Draft report on the DFID KaR- Fuel Substitution Project

Historical Framework: Major Events that have affected Inter-Fuel Substitution in Kenya

(1960s to Present)

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1.0. General situation

Percentage market shares of different fuel supplies and end uses

Most of Kenya's energy needs are met from a relatively inefficient and unsustainable form of fuel in the form of fuel-wood and charcoal. Wood-fuel (fuel-wood and charcoal) provides 70% of Kenya's final national energy demand and more than 93% of rural household energy needs. Petroleum provides 21% of the total fuel needs, electricity 10% and coal 1%[1].

Energy users fall under several classes: residential, commercial, industrial, transportation and agricultural (Figure 1). According to Ministry of Energy in 1992, the household sector is the largest user of primary energy (58% of National primary energy)[2]. Rural households purchase a small amount or collect or barter labor for fuels while urban households depend almost entirely on purchased energy or generate it using solar panels or diesel generators.

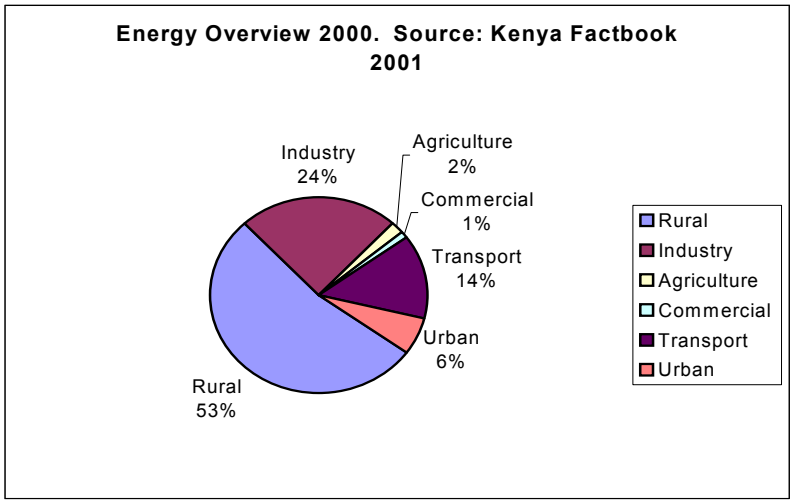

Figure 1. Energy Overview 2001

Although petroleum accounts for 21% of the energy consumed it meets 86% of modern sectors' energy needs (transport, commercial, industrial and agriculture sectors). Kenya imports all of its crude petroleum and exports some refined petroleum to its neighbors and other customers. Kerosene is the major petroleum byproduct used for household use and account for 1/10 of household energy use in developing countries.

Electricity and LPG account for 1/3 of total industrial and domestic uses. Kenya has increased its hydro-electric generation from 79.3 in 1963 to 493 megawatts in the year 2000. About 225 MW is produced from geothermal, thermal and diesel sources and imports 30 MW from Uganda. In April 2001 the World Bank advanced $100 million to Kenya government to reform and privatize the power sector. Between 1999 and 2000 there were serious power shortages resulting from prolonged droughts. To meet the increasing

[1] Kenya Fact-book 2001.
[2] MOE, 1992

demand in energy, the country's sources have increased their production capacities in the last 17 years as shown in the table below;

Table 1. Growth rate in various energy sources in the last fifteen years (1985 – 2000). Source:

	1985 (1000 tonnes)	2000 (1000 tonnes)	Growth rate
Fuel-wood	14,972	23,480	3.0
Wood for charcoal	8,754	17,513	4.7
Commercial wood	1,077	2,588	6.0
Biomass	1,112	2,177	4.5
Petroleum	2,080	3,821	4.1
Coal/Coke	97	180	4.2
Electricity (MW)	586	991	3.6
Electricity (KWh)	2480	6077	6.2

2.0. Historical changes in production, demand and supply of the various energy types

2.1. Traditional Fuels (production and consumption)

Traditional fuels also known as wood fuels (firewood and charcoal), form the basic source of energy on which about 77% of the Kenyan population depends on. A number of industries, service institutions e.g. hotels, schools, hospitals depend predominantly on wood fuel for cooking and heating. As of 1980, Kenyans were cutting trees at a rate that is higher than sustainable yields[3]. Figures extrapolated from 1983 Beijer Institute Study in Kenya indicates that the country's wood fuel deficit will double from 4.1 million m^3 p.a. in 2000 to 8.8 million m^3 p.a. by 2010[4] thus contributing to a serious wood-fuel deficit.

2.1.1. Charcoal

Production and demand

It is now estimated that 80% of wood fuel demand for urban households is met by charcoal. Charcoal is mainly produced from large woody plants especially trees found in woodlands, forests and on farm. The best charcoal both in quality and quantity is from the hardwood indigenous forest trees such as *Acacia mearnsii, A. abyssinica, A. gerardii, Petula* and *Combretum molle.* Between 1985 and 1994, about 350,000 cubic meters of wood-fuel were used from our forests alone[5].

