner CBA as an alternative to charcoal. In the social planner CBA the costs of making people switch from charcoal to the best alternative are compared to the social and environmental benefits. The aim is to find out if this kind of switch would benefit the society as a whole. The goal for the social planner is to maximise the welfare to the society.

5.1 Household CBA

The household CBA aims to find the cheapest cooking fuel source when all the relevant costs and benefits are taken into account. The functional unit used in the analysis is cooking with the fuel for 10 years.

5.1.1 Costs

The costs for the initial investment cost and daily cooking cost of each fuel source are derived from the results of our survey. The households were asked to indicate the type and cost of the equipment (e.g. stove) that they use for the fuel that they primarily cook with. The initial investment cost used in our analysis is therefore an average cost based on the responses received from the survey and not the least possible investment cost required to start using the fuel[8]. Figure 5.1 presents the average initial investment costs for each cooking fuel source commonly used in Dar es Salaam.

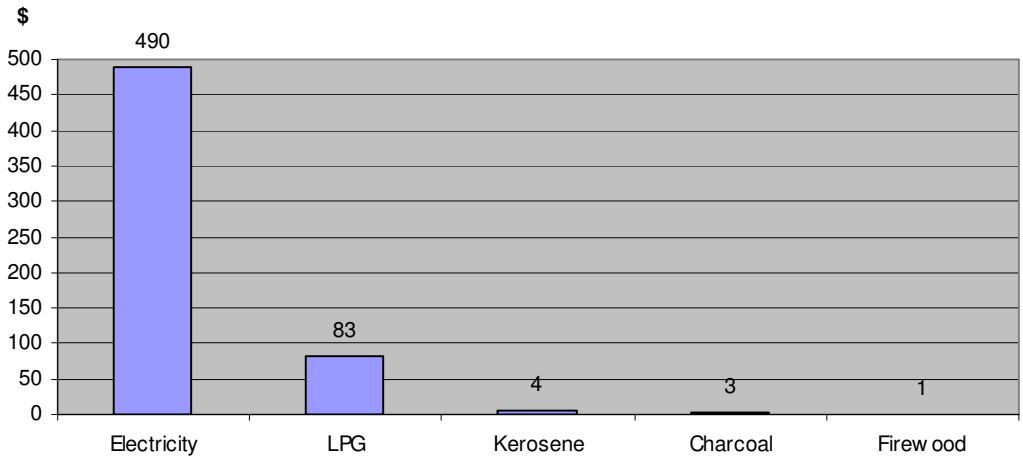

Figure 5.1 Average initial investment cost of each fuel

[8] On page 30 the lowest possible investment cost for LPG ($46) and electricity ($347) was used.

As can be seen from the graph (Figure 5.1), the initial investment cost of electricity ($490) is extremely high compared to the other alternatives. The cost comprises of the cost of an electric stove $143 (185,000 Tsh) and the cost of initial hook-up to the electricity grid $347 (450,000 Tsh). LPG has the second highest initial investment cost, but the average cost of $83 (107,000 Tsh) is only around one sixth of the cost of the initial cost of electricity. The initial investment cost of LPG includes the cost of a stove and a LPG cylinder. The average cost of a kerosene stove is $4 (5,327 Tsh), which is slightly higher than the average cost of a charcoal stove, $3 (4,100 Tsh). Firewood has the cheapest initial cost of less than $1 (670 Tsh) mainly because many households use a *mafiga*, three stones used to create a fireplace for cooking.

The results presented in Figure 5.2 are based on the monthly purchases of each cooking fuel, not including the initial investment cost, as indicated by the households that use it as their primary cooking fuel. Electricity clearly has the highest monthly cost of approximately $46 (60,000 Tsh). It is most likely that a part of this can be attributed to other uses of electricity, such as heating and lighting. Firewood is the cheapest fuel, with average monthly costs of only $5 (6,220 Tsh). The amount is significantly lower than the cost of other fuels because nearly half of the surveyed households reported to collecting the firewood themselves. Kerosene is the second least expensive alternative with an average monthly cost of around $9 (11,220 Tsh).

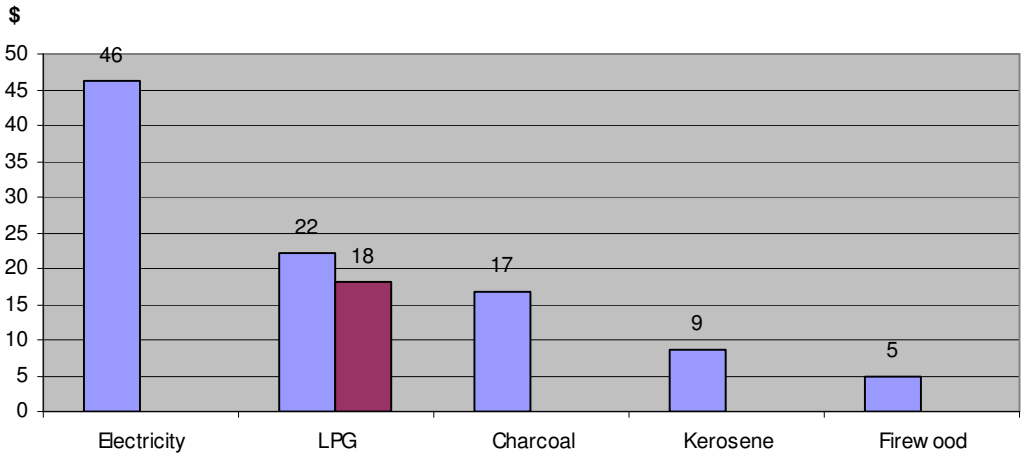

Figure 5.2 Average monthly cost of cooking with each fuel

The average monthly cost of charcoal and LPG are relatively close to each other: the difference is around $5 per month. The LPG users appear to be not as price conscious as the charcoal users since a number of respondents had trouble remembering the quantity of gas purchased each month and the corresponding cost. The charcoal users, however, were well informed about the amount they spent each month on charcoal. In general, the LPG users that had problems remembering the exact price gave higher values for gas purchased than the current market price suggests. It is therefore possible that the average monthly cost of LPG could be lower than $22 (28,630 Tsh). Furthermore, the LPG users are less likely to use energy efficiently since they have a higher income than the charcoal users.

