ESSAYS ON DISTRIBUTIONAL CONSEQUENCIES OF FUEL TAXATION IN KENYA

By

JOHN MUTWII MUTUA

Thesis Submitted in Partial Fulfilment of the Requirements for the Award of the Degree of Doctor of Philosophy in Economics of the University of Nairobi, Kenya.

October 2013.

DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

John Mutwii Mutua

School of Economics, University of Nairobi, Kenya.

X80/80066/08

------------------------------------- 15/10/2013

This thesis has been submitted for examination with our approval as university supervisors.

Supervisor

Peter K. Kimuyu

Professor of Economics

School of Economics, University of Nairobi, Kenya

---------------------------------- 19/10/2013

Supervisor

Dr Wilfred N. Nyangena

School of Economics, University of Nairobi, Kenya

---------------------------------- 24/10/2013

DEDICATION

To my late parents **Susan Mbesa Mutua & Johnson Mutua Kioko** who always encouraged me to make a difference in society and contribute to influence the World positively.

ACKNOWLEDGEMENTS

First of all, I would like to thank the ALIMIGHTY GOD for His greatness and for making all this possible. Sometimes, the challenges during the course of study were many but GOD enabled me to go through. At some point, I was not sure of what kind of contribution I was going to make, but GOD reminded me that… "*I can do all things through CHRIST who strengthens me-Philippians 4:13*". FATHER, I thank you for I know you have a good plan concerning the impact and policy influence that will result from this thesis.

I am greatly indebted to my major professor and thesis supervisor, Prof. Peter Kimuyu for his supportive role, guidance in this work and mentorship. Thank you for taking time to listen to me even when I never made sense sometimes in my writing and arguments, but you took time to offer wise counsel to streamline this thesis. I would also like to thank my second supervisor, Dr Wilfred Nyangena, for his constructive criticism and advice in this work. Thank you for connecting me with the School of Law, Business and Economics at Gothenburg University, Sweden, where I later developed deep interest in energy and environmental economics.

I would like to extend my deepest appreciation to Prof. Mwangi Kimenyi of Brookings Institution, Washington DC for his support; to Prof. Germano Mwabu, a mentor and a father; Prof. Francis Mwega, Prof. Jane Mariara (Director-School of Economics), Dr Antony Wambugu, Dr Rose Ngugi, Prof. Damiano Kulundu and Dr Almadi Obere. I thank all academic and Administration Staff from the School of Economics, for their support. In addition, much gratitude goes to Prof. Thomas Sterner (Gothenburg University), Prof. Gunnar Köhlin, (Director-Environment for Development, Gothenburg University), Much gratitude goes to Dr Moses Ikiara, former Executive Director, Kenya Institute for Public Policy Research and Analysis (KIPPRA) and Dr Eric Aligula, the Programme Coordinator, KIPPRA, for their support and encouragement. My gratitude goes to Evelyne Kilonzo, Prince Bahati and Purity Njeru for editorial support. I would also like to extend my deepest appreciation to my fellow PhD Candidates at the School of Economics, Eldah Bwoda, David Muthaka, Benson Kiriga, Renny Mutai and Mathenge Ichangi for their support. I cannot forget Philip Musyoka, a PhD Candidate, Liebig Universität, Gießen (Germany), with whom we shared many experiences in econometrics and modeling. My gratitude goes to Dr Frederick Nyang and Grace Njeru of the Energy Regulatory Commission for their support and encouragement.

My gratitude also goes out to Pastors Ambrose Nyangao and Simon Mwangi of Parklands Baptist Church for their prayers and encouragement during the course of my studies. I would like to thank my family (the Mutua's) for their prayers, encouragement and moral support during the course of my studies. Thank you my brothers and sisters: I love you.

Through it all, GOD's grace has been sufficient and to HIM be the glory!

ABSTRACT

This thesis outlines three topics on residential energy demand, distributional consequences of fuel taxation and welfare impacts of price increases for five regulated fuels in Kenya. The thesis provides a comprehensive framework to analyse factors that drive energy demand and computes the price elasticities of household demand for fuels; analyses distributional consequences of fuel taxes and estimates welfare losses due to fuel price increases; and it attempts to provide regulatory policy options for reducing fuel consumption, distributional consequences and mitigations against welfare losses.

The models of demand for fuels are based on the Linear Approximate-Almost Ideal Demand System (LA-AIDS) in which fuel budget shares are used as dependent variables. The distributional effects are estimated by use of budget shares and Suit Index while, the welfare losses are estimated using the Compensating Variation (CV) method. The data is obtained from the National Energy Survey of 2009 and other national data sets by the Kenya National Bureau of Statistics (KNBS).

The demand analysis shows that own prices, price of substitutes, household expenditure, location of household, size of household, gender, education and type of occupation of the household head are some of the key factors that drive fuel consumption. For elasticity analyses, own price elasticities were negative, while the cross price elasticities had mixed results depending on whether a fuel is a substitute or complement. By use of budget shares and the Suit Index, this study establishes that electricity and kerosene are regressive in taxes, meaning the low income deciles bear a higher burden compared to the high income ones. A tax on Liquefied Petroleum Gas (LPG) is however progressive. With regard to transport fuels, a tax increase is progressive so that the tax burden is higher for the high income group than low income ones, contrary to what is widely held. The study recommends tax reduction for regressive fuels, while sustaining or increasing current taxes on progressive fuels.

As for to compensating variation, low income households would require higher compensation to go back to the same level of utility they were before the price increases were experienced. With regard to welfare measures by expenditure deciles, the analysis shows that lower expenditure deciles require more compensation than high income deciles. Interestingly, higher income deciles require more compensation than the low ones for transport fuels, because they directly pay more given their motorization behaviour which is captive towards private transport and car ownership. In conclusion, although the Government of Kenya is committed to deregulation, some level of welfare compensation is required, particularly for low income households.

TABLE OF CONTENTS

LIST OF TABLES

List of Figures

LIST OF ABBREVIATIONS

ADNOC	Abu Dhabi National Oil Company
AGO	Automotive Gas Oil
AIDS	Almost Ideal Demand System
CAFÉ	Corporate Average Fuel Economy
CBS	Central Bureau of Statistics
CGE	Computable General Equilibrium Model
CIF	Cost Insurance and Freight
CO_2	Carbon Dioxide
COMESA	Common Market for Eastern and Southern Africa
CV	Compensating Variation
EEU	Environmental Economics Unit
EfD	Environment for Development
ERC	Energy Regulatory Commission
ERSWEC	Economic Recovery Strategy for Employment and Wealth Creation
ESMAP	Energy Sector Management Assistant Programme
EV	Equivalent Variation
FCC	Fuel Cost Charge
FDI	Foreign Direct Investment
FES	Family Expenditure Survey
GWh	Gigawatt Hours
IEA	International Energy Agency
IPPs	Independent Power Producers
ITSUR	Iterated Seemingly Unrelated Regression
KEPSA	Kenya Private Sector Alliance
KIHBS	Kenya Integrated Housing and Budget Survey
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KMI	Kenya Motor Industry Association
KNBS	Kenya National Bureau of Statistics
KPLC	Kenya Power and Lighting Company Limited
KRA	Kenya Revenue Authority
kWh	Kilowatt Hours
LA-AIDS	Linear Approximate-Almost Ideal Demand System

LCPDP	Least Cost Power Development Plan
LPG	Liquefied Petroleum Gas
MOE	Ministry of Energy
MW	Megawatt
NASSEP	National Sample Survey and Evaluation Programme
NOCK	National Oil Corporation of Kenya
OTS	Open Tender System
RMS	Regular Motor Spirit
PMS	Premium Motor Spirit
REA	Rural Electrification Authority
REPLF	Rural Electrification Programme Levy Fund
SIDA	Swedish International Development Agency
SUR	Seemingly Unrelated Regression
VAT	Value Added Tax

CHAPTER 1

INTRODUCTION: STUDY CONTEXT AND MOTIVATION

1.1 Introduction

Many developing countries have, in the recent past, witnessed increased demand for energy. The energy that is mostly consumed includes: electricity, fossils fuels and biomass. Due to increased economic activities and surges in population growth, demand for energy has surpassed supply in many developing countries. However, despite the surge in energy demand, most households still lack access to modern forms of energy. The International Energy Agency (IEA) (2011) estimates that over 1.3 billion people have no access to electricity and 2.7 billion people (representing about 39 percent) have no clean cooking fuels, globally. More than 95 percent of these people are either in Sub Saharan Africa and some parts of Asia. About 84 percent of those lacking clean cooking fuels are in rural areas.

In Kenya, majority of households still rely on biomass energy, but the country has seen increased demand for modern forms of energy such as electricity and petroleum. Demand for electricity has increased significantly while the excess capacity (the difference between supply and demand) has been declining. This has posed a challenge to policy makers due to its implications in energy security. Likewise, the demand for Automotive Gas Oil (AGO), Premium Motor Spirit (PMS), kerosene and LPG among other petroleum products, has also been increasing rapidly. In addition, biomass still provides the bulk of energy consumption, accounting for over 70 percent of total energy.

The number of connections into the electricity power system increased to 2.04 million in 2012 from 1 million in 2008. Over the same period, the percentage growth in new connections was 14.5 percent and 16.3 percent, respectively. This growth was mainly driven by increase in the number of new connections under the Rural Electrification Programme and expansion of the industrial and manufacturing sectors (KPLC, 2012). In the transportation sector, the number of vehicles increased to about 1.733 million in 2012 from about 1 million in 2008 (KNBS, 2013). The expansion and growth in the energy sector is attributed to reforms envisaged in the Sessional Paper No.4 of 2004 on Energy and Energy Act of 2006. This includes a large increase of 200,000 new connections in electricity annually and reducing system losses (from 18.7 percent of energy purchased in 2006 to 16.7 percent in 2009). The system losses in 2011 were 17.1 percent. Despite these achievements, the energy sector still faces a myriad of challenges such as frequent supply shortages, outages and high prices and tariffs.

In Kenya, commercial forms of energy, which constitute 30 percent of the primary energy used in the country, cater mainly for the monetized modern segments of the economy associated with commercial and industrial enterprises domiciled mainly in urban parts of the country. These include modern forms of energy; electricity, petroleum fuels and coal. On the other hand, non-commercial forms of energy constitute 70 percent of primary energy used in the country and they include biomass based sources; firewood, charcoal, farm and residues (Nyang and Mutua, 2011).The demand for petroleum based fuels has increased from 3.7 million tonnes in 2009 to 3.941 million tonnes in 2011(KNBS, 2012) but declined to 3.686 million tonnes in 2012 (KNBS, 2013). In the long run, it is projected to increase by more than three times in line with Vision 2030, the blue print document for economic and investment policy. Gasoline and diesel demand was 0.619 million tonnes and 1.486 million tonnes in 2012, respectively (KNBS, 2013). The balance of about 1.581 million metric tonnes is from jet fuel, illuminating kerosene, fuel oil and heavy diesel oil. The gasoline tax is Ksh. 29.795, Ksh. 29.305 and Ksh. 17.68/litre for PMS, Regular Motor Spirit (RMS) and AGO (diesel), respectively in 2011 (KRA, 2007; Ministry of Finance, 2011). PMS and AGO in Kenya are mainly used as transport fuels. Their tax rates therefore take into account transportation as their main use. Other petroleum products include fuel oil which is used for power generation and illuminating kerosene mainly used for cooking, heating and lighting, have different tax regimes. Kerosene is zero rated in excise duty and its total taxes and duties total to Ksh. 1.93.

From the foregoing, Kenya's energy sector has witnessed increased demand for all forms and sources of energy. The demand for biomass and related forms of energy such as electricity, petroleum products and renewable energy sources such as solar and wind has increased rapidly. The country's population has also increased by more than four times since independence. By 2009, it stood at over 38.6 million people and is projected to reach 67 million people by the year 2030. In the electricity sub sector, the net power peak demand is projected to increase tenfold from 1,188 MW in 2008/09 to 15,026 MW by the year 2030, while the net energy demand is expected to increase from 7,032GWh in 2011/12 to 103,518GWh in 2030 (Ministry of Energy, 2012).

In the petroleum sub sector, total demand of products is expected to increase from 3.8574 million tonnes in 2011 to 10 million tonnes by the year 2030 (KIPPRA, 2010; KNBS, 2012). Consumption of biomass which is the main source of energy for majority of the poor, has witnessed huge increases as well. The high energy consumption and demand present challenges of environmental degradation and related threats, which result to the problems of climate change and global warming.

Increased consumption of fossils leads to high emission of green house gases. From the foregoing, it is evident that the switch from biomass to more efficient and cleaner forms of energy has been undermined by chronic poverty which stands at 46 percent.

In order to meet the increasing energy demand and ensure security of energy supply in the country in line with Vision 2030 (Government of Kenya (GoK), 2008), new investments in the energy sector have to be done. Vision 2030 aims to make Kenya a middle income economy by the year 2030. This requires that the country's economy grows by over 10 percent annually in the next 20 years. In order to achieve this economic and social transformation, many flagship and economic stimulus projects have been earmarked for implementation. However, these projects require availability of reliable, affordable and cost effective energy. Despite the efforts that have been put in place to achieve economic recovery, the economy recorded a growth rate of 4.5 percent in 2011. This was mainly due to the effects of the global financial crisis, persistent drought and high cost of living. As a result, the economy is still far below the desired growth path.

The electric power projects that have been earmarked for development range from hydro power, geothermal, wind and biogas. The Government is also exploring prospects for nuclear electricity in the next 15 years (GoK, 2012). In the petroleum sub sector, there has been increase in prospective activities in the upstream exploration in various parts of the country. However, despite the efforts that have been put in place to increase supply of energy; demand is still more than available supply. The high demand for energy due to increased economic activity and population pressure has various implications for energy price taxation and the environment. While it is important to provide energy that is affordable and sustainable as well as ensure security of supply, there are associated costs due to additional investments and protection of the environment.

Consumption of petroleum products contributes the largest percentage of carbon dioxide emission and other sulphur related gases, which are harmful to the environment. As a result, energy users have to bear the cost of environmental damage and the same applies to industries that benefit from their generation and use. Electricity consumption by households/residential units as well as commercial industries, as noted earlier, has been on the increase. It can therefore be argued that high demand for energy due to increased economic activity, carbon emissions and environmental damage are some of the challenges facing the energy sector in Kenya today.

It has been argued by the Kenya Private Sector Alliance (KEPSA) that Kenya's electricity tariffs are high compared to competitor countries within the Common Market for Eastern and Southern Africa (COMESA) such as Egypt and South Africa (KIPPRA, 2010b). One of the explanations given to support the high tariffs is that taxes on electricity are high. Following this argument, the government reduced value added tax on electricity from 16 percent to 12 percent in 2007, to reduce the burden borne by households and industry. However, power tariffs still remain high due to increase in thermal power generation which is expensive compared to other power generation technologies such as hydro and geothermal; they are cheaper in the long run although their initial plant investment costs are high. Therefore, planned investments in geothermal, wind and nuclear energy technologies according to the Least Cost Power Development Plan (LCPDP) will help reduce and stabilise the generation costs in the long run. However, this will take a longer time before they are realised due to the high sunk costs involved in energy project investments of this magnitude.

In the petroleum sub sector, motorists and industries have often raised concern about high petroleum prices. Although Kenya is a net importer of petroleum products; domestic prices are mainly driven by international prices of crude and domestic taxes that is excise duty, roads maintenance levy and petroleum development levy among other taxes, which are high and increase the tax burden on consumers. However there are other costs within the petroleum price build up such as the refining costs, demurrage, storage, pipeline and other bridging transportation costs that contribute to the high prices. The wholesale margins by oil marketers are also high given the final retail price and what these firms give the retail outlets as profit margins. However, the recent discovery of oil in Ngamia 1 in Turkana County will be a great relief if the crude is commercially viable. However, actual production may take long before the first barrel is sold in retail outlets or exported to the international markets.

While the argument against what is considered as high energy taxes may be valid, it is important to establish who bears the burden of the high taxes. One way to achieve this is by estimating distributional impacts of these taxes by income group in order to determine where the burden lies. However, prior to establishing the distributional impacts, it is important to establish the key drivers of energy demand and price elasticities associated with energy consumption. Such argument is able to provide insights on the kind of demand pattern that exists in the energy sector in Kenya and how it impacts on pricing and taxation. This will then help determine progressivity or regressivity of energy taxes. Once determined, it motivates estimation of welfare losses from increased fuel prices and predicts how much is required to compensate households from welfare loss that results from energy price increases.

This thesis outlines three topics in residential energy demand, distributional consequences of fuel taxation and measures welfare impact of fuel price increase, emphasising the role of energy policy and providing policy options that will enable Kenya manage her energy sector better. It focuses on five key fuels in a household energy basket: Kerosene, Electricity and LPG (mainly used for cooking, lighting and heating) and PMS and AGO which are used in transportation. These five fuels are regulated to some level by the Energy Regulatory Commission (ERC) and are therefore a good choice for this research in addition to the key role they play in energising the economy.

Essay one (1) analyses the key drivers of Kenya's fuel demand, computes price elasticities for the five regulated fuels and shows their implications by income group and household location. The model of demand for fuels is based on the Linear Approximate-Almost Ideal Demand System (LA-AIDS) in which fuel budget shares are used as dependent variables. The data is obtained from the National Energy Survey of 2009. By estimating demand of what may be considered as sources of modern energy in Kenya, I improve the understanding that prices, income, household size, sex of the household head, location of household and type of vocation are some of the key drivers of energy demand. Further, computations of own price, cross and expenditure elasticities by income group and household location in the essay, will go a long way to show implications of socio-economic factors in fuel use and mix within the household.

In the second essay, I analyse distributional effects of fuel taxes and provide suggestions on how to mitigate such effects in Kenya with regard to either progressivity or regressivity of taxes in light of environmental sustainability and equity issues. By use of budget shares and the Suit Index, I establish whether Electricity, Kerosene and Liquefied Petroleum Gas (LPG) which are the main modern cooking, heating and lighting fuels, are regressive or progressive in taxes. In addition, analysis is done for transport fuels and policy options provided. This essay is therefore primarily concerned with policy options that will help households mitigate adverse effects of fuel taxes as well as balance between reducing tax vis a vis implications of increased consumption on emissions and other environmental detriments from policy perspective.

Third, I measure the welfare impact of fuel price increases on households by use of expenditure fuel shares and Compensating Variation (CV). I match household consumption data with National Level information on price changes. The consumption data comes from the National Energy Survey 2009, while the price data is from KNBS. The data contains annual observations from 2003-2009. I employ a single price measure, the percentage change in price from 2003 to 2009. This adoption of a long time period before the onset of the energy price increases until after the energy crisis captures a robust measure of price changes associated with the energy crisis. I then match the price change data with the consumption data to calculate the measures of compensating variation. In addition, the period 2003-2009 marks three important periods in the history of policy and economic growth paradigms in Kenya: (a) regime change that ushered in a new development dispensation, envisaged in the Economic Recovery Strategy for Wealth and Employment Creation (ERCWEC); (b) the Government developed the Sessional

Paper on Energy No. 4 of 2004 and enacted a new Energy Act 2006 that brought all energy sub sectors under one regulator; and (c) in 2008, the government launched the Vision 2030 that will oversee Kenya's development in the next 20 years.

This study contributes to dearth of existing literature in various ways. First, it applies recent techniques to estimate residential energy demand, distributional effects of fuel taxes and welfare losses from price changes. The analysis of demand follows LA-AIDS model and is estimated by use of the Seemingly Unrelated Equations (SUR). Unlike in previous studies, it further splits the sample into three income groups. Secondly, it computes own, cross and expenditure elasticities by income group and household location. This has not been done before in any energy sector related studies in Kenya. Ngui *et al*. (2011) estimated energy demand of eight fuels which included lubricants which is not technically a fuel but some oil that is used in car engines to lubricate and achieve good performance. Their study did not also explore income characteristics of the sample as well as compute elasticities by income group and household location. The choice of fuels in this study is also guided by the regulatory policy in Kenya and considers only the five key regulated fuels.

The other significant work related to this research in Kenya is that of Mutua *et al.* (2012) that analysed distributional effects of fuel taxes using urban data for the City of Nairobi that was collected in 2004. The study only examined use of transport fuels that is Premium Motor Spirit and Automotive Gas Oil. A lot of changes in the energy sector have taken place since then. The National Energy Policy 2004 and Energy Act 2006 had not been adopted by the time the data was collected. In addition, Electricity, Kerosene and LPG were not part of the analysis. Further, the data was not representative of the national sample. It only examined data from Nairobi, the main Capital City.

Lastly, no study in Kenya has provided a measure of welfare loss from energy price increases and therefore, this research will contribute to dearth of literature and help inform policy makers on the best ways to mitigate against energy price increases. It also provides useful policy options and strategies to deal with regressivity of fuel taxes and welfare losses from energy price increase.

The government is currently facing challenges in determining optimal prices and tax rates for energy and related services due to the role energy plays in economic growth and development. While it is prudent to have high taxes for highly pollutant energy sources such as fossil fuels, the government has to balance its fiscal and environmental objectives due to their impacts on prices and revenue generation. Prices affect all households in various ways depending on their level of consumption of a particular fuel as well as their incomes. This study therefore informs policy makers on levels of energy demand, distributional aspects of taxes, measures of welfare loss as well as environmental issues.

1.2 Organisation of the Thesis

This thesis is organised in three essays presented in form of chapters. Essay 1 addresses the residential energy demand in Kenya by income group and estimates own price, cross and expenditure elasticities not only by income group, but also by location. In the second essay, the distributional consequences of fuel taxes are analysed using energy household budget shares by income group and deciles and the Suit Index. The third and last essay, attempts measure the welfare impact of fuel increases by income group, household location and deciles. This analysis is preceded by an exploration of fuel price changes and deep analysis of budget shares by income group and location. Lastly, the thesis provides a summary and concluding chapter.

CHAPTER 2

RESIDENTIAL ENERGY DEMAND IN KENYA

2.1 Introduction

Demand for energy in developing countries has witnessed high increases due to population and economic growth rates. This is contrary to developed countries where population growth has almost stagnated and economic growth rates have been stable. However, developed countries have high per capita energy consumption due to high incomes and diversified energy needs compared to poor nations. They need more energy to power their transportation, cooling and heating systems, industrial production as well as in meeting other domestic energy needs. Most functions at the household are energy intensive. On the other hand, energy demand in developing countries has been hampered by high poverty rates, poor infrastructure that accompanies use of fuels and scattered nature of settlements among other factors.

Despite the challenges in energy access in developing countries, Wolfram (2012) for example argues that the world's poor and near-poor will continue to play a major role in driving medium term growth in energy consumption in the coming years. This is because as the world economy expands and poor households' incomes rise, they are likely to get connected to the electricity grid, gain access to good roads, and purchase energy-using assets like appliances and vehicles for the first time. Some countries such as Kenya are already putting in place deliberate policies and programme to increase energy access in rural and marginalised areas as well as urban slums. She is also expanding her industry in order to produce enough goods and services to meet demand for her growing population. In order to achieve growth and socio-economic outcomes desired in Vision 2030, there is need to expand her energy supply sources.

Kenya, in recent times, has seen growth in the middle class who have the ability to own energy durable goods such as fridges, cars and air conditioners etc.

The energy sector in Kenya, like in many other developing countries, has witnessed structural changes where market reforms and pricing have played a key part in driving demand. In early years, most of the energy resources were heavily regulated resulting to price distortions that did not reflect the true cost of products. As a result, it discouraged investments in the energy sector resulting into a constrained supply chain. In addition to poverty levels in these countries, the demand for energy remained low for many years. However, with introduction of socio-economic reforms and restructuring of these economies, there is increased investment and economic growth. This is good news to the poor who, for a long time, have not been able to afford most of their basic needs. Increasing population and economic growth in developing countries are thus going to be key drivers of energy consumption in these nations.

Understanding of energy demand dynamics and its key drivers in a country is therefore important given the role it plays in socio-economic, political and environmental sustainability. In this essay, I analyze demand for five residential energy sources/fuels that form a considerable part of the households' energy mix, which also play a key role in raising tax revenue that is required in increasing access and funding critical infrastructure such as electricity, water and roads which are public goods that benefit all citizens. The five fuels also have some level of regulation ranging from price caps in the case of petroleum fuels, to a regulated tariff in the case of electricity. The price of LPG is not currently regulated, but there are other regulations that allow for common use of gas cylinders. This is aimed at introducing competition in the retail market. In addition, LPG and Kerosene are zero rated in tax, while the Value Added Tax (VAT) on electricity was reduced by 4 percent in 2007 to reduce retail electricity tariffs, achieve affordability and increase usage at the household level. However, the Finance Act of 2013 reversed the VAT on electricity to 16 percent of total electricity consumption (GoK, 2013). Understanding the demand dynamics is therefore important for energy planning and policy design to improve current and future access and use.

2.1.1 Objectives of the essay

The main objective of this essay is to explore key drivers of Kenya's fuel demand and compute own and cross price elasticities as well as expenditure elasticities of selected fuels.

The specific objectives of the essay are to:

I. Analyse the key drivers of residential energy demand in Kenya by income group and location of household.

II. Estimate own price, cross and expenditure elasticity's for residential fuels by income group and location of household.

III. Suggest policy recommendations on fuel consumption and energy demand management in Kenya.

The rest of the chapter is organised as follows: section two summarises the relevant theoretical and empirical literature on energy demand, while section three provides the methodology of the study. Sections four provides empirical analysis, and section five draws conclusions and provides policy recommendations.

2.2 Literature Review

This section provides literature review on household energy demand and related issues such as energy choice, energy capital complimentarity/substitution, household expenditure, price elasticity, household characteristics and energy consumption, energy modelling and provides an overview of literature.

2.2.1 Energy demand

This sub section provides literature review on energy choices, energy capital complimentarity/substitution, household expenditure in energy goods and services, income and price elasticities with regard to energy goods and services, household characteristics and energy consumption and lastly, models that have been used in analysing energy demand.

2.2.1.1 Energy choice

The way households make choices regarding energy consumption is important for a country's energy demand management, energy pricing and environmental sustainability. Some forms of energy such as biomass are, to an extent, hazardous to the health of the households. They have been associated with many respiratory diseases so that households, given alternatives, consider this factor when making choices regarding energy use. According to Mekonen and Köhlin (2008), use of biomass fuels for cooking is a major source of health problems in many developing countries due to indoor air pollution (see also Bruce *et al.* 2000; Ezzati and Kammen, 2001). Income level is one of the most important factors that determine the choice made on energy use. From literature on household energy (Mekonen and Köhlin, 2008), it has been argued that households with low levels of income rely on biomass fuels, such as wood and dung, while those with higher incomes consume energy that is cleaner and more expensive, such as electricity. On the other hand, households in transition-between traditional and cleaner (and more efficient) energy sources- consume mostly transition fuels such as kerosene and charcoal. This is a simpler version of the energy ladder and has been discussed extensively in literature (see Hosier and Dowd, 1987; Barnes and Floor, 1999; Heltberg, 2005; Mekonen and Köhlin, 2008; KIPPRA, 2010). Fuel switching is another concept widely used in energy choice and demand studies. In this case, it is argued that the introduction of superior fuels will phase out traditional fuels as households switch to the former.

Mekonen and Köhlin (2008) use a random utility theory to analyse household fuel choice. They concentrate on factors that determine choice of a particular fuel type by use of random logit model. They analyse the fuel stacking behaviour using a multinomial logit model by grouping consumers into three categories based on the main fuel used by the household; those whose main fuel was only solid fuel (fuel wood and/or charcoal), non-solid fuel(kerosene and/or electricity)only and a mixture of solid and non solid fuels. Further, they estimate an Engle curve to examine the determinants of fuel consumption in a more rigorous manner. The analysis controlled for a number of other factors that can influence consumption of wood, charcoal, kerosene and electricity, in addition to total expenditure. These factors include household size, location of household, education level and occupation among other factors. Their analysis considered only households that consumed a positive quantity of the fuel type and therefore took into account possible sample selection bias that might arise by using Heckman's two-step estimator.

Mekonen and Köhlin (2008) study utilises panel data collected in the year 2000 and 2004 in Ethiopia, which included 1,500 households in each survey, with about 60 percent of them from Addis Ababa, the capital city. The multinomial logit results suggest that higher prices of kerosene made households choose either solid fuels only or a mix of solid and non-solid fuels, moving away from non-solid fuels. Households were more likely to choose a mix of solid and non-solid fuels when wood prices were higher. This suggests that one needs to look at other factors in addition to prices to explain fuel choice, such as the role of equipment cost, consumer habits and preferences. There is an inverse relationship between family size and probability of using non solid fuels. On the other hand, negative and significant coefficient for the square of the family size suggests that there is non-linearity. As a result, as the family size increases, the likelihood of a household using solid fuels only or a mix of solid and non solid fuels as the main fuel increased as well, but at a decreasing rate.

2.2.1.2 Energy capital complimentarity/substitution

Another theory ((Energy Sector Management Assistant Programme (ESMAP), 2000) is that of fuel ladder of energy demand where it is assumed that households will transit to cleaner fuels as their incomes increase, because they are able to adjust their preferences. Unlike with fuel preferences where more diversified demand for energy sources is explained in terms of nature of appliances used and the purpose as income increases, this theory argues that households are able to transit to cleaner fuels as their income and other factors that determine well-being improve. This theory has been criticised as unrealistic because fuel preferences could be explained by other factors (Mekonen and Köhlin, 2008).

In developing countries, it has been observed that households use a combination of fuels rather than switching to other energy sources. This may involve a combination of solid and non solid fuels. In this case therefore, a household may choose a combination of fuels from a basket of energy sources instead of moving up the ladder step by step when incomes increase. According to the World Bank (2003), households can choose a combination of high-cost and low-cost fuels, depending on their budget preferences and needs. As a result, the theory of fuel stacking (i.e. multiple uses) has been advanced contrary to the energy ladder or fuel switching (Mekonen and Köhlin 2008; Kamfor, 2002).

The above findings are supported by Briscoe (1979) while analysing energy availability and patterns of energy use in the context of a single village in rural Bangladesh. He found that different classes used approximately the same number of kilocalories[1] to cook a kilogram of food grain. The study further found that crop residues provide over 70 percent of fuel used by the study population, and therefore the cropping pattern was the primary determinant of the seasonal variation in the fuel supply. On policy implications, the study found that the standard method of assessing energy problems in rural areas of poor countries had been to compare the projected aggregate supply of energy, with the aggregate demand. Women also played a central role in determining the energy used by the household. The major use of energy was cooking food, which was predominantly a woman's task in Bengal.

Other notable examples include the repercussions from the petroleum price hikes of the 1970s that created impetus on the awareness of the importance of energy for sustained economic activity. For developing countries, such as Kenya, this awareness drew attention to the crucial role played by wood fuel in supplying the energy requirements of the household sector (Hosier, 1985). High levels of wood fuel consumption have been linked to deforestation, soil erosion, increased stress on rural

[1] Kilocalorie is unit of energy of 1,000 calories (equal to 1 large calorie). One calorie is the approximate amount of energy needed to raise the temperature of one gramme of water by one degrees celcius.

women and increase in inequality among rural dwellers. In the case of Kenya, Hosier (1985) established that energy consumption patterns varied between different groups. Formal wage earners demonstrated a lower reliance on consumption of wood fuel. On the other hand, they were more reliant on commercial fuels. Generally, access to larger parcels of land is associated with high energy consumption. They demonstrate that households' energy consumption decisions can be linked to households' characteristics, ecological variation and expanding capitalist economy.

2.2.1.3 Household expenditure

Mekonen and Köhlin (2008) show that consumption of each fuel type increases for households as their total expenditure increases, a result that was statistically significant for all fuel types except charcoal. This seems to indicate that in their sample, even consumption of traditional fuels, such as wood, increased as total household expenditure rose. It can therefore be concluded that wood is not an inferior good as suggested in literature, particular in the energy ladder hypothesis (Gor, 1994; Sasia, 1987). KIPPRA (2010) shows that the households' proportion of kerosene expenditure in the supply portfolio is high compared to the other fuels, which is consistent with findings where most households indicated that they spent a large portion of their household budget on Kerosene.

Fuel expenditure is related to appliances that are used in its consumption and it is important that they be considered when analyzing energy demand. In this sub section, I make a note on household fuel demand and appliances use. Its modelling follows fuel demand estimations and therefore this essay can greatly benefit from their review in terms of methodology used and policy implications. A number of studies (Housman, 1979; Dubin and McFadden, 1983 and Dubin, 1985) have made impressive attempts to model the joint determination of appliance demand and use with micro data on households. Baker *et al*. (1989) uses data drawn from the Annual Family Expenditure Survey (FES) of Great Britain and is pooled from the surveys for the years 1972-1983, obtaining a sample of over 80,000 households. The FES data collects detailed individual information about expenditures on different types of fuel, with separate headings for gas, electricity, coal, coke, central heating oil, paraffin and other fuels which mainly comprise of calor gas[2] and firewood.

In general, expenditures at the household levels are recorded in diaries over a two week period. In the case of fuels, this only applies to expenditures on coal and coke, oil (prior to 1977), paraffin and other fuels. They developed a theoretical model using a two-stage budgeting framework of household allocation of expenditure conditional on durable ownership. Using this model, they estimated share equations which represent linear approximations suggested in their theoretical model. To assess the overall specification of the equations, a number of statistical tests designed to pick up functional form misspecification and heteroscedasticity in the error variance are contacted. The key variables in this study were the own and cross prices. This review is useful in giving direction on best choice of model for use in this essay, because the above authors use similar household data sets and issues analysed are related.

2.2.1.4 Price elasticity

In the past years, a number of studies on price elasticities of demand for energy have been published; they range from studies on electricity, downstream petroleum products and renewable energy. By use of an inter-country translog model of energy

[2] Calor gas is a brand of bottled butane and propane (hydrocarbons) which is available in Britan and Ireland. It comes in cylinders, which have a special gas regulator. Calor was formed in 1935 and is the UK's leading supplier of liquefied petroleum gas (http://www.ask.com/question/what-is-calor-gas).

substitution response using a pooled international data, Griffin and Gregory (1976) found that own price elasticities are negative as anticipated and significantly different from zero. They further established that the cross price elasticities for energy and capital demand were substitutes and not compliments as was earlier suggested by Hudson and Jorgenson (1974).

Analysis of price responsiveness of petroleum demand shows mixed performance in many countries. In the US for example, Jones (1993) notes that price responsiveness began to attract a great deal of attention following the unexpected and substantial oil price increases of 1973-74. This phenomenon triggered many econometric studies which tried to address the underlying problem by primarily focusing on estimating short run and long run price and income elasticities of individual energy resources (coal, oil, natural gas and electricity). According to Jones (1993), single equation studies are often justified as efficient shortcuts or reduced forms for identifying the central behaviour of aspects of a particular market. They further analyse the extent to which the existing empirical results from single-equation studies of aggregate US petroleum consumption have been influenced by researchers' choice of dynamic model specification.

Baker *et al*. (1989) argue that many attempts have been made to model the effect of price changes on domestic demand both for the total of all forms of energy and for specific types of fuel. In their quest to contribute to this line of investigation, they modelled household energy expenditure using micro-data. Their argument is that much of the policy discussions on energy suffer from the absence of micro-economic data. Consumers' demand for fuel is best viewed within a household production framework where the underlying demands are for services such as heat, light and refrigeration, among other factors. This may vary in developing countries such as

Kenya due to differences in income, culture and weather patterns. To obtain this framework, in developed countries such as the UK one requires two things: a durable appliance to produce the service and fuel to power the appliance. This means that to consume certain forms of energy, one requires specific appliances to enable use of these fuels. Demand for energy is thus a joint demand for an appliance stock and for its rate of use. Fuel prices therefore affect both the rate of use of an appliance and the decision about ownership of the durable itself, the latter being determined by a trade-off between capital and operating costs.

Baker *et al.* (1989) disaggregates elasticities by demographic characteristics. For each sub group of households, the elasticities are evaluated at the corresponding group means of the data and for each household in the group; the median elasticity is selected for presentation purpose because it is not affected by outliers. The results show that, conditional on durable ownership, both gas and electricity are necessities, as one would expect, and are therefore price inelastic (especially gas). In addition, income elasticities are negative for both fuels, indicating inferiority, for about one-third of total households in the sample. This demonstrates the importance of using micro-data to get a full picture of household behaviour. Some negative values of gas consumption are explained by the ownership of electric central heating. For households with such central heating, increases in income are distributed more towards electricity consumption. The top deciles of the income distribution have the lowest income elasticity, something true of both gas and electricity. By buying new appliances, households experiencing higher income may well increase consumption of fuels among other things. The implications from Baker *et al.* (1989) is that important inter-relationship between characteristics, prices and income in the study show the usefulness of working at the micro rather than aggregate level, and this carries over welfare measurement. The welfare cost of subsidizing or taxing fuel prices will differ substantially across households with differing income and other characteristics. This issue is addressed further in chapter four of this study.

According to the Government of Kenya (1978), the major factors explaining Kenya's economic problems were caused by imported oil and high oil prices that put pressure on domestic prices. This is evident by the Central Bureau of Statistics (CBS) study done between 1969-1977. From the study, oil was the major commercial energy in Kenya and it was wholly imported. A similar situation is also evident today. However, Kenya has discovered oil deposits in the Lokichar Basin in Turkana County and these prospects may change the status quo on oil imports drastically.

Another notable study on energy demand in Kenya is that by Kimuyu (1988). Using a dynamic log- linear model, the study investigated energy demand in Kenya for the period between 1963 and 1985. The analysis used time series data. Similar to other studies such as Sterner (2007), it was established that energy demand is quite price inelastic and responds more readily to income changes than to price changes in both the short and long- run.

Bohi and Zimmerman (1984) concluded that the short run price elasticity for energy used in the residential sector was -0.2, while the long run was -0.7. They also argued that the wide variance of the elasticity estimates from the available studies make it difficult to report the price elasticity for energy use in the commercial or industrial sectors. Filippini (1999) uses a log-linear stochastic equation to estimate residential electricity demand and finds that the price elasticity was -0.3, which is a moderate responsiveness of electricity consumption to changes in price.

Dah (2011) argues that although income and price elasticities for gasoline and diesel fuel are not found to be the same at high and low incomes and at high and low prices, patterns emerge that allow for the development of suggested price and income elasticities for gasoline and diesel demand for countries in both developed and developing world. She further finds that the price elasticities cluster around the medians with the distributions skewed to the right, making the mean more elastic than the median. Although the range of estimates is wide, outliers are usually explainable and the removal of the most extreme explainable price elasticities puts the mean and median quite close to each other.

KIPPRA (2010) found that with an exception of fuel wood and LPG, the Hicksians' own price elasticities are smaller in magnitude compared to the Marshallian elasticities. This suggests that the pure effect of substitution is only partially compensated by the income effect. For some cross price elasticities, while Marshallian estimates are negative, Hicksian estimates are positive. This suggests that the income effect in these cases outweighs the substitution effect.

Generally, the differences in models and techniques used in both energy demand lead to criticism and counter-criticism over the technique used, but not one technique has ever been shown are either good or especially bad in price elasticity estimation. The selection of the models depends on the availability of data and research objectives (Fan and Hyndman, 2010).

2.2.1.5 Household characteristics and energy consumption

Household characteristics are important in energy consumption. Baker *et al*. (1989) argues that there are certain key variables that are important in energy demand studies. These variables are household size, which leads to increase in energy shares, age of household head, number of rooms and temperature that varies with time and region among other factors. These results are supported by Ngui *et al*. (2011) and Nyang (1999).

Nyang (1999) found that charcoal and LPG use increase expenditure and aggregate energy consumption because their main end use is cooking. Cooking accounts for the bulk of household energy consumption. On the other hand, main end-use of electricity utilises relatively low power, but high quality applications such as lighting, refrigeration and entertainment, rather than cooking. These results in the case of Kenya are also supported by Ngui *et al.* (2011) over ten years later, meaning that electricity use in the country has not been diversified like in middle and high income economies. With regard to gender, female headed households are more likely to choose either solid fuels only or a mix of solid and non solid fuels as their main fuel. Households headed by older persons are more likely to choose solid fuels only as their main fuel, probably due to the force of habit as non-solid fuels are relatively more recent and young household heads are more likely to adopt them. This is because young households are likely to be more educated and conscious about their living standards such as ambient air. Households with more members are more likely to use charcoal and wood, and less likely to use kerosene. Household size seems to be a proxy for poverty in many developing countries.

Households with a larger proportion of women were more likely to use charcoal, but it did not affect the choice of the other three fuel types (Baker *et al.*, 1989). The random effects model shows that more household members consume more electricity and kerosene, but wood and charcoal consumption does not depend on family size. However, the proportion of women in the household did not influence quantity of fuel demand, except for wood where a reduction in quantity demanded was observed for households with more women. Mekonen and Köhlin (2008) show that households with a more educated household head were more likely to have non-solid fuels as their main fuel. This is because households headed by more educated persons tend to be more prosperous.

2.2.1.6 Energy demand modelling

Much progress has been made in energy modelling with many new and innovative methodologies tested in both discrete and time series data. In this essay, I focus more on models that have used household survey based data sets that are useful in adopting to the Kenyan case. Deaton and Muellbaur (1980) estimated an Almost Ideal Demand System (AIDS) model. In their study, they discussed the theoretical specification of the AIDS, used British data and tested the homogeneity and symmetry demand restrictions with the results. Their results were consistent with earlier findings in that both sets of restrictions are decisively rejected. Their findings further suggest that imposition of homogeneity generates positive serial correlation in the errors in those equations and this, therefore, rejects the restrictions most strongly. The argument is that the standard rejection of homogeneity in demand analysis may be due to insufficient attention of the dynamic aspects of the consumer behaviour. Their work recommends the AIDS model as a vehicle for testing, extending and improving conventional demand analysis. Baker *et al*. (1989) uses a similar model to analyse energy expenditure using microdata and his findings support Deaton and Muellbaur (1980).

The review of literature on systems of equations seems to suggest that the starting point in demand modelling is the specification of a function which is general enough to act as a second order-approximation to any arbitrary direct or indirect utility function or more rarely, a cost function as asserted by Deaton and Muellbaur (1980). The flexible functional form property of the AIDS cost function implies that the demand functions derived from it are first order approximations to any set of demand functions derived from utility maximising behaviour. Therefore, according to Deaton and Muellbaur (1980), the AIDS model is as general as other flexible forms such as the translog or the Rotterdam models. Their paper tests symmetry; whether or not homogeneity is rejected. Many economists choose not to test for homogeneity, treating absence of money as a maintained hypothesis; the test of symmetry as a result becomes an interesting one (Deaton and Muellbaur, 1980). It is argued in the paper that even if the maintained hypothesis turns out to be false, tests based on it are not necessary without interest. They provide unconstrained parameter estimates and tests of homogeneity for commodities such as food, clothing, housing, fuel, drink and tobacco, transport and communication, other goods and services. Their results show that food and housing are necessities, while the other goods and services are luxuries.

Lastly, Deaton and Muellbaur (1980) conclude that the AIDS model is capable of explaining a high proportion of variance of the commodity budget shares. This is an indication of the suitability of the model in explaining demand analysis. However, the model has shortcomings because unless allowance is made for omitted variables by the arbitrary use of time trends, the approach is inconsistent with the hypotheses of consumers making decisions according to the demand functions governed by conventional static budget. Their results therefore seem to suggest that other factors other than current prices and current total expenditure, must be systematically modelled, if the broad pattern of demand is to be explained in a theoretically coherent and empirically robust way in order to produce better results.

According to Green and Ashton (1990) researchers should employ the AIDS price elasticity formula only when they have estimated the AIDS. In their empirical work, the two (AIDS and LA/AIDS) approaches led to essentially identical elasticity estimates. They recommend use of a theoretically correct formula for reliable results. Their observations are important in this study.

2.2.2 Summary of literature reviewed

This literature review brings out theoretical, empirical and methodological issues in household energy demand, deepening understanding on energy issues and forms the basis of model choice, estimations, interpretation and crafting policy strategies. The literature review has shown that energy choice, energy capital complimentarity and substitution, and household expenditure in energy goods and services, are important in energy demand studies. Other important factors include household income and energy prices, household characteristics such as sex and age of household head, household size, household composition, education attainment and occupation, among other factors.

From the review, it is evident that the theoretical foundations of the models used are important. Most models that have been used are based on micro-economic theories though macroeconomic models are important in analysing the impact at the macro level, where data is highly aggregated for the entire country or national population. Most of the models reviewed are based on the consumer utility theories, and in most cases, the random utility theories. Some of the key models allowed for the construction of a constant utility based measure of household welfare that is mainly used to identify welfare costs and benefits of energy price changes. In many of the studies reviewed, consumption for some fuels was split into various groups such as cooking fuel, transport fuel and heating fuels, depending on the level of development in a particular country or context.

Review of empirical models used in most energy studies show that the choice of functional form for the representation of consumer preferences must stand as one of the most important issues in any aspect of the empirical analysis of consumer behaviour. Most models that have been used include: ordinary least squares, probit, logit, multinomial logit models and Almost Ideal Demand System. The Heckman's two-step estimator has been used especially where the data has sample selection problem. Inter-country translog models of energy demand and substitution have also been widely used.

The review on systems of equations seems to point to the fact that the starting point has been the specification of a function, which is general enough to act as a second order-approximation to any arbitrary direct or indirect utility function. From the literature, the AIDS model is widely recommended in energy demand studies that look at the entire basket of goods demanded to meet a particular need. However, Deaton and Muellbaur (1980) caution that it does not imply the system, particularly in its static form, is to be regarded as a fully satisfactory explanation of consumer behaviour. Most studies that have used AIDS models have employed time series, cross sectional data and panel data sets obtained from national household surveys, family expenditure surveys and national energy surveys, both at the micro and macro-levels at the inter-country setting.

2. 3 Conceptual Framework

The conceptual framework in this chapter attempts to connect households' energy demand and welfare. It provides a conceptual rooting between energy demand and elasticities computed on one hand, and household welfare, on the other, so that it is in line with overall objective of the thesis.

The framework is premised on a consumer whose problem is to choose an option among mutually exclusive alternatives of available forms of energy/fuels to the household. The choice of the consumer depends on two crucial aspects; namely tastes or preferences and feasible alternatives (constraints). The aim therefore is to advance a theory with these two aspects. From theory, one is then able to make statements/predictions about consumer behaviour in fuel consumption and thereafter link it to welfare. Energy consumption and welfare links can be explained through various channels. First, fuel prices may increase due to imposition of a new tax or increase of existing taxes or global price volatility. Increase or reduction of prices due to these transmission mechanisms will have profound impact on the consumer, depending on the nature of fuel and current income of the household. The income of the consumer may lead to increased consumption, if the fuel in question is a normal goods or reduction in case of inferior good.