From the 1950s to the late 1980s, charcoal was produced as a by-product of land clearing in the high potential areas, marginal lands and in large settlement schemes. The *shamba* system, which was used for forest plantation establishment and management together with EATEC were the major sources of charcoal to many cities up to 1986[6]. The winding up of EATEC is expected to significantly reduce the production of high quality charcoal from *Acacia mearnsii.* By 1988, it was estimated that the total charcoal consumption for Kenya was approximately 600,000 metric tones. Out of this, large urban consumers accounted for 35%, smaller urban consumers 29% and rural consumers 38%. At that time charcoal was relatively cheap. Ten years later, a survey done in the peri-urban areas on Nairobi showed that sometimes the price

[3] Hankins, 1989
[4] Hosier, 1984
[5] Theuri, 2000
[6] Bess, 1989.

of charcoal is higher than that of kerosene and firewood, making unaffordable to many households forcing many households to turn to cheaper sources of energy such as waste plastics, saw and charcoal dusts among others[7]. On-going studies by the International Forestry Resources and Institutions (IFRI) research team from the Kenya Forestry research Institute[8] also show that although charcoal seems cheaper where it is produced, most forest adjacent communities cannot afford it because of their low income levels. Consequently most communities use firewood for cooking and heating and only engage in charcoal production primarily for income purposes. From the foregoing, it is true to say that wood fuel will continue to provide a significant amount of the national energy needs for the foreseeable future[9].

Charcoal processing is regarded as a poor man's resort to earn cash income. Processing wood for charcoal is very tedious and wasteful. Currently charcoal processing especially in gazetted forests is risky because it is considered illegal. The approximate conversion of dry wood to charcoal is 25 – 30% by weight and 40 – 53% by volume[10]. In urban areas, use of wood-fuel is predominantly in form of charcoal rather than fire- (fuel)-wood. By 1981, fuel-wood and charcoal accounted for 71% of the country's total energy supply. By 1992, the rate of wood consumption was increasing at 3.6% while that of charcoal increased at 7% per year[11].

Attempts to assess the consumption rate have been difficult due to the unavailability of reliable data especially in the rural areas. In the case of charcoal, the estimate is based on statistical information of middle and low class population and the estimated per capita or per family consumption. According to the Ministry of Commerce and Industry, about 300,000 tons of charcoal is transported to Nairobi thus leaving an apparent deficit of about 410,000 tons per annum. Further, the forest Department estimates that about 170,000 tons of charcoal comes from unknown sources outside the economic radius of 70 miles within Nairobi.

Prior to 1990 exotic plantations and farm production used to meet 70% of the charcoal production and only 30% was met by depleting natural forests. Because of increased urbanization and increasing distance of wood resources, the demand for charcoal has been rising rapidly. This has in turn created a higher wood demand, coupled with the low average conversion efficiency from wood to charcoal, rarely exceeding 35% (Table 2).

Table 2. National wood fuel demand and supply

	Year		
	1990	1996	2000
Demand	30.3.	38.9	47.4.
Supply	20.8	20.8	16.7

Supply

The Forest Department (2000) estimates about 75% of charcoal come from outside gazetted forests (farmlands and other unknown sources) and less than 30% from natural forests. It is claimed that most of

[7] Njuguna, 1999.
[8] (Njuguna *et al* 2001, 1999, and *Ongugo et al* 2001).
[9] Mugo, 1999.
[10] Kiriinya and Kimondo 2000.
[11] Walubengo and Onyango, 1992.

Nairobi's woof fuel supply comes from North Eastern Province and Rift Valley Province and some from Central Province[12] and that there is a deficit of 54,000 tons.

The Ministry of Energy had projected that the annual consumption of fuel wood and charcoal was to grow at 4.5 and 7.4% respectively between 1995 and 2000. Because of the apparent deficit in wood fuel production, it is expected that there would be increased use of agricultural residues and animal manure for household energy use, which will result in decline in soil fertility and crop yields. In 1986, the *shamba* system of forest plantation establishment was banned together with felling of indigenous trees. This directive had a profound effect on fuel-wood and charcoal production, transportation and urban charcoal prices creating a huge a deficit of fuel wood and increasing illegal deforestation. At the time (1986) wood-fuel as both a commercial and non-commercial source of energy accounted for 75% of Kenya's total energy use. The effects of the ban are yet to be fully studied and quantified, although most timber based industries claim to be importing timber. The IFRI studies have also recorded massive timber and charcoal imports from the neighboring countries (Uganda and Tanzania).

2.2. Causes of wood fuel scarcity

Simply, the steady increase in demand for energy within an economic radius of 70 miles out of the city at a rate, does not match its replenishing rate. Following is a brief account of factors that have greatly contributed to wood fuel scarcity.

2.2.1. Demographics

Demographics influence wood-fuel consumption but not entirely because factors such as incomes, fuel prices and environmental factors among others also have an effect on wood fuel consumption. The Kenyan population more than doubled from 1963 to 1989 from 10.4 to 21.4 million. It is estimated that the population increased at a rate of 3.6 % per year between 1965 and 1983 and dropped to 2.5 % per year by 1993. Between 1965 and 1983 at an average annual population growth rate of 7.7%[13].