The price of LPG will drop even more in the near future, now that the government has abolished the VAT and importation tax. In Figure 5.2 the effect of abolishing the VAT (20%) on LPG is shown by the red bar. The average monthly cost of LPG is then approximately $18, and the difference between the monthly cost of LPG and charcoal is only around $1.

5.1.2 Benefits

The costs are compared to the benefits of cooking with each fuel source. The benefits are derived from two sources: time saved and negative health effects avoided. We have decided to treat time used for cooking and health effects as benefits instead of as costs to illustrate the positive gains that can be attained by using a more modern cooking fuel. These benefits increase as you move up the energy ladder from firewood and charcoal to kerosene and finally to LPG and electricity.

According to the results of our survey, the households cooking with kerosene, LPG and electricity spent approximately two hours less time cooking every day compared to the families using firewood or charcoal. On average firewood and charcoal users spent 4 hours cooking every day, while the users of kerosene, LPG and electricity spent approximately 2 hours cooking. Some households using firewood and charcoal reported cooking up to 7 hours every day. Time savings can be considerable when switching from firewood or charcoal to kerosene, LPG or electricity. On average the time saved is estimated to be 2 hours per day. To calculate the yearly amount of time saved this number is multiplied by 365.

The time saved is valued following the guidelines used by the World Health Organization (2006) in their global cost-benefit analysis of household cooking fuels. The value of time is calculated by taking 30% of the average Gross National Income (GNI) in Dar es Salaam, which is approximately $52 (67,000 Tsh) per month (Dar es Salaam City Council 2004) and dividing this number according to the length of average work week in Dar es Salaam (45 hours per week). This calculation gives us an estimate for the value of time of 0.086 $/hour.

In our analysis the negative health effects of cooking with firewood and charcoal are treated similarly, even though we recognize that cooking with firewood is more damaging to health than cooking with charcoal. Cooking with firewood is commonly done on an open fire, which emits more particulate matters than using a charcoal stove. The reasoning behind this decision is that most of the studies found on the negative health effects combine firewood and charcoal into one fuel, biomass. We feel that this is justified since we are more interested in finding out the differences between charcoal and the more modern cooking fuels, such as kerosene, LPG and electricity, instead of looking at the health effects of firewood compared to charcoal.

Firewood and charcoal acquire no health benefits. LPG and electricity have full positive health benefits due to human health risk avoided. While kerosene is not as damaging to health as firewood and charcoal, its smoke can still cause negative health effects. According to studies looking at the emissions of different cooking fuels, kerosene emits 0.01 g of health damaging pollutants per MJ delivered compared to less than 0.001 g of LPG (Edwards et al. 2004, 404; Smith et al. 2005). Based on these numbers we have

estimated that the health benefits of cooking with kerosene are 10% of the health benefits of cooking with LPG or electricity.

To value the health benefits we have used data on the Disability Adjusted Life Years (DALYs) lost each year in Dar es Salaam that can be attributed to cooking with biomass. The national burden of disease, in Tanzania in 2002, from cooking with biomass was 4.4%. In total, 27,500 lives and 885,600 DALY's are lost each year in Tanzania (WHO 2007) due to cooking with firewood and charcoal. This number was converted to correspond with the population of Dar es Salaam by comparing the number of people in Dar es Salaam to the population in Tanzania. It is estimated that 6,072 DALY's are lost annually in Dar es Salaam due to cooking with biomass.

Each DALY lost was given a monetary value based on willingness to pay (WTP) studies from developing and developed countries on the WTP to avoid illness and fatality risk (Bowland & Beghin 2001; Pearce & Koundouri 2004). In our analysis we have used the mean WTP from these studies and adjusted it according to the differences in the per capita GDP, i.e. the purchase power parity (IMF 2007). The value derived is $1,332 per DALY. Table 5.1 presents in more detail how the value of a DALY in Tanzania is calculated.

Table 5.1 Value of Disability Adjusted Life-Year (DALY) in Tanzania.

	Value of DALY (2003$)	*GDP per capita (2003$)*	*GDP per capita ratio Tanzania to Country*	*Value of DALY in Tanzania (2003$)*
Mumbai	3,345	2,829	0.224	748
Shanghai	7,285	5,087	0.124	906
Manila	10,594	4,334	0.146	1,546
Bangkok	24,000	7,343	0.086	2,067
Krakow	20,162	11,315	0.056	1,127
Santiago	25,924	10,248	0.062	1,600
Average				1,332

Source: Adapted from Pearce & Koundouri (2004, 7).