2.3.1 The utility function

An analysis of consumer choice using the axioms of consumer choice is important in understanding utility maximisation (Mas-Collel *et al*., 1995). In this essay, the aim is to analyse energy demand and estimate own, cross and expenditure elasticities. These elasticities are later used in the third essay when analysing household welfare impact from price increases. However, before any demand system is estimated, it is important to understand the various axioms of utility maximisation to a consumer who is faced with a decision to optimise energy consumption at the household.

In order to understand how consumers make choices, a simplified analysis of introducing the concept of a utility function is provided. The main advantage is that one can apply standard constrained maximisation tools to the problem. A utility function means basically that each bundle is associated with a real number. The number indicates the bundle's place in a preference ranking.

2.3.2 Ordinary demand and comparative statics

The solution to the maximisation problem depends on preferences, prices and income. The solution to the factors of consumption gives the demand for the goods as functions of prices and income. This is called the ordinary demand functions or the Marshallian demand functions. From these, it is possible to obtain comparative statics (how equilibrium values of demand changes when exogenous variables such as income and price changes). For example, if price increases, there are two effects on demand; substitution effect and income effect (Varian, 1992).

2.3.3 Reflection on using consumer theory and welfare

Consumer analysis is not just a matter of consumers' reactions to prices. One can pick up the effect of prices and incomes on attainable utility -consumer's welfare. This is important and useful in the design of economic policy, particularly with regard to fuel consumption. Energy costs have profound impact on production of goods and services as well as in the final consumption. As a result, understanding how the various fuels interrelate in the energy demand system and the magnitude of the impact which is indicated by magnitude of coefficients and elasticities is important. Elasticities point to the likely impact and distributional consequences by the various income groups or location of households, as a result of price changes or related fiscal policy.

There are two key functions that explain utility derived from consuming a good or service. The utility function maps prices and budget into maximal utility: u= v (p, m), while the cost function maps prices and utility into minimal budget that is m= e (p,u). Given the above formulation, we can arrive at the following two solutions to the utility function:

$$u = v(p, e(p, u))$$

$$y = e(p, v(p, m))$$

The two solution functions have to be consistent with each other and the maximum utility from $e(p, u)$ is$u$, while the minimum expenditure necessary to reach utility $v(p, m)$ is m.

Given the above theoretical framework, it is important to analyse energy demand and compute own and cross price elasticities; and income/expenditure elasticity using a formula suggested by Green and Alston (1990). Empirical formulation of the LA-AIDS model and computation of elasticities is presented in Section 2.4.

2.4 Methodology of Study

The methodology used in this essay involves a model of demand for fuel based on the LA-AIDS. This is because the model is widely recommended in energy demand studies that look at the basket of goods demanded to meet a particular need as is the case in this study. The household is taken as the unit of analysis.

The model is based on utility theory and it is hypothesised that the individual utility derived from the purchase of fuels is weakly separable from quantities of all other types of goods purchased by the household. This means that the overall consumer decision problem can be broken down into separate parts, some of which could be estimated separately. As a result, it is assumed that households follow a multistage process to allocate their budget to energy needs. This is done in two stages. First, the total spending is allocated to broad categories of goods, namely fuels, and all other non-fuels. Secondly, I allocate the group expenditure among various commodities in a particular group based on prices of individual commodities and the expenditure allocated to that group in the first stage.

2.4.1 Energy demand model

The principal theoretical model used in empirical specification is based on works of Blundell (1988) and Baker *et al.* (1989). The model aims to achieve two objectives. First, it allows us the possibility of constructing a constant utility based measure of household welfare, which could be used to identify the welfare costs and benefits of energy price changes and subsidies paid to particular energy items such as cooking and transport fuels. In this essay, fuels are split into two main groups' domestic fuels comprising of kerosene, electricity and LPG, mainly used for cooking, lighting and heating. The second category includes the transport based fuels, which include PMS and AGO. The categorisation is based on their main use. For the purpose of demand modelling, the analysis takes into account these five fuels that are consumed within the household and leaves out other fuels such as fuel wood, charcoal, material residue, solar and biogas among others, although they form a considerable share in a households budget, particularly in rural and informal settlements in urban areas. The choice for these fuels is motivated and guided by policy given that they are regulated by the Energy Regulated Commission and attract formal taxes unlike other fuels such as charcoal and fuel wood. The budget shares for these fuels are taken as the dependent variables. Baker *et al.* (1989) notes that expenditures on electricity and gas are rather accurate, but other fuels expenditures are subject to large measurement errors due to severe lumpiness in purchases. Therefore, assumptions made in this essay limit us to the extreme case where other fuel expenditure and total fuel expenditure are treated as unobserved.

2.4.1.1 Two stage budgeting model

I begin by specifying a two-stage budgeting model that explains expenditure decisions on fuels and all other non-fuel goods. This can be represented by a recursive structure such that the household first appears to allocate income between fuel and non fuels and then at the second stage, the fuel expenditures are disaggregated. The restriction that the two-stage budgeting imposes on households behaviour following Baker *et al.* (1989), is shown in the following expenditure system;

$$e_j = F\left(P_j; X\right), \qquad (2.1)$$

$where\ j = Kerprice, Elecprice, LPGprice, PMSprice\ and\ \ AGOprice$

e_j and P_j are the expenditure and price for the jth fuel and X is total energy expenditure. $Kerprice, Elecprice, LPGprice, PMSprice\ and\ AGOprice$ stand for Kerosene price, Electricity price, LPG price, PMS price and AGO price, respectively. Disaggregated fuel expenditures depend only on relative fuel prices and total fuel expenditure. This is equivalent to assuming weakly separable household preference between fuel and non-fuel good (Deaton and Muellbauer, 1980a) and is an expression of the expenditure on energy goods as indicated in equation (2.1) above. The essay considers households durable stocks in a rather different light since these cannot be reasonably considered weakly separable from energy consumption. Since I make an assumption that e_j and (therefore X) to be unobserved, an impression for X must be found (Baker *et al.*, 1989).

If y can be defined to be net income and p_N to be price index composite of all non-fuel goods, the first stage of the two stage budgeting rule can be expressed as:

$$X = g(P, P_o, p_{N,} y) \tag{2.2}$$

Substituting (2.2) in (2.1) for j=*e* and g generates estimating equations of the form:

$$e_j = \tilde{f}(P_j, P_o, y) \tag{2.3}$$

$for\ j = Kerprice, Elecprice, LPGprice, PMSprice$ and $AGOprice$. $P_j\ and\ P_o$ represent price of fuels and price of other goods, respectively.

In order to parameterise equation (2.3), a functional form for preferences is required. Within fuel expenditures, I assume quasi-homothetic preferences with the implication that the cost of achieving a level of utility $U_f(q_f)$ is:

$$C\ \ p_f, U_f\ \ = \alpha\ \ p_f\ \ + \beta\ \ p_f\ \ U_f(q_f) \tag{2.4}$$

where $\alpha(.)$ and $\beta(.)$ are both linear homogeneous convex functions of the vector of fuel prices p_f. $\beta(p_f)$ can be thought of as the price index for 'supernumerary' fuel expenditures above a necessary level given by $\alpha\ \ p_f$. As alluded above, energy commodities enter a household production process whose outputs are heat, light and power. It is unlikely that the energy inputs themselves are separable and the functional form for $\alpha\ \ p_f$ described in equation 2.5 is chosen to reflect this.

Following the specification shown in equation 2.4, three elements are important in this essay: household which is the unit of analysis, the basket of goods consumed and the expenditure allocated to each item. At the household level, I have the fuel and non fuel goods. I assume that households allocate their total expenditure denoted by Y to all consumption goods $x_i \dots\dots\dots .x_m$. These consumption goods can then be uniquely allocated to a smaller number of commodity groups represented by commodity vectors $q_1 \dots\dots\dots .\, q_d$, where $d < m$. The number of commodities in the smaller commodity group should contain fewer items than what is contained in the basket of all consumption goods.

For the purposes of this essay, I assume only two commodity vectors, namely fuel which is denoted as q_f and non-fuels q_n commodity groups. If we assume utility derived from consumption of these commodities is weakly separable across these groups, the direct utility following Blundell (1988) can be written as:

$$U(x_1 \dots .., x_n) = \psi[U_f(q_f), U_{nf}(q_{nf})] \tag{2.5}$$

Allocation of expenditure to any X_i in q_z may be expressed as:

$$P_i\, x_i = \psi_i(P_z, y_z) \;\; for\; i = 1, \dots .m\; and\; z = f, n. \tag{2.6}$$

Equation 2.6 represents the second stage of the two-stage budgeting process where ψ_i is related to the utility function because agents derive utility from consuming goods and services which are determined by price and income or expenditure. P_z is the vector of prices corresponding to q_z and y_z is the allocation of total expenditure to fuel category z.

The utility functions $U(.)$, $\psi(.)$ and each $U_z(q_z)$ are assumed to be concave and continuous, with the assumption that the budget constraint is linear. In this case, therefore, it is implied that the expenditure equation 2.6 is linear and homogeneous in P_z and y_z and that the Hicksian or Compensated price derivatives are symmetric and form a negative semi-definite Slutsky Substitution Matrix. The Slutsky equation breaks down a change in demand due to price change into the substitution effect and income effect. Note that once y_z is determined at the first stage, each q_z can be determined without reference to prices outside this group.

Assuming homothetic preferences within the group, that is elasticity with respect to the total within the group expenditure is unity, and since I have five fuels, the expenditures in equation 2.6 can be written as:

$$e_j = P_i\, x_i = \psi_i(P_z)y_z) \; for\; i = 1, \dots .5 \; and \; z = f, n. \qquad (2.7)$$

Following equation 2.7, I can formulate expenditure shares for each spending by the household by goods consumed such that each expenditure share W of good *i* out of group z, expenditure y_z is given by:

$$w_i = \psi_i(P_z) \qquad (2.8)$$

Further transformations from equation 2.8 to obtain linear Engel Curves and the utility function representing the maximum utility attainable corresponding to given value of prices and income for group z using Roy's identity and other details for exposition and convenience are provided in the annex (Appendix II(a)-(2.8a-2.8g).

2.4.2 Empirical model

This sub section provides the empirical model estimated in the essay. It presents the share equation that has been reduced to the Almost Ideal form. Prior steps to this derivation are provided in Annex II following Ngui *et al.* (2011) for exposition and convenience. The reduced share equation is of the form:

$$\omega_i = \alpha_i + \sum_{i=1}^{m} \lambda_{ij}\, ln\, P_i + \beta_i ln\, (y/\alpha(P) \qquad (2.9)$$

where ω_i is the expenditure share of the i[th] commodity, α_i is the constant coefficient of the i[th] share equation, λ_{ij} are price coefficients associated with the j[th] commodity in the i[th] share equation, p_i is the price of the i[th] commodity, y is the total expenditure on the system of all commodities given by $y = \sum_{i=1}^{n} p_i q_i$ where q_i is the quantity demanded for the i[th] commodity. β_i are the expenditure coefficients, indicating whether commodities are necessities or luxuries. If $\beta_i < 0$, ω_i decreases when y increases so that commodity *i* is a necessity. Conversely, if $\beta_i > 0$, ω_i increases with y, commodity *i* is a luxury. *P* is a general price index defined as (Ngui *et al*., 2011):

$$\ln P = \alpha_0 + \sum_{i=1}^{n} \alpha_j \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \lambda_{ij} \ln P_i \ln P_j \qquad (2.10)$$

From the foregoing and in order to comply with the theoretical properties of consumer theory, the following restrictions are imposed on the parameters of the AIDS model:

$$\sum_{i=1}^{n} \alpha_i = 1, \sum_{i=1}^{n} \beta_i = 0, \sum_{i=1}^{n} \lambda_{ij} = 0 \quad \text{(Adding up)} \qquad (2.11)$$

$$\sum_{j=1}^{n} \lambda_{ij} = 0 \quad \text{(Homogeneity)} \qquad (2.12)$$

$$\lambda_{ij} = \lambda_{ji} \quad \text{(Symmetry)} \qquad (2.13)$$

The above equations are important due to the desired properties of adding up, homogeneity and symmetric properties. From this formulation, equation 2.11 allows the budget share to sum up to unity, that is it is assumed that the budget expenditure by item for all commodities sum up to unit. In this case, therefore, the budget shares for Kerosene, Electricity, LPG, PMS and AGO should add up to one (1) and this is consistent with theory given the weak seperability assumption. Equation 2.12 is based on the assumption that a proportional change in all prices and expenditures does not affect the quantities purchased, while equation 2.13 represents consistency of consumer choices.

Insights and experiences from literature review have shown that demand for energy is also influenced by other socio-demographic variables other than price and expenditure. These include: household size, total expenditure, gender, education, employment status and geographic locations. To capture the effect of these variables on the energy demand functions, the intercept of equation 2.9 was modified according to the demographic translating method (Heien and Wessels, 1990), which assumes that the other parameters in the demand system do not depend upon the social-demographic variables. According to the translating method, α_i was modified as:

$$\alpha_i = \omega_{i0} + \sum_{k=1}^{K} \omega_{ik} d_k; \quad i = 1, \ldots, m. \tag{2.14}$$

ω_{i0} and ω_{ik} are parameters to be estimated, d_k are demographic variables of which there are K. Incorporating equation 2.14 into equation 2.10 yields (Weliweta *et al.*, 2003):

$$\omega_i = \omega_{i0} + \sum_{k=1}^{K} \omega_{ik} d_k + \sum_{i=1}^{m} \lambda_{ij} lnP_j + \beta_i \ln [y/\alpha(P^*)] \tag{2.15}$$

P^* is the Stone Price Index given by

$$\ln \alpha (P^*) = \sum_{i=1}^{m} \overline{\omega_i}\, lnP_i \tag{2.16}$$

where $\overline{\omega_i}$ is the mean of the share equation.

To preserve adding property, equations 2.10 – 2.13 should hold with $\sum_{i=1}^{n} \alpha_i = 1$, replaced with $\sum_i \omega_{i0} = 1, \sum_i \omega_k = 0$

The presence of zero expenditure for some commodities for some households is a common feature in household data.[3] Including non-zero observations would result in selection bias, if non-purchasing households behave systematically different from purchasing households.

To solve this problem, a two-step estimation procedure based on Amemiya-Tobin approach is used to include all the observations at both steps to estimate a system of fuel consumption equations (Heien and Wessells, 1990). Following Heien and Wessels (1990), two decisions-whether or not to consume and how much to consume-are thus estimated separately. In the first step, the decision that a given household will purchase a specific commodity is determined from a probit regression of all available observations, taking the form:

$$Z_{ih} = f(P_{1h}, \ldots. P_{jh,} y_h, d_{1h}, \ldots, d_k) \qquad (2.17)$$

where Z_{ih} is 1 if the hth household buys the ith fuel (that is, if ω_{ih} >0) and zero otherwise. The other variables are as earlier defined. The maximum likelihood estimates from equation (2.17) are then used to compute the inverse Mill's ratio for each household h and each fuel group. The inverse Mill's ratio for the hth household that consumes the ith fuel is derived as:

$$x_{ih} = \frac{\theta(P_{1h}, \ldots. P_{jh,} y_h, d_{1h}, \ldots, d_k)}{\varphi(P_{1h}, \ldots. P_{jh,} y_h, d_{1h}, \ldots, d_k)} \qquad (2.18)$$

[3] This can be caused by the study period being too short to allow consumers to report any purchase of a specific product (infrequency of purchase), consumers not willing to buy the product (abstention), and consumers not purchasing the product at current prices and income levels (corner solutions) (see Angulo *et al*., 2001.

where θ and φ are the standard normal density and cumulative probability functions, respectively. The inverse Mill's ratio for the hth household that does not consume the ith fuel is derived as:

$$x_{ih} = \frac{\theta(P_{1h},....P_{jh,}y_h,d_{1h},...,d_k)}{1\text{-}\varphi(P_{1h},....P_{jh,}y_h,d_{1h},...,d_{k)}} \qquad (2.19)$$

In the second step, the inverse Mill's ratio for each household for each item is then used in equation 2.15 as an instrumental variable. The estimating model then becomes:

$$\omega_i = \omega_{i0} + \sum_{k=1}^{K} \omega_{ik} d_k + \sum_{i=1}^{m} \lambda_{ij} \ln P_j + \beta_i \ln\left[{}^{y}/_{\alpha(P^*)}\right] + \delta_i x_{ih} + \varepsilon_i \qquad (2.20)$$

ε_i is an error term. Heien and Wessells (1990) observe that the system will not add up if all n equations are specified as equation 2.20 which pertains only to the first n – 1 demand relations. In this case, adding up would require $\delta_i x_{ih}$ = 0, a restriction which is impossible since x_{ih} can assume any value. However, Heien and Wessels (1990) observe that the adding up constraint could be preserved by specifying the deleted equation as:

$$\omega_i = \omega_{i0} + \sum_{k=1}^{K} \omega_{ik} d_k + \sum_{i=1}^{m} \lambda_{ij} \ln P_j + \beta_i \ln\left[{}^{y}/_{\alpha(P^*)}\right] + \delta_i x_{ih} - \sum_{i=1}^{n-1} \delta_i x_{ih} + \varepsilon_i \qquad (2.21)$$

The complete demand model of the allocation of the fuel budget (Equation 2.21) can be estimated using Iterated Seemingly Unrelated Regression (ITSUR) technique together with homogeneity and symmetry restrictions maintained. Since the adding up condition makes the covariance matrix of the residuals singular, one equation has to be dropped from the system and the parameters of this equation calculated using the parameter restrictions of the system. The complete demand model of the allocation of the fuel budget in (2.22) is estimated using the Iterated Seemingly Unrelated Regression (ITSUR) to obtain determinants of budget shares in the five fuels. Further explanation on the SUR is provided below before moving to show how the elasticities are estimated. Demonstration and formulations of the SUR are summarised in Appendix II (b) following exposition and convenience by Wooldridge (2001).

The SUR is a generalisation of a linear regression model that consists of several regression equations, each having its own dependent variable and potentially different sets of exogenous explanatory variables. Each equation is a valid linear regression on its own and can be estimated separately. This is why the system is called seemingly unrelated. The SUR method is efficient and amounts to feasible generalized least squares with a specific form of the variance-covariance matrix.

2.4.2.1 Expenditure and price elasticities

Using the formulae suggested by Green and Alston (1990), I can now compute Marshallian (uncompensated), Hicksian (compensated) and expenditure elasticities from the estimated parameters of the LA-IDS model as follows:

$$e_i = 1 + \frac{\beta_i}{w_i} \qquad \text{(Expenditure elasticity)} \qquad (2.22)$$

$$\eta^*_{ij} = -\delta_{ij} + w_i + (\lambda_{ij}/w_j) \qquad \text{(Hicksian)} \qquad (2.23)$$

where δ_{ij} is the Kronecker delta, δ_{ij}=1 for i = j; δ_{ij}=0 for i ≠ j. The δ_{ij} applies only in the case of diognal elements.

$$\eta_{ij} = \frac{\lambda_{ij}}{w_i} - \beta_i \frac{w_j}{w_i} \qquad \text{(Marshallian)} \qquad (2.24a)$$

$$\eta_{ii} = -1 + \frac{\lambda_{ii}}{w_i} - \beta_i \qquad \text{(Marshallian)} \qquad (2.24b)$$

2.4.3 Data sets

This study uses data from the National Energy Survey (2009) for Kenya which interviewed 5,465 energy consumers (3,665 households and 1,800 enterprises), 853 energy providers and 180 key informant surveys. The aim of the study was to carry out an energy consumption pattern for Kenya. The study was funded by the Energy Regulatory Commission and the Ministry of Energy. This study's interest is the household data since the unit of analysis is the household. The data was collected in the eight provinces of Kenya, although this has now been replaced by 47 county governments as indicated in Kenya's constitution (2010). The data collection in the eight provinces was guided by boundaries of the old districts jurisdictions. It is these old districts that have been converted in to Counties. After selection of a representative sample from the selected districts, information was sought from various divisions and locations and whether a household is located in rural or urban areas. The sample selection was done using the National Sample Survey and Evaluation Programme (NASSEP) IV by the Kenya National Bureau of Statistics (KNBS). The sample selection process was scientific and representative of the population in the country.

Income groups

In order to achieve comparability with the National Survey Data, the sample was categorised into relatively homogenous groups based on their monthly income levels. This is because consumers with low income tend to spend a greater proportion of their income on food and other very basic necessities, while those with higher income spend more on luxuries. From the 2005/06 Kenya Integrated and Housing Budget Survey (KIHBS) framework, three income groups (lower, middle and high) exist.

According to KIHBS, those earning below Ksh. 23,670(US$ 307) are classified as low income, while those earning between Ksh. 23,671(US$ 307[4]) and Ksh. 120,000(US$ 1,555) are classified as middle income. Further, those earning above Ksh. 120,000 (US$ 1,555) are the upper income group. For purposes of this study, I use household earnings and classify those earning Ksh. 20,000 (US$ 259) and below as the low income group while those whose income range between Ksh. 20,001(US$ 259) -100,000(US$ 1,296) will form the middle income group, while those earning more than Ksh. 100,001(US$ 1,296) will be classified as high income group. Classifying the income groups this way is consistent with income groups interviewed during the survey.

Table 2.4.1 summarises income groups that were used to obtain the three categories. From the data, about 4.3 percent of household heads were earning below Ksh. 2,500(US$ 32.4) per month, while 12.41 percent earned between Ksh. 2,501(US$ 32.4)-Ksh. 5,000 (US$ 64.8). Majority of the household heads that is 21.5 percent were earning between Ksh. 5001(US$ 64.8)-Ksh. 10,000(US$ 129.6) followed by those earning between Ksh. 20,001(US$ 259) -Ksh. 50,000(US$ 648) who accounted for 20.2 percent of total household heads in the sample. Other income groups are shown in Table 2.4.1. The three income groups constructed out of the nine groups are then used in estimation of the Seemingly Unrelated Regression (SUR) for the LA-AIDS models. In the new income groups, those households whose head was earning up to Ksh. 20,000(US$ 259.2) are 2,556 (69.74 percent), while those earning between Ksh. 20,001(US$ 259) -100,000(US$ 1,296), and over Ksh. 100,001(US$ 1,296) are 968 (26.41 percent) and 66 (1.8 percent), respectively. In this essay, the income of the household head is used to represent income levels at the households, since the

[4] 1US$=Ksh. 77.16 given the mean exchange rate of June, 2009.

National Energy Survey 2009 did not obtain income information for all members of the household. The household head income is only used for purposes of splitting the sample but not in the estimations as a dependent variable. The total household expenditure is used as a proxy for income. The household head is the principal decision maker at the household unit and thus the income reported is fairly representative because in actual estimation, it is the household expenditure that is used in the regression. Using total expenditure in the analysis is thus relatively accurate than using household head income, since households rarely reveal their true incomes.

Table 2.4. 1: Average Monthly Income of Household Head (Ksh.)

Average monthly of household head(Ksh.)	Freq.	Percent	Cum.
Below 2500	157	4.28	4.28
2501 - 5000	455	12.41	16.7
5001 - 10000	786	21.45	38.14
10001 - 15000	631	17.22	55.36
15001 - 20000	527	14.38	69.74
20001 - 50000	739	20.16	89.9
50001 - 100000	229	6.25	96.15
More than 100,000	66	1.8	97.95
Ungrouped	75	2.04	100
Total	**3,665**	**100**	

Source: Authors estimations from the National Energy Survey, 2009

The model formulations from equation 2.1 to equation 2.24b are sufficient to analyse issues of demand for energy. From the model, we are able to estimate and analyse the desired models for energy demand and price elasticities of demand by income group and region.

2.5 Empirical Analysis

This sub-section provides empirical analysis on the first objective of analysing energy demand and price elasticity's by income group. Specifically, it presents descriptive statistics and results from the SUR model as well as the Marshallian, Hicksian and expenditure elasticities.

2.5.1 Descriptive statistics

This sub section provides descriptive statistics of all variables used in this essay including the budget shares for Kerosene, Electricity, Liquefied Petroleum Gas, Premium Motor Spirit and Automotive Gas Oil. The budget shares are captured by dividing the expenditure of a particular fuel by the total expenditure for all five fuels considered in the model. The budget shares add up to one (1) and this is consistent with formulations by Blundell (1988) as well as Baker (1989) in the two stage budgeting model. The other variables include the regional dummies for Nairobi, Central, Coast, Eastern, North Eastern, Nyanza, Rift Valley and Western provinces. These dummies are captured as '1' or '0'; that is 1 if the household is located in that particular Province and 0 if not located in that particular Province. Formal and informal employment was used to capture the main forms of employment that heads of households, are engaged in and they have been captured as dummies. Household size is captured as number of persons in a household, while expenditure is the log of total expenditure in the household. The prices of fuels were captured as price per unit consumed, that is price per litre in the case of PMS and AGO fuels, Ksh. /kg in the case of LPG and Ksh./kWh in the case of electricity. Gender is captured using dummies, that is '1' if male and '0' if female. Lastly, education level of household head for primary, secondary, vocational training and no education at all are captured using dummies. In the final estimation model, logarithms were taken for prices and total expenditure.

From Table **2.5.1**, the budget share for fuel consumption varies in terms of the mean, standard deviation, minimum and the maximum. With regard to cooking fuels, kerosene's budget share is 0.148 of total fuel budget of the five fuels analysed in this study. Electricity and Liquefied Petroleum Gas have budget shares of 0.563 and 0.048, respectively. On the other hand, transport fuels have mixed results in terms of budget shares. In this essay, I have considered only two types of transport fuels that is PMS and AGO. The budget share for PMS is higher than that of AGO at 0.167 and 0.078, respectively. The former is higher than the latter mainly due to the fact that consumption of fuel per capita is higher for PMS, compared to that of AGO. Households are therefore most likely to devote more resources to its consumption.

With regard to prices, the mean prices were Ksh.72.09/litre, Ksh.11.39/kWh, Ksh.176.41/litre, Ksh.76.09/litre and Ksh.66.13/litre for kerosene, electricity, LPG, PMS and AGO, respectively. The log of total household expenditure is Ksh.15,744 per annum. With regard to employment, those in formal employment constitute 0.466 and those informal employments are recorded at 0.242. On the other hand, the mean size of a household is 5 persons; an indication that the Kenyan household is becoming smaller. Most of the households interviewed show that there are more female headed households than male headed. The female account for 0.613, compared to the male at 0.387. This phenomenon can be explained by increase in the number of single mothers or delayed marriages among the male counterparts. In addition, there is migration of labour from rural to urban areas of the males and this contributes to a high percentage of households headed by female. The mean dummies of household heads with primary, secondary, vocational training and no education were 0.290, 0.314, 0.211 and 0.068, respectively. Analysis of regional dummies show that most of the households were interviewed in Rift Valley, while North Eastern had the least interviewed households. Other attributes of the variables in this study are provided in **Table 2.5.1.**

2.5.2 Econometric analysis

This sub section presents results from the LA-AIDS model which is estimated by SUR. Since I have five equations to be estimated, the choice for a SUR was the most appropriate. The dependent variables for all the five equations are fuel budget shares, while the exogenous variables are the log of prices for fuels, demographic factors and regional dummies. All the exogenous variables in the five fuel equations are the same. To ensure identification of the demand system that is the fuel demand equations are distinct; an inverse mill ratio is introduced in each fuel share equation as an instrument variable. The inverse mill ratio is different/distinct for each particular fuel equation, and thus identifies each fuel equation from the other in addition to taking care of sample selection bias and gaps in the data. The inverse mill ratio for each household and fuel group is obtained from maximum likelihood estimates from respective probit regressions. The maximum likelihood estimates are then used to compute the inverse mill ratio using formulas outlined in equations 2.18 and 2.19 suggested by Heckman (1979; 1976), for households that use a particular fuel and those that do not consume, respectively. The two formulas assume the standard normal density and cumulative probability function respectively.

Table 2.5. 1: Descriptive Statistics of Model Variables

Variable	Mean	Std. Dev.	Min	Max
Kerosene budget share	0.148	0.162	0.000	1
Electricity budget share	0.563	0.337	0.000	1
LPG budget share	0.043	0.127	0.000	0.999
PMS budget share	0.167	0.261	0.000	0.860
AGO budget share	0.078	0.126	0.000	0.874
Kerosene price (Ksh.)/Litre	72.09	89.73	0.70	2,400.00
Electricity price (Ksh.)/kWh	11.39	5.42	0.07	100.00
LPG price (Ksh.)/kg	176.41	63.26	21.60	1,800.00
PMS price (Ksh.)/Litre	76.09	6.82	67.45	110.00
AGO gas price (Ksh.)/Litre	66.13	3.46	60.25	79.00
Total expenditure (Ksh.)	15,744.39	18,041.71	300.00	355,000.00
Log of kerosene price	4.155	0.463	0.000	7.783
Log of electricity price	2.753	0.602	0.000	10.309
Log of LPG price	5.142	0.234	3.073	7.496
log of PMS price	4.328	0.088	4.211	4.700
Log of AGO gas price	4.190	0.051	4.098	4.369
Log of total expenditure	3.223	0.784	0.000	6.637
Formal employment	0.466	0.499	0.000	1.000
Informal employment	0.242	0.428	0.000	1.000
Household size	5.145	3.011	1.000	50.000
Female	0.613	0.487	0.000	1.000
Primary education	0.290	0.454	0.000	1.000
Secondary education	0.314	0.464	0.000	1.000
Vocational education	0.211	0.408	0.000	1.000
No education	0.068	0.252	0.000	1.000
Central	0.123	0.328	0.000	1.000
Coast	0.086	0.281	0.000	1.000
Eastern	0.168	0.374	0.000	1.000
North Eastern	0.037	0.189	0.000	1.000
Nyanza	0.171	0.377	0.000	1.000
Rift Valley	0.237	0.426	0.000	1.000
Western	0.094	0.292	0.000	1.000
Nairobi	0.083	0.275	0.000	1.000

Source: Author's computations from the National Energy Survey, 2009

Before running the regressions, the equations to be estimated in the global demand systems were arranged each with its determinants, whose selection was mainly guided by economic theory and empirical literature reviewed earlier. The dependent variables for each equation were the fuel budget shares. Arrangement of the systems of equations was done following Wooldridge (2001) as outlined in the methodology chapter (see also Annex-A1). The aim of the essay was to estimate energy demand for the global or overall model, and then estimate by income groups and location of household. In order to achieve this, the households were grouped into low, middle and high income groups, while household location was characterised by rural or urban. The rationale for grouping the households in this manner is to ensure that the factors determining energy demand by income level were examined intrinsically. This is important because various households, depending on their income level, respond differently to the factors that influence fuel demand. While factors that influence household energy consumption may be similar, they may vary across income groups.

In the National Energy Survey 2009, information on average monthly income of the household head was captured by nine (9) income groups. For estimation purposes, these groups were re-organized into three groups; low, middle and high income. All households earning less than Ksh. 20,000 were classified as the low income group, those households earning Ksh. 20,001 to 100,000 as middle income, while those earning more than Ksh. 100,000 are grouped as high income. Although these groups are slightly outside the categorisation in KIHBS, they are not very ‘far’ from those categorised by KNBS. In addition, since the data collected in the National Energy Survey 2009 was in nine groups as indicated, for consistency, it was logical to choose income groups consistent with the way the data was collected. With regard to regression by household location, 2,417 of the households were based in the rural areas, while 1,244 were urban based.

2.5.2.1 Analysis of demand for fuels

Regression analyses from the LA-AIDS model shows that demand for fuels is driven by certain factors depending on the extent of use of the fuel and nature of fuel; whether cooking, lighting, heating, or transporting. Kerosene, electricity and LPG are mainly used for cooking, lighting and heating while PMS and AGO are used in transportation. AGO is mainly used in public transport vehicles and other high occupancy capacity engine vehicles, emergency electric power generation; and to power machines in the agricultural sector. However, it has been established, over time, that these fuels are mainly used for transport. The five fuels chosen in this essay can be taken as modern and clean, although kerosene use is associated with the poor and is utilised mainly in areas where access to electricity is minimal. In addition, Kerosene is less clean compared to the other cooking, lighting and heating fuels. In running simulation for the SUR, Kerosene is dropped but recovered later in computing the elasticities. Kerosene was dropped due to the recent government policy to zero rate it in taxes. The model estimated is a mixed log model. Some variables such as fuel prices and expenditure are estimated in logs, while other variables were discrete in nature. Discussions on key drivers for fuel demand are provided in sub sections 2.5.2.1.1 and 2.5.2.1.2 for cooking and transport fuels, respectively.

2.5.2.1.1 Demand for cooking, lighting and heating fuels

There are enormous variations in the level of consumption and the types of fuels used. While a precise breakdown is difficult, the main use of energy in households in developing countries is for cooking, followed by heating and lighting. Because of geography and climate, household space and water heating needs are small in many countries. This sub-section concentrates on fuels that are used for cooking, lighting and heating.

Households generally use a combination of energy sources for cooking that can be categorised as traditional (dung, agricultural residues and fuel wood), intermediate (such as charcoal and kerosene) or modern (LPG, biogas, ethanol gel, plant oils and electricity). Electricity is mainly used for lighting and heating in small appliances, rather than cooking. In many developing countries, it represents a small share of total household consumption in energy terms, although high in terms of monetary value[5]. Discussion in this sub section focuses on intermediate and modern fuels. Other studies such as Ngui *et al.* (2011) that have been done recently included traditional fuels such as charcoal and fuel wood, in addition to the fuels examined in this study. Their analysis, however, did not take into consideration income groups and location of households in terms of rural and urban.

Demand for electricity

Electricity is one of the modern sources of energy that is key to serving energy needs at the household level. In the household, it is mainly used for lighting, cooking, heating, laundry and cooling, among other uses. The budget share allocated to electricity is mainly driven by its own price, the price of kerosene and LPG; and the household size (**Table 2.5.2**). As the own price of electricity increases, the budget share allocated to electricity increases. These results seem to support findings in other studies such as Baker (1989) that found that electricity was a necessity. Households cannot do away with electricity use in their homes. Households that already have

[5] World Energy Outlook, 2006, http://www.worldenergyoutlook.org/docs/weo2006/cooking.pdf

access to electricity have accumulated gadgets, over time, such as cookers and water heaters. Since they are captive to their usage, when the price of electricity increases, they are more likely to expend more money in order to attain their desired consumption and utility levels. This is consistent to other findings such as Ngui *et al.* (2011) and Mekonen and Köhlin (2008). On the other hand, increasing the price of LPG would lead to higher allocation of electricity budget share because, if the price of gas increases, households would prefer to use electricity and therefore increase its budget share. The other important factors in electricity consumption are education and gender. In addition, it is important to note that low income households are less likely to use electricity compared to the middle and high income households.

In analysing demand for electricity, four models are estimated, that is, for all income groups' combined, low income, middle income and high income groups. The electricity model shows that increasing the own price of electricity by 1 percent would increase the budget share of electricity by 0.006 percent while it is 0.017 percent and 0.003 percent in the case of low income and middle income groups respectively. However in the case of the high income group, increasing the price by the same margin would reduce the budget share allocated to electricity by 0.003 percent. As expected, the low income households are most likely to increase their budget share, while the high income group marginally decrease the share compared to the other groups. The decline in budget share for electricity for the high income group can also be explained by the nature of tariff design of electricity, where the tariff increases as one consumes more units above the consumption band recommended for residential households in the tariff design. The low income groups have low income and are, therefore, likely to allocate a higher percentage of their income on electricity consumption, hence higher impact on budget share.

With regard to prices of substitutes, increasing the price of LPG by 1 percent will increase the budget share allocated to electricity by 0.012 percent in the low income group on electricity budget share while in the case of middle and high income groups, the budget share would increase. This means that households are likely to increase their usage of electricity if LPG prices increase, hence allocate more of their budget to the former if all other factors remain constant. On the other hand, reducing the price of Kerosene by 1 percent would increase the budget share allocated to electricity by 0.022 percent in the global model, while the low income, middle income and high income groups would increase their budget shares by 0.026 percent, 0.002 percent and 0.027 percent respectively. Their findings seem to suggest that there is both income and substitution effects that result from reduction in kerosene price. Due to the price reduction, there is income effect which leads to substitution from the inferior good in this case kerosene to electricity which has a higher symbol status, hence increased budget share.

With regard to transport fuels, the budget share allocated to electricity had mixed results on price changes in PMS and AGO. Increasing the price of PMS by 1 percent will reduce the budget share on electricity by 0.007 percent for the middle income group and is statistically significant. This means that among the middle income groups, increasing the price of PMS would decrease the budget allocated to electricity. The poor who rarely use transport facilities that utilise PMS as the main fuel will most likely not use such a mode of transport, but other means such as public transport and non motorised modes. The coefficients for overall model/all income combined together and high income were not statistically significant.

Other variables had mixed results on electricity budget share. Increasing the household size by 1 percent would increase the budget share allocated to electricity by

0.001 percent among the low income households, compared to 0.001 percent and 0.002 percent for both middle and high income households respectively. However, middle income households have higher levels of significance compared to the high income group. On the other hand, increasing the expenditure by 1 percent would reduce the budget share on electricity by 0.107 percent for all income groups, while it is 0.035 percent, 0.0155 percent and 0.051 percent for low, middle and high income groups respectively. These results seem to suggest that household expenditure is a key driver of fuel budget share compared to other variables such as price, household size and gender. The results support other findings such as Baker (1989), Mekonen and Köhlin (2008), Bohi and Zimmerman (1984) and Filippini (1999).

From this analysis, it was evident that increasing household expenditure for middle and high income groups was more likely to increase the budget share that was allocated to electricity, if their income levels increase. This is consistent with other studies that have argued poor households have many other competing needs and are most likely to spend their income on these other needs instead of electricity. Furthermore, they are likely to use other cheaper sources of energy such as fuel wood, charcoal and material residual (Ngui *et al*., 2011).

With regards to gender, female headed households are most likely to increase their budget share on energy compared to those male headed. However this is only significant for all income groups, low income and high income groups. A household headed by a female is likely to increase its budget share by 0.0188 percent holding the one headed by the male gender constant. This shows that there are significant differences between female and male headed households when it comes to decision making in fuel use. A female who is taking care of both cooking and lighting at the household is more conscious about fuel use than the male. In household headed by males, they do not care much to increase the budget share for fuels, since they do not directly prepare food or heat water among others. The comfort that comes with use of modern fuel is not a major concern to them. This is a preserve for females although they pay for the energy services. However in most cases, female chores are mainly done by females in both the households headed by either male or female, and they equally do them well despite the gender of the household head. This has implications on electricity consumption.

Those in formal employment and particularly those in low income households are likely to reduce their budget share on electricity from the total energy budget. This is because formal employment is likely to increase their income, and therefore expand their basket of energy goods. For example, they could increase their expenditure on LPG and other sources of energy. From the analysis, as the education level increases, so is the electricity budget for the primary and secondary level household heads. However, those who have vocational training are not likely to increase the budget share on electricity, since they already have a high income, therefore increased consumption of electricity may not have any impact on the budget share allocated to electricity.

The other important factors driving the electricity budget share include regional dummies for Coast, Nyanza and Western Kenya. More details are provided in **Table 2.5.2**.

Table 2.5. 2: Electricity Demand Model by Income Group

	All Income Groups			Low Income			Middle Income			High Income		
Variable	**Coef.**	**Std. Err.**	**z**	**Coef.**	**Std. Err.**	**z**	**Coef.**	**Std. Err.**	**z**	**Coef.**	**Std. Err.**	**z**
Log of electricity price	0.006	0.008	0.750	0.017	0.007	2.400**	0.003	0.002	1.410	-0.003	0.015	-0.190
Log of LPG price	0.003	0.003	0.820	0.012	0.006	2.030**	0.005	0.002	2.580**	0.010	0.006	1.880*
log of PMS price	0.005	0.006	0.850	0.001	0.001	0.650	-0.007	0.003	-2.260**	0.005	0.013	0.400
Log of AGO gas price	0.008	0.003	2.690**	-0.004	0.001	-4.520**	-0.003	0.001	-2.260**	0.014	0.016	0.900
Log of Kerosene price	-0.022	0.004	-5.130**	-0.026	0.005	-4.860**	0.002	0.003	0.530	-0.027	0.018	-1.530
Log of total expenditure	-0.107	0.007	-14.320**	-0.035	0.007	-5.380**	0.015	0.004	3.810**	0.051	0.022	2.330**
Household size	-0.004	0.002	-2.470**	0.003	0.001	2.150**	0.001	0.001	1.750*	0.002	0.005	0.460
Female	0.018	0.010	1.890*	0.017	0.008	2.110**	0.000	0.004	-0.010	0.055	0.030	1.850*
Primary education	0.245	0.015	16.580**	0.047	0.014	3.430**	0.001	0.007	0.150	-0.046	0.058	-0.780
Secondary education	0.198	0.014	13.980**	0.020	0.014	1.420	0.001	0.005	0.140	-0.032	0.038	-0.830
Vocational education	0.058	0.015	3.840**	-0.031	0.016	-1.910**	-0.010	0.005	-2.000**	-0.048	0.029	-1.640*
Formal employment	-0.112	0.010	-10.900**	-0.046	0.008	-5.490**	0.003	0.005	0.730	-0.029	0.034	-0.860
Central	-0.001	0.021	-0.070	0.121	0.020	6.170**	0.027	0.008	3.480**	0.010	0.045	0.230
Coast	0.038	0.023	1.630*	0.106	0.020	5.170**	0.014	0.008	1.640*	0.139	0.046	2.980**
Eastern	0.063	0.020	3.090**	0.142	0.018	7.860**	0.011	0.008	1.470	-0.084	0.060	-1.400
North Eastern	0.216	0.030	7.160**	0.271	0.028	9.750**	0.015	0.011	1.390	(dropped)	0.000	0.000
Nyanza	0.177	0.020	8.660**	0.173	0.018	9.890**	0.012	0.009	1.400	0.016	0.035	0.440
Rift Valley	0.100	0.020	5.090**	0.170	0.017	9.810**	0.011	0.008	1.340	-0.017	0.038	-0.440
Western	0.168	0.023	7.370**	0.164	0.019	8.630**	0.007	0.011	0.640	-0.118	0.047	-2.490**
Inverse mills for electricity	-0.063	0.122	-0.510	0.114	0.207	0.550	-0.048	0.093	-0.510	0.229	0.239	0.960
Constant	0.607	0.030	20.000**	0.652	0.027	23.820**	0.048	0.013	3.700**	-0.091	0.083	-1.100

Source: Authors SUR estimations from the National Energy Survey, 2009

*Dependent variable is Electricity Budget Share;** Indicates significance at 1% confidence interval;* Indicates significance at 5% confidence interval. *** n=3,658, 2,549, 739 and 67for all income, low income, middle income and high income groups, respectively.

Demand for liquefied petroleum gas

Liquefied Petroleum Gas is one of the widely used fuels among households in urban areas and among the high and middle income households. It is mainly used for cooking and heating. In the energy ladder hypothesis, it is assumed that as the income level of a household increases, the higher the likelihood of using LPG. Analysis in this study shows that increasing the own price of LPG by 1 percent would reduce the budget share allocated to LPG by 0.032 percent for all income groups (Table 2.5.3). When the low income group is considered, the price of LPG would reduce the budget share by 0.065 percent and is statistically significant. However, this is not the case for middle and high income groups. The main reason for this could be that low income households have other needs that have to be met before increasing their budget share for LPG. This supports the energy stacking hypothesis which stipulates that households are likely to combine two or more energy sources to meet their needs. The energy ladder hypothesis too seems to be satisfied in this case because the household is not willing to move to consume more of the cleaner energy, unless there is substantial shift in their income levels and the price of LPG is held constant.

The budget share allocated to LPG responds differently to changes in the price of substitutes such as electricity and kerosene as well as transport fuels in the basket of energy goods in a household. It is observed that an increase in the price of kerosene would lead to an increase in the budget share allocated to LPG. Households which are currently consuming LPG are most likely to increase its budget share if the price of kerosene increases, as households substitute kerosene with LPG. In the case of the high income group, there is a negative relationship between the price of kerosene and the budget share allocated to LPG. If the price of kerosene is reduced by 1 percent holding the price of LPG constant, the budget share on LPG would increase by 0.018 percent. This is because kerosene an inferior good to the high income households, and therefore they would substitute its consumption with LPG due to the income effect that has resulted from the kerosene price reduction.

On the other hand, increasing the price of electricity by 1 percent will marginally increase the budget share for LPG by 0.003 percent among the high income group and is statistically significant. However, this is not the case among the low and middle income households where it is not statistically significant, although it is inversely related. For the high income households, when the price of electricity increases, households will continue to use LPG since cooking with electricity will be more expensive. Increase in the price of PMS would lead to increased budget share allocated to LPG, when all income groups are merged together as well as among the low income households when the basket of fuels consumed at the household level are considered. This change of the budget could be due to increase in transportation cost for LPG since it has to be transported by road because Kenya does not have a gas pipeline. In addition, one is most likely to use a vehicle to go buy LPG or hire taxi services and therefore increase the budget share allocated to this fuel since the reason for making a trip was to make this transaction. Similar behavior in the budget share applies to the price of AGO.

With regard to gender, women are more likely to increase the budget share allocated to LPG when estimated together for all income groups and among the low income households. In the case of the low income households, women, who in Kenya are most likely to cook function at their households, are more likely to embrace more use of LPG and therefore higher budget share than the middle and high income who already have been using this fuel. This is consistent with the energy ladder hypothesis. The larger the household size, the lower the budget share that is allocated to LPG meaning larger families require more energy to cook and therefore are not likely to use more LPG than smaller ones, hence the relationship between the budget share and household size. Increasing expenditure by 1 percent would increase the budget share on LPG for all income groups; low, middle and high income by 0.002 percent, 0.0016 percent, 0.0144 percent respectively. However, it would reduce the budget share by 0.001% in the case of the high income group. All the results with respect to expenditure are significant apart from those of the high income group. This shows that increasing the household expenditure also means increasing the budget share allocated to LPG.

With regard to education, those with primary level are not likely to increase their budget share on LPG, particularly for the low and middle income groups. The same applies to secondary education and vocational training. The high income households are likely to reduce the budget share on LPG. Education is key to accessing high paying employment opportunities, and therefore important in determining budget share allocated to LPG. Those households whose head had secondary education among the high income group, will reduce their budget share by 0.007 percent compared to those with no education.