Table 3. Kenya's population growth (millions). Source: Kenya Fact book 2001.

1969	10.9
1979	15.3
1989	21.4
1999	28

Increase in population growth rate has meant increased need for energy, food, water and other resources. This rapid increase in demand for energy resources results to many energy related problems in urban areas. Other factors such as poor infrastructure and or inconsistent government policies, which also determine energy supply, do not give the consumers wider choices of fuel type to be used. Further other studies show that consumer behavior is affected by urban fuel policies, urban energy availability and socio-economic characteristics of the households (income distribution, level of education of household head, access to modern fuels and poverty, family size, improved stoves, availability of other fuels, occupation of household head, distance to nearest supply center (Market), cost of for instance, electricity connection and distance from the nearest connection unit)[14].

[12] Ministry of Energy, 2000.
[13] Kenya 2000 fact book pg 5.
[14] Nyang (1999)

Household Affordability of energy:
Household income strongly influences type of energy used and expenditures but not quantities. As household earn more money, they move from mixes of charcoal + kerosene to LPG and Electricity. Although wood fuels are primarily used in low-income households, they continue to be used even in very high-income households probably because they are more economically accessible. Also charcoal is usually used in many households for grilling and cooking foods that take long to cook. Low-income households spend a high proportion of their income (1/5 of their monthly income) on fuels (mainly wood), which are usually of low quality while high-income households spend 1/20 of their monthly income on fuel usually of high quality fuel.

2.2.2. Migration of people from rural to cities

Rural – urban migration has expanded the monetary economy in many urban areas. The estimated urban population growth rate averages 3-7% per year due high birth rates and extensive migration from rural areas to cities. Rural – urban migrations have influenced lifestyles, which in turn have influenced fuel substitutions. Between 1963 and 1993, the urbanized population increased from 2% to about 26%. The influx has seen more low income people move into the major cities with the net result of fuel switching from firewood to charcoal and sometimes kerosene depending on total household income. In cities demand for wood products is highly concentrated causing environmental problems such as excessive harvesting of trees around urban centers whose result is deforestation around cities. However this demand also creates economies of scale in the distribution of modern fuel around cities.

Urban characteristics that influence fuel substitution
City size and stage of urbanization
Most low- income earners are found in small towns (market centers) in Kenya. In such areas there is extensive use of wood because wood availability is high around the market centers (depending on regions). Wood costs less and there is less availability of modern fuels. Higher wood availability around such areas means more use of wood as a fuel in low income households but does not affect wood use in upper income groups. In such areas there is little incentive for people to switch to other fuels even though kerosene may be available once in a while.

On the other hand in bigger towns and the peri-urban areas of Nairobi and other district headquarters there are more people with intermediate levels of wood use. There are moderate levels of wood resources around the city, undeveloped fuel markets, and intermediate levels of household income. Wood energy prices are somehow below prices of modern fuels. Because fuel-wood use exceeds wood resources available, deforestation is common around the towns and consequently people begin to substitute fuel-wood for charcoal and kerosene. In such towns transport costs of modern fuels is higher and they also have smaller markets for them which consequently low mean sales thus discouraging traders. In large cities the demand for wood is enormous making local collection and distribution difficult, which raises the cost of wood fuels and is also unavailable. The differences urbanization of different cities directly influences market size and also penetrations rates for household fuels (Table 4).

Table 4. Penetration rates for household fuels in urban and rural households. Source: Nyang 1999

Fuel	Rural%	Urban%	National%
Kerosene	95.5	92.9	94.7

Firewood	98.7	22.7	73.8
Charcoal	40.4	92.1	57.2
Electricity	3.8	49.3	57.2
LPG	3.6	20.3	9
Agricultural	70.3	3.8	48.7

Like many big cities Nairobi has areas with low levels to high levels of wood use and developed modern fuel markets. Wood resources around the city are beginning to dwindle with the result that wood energy prices are sometimes competitive with the price of alternative modern fuels. In Nairobi, the situation is complex because of the big differences in income distribution. Nairobi ranges from the least urbanized (slums) to the most urbanized (very high income earners). The result is that most households use *fuel mixes* depending on income levels rather than switch out of one type completely. However, people in more urbanized areas switch out of charcoal and kerosene to LPG or electricity[15].

2.2.3. Socio-economic factors 1963 – late 1980s

Socio-economic factors such as increasing education levels and consequently income levels characterized the above period. Up to 1990, the Kenyan economy was growing well and people could easily get employment in cities. As more people graduate from the various educational institutions and move into the urban areas, there is increased household fuel demand and fuel switching from traditional fuels to kerosene, LPG and electricity. However, in the last 12 years (1990s to date) more people have switched back to traditional fuels as unemployment and retrenchments increase, reducing the capacities of many households to afford modern fuels.

2.3. World/Global energy changes

Global changes in energy production, distribution and prices and other environmental policies almost dictate the type of fuel that households can use. For example the amount and prices tagged on crude petroleum by the major world oil producing countries have a direct influence on economies of the countries that import oil. This also impacts directly on the currencies of the importing countries.