5.1.3 Results of the Household CBA

Figure 5.4 and Figure 5.5 represent the results of the household cost-benefit analysis when the length of time observed is 10 years and the discount rate is 3%. In Figure 5.4 the monthly costs and benefits of using each fuel are presented. Figure 5.5 shows the net present values (NPV) of using each fuel for a month. As can be seen from the graph, LPG and electricity are the only cooking fuels with a positive net present value (NPV). Charcoal has the lowest NPV due to its higher cost than firewood and no benefits from time savings or human health risk avoided. The time savings and health benefits of using kerosene are not enough to completely offset the costs of the fuel. From the results it can be seen that even though firewood, charcoal and kerosene are cheaper fuels to use than LPG and electricity, when the household takes into account the benefits of time saved and human health risk avoided, LPG and electricity are the only alternatives that should be considered. The high cost of electricity makes it a less cost-effective alternative than

LPG. Therefore, according to the results of the household CBA, LPG is the most cost-effective cooking fuel.

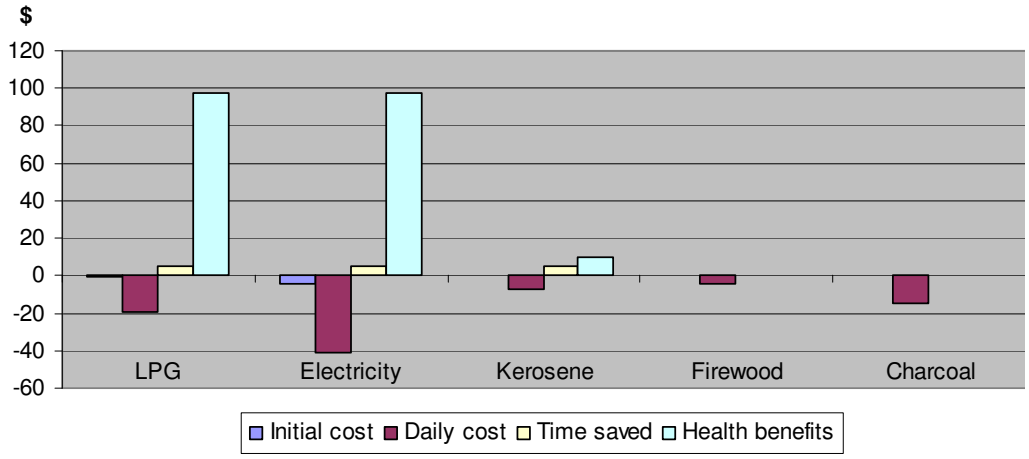

Figure 5.1 Monthly discounted costs and benefits of using each fuel (discount rate 3%, 10 years)

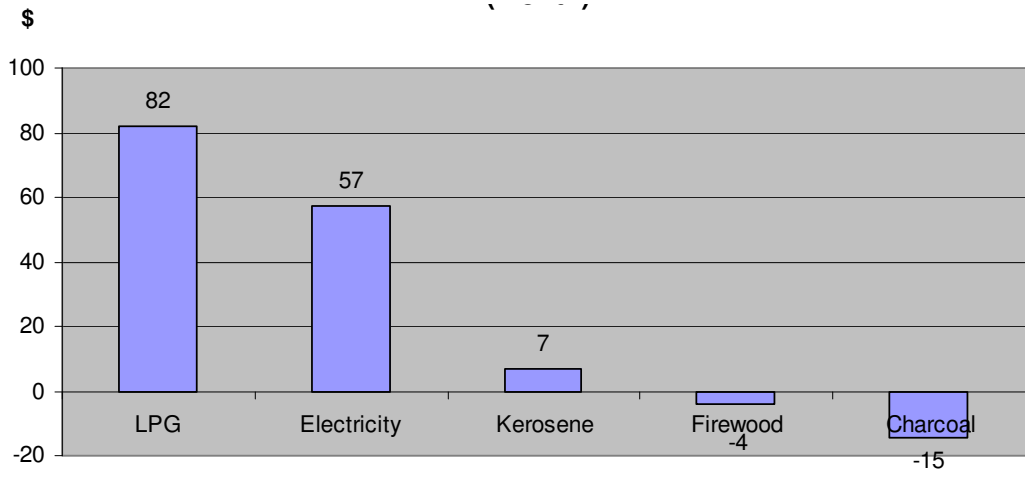

Figure 5.5 NPV of using each fuel for a month (discount rate 3%, 10 years)

5.1.4 Sensitivity Analysis of the Household CBA

A sensitivity analysis was carried out by varying the discount rate from 3% to 0% and 10% and changing the length of the analysis from 10 years to 25 years. Table 5.2 presents the results of the sensitivity analysis for the household CBA. As can be observed from the table, changing the discount rate from 3% to 0% and 10% does not have an effect on the final outcome of the analysis: LPG has the highest net present value and benefit cost ratio in all cases. Electricity and kerosene have a positive net present value but it is considerably lower than the NPV of LPG. The net present value of firewood and charcoal remains negative. Changing the length of the analysis from 10 years to 25 years increases the amount of total benefits that can be gained by using LPG, electricity or kerosene and thus the NPV and benefit cost ratios are higher for these fuels.

Table 5.2 Sensitivity analysis: Household level

Household level	*Discount rate 3%, 10 years*		*Discount rate 0%, 10 years*		*Discount rate 10%, 10 years*		*Discount rate 3%, 25 years*	
Cooking fuel:	*NPV ($)*	*B/C*	*NPV ($)*	*B/C*	*NPV ($)*	*B/C*	*NPV ($)*	*B/C*
LPG	9,842	5.08	11,213	5.10	7,552	5.03	20,717	5.17
Electricity	6,878	2.28	7,896	2.30	5,178	2.22	14,952	2.39
Kerosene	805	1.88	917	1.88	619	1.88	1,692	1.88
Firewood	-507	0.00	-577	0.00	-390	0.00	-1,062	0.00
Charcoal	-1,766	0.00	-2,009	0.00	-1,359	0.00	-3,697	0.00

5.2 Social Planner CBA

The social planner CBA was conducted to find out whether it would be beneficial for the society as a whole to make people switch away from charcoal to the best alternative, namely LPG. In the analysis, two scenarios are compared to the baseline or business as usual scenario, where no one switches away from the fuel they are currently using. The functional unit in the analysis is cooking with the fuel for 10 years multiplied by the number of targeted households.