Lastly, given Nairobi as the reference point, all other regions are less likely to increase their budget share on LPG. The regional dummies have negative coefficients indicating that LPG is likely to be used more in Nairobi than other regions **(Table 2.5.3)**. Note that all education coefficients are chance outcomes (that is not significant) except secondary education on low and middle income group and vocational education on middle income.

Their interpretation is done to indicate the direction of the coefficient although they have no consequences on policy recommendation.

Table 2.5. 3: Demand for Liquefied Petroleum Gas

	All Income Groups			Low Income			Middle Income			High Income		
Variable	Coef.	Std. Err.	z	Coef.	Std. Err.	z	Coef.	Std. Err.	z	Coef.	Std. Err.	z
Log of electricity price	0.003	0.003	0.820	0.012	0.006	2.030**	0.005	0.002	2.580**	0.010	0.006	1.880**
Log of LPG price	-0.042	0.012	-3.600**	-0.065	0.011	-5.940**	-0.005	0.008	-0.570	0.008	0.022	0.380
log of PMS price	0.034	0.008	4.140**	0.000	0.003	-0.160	0.000	0.007	-0.030	0.005	0.031	0.160
Log of AGO gas price	-0.013	0.005	-2.810**	0.017	0.002	6.930**	-0.002	0.004	-0.690	-0.006	0.031	-0.190
Log of Kerosene price	0.018	0.005	3.430**	0.037	0.008	4.840**	0.002	0.005	0.390	-0.018	0.010	-1.730*
Log of total expenditure	0.002	0.006	0.300	0.016	0.010	1.680*	0.014	0.005	2.990**	-0.001	0.011	-0.100
Household size	-0.003	0.001	-2.490**	-0.005	0.002	-2.920**	-0.001	0.001	-1.050	0.002	0.002	1.410
Female	0.003	0.004	0.800	0.005	0.006	0.830	0.001	0.003	0.180	0.006	0.009	0.720
Primary education	-0.024	0.015	-1.660*	-0.069	0.023	-2.940**	-0.020	0.011	-1.760*	0.010	0.044	0.230
Secondary education	-0.009	0.009	-1.060	-0.043	0.015	-2.880**	-0.018	0.007	-2.670**	-0.007	0.020	-0.350
Vocational education	0.012	0.007	1.760*	0.008	0.013	0.680	-0.010	0.004	-2.210**	0.006	0.012	0.540
Formal employment	0.027	0.007	3.820**	0.050	0.011	4.660**	0.008	0.006	1.460	0.011	0.016	0.720
Central	-0.040	0.010	-4.180**	-0.056	0.015	-3.730**	-0.008	0.007	-1.060	0.014	0.017	0.870
Coast	-0.064	0.013	-5.020**	-0.116	0.021	-5.590**	-0.028	0.009	-3.040**	0.025	0.022	1.120
Eastern	-0.038	0.010	-3.800**	-0.075	0.016	-4.570**	-0.021	0.008	-2.780**	-0.002	0.021	-0.110
North Eastern	-0.098	0.017	-5.650**	-0.118	0.026	-4.490**	-0.060	0.012	-4.890**	-	-	-
Nyanza	-0.022	0.009	-2.350**	-0.063	0.015	-4.230**	0.011	0.008	1.380	0.003	0.013	0.190
Rift Valley	-0.046	0.011	-4.100**	-0.080	0.017	-4.710**	-0.022	0.009	-2.470**	0.015	0.018	0.830
Western	-0.032	0.013	-2.570**	-0.075	0.020	-3.790**	-0.029	0.011	-2.630**	-0.022	0.021	-1.040
Inverse mills for LPG	-0.009	0.012	-0.780	0.012	0.018	0.660	-0.007	0.009	-0.720	-0.027	0.033	-0.820
Constant	0.140	0.019	7.390**	0.185	0.028	6.540**	0.044	0.014	3.040**	0.038	0.049	0.780

Source: Authors SUR estimations from the National Energy Survey, 2009

Dependent variable is LPG Budget Share; ** Indicates significance at 1% confidence interval;* Indicates significance at 5% confidence interval. *** n=3,658, 2,549, 739 and 67for all income, low income, middle income and high income groups, respectively.

2.5.2.1.2 Demand for transport fuels

This sub-section provides the LA-AIDS model results for transport fuel. The models estimated are PMS and AGO. Generally, in Kenya, the number of vehicles owned by households in the country has been increasing over time. In addition, with increase in population, the demand for public transport has increased over the years, increasing demand for petroleum products. However, consumption of various petroleum products responds differently to the same factors that drive consumption. In this sub section, this study attempts to provide answers to these questions.

Premium motor spirit

PMS is mainly used in private transport. It is used to fuel cars with smaller capacity engines. Over the years, the consumption of PMS has increased due to an increase in motorisation. More Kenyan households now own cars and this was not the case years back, especially among urban dwellers and those in middle and high income groups.

Demand for PMS is driven by own price, prices of substitutes, total expenditure, employment, education level, and whether a household is located in a particular region, among other factors. Increasing the own price of PMS by 1 percent would lead to reduction of budget share allocated to PMS by 0.178 percent for all income groups and is statistically significant (**Table 2.5.4**). This is consistent with demand theory. The price effect for the low and middle income households would reduce the budget share for PMS by 0.356 percent and 0.21 percent respectively. The opposite is also true; that is reducing the price of PMS by 1 percent would increase its budget share by the same percentage points. This shows that households are somewhat responsive to PMS price changes in the short run. These results support findings by Jones (1993) and Dah (2011), who have supported the idea that income and price elasticities for gasoline are important in fuel budget share allocation. The price effect for the high income households is not statistically significant. This is consistency with studies that have indicated that over 70 percent of vehicles in Kenya are in Nairobi. Consistent with economic theory, increase in its own price (that it is the price of PMS) would lead to increase in the budget share. This means that households are likely to spend more on private transportation, if the price of PMS increased unless they switched to public transport. However, due to lack of alternatives, most households find themselves using private cars which consume more fuel per capita. Other important variables include total expenditure, education and household size. As the total expenditure of the household increases, the budget share allocated to PMS declines.

The price of AGO had a positive effect on the budget share allocated to PMS. Increasing the price of AGO by 1 percent would increase the budget share allocated to PMS by 0.129 percent if all income groups were lumped together in the estimations. This outcome is statistically significant and suggests that households would use private transport, if the price of AGO is increased and other factors held constant. With regard to the low income group, increasing the price of AGO would increase the PMS budget share by 0.351 percent. In the middle income group, a 1 percent increase in the price of AGO would increase the use of private cars and therefore the budget share of PMS by 0.214 percent. This is an indication that households are sensitive to price changes across transport fuels.

Increasing the price of cooking and lighting fuels, that is electricity, LPG and kerosene has mixed results on the budget share for PMS. The coefficient for electricity has a negative effect among the low and middle income groups and is statistically significant. This indicates that when electricity prices increase, these households are likely to spend more on electricity, since it is mandatory. They would rather have light and preserve food with electricity rather than increase their budget share on PMS. The price of LPG has a significant positive effect among the low income groups and when all income groups are estimated together. This indicates that households in these income bands will increase their budget share on PMS. LPG is bought in bulk in gas cylinders of 6kg, 12kg among others once a household has made such purchases, it will last for a longer period. In this regard, some households are likely to increase consumption of other fuels such as PMS, until the next purchase of LPG.

Other important factors in determining the budget share allocated to PMS are household size, education and regional dummies in low and middle income groups. Households whose heads have primary level education are more likely to reduce their budget share on PMS, when all income groups are estimated together. Those households whose head has no education and those with secondary education have a negative effect too for low income groups, while the high income group has a positive effect for households whose head has primary or secondary education. Those with formal employment among the middle income groups are likely to reduce the budget share on PMS, while this factor is not significant for the low and high income groups.

With regard to regional dummies, estimations from the LA-AIDS model show that households at the Coast region are likely to reduce their budget share allocated to PMS, while those in Eastern and Western regions will increase the same budget significantly, compared to Nairobi among the low income households. Middle income households will reduce their budget share on PMS in Eastern and Nyanza, while in Coast it has an increasing effect. The high income households in Eastern and Nyanza have an increasing effect. The model results for PMS are provided in **Table 2.5. 4**.

Table 2.5. 4: Demand for Premium Motor Spirit (PMS)

	All Income Groups			Low Income			Middle Income			High Income		
Variable	Coef.	Std. Err.	z	Coef.	Std. Err.	z	Coef.	Std. Err.	z	Coef.	Std. Err.	z
Log of electricity price	0.005	0.006	0.850	0.001	0.001	0.650	-0.007	0.003	-2.260**	0.005	0.013	0.400
Log of LPG price	0.034	0.008	4.140**	0.000	0.003	-0.160	0.000	0.007	-0.030	0.005	0.031	0.160
log of PMS price	-0.178	0.050	-3.560**	-0.356	0.040	-8.900**	-0.210	0.055	-3.790**	0.073	0.126	0.580
Log of AGO gas price	0.129	0.049	2.620**	0.351	0.040	8.780**	0.214	0.055	3.900**	-0.078	0.128	-0.610
Log of Kerosene price	0.010	0.006	1.570	0.004	0.001	3.570**	0.004	0.007	0.510	-0.005	0.025	-0.210
Log of total expenditure	0.071	0.011	6.640**	0.014	0.003	4.000**	-0.024	0.012	-2.080**	-0.037	0.033	-1.130
Household size	0.006	0.001	3.960**	0.001	0.000	3.540**	0.000	0.001	0.350	0.003	0.005	0.750
Female	-0.009	0.008	-1.130	-0.002	0.001	-2.460**	0.004	0.005	0.830	0.001	0.023	0.040
Primary education	-0.196	0.021	-9.280**	-0.029	0.007	-4.330**	-0.009	0.024	-0.380	0.048	0.086	0.560
Secondary education	-0.180	0.018	-10.010**	-0.025	0.006	-4.490**	-0.012	0.019	-0.640	0.024	0.060	0.390
Vocational education	-0.069	0.013	-5.160**	-0.014	0.003	-4.710**	0.001	0.010	0.050	-0.032	0.035	-0.920
Formal employment	0.079	0.011	7.300**	0.011	0.003	4.210**	0.007	0.010	0.720	0.023	0.036	0.640
Central	0.108	0.021	5.040**	0.085	0.009	9.540**	0.043	0.016	2.620**	-0.022	0.054	-0.410
Coast	0.024	0.019	1.290	0.005	0.002	2.410**	0.016	0.011	1.430	-0.041	0.045	-0.920
Eastern	0.004	0.017	0.260	-0.024	0.003	-7.320**	-0.003	0.011	-0.260	-0.101	0.058	-1.730*
North Eastern	-0.029	0.025	-1.150	-0.008	0.004	-2.040**	0.035	0.017	2.090**	-	-	-
Nyanza	-0.079	0.019	-4.270**	-0.020	0.004	-5.050**	-0.048	0.016	-3.100**	-0.054	0.039	-1.390
Rift Valley	0.024	0.017	1.400	0.042	0.005	8.250**	0.038	0.012	3.100**	-0.023	0.037	-0.610
Western	-0.071	0.020	-3.540**	-0.024	0.004	-6.190**	0.010	0.017	0.570	-0.052	0.050	-1.040
Inverse mills for PMS	0.005	0.020	0.260	0.026	0.007	3.840**	0.026	0.027	0.960	0.049	0.097	0.500
Constant	0.083	0.044	1.890*	-0.012	0.013	-0.910	0.637	0.047	13.600**	0.403	0.165	2.440**

Source: Authors SUR estimations from the National Energy Survey 2009

Dependent variable is PMS Budget Share; ** Indicates significance at 1% confidence interval;*** Indicates significance at 5% confidence interval. ***n=3,658, 2,549, 739 and 67for all income, low income, middle income and high income groups respectively.

Demand for automotive gas oil

Automotive Gas Oil is mostly used in high capacity engines usually used for public transport, emergency power generation and small scale irrigation in the agricultural sector. There are also smaller vehicles with diesel powered engines which use AGO. Public transport in Kenya is mainly dominated by the *matatu* industry, which is basically the private sector providing a public good. The main shortcoming is that most of these vehicles have low occupancy compared to those in the developed world. In this case, fuel consumption per capita per trip is higher.

The budget share for AGO is determined by its own price, price of substitutes, expenditure, household size, gender, education level and regional dummies. Increasing the own price of AGO by 1 percent would reduce its budget share by 0.152 percent, 0.353 percent and 0.21 percent for all income group, low and middle income groups respectively. This means that increasing the price of AGO would reduce its budget share drastically and is statistically significant. However, own price increase or reduction is not significant among the high income group.

The price of PMS has a positive effect on the budget share of AGO for all income and middle income groups, but negative for the high income groups. This indicates that the low and middle income groups are more sensitive to price changes. Households in these income groups are more likely to shift to public transport, if the price of PMS increases and raise their budget share allocated to AGO. The price effects of electricity and kerosene is positive meaning that if these prices increase, households would reduce the budget share they allocate to public transport. As was the case with PMS, households would prefer to satisfy other critical energy needs such as cooking, lighting and cooling, which are provided by these other fuels and will therefore reduce fuel budget allocated for public transportation that is AGO budget share.

As has already been depicted in other fuels, increasing the total expenditure by 1 percent, has a positive effect on the budget share of AGO for all income groups of 0.114 percent while it would reduce the AGO budget share for low and middle income groups by 0.04 percent and 0.004 percent respectively, after a similar change in expenditure, although the latter is not statistically significant. Thus income groups will reduce their budget share on AGO due to increased expenses at the household. They are likely to sacrifice expenditure/consumption of AGO for other household needs. However, the AGO budget share for high income group would reduce by 0.088 percent from a similar increase in household expenditure and is statistically significant.

Increase in total expenditure for all income groups combined has an increasing impact on the budget share allocated to AGO, but this is not the case in the low, middle and high income groups when estimations are disaggregated. Poor households that mainly live in slums and other low income residential areas are hardly connected to transport system and are more likely to allocate smaller budgets to public transport. Most probably, they will walk or use other cheap non motorised modes of transport.

On the other hand, female headed households are more likely to reduce their budget share that is allocated to AGO compared to their male counterparts in all income groups. Females headed households in the middle income group are most probably going to increase their fuel budget share compared to those headed by males. Women in the middle income group are more economically empowered, therefore more likely to increase the budget share allocated to AGO due to their mobility as they travel to access places of work and other areas that provide opportunities to increase their incomes. In the traditional set up, men are most likely to increase their energy budget share at the expense of women who do not have access to income generating activities. In such cases, men who in most cases are the household heads are likely to have their wives walk while they use private or public transport. However, with the empowerment of the Kenyan woman, this is changing and is likely to see major shifts in the coming years.

As was the case with PMS, regional dummies have inverse relationship with budget share allocated to AGO. With Nairobi as the reference region, households at the Coast region are more likely to reduce the budget share on AGO compared to those in the Eastern region among the all group and middle income groups. The dummies, for all regions, are negative in the low income group, while they have mixed results for the middle income group where only Eastern, Nyanza and Western region had positive impact on the budget share. Households in the three regions are more likely to use public transport compared to Nairobi which is the reference point. This could be due to the fact that people have to travel longer distances in these areas to access basic facilities and markets, unlike in Nairobi where they can walk such facilities (**Table 2.5.5)**.

Table 2.5. 5: Demand for Automotive Gas Oil by Income Group

	All Income Groups			**Low Income**			**Middle Income**			**High Income**		
Variable	Coef.	Std. Err.	z	Coef.	Std. Err.	z	Coef.	Std. Err.	z	Coef.	Std. Err.	z
Log of electricity price	0.008	0.003	2.690**	-0.004	0.001	-4.520**	-0.003	0.001	-2.260**	0.014	0.016	0.900
Log of LPG price	-0.013	0.005	-2.810**	0.017	0.002	6.930**	-0.002	0.004	-0.690	-0.006	0.031	-0.190
log of PMS price	0.129	0.049	2.620**	0.351	0.040	8.780**	0.214	0.055	3.900**	-0.078	0.128	-0.610
Log of AGO gas price	-0.152	0.049	-3.080**	-0.353	0.040	-8.810**	-0.210	0.055	-3.840**	0.084	0.142	0.590
Log of Kerosene price	0.028	0.003	8.960**	-0.011	0.001	-10.170**	0.002	0.003	0.720	-0.014	0.030	-0.460
Log of total expenditure	0.114	0.005	21.690**	-0.040	0.003	-13.000**	-0.004	0.005	-0.820	-0.088	0.039	-2.220**
Household size	0.007	0.001	9.460**	-0.002	0.000	-10.240**	0.000	0.001	0.300	0.002	0.006	0.390
Female	-0.008	0.004	-2.070**	0.004	0.001	5.030**	0.001	0.002	0.310	0.036	0.029	1.240
Primary education	-0.223	0.010	-21.510**	0.074	0.006	12.740**	-0.007	0.011	-0.680	0.250	0.103	2.420**
Secondary education	-0.194	0.009	-22.150**	0.061	0.005	12.540**	-0.013	0.009	-1.540	0.125	0.073	1.710*
Vocational education	-0.086	0.006	-13.730**	0.029	0.003	11.360**	-0.002	0.004	-0.460	0.089	0.042	2.110**
Formal employment	0.081	0.005	15.720**	-0.029	0.002	-12.270**	0.011	0.005	2.460**	0.018	0.044	0.400
Central	0.039	0.013	2.900**	-0.096	0.009	-11.000**	-0.038	0.012	-3.070**	0.000	0.064	0.000
Coast	0.003	0.009	0.390**	-0.005	0.002	-2.320**	0.006	0.005	1.230	-0.122	0.055	-2.200**
Eastern	0.015	0.008	1.820*	0.022	0.003	6.820**	0.026	0.006	4.390**	-0.153	0.071	-2.150**
North Eastern	-0.094	0.012	-8.060**	0.027	0.004	7.410**	0.009	0.008	1.220	-	-	-
Nyanza	-0.096	0.009	-10.900**	0.047	0.003	13.730**	-0.009	0.007	-1.300	0.050	0.048	1.050
Rift Valley	-0.024	0.009	-2.530**	-0.033	0.005	-6.540**	-0.018	0.008	-2.300**	0.017	0.045	0.390
Western	-0.088	0.009	-9.280**	0.048	0.003	14.040**	0.015	0.008	1.850*	-0.097	0.064	-1.510
Inverse mills for AGO	0.143	0.010	14.410**	-0.078	0.006	-13.310**	0.022	0.012	1.840*	-0.129	0.115	-1.120
Constant	-0.236	0.022	-10.630**	0.093	0.011	8.120	0.195	0.022	9.030**	0.806	0.196	4.100**

Source: Author's SUR estimations from the National Energy Survey, 2009

Dependent variable is AGO Budget Share; ** Indicates significance at 1% confidence interval;* Indicates significance at 5% confidence interval. ***n=3,658, 2,549, 739 and 67for all income, low income, middle income and high income groups, respectively.

2.5.2.1.3 Fuel demand by location of households

Having discussed demand for cooking, lighting and heating fuels and for transportation needs in sub sections 2.5.2.1.1 and 2.5.2.1.2 by income group, this sub-section provides an analysis of fuel demand by location of the household. Up to this point, the location of the household was considered through regional dummies for Central, Eastern, North Eastern, Nyanza, Rift Valley, Western and Nairobi which is used as reference point in the analyses. The sample is split into rural and urban, and models estimated for each for electricity, LPG, PMS and AGO. The kerosene equation is dropped in the estimations of LA-IDS model but recovered in computations of the elasticities.

Fuel demand estimations for rural and urban households for cooking, lighting and heating shows that own fuel price, price of substitutes, expenditure, gender, education and formal employment are some of the key variables that determine demand. With regard to electricity budget share, increasing the price of electricity by 1 percent would increase its budget share by 0.034 percent and is significant for rural households, meaning that as the price of electricity increases, so does the budget share. This is contrary to expectations of economic theory because in the case of a normal good, one would expect price to be inversely related with quantity demanded for a good. However, since electricity is still a luxury to rural households, this phenomenon can happen where those who are connected increase their budget share, since it is a symbol of status. Having electricity earns one respect in society.

The price of LPG has a positive impact on budget share among rural households but negative for urban households. Kerosene price has a negative impact on electricity budget share for both rural and urban households. Increasing the price of kerosene by 1 percent would lead to reduction in the budget share for electricity by 0.022 percent and 0.013 percent in rural and urban areas respectively. Other key factors that determine budget share of electricity include household size, gender, primary education and formal employment (see Appendix **Table A1**).

On the other hand, increasing the own price of LPG by 1 percent would reduce its consumption by 0.05 percent and 0.28 percent in rural and urban based households, respectively; however, the latter is not statistically significant. The prices of close substitutes have a positive impact on its budget share. Increasing the price of electricity by 1 percent would increase the budget share for LPG marginally by 0.007 percent and 0.001 percent respectively, for rural and urban households. This means that increasing the price of electricity would increase the budget share allocated to LPG because the two fuels are used as substitutes in cooking. As a result, increasing the price of electricity would increase consumption of LPG, therefore increasing the budget share since electricity is now more expensive. Increasing the price of kerosene by 1 percent would increase the budget allocated to LPG by 0.012 percent and 0.031 percent for rural and urban households respectively, meaning that it is a close substitute to LPG. Increasing the price of kerosene would mean that households shift to consumption of LPG, thus increased budget share. Other factors portray mixed results.

Expanding the household size by 1 percent would reduce the budget share on LPG by 0.002 percent and 0.001 percent respectively, for rural and urban households. This means increasing the number of people in a household would lead to lower consumption of LPG. This is expected since the apparatus used in LPG for cooking may not be suitable to prepare food for large family sizes, particularly those located in rural areas. As a result, they would rather use any other fuel for cooking due to demand to prepare large quantities for the big family sizes. The female factor is only significant and positive among urban households. Lastly, those households whose heads have primary education are more likely to reduce their budget share on LPG (see **Appendix Table A2).**

The regional dummies for North Eastern, Nyanza and Western were positive and significant in the case of cooking, lighting and heating fuels among urban households in the case of electricity. Thus urban households in these regions are most likely to increase their budget on electricity relative to those located in Nairobi. Only North Eastern has a significant coefficient in the case of LPG consumption; however, it is negative. Thus with Nairobi as the reference point, urban households in North Eastern are most likely to reduce their budget share on LPG.

Lastly, with regard to transport fuels, increasing the price of PMS by 1 percent would significantly reduce its own budget share by 0.216 percent for urban households, but this is not significant for rural households. However, increase in the price of AGO by 1 percent would increase the PMS budget share by 0.188 percent among urban households, meaning that a reduction in the price of AGO would lead to more consumption of PMS. Other factors such as expenditure, household size, gender, education and employment had mixed results. Similar increase in household expenditure would increase budget share for PMS by 0.062 percent and 0.031 percent respectively, for rural and urban households and is statistically significant. On the other hand, those with primary education are most likely going to reduce budget share of PMS at 0.153 percent and 0.244 percent compared to those with no education for rural and urban households respectively, and is statistically significant (**Appendix Table A3**).

With regard to budget share of AGO, increase in the price of substitute that is price of PMS by 1 percent would increase its budget share by 0.188 percent for urban households, and this is consistent with consumer theory. Increasing the price of PMS would lead to increase in budget share on AGO since those using private and smaller cars may shift to using AGO powered cars or opt to use public transport. Other variables such as expenditure and household size have positive and significant coefficient for both rural and urban households. However, those households whose heads have primary education would reduce their budget share for AGO in both rural and urban areas (**Appendix Table A4**). On the other hand, with regard to regional dummies, only the Coast region had a positive coefficient, while North Eastern, Nyanza, Rift Valley and Western had negative significant coefficients.

2.5.3 An analysis of elasticities

This sub-section presents elasticity results for the five regulated fuels. The elasticities are computed after estimation of the SUR model. Given the five systems of models estimated by income group, elasticities are computed for low, middle and high income groups by fuel type. In addition, computations are also done by household location. As was described earlier in the methodology section, this sub-section presents estimates for Marshallian, Hicksian and expenditure elasticities by fuel. Elasticity is the ratio of the percentage change in one variable to the percentage change in another variable. It is a tool for measuring the responsiveness of function to changes in parameters in a unit-less-way.

From economic theory, elasticity of demand measures how quantity demanded changes in response to changes in prices or income/expenditure. Estimations on elasticity look at price elasticity of demand, own price elasticity and cross price elasticity, which is a measure of responsiveness of demand for a good to a change in the price of another good. This means price change in one fuel due to change in the price of a substitute fuel for example kerosene and LPG which are used for cooking. Income elasticity is proxied by estimations of expenditure elasticity. Households are often unwilling to reveal their true incomes, but are likely to reveal their expenditures. Expenditure elasticity is a measure of the responsiveness of demand to changes in income. It shows how the quantity purchased changes in response to a change in the consumer's income. The sub section also highlights on Hicksian or Compensated Demand[6]; and Marshallian, ordinary, or uncompensated demand[7].

Following the study methodology and explanation on elasticity already provided, this sub-section provides analysis for own price elasticity. In the computation, the elasticities were first generated after estimation of the SUR models and mean elasticity obtained for each variable by income group. The elasticity estimates varied across the income groups that are for all income, low, middle and high income.

---

[6] Hicksian or Compensated Demand: The Hicksian demand function (after British economist Sir John R. Hicks) shows the relationship between the price of a good, P1, and the quantity purchased on the assumption that other prices, P2, and utility, U0, are held constant. (www.wikepedia.org).

[7] Marshallian, Ordinary or Uncompensated Demand: The Marshallian demand function (after British economist Alfred Marshall) shows the relationship between the price of a good, P1, and the quantity purchased, Q1, on the assumption that other prices, P2, and the consumer's budget (or income), Y0, is held constant (www.wikepedia.org).

2.5.3.1 Marshallian-Uncompensated elasticities

The Marshallian-uncompensated elasticity shows the relationship between the price of fuel in this case electricity, and the quantity purchased, holding other prices such as for LPG, kerosene, PMS and AGO; and the consumer's budget (or income), are held constant. Consistent with the LA-AIDS model, the elasticities are computed for all income group, low, middle and high income groups. Marshallian elasticities are expected to be higher than the Hicksian- compensated elasticities. This is because the Marshallian demand equation is obtained from maximising utility subject to the budget constraint, while the Hicksian demand equation is derived from solving the dual problem of expenditure minimisation at a certain utility level. Elasticities derived from Marshallian demand are therefore uncompensated, while those derived from Hicksian demand are compensated elasticities.

The Marshallian-uncompensated elasticities for all groups estimated together showed that the own price elasticities were negative, consistent with economic theory for normal goods. Results for the Marshallian-uncompensated elasticities for fuels are reported in **Table 2.5.6** by income group and location of household. The own price elasticity for electricity for all groups, low, middle and high income are somewhat inelastic and negative, indicating that increasing the price of electricity would lead to decrease in the budget share allocated to electricity by the household. Increasing the own price of electricity by 1 percent , would reduce its budget share by 1.1 percent, 0.99 percent, 0.98 percent and 0.96 percent for all income, low income, middle and high income groups; respectively. Analyses by household location show that increasing the price of electricity for example by 1 percent, would reduce the budget share for electricity by 1.02 percent and 1.09 percent in rural and urban areas respectively. This shows that the demand for electricity is almost perfectly elastic for all income groups and household location in rural and urban households.

Due to existence of alternative sources of energy at the households, they are able to adjust their budget shares and therefore re-allocate some part of their income to other fuel expenditures such kerosene and LPG. This is supported by the cross price elasticity results between electricity and other fuels. The cross price elasticity of electricity with LPG and kerosene are negative, meaning that they are substitutes in the lower income group, but compliments in the case of the middle income group. This means that the middle income groups are not likely to shift to consumption of kerosene, even if its price elasticity increases. The cross price elasticities are also negative for prices of PMS and AGO, although they are not substitutes. However, the negative coefficients can be explained by the fact that it is the budget share that matters in this case. As was seen earlier in the LA-AIDS model results, the budget share in any of the fuels in the basket will affect the budget share allocated to individual fuels.

Table 2.5. 6: Marshallian-Uncompensated by Elasticities by Income Group and Location

Variable	Electricity P	LPG	PMS	AGO	Kerosene
(a) All Income Groups					
Electricity	-1.091	-0.099	-0.929	-0.862	-0.164
LPG	0.968	-2.446	1.169	-0.443	0.631
PMS	0.118	0.374	-2.505	1.210	0.159
AGO	0.268	-0.132	2.552	-3.754	0.642
Kerosene	-0.298	0.103	0.187	0.197	-1.422
(b) Low Income					
Electricity	-0.991	-0.005	-0.339	-0.448	-0.102
LPG	0.409	-3.193	0.002	0.588	1.275
PMS	0.018	0.013	-4.126	3.144	0.053
AGO	-0.108	0.277	6.598	-7.715	-0.251
Kerosene	-0.209	0.412	0.088	0.067	-1.000
(c) Middle Income					
Electricity	-0.976	0.028	-0.003	0.006	0.019
LPG	0.190	-1.142	0.008	-0.069	0.084
PMS	-0.851	-0.026	-2.88	1.861	0.008
AGO	-0.065	-0.051	4.033	-4.982	0.043
Kerosene	0.015	0.020	0.367	-0.025	-1.097
(d) High Income					
Electricity	-0.956	0.078	0.065	0.088	-0.019
LPG	0.357	-0.723	0.169	-0.202	-0.606
PMS	0.008	-0.007	-0.388	-0.729	0.082
AGO	0.178	-0.199	-1.570	0.502	-0.348
Kerosene	-0.192	-0.102	0.024	-0.062	-0.292
(e) Rural					
Electricity	-1.021	-0.909	-0.149	-0.121	-0.168
LPG	0.264	-2.690	1.151	-0.076	0.415
PMS	-0.069	-0.357	-0.358	-0.776	0.157
AGO	-0.015	-0.011	-1.735	0.729	0.309
Kerosene	-0.246	0.092	0.083	0.106	-1.159
(d) Urban					
Electricity	-1.090	-0.057	-0.035	-0.026	-0.093
LPG	0.188	-1.974	0.731	-0.921	1.036
PMS	0.116	0.226	-2.875	1.691	-0.003
AGO	0.379	-0.365	3.688	-4.788	0.756
Kerosene	-0.207	0.226	-0.121	0.245	-1.555

Author’s computations from National Energy Survey, 2009

In the case of LPG, its own price elasticity is negative and highly elastic meaning that LPG is still a luxury fuel in all income groups low, middle as well as high income groups. However, the degree of elasticity is highest in absolute terms among the low income households where increasing the price of LPG by 1 percent would reduce its budget share by about 3.2 percent. On the other hand, the budget share for elasticity for all income group, would reduce by 2.4 percent if its own price is increased by the same margin. The cross price elasticity of LPG with the other fuels such as electricity and kerosene is negative in the case of electricity, but positive in the case of kerosene for all income groups. In other words, while LPG is a substitute of electricity, it is a complement to kerosene. Increasing the price of LPG by 1 percent would increase the budget share of kerosene by 0.1 percent.

The Marshallian elasticities for kerosene show that in the case of all income groups, increasing the own price of kerosene by 1 percent would reduce its budget share by 1.4 percent. The results also confirm that kerosene and electricity are close substitutes. Reducing the price of kerosene by 1 percent would increase the budget share on electricity by 0.16 percent, meaning that households would allocate more budget to electricity which is a more superior fuel. This finding seems to support the 'fuel switching' and 'fuel stack hypothesis' whereby, if the income of consumer improves, they will consume more of the cleaner fuel, all other factors held constant, or consume both fuels together but in different quantities depending on their affordability and quality. The own price elasticity of kerosene in the low income group is perfectly elastic. This is important for policy in Kenya and other developing countries, where kerosene consumption is important due to high poverty rates and low access of other modern forms of energy such as electricity and natural gas.

The middle income are more responsive to kerosene prices compared to the high income group where increasing the price of kerosene by 1 percent would reduce kerosene budget share by about 1.1 percent and 0.3 percent respectively. The result confirms that to the high income households, kerosene is an inferior good and therefore increasing or reducing its price will have very little impact on the budget share high income groups allocate to it. Cross price elasticity of kerosene and other fuels shows mixed results across all the four income groups and household location in terms of rural and urban. The urban households are more responsive to kerosene price changes than their rural counterparts, where increasing its price by 1 percent would reduce the budget shares by 1.2 percent and 1.5 percent respectively. The difference in elasticities could be attributed to differences in income and electricity access levels. Urban areas have relatively higher incomes and electricity access rates compared to the rural areas.

With regard to transport fuels, increasing the own price for PMS by 1 percent would reduce its budget share by 2.5 percent for the ‘all income group’, while it would reduce by 4.1 percent, 2.9 percent and 0.39 percent for the low, middle and high income groups. The results show that price changes among the low income group will have minimal effects unlike in other income groups. The price effect in the high income group is inelastic compared to middle income group which is elastic. Households in the middle income group are more likely to switch to other modes of transport when the price of PMS continues to increase. On the other hand the cross elasticities is positive in the case of AGO for the all income groups, meaning that if the price of PMS increases, households are not likely to switch and allocate more budget share on AGO.

The other income groups have mixed results, for example increasing the price of PMS by 1 percent will increase budget share allocated to AGO by 6.6 percent for the low income group, while it would increase the budget share for the middle income group by 4.0 percent meaning that increasing the price of PMS would lead to increased consumption or increase in the budget share allocated to AGO. Thus that increasing the price of PMS will not necessary lead to consumption of more AGO because this will require change of engines of vehicles and this is not possible unless one changes the type of car they are using. Only the high income group has an inverse relationship whereby increasing the price of AGO by 1 percent would reduce the budget share allocated to PMS by 1.5 percent meaning that increasing the price of AGO would lead to arise in the budget share allocated to PMS. These results seem to suggest that AGO and PMS are substitutes as the households make choices on the mode of transport to use. Although chemically the two fuels are intrinsically different hydrocarbons and mechanically they cannot be used in the same engines increasing the price of AGO and other factors held constant would lead to switching to use of smaller cars, which are powered by PMS. The price of petroleum products normally increases at the same time and this has been evident by the recent adjustments of maximum prices by the ERC, where all prices increase or decline depending on international price changes or tax regimes in the domestic economy.

AGO is critical in public transportation. Increasing its own price elasticity by 1 percent will reduce its budget share for all income groups by about 3.8 percent indicating that it is elastic and therefore households are sensitive to price changes. The reduction in AGO is even higher for the low income group, where the budget share will reduce by 7.7 percent from a 1 percent price increase. However in the case of middle and high income groups, increasing the price of AGO by 1 percent will reduce its budget share by about 0.5

percent and 0.5 percent respectively. This is an indication that the low and middle income groups are more likely to change consumption of AGO, and therefore reduce the budget share after price changes. The richest household is somehow inelastic to price changes since the frequency of use of public transport is low. In addition, if already they have AGO powered vehicles, they will still continue to use them due to their high income levels and enjoy the low prices.

On the other hand, the results seem to suggest that the middle income group will shift to use of private transport/own cars, if the price of AGO increases. The main reason could be the increase in cost of public transport relative convenience, comfort and affordability of private transport vehicle, which use PMS for majority of the households. The cross price elasticity for AGO and PMS shows mixed results. For example, increasing the price of AGO by 1 percent would increase the budget shares of PMS by 1.2 percent for all income groups and 3.1 percent among the low income households.

In the case of middle income group, increasing the price of AGO would increase the budget share of PMS by 1.8 percent while that of the high income group would reduce by 0.7 percent. In this case, therefore, the middle income group is more elastic to AGO price changes with respect to PMS than the high income group. The budget share allocated to AGO is likely to increase more among the middle income than the high income, while the low income will drastically reduce their budget share. Richer income groups are not likely to change consumption of AGO just because the price of a substitute has changed. They will continue to consume not because it is a necessity, but a lifestyle and they would rather maintain the status quo than reduce consumption. To the high income group, use of guzzlers which consume AGO is a symbol of high status quo, and they would rather continue using these cars despite the price increase (**Table 2.5.6)**.

Analysis of Marshallian –uncompensated elasticities by location of households is important given the socio-economic differences that exist between rural and urban areas. The analysis shows mixed results on impact among urban households in urban and rural areas. For example, the own price elasticity of electricity in rural households is -1.021 compared to -1.090 in urban households. The own price elasticity of LPG among rural households -2.960, while that of urban households is lower at -1.974 meaning that increasing the price of LPG by 1 percent would reduce its budget share by about 3 percent and 2 percent for rural and urban households, respectively. It is therefore evident that urban households experience lower impact compared to their rural counterparts. In the case of kerosene, rural households would reduce their budget share of kerosene by about 1.2 percent while that of urban households would reduce by about 1.6 percent meaning that urban households experience a higher negative impact from kerosene price changes.

In the case of transport fuels, the own price elasticity of PMS among rural households is -0.358 compared to their urban counterparts at -2.875. Increasing the price of PMS by 1 percent would reduce the budget share on PMS by 0.36 percent and 2.9 percent respectively. Thus households in urban areas are more responsive to price changes in PMS than in the rural areas. With regard to AGO, the own price elasticity in rural areas was -0.776 compared to -4.788 among urban households, meaning that a 1 percent increase in the price of AGO would lead to 0.8 percent and 4.8% reduction in its budget share in rural and urban areas, respectively. The results show that households in urban areas are more sensitive to price changes than in rural areas. These results could be interpreted to mean that households in rural areas have to connect to urban centres which are likely to be a distance away from places where they live compared to those in urban areas who can walk to their places of work and also who can access health, education and other economic opportunities with ease.

2.4.3.2 Hicksian-Compensated elasticities

Hicksian or Compensated Demand (elasticity) shows the relationship between the price of a good, in this case fuel; and the quantity purchased on the assumption that other fuel prices and utility are held constant. The compensated elasticities are normally lower than the uncompensated or Marshallian elasticities because they are derived from solving the dual problem of expenditure minimisation problem at a certain utility level, unlike the Marshallian elasticities that are derived from maximising utility subject to a budget constraint. The price change brought in one of the fuel substitutes brings about substitution and income effects and this is what brings about the compensation element. In this section, I compute the compensated elasticities in addition to the uncompensated ones. The Hicksian-compensated elasticities are reported in **Table 2.5.7**.

Table 2.5. 7: Hickisian-Compensated Elasticities by Income Group and Location

Variable	Electricity P	LPG	PMS	AGO	Kerosene
(a) All Income Groups					
Electricity	-0.816	0.175	0.182	0.188	0.110
LPG	0.128	-2.415	1.201	-0.411	0.662
PMS	0.303	0.558	-2.321	1.395	0.343
AGO	0.430	0.035	2.719	-3.587	0.808
Kerosene	-0.278	0.124	0.039	0.218	-1.402
(b) Low Income					
Electricity	-0.644	0.341	0.312	0.301	0.243
LPG	0.454	-3.148	0.048	0.634	1.320
PMS	0.146	0.137	-3.999	3.242	0.180
AGO	-0.095	0.291	6.612	-7.702	-0.238
Kerosene	-0.064	0.557	0.234	0.079	-0.855
(c) Middle Income					
Electricity	-0.580	0.424	-0.393	0.402	0.415
LPG	0.234	-1.098	0.051	-0.026	0.128
PMS	0.004	0.063	-2.792	1.951	0.097
AGO	-0.016	-0.002	4.082	-4.934	0.091
Kerosene	0.116	0.121	0.137	0.125	-0.997
(d) High Income					
Electricity	-0.523	0.511	0.497	0.521	0.413
LPG	0.385	-0.695	0.198	-0.174	-0.578
PMS	0.084	0.083	-0.313	-0.654	-0.007
AGO	0.144	-0.234	-1.605	0.467	-0.383
Kerosene	-0.017	0.074	0.199	0.113	-0.117
(e) Rural					
Electricity	-0.750	0.180	0.122	0.151	0.103
LPG	0.306	-2.647	0.193	-0.033	0.457
PMS	0.105	0.533	-0.182	-0.601	0.333
AGO	0.097	0.123	-1.622	0.842	0.422
Kerosene	-0.171	0.168	0.158	0.182	-1.084
(f) Urban					
Electricity	-0.769	0.263	0.285	0.294	0.227
LPG	0.026	-1.967	0.739	-0.914	1.044
PMS	0.259	0.369	-2.731	1.834	0.140
AGO	0.567	-0.178	3.875	-4.602	0.943
Kerosene	-0.189	0.245	-0.102	0.263	0.536

Author's computations from National Energy Survey, 2009

The analysis shows that increasing the own price of electricity by 1 percent would reduce its budget share by 0.8 percent which is lower compared to the change of about 1.1 percent in the case of Marshallian elasticity. The cross price elasticity for electricity with respect to LPG, kerosene, PMS and AGO were all positive. Increasing the price electricity by 1 percent would increase the budget shares for LPG, kerosene, PMS and AGO by 0.17 percent, 0.11 percent, 0.18 percent and 0.19 percent respectively, for the all income group. These elasticity levels are lower than those obtained in the case of uncompensated estimations and are positive meaning that increasing the prices of these other fuels would still lead to increase in the price of electricity, hence its budget share. The cross price elasticity with respect to electricity is positive for all income groups and inelastic except for the high income group where it is negative. This satisfies the energy ladder hypothesis.

With regard to LPG, increasing its own price by 1 percent would lead to reduction of its consumption by 3.1 percent. Although this elasticity is lower than the one obtained for the uncompensated demand, it is still elastic. Thus, LPG is a luxury fuel to many households. Consumers are likely to switch to other cheaper fuels such as kerosene and electricity as well as charcoal and fuel wood. Charcoal and fuel wood have not been considered in this study due to focus on fuels that attract formal taxes. The cross price effects are positive for close substitutes such as electricity and kerosene.

The Hicksian elasticity results show that the own price elasticity of kerosene has negative effect as expected; therefore increasing the price of kerosene would reduce the amount consumed. The cross price of electricity with close substitutes shows mixed results for all income groups. With regard to transport fuels, that is the price of PMS and price of AGO, the own price elasticities are negative and elastic, meaning that by increasing their prices, consumption will decline. A 1 percent increase in the price of PMS and AGO would reduce their respective budget shares by 2.3 percent and 3.6 percent respectively, for the all income group meaning the two fuels are responsive to own price changes. In the low income group, increasing the own price of PMS and AGO would reduce their budget shares by about 4 percent and 7.7 percent respectively. In the middle income group, a similar change in their prices would reduce their own budget shares by 2.8 percent and 4.9 percent respectively; hence households would highly reduce consumption of transport fuels due to price increase. The two products are elastic (in price) in this income group. However, the price elasticities among the high income group for the two fuels had mixed results. Increasing the price of PMS by 1 percent would lead to reduction in its budget shares by 0.31 percent in this income group. However, increasing the own price of AGO by 1 percent would increase its budget share by 0.47 percent, thus an increase in price would lead a rise in consumption of the fuel, contrary to expectation that increase in price would lead to a reduction in consumption.

The price of PMS is more inelastic than that of AGO, the high income group is thus not likely to reduce consumption, to a large extent, due to price increases. Driving among the high income group is captive that is households in this income group cannot do without cars because it is a way of life and a necessity; therefore households are not likely to switch to other modes of transport. With regard to cross price elasticities, increasing the price of PMS by 1 percent would increase the budget share allocated to AGO by 6.6 percent while a similar increase in the price of AGO would increase the budget share on PMS by 3.2 percent. However among the middle income group, the fuel budget share would increase by 4.1 percent and 1.9 percent respectively, meaning that the two are substitutes of one another in this income group. Increasing the price of PMS would lead to an increase in consumption of AGO, since the motorists in the middle income group would switch to public transport which mainly consumes AGO. On the other hand, increasing the price of AGO would also increase consumption of PMS because the two fuels are ‘substitutes’, in terms of mode of transport, used though mechanically they are not substitutable.

Analyses of Hicksian–Compensated elasticities by location of household are important given significant differences that exist between rural and urban areas as seen in the case of Marshallian elasticities. The analyses show that increasing the own price of electricity by 1 percent would reduce its own budget share by 0.75 percent among rural households to 0.77 percent in the case of urban households, indicating a very small differences in magnitude in the two locations. On the other hand, increasing the own price of LPG by 1 percent will reduce its budget share by 2.6 percent among rural households while that of urban households would reduce by 1.9 percent meaning urban households experience lower impact compared to their rural counterparts. In the case of kerosene, rural households bore a lower negative elasticity of -1.084, compared to that of urban households of 0.536, thus increasing kerosene price by 1 percent would reduce its budget share by 1.1 percent among rural households, while that of urban households would increase by about 0.54 percent. These results seem to suggest that urban households experience a positive and lower impact from price changes compared to their counterparts in rural areas.

In the case of transport fuels, increasing the own price of PMS by 1 percent would reduce its budget share by 0.18 percent among rural households, compared to 2.7 percent in their urban counterparts. Households in urban areas are more responsive to price changes in PMS than in the rural areas. With regard to AGO, increasing its own price by 1 percent would reduce the budget share among rural households by 0.84 percent compared to 4.6 percent in the case of urban households, this means urban households are more sensitive to price changes compared to rural areas. These results, as was the case in Marshallian elasticities, could be interpreted that households in rural areas have to connect to urban centres that are likely to be a distance from where they live, compared to those in urban areas who can walk to their places of work and access health, education and other economic opportunities with ease.

2.5.3.2 Expenditure elasticity

Expenditure elasticity shows how the quantity purchased changes in response to a change in the consumer's income. The significance of expenditure elasticity varies depending on the type of fuel and income group. The expenditure elasticities are reported in **Table 2.5.8**.