Indirectly, the current global trends of structural adjustments especially in Kenya will affect the production and consumption of traditional fuels (wood and charcoal) in various ways. Few personnel in many sectors mean that there will be a decrease in natural resource management practices, especially forestry activities. Rule enforcement has been drastically reduced giving way to increased and uncontrolled illegal exploitation of forest resources and increased environmental problems. Few extension agents in government ministries also mean that reduced on-farm technical back up will reduce opportunities for sustainable charcoal production and other services.

2.4. Changing and conflicting natural resource policies

Unstable and unclear policies in natural resource management have contributed greatly to the deterioration of many natural resources. Policies have been a hindrance to both production and conservation of energy in Kenya. Illegal, but politically tolerated land clearing activities for agricultural expansion and settlements provide up to 80% of the charcoal supplied in urban areas[16]. Whereas this has

[15] Nyang (1999).
[16] Schraum, 1987

in some cases alleviated charcoal and firewood shortages on a short-term basis, its effects in the long term are more difficult to address taking into account the massive environmental destruction that comes with it and consequently contributes to further fuel wood crisis.

Irregular excision of forest-land for human settlements and other development reasons is probably the best example of natural resource policy conflicts. Through excisions, Kenya's forest cover is reported to have decreased from the previous 3% by independence to the current 2% or less. In 2001, a further 167,000 hectares were proposed for excision for agricultural /settlement purposes. A clear policy on energy production, distribution and use is yet to be drawn.

2.5. Wood fuel Prices

Pricing of wood fuel is affected by the liberalizing of many sectors within the economy. The forest department increased firewood charges from Ksh 5 in 1960s, to the current Ksh 39, which allows household to collect a head-load of firewood per day per month. Increase in prices is justified by the current global trends such as increase in petroleum prices, which increases forest monitoring and protection costs among others. The current prices of wood fuel are unaffordable to the majority of the population. A recent report revealed that about 56% of the Kenyan population lives below poverty level (Daily Nation March 2002).

3.0. National biomass strategy in place to mitigate the environmental effects of charcoal/fuel wood use

Currently there is no government led strategy to mitigate against charcoal or fuel-wood use. Apart from the enacting the Environmental Management and Coordination Act, in the year 2000, – no specific measures have been taken to regulate the production of wood-fuel. The current forest bill is also not explicit on biomass energy production and conservation.

However there are a number of civil society and private initiatives led by the Kenya Forest Working Group, Traffic (Trade Related Analysis of flora and fauna in Commerce) and which have put in place a not so organized monitoring system for the flow of fuel wood and charcoal. These organizations are now advocating for the enactment of the Fuel-wood and Charcoal Act.

3.1. Improved Stove Programmes

Description of existing take-up of improved stove designs and programmes in place.

The vast majority of Kenya's population use three-stone hearths for cooking. For a long time, the most popular urban stove was the charcoal-burning traditional metal stove (TMS). The TMS is easy to fabricate from scrap metal and is very similar to the traditional charcoal-burning metal *sigiri* of Uganda or the all - metal *mbaula* of Malawi and Zambia (UNCHS, 1993). Under the auspices of MOERD, a USAID-funded project, the Kenya Renewable Energy Development Project (KREDP) embarked on an improved stove research and development project in 1982. It was under this project that the famous improved Kenya Ceramic Jiko (KCJ) was developed thus initiating the campaign for improved woodstove programs focusing on the needs of different sectors. The major focus was charcoal stoves for urban household, community stoves for large institutions and wood stoves for rural areas.

The KCJ is popular in many households in many urban households due to its high thermal efficiency and hence economical use of charcoal. By 1986 a total of 250,000 improved charcoal stoves had been produced and sold in urban areas. The same was not successful in rural homes because most people felt that Ksh 250 was too much. The fact that they did not have to buy wood did not also give them incentives to conserve it. The program was successful in urban areas largely because of the increasing fuel prices, static income levels and fuel wood shortages (Walubengo 1992). More energy saving stoves continues to be produced and sold in the major urban areas. The KCJ industry is now a relatively mature cottage industry and the level of specialization in the manufacture and level of mechanization of KCJ production and marketing has remarkably increased over the years. Mechanization has enhanced liner production to 3200 per month and the total production rate in Nairobi is approximately 13,800 stoves per month, which yields 165,000 stoves per year (UNCHS, 1993).

Despite the above success story of KCJ, recent research has raised concerns about the future of KCJ. A 1987 household survey carried out by KENGO indicated that KCJ was largely confined to the middle-class neighborhoods of Nairobi while penetration in lower income areas such as Kibera was a lot lower than anticipated (Joseph et al, 1990). Nine years later, it was estimated the penetration rate of the KCJ to be 54% in urban households that use charcoal and 32% in households that use charcoal, approximately 40% at the National level[17]. The overall penetration rate for Nairobi was estimated at 13% suggesting that the dissemination of KCJ is far from complete. Another major concern is decline in KCJ quality currently produced and marketed in Nairobi as shown by a study by ESD[18]. As the attention of NGOs, Government and research institutions on the KCJ is waning, stove producers are increasingly producing sub-standard stoves whose charcoal savings is about 24% as opposed to 30-50% as estimated in late 1980s[19]. This is resulting in considerable consumer anxiety. The study found out that in pursuit of higher profits and/or under duress of fierce competition, a number of stove producers are compromising on the amount and quality of vermiculite-cement and metal sheets used in KCJ, thus lowering their charcoal-saving potential and life-span. Therefore, quality control is urgently required as well as additional financial, R&D and policy support wider dissemination of KCJ particularly in peri-urban and rural areas of Kenya.