- **Scenario 1:** The first alternative to the baseline scenario is to target 30% of the households using charcoal in Dar es Salaam. This number is based on the results of our survey, according to which approximately 30% of the charcoal users have a similar income profile as LPG users.
- **Scenario 2:** The second alternative to the baseline scenario is targeting all the households using charcoal in Dar es Salaam.

The costs and benefits of these two alternatives are compared to the business as usual scenario. A third scenario, involving micro-financing is possible; however, such a scenario would involve costs that we are not able to calculate at this time and is a subject for further study.

Figure 5.6 represents the composition of costs and benefits in the social planner CBA compared to the household CBA. As can be seen from the figure, in the costs column, the costs of an awareness raising campaign are added to the social planner analysis. On the benefit side, the environmental benefits of greenhouse gas emissions and deforestation averted are included in the social planner CBA.

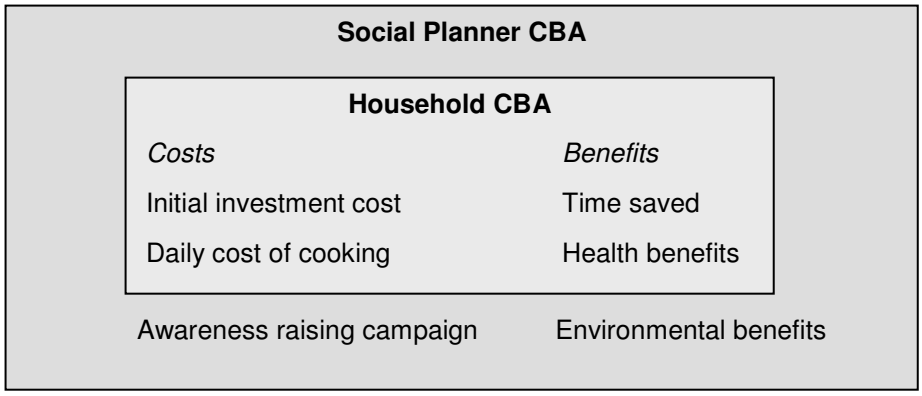

Figure 5.6 Composition of costs and benefits of the social planner CBA compared to the household CBA.

5.2.1 Costs

The costs comprise of the initial investment cost, daily cooking cost and marketing campaign costs. The initial investment cost required to start using LPG includes the cost of a stove, LPG cylinder and hose pipe. The cheapest complete LPG equipment called the Oryx Chap Chap can be bought from Oryx for approximately $46 (60,000 Tsh). This particular equipment was chosen because it is the most affordable and has a convenient size. It is also estimated that the future growth in sales will most likely result from selling these smaller LPG cylinders (Tanzania Association of Oil Marketing Companies 2001).

The cost of cooking was derived from the results of our survey. On average, households spend approximately $17 on charcoal and $22[9] on LPG every month. In the cost-benefit analysis the difference in the yearly cost of cooking is used to take into account the fact that households switching from charcoal to LPG will have to spend a little more money on their cooking fuel.

An awareness raising campaign is needed to inform the charcoal users about the health and time benefits of cooking with LPG as well as the safety of the LPG equipment. This campaign could entail television and radio ads, use of billboards, and demonstrations that illustrate how to use and the benefits of using LPG. The annual costs of such a marketing campaign are estimated to be one million US dollars. It is assumed that this is enough to reach all of the charcoal using households in Dar es Salaam (approximately 330,000). This number is likely to be a high estimate. Actual cost information for a similar information campaign done in Dar es Salaam, was not found for the analysis. Instead we have used information derived from other countries in Africa (Habermel 2007). In the first scenario the marketing campaign is assumed to have a positive response rate of 30% of the total charcoal users in Dar es Salaam. The second scenario assumes a 100% response rate, which is most likely, not an attainable goal.

In Figure 5.7 the composition of the costs is presented. As is illustrated in the chart, the difference in the daily cost is the largest cost factor with 81%. The marketing campaign

[9] This price will go down in the near future when the government's abolition of the VAT and importation tax take affect.

and initial cost of LPG account for 13% and 6%, respectively. When the effect of abolishing the VAT on LPG will take effect, it will lower the difference in the daily cooking cost considerably.

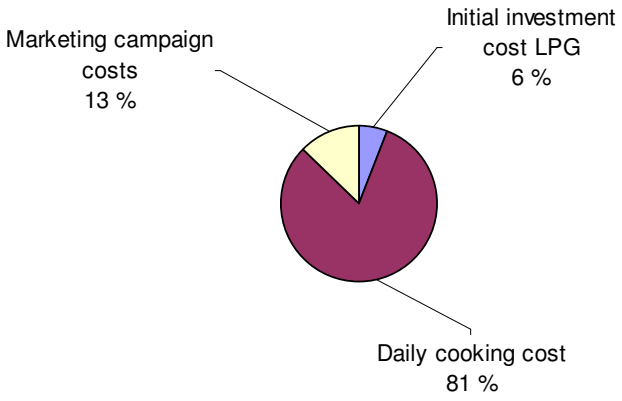

Figure 5.7 Discounted costs (discount rate 3%)

5.2.2 Benefits

The benefits accrue from three sources: time saved, human health risk avoided and environmental benefits. The benefits of time saved and human health risk avoided are calculated in the same manner as in the household CBA. The numbers for the household level CBA are converted to represent the social level by multiplying the values by the number of targeted households. In addition, the environmental benefits of deforestation and greenhouse gas emissions averted are included in the social planner CBA.