Table 2.5. 8: Expenditure Elasticities by Income Group and Location

	All Income Groups	Low Income	Middle Income	High Income	Rural	Urban
Electricity	0.719	0.907	1.038	1.134	0.711	0.841
LPG	1.059	1.552	1.482	0.960	1.441	0.257
PMS	1.629	1.124	0.785	0.669	1.550	1.271
AGO	3.158	0.252	0.919	-0.657	2.132	3.534
Kerosene	0.202	1.44	0.99	1.74	0.752	0.181

Author’s computations from National Energy Survey, 2009

The analyses show that the expenditure elasticity of electricity is positive for all income groups. Increasing the household income by 1 percent would increase the budget share allocated to electricity by 0.72 percent, 0.91 percent, 1.0 percent and 1.1 percent for all income group, low, middle and high income groups, respectively. This means that increasing household income would increase the expenditure on electricity which is captured by the budget share. The lower income households have more inelastic expenditure elasticities than the high income groups. A 1 percent increase in household income would raise the budget share allocated to LPG by about 1.1 percent, 1.6 percent, 1.5 percent and about 0.6 percent respectively, for all income, low, middle and high income groups, respectively. The low income households have a higher elastic demand than high income households, an indication that LPG is considered a modern and luxury fuel in most households in this income group. Increase in income by one unit would lead to increase in LPG consumption by more than one unit. On the other hand, increasing household income by 1 percent would increase the budget share on LPG by 1.4 percent and 0.26 percent in rural and urban areas respectively. Thus in rural areas, households are responsive to income changes, while in urban areas, they are inelastic or unresponsive when income changes. The results point to the fact that urban households are inelastic in LPG consumption and are therefore highly dependent on its use for cooking and other households' functions.

In the case of kerosene, the expenditure elasticities were positive and significant for all groups; hence an increase in income would lead to more consumption of kerosene. This is true since our data set constituted of both rural and urban households. Kerosene is therefore critical in a household's energy needs across all income groups. This was demonstrated recently in Kenya, when kerosene was zero rated in tax to cushion the poor from price increases which were mainly triggered by international markets.

Estimations for expenditure elasticity in transport fuels indicate that they are significant in all income groups. However, they are positive for all fuels and income group with exception of AGO consumption among the high income group, which has a negative expenditure elasticity. Therefore, an increase in household expenditure would lead to increased budget share allocated to transport fuels. From the findings, increasing the household expenditure/income by 1 percent would increase the budget share on PMS by 1.6 percent, 1.1 percent, 0.78 percent and 0.67 percent for all income, low, middle and high income groups, respectively. High income households thus have a more inelastic expenditure elasticity than low income ones. On the other hand, similar household expenditure/income changes would increase the budget shares by 1.5 percent and 1.3 percent in rural and urban areas, respectively.

The results show that increasing the household expenditure by 1 percent would increase the budget share allocated to AGO by about 3.2 percent, 0.25 percent, 0.9 percent for all income group, low income and middle income groups' respectively. However, increasing household expenditure/income by 1 percent among the high income group would reduce the budget share allocated to AGO by 0.66 percent meaning that at a certain level, AGO is inferior good to the high income group and therefore they are likely to consume more of PMS, which has a higher price compared to AGO. Interestingly, expenditure elasticity for AGO in low income group is inelastic. The low income group has no other alternative to turn to when the price of AGO increases it does not own private cars, thus relying on urban transport which is mostly powered by AGO. The negative expenditure elasticity of AGO among the high income group is an indication that the group will allocate a lower budget share fuel for their guzzlers when their income increases. On the other hand, increasing the household expenditure by 1 percent would increase the budget share on

AGO by 2.1 percent and 3.5 percent for the rural and urban areas respectively. This shows that they are responsive to increased income and vice versa. The urban households are more responsive than their rural counterparts since they have to travel to and from work.

2.6 Conclusions and Policy Recommendations

2.6.1 Conclusions

This study has reviewed literature, provided a methodology to analyse fuel demand for both cooking fuels and transport fuels, provided an empirical analysis of fuel demand and computed elasticities of demand for kerosene, LPG, electricity, PMS and AGO.

The literature review showed that energy choice, energy capital complimentarity and energy substitution and household expenditure in energy goods and services are important in energy demand studies. Other important factors include income and price elasticities with regard to energy goods and services, household characteristics such as gender and age of household head, household size, household composition, education attainment and occupation among other factors.

The descriptive statistics have shown that fuel budget share varies from fuel in terms of the mean, standard deviation, minimum and the maximum. Electricity has the highest budget share followed by PMS among the fuels consumed by the household. Fuel products price varies across the various sources of energy, from cooking to transport fuels. In addition, petroleum prices are influenced by international prices where impacts are felt at the household, depending on the level of income.

The fuel demand analyses shows that prices of fuel, expenditure/income, region, income group, household size, education level, form of employment and gender are some of the key determinants of fuel consumption. Analyses by income groups show that the impact of various factors vary depending on the level of income.

Estimations of elasticities have indicated that they vary by fuel, income group and household location. Most of the fuels are price inelastic, thus an increase in a unit would lead to less than a unit increase or reduction in consumption. Majority of cooking, lighting and heating fuels are inelastic and have either positive or negative impact depending on whether they are substitutes or compliments. The own price effect of transport fuels such as PMS is elastic for middle income households, meaning that an increase in price by 1percent would lead to a more than 1 percent decrease in consumption of PMS. Thus, private motorists among the middle class are sensitive to price changes and are likely to opt for public transport due to an increase in the price of PMS.

The expenditure elasticities in all income groups are positive except for AGO among the high income group. Increasing the income/expenditure would lead to more consumption of fuels, therefore a higher budget share that is allocated to consumption of a particular fuel. Cooking, lighting and heating fuels have more inelastic expenditures among the low income households than high income ones. Expenditure elasticity on LPG is elastic, hence a luxury fuel among many households.

2.6.2 Policy Recommendations

National Energy Policy

This study has highlighted the need for a good comprehensive energy strategy that will enhance Kenya's ability to develop sustainable energy sources and achieve success in her overall sustainable development. It is therefore critical that a National Energy Policy is developed using a multi-stakeholder process to replace the Sessional Paper No. 4 of 2004 on Energy in line with the spirit of the Kenya's constitution. This would help manage energy sources more efficiently and meet the growing demand as well as capture devolution issues. Although the analysis in this study left out biomass fuels due to the focus and scope of the research that dwelt on regulated fuels, the available fuels that are consumed have implications on demand management and sustainability of the environment.

Electricity Services

The Electric Power Act of 1997 and Energy Act 2006 have formed the basis for reforms in the electricity sub sector today. The two Acts reformed the electricity sector by providing for competitive environment in electricity generation, transmission and distribution. The Power Act of 1997 split the generation from transmission and distribution, while the Energy Act 2006 split further the transmission from distribution and created a transmission company that is responsible for new transmission lines in the country. In addition, it created the Rural Electrification Authority to ensure increased penetration of electricity in rural areas. The electricity sector is currently regulated by the Energy Regulatory Commission which is responsible for economic and technical regulation for electricity, renewable energy and downstream petroleum. Reforms to date have transformed the state owned monopolies in generation, transmission and distribution and further introduced Independent Power Producers (IPPs) in a competition-for-generation market environment. However, care has to be taken that competition is not allowed solely on the basis of cost, since electricity services also have environmental and social impacts. The government should ensure competition benefits are passed on to the consumer.

Therefore, there is need to reduce electricity tariffs by subsiding the fuel adjustment cost which is a pass through to consumers. This is because electricity prices are inelastic, therefore those using electricity may not substitute to other forms of energy.

Promotion of Clean Lighting and Cooking Fuels

The promotion of clean fuels for cooking and lighting is one of the key policies advocated for in the Sessional Paper No. 4 on Energy of 2004. The government has recently been proactive in achieving this key objective. Kenya has thus been declared a ‘’Kerosene free nation’’ and the government is putting in place critical measures to ensure penetration of clean energy to households. However, in the meantime, consumption of kerosene and other dirty fuels will continue in the short and medium term as penetration of these other technologies such as increased use of LPG and new renewable energy technologies such as photovoltaic, wind and biogas are fully implemented in large scale.

Kerosene is already subsided but to make it affordable, there is need to reduce transportation costs to depots and inaccessible areas such as slums and the marginalised areas. This will provide affordable energy to low income households, as the government puts in place policies to increase penetration of cleaner technologies.

There is also need to increase penetration of LPG among the low income households by reducing its price to make it affordable. This can be achieved through tax incentives to the fuel itself as well the apparatus used. In addition, there is need to increase storage facilities and refilling stations to reduce wholesale related costs.

Transport

Motor vehicle transport is the largest consumer of commercial energy in Kenya, and the largest emitter of greenhouse gases. It predominantly uses gasoline and diesel fuels. Whilst developed countries have ongoing research programmes on alternative vehicle technologies such as electric cars and hydrogen fuel cells powered cars, none of the technologies are commercially available. Due to the small size of the Kenyan economy, it cannot afford to import these technologies until they are commercially produced and affordable to Kenyans. Since public and commercial vehicle technologies will not change in the medium term, Kenya's dependence on fossil fuels for transportation will continue. Currently, the government is emphasising on age and engine size of vehicles in order to cut on fuel consumption and emission. However, there is currently little evidence of vehicle purchase decisions being based on fuel economy, and existing driver behaviour does not favour fuel efficiency. Only government institutions and parastatals have been directed to sell guzzlers and fuel inefficient vehicles, but the public continues to import fuel inefficient vehicles. With regard to pricing, cost build up of petroleum products needs to be investigated to ensure that only prudently incurred costs are factored in product prices.

Thus fuel-efficient vehicles should be encouraged, for example through incentives to promote the importation of newer, small-engine and more fuel efficient vehicles. At the same time, public awareness campaign should be conducted on the benefits of fuel economy.

With regard to transport fuels, there is need to ensure that only prudently incurred costs enter in the petroleum pricing formula to protect consumers from unnecessary costs that marketers introduce in the price build up.

Public (Mass) Transport

Public transport is key to sustainable use of energy since it can provide services to many passengers without necessarily increasing the number of vehicles. Its success, however, depends on government policy to decongest cities from unnecessary traffic jams and vehicular emission of pollutant gases. This is mainly achieved through a combination of strategies such as expanding roads and investing in fuel efficient public transport vehicle. A high percentage of buses and *matatus* in Kenya comprise of old stock, with poor fuel economy and no emissions control. Use of cleaner fuels in public transport has not been in use in Kenya. It is only in the case of taxis, where a few companies have imported hybrid vehicles which use green energy and fuel at the same time, but these are small occupancy vehicles. Majority of the buses still use diesel. Increase in number of tourists in the country has further raised demand for high occupancy vehicles, hence demand for diesel. Major cities such as Nairobi and Mombasa do not have well organised public transportation systems, although the population has fully grown and overwhelmed the current transport system.

The public (mass) transportation should therefore be promoted (fuel economy, emissions, quality of service), and the public encouraged to use this form of transport.

Areas of Further Research

Energy End Use Analysis

As a means of determining the energy use patterns of the various sectors of the economy to support findings of the National Energy Survey 2009, a comprehensive study should be undertaken. The results of this study would provide necessary information regarding potential areas for energy efficiency applications and reflect on how newly found oil in Kenya's Lokichar Basin in Turkana County should be utilised in the energy mix in the future.

Therefore a study of energy end use practices in all sectors (public, commercial, residential, etc.) of the economy should be conducted in collaboration with National Research and Data Collection Bureaus and Universities with experience in conducting surveys. This study will highlight key opportunities and challenges in demand management and energy savings.

CHAPTER 3

DISTRIBUTIONAL CONSEQUENCES OF FUEL TAXES IN KENYA

3.1 Introduction

Over the next 25 to 30 years, nearly all the growth in energy demand, fossil fuel use, associated local pollution, and green house gas emissions is forecast to come from developing countries (Wolfram *et al*., 2012). This is because developing countries are witnessing high economic growth rates mainly driven by population and capacity to absorb new investments. Developing countries and particularly in Africa are rich in natural resources, therefore attracting Foreign Direct Investment (FDI) compared to the developed countries whose economies have stabilised in their growth paths. However, despite the economic growth witnessed in these countries, majority of the people are still living below the poverty line and huge income disparities exist between the low and high income earners. As a result, most households continue to use traditional sources of biomass that are dirty.

In Kenya, demand for energy has been increasing as efforts are put in place to increase incomes and improve access. Electricity connections in the last seven years have grown by more than 10 percent every year, but still the demand is higher than available supply. In the petroleum sub sector, demand has more than doubled, mainly driven by growth in vehicles and increased economic activity, which has increased movements and number of trips from one destination to another as economic agents transact various businesses across the country. In order to meet this growing demand, there is need to invest in infrastructure. However, to increase the level of investment in infrastructure, the government requires to raise more revenue to fund new road constructions, power generation plants, transmission and distribution of electricity.

Over the years, Kenya's budget deficit has increased and the government has had to borrow from the domestic and external market to fund infrastructure projects and other basic goods and services such as education, health, food security as well as water and sanitation. Due to these challenges, the government, at times, has been forced to increase some of the taxes and tax rates on energy goods and services to raise revenue and achieve environmental protection since some of these energy sources result to high emissions of carbon dioxide and other greenhouse gases. According to Fullerton *et al.* (2010), the case for using taxes, charges and emissions trading schemes (rather than regulation) to help achieve environmental goals is primarily a matter of cost-efficiency. Although emission trading schemes may not be frequently used in developing countries such as Kenya to achieve environmental quality, policy makers are preparing their economies to embrace them once they are introduced due to their long term benefits to curtail climate change.

Fullerton *et al.* (2010) further assert that economic instruments such as taxes are important and may be able to achieve a given level of environmental protection at lower cost, by providing incentives for polluters to choose the most cost-effective abatement mechanisms and encouraging the greatest abatement effort from those polluters for whom it is least expensive They also provide ongoing incentives for innovation in pollution control; and may be less prone to influence by polluters themselves than regulations negotiated, case-by-case, with individual firms. However, they are not a panacea.

In Kenya, reforms in fiscal policy have seen taxes on motor fuels and the annual vehicle excise duty differentiated to reflect the environmental attributes of fuels and vehicles. Pricing of electricity is also done in such a way that it penalises consumer who consumer more than what is considered economically and environmentally unsustainable. However, use of taxes has distributive effects that, if not well addressed, will penalise one group of households, for example the low income at the expense of the high income. It is therefore important to take into account how tax on fuel is distributed across households with different levels of income in order to achieve a meaningful and sustainable policy.

3.1.1 The problem

It has been argued that Kenya's electricity tariffs are high compared to her competitor countries such as Egypt and South Africa within the Common Market for Eastern and Southern Africa (COMESA) region (Aligula, 2006). One of the explanations that has been given to support the high tariffs hypothesis is that taxes on electricity are high. This led the government to reduce value added tax (VAT) on electricity from 16 percent to 12 percent in 2007. However, power tariffs still remain high, due to increase in petrol thermal power generation which is expensive compared to other generation technologies such as hydro, geothermal and coal. These fuel sources are cheaper in the long run, although their initial plant costs are high. Therefore, planned investments in geothermal, wind, coal and nuclear energy technologies according to the Least Cost Power Development Plan (LCPDP) will help stabilise or reduce the generation energy charges in the long run.

In the petroleum sector, motorists and industry have often raised concern about high petroleum prices. It is, however, important to note that Kenya is a net importer of petroleum products, therefore domestic prices are mainly driven by international prices of crude. The volatility in the international markets often triggers a spiral effect in petroleum products price increases in the domestic economy. However, Kenya recently discovered oil in Turkana County and this will be a relief to consumers, if the oil reserves are commercially viable as this will drastically reduce the domestic pump prices. Oil prices are mainly driven by products price at the point of purchase, insurance and freight cost to the port or point of entry as well as refinery fees, pipeline transport costs, bridging costs, taxes and levies.

It has been argued that domestic taxes; excise duty, the roads maintenance levy, and petroleum development levy, among other taxes are high and therefore contribute to tax burden on consumers. However, there are other costs within the petroleum price build up such as the refining costs, demurrage, storage, pipeline and other bridging transportation costs that contribute to the high prices. The wholesale margins by oil marketers are also high, given the final retail price and what these firms give the retail outlets as margins.

While the argument against what is considered as high energy taxes may be valid, it is important to establish who bears the burden of the high taxes. One way to achieve this is by estimating the distributional impacts of these taxes by income groups in order to determine where the burden lies. This would help determine whether fuels taxes in Kenya are progressive or regressive.

3.1.2 Objectives of essay

The main objective of this essay is to estimate distributional effects of fuel taxes in Kenya, with a view of evaluating whether they are progressive or regressive and provide policy recommendations on suitable tax policy on fuels.

The specific objectives of the essay are to:

I. Analyse household budget shares by income groups and deciles

II. Estimate distributional effects of fuel taxes

III. Provide recommendations on fuel consumption behaviour change and appropriate tax policy

3.2 Literature Review

This sub-section provides a review of literature on fiscal policy and energy taxation, energy taxes and public expenditure, and lastly a review of distributional aspects of fuel taxes.

3.2.1 Fiscal policy and energy taxation

Energy tax policy involves the use of one of the government's main fiscal instruments, taxes (both as an incentive and as a disincentive) to alter the allocation or configuration of energy resources and their use (Sherlock *et al*., 2011). In theory, energy taxes and subsidies, like tax policy instruments in general, are intended either to correct a problem, distort e energy markets or to achieve some economic (efficiency, equity or even macroeconomic) objective. In practice, however, energy tax policy is made in a political setting, determined by fiscal dictates and the views and interests of the key players in this setting, including policy makers, special interest groups and academic scholars. As a result, enacted tax policy embodies compromise between economic and political goals, which could either mitigate or compound existing distortions.

The distributional impact of taxes has been studied for a long time in various areas of research. Since Adam Smith advanced the cannons of taxation, many studies have been done to evaluate the characteristics of a good tax system. Smith (1957) outlined four key canons of taxation which he supplemented with three minor ones. These were the cannons of equity, convenience, certainty and economical that is a good tax system should achieve equity in tax implementation, be convenient and therefore readily and easily assessed; collected and administered; certainty in that it has to be consistent; and, stabilize in the prediction of tax payer bills and the amount of revenue collected. Lastly, it has to be economical in terms of compliance and administration, with the costs involved be minimal. The additional canons are adequacy, achievement of social benefits, and neutrality that is it should encourage efficient allocation of resources across the nation (Smith, 1957).

Barthold (2004) provides a background on the economic theory for employing taxation as a tool for environmental policy in which three principles are identified. First, there is the benefit principle taxation where taxes are assessed as user fees to fund specific direct expenditure programmes. For instance, the purpose of the federal motor fuel taxation expansion in the United States in 1956 was to fund highway construction. Many countries and particularly from the developed world have used the tax code to deliver Pigouvian[8] subsidies or impose Pigouvian taxes on polluters. Pigou argues that a tax equal to the difference between marginal social cost and private marginal cost would lead the market

[8] A Pigovian tax applies to a market activity that is generating negative externalities. The tax is intended to correct an inefficient market outcome, by being equal to the negative externalities. In the presence of negative externalities, the social cost of a market activity is not covered by the private cost of the activity (en.wikipedia.org/wiki/pigovian tax).

to an efficient outcome, since it internalises the externality into private costs (Barthold, 2004).

The political elite in many nations have often concluded that fuel tax increases are unpopular in instances where imposing such taxes is likely to increase political risks of losing an election or political supremacy and ideology. For instance, a common argument against transport fuel taxes is that fuel demand is inelastic and, therefore, the environmental benefit of the fuel taxes is small. However, authors such as Sterner (2007) who are pro fuel taxes, conclude that the long run price elasticity of gasoline is high, but in the short run, it may be quite inelastic. The complicated political economy of fuel taxation is addressed in Hammar *et al*. (2004). The study notes that the overall economic and political situation, structure of transport system, as well as characteristics of fuel markets play a key role in gasoline taxes.

3.2.2 Energy taxes and public expenditure

Understanding taxation and public expenditure is important in distributional effects of tax studies because they provide motivation to introduce such taxes and help understand how the Nation's expenditure for goods and services is affected. Many studies done in the past have concentrated on taxes and public expenditures and, a large extent, focused on marginal tax rates. Franzen *et al*. (1975) examined the re-distributional effects of taxes and public expenditures in Sweden. The purpose of the study was to provide estimates of taxes and government expenditures on households by type of household and income class. The income concept chosen was that of total net income, which includes all taxable income. In addition to money income, the study examined some imputed income mainly from owner-occupied homes and realised capital gains. Interests paid and costs incurred in earning income were deducted. To measure redistributive effects of a change in taxes or transfer payment, the study estimates the amount of lump-sum transfer which has to be received by the household to make it indifferent to change. Franzen *et al.* (1975) notes that an alternative approach is to estimate the amount of lump-sum transfer which has to be received by the household, after the change to enable it maintain its initial quantities of goods and factors. The study uses a sample of approximately 16,000 households. Empirical data for the analysis of indirect taxes was derived from a sample of consumer expenditures carried out by Sweden's National Bureau of Statistics. The study finds that taxes and transfers as well as expenditures on goods and services are favourable to low income groups compared to a proportional system. The existing system favours single persons with children in comparison to other types of households.

3.2.2.1 Externalities

The government, in most cases, spends to provide goods and services that are beneficial to society or imposes taxes to curtail certain consumption that are harmful to the public. An externality is a spill over from an economic transaction to a third party, one not directly involved in the transaction itself. Externalities are often present in energy markets as both the production and consumption of energy often involve external costs (or benefits) not taken into account by those involved in the energy-related transaction. Instead, these externalities are imposed on an unaffiliated third party. In the presence of externalities, the market outcome will likely lead to an economically inefficient level of production or consumption (Parry *et al.*, 2005).

A broad array of externalities is associated with our consumption of energy. Burning fossil fuels contributes to air pollution (sulphur dioxides, nitrogen oxides, particulates) and generates greenhouse gases. In addition, our use of petroleum in transportation contributes to roadway congestion, accident externalities, and other traffic related market failures (see Parry *et al*., 2005 for more information on driving related externalities). Economic theory suggests that we should tax externalities directly. Alternatively, one can subsidise clean alternatives to fossil fuels through production and investment tax credits. This is an inefficient way to correct the externality. The subsidy not only lowers the price of renewable energy production relative to the price of fossil fuels, but also the price of energy on average, hence encouraging increased consumption (Metcalf, 2007).

3.2.2.2 Policy intervention in energy markets

The primary goal of taxes worldwide is to raise revenues. There are times, however, when tax policies can be used to achieve other goals such as an economic stimulus or social objectives. Tax policy can also be used to correct market failures, which, without intervention, result to market inefficiencies. There are a number of market failures surrounding the production and consumption of energy. Tax policy, as it relates to energy, can be used to address these market failures.

The various tax benefits create incentives that have the potential to affect economic decisions and allocate economic resources from other uses to the tax-favoured uses. Such tax preferences may produce an allocation of resources that is more efficient for society at large, if they are properly designed to overcome negative effects (such as atmospheric pollution) that would otherwise result from a purely market based outcome, without any government intervention (Joint Committee on Taxation, 2009). The extensive variety of tax expenditures for energy production and conservation has been criticised for lacking well defined objectives and coordination among provisions having similar objectives.

Some argue that the simultaneous existence of tax preferences for the fossil fuel industry and renewable energy production represents an incoherent government policy. Others have noted that the incentives for renewable energy and conservation are not themselves designed in a coordinated way to produce the most efficient or equitable subsidies for renewable energy and conservation. These arguments are important in understanding fuel taxation and climate policy, particularly in developing countries as has been argued by Sterner (2012).

3.2.3 Distributional effects of energy taxes

Hughes (1986) estimates the impact of fuel price and tax changes on the general price level and the distribution of income in the case of Thailand. Using data for 1975-1976 and 1981-1982, they find that inflationary impact of fuel tax changes is insignificant because of both the openness of the economy and the low energy intensity of manufacturing and other production in Thailand. In contrast, taxes on imports engender price increases not only for imports, but also for goods which substitute imports. They find that the net effects of taxes on petroleum products (other than kerosene) are progressive in their distributional impact. A major policy conclusion from their findings is that fuel taxes could be used to increase both equity and allocative efficiency, without inducing significant inflationary responses.

A common argument against transport fuel taxes is that fuel demand is inelastic and, therefore, the environmental benefit of the fuel taxes is small and a tax increase would not reduce fuel consumption. Sterner (2007), however, concludes that the long run price elasticity of gasoline is high, but in the short run, it may be quite inelastic. This has implications for policy makers who often depend on observable short run process.

Hammer *et al*.(2004) points out that the basis for the correlation between fuel taxes and fuel consumption is twofold; not only do lower taxes encourage high consumption, but high consumption also makes it politically complicated to raise taxes (Hammar *et al.*, 2004).

Barron et al. (2004) analyse changes in excise tax and presents an example of the effect the change in the excise tax can have on retail gasoline prices. Two general settings are used for analysing the effect of excise taxes. One assumes that firms sell a homogenous good and compete through output choice (Cournot competition) with price determined only indirectly from market demand. The second assumes firms sell differentiated products and compete in prices (Bertrand competition). Both approaches according to Barron *et al.* (2004), share common features, including the identical characterisation of the effect of change in a unit tax on market prices, for the limiting case of perfect competition. From the analysis, gasoline sellers would certainly like to raise their prices by the full amount of tax, but something stops them. The simple economic theory of supply and demand predicts that excise taxes will not be paid entirely by the consumer through higher prices. Some of the tax burden will fall on the suppliers-refiners and dealers. Interestingly, their findings do not support the more extreme over shifting of tax changes recently found in non-gasoline markets that can arise if one adopts more complex assumptions regarding the curvature of demand functions by the consumer through higher prices. The findings, therefore, provide support to standard economic theory, as well as a means of illustrating some of the subtleties of the analysis, including the implicit assumption regarding the implications of the buying and selling prices to middle men.

Distributional effects of fuel taxation have for some time now dominated debate in energy taxation. While it is commonly argued that gasoline taxes are regressive and therefore not justifiable on such grounds, West (2004) questions this belief. He finds that a tax on miles or gasoline is progressive over the bottom half of the income distribution, but regressive over the wealthiest part. This is because many of the lower income households do not own any vehicles and a price increase would make poorer households to reduce their driving distance more than wealthy households. The study states that greater price responsiveness among low-income households enhances the degree of progressivity in the lower-income groups, while mitigating the degree of regressivity in the upper-income groups. Furthermore, it concludes that gas or mile taxes are significantly less regressive than other possible policy choices for vehicle emission control such as newness subsidies or engine size taxes (West, 2004). Ziramba *et al*. (2012) find that gasoline taxes in South Africa are clearly progressive. Mutua *et al.* (2012) finds similar results for households in Kenya.

Other studies such as Datta (2008) have estimated incidence of fuel taxation. They test the validity of the claim that fuel taxes are regressive by use of data from India. The study uses data from a representative household survey covering more than 124, 000 households, and finds that a fuel tax is progressive. By use of an input-output approach, they analyse the distributional effects from price changes in non fuel goods that is those arising out of fuel tax. Their findings show that the progressivity result holds even when one considers indirect assumption of fuel, through its use as an intermediate input.

Mutua *et al.* (2009) shows that the lowest income household deciles in the City of Nairobi spend somewhat less than 10 percent of their total household expenditures on public transport. In the middle income households, the share is higher, nearly 14 percent for several of the middle income household deciles. For the income deciles with the highest household incomes, the public transport expenditure share of total expenditures drops considerable, and for the highest income deciles, only about 3.5 percent of the total household expenditures constitute public transport expenditures. The low and middle income deciles spend very little of their total expenditure on private transport; the 70 percent lowest income households have all a budget share for private transport of less than 2 percent. This could be compared to the highest income deciles, in which the share of private transport expenditures is 12 percent. When the impacts for public and private transport are combined, the study finds that the total share of transport fuel expenditures to total household expenditure is lower for low income households compared to the high income households. Mutua *et al*. (2009) conclude that transport fuel taxes in the City of Nairobi are not regressive but progressive. It also notes that there is need to improve the public transport system and encourage mass transit so as to reduce private ownership of vehicles and gasoline consumption. This could be done through improvement in the railway system and public bus/metro system. In addition, there is need to revise taxes on high gasoline consumption vehicles which are not used for public transport. This will reduce per capita consumption of gasoline and hence achieve abatement. Lastly, there is need to examine the revenue potential from gasoline taxes and evaluate how these taxes can be used to compensate citizens from welfare losses by improving service delivery in roads, transport and health sectors among others.

Mutua *et al.* (2012) estimate distributional effects of transport fuel taxes by expenditure and income deciles, calculates tax burdens and Suits indices for private transport fuel taxes, and combined distributional effects of both private and public transport fuels. The sample was drawn from Nairobi, the Capital City of Kenya, which has a population of over 3 million people. The analysis of distributional effects of gasoline taxes shows strong progressivity. The study analysed only PMS and AGO oil fuels.

3.2.4 Energy and elated environmental policy instruments

Fiscal instruments are an important item in the policy maker's toolkit for promoting efficient energy use and protecting environmental quality. These policy instruments can help bring prices of goods and services closer to their full social cost, the private cost plus the external cost. This encourages cleaner production and consumption decisions and can help societies achieve better balance between environmental quality and other valued goods and services such as affordable transportation, food, housing and energy (Goulder, 2005). Fiscal instruments in the energy sector in Kenya vary from taxes and duties, and levies that have been implemented to meet certain objectives in revenue maximisation, environmental protection and transport management among other desired policy targets. The taxes vary depending on sector. For example in Kenya's petroleum sector, we have the import duty, road maintenance levy, petroleum development levy, petroleum regulation levy and value added tax (VAT) which is levied on fuel transportation, forming part of the price component.

However, tax rates on these products vary depending on use and other desired environmental protection objectives. PMS and Regular Motor Spirit (RMS) have the highest taxes. LPG and kerosene have lower taxes due to objectives of clean energy, poverty reduction and afforestation. In the electricity sub-sector, we have VAT which previously was 12 percent of total consumption cost, but has since been increased to 16 percent with implementation of the Finance Act 2013 (GoK, 2013), Rural Electrification

Levy which is 5 percent of total consumption, and the ERC Levy which is 3 Ksh. cents per kWh.

3.2.5 Overview of literature

An overview of literature on distributional effects of fuel taxes shows that most studies have used expenditure deciles, Suit Indexes, Compensating Variation to evaluate effect of price hikes on welfare, Social Accounting Matrix-Input-Output Models and CGE models. These models have been widely used to come up with results that have provided policy guidelines in energy taxation implementation and management in many countries.

3.3 Conceptual Framework

This sub-section provides a conceptual rooting between taxes and welfare. Welfare refers to how worse or better off householders are from consuming available fuels given the prevailing economic environment and policy changes. From the literature review, I have established various linkages between energy consumption, income and taxation. In this conceptual framework, I explain further the linkages between taxes and welfare in order to understand fully the problem at hand.

Energy is a basic component and key requirement in sustaining the life and welfare of a household. A household has various needs and to meet them, it has to spend. The most basic need at the household is food, shelter and water. However, energy is needed to prepare the food and meet other social amenities as well as help in the production process at the household. The household energy budget share is critical in determining the share allocated to other needs. The budget share is explained further in subsequent sections.

The unit of analysis in this essay is the household. The household is the basic unit of production in any economy and therefore it represents the production and consumption behaviour of the global economy. Households, in this case, are the key economic agents. As argued by Varian (2003), when there are many economic agents, each might reasonably be assumed to take market price outside their control. Given these exogenous prices, each agent could then determine his or her demand and supplier for the good in question. The price is adjusted to clear the market, and at such an equilibrium price, no agent would want to change his or her actions. This single market model advanced here is the partial equilibrium model in that all prices, other than the price of the goods being studied, are assumed to be fixed. In the partial equilibrium model, all prices are variable, and equilibrium requires that all markets clear. Thus, general equilibrium theory takes account of all interactions between markets and the functioning of individual markets. Understanding general equilibrium is important in understanding household welfare, therefore it is briefly highlighted in this sub section based on work by Varian (1992) and Mas-Collel *et al*. (1995).

Varian (1992) discusses the concept of agents and goods. The concept of a good is however very broad. A good can be distinguished by time, location and state of the world. It is assumed to be a market for each good, in which the price of that good is determined. In the pure exchange model, the only kind of economic agent is the consumer who is described completely by his preferences. In a case where there are many agents, it is reasonable to assume that each agent takes the market price as independent of his actions. This concept is explained further by the Walrasian equilibrium and the first theorem of welfare economics (See Varian, 1992; Mas-Collel *et al*.1995). Pareto efficiency postulates that a feasible allocation x is a weakly Pareto efficient allocation, if there is no other feasible allocation *x'* such that all agents strictly prefer *x'* to *x*. A feasible allocation *x* is a strong Pareto efficient allocation if there is no feasible allocation x' such that all agents weakly prefer *x'* to *x*, and some agents strictly prefer *x'* to *x*.

Introduction of taxes distorts a Pareto efficient allocation of goods and services. Principally, a Pareto efficient allocation is one for which there is no way to make all agents better off. In other words, a Pareto efficient allocation is one for which each agent is well off as possible, given the utilities of other agents (Varian, 1992). Fuels can be assumed to be goods that have to be allocated efficiently. However, the introduction of a tax element in the pricing system distorts efficient allocation of fuel at the household and therefore in the economy, since aggregation of households constitutes the economy. Understanding consumer welfare and how introduction of a tax affects consumption pattern of fuels at the household is thus important.

Provision of energy goods and service requires investment in the supply chain in order for the goods to reach the final consumer, in this case the household. The households, therefore, have to pay for the goods and services that they consume. A price is a signal of value or quality of a good. Energy goods/fuels vary in terms of value and quality, so do their prices. The household has to pay for cooking, lighting, heating as well as transportation fuels. The main cooking and lighting fuels are electricity, kerosene and LPG, while PMS and AGO are the main transport fuels. In order to consume these fuels, a household has to pay a price for each depending on their level of affordability and utility. Price is therefore a key signal in the way fuel allocation takes place within the household and the price level has implications on welfare depending on the income level of the household. The link between prices, taxation, income and welfare are therefore important when analysing distributional effects of fuel taxes.

Income is key in the provision and allocation of fuel at the household level. Income provides the budget constraint around which a household can consume goods and services. A household can only consume goods within its budget constraint. The household income is used to purchase basic goods and services such as food, water, shelter and other amenities. A household income is determined by the ability of the household to access employment opportunities, resource endowment in the area it is located, education level and work experience among other factors. In analysing distributional effects of fuel taxation, it is important to differentiate between households by permanent and temporary income. The permanent income approach states that the choices made by consumers regarding their consumption pattern are largely determined by change in permanent income, rather than change in temporary income. The key conclusion in this theory is that transitory or temporary changes in income have little effect on consumer spending behaviour, whereas permanent income can have large effects on consumer spending behaviour.

The concept of income in this essay is therefore important in analysing distributional effects of fuel taxation. The ability to pay for energy goods depends on a household income. On the other hand, tax rates have implications on disposable income, as households spend what remains after the taxman has taken income tax and other related taxes. Commodity taxes including fuel have implications on a household consumption. Increasing tax on kerosene, electricity and LPG will increase their prices, thus increasing the cost of cooking, lighting and heating at the household. Similarly, increasing the tax on transportation fuels will increase the cost of both private and public transport, because fuel forms the highest component of transportation costs. Increasing income tax paid by the household or other indirect taxes it pays to the exchequer as a result of consuming energy goods, would reduce their disposable income available to purchase other basic goods. Taxation, therefore, can adversely affect the welfare of the household, if it is regressive.

In comparative static, analysis of how an economic outcome varies as the economic environment changes is one of the best ways to determine the impact of policy changes. Policy changes can, for example come in the form of taxes or subsidies. The most important thing about taxes is that there are two prices in the system, the demand price and the supply price. The demand price is paid by the demanders of the good, and the supply price is received by the suppliers of the good; the two differ by the amount of the tax or subsidy. For example, quantity tax is levied on the amount of a good consumed. This means that the price paid by the demanders is greater than the price received by the suppliers by the amount of the tax. A value tax on the other hand is a tax levied on the expenditure of a good. It is usually expressed as a percentage amount such as 12 percent tax in the case of electricity in Kenya. Subsidies have similar structure; a quantity subsidy of amount 's' means that the seller received 's' dollars more per unit than the buyer pays (Varian, 1992). The solution of the equilibrium prices and quantity takes into consideration taxes and subsidies and ably leads to welfare analysis.

Taxes and subsidies are therefore key in distributional analysis. Tax progressivity or regressivity of a fuel is determined by its nature and whether it is a basic, normal or giffen good. Fiscal policy of any Government should therefore, in consultation with other responsible agencies, evaluate the impact of fuel taxes before any increases due to the impact they have on prices and welfare of the household. A regressive tax on fuel has a heavier burden than a progressive tax. Linkages between budget shares, fuel prices, household income which is represented by the income of the household head and tax policy forms, the core of discussion in this essay.

3.4 Methodology of Study

The methodology in this essay involves development of fuel expenditure models and analysis of tax incidence on fuel following Blackman *et al.* (2009) and Suits (1977). Related studies have also been done by Poterba (1991); West (2004), Hassett *et al*. (2009); Metcalf (1999), Datta (2008), Ziramba (2012) and Mutua (2009; 2012) for transport fuels in the City of Nairobi. In this essay, I estimate budget shares for the various fuels, incidence of tax which is passed through to the consumer as prices increase or reduce and estimation of Suit Index which shows how progressive or regressive an increase of a fuel tax affects the household.

3.4.1 Distributional effects of fuel taxes

Distributional analysis of effects of fuel taxes in this essay is in two parts. First, I compute energy budget shares of household expenditures for each category of population classified by household income deciles. Secondly, Suit Indices (Suits, 1977) to determine whether fuel taxes are progressive or regressive are computed. It is important to take into account those directly paying for energy services as was seen in the demand analyses in Essay One (1), those with a positive budget were considered.

3.4.1.1 Fuel budget shares and expenditure

The budget share for each income decile is calculated following Ziramba *et al*. (2012), Datta (2008), West (2004), Mutua *et al.* (2009) and Blackman *et al*. (2009). The interest in the analyses is that part of the expenditures dedicated to fuel at the household.

The essay uses a simple analytical framework to assess the incidence of fuel price hikes due to a tax increase or reduction. The average household expenditure on fuel type j in expenditure decile s, $W_{f\,js}$, is defined as the price of that fuel type, $P_{f\,j}$, multiplied by the average quantity consumed, $Q_{f\,js}$

$$W_{f\,js} = P_{f\,j}Q_{f\,js} \tag{3.1}$$

This essay considers distributional effects of fuel taxes in five key fuels; electricity, kerosene, LPG, PMS or gasoline and AGO or diesel. The first three are household domestic fuels used mainly for cooking, lighting, heating and cooling. The last two are transport based fuels. Gasoline is used mainly in small occupancy vehicles mainly used in private transport, while diesel is used in high occupancy vehicles generally used for public transport and transportation of goods both in roads and railway. I primarily focus on two household transport needs, that is private or public transport, but not freight transport which is provided by lorries and trucks. After selecting the five fuels, I consider direct expenditure on electricity (e), kerosene (k), LPG (l), PMS/gasoline (g) and AGO/diesel (d). In addition, I include indirect expenditure on diesel (b) from the expenditure households incurred when they use public transport/bus/'*matatu'*. Thereafter, I estimate the impact of taxes on household expenditure by estimating the Suit Index to determine whether they are progressive or regressive. The formulation of the expenditure analysis is as outlined as:

The total expenditure on all categories of fuels in decile s, W_{Ts}, is

$$W_{Ts} = W_{fes} + W_{fks} + W_{fls} + W_{fgs} + W_{fds} + W_{fbs} \quad (3.2)$$

Following equation (3.2), the budget share on a particular fuel can be expressed as

$$w_i = \frac{w_{fj}}{w_{Ts}} \quad (3.3)$$

$$j = 1, \ldots..5$$

Direct expenditure on electricity, kerosene, LPG, PMS (gasoline) and diesel (AGO) are derived from the National Energy Survey 2009. However, transport fuels have indirect expenditure for example those households spending on public transport, since they do not own a vehicle. Indirect expenditure on diesel via spending on bus/*matatu*/public transport diesel in decile s, W_{fbs}, is the expenditure on bus travel, that is derived from the survey data, times the percentage of this spending devoted to fuel, α_{fb}., derived from the study on Public Transport (Aligula *et al*., 2005). This is formulated as follows:

$$W_{fbs} = W_{bs}\alpha_{fb}. \quad (3.4)$$

Aligula *et al*. (2005) estimated that 30 percent of public transport expenditures in the City of Nairobi were fuel related, while direct expenditure on private transport was 80 percent of total cost. Mutua (2012) using data from the KIPPRA Public Transport Study Survey, 2005, assumed the same percentages in computation of fuel expenditures and Suit Index. This is used in this essay for ease of exposition and convenience.

3.4.2 Analysis of the Suit Index

The distributional effects of energy taxes illustrated above by use of budget shares can be complemented further with the Suit Index. The aim is to examine whether fuel taxes such as VAT and other levies on electricity, kerosene tax, tax on LPG as well as gasoline that is PMS and AGO/diesel are progressive in the case of Kenya. To measure the progressivity or regressivity of a tax, a figure similar to the Lorenzo curve, but one in which the accumulated percent of tax burden is plotted vertically against the accumulated percent of income on the horizontal axis, is used.

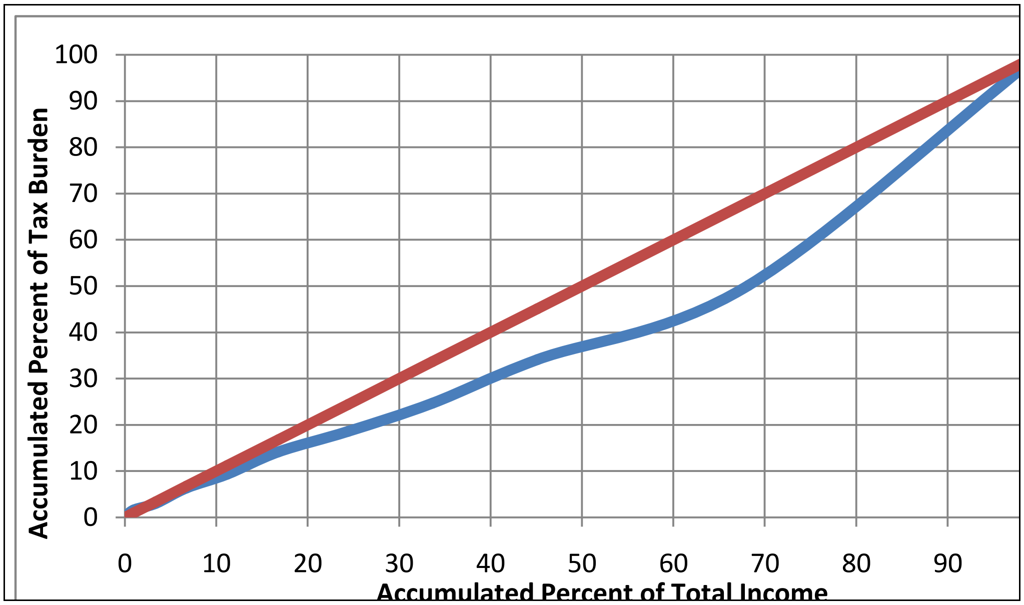
This sub-section of the methodology is drawn in full from Suits (1977) for ease of exposition and convenience. Suits outlined five key steps that have been used to compute the Suit Index for fuel taxes. Following these steps and by illustrations in Figure 3.5.1, I demonstrate how to compute the index.

Analogously to the Gini coefficient ratio, I define the index of progressivity *S* for Kenya in terms of *K*, the area under the triangle and the *L*, the area between the Lorenz curve and the horizontal axis. The equation to estimate the Suit Index is specified as follows:

$$S = \frac{(K-L)}{K} = 1 - (\frac{L}{K}) \qquad (3.5)$$

The relationship between *K* and *L* is illustrated further in **Figure 3.5.1**.

Figure 3.5 1: Illustration of the Relationship between Income and Tax Burden



Source: Suits, 1977

3.4.2.1 Properties of the Suit(S) Index

The Suit Index exhibits certain properties which make it unique in policy analysis, particularly when it comes to scenario building on expected outcomes of various tax rates in fiscal policy making. According to Suits (1977), it facilitates exposition to represent the accumulated percentage income, measured on horizontal axis as a variable *y* that ranges from 0 to 100. The ordinate of the Lorenz curve representing the corresponding accumulated percent of total tax burden for a given tax *x*, then becomes $T_x(y)$. In this case, the area under the curve corresponding to tax *x* is given by:

$$L_x = \int_0^{100} T_x(y)\,dy \tag{3.6}$$

Recalling that the area of the triangle has been designated *K*, it therefore follows that the index of progressivity or regressivity of the tax is given by:

$$S_x = 1 - (\frac{L_x}{K}) \qquad (3.7)$$

The above formula is applied to calculate the area under the curve as stated in equation 3.8.

3.4.2.2 Calculation of the index

In practice, the value of $T_x(y)$ is known for only a few discrete values of *y*. The values are given for only 11 values of *y* : for $y_1, y_2 \dots y_{10}$, corresponding to the population deciles and for y=0. According to Suits (1977), this information is adequate to provide a close approximation to the value of the integral:

$$L_x = \int_0^{100} T_x(y)\,dy \qquad (3.8)$$

3.4.3 Permanent and temporary income

In analysing the progressivity or regressivity of taxes, I consider the permanent and temporary income approaches in order to determine the lifetime and temporary income impacts. The permanent income approach states that the choices made by consumers regarding their consumption pattern are largely determined by change in permanent income, rather than change in temporary income. The key conclusion in this theory is that transitory, temporary changes in income have little effect on consumer spending behaviour, whereas permanent income can have large effects on consumer spending behaviour. Measured income and consumption contain a permanent element which is usually anticipated and planned; and a transitory element which has a windfall gain or unexpected element. Friedman (1957) concluded that the individual will consume a constant proportion of his/her permanent income; and that low income earners have a higher propensity to consume, while high income earners have a high transitory element to their income and a lower than average propensity to consume.

Studies have shown that the uses of annual income are somewhat more likely to support the common assertion that fuel taxes are regressive in Western countries (KPMG, 1990; Sterner, 2012). However, this approach has been criticised on grounds that households make consumption choices on the basis of their ''lifetime'' or ''permanent'' income rather than annual income (Friedman, 1957). This essay following Sterner (2012) reports and compares both measures, but is more confident in using expenditure data as a proxy for lifetime income to sort households into income/economic strata and normalise changes in wellbeing depending on level of tax burden.

3.5 Data Sets

This essay uses data from the National Energy Survey 2009 for Kenya that was used in chapter two in addition it utilises other secondary data sets from the KNBS, Ministry of Finance, Kenya Revenue Authority (KRA) and ERC to analyse the distributional consequences of fuel taxation. The data sets are national statistics that are reliable and good enough to analyse and inform policy.

3.6 Empirical Analysis

This sub-section provides an analysis of distributional aspects of fuel taxes in Kenya. It, specifically, provides descriptive statistics, profile of fuel taxes, fuel expenditure shares by deciles and distributional effects of fuel taxes that cover regressivity and progressivity of fuel taxes in Kenya.