4 Modern Fuels

4.1. The Oil Crises

As earlier stated Kenya's energy needs are met by wood fuel (fuel wood and charcoal), which account for 70%. Petroleum provides 21% of the total fuel needs electricity 10% and coal 1%. Imported energy constitutes about 72% of the total commercial energy used, leaving 28% to be supplied by domestic sources. Petroleum provides 67% of industrial and commercial energy needs. Electricity is the second most important source of energy for commercial energy. The domestic end uses account for 59% of the total LPG used in the country. Commerce and industry accounts for 41%.

The hike in oil prices in 1975 and 1978 has been devastating in many developing countries[20]. The Kenya government decontrolled the prices of petroleum in 1994 and continues to levy high taxes on petroleum and petroleum products, which has almost excluded some income brackets from using them. The prices

[17] Nyang, (1999).
[18] ESD, (2000)
[19] Hankins, (1989)
[20] Hosier Richard, (1985).

for traditional fuels are relatively lower forcing most people to use more charcoal or wood. It has been observed that countries that tax energy are among the worlds' poorest.

4.1.1. Historical changes in the oil Industry

1963-1971 First oil deregulation. The white rule forbade the oil companies from importing refined petroleum products. This was largely to ensure supply of LPG and to protect commercial interest of oil refinery.

1973 to date Rural Electrification was introduced as a result of the desire to supply electricity to the rural agro-industries and other ventures due to the demand of rural population. However, only 3% of the rural areas have benefited from this scheme.

1971-1974 Introduction of price control. The government's view of excessive spending on advertising by oil companies. It was felt that savings resulting from reduced spending could be passed to consumers in form of lower petroleum prices. This reduced the profit margins of oil companies by increasing taxes with no corresponding increase in prices.

1994 Liberalisation of petroleum as part of market reform process, petroleum procurement, distribution and pricing was liberalised in an effort to create competition for petroleum products and improve energy supply.

1994 Deregulation of oil industry. The aim was to dismantle all government controls that hindered the free market system. Oil companies were now able to import refined products from the cheapest sources. Excessive importation of oil products meant reduction of cooking gas, which was experienced until 1998. Major companies have now installed LPG storage and handling facilities and are able to import the gas from various sources.

4.2. Energy conversion technology

4.2.1. Liquefied Petroleum Gas (LPG)

There are 5 major oil companies dealing in the LPG commodity. They include Total, Mobil, Caltex, Shell/BP and BOC gases. Total Kenya commands about 45% of the market while the rest is shared between other oil companies and BOC gases. In the year 2000, the oil refinery production of 34000 tonnes of LPG satisfied the country's consumption of 33000 tonnes.

Table 5. Summary of market shares for different distributors for Kerosene and LPG.

Firm	Total Petroleum Market share(%)	LPG Market share(%)	Kerosene Market share(%)
Total Kenya	19.1	45	21
Mobil oil	14.7	12	12
Caltex	16.7	10	22
Kenol/Kobil	18		25
Shell/BP	31.4	18	18
BOC Gases	0	5	

Small independent oil companies supply the balance of 2% market share for kerosene*

Key Locations of Distributors

* There is little documentation on the small independent oil companies.

LPG is marketed through multinational oil companies with various groups having their own designated cylinders of different sizes. The major oil companies concerned with LPG distribution have a network of service stations country- wide, which serve as focal points for LPG distribution. Up country consumers re-fill their gas through these outlets. In urban areas especially Nairobi, the companies have commissioned some agents to sell the gas/gas bottles in residential estates. Companies like Total Kenya has introduced LPG sales containers in the residential areas where consumers refill their containers.

Status of distributors i.e. recent changes e.g. sector expansion rate
Previously, LPG was distributed only through petrol stations. The major oil companies have in the past extended their retailing to supermarkets and other agents/independent distributors. They have intensified LPG marketing through media campaigns. LPG consumption has grown rapidly in the last one year estimated at 6% in urban areas.

Marketers really increased their sales due to power rationing that occurred in Kenya since 1999. Distributors had to ensure LPG was cheaply available to consumers by introducing smaller units for instance Total Kenya introduced 3Kg Baby Meko and Caltex had to come up with a 4Kg Nova cylinder. Use of the umbrella body of savings and credit organisations (KUSCO) as an outlet for distribution and sales of gas cyliders has also increased the market penetration.