According to the Ministry of Forestry and Beekeeping the annual reduction in forest area is somewhere between 130,000 and 500,000 hectares, with only 25,000 hectares being planted every year (PREM 2007a). In the cost-benefit analysis we have used the lowest range of this estimate (130,000 hectares minus the 25,000 hectares that are planted). According to a report made by the Stockholm Environment Institute in Tanzania (Malimbwi 2002, 32), approximately 75% of the deforestation can be attributed to charcoal making. TaTEDO reports that 50% of charcoal that is produced in Tanzania is consumed in Dar es Salaam. Taking all of this into account, the forest area lost annually that can be attributed to charcoal consumption in Dar es Salaam is estimated to be 39,375 hectares.

The value of forest is calculated by using valuation data from a study conducted in Tanzania at the Rufiji floodplain and delta close to Dar es Salaam (Turpie 2000). In the study the direct use value of woodlands, comprised of forest products, is valued at 14$/ha. The direct use value was calculated by estimating the value of products that can be derived from the forest. These products include food and medicinal plants, palms and other products such as fuel wood, charcoal, timber, animals and birds, and honey. In our analysis the value of charcoal products is subtracted from the total direct use value to avoid double counting. The largest part of the direct use value comes from timber (72%)

and fuel wood (16%) while the other products account for less than 5% of the total value each (Turpie 2000).

The indirect use value consists of carbon sequestration benefits, which, according to the study conducted in Tanzania, is estimated to be 650$/ha. (Turpie 2000, 81.) This value is at the low end of estimates. In their study on the value of the world's ecosystem services, Costanza et al. (1997, 256) estimated the value of a tropical forest to be approximately 2,007 $/ha. According to Pearce (2001, 291) the value of carbon sequestration of forests is around 2,000 $/ha. We have decided to use the estimate from Turpie, because she estimates the value of the specific kind of forest around the area of Dar es Salaam, which is our main focus. In addition, we feel that when a lower estimate is used, the outcome of the analysis is not an overestimation, and the results are robust. Therefore, in our analysis, the total value of woodlands is the sum of indirect and direct value, which is estimated at 664$/ha. This total value is used in our analysis as an opportunity cost of forest lost to the production of charcoal.

The amount of greenhouse gas emissions averted was calculated by comparing the differences between the emissions across the chain, from the production, transportation and end-use of charcoal and LPG. The data is based on a life-cycle analysis on cooking fuels from Kenya (Bailis et al. 2004) as well as a study on greenhouse gas emissions of different cooking fuels from India (Smith 2000). Only Kyoto Protocol gases (most importantly CO2 and methane) were included in our analysis, leaving out the global warming potential of particulate matter.

The production of charcoal in inefficient earth-mound kilns causes emissions of carbon dioxide (CO2) and methane (CH4) (Smith 2000). The numbers used assume full regeneration of biomass, meaning that the emissions of CO2 from charcoal production are omitted from the assessment.

The emissions from the transportation are based on emissions data from the US Environmental Protection Agency for heavy-duty diesel trucks by converting these numbers to reflect the condition and age of vehicles that are used for charcoal transportation in Kenya (Bailis et al. 2004).

According to the findings, cooking with charcoal causes higher greenhouse gas emissions than using LPG. Use of inefficient cooking stoves wastes a considerable amount of energy and causes incomplete combustion that creates methane. Compared to CO2 methane has a very high global warming potential (around 25 times more than CO2) (Bailis 2004).

Table 5.3 presents in detail how the calculations for the greenhouse gas (GHG) emissions were conducted. According to the results the households use, on average, 444 kg of charcoal and 156 kg of LPG per year. This number was then multiplied by the caloric value of each fuel and the emissions of GHG in kg of carbon emitted per MJ. The difference in the yearly GHG emissions for a household, measured in metric tonnes of carbon, is then multiplied by the number of targeted households to derive the total amount of avoided GHG emissions for each scenario.

Table 5.3 Greenhouse gas emissions

	Charcoal	*LPG*
Average use (kg/year)	444	156
Caloric value (MJ/kg)	20.1	48.4
GHG emissions (kg-C/MJ)	0.215	0.045
GHG emissions metric tonnes carbon/year	1.921	0.336

Source: Adapted from Bailis et al. (2004)

The value of one tonne of carbon is based on extensive research conducted by Tol (2005), where the estimates from different studies of the social cost of carbon are evaluated. According to the findings, when the estimates of all peer-reviewed studies are combined, the median for one tonne of carbon emitted is $14/tC (Tol 2005, 2071). We use this number as the value for averted greenhouse gas emissions.

Table 5.4 shows an overview of the calculation of benefits used in the social planner CBA. These numbers are for Scenario 2, targeting 100% of charcoal using households. The value of the benefits from time saved is 20.5 m$/year, yearly health benefits are 8.1 m$, and the total environmental benefits are 33.3 m$/year. The benefits for Scenario 1, targeting 30% of charcoal users, are derived by using 30% of the benefits from Scenario 2.

Table 5.4 Benefits for Scenario 2: Targeting 100% charcoal users.