3.6.1 Descriptive statistics

This sub-section provides descriptive statistics for all the five fuels.. The summary statistics are provided for fuel expenditures, fuel budget shares by income group and trend analysis of fuel prices. The results are presented in tables 3.6.1 to 3.6.3.

Fuel Expenditures by Income Groups

As seen above, the sample has been split into three income groups mainly, low income, middle income and high income groups. In the case of electricity, the mean expenditure when all groups are amalgamated together is Ksh. 1,230 per month, while the maximum expenditure was recorded at Ksh. 73,704 and the minimum was zero. LPG had the lowest mean expenditure of Ksh. 214. The highest mean monthly expenditure is that of PMS at Ksh. 3,408 followed by AGO at Ksh. 1,751. Kerosene's mean expenditure is Ksh. 316.

As expected, the high income group recorded the highest monthly fuel expenditure for all income groups electricity, LPG, PMS and AGO at Ksh. 4,151, Ksh. 664, Ksh. 9,530 and Ksh. 15,000, respectively. The group has very low expenditure of kerosene of Ksh. 106. The middle income group is second in expenditures of these fuels except for PMS and AGO where they spend more on the latter. This is an indication that they use public transport more, hence consumption due to their higher indirect consumption and payment for the fuel. Expenditure on kerosene is highest in the low income group and lowest in the high income group. This indicates that while kerosene is a basic fuel among the poor, it is an inferior good among the high income group, thus as the income of a household increases, it is likely to consume less kerosene. Low income households do not have options on fuel choice particularly in the urban areas where they consume more kerosene in lighting and cooking. They do not have access to other alternative fuels such as LPG and electricity which requires one to afford such fuels as well as equipments, which facilitate their utilisation. See **Table 3.6.1** on households' expenditures for the various income groups by month.

Fuel Budget Shares by Income Group

Budget shares are critical in the allocation of a household. They provide an indication of how the household allocates the fuel needs available given its budget constraint. **Table 3.6.2** summarises fuel budget shares by income group. When budget shares are summarised for all income groups, electricity had the highest budget share followed by kerosene (0.148) and LPG (0.043) among cooking, lighting and heating fuels at 0.563.

The fuel budget share depicts a similar pattern for all other income groups apart from the kerosene budget share which declines as the income of the household increases, meaning that the highest income group has very low budget share for kerosene. Transport fuels have the highest budget shares for all income groups. The middle income group has the highest budget share in the case of PMS, while the high income group has the highest budget share for AGO. High income households have choices to make in private transport due to availability of more than one car in the household. Due to their high income levels, they are able to afford expensive cars which consume AGO because of their high engine capacity in fuel utilisation. This is one of the main factors responsible for the high budget share of AGO compared to PMS and other fuels in other income groups.

Table 3.6. 1: Household Fuel Expenditure, Ksh. per Month by Income Group

Variable	Mean	Std. Dev.	Min	Max
All Income Groups				
Electricity	1,230	1,698	0	73,704
Kerosene	316	451	0	8,080
Liquefied Petroleum Gas	214	536	0	5,700
Premium Motor Spirit	3,408	2,034	400	30,000
Automotive Gas Oil	1,751	2,031	140	41,600
Total Expenditure	15,744	18,042	300	355,000
Total Monthly Expenditure	6,919	4,541	3,125	78,964
Low Income Group				
Electricity	1,132	1,523	0	73,704
Kerosene	335	454	0	8,080
Liquefied Petroleum Gas	83	308	0	2,600
Premium Motor Spirit	2,280	48	560	4,000
Automotive Gas Oil	1,130	31	140	2,280
Total Expenditure	10,386	7,876	594	140,300
Total Monthly Expenditure	4,961	1,642	3,125	78,964
Middle Income Group				
Electricity	1,156	902	1	15,000
Kerosene	286	469	0	6,000
Liquefied Petroleum Gas	371	648	0	4,000
Premium Motor Spirit	6,692	685	1,187	16,000
Automotive Gas Oil	2,626	186	500	6,750
Total Expenditure	21,753	13,467	2,130	123,707
Total Monthly Expenditure	11,116	1,321	5,413	20,426
High Income Group				
Electricity	4,151	5,472	500	34,000
Kerosene	106	416	0	3,700
Liquefied Petroleum Gas	664	1,101	0	5,700
Premium Motor Spirit	9,530	2,948	500	30,000
Automotive Gas Oil	15,000	1,052	9,000	21,000
Total Expenditure	80,817	60,375	6,834	355,000
Total Monthly Expenditure	30,439	6,934	19,200	62,185

Source: Author’s Computations from National Energy Survey, 2009

Table 3.6. 2: Fuel Budget Shares by Income Group

Variable	Mean	Std. Dev.	Min	Max
All Income Groups				
Electricity	0.563	0.337	0.000	1.000
Kerosene	0.148	0.162	0.000	1.000
Liquefied Petroleum Gas	0.043	0.127	0.000	0.999
Premium Motor Spirit	0.167	0.261	0.000	0.860
Automotive Gas Oil	0.078	0.126	0.000	0.874
Low Income				
Electricity	0.754	0.197	0.000	1.000
Kerosene	0.202	0.166	0.000	1.000
Liquefied Petroleum Gas	0.043	0.146	0.000	0.999
Premium Motor Spirit	0.000	0.018	0.000	0.860
Automotive Gas Oil	0.001	0.016	0.000	0.649
Middle Income Group				
Electricity	0.100	0.052	0.000	0.425
Kerosene	0.025	0.035	0.000	0.375
Liquefied Petroleum Gas	0.031	0.051	0.000	0.285
Premium Motor Spirit	0.606	0.061	0.219	0.795
Automotive Gas Oil	0.239	0.028	0.041	0.485
High Income Group				
Electricity	0.121	0.106	0.019	0.547
Kerosene	0.008	0.021	0.000	0.124
Liquefied Petroleum Gas	0.045	0.036	0.000	0.155
Premium Motor Spirit	0.316	0.070	0.026	0.566
Automotive Gas Oil	0.510	0.087	0.241	0.781

Source: Author’s Computations from National Energy Survey, 2009

Trend Analysis of Fuel Consumption

Analysis of fuel consumption for the period 2001 to 2011 shows a major increase in consumption of all fuel types. According to **Table 3.6.3** all fuels witnessed increased consumption. With regard to electricity, the number of connections increased by almost three times from 537,097 in 2001 to 1,463,639 in the year 2010, while it was recorded at 1,700,000 in 2011. The annual percentage electricity connections increased from 6.2 percent in 2001 to 15.5 percent in 2010, and 19.8 percent in 2011. The year 2009 and 2011 recorded the highest annual connections at 19.5 percent and 19.8 percent mainly driven by the Rural Electrification programme, with the creation of Rural Electrification Authority (REA).

In terms of energy consumption in the electricity sub-sector, it increased from 4,564.8GWh in 2001 to 6,975.8GWh in 2010, while 7,032GWh was recorded in 2011. Other cooking and lighting fuels that is kerosene and LPG, recorded consumption of 306.1 thousand tonnes and 35.6 thousand tonnes, respectively. Interestingly, kerosene consumption has had mixed reactions in the last ten years. Its consumption declined to as low as 190 thousand tonnes in 2003 then increased to 307 thousand tonnes in 2005. The slow increase in kerosene consumption could be attributed to increased electrification that has reduced its demand among the middle and high income groups, as well as reduction of the number of people under the poverty line.

The number of households under the poverty line has reduced from 56 percent in 2002 to 46 percent in 2009. With regard to transport fuels, consumption of PMS and AGO has increased from 374.3 thousand tonnes and 663.7 thousand tonnes in 2001 to 597.2 thousand and 1,517 thousand tonnes in 2010, respectively. The increase is attributed to rapid increase in the number of vehicles and motorisation. The number of vehicles has increased from 0.75 million in 2005 and 1.16 million and 1.73 million in 2010 and 2012, respectively. This shows that households and the Kenyan economy have generally acquired more vehicles, hence increased consumption of transport fuels.

Table 3.6. 3: Trends in Fuel Consumption and Electricity Connections, 2001-2011

	Electricity connections and consumption			**Consumption of petroleum fuels (000's tonnes)**			
Year	Electricity connections	Electricity connections (% increase)	Electricity(GWh)	Kerosene	Liquefied Petroleum Gas	Premium Motor Spirit	Automotive Gas Oil
2001	537,079	6.2	4,564.8	306.1	35.6	374.3	663.7
2002	593,621	10.5	4,924.2	273.6	40.5	365.8	627.3
2003	643,274	8.4	5,041.0	190	40.9	327.9	649.6
2004	686,195	6.7	5,356.4	236.1	41.7	326.4	789.4
2005	735,144	7.1	5,574.9	307	49.4	333.7	892.4
2006	802,249	9.1	5,905.7	281.4	95.6	403.9	1,081.9
2007	924,329	15.2	6,347.2	265.2	77.4	367.1	1,116.5
2008	1,060,383	14.7	6,485.4	244.7	84.4	381.3	1,141.1
2009	1,267,198	19.5	6,507.2	332.8	74.6	461.7	1,416.1
2010	1,463,639	15.5	6,975.8	316	87.8	597.2	1,517.3
2011	1,700,000	19.8	7,032.3	324	91.6	562.1	1,462.3

Source: KNBS, Various Issues and KPLC Annual Reports, 2003-2012

Trends Analysis of Fuel Prices

In the last ten years, the nominal prices of fuels have been on the rise. This is important in explaining that fuel expenditures and budget shares are critical in policy advice. **Table 3.6.4** shows trend analyses for fuel prices from 2001-2011. The prices of most fuels increased threefold. However, electricity prices decreased from Ksh. 9.13/kWh to Ksh. 5.70/kWh in 2004. The high prices in 2001 are attributed to increases in Fuel Cost Charge (FCC) due to a rise in generation from petroleum thermal sources, which according to electricity tariff policy, is passed through to the consumer. In 2002 to 2004, there was an increase in power generation from hydropower sources during the same period, which is cheaper, therefore leading to reduction in power prices. At the same time, the government reduced taxes on automotive gas oil and fuel oil, which is used for power generation. The price of electricity increased from Ksh. 7.06/kWh in 2005 to Ksh. 15.20/kWh in 2010, hence more than doubling during the period. This is attributed to increased generation of power from petrol thermal sources and depreciation of the Kenya shilling that led to increased fuel adjustments costs. The electricity tariff declined to Ksh. 13.29/kWh in 2011.

The trend analyses of kerosene price, mainly consumed by the low income households, shows that it has been on the rise. The price of kerosene increased from Ksh. 33.95/litre in 2001 to Ksh. 75.15/litre in 2008. Due to the strengthening of the shilling in 2009 and global economic crisis which damped growth of many countries, the global prices of petroleum fuels generally came down translating into decline in domestic price, which was recorded at Ksh. 61.8/Litre. During the same period, the National Treasury reduced tax on kerosene by Ksh. 7.00/litre. However, in 2010 the price increased to Ksh. 74.12, mainly due to a rise in global prices of crude petroleum, and depreciation of the local currency. The price of kerosene is now zero rated in tax, but has a petroleum regulation levy of 0.4 Kenya cents/litre.

The price of LPG just as the case of kerosene has been increasing from Ksh. 1,183.32/13kg gas cylinder in 2001 to Ksh.2, 191/13kg gas cylinder in 2010. The price increases have occurred despite the zero rating of LPG for domestic consumption in taxes. On the other hand, with regard to transport fuels, the price of PMS has increased from Ksh. 56.18/litre in 2001 to Ksh. 97.12/litre in 2008, mainly due to the global crude price increases when the international price per barrel was recorded at US$ 147/barrel. The price declined in 2009 but increased in 2010 to Ksh. 95.65/litre. On the other hand, the price of AGO has increased from Ksh. 46.01 in 2001 to Ksh. 87.10 in 2010. With introduction of petroleum price regulations in December 2010, its duty reduced by Ksh. 2 due to its use in public transport which benefits the poor and cargo transportation.

Table 3.6. 4: Trend Analysis of Fuel Prices

	Electricity price(Ksh./kWh)	**Petroleum fuels prices (Ksh./Litre)**			
Year	Electricity	Kerosene	Liquefied Petroleum Gas (Ksh./13kg)	Premium Motor Spirit	Automotive Gas Oil
2001	9.13	33.95	1,183.32	56.18	46.01
2002	6.84	33.12	1,258.85	55.19	44.35
2003	6.09	35.49	1,339.12	59.89	47.39
2004	5.70	40.33	1,424.59	66.21	52.82
2005	7.06	43.90	1,515.52	72.54	62.27
2006	8.09	56.03	1,612.26	78.19	68.04
2007	8.32	57.25	1,705.76	80.08	68.23
2008	8.51	75.15	1,845.46	97.12	89.27
2009	13.49	61.80	1,936.56	82.14	73.12
2010	15.20	74.12	2,191.00	95.65	87.10
2011	13.29	88.34	2,510..55	113.39	105.53

Source: KNBS Economic Surveys & Statistical Abstracts, 2003-2012; KPLC Annual Reports Publications, 2003-2012

3.6.2 Profile of fuel taxes in Kenya

This sub-section of the essay provides a discussion on fuel taxes. The Government of Kenya through the National Treasury levies various taxes for fuels. The aim is to raise government revenue to finance the National Budget as well as meet other objectives such as reduction of pollution to the environment and mitigate against other environmental degrading effects such as climate change. Taxes on electricity, kerosene, LPG, PMS and AGO are discussed. Taxes have been used as environmental/economic instruments to help achieve equity and environmental sustainability.

Electricity Taxes

Electricity consumers are subjected to three main forms of taxes; Rural Electrification Programme Levy Fund, the ERC levy and a value added tax. Recently, a Water Resources and Management Authority (WARMA) levy was introduced to electricity generation, which is passed on to consumers as a pass through facility. The Rural Electrification Programme Levy Fund was established on 17th of July 1998 in accordance with the power conferred to the Minister of Energy (now Cabinet Secretary, Ministry of Energy and Petroleum) by sections 129 and 130 of the Electric Power Act, 1997. The Permanent Secretary in the Ministry of Energy (now Principal Secretary, Ministry of Energy and Petroleum) at any one time is the designated officer to administer the fund (GoK, 1998). The levy was previously managed at the Rural Electrification Programme Department in the Ministry of Energy, but is now implemented by the Rural Electrification Authority. The levy is 5 percent of the total electricity consumption by a consumer and is collected by KPLC on behalf of the rural agency. The second form of tax levied on electricity is the VAT. The VAT on electricity is currently 16 percent. Previously it was 12 percent between 2007-September 2013 after the National Treasury reduced the tax to lighten the burden of power costs to consumers as a result of the increased cost of living. The National Treasury recently reinstated the current VAT with the implementation of the Finance Act 2013(National Treasury, 2013) to increase government revenue. The third form of tax is the ERC levy, which is 3 Kenya cents/kWh and is meant to facilitate regulation of the electricity sub-sector. The tax component in the electricity power bill is at least 17 percent when the additional levies on rural electrification and regulation levy are included. **Table 3.6.5** shows electricity taxes in Kenya.

Table 3.6. 5: Electricity Taxes

Electricity Taxes	**Level of Tax**
Rural Electrification Programme Levy	5.00%
ERC Levy (Kenya cents/kWh)	3.00
Value Added Tax	12.00% (16%, September 2013).

Source: KPLC, ERC and KRA Websites, 2012

Petroleum Taxes

The key taxes levied on petroleum products in Kenya include: the excise duty, road maintenance levy, petroleum development levy, petroleum regulation levy, import declaration and remission taxes. The excise duty is levied as per the East African Community (EAC) custom guidelines and the duty is similar across the member countries. The levels of other taxes, however, vary depending on product and its main use.

With regard to kerosene, it has been zero rated in excise duty and is not subject to road maintenance levy since it is mainly used for lighting and cooking among the rural households and urban poor, where affordability and access of cleaner fuels such as electricity and LPG is a challenge. However, there is still a development and petroleum regulation levy of 4 Kenya cents per litre, respectively. In addition to these taxes, there is an import declaration charge which is 2.25 percent of total product imported and a remission tax of Ksh. 0.45/litre. The excise tax on kerosene has been zero rated in excise tax to cushion the poor against the high petroleum prices, which have mainly been driven by increase in global prices of crude per barrel and depreciation of the Kenya shilling. LPG has been zero rated for excise duty and no road maintenance levy is charged. However, all other levies for development and as import declaration and import remission apply.

As for transport based fuels, the excise duty is Ksh. 19.895, Ksh. 19.505 and Ksh. 7.305 for PMS, RMS and AGO, respectively. However, consumption of RMS is minimal, thus it is not analysed further in this essay. The duty on AGO which was previously Ksh. 10.305 was reduced by Ksh. 2.061 per litre to cushion users of public transport and freight transport for bulk goods mainly used in the manufacturing sector. The aim is to cushion the poor from high public transport prices and reduce the cost of doing business in the country, particularly among the industrial and commercial enterprises that are the key engines for economic growth. **Table 3.6.6** provides more details on petroleum taxes.

Table 3.6. 6: Petroleum Taxes

Product	Excise duty (Ksh./litre)	Road maintance levy (Ksh./litre)	Petroleum development levy (Ksh./litre)	Petroleum regulation levy (Ksh./litre)	Remission (Ksh./litre)	Import declaration (percent)
Kerosene	0	0	0.4	0.4	0.45	2.25%
LPG	0	0	0.4	0.0	0.45	2.25%
RMS	19.505	9	0.4	0.4	0.45	2.25%
PMS	19.895	9	0.4	0.4	0.45	2.25%
AGO	10.305[9](8.244)	9	0.4	0.4	0.30	2.25%

KRA, 2007; Government of Kenya (2011)[10]

Petroleum Price Margins in Kenya

Petroleum price margins to industry players are important in the sustainability of their business and have various impacts on the final consumer of these products/fuels. Price build up of petroleum products is determined by various cost components in the petroleum supply and distribution chain. In any business enterprise, it is important that prices reflect the cost of supplying products and services and the petroleum supply chain is no exception. The price offered is a signal for quality and value of a product. In Kenya, the petroleum supply chain is dominated by about four major companies (Kenkobil, Total Kenya, Shell (Now Vivo Energy) and Oil Libya), the National Oil Corporation of Kenya (NOCK) and independent dealers. The major four companies comprise over 80 percent of

[9] Excise duty on AGO was reduced by Ksh. 2.061/litre in July 2011 to help cushion users of public transport. AGO benefits majority of households.
[10] There is an import declaration fee of 2.25 percent on all petroleum products.

the total demand[11]. NOCK's market share is less than 5 percent, despite it being created to stabilise the local price through importation and exploration of petroleum products. It was envisaged that the company would secure security of supply and stabilise petroleum prices in the country, but this has not happened to date. The company has been constrained by inadequate funding, low human capacity and lack of facilities to expand its exploration function that would discover oil reserves and provide for domestic production and export. This would reduce reliance on imported petroleum products and save the economy billion of dollars in foreign exchange.

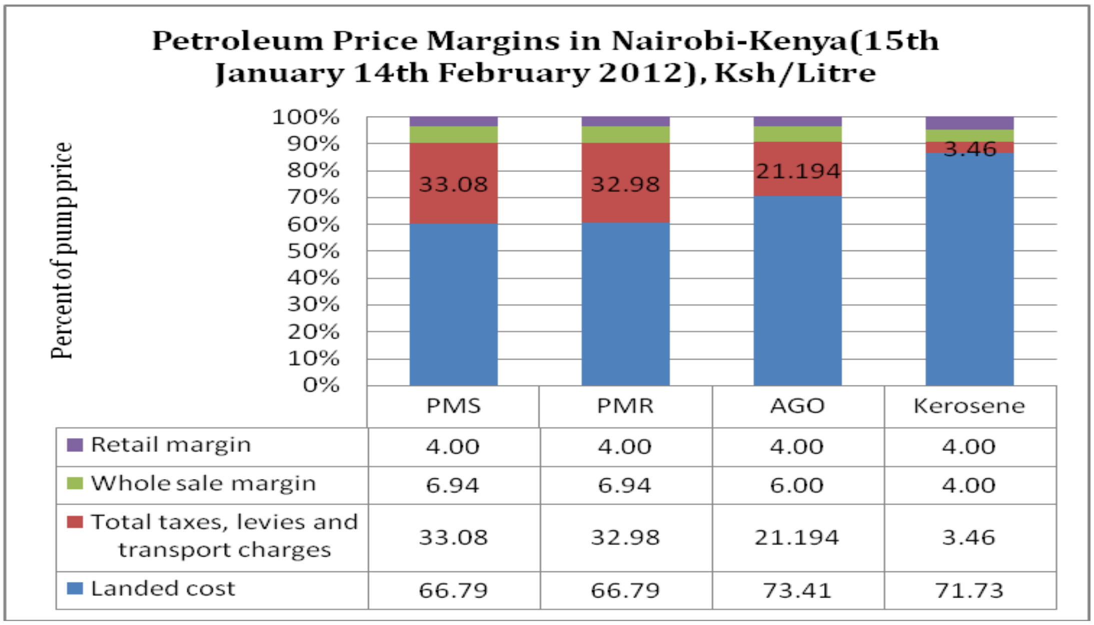
The petroleum supply chain begins from the Open Tender System (OTS) where the demand for the next month is determined and open tenders floated competitively. Oil marketers bid mainly for the Cost, Insurance and Freight (CIF) component to the port of Mombasa, since crude and finished products at the Abu Dhabi National Oil Company (ADNOC) including the Murban crude, are fixed every month retrogressively.

Petroleum price build up comprises of four key components; landed cost or what is referred to ex-KPRL price per litre, taxes and levies, fees and transport charges and price margins to marketers. as from January 15th to 14th February 2012, price review period, the total taxes were Ksh. 29.350/litre, Ksh. 17.68421.09/litre, Ksh. 0.45/litre for PMS, AGO and kerosene, respectively. Fees and transport charges to Nairobi for the three products were Ksh. 3.73/litre, Ksh. 3.51/litre and Ksh. 3.01litre, respectively. Taxes for PMS are the highest, while kerosene has the lowest tax since it is used in many low income households and in areas that have no access to electricity. **Figure 3.6.1** shows petroleum

[11] Other multinational companies such as Caltex and AGIP have exited the downstream petroleum market. There have also been mergers and acquisition; BP merged with Shell, Total bought out Caltex, and Elf interests was bought by Engen. Shell has sold part of its business to Herios, a Dutch based company that has now been renamed Vivo Energy. The market shares by companies as of January 2012 are summarised in AppendixTable A6.

price margins in Nairobi during the review period. **Table 3.6.7** shows a breakdown of all components of the petroleum pump prices in Nairobi. The prices vary across other towns and counties due to variance in transport charges. Taxes levies and other charges for PMS/RMS and AGO contribute about 30 percent and 20 percent of total price respectively, while the tax component from kerosene is less than one percent.

Figure 3.6. 1: Petroleum Price Margins in Nairobi (15th January-14th February 2012), Ksh./Litre



Source: Author's Computations from ERC Data, January 2012

Table 3.6. 7: Breakdown of Petroleum Price Margins in Nairobi (15th January-14th February 2012), Ksh./Litre

Cost Element	PMS	RMS	AGO	Kerosene
Landed cost	66.79	66.79	73.41	71.73
Total taxes and levies	29.35	29.25	17.684	0.45
Fees and transport charges	3.73	3.73	3.51	3.01
Total taxes fees and transport charges	33.08	32.98	21.194	3.46
Whole sale margin	6.94	6.94	6.00	4.00
Whole sale price	106.81	106.71	100.604	79.19
Retail margin	4.00	4.00	4.00	4.00
Pump Price	**110.81**	**110.71**	**104.604**	**83.19**

Source: Author's Computations from Monthly Petroleum Price Review Data (ERC, 2012)

3.7.3 Budget shares and distributional effects of fuel taxes

This sub-section provides deeper analyses of fuel taxes in Kenya. It analyses and discusses households' expenditure shares and temporary income shares by deciles and fuel shares as a percentage of total household expenditure and incomes by deciles, analyses the Suit Index (coefficient) and provides discussion of the results.

3.7.3.1 Analyses of expenditure and income by deciles

The analyses of total household expenditure and income by deciles show that the lower deciles have the lowest incomes and expenditures levels as expected. As already seen from the KNBS Housing and Budget Survey 2005/06, those households with income levels below Ksh. 23,670 are classified as low income, those earning between Ksh. 23,671 to Ksh. 100,000 are the middle group, while those earning over Ksh. 100,000 are the high income group. Going by the expenditure approach, about 49.65 percent of households are in the low income deciles, while 42.02 percent are by the household income. These results are consistent with poverty levels in the country at 46 percent. This aggregation by deciles, however, is different from the way analyses of poverty are done, because the key issue is to profile households by expenditure and income. The aim is to show the distribution of the households by expenditures and incomes in the sample (**Table 3.6.**8).

Table 3.6. 8: Analysis of Monthly Expenditure and Income by Deciles

	By Actual Expenditure Deciles (Ksh.)			By Temporary Income Deciles (Ksh.)		
	Expenditure	Percent	Cumulative percent	Income	Percent	Cumulative percent
1	2,986.070	1.90	1.90	6,143.06	2.79	2.79
2	5,246.168	3.34	5.23	8,771.89	3.99	6.78
3	6,865.112	4.36	9.60	10,075.36	4.58	11.36
4	8,475.446	5.39	14.99	12,279.01	5.58	16.94
5	10,154.500	6.46	21.44	15,124.24	6.87	23.81
6	11,949.790	7.60	29.04	18,519.26	8.42	32.23
7	14,398.750	9.15	38.19	21,538.64	9.79	42.02
8	18,025.810	11.46	49.65	27,190.25	12.36	54.38
9	24,461.770	15.55	65.20	34,924.40	15.87	70.25
10	54,740.750	34.80	100.00	65,443.20	29.75	100.00

1US$Ksh.=77.5, CBK, June 2009; 1US$=Ksh. 83.22, CBK, April 2012

3.7. 3.2 Fuel expenditure shares by deciles

Analyses of fuel expenditure shares by deciles (**Table 3.6.9**) show variances by use and fuel type. The cooking, lighting and heating fuels include electricity, kerosene and LPG, while PMS and AGO are transport fuels. The fuel uses and other characteristics have already been discussed in earlier chapters in this essay. Generally, as can be observed from Table **3.6.9**, the basic fuels such as electricity and kerosene have higher expenditure shares in the lower deciles, while LPG and the transport fuels have higher expenditures share as one moves to the high income deciles. Interestingly, the lowest expenditure decile has a very high budget share (percent of total expenditure) at 6.75 in the case of PMS. This could be explained by the growing phenomenon in rural areas, where transport is now provided by motor cycles and bicycles popularly known as the *'Boda Bodas'*. Due to their high per capita consumption of fuel, they tend to charge high prices/fares for their services, since they can only carry one or two passengers per trip. This mode of transport involves long distances travelling especially in the rural areas. As a result, users of this mode of transport majority of who are in the poor deciles, are likely to spend more on PMS despite its high budget share in the lowest deciles, which is contrary to expectations in developed countries. In Kenya, the profit margin for oil marketers for PMS in January 2012 was approximately, Ksh.6.94 (6.3 percent) while that of retailers was Ksh.4.00(3.6) of the total price. Thus the total profit margins shared between the wholesaler and the retailers was Ksh. 10.94(9.8 percent) of the total price of PMS paid by consumers.

On the other hand, the richest decile is likely to spend less of their total budget on PMS, given their high incomes, meaning a smaller proportion of their income is dedicated to purchases of PMS. In the case of AGO, the lowest decile has a higher budget share than the 2nd, 3rd and 4th deciles. Again, this is due to usage of public transport and given the limited choices available. They still have to ride on a bus or *matatu* to places of work and health facilities, hence the high budget share as a percentage of the total expenditure.

Table 3.6. 9: Fuel Expenditure Shares by Deciles as Percent of Total Household Expenditure

	Cooking, Lighting and Heating Fuels			**Transport Fuels**	
Deciles	Electricity	Kerosene	LPG	PMS	AGO
1	23.86	7.81	0.06	6.75	2.69
2	12.87	5.54	0.25	4.89	1.96
3	8.58	4.10	0.47	4.51	2.26
4	7.75	3.79	0.59	5.52	2.22
5	7.36	3.35	1.07	9.18	3.75
6	7.34	2.72	1.22	10.03	4.23
7	6.55	2.48	1.62	11.70	5.28
8	6.78	2.15	1.58	15.33	7.25
9	4.71	1.38	1.80	14.52	7.61
10	4.18	0.54	1.50	7.44	9.10

Source: Author's Computations from National Energy Survey, 2009

Cooking, Lighting and Heating Fuels Expenditure Shares by Deciles

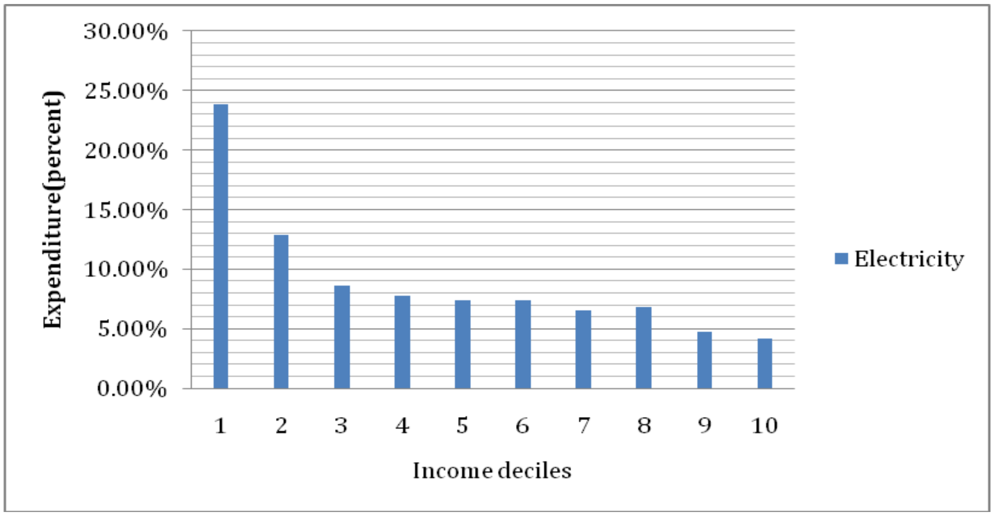
This sub-section of the essay analyses cooking, lighting and heating fuels expenditure shares by expenditure/income deciles. The shares vary depending on whether a fuel is a basic need or a luxury. The basic fuels are those that are fundamental to provision of energy needs at the households and the household cannot function well without them. The luxury fuels are those that a household can do without, but symbolise a higher status in society and also signify environmental quality. As people become more well of, they are conscious of the environment they live in, therefore becoming choosy on the type of fuel used. It should be noted that the analyses as outlined earlier does not consider other sources of energy at the household level such as material residual, fuel wood, charcoal and renewable energy such as wind and solar as focus is on fuels that attract some form of formal tax, regulated by the ERC and that are also widely used by the household.

Electricity Expenditure Shares

Electricity is one of the most important fuels at the household level that attracts some forms of tax. The electricity expenditure shares as a percentage of total monthly expenditure are presented in **Figure 3.6.2**. The figure shows that households in the lowest income decile allocate about 24 percent of its budget on electricity consumption while those in the highest deciles allocate only about 4 percent of the total household energy budget. This indicates that the lower income deciles have a heavier electricity budget burden compared to the high income deciles. Households in the lower income deciles allocate a higher percentage of their total income on electricity, and they thus have to forego other needs at the household to provide for this particular basic need.

The analyses also suggest that a tax increase on electricity which is levied uniformly across consumers will negatively affect low income earners than the middle and high income groups. The impact of the incidence of the tax will be more severe on lower income households and least severe on the high income deciles, since the richer households have a lower proportion of their income that is allocated to electricity. Following the fuel ladder and fuel stacking hypothesis, the richer households are able to accommodate more modern and cleaner fuels due to their affordability and access in the consumption basket.

Figure 3.6. 2: Electricity Expenditure Shares as % of Total Monthly Expenditure

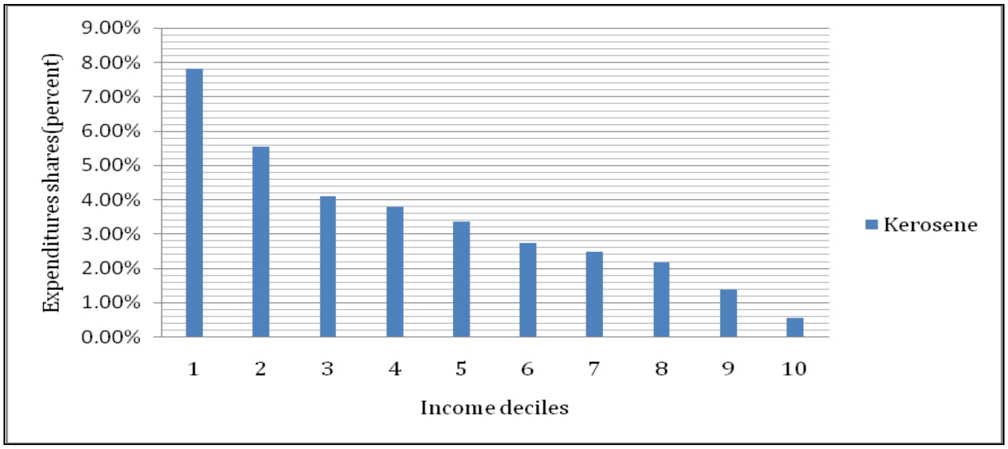


Source: Author's Computations from National Energy Survey, 2009

Kerosene Expenditure Shares

Kerosene is one of the fuels that is prominent and critical in a household's energy basket. It is a basic necessity among the low income households, particularly those in rural and informal settlements in urban areas, where access to electricity and other forms of modern energy lacks. As is the case of electricity, lower income households allocate a higher percentage of their budget on electricity amounting to 7.8 percent in the first income deciles compared to about 0.4 percent in highest income deciles. **Figure 3.6.3** shows kerosene expenditure shares as a percent of total monthly expenditure. This indicates that kerosene is a basic necessity in the low income deciles and therefore households allocate substantial amounts of their income on its consumption. The higher income deciles allocate very little of income on kerosene consumption due to the fact that they rarely use it and also have high incomes. To these households, kerosene does not form a substantial component in the fuel budget share. It is lower than what is allocated to kerosene among all income deciles. An increase in the price of kerosene due to increase in a tax for example, will have a higher burden on low income households than the high income ones. This explains the policy stance taken by the Government of Kenya to zero rate kerosene in tax, in order to reduce the burden on households.

Figure 3.6. 3: Kerosene Expenditure Shares as % of Total Monthly Expenditure



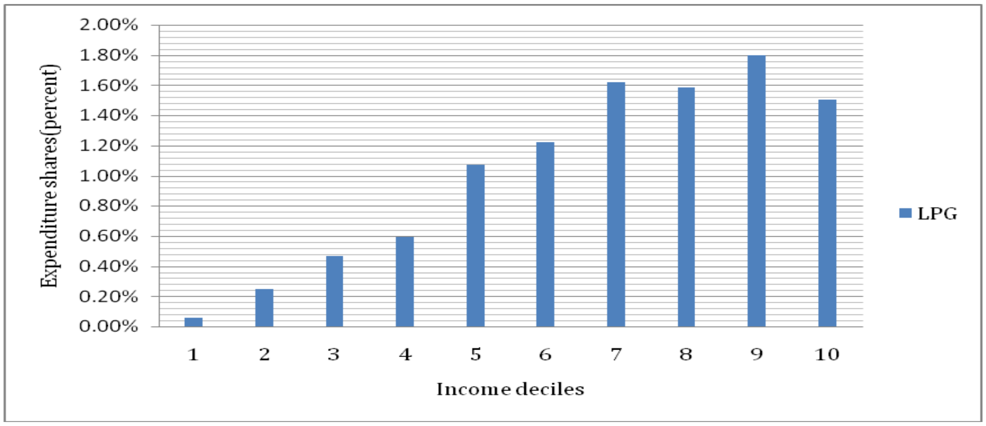
Source: Author's Computations from National Energy Survey, 2009

3.6.3.2.1 Liquefied Petroleum Gas (LPG) Expenditure Share

The LPG has gained increased prominence in its use among middle urban households and the high income groups in the country in recent past. LPG is considered one of the cleanest cooking fuels and its consumption plays a key role to reduce afforestation and indoor pollution. However, consumption patterns for LPG show that it is mainly consumed among the middle and higher income groups. The supply of LPG is mainly through 6kg and 13kg gas cylinders, which create a barrier to access the low income groups. Although the gas is long lasting, it is expensive compared to other liquid fuels such as kerosene. Analyses of LPG expenditure shares by income deciles show that the low income groups allocate a very small percent of their income on LPG, while the high income deciles allocate slightly over 1.5 percent of their total income on its consumption. **Figure 3.6.4** shows LPG expenditure shares as a percent of total household monthly consumption. The allocation in the low income decile is minimal, but increases as one moves to the high income deciles. The low allocation could be attributed mainly to affordability and access. The low income groups have very poor access and their incomes cannot enable them acquire equipment and other facilities that go with LPG consumption.

The results of LPG expenditure shares by income decile are also presented in **Figure 3.6.4**. Given the distributive pattern of the budget share, a price increase due to a tax increase for example would be borne more by the high income groups, particularly the middle class than the low income deciles. In order to increase uptake of LPG, there is need to reduce its burden on the middle and high income groups. Although LPG is zero rated in excise duty, there are still other forms of taxes which inhibit its consumption. However, the big challenge in LPG consumption has to do with infrastructure constraint which has undermined importation of the gas in large quantities. The tax burden is on the higher income deciles, therefore policies should target these income groups if usage of LPG is to increase while protecting the environment and reducing in-door pollution.

Figure 3.6. 4: LPG Expenditure Shares as % of Total Monthly Expenditure



Source: Author's Computations from National Energy Survey, 2009

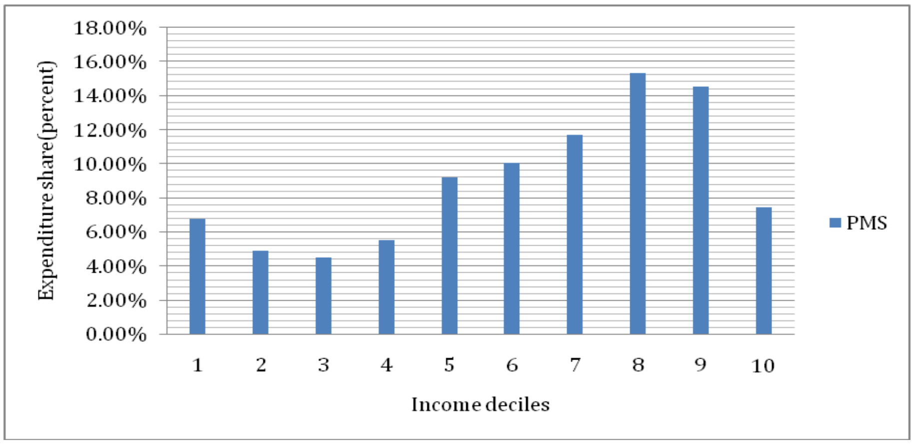
3.6.3.2.2 Transport fuels expenditure shares

Fuel expenditure shares analyses in this sub-section are on transport fuels, that is Petroleum Motor Spirit and Automotive Gas Oil. The expenditure shares in this analyses as was the case in the cooking and lighting fuels considered direct expenditures, that is the expenditures that were incurred by direct purchase of the fuels.

Premium Motor Spirit expenditure share

The PMS is one of the popular fuels in the transport sub sector and is second to AGO. PMS is mainly used in small engine capacity vehicles, which are mainly for private transport. Kenya has seen an upsurge in demand for smaller occupancy vehicles, mainly due to a growing middle class and poor urban transport system that is not well integrated to provide travel needs for all revellers. The analyses of PMS expenditure shares show that the middle and upper income deciles allocate a higher percent of their income on its consumption. The highest expenditure share at about 15 percent is recorded in the 8^{th} income decile, while the low income decile allocates as low as 4 percent in the 2^{nd} income decile. **Figure 3.6.5** shows PMS expenditure shares as a percent of total monthly expenditure. The distributive pattern of PMS budget shares suggests that the high income decile allocates high percentage of their income on this particular fuel. This means that a price increase, for example due to increase in the tax of PMS, would burden the middle and high income deciles more than the low income deciles.

Figure 3.6. 5: PMS Expenditure Shares as % of Total Monthly Expenditure

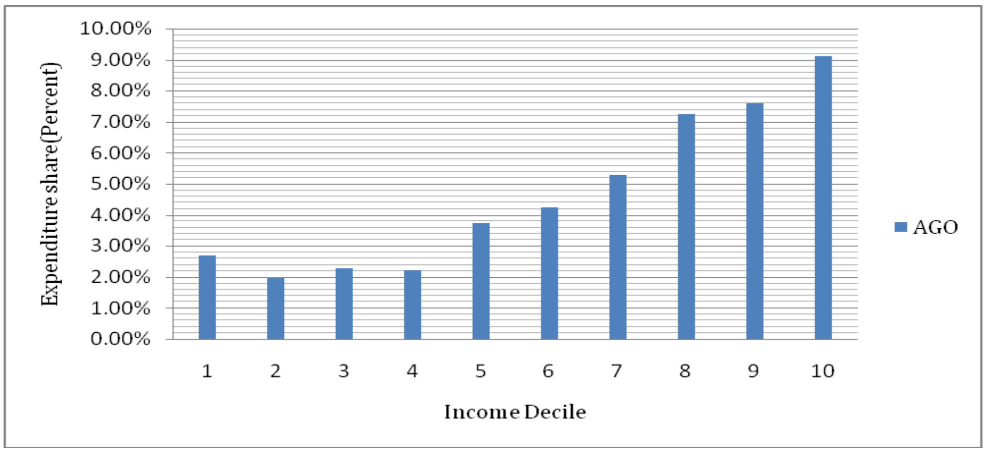


Source: Author's Computations from National Energy Survey, 2009

Automotive Gas Oil expenditure share

Automotive Gas Oil is mainly consumed in high capacity engine vehicles which are mostly used in public transport by buses and *'matatus'*, and the freight transport by trucks, as well as 'fuel guzzlers' owned by the affluent, Government Ministries and other Public/State Departments. The distributive pattern of AGO is similar to that of PMS, but lower in terms of allocated budget. As shown in **Figure 3.6.6**, the high income decile allocates a higher budget share on AGO compared to the low income deciles. From the analyses, the second decile has the lowest expenditures share of 2 percent compared to 9 percent in the 10^{th} income decile. The analyses seem to indicate that those households with high income bear more burden on fuel consumption compared to low income group, but the level of burden is lower than that of PMS. A price increase due to tax increase will be borne more by the high income decile, and it compares to the low income one. Due to its strategic importance in the transport system, tax on AGO is lower than that of PMS by close to Ksh. 10. The government recently reduced the excise duty on AGO by about Ksh. 2, to reduce the cost of living imposed by increased international prices of petroleum products and inflation.

Figure 3.6. 6: AGO Expenditure Shares as % of Total Monthly Expenditure



Source: Author's Computations from National Energy Survey, 2009

3.6.3.3 Distributional effects of fuel taxes

Analyses of distributional effects of fuel taxes in this essay are achieved through computation of the Suit Index as outlined in the methodology of study. In the analyses, income and fuel expenditures for every income decile is accumulated for all the five fuels. Analogous to the Gini coefficient ratio, I define the Index of Progressivity, *S* for Kenya in terms of *K*, the area under the triangle and *L*, the area between the Lorenz curve and the horizontal axis. Through accumulation of the expenditure budget shares for the five fuels, it has been possible to find *L*. The results of *L* for cooking, lighting and heating fuels; and transport fuels are presented in **Table 3.6.10** and **Table 3.6.11,** respectively. In the case of cooking, lighting and heating fuels, the results show that the accumulated shares for electricity are 0.603 and 0.575 using life time income and temporary income approach respectively. In the case of kerosene, the accumulated shares are 0.702 and 0.675, while those of LPG are 0.437 and 0.404, respectively. Positive *L*, which is above 0.5, shows a higher burden for the lower income deciles. **Figure 3.6.7** shows accumulated distribution of cooking, lighting and heating fuels expenditure shares by income deciles for all the three fuels. Kerosene has a higher burden followed by electricity and LPG in that order.