4.2.2. LPG Consumers
LPG is used as fuel for cooking, heating and drying processes in domestic, industrial and agricultural sectors. Domestic supply of LPG is usually carried out in smaller sized cylinders, which are available from distributors who sometimes deliver to the doorsteps of households and swap cylinders. The supply is such that customers pay a one time only deposit for the cylinder and an amount for each refill of LPG.

Homes and restaurants usually bottled gas (in cylinders). Bulk consumers constitute industrial manufacturers (steel rolling mills, glass manufacturing etc), hotels and restaurants, schools and colleges.

Type and Status of Urban Consumers
There are LPG distributors in residential areas in urban centres. The ministry of Energy study on Kenya's energy demand and supply, 2001 estimates that 83% of LPG consumers in urban areas get their supplies from within a 5-km radius. Majority (71%) of these are LPG users of 12-15kg while 17% use 6kg and 11% use 3kg. The report reiterates that most of the small cylinder users represent new LPG users, most of which are in low income group and rural areas.

Drivers for switching of this fuel, including current price levels
Despite the huge demand for LPG in Kenya, several factors exists that hinder the wide spread use of a relatively safe and efficient fuel for domestic and commercial use.

- Pricing of LPG:- LPG is relatively expensive compared to other fuels. It is subject to import duty (Ksh.3.02/kg; VAT of 18% and a petroleum levy of KSh.0.15/kg). The present average price of LPG in Nairobi is KSh.81.60/kg. Prices vary according to retailers and distance from the supply source.
- Cost of equipment that allows LPG use: high initial costs of LPG appliances (cylinders and cookers) are out of reach for lower income groups. On their own, such equipment are not ordinarily expensive, but the modest use is in heavy taxation. For instance as at April 2001, 30% of the total cost of the simplest equipment comprised of direct taxation[21]. The introduction of small cylinders (3, 5, 6 kg) and

[21] The point, (2001)

inexpensive fix-on grills have made LPG more affordable to lower income consumers. These simple appliances have been made available on the market through credit arrangements with savings and credit co-operatives and other credit institutions.

- As an imported product, LPG is affected by international fluctuations of crude prices.
- Relatively low per capita demand makes the unit cost of supply and distribution high.
- Standardisation of Valves: LPG sector is devoid of competition because LPG companies compel consumers to purchase separate valves/regulators for gas cylinders. Due to different valves/regulators, the cylinders from different companies are not compatible with one another. Consumers are therefore unable compare prices and go for cheaper equipment. If the government imposed a standard valve it could act as regulatory mechanism geared towards enhancing competition.

4.2.3. Technologies Used in Energy Conversion

Cooking: - 12.5 kg gas cylinders, 6kg Meko cylinder and 3kg Meko (complete cooking unit i.e. cylinder, grill and burner)

Lighting:- A Lantern is used on both 3kg and 6kg cylinders. Two types of lanterns are normally used; the manual and automatic lanterns. A matchbox is required to light the manual lantern while the automatic lantern is self-starting i.e. you do not need a matchbox.

LPG cylinders (bottled gas consumers) are available in various sizes from 3, 4, 7 13-kg for domestic consumers. LPG for industrial and commercial use is supplied using cylinders of larger capacities i.e. 25kg and 50kg sizes to reduce the number of cylinders stored at customer's site. Bulk industrial consumers take up to 20 tonne tanks of LPG.

4.3. Kerosene

The price of kerosene is subsidized and has been kept low because it is used for cooking in urban areas or lighting in urban areas. LPG is not subsidized but its demand has continued to grow among the middle and high-income households. The major reasons for this include reduced cooking times, frequent meals, and changes in dietary patterns

Type and size of distributors

Like other petroleum -based fuels, Kerosene is marketed by multinational oil companies and by small private companies. It is mainly distributed as illuminating Kerosene or jet AI. Unlike other petroleum fuels, there are numerous kerosene retailers who buy kerosene for resell making the commodity easily available in both urban and rural areas.

Key locations of distributors

Over Five oil companies market Kerosene. Kerosene is mainly distributed through petrol stations countrywide, They are mainly located in urban areas where over 80% of the petrol stations are found. Resellers also buy kerosene from these stations and distribute them to rural areas or urban residential estates.

Status of distributors i.e. recent changes e.g. sector expansion rate

The distribution of kerosene as with other refined white oils is by pipeline from Mombasa to the major locations (Nairobi, Nakuru, Eldoret, and Kisumu). Kerosene is distributed from these points to retail outlets

(service stations) directly or to distributors through resellers appointed by the marketing companies to reach more remote consumers.

Demand for kerosene, which had recorded an increase of 27.8% in 1999 declined by 5.7% in 2000 to record 383.7 thousand tonnes from 406 thousand tonnes, recorded in 1999. This has been attributed to price increases and governments measure to limit kerosene use to adulterate petroleum products.

4.3.1. Kerosene Consumers

More than 94% of Kenyan population use kerosene, a figure that has significantly risen in the last one year as a result of power rationing of electricity. In rural and urban areas, 94.5% and 92.5% respectively of the population use kerosene for cooking and lighting.