Benefit	*Quantity (year)*	*Value ($)*	*Total value (m$/year)*
Time saved	238,372,010 h	0.086	20.5
Health risk avoided	6,072 DALYs	1,332	8.1
Deforestation avoided	39,275 ha	664	26.1
Greenhouse gas emissions	517,702 t/C	14	7.2
Total benefits			**61.9**

Figure 5.8 presents the composition of benefits. As can be seen from the graph the value of avoided deforestation dominates the results, with nearly half of the total benefits. This finding seems a little surprising when compared to the results of similar studies. However, we have used estimates that tend to be on the lower end and have found data to support our numbers. We expected the human health risk avoided to be a higher percentage of the total benefits. The value given to the human health risk avoided is adjusted according to the differences in the per capita GDP. Since this is extremely low in Tanzania, it drives down the health benefits.

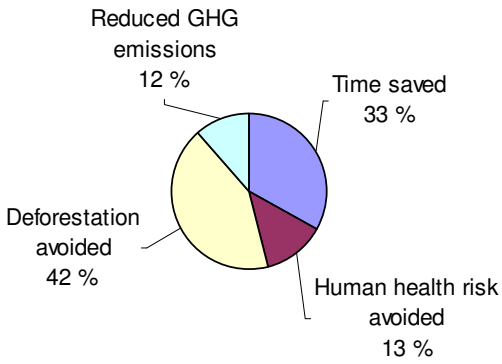

Figure 5.8 Discounted benefits (discount rate 3%)

5.2.3 Results of the Social Planner CBA

Table 5.5 presents the results of the social planner CBA, when the discount rate used is 3% and the length of the analysis is 10 years. The results show that the net present value and benefit cost ratio are higher for the second scenario, targeting all the charcoal users. However, targeting all the households is most likely not feasible due to financial constraints. It is also not likely that a 100% response rate to the marketing campaign will be achieved. In conclusion, it is clear that targeting 30% of charcoal using households in Dar es Salaam is not only feasible but quite beneficial with a net present value of 95 million US dollars and a benefit cost ratio of 2.2.

Table 5.5 NPV and benefit cost ratio for the different target scenarios (discount rate 3%, 10 years)

	NPV (m $)	B/C
Target 30% of charcoal users	95	2.20
Target 100% of charcoal users	320	2.23

5.2.4 Sensitivity Analysis of the Social Planner CBA

A sensitivity analysis was carried out by varying the discount rate from 3% to 0% and 10% and changing the length of the analysis from 10 years to 25 years. Table 5.6 presents the results of the sensitivity analysis for the social planner CBA. Changing the discount rate from 3% to 0% and 10% does not change the results: both scenarios have a highly positive net present value and a good benefit cost ratio. Changing the length of the analysis from 10 years to 25 years increases the potential benefits that can be gained by making people switch from charcoal to LPG, and raises the NPV and benefit cost ratio.

Table 5.6 Sensitivity analysis: Social planner level

Social planner Level	*Discount rate 3%, 10 years*		*Discount rate 0%, 10 years*		*Discount rate 10%, 10 years*		*Discount rate 3%, 25 years*	
Scenario	*NPV (m$)*	*B/C*	*NPV (m$)*	*B/C*	*NPV (m$)*	*B/C*	*NPV (m$)*	*B/C*
1: Target 30%	95	2,39	111	2,42	75	2,42	208	2,49
2: Target 100%	320	2,42	373	2,46	252	2,46	700	2,53

5.3 Uncertainties and Limitations of the Cost-Benefit Analysis

Some of the cost data we received in the survey was inconsistent with the reported amount of fuel purchased. This was the case especially for LPG. It is possible that due to the higher income levels of the families they are less concerned with the money they spend on their cooking fuel. However, for a poor family the cost of a cooking fuel is a major portion of their consumption. To overcome this uncertainty in the cost data we double checked the numbers from other sources, such as LPG retailers and other studies made on LPG use in Africa.

Where possible we used benefit data from Tanzania, but in cases where we could not do so, we derived the values from studies made in other developing countries or developed countries. The numbers were adjusted according to the GDPs but uncertainty on the correct amount of benefits transferred still exists. This was the case for example for the value of human health risk avoided and the indirect value of forest from carbon sequestration. In addition, the marketing costs are a rough overestimate of what such a campaign would most likely cost. The costs were over estimated so that the benefits would not be accidentally inflated.

The amount of forest area lost to charcoal production every year is based on a very rough estimate from the Ministry of Forestry in Tanzania, which says that the rate of deforestation is between 130,000 and 500,000 hectares per year (PREM 2007a). We have used the lowest end of this estimate in our study correcting the figure to correspond to deforestation attributed to charcoal production.

6. Conclusions and Recommendations

In this final chapter we will make conclusions based upon the research that we have detailed in this report. After making conclusions concerning what our research has illustrated about the fuel substitution issue in Dar es Salaam, we will make some recommendations. Recommendations based directly on our research, as well as some general recommendations for improving the sustainability of the charcoal chain will be presented.

6.1 Conclusions

A survey of 235 households in Dar es Salaam has given insight into the cooking fuel choices of citizens. We have discovered that while people do understand the environmental consequences of charcoal production they continue to use it because they believe it is less expensive and easier to use than the alternatives. While a small percentage of people do cite cost as a reason not to switch to a modern fuel, such as LPG, the most often cited reason for not switching to LPG is its perceived lack of safety. This could mean that allaying such fears could cause an increase in LPG users.

In this study, we have compared the use of five fuels and performed a cost-benefit analysis on two levels. We used the results of our survey to gain insight into the habits of different fuel users, and this data was used to generate the two CBAs. The survey showed that firewood is used by the poorest in society and we have concluded that its use will continue. Though firewood is less expensive than charcoal, its health and environmental effects are the same as, if not worse than charcoal, therefore it is not a desirable alternative. Kerosene is used by the smallest families and does not have the capabilities to replace charcoal. The results of the household level CBA show that electricity and LPG are the only two fuels with positive Net Present Values. Because of this, they are the only two acceptable alternatives to charcoal.