Table 3.6. 10: Computations of L for Cooking, Lighting and Heating Fuels

	Electricity		**Kerosene**		**LPG**	
Decile	(a)	(b)	(a)	(b)	(a)	(b)
1	0.001	0.001	0.001	0.001	0.000	0.000
2	0.004	0.004	0.004	0.005	0.000	0.000
3	0.007	0.008	0.009	0.010	0.001	0.001
4	0.013	0.013	0.016	0.017	0.002	0.002
5	0.020	0.021	0.026	0.028	0.005	0.005
6	0.029	0.033	0.039	0.043	0.010	0.011
7	0.044	0.047	0.057	0.061	0.020	0.022
8	0.068	0.073	0.085	0.091	0.039	0.042
9	0.110	0.113	0.133	0.136	0.080	0.081
10	0.308	0.263	0.332	0.284	0.281	0.240
*L*i.e. **Sum(L)**	**0.603**	**0.575**	**0.702**	**0.675**	**0.437**	**0.404**
Suit Index	**-0.206**	**-0.150**	**-0.404**	**-0.351**	**0.127**	**0.193**

Source: Author’s Computations from National Energy Survey, 2009

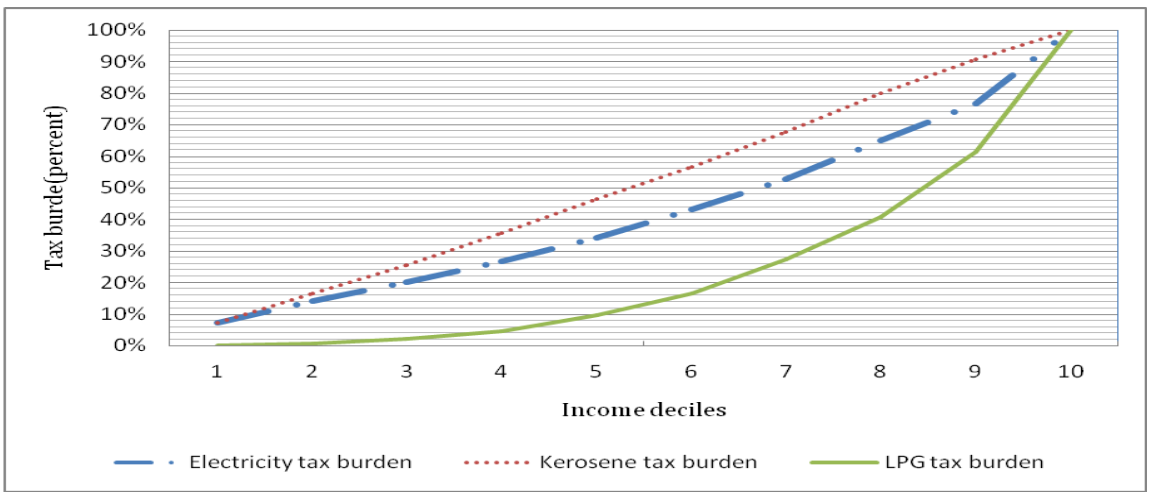
*Suit coefficient=1-(L/0.5); * *(a) =Life time income approach; (b) =Temporary income approach

Table 3.6. 11: Computation of L for Transport Fuels

	PMS		AGO	
Decile	(a)	(b)	(a)	(b)
1	0.000	0.001	0.000	0.000
2	0.001	0.002	0.001	0.001
3	0.003	0.003	0.002	0.001
4	0.006	0.006	0.004	0.002
5	0.012	0.012	0.007	0.005
6	0.021	0.023	0.013	0.009
7	0.038	0.041	0.025	0.017
8	0.071	0.077	0.049	0.034
9	0.135	0.138	0.118	0.068
10	0.174	0.149	0.174	0.226
L i.e. **Sum(L)**	**0.461**	**0.451**	**0.393**	**0.363**
Suit Index	**0.078**	**0.099**	**0.214**	**0.275**

Source: Author's Computations from National Energy Survey, 2009;*Suit coefficient=1-(L/0.5);* *(a) =Life time income approach; (b) =Temporary income approach

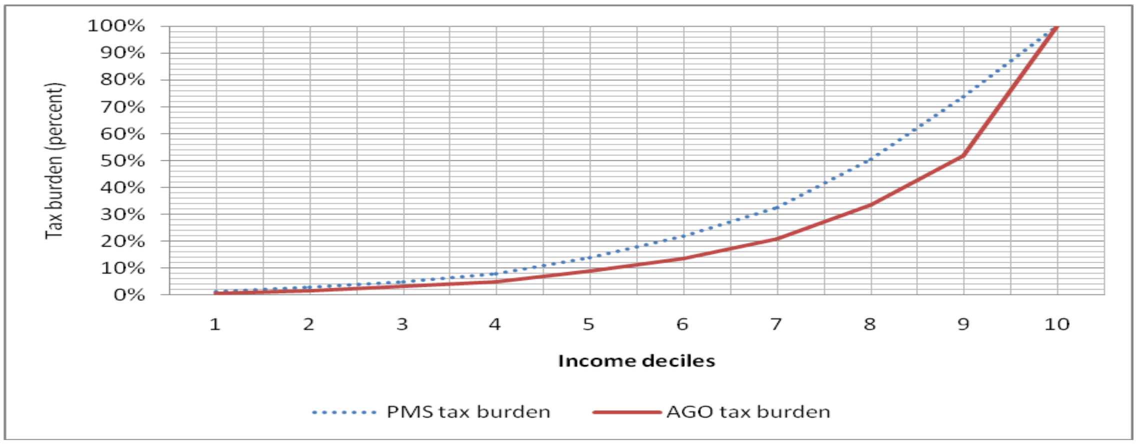
Figure 3.6. 7: Distribution of Expenditure for Lighting, Cooking and Heating Fuels



Source: Author's Computations from National Energy Survey, 2009

With regards to transport fuels, the estimated accumulated shares for PMS are 0.461 and 0.451 for life time income and temporary income approach respectively. The accumulated shares for both fuels are higher in the life time income approach, than temporary income approach. They are, however, lower than those estimated in Mutua *et* *al.* (2012) from the Urban Transport Study Survey in 2004/05. The distributive properties of expenditure shares for transport fuels are also supported by **Figure 3.6.8.** From the figure, fuel burden is lower for low income deciles compared to high income decile. The results also show that PMS has a higher burden on households compared to AGO.

Figure 3.6. 8: Distribution of Fuel Expenditure Burden for Transport Fuels



Source: Author's Computations from National Energy Survey, 2009

3.6.3.4 Regressivity and progressivity of fuel taxes

This last sub-section of the empirical chapter summarises the distributional aspects of fuel taxes. The section tries to answer the question that was posed earlier in the statement of the problem and objective of study on whether fuel taxes are regressive or progressive. **Table 3.6.12** summarises the Suit Index (coefficients) for the cooking, lighting; and, heating fuels and the transport fuels. The Suit Indexes are -0.206, -0.404 and 0.127 for the life time income approach for electricity, kerosene and LPG respectively, while in the temporary income approach they are -0.150, -0.351 and 0.193, respectively. In the case of electricity and kerosene, the tax burden is negative and therefore regressive. This means that lower income households bear a higher burden from a tax increase compared to the high income deciles. However, in the case of LPG, a tax increase will be progressive, thus the burden will be more in high income households compared to low income households.

With regards to transport fuels, in the lifetime income approach, the Suit Indexes are 0.078 and 0.214 for PMS and AGO, respectively. On the other hand, the temporary income approach shows that the Suit Indexes are 0.099 and 0.275, respectively. In both cases, the tax burden is larger in high income deciles compared to low income ones, hence the tax burden is progressive. A tax increase in PMS and AGO hurts more high income earners because of the progressivity in nature.

Table 3.6. 12: Suit Indices for Fuel Taxes in Kenya

Parameter	**Cooking, Lighting and Heating Fuels**			**Transport Fuels**	
Suit Index	Electricity	Kerosene	LPG	PMS	AGO
Lifetime income approach	-0.206	-0.404	0.127	0.078	0.214
Temporary income approach	-0.150	-0.351	0.193	0.099	0.275

Source: Authors Computations from the National Energy Survey, 2009

From the analyses and discussions, I conclude that the basic cooking, lighting and heating fuels are regressive in taxes, therefore any tax increase would have a greater burden on the low income households compared to the high income ones. It is only LPG whose tax burden is progressive in the case of cooking fuels. Analyses of tax burden for transport fuels that is PMS and AGO, shows that they are progressive in the case of Kenya. The degree of progressivity, however, varies depending on type of fuel used in transport.

3.7 Conclusions and Policy Recommendations

The aim of this essay was to analyse distributional effects of fuel taxes in Kenya and provide policy recommendations on optimal tax policy. The fuels considered were electricity, kerosene and LPG (cooking, lighting and cooking fuels); and, PMS and AGO (transport fuels). I began by asking whether fuel taxes are progressive or regressive in the case of Kenya.

3.7.1 Summary conclusions

In this essay, I reviewed relevant literature on distributional aspects of fuel taxes in both developed and developing countries. From the literature survey, it is evident that the conclusion on whether fuel taxes are regressive as the case is popularly thought on transport fuels has mixed results. Most of the studies have been done in transport fuels and very few in cooking, lighting and heating fuels. The distributional impact of taxes has been studied for a long time. Since Adam Smith came up with the canons of taxation, many studies have been done to evaluate the characteristics of a good tax system. Other such studies concentrated on taxes and public expenditures and have mainly, to a large extent, focused on marginal tax rates at the macroeconomic level.

From the literature review, a common argument against transport fuel taxes is that fuel demand is inelastic; therefore the environmental benefit of the fuel taxes is small. It is assumed that a tax increase would not reduce consumption, hence associated emissions. However, some reviewed studies concluded that the long run price elasticity of gasoline is high, but in the short run it may be quite inelastic. Very few studies have been done on cooking, lighting and heating fuels such as electricity, kerosene and LPG, yet they also attract some form of taxation. The distributional aspects of fuels taxes have implications for policy makers, who often depend on observable short run progress.

The literature review also revealed that fiscal instruments are important items in the policy makers' toolkit for promoting efficient energy use and protecting environmental quality. These policy instruments can help bring prices of goods and services closer to their full social cost, the private, plus the external cost. This encourages cleaner production and consumption decisions and can help societies achieve better balance between environmental quality and other valued goods and services such as affordable transportation, food, housing and energy. Fiscal instruments in the energy sector in Kenya vary from taxes, duties and levies that have been implemented to meet certain objectives in revenue maximisation, environmental protection and transport management among other desired policy targets. The taxes and rates vary depending on sector and fuel type.

This essay has used data from the National Energy Survey (2009) which interviewed 3,665 households and time series data from various publications of KNBS, to provide both discrete and trend analyses of various fuels. In order to achieve comparability with National Survey Data by KNBS, the sample was categorised into relatively homogenous groups based on their monthly income/expenditure. This was done because consumers with low income tend to spend a greater proportion of their income on food and other basic necessities, while those with higher income spend more of their income on needs and luxuries. Thereafter, the analyses were done by income and expenditure deciles.

The empirical sub-section has provided an analysis of distributional aspects of fuel taxes in Kenya. The sub-section specifically provided descriptive statistics, profile of fuel taxes, fuel expenditure shares by deciles, and distributional effects of fuel taxes that cover regressivity and progressivity of fuel taxes in the case of Kenya.

The essay has further provided trend analyses of fuel consumption, prices and price margins of some of the key fuels used in cooking, lighting and heating, as well as transport related fuels to augment the analyses of budget shares and other related properties of the primary data. From the analyses, it has been established that budget shares are critical in the allocation of a household fuel. They provide an indication of how the households allocate fuel needs available given its budget constraint. The analyses of fuel expenditure shares by deciles show variances by use and fuel type. Generally, the basic fuels such as electricity and kerosene have higher expenditure shares in the lower deciles, while LPG and transport fuels have higher expenditure shares among the high income deciles.

Analyses of distributional effects of fuel taxes were achieved through computation of the Suit Index as outlined in the methodology section. As indicated earlier, analogously to the Gini coefficient, the essay has defined and estimated the Index of progressivity or regressivity. The Suit Index analysis has shown that in the case of electricity and kerosene, the tax burden is negative therefore regressive, meaning lower income households bear a heavier burden from a tax increase compared to the high income deciles. However, in the case of LPG, a tax increase will be progressive, thus the burden is more in high income households compared to low income ones. On the other hand, transport fuels have a larger tax burden in high income deciles compared to low income ones. Therefore tax burden is progressive. A tax increase in PMS and AGO hurts the high income earners more because of its progressivity in nature.

3.7.2 Policy recommendations

Cooking, Lighting and Heating Fuels

Cooking, lighting and heating fuels play a key role as basic goods and critical necessities within the household. For this reason, it is important to come up with concrete recommendations that would help reduce tax burdens that are levied on these fuels as well as achieve efficiency in their use. This sub section provides recommendations for each of the three fuels.

Firstly, the government should sustain the life line tariff in electricity pricing to reduce the burden of power bills to the low income households. In this case, the threshold from the present consumer categories should be retained to benefit the poor households more, because, a tax on electricity is regressive to the poor. Sustaining the life line tariff provides a relief to the household as it will pay a constant tariff for the first 50kWh, therefore low taxation, hence a lighter burden.

Secondly, through partnerships with the private sector, the government should diversify and increase electric power generation from cheaper technologies in order to reduce fuel adjustment costs, forex and inflation adjustments, which are passed through to the consumer. Given that tax on electricity is regressive and with a heavier burden on the low income households, this would be a relief to consumers.

Thirdly, sustenance of the zero tax regime in kerosene should be upheld in order to cushion the poor during hard economic times. However, due to emissions of carbon dioxide and other indoor pollutions, there is need to have some form of tax to reduce too much use of kerosene.

Fourthly, more incentives are needed to increase uptake of LPG. This can be achieved through zero rating it in tax and providing incentives to investors to put more resources on infrastructure provision to increase access among low income households and reduce the burden for the middle and high income households. Increased use of LPG will lead to reduction in kerosene use, which has higher indoor pollution and contributes more carbon dioxide (CO_2) that is detrimental to household members' health and environmental quality.

Transport Fuels

Firstly, the current tax rate on PMS should be sustained so as to discourage use of low occupancy vehicles that are responsible for higher emissions of greenhouse gases and other associated externalities such as traffic jams. Secondly, a further tax reduction on AGO which is meant for public and freight transport should be effected, however tax on 'fuel guzzlers' should be increased so as to deter use of such vehicles which emit high amounts of carbon dioxide and other greenhouse gases.

Thirdly, the Government through the various agencies should improve information gathering on fuel consumption and CO_2 emissions available to consumers. For example, some fuel efficiency tests can be somewhat misleading as they do not accurately reflect average use in fuel economy.

Fourthly, regulatory standards for fuel consumption or CO_2 emissions that remove the uncertainty over how much investment in fuel efficiency is viable are required. Therefore instruments that have been used before such as limits on age of vehicles should be enhanced and monitored to ensure compliance.

Fifthly, although the Kenyan Government has previously focused on the age limit of the vehicle, it is important to differentiate vehicle taxes according to CO_2 emissions or fuel economy so as to encourage consumers to prefer improved efficiency. This will reduce importation of fuel guzzlers that are inefficient in fuel consumption and which emit much CO_2.

Sixthly, the government should consider introducing a statutory fixed monetary levy that should be regulated by the Ministry for Energy and Petroleum in concurrence with the National Treasury. This fund should principally be utilised to smooth out fluctuations in the price of liquid fuels through slate payments; to afford synfuel (synthetic fuel obtained from coal, natural gas or biomass) producers tariff protection and to finance the crude oil "premium" (price differential applicable to Kenya's oil purchases). This has worked well in South Africa for some years now.

Lastly, the Government of Kenya and indeed other governments in the region have to recognise their responsibility to minimise the costs of intervention in promoting fuel efficiency in both private and public transport. For example, they could keep the differentiation of vehicle taxes simple and similar across regional markets and ensure coherence with vehicle fuel efficiency labelling systems.

CHAPTER 4

MEASURING WELFARE IMPACT OF FUEL PRICE INCREASES ON KENYA'S HOUSEHOLDS

4.1 Introduction

The energy sector in Kenya has been hit by various episodes of price increases that have not only hurt the poor, but also eroded disposable incomes of majority of households. The unprecedented increase in fuel prices in 2008 due to increase in global fuel prices had a spiral effect on the Kenyan economy. At the time, many households found themselves unable to meet their energy needs for transportation, cooking, lighting and heating. The cost of electricity increased three fold mainly driven by increased fuel cost charge due to increase in petroleum thermal power in the generation mix on account of reduction in water levels in hydropower dams and related hydro risks, foreign exchange and inflation adjustments.

The striking increase in world oil prices and the global food crisis were two prominent news headlines in the first half of 2008. During the time, the average price of a barrel of oil witnessed high increases recording the highest price ever of US$ 147 in July 2008. According to Huang *et al*. (2009), the prices surpassed the US $100 mark for the first time in mid-February 2008. In addition, the real price of oil skyrocketed to surpass the old time high of 1981 during the Iraq-Iran war. The prices were later dampened by the global financial crisis in late 2008, which led to a slump in global economies so that the oil prices plugged downwards to about US$ 40 by the end of 2008. The high oil prices hit hard at every stage of the food production chain, from fertilizers to tractors to transport.

In addition, a complex combination of events threw the world food supply and demand out of balance in mid-2008, resulting in the world's worst food crisis since the 1970s.

Kenyan households are not immune to the effects of high global energy prices, which compete with food prices as the key basic living expenditures on the consumers' budgets. High prices inevitably erode the Kenyan household's purchasing power, especially low-income households. In particular, high costs of energy may curtail household spending for other essential goods and services, such as health care, shelter and education. There is, therefore, a policy value in investigating demand for fuels as well as in evaluating the consumer welfare effects of increased fuel prices.

Fuel demand has been exacerbated by increased economic activity, population pressure and lifestyle changes as more households become motorised, particularly with fuel guzzlers. While the world is shifting gears to fuel efficient cars in the face of tough economic times, many fuel guzzlers are finding their way into Kenya's domestic market. Many motor dealers in the developing world are holding huge stocks of cars with large engines whose demand in developed nations has drastically reduced due to the need for efficient and environmentally friendly vehicles (Watson *et al*., 2012).

Many vehicle manufacturers and assemblers in the developed world are reducing the prices of high engine capacity cars as they seek to dispose them off due to low demand in the developed markets caused by high fuel prices and changing government policy on the environment. As a result, these high engine capacity cars are finding easy markets in African countries, including Kenya, where financial institutions have intensified the sale of personal loans, which have increased the capacity of the middle class to own vehicles. Many new car owners hardly pay attention to the efficiency of their car engines. They purchase cars without checking details on fuel economy and emission standards. Such ignorance exposes these car owners to effects of fuel price increases, which consumers in developed countries are evading.

Data from the Kenya Motor Industry (KMI) shows that of the 1,697 personal cars bought in 2011 among the association members, 1,267 l cars had an engine capacity of between 1800cc and 2500cc as compared to only 430 cars, which were below 1800cc (Kenya Motor Industry, 2012). This means that fuel economy cars were only 33 per cent of the total new personal cars market in the first ten months of the year 2012. Middle income earners in developed countries have increased their uptake of low engine capacity cars, forcing manufacturers to compete in the race towards lower engine capacity of below 1300cc. This is happening at a time when global fuel prices have hit record high, prompting manufacturers to increase the production of fuel-efficient vehicles. Regulators in the developed world, such the European Union, are also tilting the ground in favour of fuel economy cars, with new policy changes, giving room to electric cars and other energy saving models. This is cognisant in the policy to reduce gasoline consumption as it is absent in Africa and other developing countries.

The key issues with regard to energy pricing are international prices, domestic taxes, environmental factors and energy efficiency, incomes and the energy mix at the household level, among other factors.

4.1.1 The problem

Kenya's households have been affected by the unprecedented increases in fuel prices both for cooking and transport needs. There have been high increases in the prices of cooking fuels such as kerosene, LPG and electricity as well as the main transport fuels such as PMS and AGO. The increase in prices of these fuels due to either external causes or internal factors, means that such increases due to taxes or removal of subsidies have implications for welfare to the household.

In this essay, I examine the welfare implications of fuel price increases on Kenya's households. The energy sector in Kenya has been bit by various episodes of price increases that have eroded disposable incomes of majority of households. The unprecedented increase in fuel prices as a result of the global fuel prices has had a spiral effect on the Kenyan economy and therefore households. Many households and particularly the low and middle income, have found themselves unable to meet their energy needs for transportation, cooking, lighting and heating. The price of electricity has also witnessed sharp increase in the last twelve months due to fuel costs adjustments, foreign exchange and inflation adjustments.

4.1.2 Objectives of the essay

The main objective of this essay is to measure welfare impact of fuel price increases on Kenya's households, determine the level of welfare loss or gain and provide policy recommendations on the best ways to deal with such losses/gains.

The specific objectives of the essay are to:

I. Provide an analysis of fuel price changes
II. Analyse household compensating variation by income group, location and household income deciles
III. Provide policy recommendations on best ways to deal with welfare losses or achieve welfare gains from fuel consumption

4.2 Literature Review

This sub-section reviews literature on welfare impact with special focus on fuel prices. The literature reviewed focuses on theoretical and empirical sides of studies done in developed and developing countries.

4.2.1 Theoretical literature on welfare and fuel prices

Estimating the welfare effects of a price change is one of the fundamental topics both in economic theory as well as in applied policy analysis (Hoderlein and Vanhems, 2010). While measures of this welfare change like compensating variation or equivalent variation are theoretically well understood, the empirical side of welfare analyses in a heterogeneous population is less well developed. The challenge comes from the fact that in the common cross section data sets, we observe every single individual only once, and, in particular, we do not observe the same individual under both the old and new price regimes. Hence, we have to infer the effects by looking at comparable individuals. However, any analysis is then faced with the problem of unobserved (preference) heterogeneity that is the fact that even after accounting for all observable variables, individuals remain profoundly different. Thus, according to Hoderlein and Vanhems (2010), adequate means and methods for controlling this complication are called for when evaluating welfare effects.

4.2.1.1 Implications/Experiences of fuel prices

Fuel prices have profound implication on welfare all over the world. This, however, depends on the response from the respective Governments on how households cope with high fuel prices both in the short and long terms. Kilian (2008) has argued that the price of energy is only one of many prices faced by households and firms,yet it attracts a disproportionate amount of attention in the media and from policy makers and economists. A common perception is that energy price increases are fundamentally different from increases in prices of other goods. He further provided three reasons on why energy prices enlist much concern from policy makers and consumers. First, energy prices experience sharp and sustained increases at times that are not typical of other goods and services. Secondly, these price increases matter more than in the case of other goods because the demand for energy is comparatively inelastic. Thirdly, energy prices are determined by factors exogenous to the domestic economy and particularly when the country is a net importer.

4.2.2 Empirical literature

In this sub section, I review empirical literature on price increases and consumer welfare. Experience is drawn from the developed and developing countries. To analyse the consumer welfare effects of price changes in food and energy, Huang and Huang (2009) develop a measure of Hicksian compensating variation as a function of all commodity prices and compensated price elasticities. The unique feature of this approach is that all direct- and cross commodity effects of a demand system are incorporated into the welfare measurement. They first compile consumption expenditure data covering 1960 to 2006 from *US Personal Consumption Expenditures* by the Bureau of Economic Analysis, US Department of Commerce. This data set consists of about 80 individual expenditure items categorised in three general groups: durable goods, non-durable goods, and services. In the data series, quantities and prices of each expenditure item are presented in the form of indexes with year 2000 as the base year, while the data of expenditures are measured in billion dollars.

Using this data set, Huang and Huang (2009) then estimate a US complete demand system of 11 expenditure categories, with food and energy as separate categories, and improve the parametric constraints of homogeneity, symmetry, and Engel aggregation into the estimation. The results show that the price elasticity of demand for energy is -0.084, meaning that energy is price inelastic. On average, a one percent increase in the price of energy would decrease the quantity demanded by 0.084 percent. With a low price sensitivity of demand and little scope to raise supply in the short run, a small increase in the demand for energy or a decrease in the quantity available in the market can still lead to a very large increase in the price of energy. This explains the soaring energy price in response to an increase in the demand for energy (Huang and Huang, 2009).

4.2.2.1 The Consumer welfare effects of increased prices

Consumer welfare effects of increased prices are key in welfare studies and have implications for policy. Labandeira *et al.* (2007), in analysing consumer welfare effects of increased prices use demand elasticities and the famous Slutsky equations. They compute the compensated demand elasticities for use in measuring the Hicksian compensating variation under various scenarios of price changes. Since food and energy prices are increasingly intertwined, they estimate the loss of consumer welfare caused by the simultaneous increase in the respective prices.

Labandeira et al (2007) further present a micro simulation model to calculate the effects of a tax levied on Spanish energy-related CO_2 (carbon dioxide) emissions in order to comply with EU targets. This tax component, which is passed on to consumers, has implications for overall energy pricing. The model uses the results of estimation of a demand system with Spanish household data from 1973 to 1995, which is especially designed for simultaneous analyses of different energy goods. Their objective was to obtain in-depth information on the behavioural responses by different types of households that would allow determination of welfare effects of tax-induced price changes. In addition, they analysed the distribution across society and the environmental consequences within the residential sector. The results show a significant response by households, sizeable emission reductions, important tax revenues, moderate welfare changes and distributional effects. The simulated policy can therefore be considered a feasible option for tackling some of the current and severe inefficiencies in Spanish energy and environmental domains (Labandeira *et al*., 2007).

Evidence from literature also shows that evaluation of consumers welfare can be examined using the Equivalent Variation (EV) and Compensating Variation (CV) approaches. Nikban and Nakhaie (2011) survey the effects of energy carriers' prices variation in the Iranian economy. They evaluate consumers' welfare variation from increase in energy prices by use of two indexes that is the Equivalent Variation and Compensating Variation between 1973-1998. In order to study welfare costs, they first assess demand functions for different kinds of energy carriers. The selected model used for assessing demand equations was AIDS (Almost Ideal Demand System). The applied data includes price of energy carriers and its extent of consumer share from 1973 to 2008. Results show that increase in prices by 1 percent account for 0.165 percent decrease in utility level of consumers in society and to compensate consumers to achieve their initial utility level, a sum of IRRs.510,000[12] should be paid (Nikban and Nakhaie, 2011).

Some studies on the welfare impacts of energy prices touch on competition issues and how they relate to overall welfare outcomes. The argument is that the introduction of competition in the supply of these energy goods will force tariffs to become more cost-reflective. This argument is supported by findings that maintaining cross-subsidies between consumer groups have not posed any difficulties, particularly in electricity and gas, despite existence of monopoly concessions in countries such as the UK. Profits lost by subsidising one group of consumers have, in most cases, been compensated by higher price-over-cost margins for other groups. Competition is likely to change application of fiscal policy and how it has been used to achieve welfare and revenue objectives. For example, the analysis on the relation between energy prices and welfare by Hancock and Waddams (1995) and Burns *et al*., (1995) show that welfare implication does vary depending on the income level of the household. These studies confirm that poorer households are more vulnerable to changes in energy prices than the high income ones.

Gomez-Lobo (1996) uses an econometric model of household consumption behaviour to examine the same issues on energy prices and consumption as established in Hancock and Waddams (1995) and Burns *et al*., (1995). Their model, however, allows for behavioural responses to price changes, and provides fairly precise and quantitative welfare results than those in previous studies. They estimate the model using data from the Family Expenditure Survey (FES) from 1985 to 1993. The FES is a yearly Random Survey of about 7,000 households in the UK, which contains detailed information on

[12] Iranian Rial (IRR) is the Iranian currency. I US$=12,284IRRs. This means the household should be compensated with US$ 41.52 to achieve their initial level of utility based on September 2012 exchange rates.

household expenditure, income, ownership of durables, demographic characteristics and other variables similar to the Kenya's Integrated Household Budget Survey (KIHBS). Of specific importance in their analyses was information on electricity and gas supply connections to the household's dwelling, gas and electricity expenditure, mode of payment of gas and electricity bills, type of central heating and the holdings of energy-using durables.

Consumption of fuels vary depending on whether a country is developed, in transition or developing; whether it is urban or rural household or even whether it is among the high, middle or low income groups. For example, households in most regions of England and Wales, both of which are within the United Kingdom, have a tendency to consume more LPG than their counterparts in Scotland. The reverse is true for electricity, pointing to the predominance of electricity as an energy source in Scotland compared to these other countries (Gomez-Lobo, 1996). In addition, households that have central heating are able to manage their energy expenditure better compared to those with individualised heating systems.

In the case of electricity, Gomez-Lobo (1996) also controlled for the presence in the household of a washing machine and a fridge and/or freezer, both of which have the expected positive effect on electricity expenditure. He further found that a dummy variable for those households that paid services in their rent or communal charge had the expected sign, since part of their energy expenditure is paid indirectly. The temperature variable is lagged one quarter and has the expected negative sign. The own-price coefficients in both equations are positive and, in the case of electricity, not significantly different from zero (at a 95 percent significance level). A positive or zero coefficient is not inconsistent with negative own-price elasticities, since the dependent variable is the share of the good in total expenditure. For goods that have inelastic demands, the quantity purchased will decrease with a price increase, while the share in total expenditure nonetheless rises (Gomez-Lobo, A, 1996).

As a welfare measure, Gomez-Lobo (1996) further uses the compensating variation. This corresponds to the amount of monetary resources that must be given to a household after a price change in order for that household to be able to obtain the same utility level that it enjoyed before the change. Since the parameter estimates from the demand system are also the parameters of the utility function, Gomez-Lobo (1996), was able to estimate the compensating variation for each household. The analysis established that majority of households have a negative compensating variation. This means that income must be subtracted from these households in order for them to have the same level of welfare they had prior to the price change. In other words, these households are better off after the tariff rebalancing than before. The negative effects of the rise in the fixed charge are more than compensated by the savings due to the fall in the variable price.

Leyaro (2009) analyses the effect of commodity price changes on household consumption (welfare) in Tanzania during the 1990s and 2000s and also simulates the welfare effect attributable to tariff reductions. The aim in the study was to measure the total household welfare effect, distinguishing both static and dynamic effects of commodity price changes. He estimates consumers' responses using Deaton's method, based on median unit values (price) and household budget shares. The budget shares obtained are then utilised to evaluate the distributional impacts of the relative commodity price changes on consumer welfare in terms of compensating variation. The results indicate that, in real terms, price increases worsened the welfare of most consumers during the1990s and 2000s. The poor, and in particular those in rural Tanzania, bore much of the brunt compared to the non-poor. The welfare losses in the 2000s were greater than those in the 1990s, meaning that households in the former are worse off. Simulations of the model using tariff reductions show that tariff reforms tended to offset the welfare losses for all household groups, as expected tariffs were reduced for most products. The non-poor, especially rural non poor, and the urban poor benefited more in relative terms from tariff reductions (Leyaro, 2009).

Huang *et a*l., (2009) analyse how increased food and energy prices affect consumer welfare in the USA. They estimate a complete demand system and welfare impacts. They first estimate a US complete demand system by compiling consumption expenditure data covering 1960 to 2006 from US Personal Consumption Expenditures by the Bureau of Economic Analysis, US Department of Commerce. This data set consists of about 80 individual expenditure items categorised in three general groups: durable goods, non-durable goods, and services. In the data series, quantities and prices for each expenditure item are presented in the form of indexes with year 2000 as the base year, while the data on expenditures is measured in billion dollars. The analyses show that energy is price inelastic. Based on the estimated demand elasticities, they further apply the Slutsky equation to calculate compensated demand elasticities for use in measuring the Hicksian compensating variation under various scenarios of price changes. Since food and energy prices have become increasingly intertwined, they estimate the loss of consumer welfare caused by the simultaneous increase of their prices.

In addition, Huang et *al*. (2009), using the loss of consumer welfare under various scenarios of price changes in food and energy; calculate the "burden indexes" which are defined as the ratios of consumer welfare loss to income per person of the two lowest 20-percent income quintile households. The results show that in the lowest 20-percent income quintile, the burden indexes would increase from 3.61 percent to 17.4 percent, because of increases in both the food and energy prices from 5 to 25 percent. In the second lowest 20 percent income quintile, however, the same increases of both food and energy prices would increase the burden indexes from 1.38 percent to 6.67 percent, which is substantially smaller than those of the lowest income quintile households.

Hoderlein and Vanhems (2010) provide an analysis of welfare using a non-seperable model for the USA. They propose a framework to model empirically welfare effects that are associated with a price change in a population of heterogeneous consumers. To operationalise the model, they apply all concepts of measuring the heterogeneous effect of gasoline price using US consumer data. In the framework, individual demands are characterised by a non-separable model which is non-parametric in the regressors, as well as monotonic in unobserved heterogeneity. They first provide and discuss conditions under which the heterogeneous welfare effects are identified, and establish constructive identification. They propose a sample counterpart estimator and analysis of large sample properties. For both identification and estimation, they distinguish between the cases when regressors are exogenous and endogenous. The application of the model to all concepts of measuring the heterogeneous effect of a chance of gasoline price using US consumer data shows very substantial differences in individual effects.

Andriamihaja and Giovanni (2007) estimate the effect of a rise in petroleum prices on living standards in Madagascar. They combine information on expenditure patterns from the *Enquete Aupres des Menages* (2005) with an input-output model describing how petroleum price increases impact across economic sectors. They identify both direct welfare effect (heating and lighting one's house becomes more expensive) and indirect effect (the price of food and anything else which has to be transported from factory to shop rises). They find a 17 percent rise in oil prices produces, on average, a 1.75 percent increase in household expenditures (1.5 percent for high-income households, 2.1 for the households in the bottom expenditure quintile). Approximately 60 percent of the increase in expenditures is due to the indirect effect, mostly via higher food prices. Although energy price increases hurt the poor more in percentage terms, subsidising would involve a substantial leakage in favour of higher income households. This raises the issue of identifying the more cost-effective policies to protect the poor households against energy price increases.

Granado, *et al*. (2010) reviews evidence on the impact of fuel subsidy reform on household welfare in developing countries. They argue that, on average, the burden of subsidy reform is neutrally distributed across income groups; a US$0.25 decrease in the per litre subsidy results in a 6 percent decrease in income for all groups. More than half of this impact arises from the indirect impact on prices of other goods and services consumed by households. Their analyses point to the fact that fuel subsidies are a costly approach to protecting the poor due to substantial benefit leakage to higher income groups. In absolute terms, the top income quintile captures six times more in subsidies than the bottom quintile. Issues that need to be addressed when undertaking subsidy reform are also discussed, including the need for a new approach to fuel pricing in many countries.

Adenikinju (2011) argues that a subsidy results in substantial loss of revenue and an exponential growth in domestic oil consumption as low price does not signal real cost of consumption. He further argues that subsidies have contributed to the collapse of local refineries as price of fuel did not reflect the cost of supply, dilapidated supply and distribution infrastructures, reluctance of private investors to invest in refineries, sporadic fuel shortages at fuel stations, smuggling and adulteration of products. Attempts to remove subsidies have generated oppositions from consumers already used to cheap energy prices due to presumptions that any price increase will fuel inflation and reduce economic welfare. The pricing structure in Nigeria is such that pump prices of fuels (in particular PMS) are administratively determined. Prices have generally lagged behind inflation rate, exchange rate changes as well as changes in product costs leading to substantial subsidy.

Twimukye and Matovu (2009) in analysing the macroeconomic and welfare consequences of high energy prices in Uganda, found that the current wave of volatile international oil prices coupled with low hydro-energy generation continue to exert negative impacts on the Ugandan economy. They analyse the extent to which changes in energy prices affect the economy and examine policy options that can be undertaken to circumvent the negative effects. The impact of higher oil prices takes a large toll on all sectors including agriculture, manufacturing and services. With the existing loses in productivity of generating hydro electricity, this has exacerbated the energy crisis. The combined output loss for the manufacturing sector due to increase in fuel prices and a shortage of electricity is estimated at 2 percent on annual basis. While the government has little control on the international prices of oil, further private and public investments in the energy sector are called for to alleviate the shortages of energy.

Simler (2010) assesses the welfare impact of food and fuel price shocks. The objective of his analysis was to provide a rapid assessment of the poverty impact of a commodity price shock, and the effect of potential mitigating policies. The study takes advantage of both macro and micro data because it is easier to standardise across countries, including data on poor settings. The study finds that in Zambia, a 40 percent increase in fuel prices together with a 50 percent increase in maize, wheat (35 percent), rice (25 percent) and other cereals (20 percent) would increase overall poverty incidence from 68.2 percent to 71 percent, while increasing the poverty gap from 28.2 percent to 30 percent. This is an indication that fuel prices have detrimental effects on welfare.

Portney *et al*., (2003) discuss several rationales for the Corporate Average Fuel Economy (CAFE) programme in the United States of America (USA), including reduced oil dependence, reduced greenhouse gas emissions, and the possibility that fuel saving benefits from higher vehicle standards might exceed added vehicle costs. They summarise welfare effects of tightening standards, accounting for prior fuel taxes, and perverse effects on congestion and traffic accidents through the impact of improved fuel economy on the incentive to drive. Implications of CAFE on local air pollution and the controversy over CAFE, vehicle weight, and road safety, are also discussed. Finally, they describe ways in which the existing CAFE programme could be substantially improved and identify a variety of alternative and much superior policy approaches.

Ellis (2010) examines the effects of fossil-fuel subsidy reforms. She argues that reforming subsidies for fossil fuels is a challenging prospect for many governments. To help policy-makers better appreciate the trade-offs between economic, environmental and social impacts; various organisations have analysed fossil-fuel subsidies and their effects, often with the aid of complex economic models. Measuring the impacts of subsidy reform is a critical step in determining under what conditions the net effect of subsidy removal is positive and what supporting measures need to be undertaken to ensure that negative effects are minimised. Despite the fact that further research can, and should be undertaken, the study strongly supports the conclusion that there are significant environmental and economic benefits that would result from the reform of fossil-fuel subsidies. Fossil-fuel subsidy reform should be considered as a key element of a larger overall package for global climate-change mitigation. On this basis, there is a mounting body of evidence that policy-makers should not wait to begin the reform process.

Golub (2010) examines the welfare and equity impacts of gasoline price changes under different public transportation service levels. He argues that impacts on public transit ridership of changes in gasoline prices and service levels have been studied. Further, he observes that combined effects of gasoline price changes under different levels of transit service have hardly been studied. The study discusses a consumer welfare calculation based on a binary choice model for commuters in idealised corridors with varying public transportation levels of service. The findings show that welfare losses are seen to be greatest for commuters in corridors with poor public transit options, and losses increase with rising gas prices. Low-income commuters are seen to suffer more welfare loss in corridors with low-performing transit options than in corridors with well-performing public transit systems. This simple model points to the need for more research regarding the impact of high gas prices on low-income households' commute behaviour and access to jobs.

4.3 The Conceptual Framework between Taxation Fuel Prices and Welfare

This sub-section presents the conceptual framework between taxation, fuel prices and welfare. The discussion is motivated around fuel prices and how they impact on household welfare. Taxation and welfare were extensively discussed in the previous chapter.

4.3.1 Theoretical foundations for public policy on taxation, pricing and welfare

In this this sub-section of the essay, I present the conceptual framework between taxation, fuel prices and welfare. The discussion is motivated around fuel prices and how they impact on household. As a starting point, it is important to recognise that in most modern industrial economies, primary reliance on the production and distribution of goods rests in the private sector rather than the public sector (Stiglitz, 2000). One of the most enduring tenets of economics holds that this form of economic organisation leads to an efficient allocation of resources. However, this is not always the case and market failure does occur. This was in fact recognised early by Adam Smith in 1776 in his work on the Wealth of Nations (Smith, 1957). For this reason, developments in public policy have advanced various theories on efficiency and distribution which focuses on welfare. The social welfare function which provides a framework within which the distributional consequences of a policy may be analszed has been used extensively in welfare analyses. It specifies the increase in utility of one individual that is required to compensate for a decrease in utility of another.

Utility theory is important in welfare analyses. In the utilitarian social welfare function, social welfare function is equal to the sum of the utilities of the individuals in society. On the other hand, we have the Rawlsian social function where social welfare is equal to the utility of the worst-off individuals in society. The other important concept in analysing welfare is consumer surplus which shows how much individuals are willing to pay for a project or programme in addition to what they have to pay. It is used to measure the aggregate benefits of a project or programme. Related to consumer surplus is dead-weight loss which is used to measure the inefficiency of a tax. It shows how much revenue could have been generated by a lump-sum tax that would have left individuals just as well off as the tax that was imposed (Stiglitz, 2000; Musgrave *et al*., 1989).

Musgrave *et al*. (1989) and Stiglitz (2000) have done extensive work on the field of Public Economics which forms the basis for current work on welfare and fiscal policy. I borrow heavily from their work in developing this conceptual framework. Prices are impacted by taxes in various ways and it is therefore important to understand the relationship between taxes, prices and welfare. Musgrave *et al*., (1989) have extensively discussed about fiscal instruments of distribution policy. Among the diverse fiscal devices, redistribution is implemented most directly by a tax transfer scheme, which combines a progressive taxation of high-income with a subsidy to low income households. Alternatively, redistribution may be implemented by progressive taxes used to finance public services, especially those related to basic goods such as housing, which particularly benefit low-income households.

In order to construct good roads or improve public transport which benefits the low income, the government also has to implement various taxes such as the road maintenance levy fund. In the electricity sub sector, we have the rural electrification levy, whose main purpose is to provide electricity access in rural and marginalised areas to benefit the low income households. Lastly, redistribution may be achieved by combination of taxes on goods purchased largely by high-income consumers, with subsidies to other goods which are used chiefly by low-income consumers.

In choosing among alternative policy instruments, allowance must be made for resulting dead-weight losses or efficiency costs which arise as a consumer or producer choices are interfered with. Redistribution which occurs through an income tax-transfer mechanism has the advantage that it does not interfere with particular consumption or production choices. However, it is important to note that this mechanism is not without its 'efficiency cost' since the choice between income and leisure will be distorted. An optimal solution might call for a complex mix of taxes and subsidies.

In analysing consumer choice, the opportunity set is defined by the consumer's budget constraint and the consumer's preferences which are described by use of indifference curves. The individual chooses the point on the budget constraint which is tangent to an indifference curve putting him/her on the highest indifference curve feasible, given the budget constraint. As Stiglitz (2000) has noted, economists have tried to use the same framework to analyse social choices. However, assessing the distributional effects of a tax is often far more complex than assessing the efficiency effects. There are many groups in a society and each may be affected differently. Some low and middle income individuals or households may be hurt, while others may be helped. In some cases, the rich may be helped the most, the poor helped moderately, and the middle class only slightly made worse off.

According to Stiglitz (2000), in practice, governments focus on a few summary measures of inequality. Since the poor are of particular concern, they receive special attention. The poverty index measures the fraction of the population whose income lies below a critical threshold. Those below that threshold are considered to be in poverty. Approaches such as the compensation principle, trading-off measures and the weighted benefits approach have been used to analyse distributional effects of tax reforms.

The compensation principle states that if the aggregate willingness to pay exceeds the cost, the project or service should be undertaken. Most economists, according to Stiglitz (2000), criticise this principle because it ignores distributional concerns. The argument suggests that only if the compensation is actually paid to those adversely affected can we be sure that the project or service is desirable, for then it is Pareto improvement. As a result, since the compensation principle does not pay adequate attention to distributional concerns, economists have turned to the other two approaches. The trade-offs across approaches look at the measures of efficiency (net benefits) and inequality. In this case, it is easier for public decision making because it evaluates whether the increase in efficiency is worthy the increase in inequality and vice versa. Ideally, in the measure of total efficiency and inequality, one looks at the impact on each individual, and then uses the social welfare function to add up the effects. However, in practice, the government does not attempt to identify impacts on every individual, but it ascertains the effects on each major group.

Lastly, the weighted need benefit looks at all information required for policy makers to make a decision. If the aggregate net benefits (the willingness to pay minus costs) is positive, and if the poor are net beneficiaries and the rich net losers, then the project increases both efficiency and equity and thus should be adopted. However, Stiglitz (2000) has argued that often it is more complicated because the poor and the rich may be worse off, but middle-income individuals better off. However, to assess the change in welfare, weights are assigned to the net gains of different groups to summarise the impacts in a single number. The social welfare function helps to achieve this. Due to the concern for equity, effects on higher-income groups are weighted less heavily. However, how much less heavily may determine whether it is desirable to undertake a project or provide a good/service. For instance, a project that helps the middle class but hurts the poor and the rich might not be undertaken, if the weighted loss of the poor is heavier than the gains to the middle class. The three approaches are used to make public policy decision when there is no Pareto improvement.

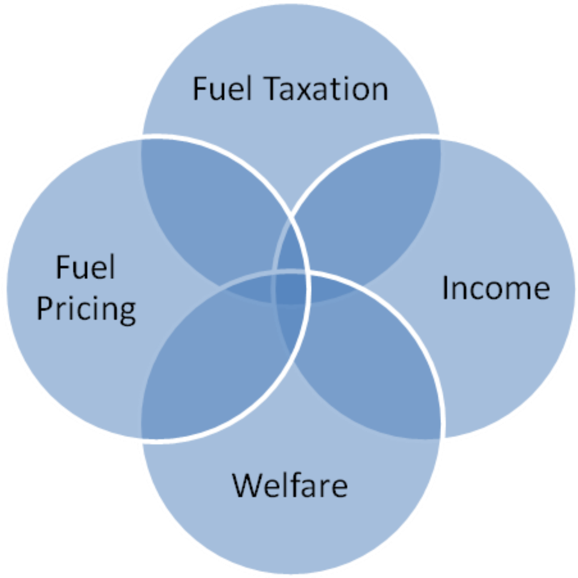
Having looked at social welfare issues at the general or global level, I now turn to specific analyses in the energy sector. The concept of welfare and distribution has similar impacts on consumers of energy goods and services. In society we have the low-income, middle-income and high income among consumers of various fuels. A tax on fuels, therefore, has implications on consumption by households depending on their income levels. Thus it is important to understand how price changes either due to increase in tax or price volatility will impact on consumers. A progressive tax will affect the high income households while a regressive tax is detrimental to the low income households.

Following this discussion, taxation, pricing, income levels, poverty and distributional consequences due to price increases are key to conceptual thinking. Using **Figure 4.3.1**, I explore further the conceptual rooting between taxation, fuel prices and welfare. The framework shows that there is a close relationship between taxation, fuel pricing and welfare. Income is introduced in the analyses because it is used to determine the various income groups and deciles in order to analyse the various levels in welfare.

4. 3.2 Fuel taxation

In Chapter Three (3), I explored the various linkages between taxation and welfare and established that they have various consequences on households. A tax that is progressive hurts the middle and high income group more compared to the low income group. Such a tax is therefore good for developing countries such as Kenya because of its progressive nature. On the other hand, a regressive tax has a negative impact and therefore hurts the poor more compared to richer households. The level of tax progressivity or regressivity therefore has implications on the final price paid by consumers. If the tax is progressive, it will lead to a price which is comfortable to the poor, but a regressive tax would have adverse effects on the price of the same fuel, therefore hurting the poor more. As has been argued by Stiglitz (2000) and Musgrave *et al*., (1989), consumer surplus is affected by taxes. Taxes on the other hand, impact on prices. In this case therefore, the relationship between taxation, pricing and income are important in analysing welfare. The various relationships as are shown in **Figure 4.3.1**.

Figure 4.3. 1: Conceptual rooting between fuel taxation, pricing and welfare



Source: Author's construct

4. 3.3 Fuel pricing

Fuel pricing is important in welfare analyses and is impacted by tax policy and the income levels of the household head. Price increase can occur due to increases in tax, cost of production, inflation, or due to price volatilities, among other factors. Increasing the tax level, for example tax on kerosene or electricity, would lead to an increase in the price of the fuels, since tax has to be paid as an obligation to the State in addition to the cost of production and distribution. The petroleum pricing formula for Kenya, for example, is a 'cost plus' and therefore the final price comprises the landing cost at the port of Mombasa, cost of transportation through the pipeline, bridging costs from the depots in Nairobi, Nakuru, Eldoret and Kisumu; and, taxes. (this was further explained in the previous chapter). The taxes, levies and other charges are about 26 percent of the total price and form a considerable part of the final price. The taxation level, therefore, has a direct impact on prices and distributional consequences given the income levels of the households.