Type and status of urban consumers

Urban consumers of kerosene vary with income i.e. 97. % and 88% for low and medium class use kerosene. About 46% of the highest income group use kerosene. The study estimates kerosene consumption in urban areas to be more than double the rural areas i.e. households in urban consume average of 90 litters/year compared with 40.58 litters/year in rural areas. Per capita consumption is an average of 15.87 litres with urban areas consuming 23.16 litres and the rural population 8.58 litres/year.

Drivers for switching of this fuel, including current price levels

- Kerosene enjoys an indirect subsidy making it relatively cheap thus encouraging more people to use it.
- Retailing of kerosene leads to very high mark ups resulting into rise in prices. Demand is constrained by transport cost and inefficient distribution. Current Retail Prices for kerosene is Ksh.34 up from Ksh.22.21 in 1998.
- Kerosene appliances are relatively inexpensive and within means of most low-income consumers.
- Kerosene as a fuel is convenient and relatively safe to handle.

4.4. Technologies used in energy conversion

88% of population use Kerosene for lighting with various units - Lanterns 64%, tin lamps 32% and pressure lamps 3.8%. Domestic cooking accounts for 31% with 36% using it on the simple cooking stoves.

4.5. Availability of main resources for different modern fuels

Kenya has a great potential for modern fuels, ranging from solar, wind, geothermal, thermal, micro hydros etc.

- Solar energy is proving to be very popular and appears to be an attractive option, especially where national grid is not possible. There is an active commercial market for solar home systems with average annual installations of 20,000 units. The PV industry is worth over US $6 million per year and there are hundreds of PV businesses in terms of manufacturers, vendors, installers and after-sale providers that respond to this market.
- Wind - Kenya has good potential sites, suitable for wind generators and windmills. Studies have shown the country has a mean wind speed of 3.0ms^{-1} with many locations exceeding wind speed[22] of 4.0ms^{-1}, much significance to wind power utilisation. Besides these, there are

[22] Oludhe, C. Wind : A promising energy alternative for power generation. an article in The Solarnet. Vol.1, No. 1 January - April 1999.

reputable Kenyan companies that import and install small wind generators suitable for stand-alone home power requirements.

- Oil exploration. No commercially oil reserves have been found but there is intensified exploration.
- Geothermal. The best prospective areas for geothermal areas are situated along the Kenya Rift valley that extends from the Ethiopian border in the North to the Tanzanian border in the South, some 750km long and on average 60 - 70km wide[23]. About 20 geothermal resource areas have been identified although much exploration has taken place on only two sites, Olkaria and Eburu. Kenya currently produces over 0.4bkwh of geothermal power, about 10% of the total output. The Ministry of Energy estimates that Kenya has a potential for over 2,000mw of installed capacity of geothermal electricity, second only to New Zealand[24]
- There are plans to generate power of up to 22 mw of bagasse power.
- Other potentials include biogas, micro hydro power, waste to energy, ethanol and coal. There is a growing interest in developing nuclear energy as a possible source of energy for the future.

4.6. Electricity

The persistent drought experienced in 1999 - 2000, coupled with lack of adequate investment, has severely affected power generation in the country. The government of Kenya has encouraged private sector participation in power generation, promotion of intra and inter-regional power trade, implementation of committed generation plants e.g. diesels (Kipevu II and Fast track), geothermal (Olkaria II, III) and Sondu miriu hydro.

4.6.1. Major events

1999 - 2001 Power Rationing - Failure of rains for 3 consecutive seasons and high dependence on hydropower led the government to ration an average of 128GWh* power countrywide. Use of electricity dropped by 9.9%. Tariffs for electricity went up i.e. at 13* US cents per unit). Most consumers switched to other fuels like LPG and Kerosene. Most urban households for alternative lighting used candles. Commercial consumers switched to diesel powered engines (which attracted less taxation)

4.6.2. Electricity producer(s)

The key players in Kenya's electricity sub-sector include;

- Kenya Electricity Generating company limited (KenGen) and private producers (Independent power producers and emergency power producers) on the generation side;
- Kenya power and lighting company limited (KPLC) as a monopoly transmitting and distributing power.

After liberalisation and restructuring, KenGen took over all the generation assets formerly owned and operated by KPLC, which include hydro, geothermal and thermal plants as well as wind turbines.

KenGen produces 90% of the electric power transmitted and distributed by KPLC. Independent power producers (IPPs) produce 10% of the electric sold by KPLC[25]. IPPs include;

- Ibera-Africa Power (Kenya) ltd- Operates a diesel plant in Nairobi (56 MW)

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[23] Theuri, (1999)

[24] http:www.eia.doe.gov/emeu/cabs/eafrica.html.

* ESI Africa 1 2001 - Kenya turns the corner in battle to meet electricity demand.

* Daily Nation, 10th September 2001- Manufactures association opposes new electricity company plan

[25] Nyang', (2000)

- Westmont Power (Kenya) limited - operates a gas turbine plant in Mombasa (44 MW)
- Ormat power - based at Olkaria generates about 64 MW and is the first to develop a geothermal plant.
- Tsavo Power company - currently developing a 74 MW diesel plant in Mombasa.