Electricity and LPG are capable of replacing charcoal and both are desirable alternatives in terms of the environment and health effects, as well as time saved. However, the high cost of electricity makes LPG the clear winner. The price difference between LPG and charcoal, while significant for some of the population, can be overcome for approximately 30% of the population. This 30% could even be higher at this point due to the government's recent abolition (after the survey was taken) of the import and VAT on LPG which will close the price gap between the two fuels even more. We checked to see how sensitive our analysis is to the price of LPG and of course we found that the decrease in taxes only makes LPG more desirable.

To examine the benefits of targeting the 30% of charcoal users that have the same income levels as LPG users, we did a social level CBA, in which we examined two scenarios. The two scenarios were compared to a baseline scenario where households continue to use their current fuels. The first scenario to be compared is one in which 30% of the targeted charcoal using population respond to an extensive LPG marketing

campaign. The second scenario is one in which 100% of the targeted charcoal using population responds to said campaign.

Both scenarios have a promising benefit-cost ratio, and both have positive Net Present Values. Though the NPV for the second scenario, in which 100% of the targeted charcoal users respond, is significantly higher than the first scenario, we conclude that realization of the second scenario is unrealistic. Due to the great positive benefits of the first scenario and the feasibility of this scenario we recommend that it be pursued in reality.

6.2 Recommendations

The following section will elaborate on recommendations we can make based on our field research as well as our literature review.

Marketing Campaign

We suggest that **30% of charcoal users be targeted with an extensive marketing campaign by Oryx.** Emphasizing the *safety* and *time saving* abilities of LPG in television and radio ads, billboards, and even demonstrations will aid in the substitution of charcoal and eventually slow down the high rate of deforestation that is plaguing the nation.

Legislate LPG Safety Regulations

To aid Oryx in convincing the population that LPG is safe to use it would be beneficial for the government to **pass safety regulating laws for LPG equipment**. Publicizing the existence and enforcement of these laws would increase the speed with which people believe in the safety of using LPG, and therefore increase the speed with which they switch to LPG.

Further Recommendations

Of course, 30% of the charcoal users switching to LPG means that there is still 70% that have not switched. We expect that if a significant number of people do start using LPG (for example the targeted 30%) the price of LPG will go down, availability will go up, and more people will be talking about it and recommending it to friends and family. In this way, the percentage of people using LPG will go up and the percentage of people using charcoal will go down. . The hope is that a significant decrease in charcoal usage will improve the sustainability of the industry and will lift the burden from the natural forests that are so important to the local eco-system.

However, just as a small percentage of people have continued to use firewood, it is expected that charcoal will also continue to play a role in Tanzanian households. Because of its continued role more will have to be done to increase the sustainability of the charcoal chain itself. Such improvements could be **improving charcoal kiln efficiency**, **improving charcoal stove efficiency**, **creating production forests** from which charcoal will be made, working to find **alternative livelihoods for charcoal producers**, using **payments for environmental services** (PES), **improving the**

charcoal taxing system so that it is more effective, and **earmarking taxes from charcoal** for monitoring forests and implementing sustainable forestry practices.

There are many options for improving the sustainability of the charcoal chain. In this study we have shown that fuel substitution is a viable option that can be implemented in the near future. Our research has shown that a significant portion of the population of Dar es Salaam can be convinced to start using LPG. This shift must be accompanied by improvements in the sustainability of the charcoal chain itself. Here we have listed many of the options available. If the relevant stakeholders take action as we have suggested, the rapid destruction of one of Tanzania's finest resources will be slowed if not stopped and the forests will be preserved for future generations.

In their natural condition, or under wise management...these forests would be a never failing fountain of wealth and beauty.

~John Muir~

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Appendix I. Survey

Interviewer Name: Municipality: _____
Survey No.: Area:_____

Household Cooking Fuel Survey in Dar es Salaam

Hello my name is____ and I am a student conducting a small survey on the different types of fuels used by households in Dar es Salaam. The survey is part of a larger project undertaken by the Tanzanian Center for Environmental Economics Development Research (CEDR) and the VU in Amsterdam. I was hoping you might be willing to answer a few questions. This will take 15 minutes. All the information will be used for research purposes only and will be strictly confidential.

Family Size ***(including respondent)***			
a) 1-2	b) 3-4	c) 5-7	d) 8+

A. Cost of Fuels

What are your most important energy sources for cooking? (no more than two)

1. Firewood (*please answer questions in section A1, page 1*)
2. Charcoal (*please answer questions in section A2, page 3*)
3. Kerosene (*please answer questions in section A3, page 5*)
4. Liquid Petroleum Gas (LPG) (*please answer questions in section A4, page 7*)
5. Electricity (*please answer questions in section A5, page 8*)
6. Other (*please answer questions in section A6, page 10*)

AX. Specify fuel:_____

i. What equipment do you use for cooking with this fuel and how much did it cost to purchase?

	Equipment	**Cost (Tsh)**

ii. *Please indicate the quantity and cost of this fuel you purchase on average at one time.*

Quantity	**Unit**	**Total Price (Tsh)**	**Unit of time Day/week/month**

iii. How often do you purchase this fuel? _____

iv. How much time (including travel time) does it take for you to make one purchase of this fuel? _____ h/min (*circle one*).

v. How many days per week do you cook with this fuel? _____
vi. How many hours/minutes do you spend cooking with this fuel per day?___ h/min

vii. What are your reasons for cooking with this fuel? (*check all that apply, then specify the most important reason*)

		Reason	Most Important Reason (*check only one*)
a	It is inexpensive		
b	It is easy to purchase		
c	It is easy to use		
d	It is safe to use		
e	It has no negative health effects		
f	Food cooked with it tastes better.		
g	The initial investment cost (e.g. stove) for it is inexpensive		
h	It is traditionally used in my household		
i	It gives high heat/cooks food fast.		
j	It is clean to cook with.		
k	Other (*specify*):		

viii. Do you think that there are any negative health effects to cooking with this fuel?
a. Yes. What effects?_____
b. No.
c. Don't know

ix. Do you think that there are any safety risks to cooking with this fuel?
a. Yes. What risks?_____
b. No.
c. Don't know

x. What share if any of overall household use of this fuel is for commercial activities?_____ percent.

