Title:
ENERGY DEMAND AND CONSERVATION IN KENYA: INITIAL APPRAISAL

Author:
Schipper, Lee

Publication Date:
03-13-2013

Publication Info:
Electric Power Research Institute Workshop on Energy and the Developing Nations , Hoover Insitution, Stanford University, March 19, 1980

Permalink:
http://escholarship.org/uc/item/3dm3k3pt

Local Identifier:
LBNL Paper LBL-10538

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

ENERGY & ENVIRONMENT DIVISION

Presented at the Electric Power Research Institute Workshop on Energy and the Developing Nations, Hoover Institution, Stanford University, March 19, 1980

ENERGY DEMAND AND CONSERVATION IN KENYA: INITIAL APPRAISAL

Lee Schipper

March 1980

Prepared for the U.S. Department of Energy under Contract W-7405-ENG-48

LBL-10538

Energy Demand and Conservation in Kenya: Initial Appraisal

Lee Schipper
Beijer Institute of Energy and Human Ecology, Stockholm

and

Lawrence Berkeley Laboratory
University of California
Berkeley, California

Revised for Electric Power Research Institute
Workshop on Energy and the Developing Nations
Hoover Institution, Stanford University

March 1980

Based upon an earlier work, "Energy Demand and Conservation in Kenya," by L. Schipper and O. Mbeche, presented at the conference "Energy and Environment in East Africa," Nairobi, May 5-11, 1979. This work was sponsored by the Beijer Institute, Stockholm, and was initiated when the author was a guest researcher at the Royal Swedish Academy of Sciences. Support from the Energy Information Administration of DOE through the Lawrence Berkeley Laboratory is also acknowledged.

In this brief paper we report on ongoing research into the use and conservation of energy in Kenya. We present a partial accounting of energy use in Kenya, and discuss evidence that some energy conservation has been taking place. A fuller accounting for all commercial energy flows is both possible and desirable. The work presented herein should serve as a basis for further data collection and analysis in Kenya, and can be used as a model for similar efforts in other countries. We intend to continue much of this energy accounting in Kenya in the latter half of 1980.

I Introduction

The Kenya Bureau of Statistics has supplied the International Energy Agency with vital data on the supplies of energy during the past 14 years. Missing from these data, but discussed by other researchers (1) is information on non-commercial fuels: Wood and charcoal, dung, waste paper, agricultural wastes, and even solar energy. We have been able to estimate part of the impact of the use of solar energy in Kenya, and do so below in discussing end use of energy. The rough energy supply balance for Kenya is shown in Table 1.

The demand for energy has been heretofore studied only in the aggregate. It is clear, for example, that a country like Kenya uses very little space heating, and under certain circumstances, need not indulge very heavily in air conditioning except at the coast. Other end use demands can be roughly estimated from known output of the East African Oil Refinery (EAOR) as well as net imports of oil products. Electric power production is controlled principally by the East African Power and Light Company, and aggregated data on sales have always been generally available.

In this research, however, we take a more detailed approach to accounting for energy end uses. Following earlier work (Schipper and Lichtenberg, 1976), we disaggregate important energy end uses into various economic or physical activity levels (miles driven, tons produced, households) and into energy intensities (joules/mile, joules/ton, kWh/household). To do this is to pay particular attention to the economic and demographic structure of the country: How many autos are there, and how far are they driven? How much steel is produced by individual plants, at what energy intensity? How many people visit a given hotel in a given year? In this way we can relate energy demands to specific economic activities that are often directly related to the degree of economic development in Kenya, particularly in the cities.

Why should developing countries worry about energy efficiency and conservation? It is often argued that their per capita use among those people and institutions actually coupled to the market economy is so little, that there is literally nothing to conserve. We found the opposite to be the case. Many factory managers and buildings experts were concerned about the cost of energy. Government officials and oil company planners as well were worried about the cost to Kenya of importing increasing amounts of increasingly expensive oil. Ironically the EAOR was a profitable earner of export dollars before the embargo, since a large portion of the crude refined there was reexported, the profits paying for the net outflow of hard currency to buy all the crude. The Oil Embargo and subsequent price rise changed that situation.

The other important concern voiced in Kenya is over the commercial non-commercial interface among energy supplies. Most world statistics only count commercially-sold energy, particularly that used in activities that are accounted for in the nominal GNP. Of course, there is intense competition among these two kinds of energy sources--deforestation and high cost charcoal may make commercial gas cylinders or solar cooking the only viable option for rural families who cook; low cost commercially sold wood replaced oil (until recently) in one of the manufacturing firms we visited; bark could serve as a firing fuel for the paper mill except that it proved to be cheaper in the past to debark trees where they were cut, by hand, and leave the residue behind. Oil is used instead to raise steam at the mill.