The emergency power producers are Aggreko PLC (45mw), Cummini power (30mw) and Dentz (30 MW). Kenya also imports electricity (30mw per year) from Uganda. The total power generation mix consists of hydropower (64.4%installed), thermal (11.7%), geothermal (5.8%), gas turbine (7.7%) diesel (10.5%) of the interconnected system totalling to 1048mw and 908mw of installed and effective capacity (KenGen)

Figure 2. Key locations and status of electricity producers. Source: ESI Africa 2001.

Power generated from hydro energy currently forms 70% of the total electricity output. The KenGen's hydropower stations have a total installed capacity of 601.2MW. The power stations comprise the Seven Forks hydro stations, 7 Mini hydro stations and Turkwel hydro project (Figure 2).

4.6.3. Electricity Consumers

The 1999 census estimates the number of household using electricity to be 6.4 million. The end use market is divided into five consumer category: domestic, small commercial/off pick (water heating, irrigation and pumping); large commercial; industrial and street lighting. The most important market segments in urban areas are large commercial, industrial, domestic and small commercial. At household level, electricity is used for lighting (98%), entertainment e.g. televisions, radios (10.8%), ironing (8.4%), refrigeration (4.2%), heating water (2.6%), domestic cooking (2.4%), home businesses (2.0%) and house

heating (1%). In the urban areas, 45% of household use electricity. Although a high percentage of urban households use electricity (45%), 89% of the high and the middle income households are connected to electricity. Only 20% of the urban poor households have access to electricity.

Drivers for switching of this source, including current price levels
Electricity remains an expensive source of energy and would still be out of reach for many urban low-income families and majority of rural population (regardless of economic status). It is estimated the connection fee without government subsidy is between Kshs.20,000 - Kshs.200,000 per household depending on the load factor and distance from the mains. At least Kshs.1,000,000 is required to install a one-kilometre electrical transmission line. Also the price of electricity consists of too many taxes and therefore becomes expensive for households and small businesses.

Electrical appliances attracts high taxes and thus costly for many households. It is expensive to power some of the appliances using electricity. The local sources of electricity require high cost of capital investment due to importation, thus the marginal cost of electricity is not likely to go down. There is unmet demand of 25% of electricity i.e. the gross generation is 4500 GWH while the total demand is 6000 GWH

5.0. Other fuels

5.1. Wind

Wind energy has been used in Kenya for water pumping purposes since the beginning of the last century[26]. The use of wind gradually diminished in the fifties and sixties as fossil fuels for agriculture became subsidised in Kenya.

Currently, the country has three wind turbines two rated at 0.4 mw connected to the grid while the third turbine is running in hybrid with a diesel system for a remote town in Northern Kenya. About 320 farm type windmills are used for water lifting.

Distribution **-** Three large scale wind generators for grid connection has been imported in Kenya. Ministry of Energy and KPLC installed a hybrid wind/diesel system in Marsabit and a two-mill wind farm at 400kw at Ngong. There are a number of organisations that have attempted to design, develop and commercially manufacture wind pumps that would be cheap and competitive.
These include

- Bobs Harries engineering - manufactures kijito wind pumps
- Pwani fabricators in Mombasa - produce climax design mainly suitable for use in coast regions
- UNIDO /KIE and the Mbita mission hills produce wind mills for areas around lake Victoria region
- University of Nairobi, NCCK/ Christian industrial training centre.

Factors for switching

- Lack of appropriate technology and effective promotion strategies
- The capital costs of wind pumps are prohibitive.

5.2. Solar

Kenya has a great potential for use of solar energy throughout the year. Despite this potential, the current contribution of solar energy is minimal with only 1.2% of households using it for lighting. Use of solar is

[26] Theuri, (1999)

fairly restricted to sun drying of crop harvest and power supply to electronic gadgets using thermal collector cells.

There are over 150,000 systems in place (1999 figures). Of those using Solar, 69% use Photovoltaic panels with power rating 12-15 watts at a cost of Kshs.10,000-20,000. Solar for water heating in urban areas is relatively un popular because of cost and lack of awareness in households.

Distributors - a number of organisations have been involved in the importation, distribution and maintenance of solar system.

5.3. Conclusions

From the foregoing it is clear that households use more than one fuel type. Many households prefer to use fuel mixes as summarized in the table below;

Table 6. Proportion of households using various fuel mixes. Source: Nyang 1999:

Proportion of HHs in Kenya using various fuels mixes

Fuel Mix	Rural %	Urban %	National* %
1. Kerosine + firewood	50.8	2.5	35.1
2. Kerosine + Charcoal + firewood	38.8	13.6	30.6
3. Kerosine + Charcoal	0.4	29.6	9.9
4. Electricity + Kerosine + Charcoal	0.4	24.4	8.2
5. Elect. + lpg + Keros. + Charcoal	0	10.4	3.4
6. Electricity + Lpg + Charcoal	0	2.7	0.9
7. Electricity + Charcoal	0	2.7	0.9
8. Other mixes	9.6	14.1	11

* Weighted National Means

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