Only *charcoal* users:

xi. Do you think that cooking with charcoal has any negative effects on the natural environment of Tanzania?
a. Yes. What effects?_____
b. No.
c. Don't Know

Only *LPG* users:

xii. How often have you been unable to purchase a refill gas canister because the Oryx agent didn't have any?
a. Never
b. Every time I try to purchase it.
c. Once a year
d. A few times a year.
e. Other (*specify*): _____

Only *electricity* users:

xi. Do you get charged for the electricity that you use?
a. Yes, I pre-pay my bill
b. Yes, TANESCO charges me the correct amount.

c. No, they overcharge me.
d. Don't Know

xii. How often do you have to use another type of fuel to do your cooking because there is a power shortage?
a. Never
b. Once a month
c. A few times per month.
d. Once a week.
e. A few times per week
f. Every day.
g. Don't know.

xiii. Do you have positive feelings about TANESCO? Please explain:

B. Fuel Switching/Adding

Did you start using your current cooking fuel within the past 5 years?
1. Yes (*please answer questions in section B1.*)
2. No (*please skip to section C.*)

B1. Switched/Added

i.. What type of fuel/(s) were you using before you started using your current fuel? _____

ii. Has the use of this new fuel caused you to:
a. Minimize the use of other fuels
b. Stop using another fuel
c. Didn't change the use of other fuels at all.
d. Other (*specify*): _____

iii. What are your reasons for switching to another fuel or adding a new fuel? (*check all that apply, then specify the most important reason*)

		Reason (*check all that apply)*	Most Important Reason (*check only one*)
a	Recommendations from friends/family		
b	Advertising Campaigns		
c	Representative from a company		
d	A rise in income		
e	Purchase price		
f	Ease of acquisition		
g	Convenience of use		
h	Safety of use/Health		
i	Habit/tradition		
j	Better tasting food		
k	Low initial investment cost		
l	Other specify:		

C. Knowledge of Alternatives

C1. LPG Alternative *(Skip this section if you currently use LPG)*

i. Would you consider switching to LPG?
a. Yes, Why?_____
b. No, Why not? _____

ii. Do you think that the daily cost of cooking with LPG would be
a. more expensive than your current fuel.
b. the same cost as your current fuel.
c. less expensive than your current fuel.
d. Don't know.

iii. How far do you think you would have to travel to purchase LPG?_____h/min

iv. Do you think LPG is safe to use?
Yes, why?_____
No, why?_____

v. Do you think that using LPG for cooking would be
a. easier than your current fuel
b. the same as your current fuel
c. more difficult than your current fuel
Why?
_____
d. Don't know.

vi. What do you think the initial investment cost (stove etc.) required for LPG is

vii. The initial investment cost for LPG is 60.000 Tsh.
Does this initial investment cost prevent you from switching to LPG?
a. Yes, what cost would be acceptable? _____
b. No

viii. There are several micro-financing institutions in Dar es Salaam. If they were willing to give you a loan for the amount needed to pay the initial investment cost for LPG with a payback period of 6 months and an interest rate of 10%, would you take advantage of the opportunity?
(*please circle all that apply*)
a. Yes
b. No, the interest rate is too high. What rate would be appropriate? ____
c. No, the payback period is too short. What is an appropriate time? ____
e. No, I don't want to take a loan.
f. Don't know

C2. Electricity Alternative *(Skip this section if you currently use electricity)*

i. Would you consider switching to electricity?

a. Yes, Why? _____
b. No, Why not? _____

ii. Do you think that the daily cost of cooking with electricity would be
a. more expensive than your current fuel.
b. the same cost as your current fuel.
c. less expensive than your current fuel.
d. Don't know.

iii. Do you think that using electricity for cooking would be
a. easier than your current fuel
b. the same as your current fuel
c. more difficult than your current fuel
Why?
_____
d. Don't know.

iv. What do you think the initial investment cost (stove, connection cost etc.) required for electricity is? _____

v. The initial investment cost for electricity is around 450,000 Tsh.
Does this initial investment cost prevent you from switching to electricity?
a. Yes. What cost would be acceptable? _____
b. No

vi. There are several micro-financing institutions in Dar es Salaam. If they were willing to give you a loan for the amount needed to pay the initial investment cost for electricity with a payback period of 6 months and an interest rate of 10%, would you take advantage of the opportunity?
(*please circle all that apply*)
a. Yes
b. No, the interest rate is too high. What rate would be appropriate? ____
c. No, the payback period is too short. What is an appropriate time? ____
e. No, I don't want to take a loan.
f. Don't know

D. Personal details

Gender: Male / Female
Age: 18-25, 26-35, 36-45, 46-65, 65+
Highest level of education: No education/Preschool, Primary School, Secondary School, Lower university degree, Higher university degree
Monthly income of head of household:

Thank you for your participation. We appreciate your help.

For interviewer only:
Do you think that the person interviewed with this survey is a good candidate (friendly, knowledgeable, etc.) to have a follow-up interview with?