4.4 Methodology of Study

The methodology in this essay involves use of the Compensating Variation (CV) approach outlined in sub section 4.4.1. CV is more suited for welfare analyses given the nature of the National Energy Survey Data, 2009. The methodology uses Hicksian elasticities obtained in essay one to measure the compensation to consumers required to achieve their initial utility level given the surge in energy prices that has taken place. It draws heavily for exposition and convenience from Friedman *et al.*, (2002).

4.4.1. Welfare analysis

Welfare analysis in this essay as indicated above follows the Compensating Variation approach. CV is a measure of utility change introduced by Hicks (1939). It refers to the amount of additional money an agent would need to reach its initial utility after a change in prices, a change in product quality or the introduction of new products. Compensating variation can be used to find the effect of a price change on an agent's net welfare. CV, therefore, reflects new prices and the old utility level. It is often written using an expenditure function $e(p, u)$:

$$CV = e(p_1, u_1) - e(p_1, u_0)$$

$$w - e(p_1, u_0)$$

$$e(p_o, u_0) - e(p_1, u_0);$$

where W is the wealth level, p_0 and p_1 are the old and new prices respectively, and u_0 and u_1 are the old and new utility levels, respectively. The first equation can be interpreted as saying that, under the new price regime, the consumer would accept CV in exchange for allowing the change to occur. The above basic formulation is important in building the welfare analysis model for this essay.

In order to analyse the impacts of the price increases on household welfare, changes in consumer surplus brought about by the change in price, I begin by specifying a minimum expenditure function$C(P, U)$, which, given the existing price , relates to the minimum cost needed to attain utility level Uu (see Deaton and Muellbauer, 1980), for a discussion of the general properties of cost functions. A first-order Taylor expansion of the minimum expenditure function with respect to price will yield an approximation of the income required to compensate the household after a price change and to restore the household to the change in utility level. Thus, this expression will approximate the compensating variation. Recognising that the partial derivatives of the minimum expenditure function with respect to price yields quantities consumed, the following simple expression can be derived:

$$\Delta C \approx q\Delta p \tag{4.1}$$

where q is a $1 \times n$ vector of consumption goods quantities, Δp is an $n \times 1$ vector of price changes, and n the number of consumption goods in the total demand system. This approximation of compensating variation however requires information on pre-crisis consumption quantities and price changes; neither price level nor, more important, post crisis consumption crisis are needed (Friedman *et al*., 2002). It is straight forward to reformulate equation (4.1) in terms of household budget shares, , and proportionate price changes in the following equation:

$$\Delta \ln C^{h} \approx \sum_{i=1}^{n} w_i^h \Delta \ln P_i^h \qquad (4.2)$$

where i refers to individual goods in the commodity system and h refers to the household. The budget share w_i^h is simply the household cost of good i divided by the time which the new regime took over government that is post KANU era's total household expenditures. Equation (4.2) is important because of the fact that any distributional impact of price changes must derive both from the presence of large relative price changes and large differences in the budget shares across households.

In general, the cost of attaining pre-regime shift utility levels will increase less rapidly than equation 4.2 may suggest, because households can substitute away from goods whose prices have risen disproportionately. Thus, this expression provides a maximum bound on the impact of the energy crisis as it does not take into account the substitution towards relatively less costly fuels that will take place. Equation 4.2 may therefore not be an entirely accurate approximation. Returning to the minimum expenditure function, a second-order Taylor expansion of the minimum expenditure function does not allow for substitution:

$$\Delta C \approx q\Delta p + \frac{1}{2}\Delta P^{T} s \Delta p \qquad (4.3)$$

In equation 4.3, q and Δp are quantity and price change vectors as before and S is the $n \times n$ matrix of compensated derivatives of demand. As was the case in equation 4.2, I can reformulate equation4.3 in terms of budget shares and proportional price changes as:

$$\Delta \ln C^h \approx \sum_{i=1}^{n} w_i^h \Delta \ln p_i^h + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} c_{ij} \Delta \ln p_i^h \Delta \ln p_j^h \quad (4.4)$$

where w_i^h is budget share of the i[th] household. Expression c_{ij} contains the Slutsky derivatives s_{ij} and is defined by the equation.

$$c_{ij} = p_i s_{ij} p_j / C^h$$

With some simple algebraic manipulation, it can be shown that the c_{ij} term is equivalent to $w_i \epsilon_{ij}$,

$$c_{ij} = \frac{p_i s_{ij} p_j}{C^h}$$

where ϵ_{ij} is defined as the compensated price elasticity of good i with respect to price change j, and w_i is budget share for fuel i. Following this formulation, equation 4.4 can be expressed as:

$$\Delta \ln C^h \approx \sum_{i=1}^{n} w_i^h \Delta \ln p_i^h + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} w_i^h \ \varepsilon_{ij} \Delta \ln p_i^h \Delta \ln p_j^h \quad (4.5)$$

In this essay, I use the two formulations of compensating variation provided in equation (4.2) and (4.5) to explore the possible differential impacts of price changes in Kenya's energy sector between 2003 and 2009. These two years are significant in the Kenyan economy. The year 2003 marked a regime change, while the year 2009 marked the end of the global economic crisis and decline in fuel prices. The only additional piece of information required in equation 4.5 and not found in equation 4.2 is the ε_{ij} terms. Following Friedman *et al.*, (2002), an approximation to the compensating variation that also accounts for potential household substitution behaviour requires estimates of a complete set of price elasticities in addition to the pre-crisis consumption quantities and post crisis price changes.

According to Friedman *et al*. (2002), the way elasticities are estimated depends on the type of data used in the analyses. I use Hicksian-compensated elasticities obtained from chapter of this thesis that were computed after estimating the LA-AIDS model using data from the National Energy Survey 2009. The only dilemma is that I do not have similar National Energy Survey for previous periods. Although housing and budget surveys have been done before, they do not have good information as the dynamics of data collection and requirements are different. As a result, I work backwards and use prices for 2003 and 2009 to obtain equivalent fuel prices for 2003.

4.5 Data Sets

This essay used household data from the National Energy Survey (2009) and time series data from the Kenya National Bureau of Statistics to compute price changes that are used in estimation of the compensating variation. This is because the last extensive energy survey in Kenya apart from the 2009 survey was done in 1984 and it mainly focused on biomass fuels. Using the price changes, I work backwards to obtain what would have been energy budget shares and fuel prices then.

4.5.1 Analysis of price changes

In order to compute price changes, I use time series data for the five fuels from 2003-2009. The time series data was collected from various Kenya National Bureau of Statistics Economic surveys. The aim of this data is to obtain average price changes to 2009. The price change is then used to work backwards and compute what prices for the various fuels would have been, if the National Energy Survey (2009) was done in 2003. The price change is then used in computation of compensating variation (welfare analysis). This year (2003) is taken as the starting year as this is when there was a regime change from '*Moi* to '*Kibaki'* administration[13]. The National Energy Survey 2009 was done in 2009 when the global economic crisis ended and low levels of growth recorded. . The data was also collected after the reforms in Kenya's energy sector, which saw the implementation of the Sessional Paper No. 4 of 2004 and enactment of the Energy Act 2006 which brought all energy sub sectors under a single regulator.

The last column of **Table 4.5.1** shows the average price change for each fuel. From the table, it is evident that electricity prices have experienced the highest price change of 200.11 percent, while PMS had the least price change of 35.49 percent. The other price changes in the same period were 74.74 percent, 50.76 percent and 44.61 percent for kerosene, AGO and LPG, respectively.

Table 4.5. 1: Historical Fuel Price Changes

Product	Electricity(Ksh./ kWh	Kerosene(Ksh./ Litre)	LPG(Ksh./ 13kg)	PMS (Ksh. /Litre)	AGO(Ksh./ Litre)
2003	4.00	35.49	1,339.12	59.89	47.39
2004	3.80	40.33	1,424.59	66.21	52.82
2005	5.00	43.90	1,515.52	72.54	62.27
2006	7.42	56.03	1,612.26	78.19	68.04
2007	7.49	57.25	1,705.76	80.08	68.23
2008	7.67	70.47	1,845.46	93.82	85.26
2009	12.00	62.01	1,936.56	81.15	71.45
2010	15.20	74.12	2,191.00	95.65	87.10
2011	13.29	88.34	2,510.55	113.39	105.53
Av. % Change 2003/2009	**200.11**	**74.74**	**44.61**	**35.49**	**50.76**

Source: Kenya National Bureau of Statistics (KNBS), Economic Surveys, 2003-2009

[13] Moi was the second President of the Republic of Kenya whole ruled between 1978-2002. Kibaki was the third President of the Republic of Kenya and ruled between 2003-2013. He is credited for introducing far reaching reforms in transport, energy and other infrastructure sub sectors in the country.

4.5.2 Compensated own and cross elasticities

Elasticities are key to completing analyses of compensating variation. In this essay, I use own and cross price elasticities computed from the LA-AIDS model estimated in chapter two. A summary of elasticities for the global model is presented in **Table 4.5.2**. The own price elasticities for each fuel are located on the diagonals of the matrix and are negative for all fuels. This matrix of own and cross price elasticities is used to estimate the compensating variation using equation 4.5. The compensating variation estimated using these elasticities allows for substitution between fuels.

Table 4.5. 2: Hicksian-Compensated Own and Cross Price Elasticities

Variable	Electricity P	LPG	PMS	AGO	Kerosene
Electricity	-0.816	0.175	0.182	0.188	0.110
LPG	0.128	-2.415	1.201	-0.411	0.662
PMS	0.303	0.558	-2.321	1.395	0.343
AGO	0.430	0.035	2.719	-3.587	0.808
Kerosene	-0.278	0.124	0.039	0.218	-1.402

Source: Author's Computation from the National Energy Survey, 2009

4.6 Empirical Analysis

In this section, I provide welfare analysis as a result of changes in fuel prices. The price changes are mainly due to changes in international prices, tax regimes and domestic inflation among other factors. I examine distributional aspects of fuel budget shares and welfare implications of price changes. Since the results of only one National Energy Survey, 2009, are available, I work backwards to obtain the price level in 2003 so as to compute welfare losses or gains in the present period. The section thus provides descriptive statistics, fuel expenditure shares by deciles and compensating variation due to prices changes in fuel prices by income groups and location of household.

4.6.1 Summary statistics

This sub-section provides descriptive statistics for all the five fuels analysed. The statistics are provided for budget shares by location since shares by income group are in essay 1. The essay, therefore, extends analyses of energy budget share to include analyses by household location. The results are presented in Table **4.6.1**.

4.6.1.1 Budget shares by location of household

This sub-section of the essay provides budget shares by location of the household. The analyses distinguish between households located in the rural areas and those in urban areas. In the National Energy Survey, there were 2,417 and 1,244 rural and urban households, respectively. **Table 4.6.1** shows that rural households have relatively higher budget shares for electricity at 0.639 compared to urban households at 0.417. With regards to kerosene, rural households have a slightly lower budget share than their urban counterparts at 0.148 and 0.149, respectively. However, urban households have a higher budget share for LPG compared to rural households. The budget share depends on the household income level, type of fuel and use among other factors.

On the other hand, in regards to transport based fuels, urban households have higher budget shares compared to rural households. The budget share for urban households with regard to PMS and AGO is 0.231 and 0.112 compared to that of rural households of 0.134 and 0.060, respectively. This, once again, is an indication that urban households have higher incomes and are therefore able to purchase cars and afford automotive fuel compared to their rural counterparts.

Table 4.6. 1: Budget Shares by Location of Household

Variable	Mean	Std. Dev.	Min	Max
Rural Households				
Electricity	0.639	0.320	0.000	1.000
Kerosene	0.148	0.137	0.000	1.000
Liquefied Petroleum Gas	0.019	0.085	0.000	0.999
Petrol Motor Spirit	0.134	0.246	0.000	0.860
Automotive Gas Oil	0.060	0.114	0.000	0.781
Urban Households				
Electricity	0.417	0.320	0.000	1.000
Kerosene	0.149	0.202	0.000	1.000
Liquefied Petroleum Gas	0.091	0.173	0.000	0.923
Petrol Motor Spirit	0.231	0.276	0.000	0.795
Automotive Gas Oil	0.112	0.141	0.000	0.874

Source: Author's computations from the National Energy Survey, 2009

4.6.1.2 Mean budget shares and price changes for selected fuels

This sub-section of the essay discusses budget shares and fuel price changes. Since I do not have household energy survey data similar to the National Energy Survey (2009), I work backwards to obtain fuel shares and expenditures in 2003 and then use compensating variation to estimate loss or gain in welfare in the present period. This is explored further in sub-section 4.6.3. **Table 4.6.2** summarises fuel budget shares for all income groups and fuel price changes (in the last column). As can be seen, nominal fuel prices have drastically increased from 2003 to 2009.

The price of electricity increased by 200 percent meaning that if all other factors such as income are held constant, households would be worse off in 2009 than 2003 due to the high price change that would probably mean households cannot afford the same kilowatts per hour of electricity they consumed before. The same applies to the prices of other sources of energy and their consumption at the household level. The price change from

2003-2009 is therefore critical in computing what otherwise would be prices of various fuels and budget shares in 2003, if a similar National Energy Survey was undertaken.

Table 4.6. 2: Mean Budget Shares and Price Changes for Selected Fuels

Variable	Mean	Std. Dev.	Min	Max	Av. % Change 2003/2009
Electricity	0.563	0.337	0.000	1.000	200.11
Kerosene	0.148	0.162	0.000	1.000	74.74
Liquefied Petroleum Gas	0.043	0.127	0.000	0.999	44.61
Petrol Motor Spirit	0.167	0.261	0.000	0.860	35.49
Automotive Gas Oil	0.078	0.126	0.000	0.874	50.76

Source: Author's Computations from the National Energy Survey, 2009

4.6.3 Welfare analysis

In this sub section, I estimate welfare levels due to fuel price changes and provide discussions on implications for policy. The analyses use the CV approach for welfare analyses. As illustrated in the methodology, the CV is a measure of utility change. It refers to the amount of additional money an agent would need to reach its initial utility after a change in price, product quality or introduction of new products. Compensating variation can therefore be used to establish the effect of a price change on an agent's net welfare. It reflects new prices and the old utility level.

The question I ask is whether households were better off in 2009 than in 2003 given changes that have taken place in terms of incomes and fuel prices. Due to change in tax regimes and inflation levels, fuel prices have increased and perhaps this has not been in tandem with change in incomes; households' welfare may have declined or increased. The welfare analyses by use of CV try to answer this question. The analyses use elasticities computed in essay one (1) from the LA-AIDS model. The elasticities were computed after estimating the model where household expenditure, demographic variables, own price, prices of substitutes to a particular fuel among other variables, were key determinants of household fuel demand. The elasticities are then used in equation 4.5 to compute welfare by fuel type and total welfare.

4.6.3.1 Compensating variation by income group

From the analyses, the impacts of price changes on households are not uniform. They vary depending on the nature and use of a particular fuel. Household consumption choices, sources of income and location are key in determining the impact of energy prices on welfare. Households make fuel choices differently and location in urban or rural areas matters. The welfare analyses results are presented in **Tables 4.6.3** and **4.6.4**.

The analyses of welfare by income group shows that the compensating variation for all groups combined is highest for kerosene at 61.9 percent, followed by electricity at 8.28 percent. Kerosene consumers have lost significantly in terms of welfare compared to users of other fuels. Welfare losses were lowest for LPG, in the case of cooking and lighting fuels. With regards to transport fuels for the combined income groups, the welfare loss for PMS was 5.1 percent compared to AGO's 3.2 percent, thus the former experienced more loss. The total welfare loss for all income groups and fuels was 80 percent. Therefore, households were worse off in 2009 than 2003 by a very large percentage change. Despite significant gain in poverty reductions from 56 percent in 2002 to 46 percent in 2009, majority of them experienced considerable welfare losses due to increase in fuel prices.

The low income households have experienced the greatest welfare losses. In particular, welfare loss due to increase in price of kerosene was largest at 82.8 percent, followed by electricity at 11.2 percent. LPG recorded the lowest welfare loss of 1.6 percent.

Kerosene's welfare loss can be explained by high changes in its price which was 74.7 percent between 2003 and 2009. International prices for crude petroleum increased significantly explaining the high price increase. That is why the government zero rated kerosene to cushion the poor. However, this may not be the best option given other costs related to environmental degradation and respiratory diseases among other negatives are associated with its use. In regards to transport fuels, the welfare losses were minimal for the low income households. The total welfare loss due to increase in price of fuels was highest for the low income households at 95.6 percent, implying these households are worse off than 7 years ago.

Table 4.6. 3: Compensating Variation by Income Group (Percent)

Variable	Mean	Std. Dev.	Min	Max
All Income Groups				
Electricity	8.281	9.027	0.000	55.813
Kerosene	61.895	36.995	0.000	109.898
Liquefied Petroleum Gas	1.597	4.674	0.000	36.856
Petrol Motor Spirit	5.075	7.922	0.000	26.127
Automotive Gas Oil	3.204	5.186	0.000	35.865
Total welfare	80.052	26.283	33.701	109.898
Low income Group				
Electricity	11.229	9.279	0.000	55.813
Kerosene	82.785	21.826	0.000	109.898
Liquefied Petroleum Gas	1.586	5.373	0.000	36.856
Petrol Motor Spirit	0.014	0.543	0.000	26.127
Automotive Gas Oil	0.022	0.644	0.000	26.628
Total welfare	95.635	12.982	0.000	109.897
Middle Income Group				
Electricity	1.375	1.939	0.000	20.907
Kerosene	10.873	5.771	0.000	46.666
Liquefied Petroleum Gas	1.124	1.885	0.000	10.503
Petrol Motor Spirit	18.251	2.462	0.000	24.149
Automotive Gas Oil	9.728	1.450	0.000	19.915
Total welfare	41.352	5.475	0.000	66.258
High Income Group				
Variable	Mean	Std. Dev.	Min	Max
Electricity	0.203	0.810	0.000	6.946
Kerosene	6.117	10.309	0.000	60.087
Liquefied Petroleum Gas	0.772	1.222	0.000	5.703
Petrol Motor Spirit	4.432	5.016	0.000	17.192
Automotive Gas Oil	9.664	10.752	0.000	32.072
Total welfare	21.188	23.541	0.000	76.812

Source: Author’s Computations from the National Energy Survey, 2009

Table 4.6. 4: Compensating Variation by Location of Household (Percent)

Variable	Mean	Std. Dev.	Min	Max
Rural Households				
Electricity	7.230	7.642	0.000	55.813
Kerosene	61.388	40.258	0.000	109.898
Liquefied Petroleum Gas	0.611	2.936	0.000	36.856
Petrol Motor Spirit	3.554	7.125	0.000	26.127
Automotive Gas Oil	2.165	4.468	0.000	32.072
Total welfare	74.948	36.729	0.000	109.898
Urban Households				
Electricity	4.035353	8.878565	0.000	55.8129
Kerosene	22.20933	33.51489	0.000	109.8979
Liquefied Petroleum Gas	1.620963	4.74657	0.000	34.04956
Petrol Motor Spirit	3.411282	6.810916	0.000	24.14903
Automotive Gas Oil	2.238543	4.635154	0.000	35.86539
Total welfare	33.51547	38.8022	0.000	109.8979

Source: Computations from the National Energy Survey, 2009

As expected, welfare loss associated with cooking and lighting fuels was low for middle income groups but high for transport fuels. Middle income households experienced welfare losses of 1.4 percent, 10.9 percent and 1.1 percent for electricity, kerosene and LPG, respectively, compared to the low income whose welfare loss was 11.2 percent, 82.8 percent and 1.6 percent, respectively. However, in regard to transport fuels, the middle income households experienced greater welfare losses than the low income households. In the case of electricity, its pricing is such that as consumers' utilise more units, the burden increases. Electricity prices vary all over the world, even within a single region or power-district of a single country. In standard regulated monopoly markets, they typically vary for residential, business and industrial customers; and for any single customer class, these prices may vary by time of day, capacity or nature of the supply circuit. In Kenya, all consumers pay a fixed charge/tariff of of Ksh. 120 in addition to energy consumption in each consumer category. However, as households consume more units, the tariff increases. This, in part, explains why welfare loss is highest for high income household as the burden increases with consumption.

The current energy charges for electricity on consumers in Kenya are such that for the first 0-50 kWh, there is a cost charge of Ksh. 2.00, while the next consumer category who consume between 51-1,500 units, pay a tariff of Ksh. 8.10/kWh. Those consuming more than 1,500 units are charged Ksh. 18.57/kWh for any extra units. Following this pricing schedule, it is evident that as a household consumes more units after the first 50kWh, the tariff increases and therefore the burden to pay for extra units. This, in part, explains why the welfare loss is higher for middle income households than low income. Interestingly, the high income group has a lower welfare loss than the middle income group mainly due to their higher incomes compared to energy consumed.

In regards to kerosene, the welfare loss for the middle income group is lower than that of the low income group. The welfare losses are 10.9 percent and 82.9 percent, which is higher than the loss experienced among the high income group of 6.1 percent. The welfare loss for the middle income group was highest in the case of PMS, which was recorded at 18.2 percent, while that of AGO was 9.7 percent. Transport fuels accounted for most of the welfare loss among middle income households. The total welfare loss for such households is 41.3 percent, hence middle income households are worse off than they were in 2003, given that the effect of fuel prices compared to the low income households had the largest welfare loss of 95.6 percent.

Lastly, welfare analyses for the high income group show that the welfare losses are minimal for all cooking fuels compared to the other income groups. The welfare losses for electricity, kerosene and LPG were 0.2 percent, 6.1 and 0.8 percent, respectively (**Table 4.6.3**). The high welfare loss in the case of kerosene could be attributed to its consumption among the high income group in the rural and peri-urban areas where there is no electricity connection. In such a case, although a household may be able to afford electricity and LPG, there is no access; therefore it ends up consuming too much kerosene especially in lighting and cooking affecting to some extent their welfare. This is supported further by a welfare loss of 61.4 percent for the rural households (**Table 4.6.4)**. In regards to transport fuels, the welfare losses are lowest for PMS and AGO in the low income group compared to the middle and high income groups. The middle income group experiences the highest welfare loss in transport fuels. The total welfare loss for the high income group is lowest at 21.2 percent meaning that if households were to be compensated, they would get the least package. This level of welfare loss has implications when it comes to government policies on taxation and income transfers among income groups. Also taxes on fuels have no major implications/consequences to the high income groups compared to the low income groups.

4.6.3.2 Compensating variation by household location

In order to summarise the compensating variation results by location of households, I estimate the LAIDS model for each location. The estimations were done for the rural and urban households. The non-parametric regressions lines were estimated separately for each location and then the mean compensating variation for all the five fuels summarised. From the analyses, the compensating variation for rural households was highest with regard to cooking and lighting fuels. The compensating variation for electricity was 7.2 percent compared to that of kerosene at 61.4 percent. Thus kerosene consumers in the rural areas experienced higher welfare losses than electricity consumers. LPG imposed the lowest welfare loss of 0.6 percent. In regards to transport fuels, PMS generated a higher welfare loss of 3.5 percent compared to AGO's 2.2 percent. This is consistent with findings from analyses by income groups where the low income households had the lowest welfare losses for transport fuels. Majority of the poor households are located in the rural areas. The total welfare loss for rural households was 74.9 percent. Rural households have therefore experienced major welfare losses compared to those in urban areas (**Table 4.6.4**).

On the other hand, urban households experienced lower compensating variation or welfare losses compared to the rural households, but higher welfare losses for transport fuels. The compensating variation for electricity was 4.0 percent, while that of kerosene was 22.2 percent. Unlike in the rural households, welfare losses for LPG are higher for urban households because they have higher access to LPG than their rural counterparts. As a result, they require more compensation for welfare losses due to price changes, if their incomes are not increased/adjusted commensurately to match increasing LPG prices. The variations for transport fuels are not that wide compared to the rural areas. The welfare losses for PMS and AGO were 3.4 percent and 2.2 percent, respectively. The total welfare loss among urban households was 33.5 percent which is lower than that of the rural areas, hence urban households have smoothened their consumption and they therefore experience lower welfare losses after price increase.

The analyses has shows that the diversity of impacts was due to wide variation in household structures, geographical variations between rural and urban areas and consumption levels as depicted in the budget share of fuels.

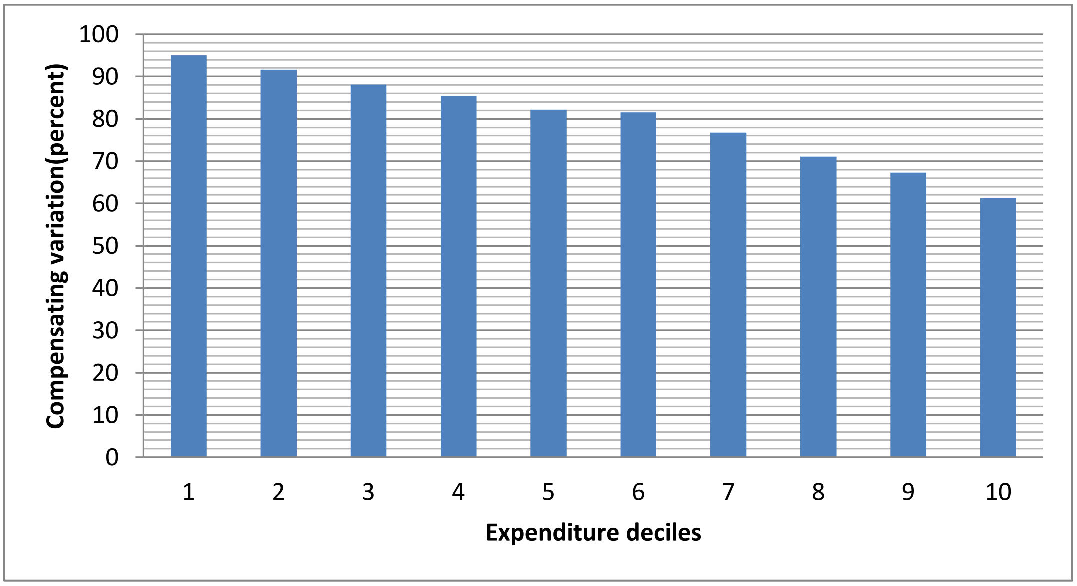
4.6.3.3 Welfare analysis by deciles

This sub-section computes the change in welfare in terms of deciles based on fuel budget shares and total expenditure which has been used as a proxy for income. Households are rarely able to reveal their true income, but their expenditure profile is useful approximation of how much they earned in a month or years. For one to spend, he/she has income to purchase and/or acquire goods and services. In this part of the analysis, I first compute the compensating variation by income and location of household, then by use of expenditure deciles, compute welfare losses and summarise them by expenditure deciles (from the 1st to 10th decile). The first decile is the poorest, while the 10th the richest deciles in terms of total expenditure and therefore assumed to be the wealthiest.

4.6.3.3.1 Compensating variation by income deciles

This sub-section presents results of total welfare by income deciles. The deciles computations are based on total expenditure. The results for compensating variation for all income group show that the poorest decile (1st decile) needs to be compensated for up to 95 percent. The poorest suffer most from welfare losses. On the other hand, the 5th decile requires compensation of up to 82.2, percent while the richest decile compensation is 61.3 percent. These results are consistent with findings from the second essay where I argued that in regards to cooking fuels, the poorer decile experienced the highest burden, while for transport fuels, high income deciles shoulder a greater burden since majority own cars and have higher motorisation levels. Considering the entire sample, total welfare loss is greatest on low expenditure deciles than the high expenditure ones; therefore the former requires more compensation to smoothen their fuel consumption (**Figure 4.6.1)**.

Figure 4.6.1: Compensating Variation by Expenditure Deciles for All Income Groups (percent)

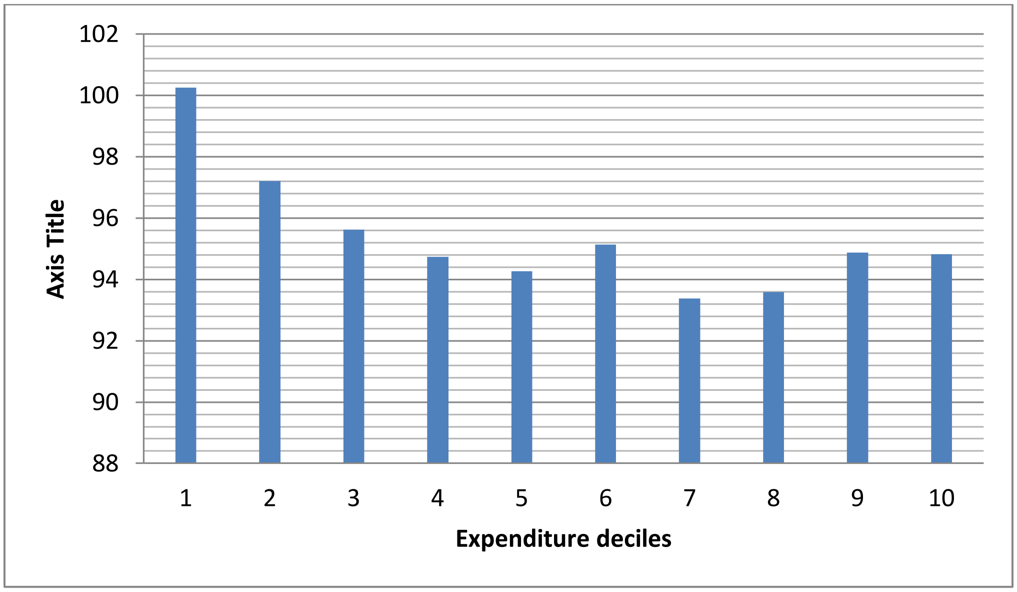


Source: Author's Construct from National Energy Survey, 2009

The analyses of total welfare by expenditure decile for the low income households show that the lowest decile needs to be compensated by more than 100.2 percent, this 1st decile was worse off in 2009 compared to 2003 by a very large percentage loss. Generally, the total welfare or compensating variation declines as one moves from the poorest to the richest deciles within the low income group. However, it is important to note that the compensating variation for all deciles was above 94 percent. **Figure 4.6.2** presents the total compensating variation for the low income group.

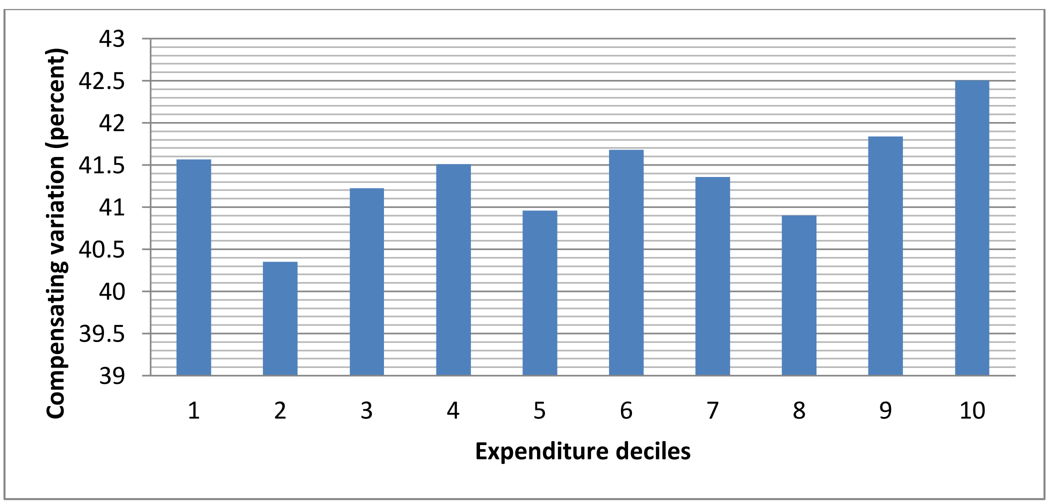
In regards to the middle income households, the compensating variation was 41.6 percent for the 1st expenditure decile, 40 percent for the 5th decile, and as for the 10th decile compensating variation was 42 percent. There was no much deviation from the total welfare loss of 41.3 percent for the middle income households as discussed in sub section 4.6.3. However, it is clearly evident that households for the middle income group have lower compensating variation than the low income group (**Figure 4.6.3)**.

Figure 4.6.2: Compensating Variation by Expenditure Deciles for Low Income Group (percent)



Source: Author's construct from National Energy Survey, 2009

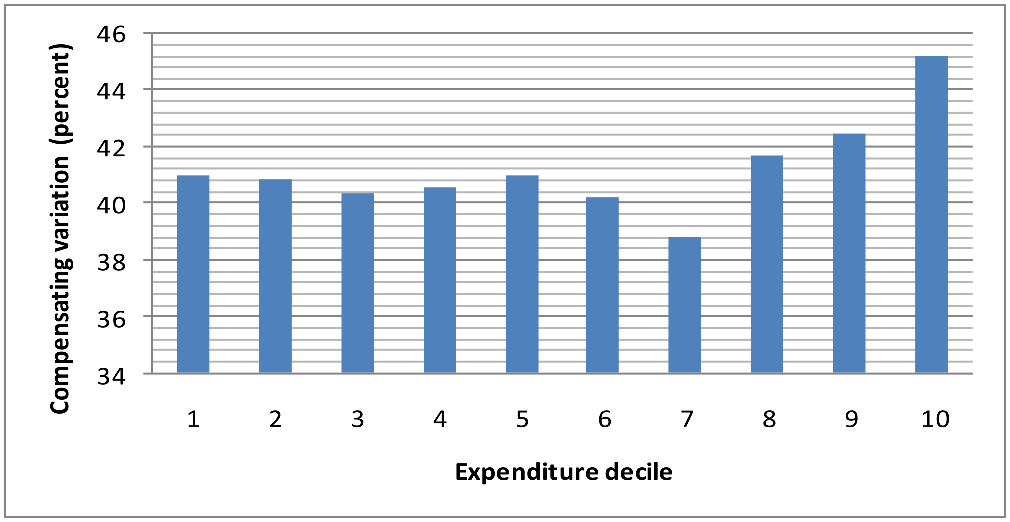
Figure 4.6.3: Compensating Variation by Expenditure Deciles for Middle Income Group (percent)



Source: Author's construct from National Energy Survey, 2009

In regards to the high income group, the compensating variation/welfare loss is higher for higher income deciles than the low income deciles. While the compensating variation for the 2nd decile is 40.8 percent, it is 42.5 and 45.2 for the 9th and 10th deciles respectively. This implies that higher expenditure deciles require more compensation than the lower one. This is because of higher budget share for transport fuels, hence greater welfare loss than lower income deciles in the same category. Richer deciles have higher incomes; can afford more cars, especially the fuel guzzlers. Due to high consumption of fuel by such cars, they are most likely to spend more on fuels (**Figure 4.6.4)**.

Figure 4.6. 1: Compensating variation by expenditure deciles for high income group (percent)



Source: Author's Construct from National Energy Survey, 2009

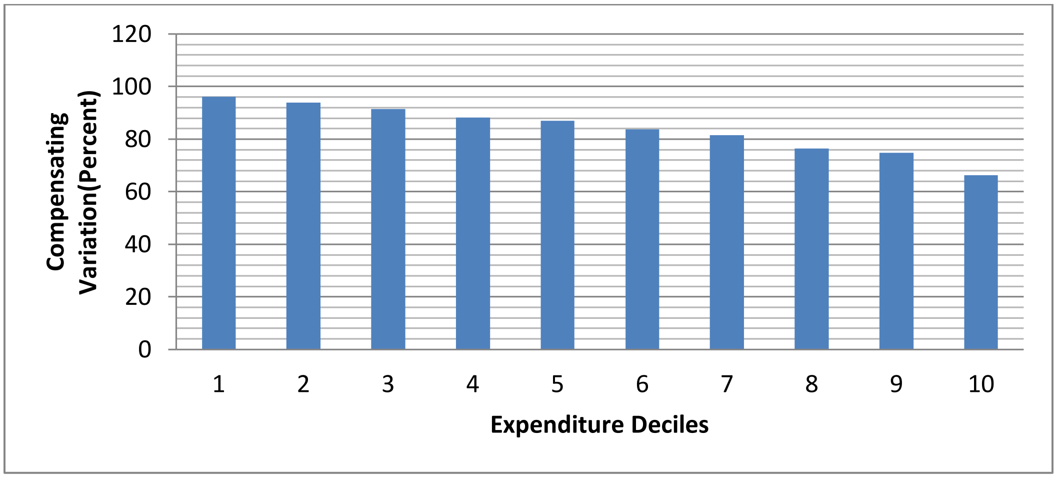
4.5.3.3.1 Compensating variation by location and by expenditure deciles

In this sub-section, I discuss compensating variation by location of households and expenditure deciles. These analyses were important because of the dynamism of the rural and urban areas, their structural differences in terms of incomes, demographics, choice of energy consumed, and generally, budget shares for the various fuels. The analyses have been done for rural and urban areas (**Figure 4.6.5** and **Figure 4.6.6**). in regards to rural households, the analyses show that the compensating variations for the 1st decile was 96.1 percent, while the 2nd and 3rd deciles recorded 93.8 percent and 91.4 percent, respectively. On the other hand, the higher income deciles recorded lower compensating variation. The 8th, 9th and 10th deciles recorded 76.4 percent, 74.7 percent and 66.2 percent, respectively.

It is clear that as one moves to high expenditure deciles, the compensating variation declines; meaning the lower deciles experience higher welfare loss compared to high expenditure deciles.

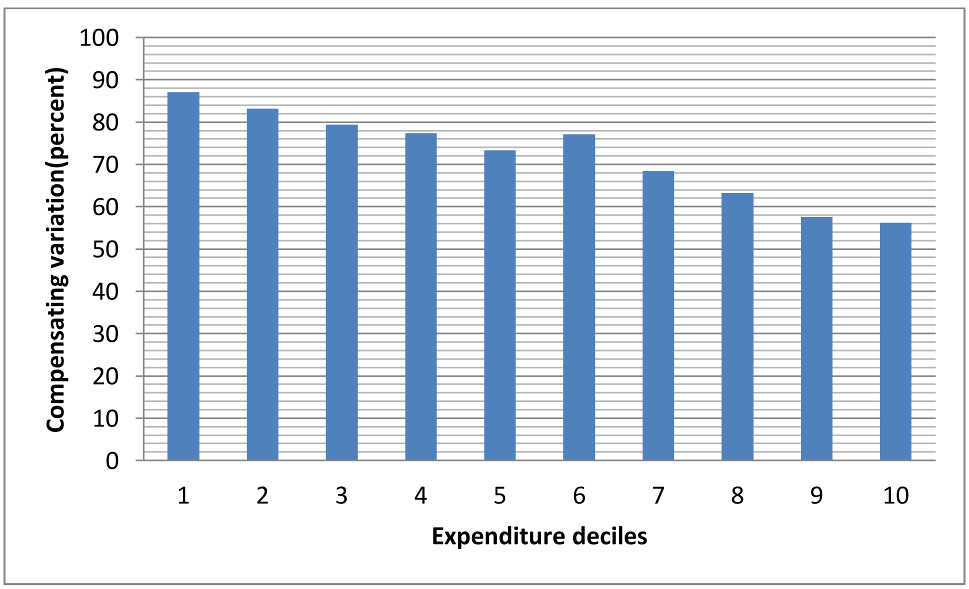
Regarding urban households, the total compensating variation by expenditure deciles showed similar trends as rural households. However, the magnitude of the welfare loss was slightly lower compared to the rural households. The compensating variation for the 1st, 2nd and 3rd expenditure deciles were 87.1 percent, 83.1 percent and 79.4 percent, respectively. On the other hand, compensating variation for higher income deciles was much lower at 63.2 percent, 57.6 percent and 56.2 percent for the 8th, 9th and 10th expenditure deciles, respectively. This shows that higher expenditure deciles require lower compensation than the lower deciles, and this is consistent with findings of welfare loss by fuel budget shares and income groups.

Figure 4.6. 2: Compensating variation for rural households by expenditure deciles (percent)



Source: Author's construct from National Energy Survey, 2009

Figure 4.6. 3: Compensating variation for urban households by expenditure deciles (percent)



Source: Author's Construct from National Energy Survey, 2009

From the discussions, it is evident that the variance of fuel in the fuel basket may decrease the amount of compensating variation, and as a whole, compensating variation of richer expenditure deciles are lower than those for poor deciles. One can also conclude that compensating variation is low for high income groups than high income groups for cooking and lighting fuels, but this does not apply for transport fuels where welfare loss is higher for high income households. Rural households have higher welfare losses than their urban counterparts for all fuels. The analyses by expenditure deciles show that low income households experience higher compensating variation than middle and high income households. The analyses further lead to the conclusion that rural households require more compensation than their urban counterparts for all expenditure deciles.

4.7 Conclusion and Recommendations

4.7.1 Summary and Conclusions

The aim of this essay was to measure the welfare impact of fuel price increases on Kenya's households and provide policy recommendations on how to compensate households due to welfare losses. The fuels considered were electricity, kerosene and LPG (cooking, lighting and cooking fuels); and PMS and AGO (transport fuels). The essay disaggregated households into three income categories, namely, low income, middle and high income; and also estimated welfare for the entire sample. It further considered welfare impact by location of households where in this case rural and urban households are analysed. Prior to this disaggregated groups estimation, compensating variation for all households was analysed. Thirdly, it analyses compensating variation by expenditure deciles. The main question in the essay was 'who experiences the highest welfare losses in terms of fuel budget shares, by income group and geographical location of households'. Lastly, the essay makes a note on welfare implications from fuel price increases and recommends whether fuel taxes and prices should be reduced or increased, and whether fuel subsidies are necessary to compensate households from welfare losses.

The essay reviewed relevant literature on distributional and welfare aspects of fuel prices and taxes in both developed and developing countries and examined implications for household welfare. Findings show that in most studies, particularly in the electricity sub sector, a majority of households have a negative compensating variation. This means that income must be taken away from these households in order for them to have the same level of welfare as before the price change. In other words, these households are better off after tariff rebalancing than before. The negative effects of the rise in the fixed charge are more than compensated for by the savings due to the fall in the variable price. The review has also shown that the current wave of volatile international oil prices coupled with the low hydro-energy generation continues to exert negative impacts on many economies.

Further, in real terms, price increases have worsened the welfare of most consumers during the1990s and 2000s. The poor, and in particular the rural poor, bore much of the brunt compared to the non-poor. The welfare losses in the 2000s were greater than those in the 1990s, thus households later were worse off.

In regards to subsidies, it has been argued that they result in substantial loss of revenue and an exponential growth in domestic oil consumption as low prices do not signal real cost of consumption. It is, therefore, clear that reforming subsidies for fossil fuels is a challenging prospect for many governments. To help policy-makers better appreciate the trade-offs between economic, environmental and social impacts, it is important to analyse fossil-fuel subsidies and their effects on household welfare. Measuring the impact of subsidy reforms is therefore a critical step in determining under what conditions the net effect of subsidy removal is positive and what supporting measures need to be undertaken to ensure that negative effects are minimised.

As for methodology, some studies use the compensating variation approach, while others prefer the macroeconomic analyses of welfare through models such as the CGE.. Others use the expenditure shares and Suit Index to analyse distributional effects of prices increases or due to taxes and subsidy changes.

The findings show that the mean fuel budget shares for cooking and lighting fuels are higher for low income households, but lower for high income ones. On the other hand, middle and high income households have higher budget shares for transport fuels and LPG. In regards to compensating variation, low income households would require higher compensation to go back to same level they were before the price increases were experienced. Fuel prices increases have been volatile and higher than increase in real income and wealth. Low income and rural households require more compensation for welfare losses for cooking and lighting fuels, than the middle and high income ones. As for welfare measures by expenditure deciles, it is evident that lower expenditure deciles require more compensation than high income deciles. Interestingly, higher income deciles require more compensation than the low income deciles in the case of transport fuels.

4.7.2 Policy Recommendations

In essays one and two, I dwelt more on demand, supply and fiscal policy dimensions of distributional consequences of energy taxes. In this essay, I focused more on welfare, taxation and pricing related policy recommendations. Pricing of fuels in Kenya has been done in a reformed market since the unbundling of the National Power Utility in 1998 and liberalisation of the petroleum sub sector in 1994. However, in December 2010, the Government introduced price regulations to cushion households from price volatilities which are mainly driven by increases in Murban crude petroleum prices. However, when the international prices fall, the oil marketers do not commensurately adjust pump prices downwards. Fuel pricing in Kenya is cost reflective, while, at the same time, ensures economic feasibility and financial viability of service providers. The price of electricity is based on a cost build up from power generation, transmission and distribution, while that of petroleum products begins with the Open Tender System (OTS) and then landed cost. Thereafter, other costs such as storage, transport, taxes and levies are added. The petroleum pricing formula which is implemented by the energy regulator is therefore a cost plus model. Fuel pricing in Kenya, is thus determined in a market with some extent of free market and some level of regulation.

As seen earlier, although the Government of Kenya is committed to deregulation, some level of welfare compensation is required, particularly to the low income households. Experience has shown that indiscriminate use of energy subsidies is expensive for the economy and therefore the government needs to be careful when proposing or implementing such subsidies to the poor groups due to welfare losses.

As a result of subsidies, everybody in the chain looses; the government, private sector and the consumers. For example, tax reductions and subsidies meant to bring fuel prices down such as the ones for kerosene and AGO need to be implemented with care. Therefore designing an appropriate and credible compensatory programme for the genuinely vulnerable class will be helpful in the process.

Electricity

Electricity in Kenya is distributed by the Kenya Power and Lighting Company (KPLC) Limited through a single buyer model where it purchases generated electric power from KenGen and Independent Power Producers. Electricity access is key in determining welfare and standard of living of households due to its multiplicity in use. In this essay, it has been established that electricity use is regressive in taxes due to the fact that more compensation is required to mitigate against high welfare losses due to price increases, particularly to the low income households.

Firstly, the energy regulator should consider revising the life line tariff in electricity pricing in Kenya so as to protect the very 'poor' due to high welfare losses among the low income group. This should be revised periodically to coincide with the cost of services studies which are done to provide guidelines on revised prices.

Secondly, the Government should consider reducing the VAT on electricity for the first 50kWh consumed to cushion low income households from welfare losses. VAT on electricity has been increased to 16 percent from 12 percent and this is not desirable to poor households. Reducing the tax will increase consumption by households as well as spare some more income to provide for other basic needs.

Lastly, there is need to promote energy conservation in order to save energy, therefore help households spend less on electricity to mitigate against the high welfare losses.

Kerosene

Kerosene has been used as a household fuel for many years. However, with the advent of electricity for lighting and natural gas for cooking, it receded from the horizon of western countries, hence becoming a fuel for developing countries such as Kenya. Since households in Kenya will continue to use kerosene for some time, an efficient device/mechanism which works on readily available liquid fuel to produce high quality light for illumination and heat for cooking should be developed. This will in the long run reduce the amount of kerosene used in households, therefore minimising welfare losses, while reducing indoor pollution.

Secondly, subsidised kerosene is sold at much lower prices than gasoline or diesel and is frequently diverted to the black-market for use in transport fuel adulteration with PMS, AGO or in power generation in some developing countries. For this reason, measures should be put in place to ensure that no adulteration of fuels with kerosene occurs. This will ensure that the benefit from subsidised kerosene only goes to low income households which are targeted by such a policy initiative.

Thirdly, the current subsidy on kerosene which has played a key role to protect the poor against welfare losses due to their reliance on the fuel should be sustained. The subsidy is a relief to households as it reduces the price of kerosene, therefore reduction in the budget share. As a result, households can use the savings to provide for other basic needs such as food, water and shelter.

Liquefied Petroleum Gas

It is widely acknowledged that substituting traditional solid biomass or coal with cleaner fuels is one effective way of reducing household energy poverty. LPG is a merit good, proper use can virtually eliminate indoor and outdoor air pollution from fuel combustion, benefiting not only the user but also others in the vicinity. Yet, many people are not aware of the extent of harm caused by traditional solid fuels; hence they do not recognise the full benefits of switching to LPG or other gaseous fuels. It is therefore important for the government to develop policies and strategies to promote use of LPG which is cleaner and efficient in utilisation.

Firstly, deliberate strategies should be made to reduce the price of LPG to consumers by exploiting economies of scale. This should be achieved through establishment of strong hospitality and third party arrangements between marketers in storage and transportation. In addition, there is need for bulk and joint purchase as well as importation in large import parcels.

Secondly, as the government endeavours to bring the price of LPG down, it is critical to reduce the high demurrage charges through rapid custom clearance, reduced port congestion and adequate port receiving capacity. The construction of the African Oil and Gas Terminal in Mombasa will help ease supply constraints and demurrage costs.

Thirdly, petroleum market competition should be enhanced by posting prices by location and cylinder size on the Government, Energy Regulatory Commission and Petroleum Institute of East Africa websites. This will foster competition and benefits to consumers.

Fourthly, the government should increase penetration of LPG by providing infrastructure such as depots, refilling stations in rural and marginalised areas in cities to increase access and use. This can be achieved through improvement in auxiliary infrastructure, improved road conditions and port infrastructure.

Fifthly, target financial assistance is key to the provision of LPG in the country. The government should therefore move away from universal price subsidies through expansion of social safety net programme to help households pay for LPG using cash transfer or vouchers. In addition, it would be important to spread or reduce upfront adoption cost through dealer incentives for cylinder deposit fee and stove dealer-financed instalment plan, microfinance scheme and small cylinders in niche market.

Measures should be taken to minimise shortages by ensuring minimum commercial and/or strategic stockholding regulations, and reasonable returns (through, for example, removal of universal price subsidies) to efficient operators to build capital for construction of storage facilities.

Lastly, ERC should raise awareness and involve consumers in improving market conditions by publishing price information, industry statistics, frequently asked questions, safety tips and names of companies violating rules that directly affect consumers on the web and in reports; and establishing a simple mechanism for registering complaints in government, industry associations and company websites.

Transport Fuel

In Kenya, as has happened in many oil importing countries, motor vehicle fuel prices have increased significantly in recent years and are likely to stay high in the future. It is important to note that fuel prices are an emotional issue among consumers. Even at lower prices, many motorists feel they pay more than is fair. There are frequent demands for investigations into fuel price gouging, and popular campaigns to promote cheaper fuel through public policies and consumer boycotts. As a result, consumers, consumer groups and policy makers are unclear about how best to respond to rising fuel prices. It is therefore important to keep in mind the implications of high transport fuel prices on household welfare as well as impact of fuel consumption on welfare. From the foregoing, the following recommendations can be made:

Firstly, considerations should be made to reduce tax on AGO further to ensure that it will benefit the low income and vulnerable households to avoid welfare losses. Any subsidy or tax reduction to increase fuel affordability should be targeted at economically disadvantaged people and suitable for any transport mode. For example, low income people could receive an annual subsidy that may be used for fuel, public transit, taxi fares or to help pay for location-efficient affordable housing.

Secondly, in line with what is happening to developed and transitional economies, government policies should encourage resource efficient industries, particularly those that increase transport system efficiency. Support for vehicle and petroleum industries should be evaluated critically to determine whether they are cost effective compared to other industrial development investments and consistent with strategic objectives and future consumer demands. Businesses that depend on energy intensive transport (manufacturing and assembly of fuel inefficient automobiles, recreational vehicles and motorised sports equipment) should be encouraged to diversify and develop alternative products that will be profitable if fuel prices increase. This will in the long run help to achieve competitive prices and reduce welfare losses from price increases.

Lastly, the current transport system in Kenya is inefficient. Large efficiency gains can be achieved in cost effective ways that provide multiple benefits. Welfare loss to consumers and other negative impacts on the economy can be minimised by making fuel price increases gradual and predictable, and matching them with policies that improve vehicle efficiency and transport options. Generally, there is no equity justification to subsidise fuel since their primary effect would be to allow middle- and upper-income motorists to purchase less efficient vehicles and drive more. Targeted subsidies and policies that improve affordable transport options can do far more to help disadvantaged people while also helping to solve other transport problems.

CHAPTER 5

SUMMARY AND CONCLUSIONS

5.1 Introduction

These essays on distributional consequences of fuel taxation in Kenya were presented in five chapters. Chapter one provided the introduction and motivation as well as the organisation of the study. Chapter two presented the second essay that examined key drivers of energy demand and computed own, cross and expenditure elasticities for kerosene, electricity, LPG, PMS and AGO. Chapter three analysed distributional effects of fuel taxes and examined residential energy budget shares by income group and deciles and estimated the impact of fuel taxes by use of the Suit index. Chapter four measured welfare impact of fuel price increase on Kenya's households. Lastly, this chapter provides a summary of literature, methodology of study, key findings and provides key conclusions and recommendations, key contributions and areas of further research from the study.

Energy demand in Kenya exceeds the available supply and this has constrained provision of services to households. The available energy is also expensive and many households cannot afford use of some of the cleaner technologies available. The situation is exacerbated by under investment in the sector, particularly in electricity generation, thus the per capita generation and consumption is very low at 156kWh/Per capita compared to other countries that Kenya desires to be in the next twenty years. Currently, Kenya is a net importer of all petroleum products and is therefore susceptible to international price shocks which contribute to high domestic prices. Given the low per capita income and poverty levels, many households cannot afford to adequate energy for use.

In essay one, I established that fuel demand is driven by own and cross prices, income of household, household size, education level, type of employment, gender of household head and regional dummies among other key variables. Estimations for elasticity have shown that most fuels are price inelastic, meaning a unit increase in price would lead to a less than unit increase in quantity demanded/increase in budget share. Results for cross price elasticity are mixed and depend on use of a fuel type and whether it is a necessity. Expenditure elasticities are positive as expected from theory and more inelastic in the case of kerosene, electricity and LPG.

In essay two, analyses for budget shares revealed that basic and necessity fuels such as kerosene and electricity have higher budget shares among the low decile households, while LPG and residential transport fuels have higher budget shares among the higher income deciles. Secondly, analysis of distributional effects of fuel taxes have concluded that kerosene and electricity are regressive in taxes, therefore a tax increase on those fuels will increase the burden to low income households compared to those in high income deciles. On the other hand, in the case of transport fuels, the tax burden is more on higher income deciles which comprise households that own cars. These results support other findings for example Hughes (1996), Sterner (2007), West (2004), Datta (2008) and Mutua *et al.*, (2009; 2012) in the case of transport fuels. From the foregoing, I conclude that kerosene are regressive in taxes, while LPG, PMS and AGO are progressive in taxes.

Essay three has examined the impact of fuel price increases on household welfare. A price increase can either be due to cost of production, imposition of a tax or increase in the tax rate and international price shocks among other factors. By use of compensating variation approach, the findings have shown that low income households have experienced higher welfare losses compared to the high income group. As a result, low income households would require higher compensation for kerosene and electricity in order to go back to the same utility level they were before the price increase compared to users of transport fuels (PMS and AGO). These results support findings from other studies that have been done for example Nikban and Nakhaie (2011); Gomez-Lobo (1996); Leyaro (2009); Huang (2009); Andriamihaja and Giovanni (2007); Twimukye and Matovu (2009); Simler (2010); Ellis (2010) and Golub(2010) among others. The essay has therefore contributed to the existing literature on work that has been done on the impact of energy prices on household welfare. Given the nature of the Kenyan sample in the National Energy Survey data (2009) which had a national outlook and provided information for both rural and urban households, the essay findings have provided strong policy recommendations which are important in dealing with welfare losses from fuel price increases in developing countries.

5.2 Key Policy Strategies and Recommendations

In summary, key policy recommendations can be made from the three essays discussed under the main themes of energy demand, distributional effects of fuel taxes, and fuel price increases and household welfare losses. Lastly, some recommendations on areas of further research have been provided.

With regard to energy demand, the Government should develop a Comprehensive National Energy Policy using a multi stakeholder approach and come up with strategies to improve energy access and address pricing issues. The current levels of energy access are low; therefore deliberate strategies are needed to improve this.

Electricity is regressive in tax and price inelastic and therefore the burden and welfare losses to consumers are higher in case of fuel price increases for low income households. The government should therefore maintain some level of subsidy to cushion the poor from the detriments of a regressive tax and pricing mechanism.

A strategy for increasing LPG penetration should be implemented to increase access to the rural and urban poor. The poor can only afford purchases in small quantities and the Energy Regulatory Commission as well the Ministry of Energy and Petroleum should put in place strategies to promote uptake of safe micro technologies in LPG use. With regard to transport fuels, the Government should encourage efficiency by enforcing importation of vehicles as per the allowed emissions standards, importation of smaller engine vehicles and promote public transport which has economies of scale in fuel use.

In the case of distributional effects of fuel taxes, there is need to sustain the zero tax on kerosene and the Life Line Tariff (subsidy) on electricity to cushion the low income households from higher tax burdens. This is because tax on kerosene and electricity is regressive and low income households experience the highest burden. In order to promote use of LPG which is clean, there is need to reduce taxes on its utilisation facilities so as to reduce the burden to low middle income households and promote use among the low income ones. In regards to transport fuels, there is need to reduce tax on AGO and promote use of public transport so as to benefit low income households and reduce other negative externalities such as CO_2 emissions that are as result of burning hydrocarbons.

Lastly, on price increase and household welfare losses, the government should come up with strategies to ensure that there is fair competition in the energy sector, while providing some level of compensation to low income households. This is due to welfare losses experienced by consuming fuels such as kerosene and electricity that are price inelastic.

5.3 Key Contributions

This thesis has applied recent techniques to estimate residential energy demand, distributional effects of fuel taxes as well providing a measure of welfare analyses for fuel price increases on households. The analyses of demand involved application of the LA-AIDS model and a split of the sample into three income groups. It also estimated a global model of demand for the entire sample. The study further computed own, cross and expenditure elasticities by income group and household location. This has not been done before in any energy sector related studies in Kenya. The analyses of distributional effects of taxes are unique and provide a combination of fuel expenditures and fuel budget shares by income group as well by deciles.

Secondly, the thesis computed tax burden by use of Suit Index which is an innovative methodology of establishing how the burden is spread across households by deciles. The Suit Index is also done for kerosene, electricity and LPG (cooking, lighting and heating fuels). No study in Kenya has used this Index to compute tax burdens for these basic fuels. Previous work by Mutua *et al*., (2012 used urban data for Nairobi to estimate tax burden for transport fuels.

Lastly, it has used Compensating Variation to estimate household welfare losses due to a price change. The analyses was innovative because it utilised Cross Sectional data from the National Energy Survey (2009) and worked backwards using time series price changes to obtain what would have been fuel prices for 2003, if a similar National Energy Survey was carried out then.

In terms of policy, the essays have contributed to the dearth in knowledge in distributional consequences of fuel taxation and analyses of welfare losses. The results will be useful in advising policy makers in energy regulation and fiscal policy on the implication of increasing a tax on basic fuels such as kerosene and electricity that are regressive in taxes for low income deciles. This justifies the policy to sustain the life line tariff and zero rate kerosene in tax to protect the poor. In regards to transport fuels, the government should not shy from taxing fuels such as PMS which are progressive in taxes for the low income households and whose burden is more for high income deciles.

5.4 Areas of Further Research

Further research should be undertaken to determine energy use patterns of the various sectors of the economy to add to data and findings from the National Energy Survey (2009). The results from this study would be useful in providing information regarding potential areas of energy efficiency and provide advice on how to use it in the best way, the oil find in Ngamia One in Turkana County and any other hydrocarbons that will be discovered and exploited in the future. To this end, a study on energy use in all sectors should be conducted by the Kenya National Bureau of Statistics in collaboration with national research institutions and universities.

Secondly, there is need to continually update the Cost of Service Studies in electricity and petroleum sub-sectors and introduce new innovations in modelling marginal costs, fuel cost charge adjustments as well as inflation and foreign exchange pass-through so as to have a fairly cost reflective tariff, since it has been established that a tax on electricity is regressive and has a high welfare loss implication to low income households.

Thirdly, the Petroleum Pricing Formula by the Energy Regulatory Commission should be reviewed by testing the model with data that has been collected from the price adjustments reviews done every month. This will help determine the prudently incurred costs in the supply chain and provide advice on further improvement on the model so as to protect consumers, while ensuring that oil marketers remain financially viable.

REFERENCES

Adenikinju, A. (2011). *Energy pricing and subsidy reforms in Nigeria*. Ibadan: Department of Economics, University of Ibadan.

Aligula, E. M. (2006). *Policy options for reducing the impact of energy tariffs in Kenya*. Nairobi: National Economic and Social Council.

Aligula, E. M., Abiero-Gariy Z., Mutua, J. M., Owegi F., Osengo C. and Olela R. (2005). *Urban public transport patterns in Kenya: A case study of Nairobi city* (Special Report No. 7). Nairobi: Kenya Institute for Public Policy Research and Analysis.

Andriamihaja, N. A. and Giovanni V. (2007). *Madagascar: An evaluation of the welfare impact of higher energy prices in Madagascar* (Africa Region Working Paper Series No. 106). June 28.

Angulo, A.M., Gil, J.M. and Gracia, A. (2001). The demand for alcoholic beverages in Spain. *Agricultural Economics*, 26, 71–83.

Baker, P., Blundell, R. and Mickelwright, J. (1989). Modelling household energy expenditures using micro-data. *The Economic Journal*, 99: 397, 720-738.

Baker, P., Blundell, R. W. and Micklewright, J. (I987a). *Modelling energy demand and household welfare using micro-data* (Department of Economics Discussion Paper I6I). Queen Mary College, University of London.

Barnes, D.F. and Floor, W. (1999). Biomass energy and the poor in the developing world. *Journal of International Affairs*, 53:237-59

Barron, J.M., Blanchard, K. H. and Umbeck, J. R. (2004). An economic analysis of a change in an excise tax. *The Journal of Economic Education*, 35(5):184-196.

Barthold, T.A. (2004). Issues in the design of environmental taxes. *The Journal of Economic Perspective*, Vol. 1 (winter, 2004), 133-151.

Blackman, A., We R.O. and Alpizar (2009). *Fuel tax incidence in developing countries: The case of Costa Rica* (Resources for Future Discussion Paper 09-37).

Blundell, R. (1988). Consumer behaviour: Theory and empirical evidence-A survey. *The Economic Journal*, 98: 389, 16–65.

Bohi, D.R. and Zimmerman, M. (1984). An update of econometric studies on energy demand. *Annual Review of Energy*, 9, 105-154.

Briscoe J. (1979). Energy use and social structure in a Bangladesh village. *Population Council*, Vol. 5(4): 615:641

Central Bank of Kenya (2009). *Statistical bulletin*. June. Nairobi

Central Bank of Kenya (2012). *Statistical bulletin*. June. Nairobi.

Dah, C.A. (2011). Measuring global gasoline and diesel price and income elasticities. *Energy Policy*, 41 (2012), 2–13

Datta, A. (2008). The incidence of fuel taxation in India. In Sterner T. (Ed.). *In fuel taxes and the poor*.

Deaton, A. and MuellBauer, J. (1980). An almost ideal demand system. *The American Economic Review*, 70: 3, 312–326.

Deaton, A. (1990). Price elasticities from survey data: Extension and Indonesian results. *Journal of Econometrics*, 44, 281–309.

Ellis, J. (2010). *The effects of fossil-fuel subsidy reform: A review of modelling and empirical studies*. The Global Subsidies Initiative (GSI) and International Institute for Sustainable Development (IISD).

Energy Regulatory Commission (2012). *Monthly petroleum price reviews* (15th January to 14th February). Author.

Energy Sector Management Assistance Programme (2000). *Photovoltaic applications in rural areas of the developing world* (ESMAP Technical Paper 009). Washington, DC: World Bank. Retrieved http://www.esmap.org/filez/pubs/photovolruralareas21992.pdf

Ezzati, M. and Kammen, D.M. (2001). Indoor air pollution from biomass combustion and acute respiratory infections in Kenya: An exposure-response study. *The Lancet* 358(9282): 619-24.

Fan, S. and Hyndman, R. (2010). *The price elasticity of electricity demand in South Australia*. Clyton, Victoria: Business and Economics Forecasting Unit, Monash University.

Filippini, M. (1999). Swiss residential demand for electricity. *Applied Economics Letters*, 6, 533-538.

Franzen, T., Lovgren K. and Rosenberg I. (1975). Redistribution effects of taxes and pubic expenditures in Sweden. *Scandinavian Journal of Economics,* 77(1): 31-55.

Friedman, J. and Levinsohn, J. (2002). Distributional impacts of Indonesia's financial crisis on household welfare: A rapid response methodology. *World Bank Economic Review*, Vol. 16, No. 3, 397-423.

Friedman, J. and Levinsohn (2002). The distributional effects of Indonesia's financial crisis on household welfare: A "rapid response" methodology. *World Bank Review*, Vol.16, No. 3 397-423. Washington DC: World Bank.

Friedman, M. (1957). *A theory of the consumption function.* Princeton University Press.

Fullerton, D., Leicester, A. and Smith, S. (2010). Welfare and equity impacts of gasoline price changes under different public transportation service levels. *Journal of Public Transportation*, Vol. 13, No. 3. Arizona State University.

Gomez-Lobo, A. (1996). The welfare consequences of tariff rebalancing in the domestic gas market. *Fiscal Studies*, Vol. 17, No. 4, pp. 49-65.

Gor, S. (1994). *Consumption of commercial energy in the residential sector of Kenya 1970-1990* (Unpublished M.A. Thesis). Nairobi: Kenyatta University.

Goulder, L. H. (2005). *Fiscal instruments for pollution control: Attractions, limitations and strategies*. Stanford University, Resources for the Future and NBER. Mimeograph.

Government of Kenya (1978). *Statistics of energy and power, 1969-1977*. Nairobi: Government Printer.

Government of Kenya (1998). *Electric power act, 1997.* Nairobi: Government Printer.

Government of Kenya (2004). *Sessional paper No. 4 on energy*. Nairobi: Government Printer.

Government of Kenya (2008). *Vision 2030: A globally competitive and prosperous Kenya*. Nairobi: Government Printer.

Government of Kenya (2011), *Budget Statement for the Fiscal year 2011/12.* Retrieved http://www.statehousekenya.go.ke/publications/07-06-2011-12-BudgetSpeech-Distribution%20Final%20_MF.pdf

Government of Kenya (2013). *The finance act 2013*. Nairobi: Government Printer.

Granado, J., Coady, D. and Gillingham, R. (2010). *The unequal benefits of fuel subsidies: A review of evidence for developing countries*. IMF Working Paper Fiscal Affairs Department, Washington DC.

Green, R. and Alston, J. (1990). Elasticities in AIDS models. *American Journal of Agricultural Economics,* 72, 441 – 445

Greene, W.H. (2003a). *Econometric analysis* (5th Ed.). Prentice Hall, New Jersey.

Griffin, J.M. and Gregory, P.R. (1976). An inter-country translog model of energy substitution responses. *American Economic Association*, 66: 845-57.

Hammar, H., Löfgren, Å. and Sterner, T. (2004). Political economy obstacles to fuel taxation. *The Energy Journal*, 25(3), 1-17.

Hancock, R. and Waddams Price, C. (1995). Competition in the domestic British gas market: Efficiency and equity. *Fiscal Studies*, Vol. 16, No. 3, pp. 81–105.

Hausman, J. (I 979). Individual discount rates and the purchase of and utilisation of energy-using durables. *The Bell Journal of Economics*, Vol. 10, pp. 33-54.

Heckman, J. J. (1976). The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models. *Annals of Economic and Social Measurement* 5, 475–492.

Heckman, J. J. (1979). Sample selection bias as a specification error. *Econometrica* 47, 153–161.

Heien, D. and Wessells, C.R. (1990). Demand systems estimation with micro data: A censored regression approach. *Journal of Business and Economic Statistics*, 8, 365-371.

Heltberg, R. (2005). Factors determining household fuel choice in Guatemala. *Environment and Development Economics* 10:337-61.

Hicks, J.R (1939). *Value and capital: An inquiry into some fundamental principles of economic theory*. Oxford: Clarendon Press.

Hoderlein, S., and Vanhems, A. (2010). *Welfare analysis using non-separable model*. Department of Economics, Boston College.

Hosier, R.H. and Dowd. J. (1987). Household fuel choice in Zimbabwe: An empirical test of energy ladder hypothesis. *Resources and Energy*, 9:347-61

Huang, K. S. and Huang, S.W. (2009). *How increased food and energy prices affect consumer welfare*. Selected paper prepared for presentation at the Agricultural & Applied Economics Association 2009 AAEA & ACCI Joint Annual Meeting, Milwaukee, Wisconsin, July 26-29.

Hudson, E.A. and Jorgenson, D, W. (1974). US energy policy and economic growth. *Bell Journal of Economics*, 5: 461-14.

Hughes, G.A. (1986). A new method for estimating the effects of fuel taxes: An application to Thailand. *The World Bank Economic Review*, 1(1):65-101.

International Energy Agency (2011). *World energy outlook 2011*. Paris: Author. Retrieved http://www.worldenergyoutlook.org/

Joint Committee on Taxation (2009). *Tax expenditures for energy production and conservation (JCX-25-09).* April 21. Retrieved www.jct.gov.

Jones, C.T. (1993). A single-equation study of US petroleum consumption: The role of model specification. *Southern Economic Association,* 59(4): 687-700.

Kamfor (2002). *Study on Kenya's energy demand, supply and policy strategy for households, small-scale industries, and service establishments* (Final Report). Ministry of Energy.

Kenya Motor Industry (2012). Vehicle Ages, *Kenya Motor Industry Briefs*. http://www.kmi.co.ke/kmi-briefs/vehicle-ages

Kimuyu, P.K. (1988). *Demand for commercial energy in Kenya: A structural investigation* (Unpublished PhD thesis). University of Nairobi.

Kenya Institute for Public Policy Research and Analysis (2005). *Public transport survey data*. Nairobi: Author.

Kenya Institute for Public Policy Research and Analysis (2010). *Energy consumption patterns in Kenya* (Client Report for the Energy Regulatory Commission).

Kenya Institute for Public Policy Research and Analysis (2010b). *Study on the demand for petroleum products in Kenya* (Client Report for the Ministry of Energy).

Kenya National Bureau of Statistics (2013), *Economic survey*. Nairobi: Government Printer.

Kenya Power and Lighting Company Limited (2012). *Annual report and financial statement 2011/2012*. Nairobi: Author.

KPMG Peat Marwick (1990). *Changes in the progressivity of the federal tax system, 1980–1990* (Prepared for the Coalition against Regressive Taxation). Washington, DC.

Kenya Revenue Authority (2007). *Customs and domestic taxes*. Retrieved www.kra.go.ke.

Labandeira, X. and Rodriquez M. (2007). *Wide and narrow approaches in climate policies, the case of Spain* (Working Paper 39). FEDEA.

Leyaro, V. (2009). Commodity price changes and consumer welfare in Tanzania in the 1990s and 2000s. School of Economics, University of Nottingham.

Mas-Collel, A, Whinston, M.D and Green, J.R (1995). *Microeconomic theory*. New York/Oxford: Oxford University Press,.

Mekonen, A. and Köhlin, G. (2008). *Determinants of household fuel choice in major cities in Ethiopia*. Environment for Development Initiative and Resources for the Future.

Metcalf, G.E. (2007). *Using tax expenditures to achieve energy policy goals*. Cambridge: National Bureau of Economic Research.

Metcalf, G.E (2009). A distributional analysis of green tax reforms. *National Tax Journal* 52(4): 655-81.

Ministry of Energy (MOE) (2012). *Least cost power development plan (2011-2031)*. Retrieved http;//www.energy.go.ke or http://erc.go.ke

Musgrave, R.A. and Musgrave, P.B. (1989). *Public finance in theory and practice* (5th Ed.). McGraw-Hill.

Mutua, J. M, Börjesson M. and Sterner T. (2009). Transport choice, elasticity and distributional effects of fuel taxes in Kenya. In Lin H. L., Janet E. M., Hope A., Larry K. and Kurt D. (Eds). *Critical Issues in Environmental Taxation*, Vol. VII, Oxford University Press.

Mutua, J. M., Börjesson M. and Sterner T. (2012). Distributional effects of fuel taxes. In Sterner, T. (Ed). *Fuel taxes and the poor, the distributional effects of gasoline taxation and their implication on climate policy*. RFF Press Rutledge.

Ngui, D., Mutua, J.M., Osiolo, H., and Aligula, E. (2011). Household energy demand in Kenya: An application of the linear approximate almost ideal demand system (LA-AIDS). *Energy Policy*, 39(7084-7094).

Nikban, A. and Nakhaie, H. (2011). *Evaluation of consumers' welfare costs due to rise of energy carriers prices* (subject of study: Iran). 3rd International Conference on Information and Financial Engineering IPEDR, Vol.12. Singapore: IACSIT Press.

Nyang, F.O. (1999). *Household energy demand and environmental management in Kenya* (PhD Dissertation). Universiteit Van Amsterdam.

Nyang, F.O. and Mutua, J.M. (2011). *Meeting sectoral energy demand in Kenya: Issues and policy options*. Paper presented at the National Energy Conference, Nairobi-Kenya, 4-6 October.

Porteba J.M. (1991). Is the gasoline tax? *Tax Policy and the Economy*, Vol. 5. Bradford, Cambridge: MIT Press.

Portney, P.R., Parry, I.W.H., Gruenspecht, H.K and Winston, H. (2003), *The economics of fuel economy standards* (Resources for Future Discussion Paper 03-44). Washington, DC.

Sasia, J.O. (1987). *Demand for gasoline and light diesel in Kenya* (M.A Thesis). University of Nairobi.

Sherlock, M.F. and Crandall-Hollick, M.L. (2011). Energy tax policy: Issues in the 112th congress. *Congressional Research Service*, 7-5700

Simler, K. (2010). *Assessing welfare and impact of food and fuel price shocks*. Washington, DC: World Bank. Retrieved http://siteresources.worldbank.org/INTPOVERTY/Resources/WelfareImpact_PriceShocks.pdf.

Smith, A. (1957). *An inquiry into the nature and causes of the wealth of nations*. Modern Library (c) 1937, Random House, Inc. Retrieved http://www.marxists.org/reference/archive/smith-adam/works/wealth-of-nations/index.htm

Sterner, T. (2012). *Fuel taxes and the poor, the distributional effects of gasoline taxation and their implications for climate policy*. Washington DC: Resources for the Future Press.

Sterner, T. (2007). Fuel taxes: An important instrument for climate policy. *Energy Policy* 35 (2007) 3194-3202.

Stiglitz, J.E. (2003). *Economics of the public sector*. W.W Norton.

Suits, D. B. (1977). Measurement of tax progressivity. *The American Economic Review*. Vol. 67, No. 4 (Sep., 1977), pp. 747-752.

Twimukye, P. and Matovu, J.M. (2009). Macroeconomic and welfare consequences of high energy prices. *Economic Policy Research Centre (EPRC)*. Kampala. Retrieved http://ideas.repec.org/p/ags/eprcrs/54803.html

UNEP (2012). *50 by 50: Promoting global fuel efficiency: Summary of the key issues*. Nairobi: Author.

Varian, H.R. (1992). *Microeconomic analysis* (3rd Ed.). New York: W.W Norton and Company, Inc.

Weliwita, A., Nyange, D. and Tsujii, H. (2003). Food demand patterns in Tanzania: A censored regression analysis of micro data. *Sri Lankan Journal of Agricultural Economics*, 5: 1, 9 – 34.

West, S.E. (2004). Distributional effects of alternative vehicle pollution control policies. *Journal of Public Economics*, 88(2004) 735-757.

Wikipedia (2013). Pigovian Tax, Wikipedia, the free encyclopaedia. Retrieved en-wikipedia.org/wiki/pigoviantax.

Wolfram, C, Shelf, O. and Gertler, P. (2012). How will energy demand develop in the developing world? *The Journal of Economic Perspectives*, Vol. 26, No.1 (Winter 2012), pp. 119-138.

Wooldridge, J.M. (2001). *Econometric analysis of cross section panel data.* Massachusetts, London, England: The MIT Press.

World Bank (2003). *Household energy use in developing countries: A Multi country study* (ESMAP Technical Paper No. 042). Washington, DC: Author. Retrieved http://siteresources.worldbank.org/INTPSIA/Resources/490023-1120845825946/FuelUseMulticountryStudy_05.pdf

Ziramba, E., Kumo, W. and Akinboade, O.A. (2012). Economic instruments for environmental regulation in Africa: An analysis of the efficacy of fuel taxes for pollution control in South Africa. In Sterner, T. (Ed.). *Fuel taxes and the poor, the distributional effects of gasoline taxation and their implication on climate policy*. RFF Press & Rutledge.

APPENDIX I

Table A 1: Demand Model for Electricity by Location of Household

	Rural			Urban		
Variable	Coef.	Std. Err.	z	Coef.	Std. Err.	z
Log of electricity price	0.034	0.014	2.490**	-0.011	0.010	-1.160
Log of LPG price	0.007	0.004	1.800*	0.001	0.006	0.210
Log of PMS price	-0.015	0.010	-1.430	0.010	0.008	1.170
Log of AGO gas price	-0.004	0.005	-0.820	0.013	0.004	3.300**
Log of Kerosene price	-0.022	0.006	-3.770**	-0.013	0.007	-1.850*
Log of total expenditure	-0.110	0.009	-11.810**	-0.061	0.013	-4.750**
Household size	-0.008	0.002	-3.910**	-0.005	0.003	-1.500
Female	0.031	0.012	2.620**	-0.001	0.017	-0.070
Primary education	0.195	0.019	10.500**	0.318	0.027	12.000**
Secondary education	0.161	0.019	8.570**	0.251	0.022	11.470**
Vocational education	0.013	0.021	0.620	0.121	0.021	5.720**
Formal employment	-0.085	0.013	-6.700**	-0.096	0.018	-5.370**
Central	-0.179	0.197	-0.910	-0.066	0.029	-2.240**
Coast	-0.150	0.197	-0.760	0.016	0.029	0.540
Eastern	-0.118	0.197	-0.600	-0.001	0.029	-0.050
North Eastern	0.076	0.200	0.380	0.119	0.040	2.980**
Nyanza	-0.003	0.197	-0.010	0.130	0.027	4.900**
Rift Valley	-0.078	0.197	-0.400	0.039	0.025	1.550
Western	-0.011	0.197	-0.060	0.141	0.031	4.540**
Inverse mills for AGO	-0.118	0.149	-0.790	0.003	0.210	0.010
Constant	0.897	0.199	4.510**	0.424	0.044	9.540**

Source: Authors SUR estimations from the National Energy Survey, 2009

* Dependent variable is Electricity Budget Share; ** Indicates significance at 1% confidence interval;* Indicates significance at 5% confidence interval. *** n=2,407 and 1,247 for rural and urban, respectively.

Table A 2: Demand Model for LPG by Location of Household

	Rural			Urban		
Variable	Coef.	Std. Err.	z	Coef.	Std. Err.	z
Log of electricity price	0.007	0.004	1.800*	0.001	0.006	0.210
Log of LPG price	-0.050	0.015	-3.300**	-0.028	0.020	-1.390
Log of PMS price	0.033	0.011	3.120**	0.022	0.014	1.580
Log of AGO gas price	-0.003	0.006	-0.410	-0.026	0.008	-3.510**
Log of Kerosene price	0.012	0.005	2.250**	0.031	0.012	2.550**
Log of total expenditure	0.013	0.007	1.910**	-0.022	0.011	-1.940**
Household size	-0.002	0.001	-2.150**	-0.001	0.002	-0.410
Female	-0.004	0.004	-1.210	0.017	0.010	1.720*
Primary education	-0.037	0.017	-2.220**	-0.015	0.028	-0.530
Secondary education	-0.021	0.010	-2.110**	0.011	0.017	0.630
Vocational education	0.001	0.007	0.090	0.026	0.013	1.930**
Formal employment	0.023	0.008	3.040**	0.017	0.014	1.180
Central	-0.140	0.060	-2.360**	-0.017	0.019	-0.910
Coast	-0.169	0.060	-2.800**	-0.053	0.023	-2.260**
Eastern	-0.155	0.060	-2.590**	0.018	0.020	0.930
North Eastern	-0.164	0.061	-2.690**	-0.124	0.031	-4.030**
Nyanza	-0.139	0.059	-2.340**	0.022	0.018	1.240
Rift Valley	-0.167	0.060	-2.770**	0.018	0.021	0.850
Western	-0.152	0.060	-2.510**	0.000	0.025	0.010
Inverse mills for AGO	0.012	0.014	0.850	-0.034	0.023	-1.480
Constant	0.208	0.061	3.380**	0.183	0.037	5.020**

Source: Authors SUR estimations from the National Energy Survey 2009

* Dependent variable is LPG Budget Share; ** Indicates significance at 1% confidence interval;* Indicates significance at 5% confidence interval. *** n=2,407 and 1,247 for rural and urban, respectively.

Table A 3: Demand Model for Premium Motor Spirit by Location of Household

	Rural			Urban		
Variable	Coef.	Std. Err.	z	Coef.	Std. Err.	z
Log of electricity price	-0.015	0.010	-1.430	0.010	0.008	1.170
Log of LPG price	0.033	0.011	3.120**	0.022	0.014	1.580
Log of PMS price	0.066	0.073	0.890	-0.216	0.076	-2.850**
Log of AGO gas price	-0.095	0.072	-1.320	0.188	0.074	2.540**
Log of Kerosene price	0.011	0.007	1.450	-0.004	0.012	-0.310
Log of total expenditure	0.062	0.014	4.350**	0.031	0.018	1.710*
Household size	0.007	0.002	4.120**	0.003	0.003	0.890
Female	-0.016	0.009	-1.730*	0.005	0.014	0.360
Primary education	-0.153	0.027	-5.570**	-0.214	0.038	-5.620**
Secondary education	-0.132	0.024	-5.510**	-0.206	0.031	-6.720**
Vocational education	-0.020	0.019	-1.060	-0.116	0.020	-5.800**
Formal employment	0.062	0.013	4.660**	0.059	0.019	3.050**
Central	0.181	0.156	1.160	0.096	0.031	3.050**
Coast	0.113	0.156	0.720	0.070	0.025	2.810**
Eastern	0.152	0.155	0.980	-0.037	0.025	-1.480
North Eastern	0.020	0.158	0.130	0.108	0.035	3.040**
Nyanza	0.047	0.156	0.300	-0.045	0.027	-1.670*
Rift Valley	0.113	0.155	0.730	0.035	0.023	1.500
Western	0.063	0.156	0.410	-0.047	0.030	-1.540
Inverse mills for AGO	0.000	0.025	0.000	-0.059	0.036	-1.640
Constant	-0.105	0.163	-0.640	0.306	0.072	4.230**

Source: Authors SUR estimations from the National Energy Survey, 2009

* Dependent variable is PMS Budget Share; ** Indicates significance at 1% confidence interval;* Indicates significance at 5% confidence interval. *** n=2,407 and 1,247 for rural and urban, respectively.

Table A 4: Demand Model for Automotive Gas Oil by Location of Household

	Rural			Urban		
Variable	Coef.	Std. Err.	z	Coef.	Std. Err.	z
Log of electricity price	-0.004	0.005	-0.820	0.013	0.004	3.300**
Log of LPG price	-0.003	0.006	-0.410	-0.026	0.008	-3.510**
Log of PMS price	-0.095	0.072	-1.320	0.188	0.074	2.540**
Log of AGO gas price	0.088	0.072	1.220	-0.207	0.074	-2.810**
Log of Kerosene price	0.013	0.004	3.640**	0.033	0.006	5.270**
Log of total expenditure	0.060	0.007	8.490**	0.134	0.009	15.300**
Household size	0.004	0.001	5.220**	0.008	0.001	5.490**
Female	-0.008	0.004	-1.910**	0.000	0.007	-0.020
Primary education	-0.113	0.014	-8.390**	-0.293	0.019	-15.72**
Secondary education	-0.097	0.012	-8.330**	-0.256	0.015	-17.09**
Vocational education	-0.029	0.009	-3.380**	-0.128	0.010	-13.34**
Formal employment	0.042	0.006	6.550**	0.096	0.009	10.230**
Central	0.117	0.073	1.590	0.030	0.020	1.510
Coast	0.049	0.072	0.680	0.021	0.012	1.750*
Eastern	0.052	0.072	0.730	0.015	0.013	1.130
North Eastern	-0.023	0.073	-0.310	-0.070	0.017	-4.140**
Nyanza	-0.001	0.072	-0.020	-0.108	0.013	-8.250**
Rift Valley	0.059	0.072	0.820	-0.024	0.013	-1.830*
Western	-0.003	0.072	-0.040	-0.095	0.015	-6.500**
Inverse mills for AGO	0.045	0.013	3.540**	0.190	0.018	10.600**
Constant	-0.110	0.076	-1.430	-0.294	0.036	-8.100**

Source: Authors SUR estimations from the National Energy Survey 2009

* Dependent variable is AGO Budget Share; ** Indicates significance at 1% confidence interval;* Indicates significance at 5% confidence interval. *** n=2,407 and 1,247 for rural and urban, respectively.

APPENDIX II:

(AIIa) Methodology of the study

(Continued from Page 38 on the methodology of study)

Each expenditure share *w* of good *i* out of group expenditure *z* is independent of y_z and depend only on group prices. Generalising equation 2.7 to allow linear Engel (expenditure/income) curves with non-zero intercepts, expenditure on good *i* may be written as (See also KIPPRA, 2010; Ngui *et al*., 2011):

$$P_i x_i = \alpha_i(P_z)P_i + f_i(P_z)y_z \tag{2.8a}$$

Using Roy's identity, the indirect utility function representing the maximum utility attainable corresponding to given values of prices and income for group *z* take the form:

$$V_z = G_z\{[y_z - \alpha_z(P_z)]/\beta_z(P_z)\} \tag{2.8b}$$

where $\alpha_z(P_z) = \sum_i P_i\,\alpha_{zi}(P_z), \beta_z(P_z) = \sum_i P_i\,\beta_{zi}(P_z)$

G_z is some monotone increasing function. These preferences generally known as Gorman Polar form display quasi-homothetic (linear Engel curve) behaviour and do not imply unitary elasticities with respect to the total within group expenditure. Therefore, the cost of achieving a level of utility $U_z(q_z)$ follows (Baker *et al*., 1989: 723):

$$C(P_z, U_z) = \alpha(P_z) + \beta(P_z)U_z(q_z) \tag{2.8c}$$

where $\alpha(\cdot)$ and $\beta(\cdot)$ are both linear homogeneous concave functions of the vector of fuel prices P_z. Differentiating the cost function (2.11) with respect to price (Hicksian or compensated demand), and substituting the utility term U_z in the compensated demand function using the identity $C(\cdot) \equiv y_z$ gives the following Marshallian demand function:

$$x_i = \alpha_i(P_z) + f_i(P_z)\frac{[y_z - \alpha(P_z)]}{\beta(P_z)}\beta(P_z) \ \ for\ z = f, n$$

(2.8d)

where $\alpha_i(P_z)$ and $\beta_i(P_z)$ refer to the corresponding price derivatives of $\alpha(\cdot)$ and $\beta(\cdot)$, respectively.

According to Blundell (1988) the choice of functional form for the representation of consumer preferences must stand as one of the most important issues in any aspect of the empirical analysis of consumer behaviour. In this essay, the Price Independent Generalised Linear (PIGL) functional form suggested by Deaton and Muellbauer (1980) is chosen. In general, PIGL has an indirect utility function of the form (Ngui *et al*., 2011):

$$V = G_s\{(Y^{\alpha'} - \alpha(P)^{\alpha'})/\beta(P)^{\alpha'} - \alpha(P)^{\alpha'}\} \qquad (2.8e)$$

where $\alpha(P)$ and $\beta(P)$ are linear homogeneous, concave functions of prices. When $\alpha' = 1$, that is there is constant elasticity, the indirect utility equation 2.13 becomes quasi-homothetic and by appropriate choice of $\alpha(P)$ and $\beta(P)$ can be made to nest the popular Stone-Geary or Linear Expenditure System (LES) model. Note that the share equations corresponding to equation (2.13) are highly linear and to avoid this, Deaton and Muellbauer (1980) work with the logarithmic (PIGLOG) case in which $\alpha' > 0$.[14]

[14] However, by defining $P_i^* = {p_i}/{y}$ and expressing,

This formulation takes a specific functional form such that:

$$\ln \alpha(P) = \alpha_0 + \sum_{i=1}^{m} \alpha_j lnP_i + \frac{1}{2}\sum_i \sum_i \ln\left(y/\alpha(P)\right) \quad (2.8f)$$

and

$$\ln b(P) = \prod_j P_j^{\beta j} + \ln \alpha(P) \quad (2.8g)$$

AII (b) Methodology of study

Demonstration of SUR

The SUR is a generalisation of a linear regression model that consists of several regression equations, each having its own dependent variable and potentially different sets of exogenous explanatory variables. Each equation is a valid linear regression on its own and can be estimated separately. That is why the system is called seemingly unrelated. The SUR method is efficient and amounts to feasible generalised least squares with a specific form of the variance-covariance matrix. The SUR is summarised following exposition and formulations by Wooldridge (2001)

$$\boldsymbol{y_1} = X_1\beta_1 + u_1$$

$$a(P,) = [\sum_{ij} \theta_{ij} (p_i^* p_j^*)^{\alpha/2}]^{1/\alpha},$$

and β= $(P,) = [\prod_i p_i^{f \quad i(p)\alpha}]^{1/\alpha}$

where $\prod_i$ represents the product arguments indexed by I, the expenditure share equation take the form

$$\omega_i = \sum_i \theta_{ij} (p_i^* p_j^*)^{\alpha/2} + f_i(P)[1 - \sum_{ij} \theta_j (p_i^* p_i^*)^{\frac{\alpha}{2}}]$$

In this case, the non linearity appears simply through the a in the $(p_i^* p_j^*)^{\alpha/2}$ terms. A simple grid search over $a > 0$ can be used to choose α.

$$\boldsymbol{y_2} = X_2\beta_2 + u_2$$

$$\boldsymbol{y}_3 = X_3\beta_3 + u_3$$

$$\cdots$$

$$\boldsymbol{y_G} = X_G\beta_g + u_G$$

where X_g is $1 \boxtimes K_g$ and β_g is $K_g \boxtimes 1$, $g = 1,2 \ldots G$. The model assumes that X_g is the same for all g (in which case the β_g has the same dimension). However, the general model allows the elements and the dimension of X_g to vary across equations. The name SUR, therefore, comes from the fact that since each equation in the system has its own vectorβ_g, then the equations are unrelated. Nevertheless, correlation across the errors in different equations can provide links that can be exploited in estimation (Wooldridge,2001).

In this essay, the y represents the fuel budget share for each fuel, while X represents the exogenous variables such as fuel prices, demographic characteristics, expenditure and regional dummies. The above system of equations represents a structural model (without omitted variables, errors-in-variables, or simultaneity). However we can assume that:

$\mathrm{E}\ \mathrm{u_g}\ \mathrm{x_1}, \mathrm{x_2}, \ldots \mathrm{x_G}\ = 0$, for $\mathrm{g} = 1, \ldots, \mathrm{G}$

As has been outlined by (Wooldridge, 2001), $\mathrm{u_g}$ is uncorrelated with the explanatory variables in all equations, as well as all functions of these explanatory variables. This is an important assumption as it solves the problem of multicollinearity, therefore the random error has no effect on the dependent variable since $\mathrm{X_g}$ has been controlled for. That is:

$$E\ y_g\ x_1, x_2, ..x_G\ = E\ u_g\ x_g\ = x_g\beta_g, \quad g = 1, \dots, G.$$

The multivariate linear model for a random draw from the population can be expressed as

$$y_i = X_i\beta + u_i$$

where β is the $K \boxtimes 1$ parameter vector of interest and u_i is a $G \boxtimes 1$ vector of unobservable. The above quation explains the *G* variables $y_{i1} \dots \dots y_{iG}$ in terms of $X_i$and the unobservable u_i.

The SUR model can be expressed as the above equation by defining

$$\boldsymbol{y}_i = (y_{i1,} y_{i1,} \dots y_{iG})', \quad \boldsymbol{X}_i = \begin{matrix} x_{i1} & 0 & .. & .. & 0 \\ 0 & x_{i2} & & & 0 \\ 0 & 0 & & & \\ .. & & & & 0 \\ 0 & 0 & .. & .. & x_{iG} \end{matrix}, \quad \beta \begin{matrix} \beta_1 \\ \beta_2 \\ .. \\ .. \\ \beta_G \end{matrix}, \text{ and } \boldsymbol{u}_i =$$

$(u_{i1,} u_{i1,} \dots u_{iG})'$

Note that the dimension of X_i is $G \boxtimes (K_1 + K_1 + \dots + K_G)$. Following this formulation, we can define $K \equiv K_1 + \dots + K_G$. K is basically the number of fuels which in this essay are five; kerosene, electricity, LPG, PMS and AGO.