Ultimately, then, there is much interaction and potential substitution among commercial and non-commercial or renewable energy sources. The problem is just that the average Kenyan, whether rural or urban, has little income with which to buy equipment that would make electric or gas cooking possible; has little choice in how efficient higher cost wood is turned into charcoal, and must interact with a market economy that is more or less dependent upon the inflow of commercial imported oil for its health. Better understanding of the efficiency of end use energy in Kenya, and recognition of the many ways in which commercial and non-commercial energy sources, efficiently deployed, could complement each other, may be the key to Kenya's energy future. For as oil prices rise, internationally, Kenya, like the countries of the OECD, may find that as all other energy sources are also rising in cost the most effective weapon against these costs remains energy conservation, the effective use of all forms of energy.

In addition to officially published statistics, we relied on a certain number of key institutions for data. Oil companies, the Eastern African Power and Light (EAPL), architectural engineering firms, industrial plant engineers who were interviewed, producers of solar heating equipment, and transportation experts all provided data, which we reference whenever possible (and not proprietary). Our interviews led us to discuss energy use with fifteen of the largest industrial firms in Kenya, representing production of steel, paper, cement, foodstuffs, beer, trucks, tires, and energy itself--the oil refinery and the Kenya Pipeline.

II End Use Analysis

II.A Industrial Energy Use

There exists to date no detailed surveys by firm or product of industrial energy use in Kenya. However, we found very quickly that the requisite data exist, given the relatively small number of firms listed in the Directory of Industries (1974 and 1977 editions). We did not have time to survey electricity and fuel use of each type of producer, but were able to sample data from individual firms, oil companies, and East African Power and Light. Finally, we conducted on-site interviews with engineers responsible for heat and power in over a dozen important firms. Eventually we plan to completely classify energy use in Kenyan industries, and measure energy intensities, and thereby the potential for increased energy efficiency in industry.

The outlook for conservation was mixed. We found one firm where the engineers complained that no one would spend a small amount to fix obvious leaks, improve boiler efficiency, or "optimize" a process, even if the proceeds for such investments were large. An engineer at a metal processing firm told us he was happy if the equipment would simply work at start-up.

On the other hand, a major tire manufacturer pointed out that their factory had reduced energy intensities, taking part in a world wide competition among other firms owned by the same parent company. A manufacture of food and household items (like detergents) has just hired an engineer who plans to make important process modifications to reduce energy use; in addition this firm is eliminating the use of firewood. Firewood to them was cheaper than oil, while scarce to rural people who can't use oil anyway. Government policy now aims to conserve wood for uses other than process heat.

Included in the section on industry is the Kenya Oil Pipeline, which supplies the Nairobi area from Mombassa with around 1.2 million tons of oil each year. We give data on pumping energy consumed per cubic meter of oil pumped in Table 2. Additionally, we estimate the amount of fuel required to haul a ton of oil uphill from Mombassa to Nairobi, and return the empty lorry. Using data from a report from the Oak Ridge National Laboratory we estimate the energy intensity of tanker transport from U.S. data to be around 2000 BTU/ton mile (certainly a lower limit for Kenya);* using a round trip of 500 miles, we found that the consumption of oil for this mode was around 20 times greater than the consumption of electricity for pumping a given quantity of oil. Moreover, the presence of tankers on the road and apparently serious problems for the road surface. While the pipeline certainly has impacts that we have overlooked, these environmental and energy advantages cannot be dismissed.

What of the tanker drivers who might now be unemployed? This is a problem that surfaces in every country as energy development proceeds. However, one of us (LS) observed a yard in Mombassa where the tanks were being removed from tankers that were then converted to flatbed trucks. This suggests that the impacts of energy development can be mitigated, given time and careful planning. The re-emergence of Uganda as a potentially friendly nation and user of EAOR products increases greatly the prospects for the northwest extension of the pipeline; road interests support this as a way of clearing up traffic--and potholes--on the vital route from Nairobi to Kampala.

Table 2 gives an overview of energy intensities in key firms. For some several years data or comparative figures from other parts of the world are given. The EAOR increased its size after 1973 but did not increase output. Consequently efficiency fell. A conservation program gained back some of these losses. As output increases the energy intensity will fall again. Given the rapid pace of growth of industry in Kenya, we expect to see new technologies in other industries that will allow output to increase considerably faster than energy use, particularly as energy prices rise.

---

*Other estimates compiled by O. Mbeche from information of transportation companies in Kenya put the cost much higher.

II.B Commercial Buildings

Commercial buildings include many kinds of enterprises; the most important for Kenya are public services (schools, hospitals), hotels and restaurants, office buildings (including government) and stores. Most of these are classified under the old EAPL tariff system into Tariff 3 and 4. Similarly some of the classes of users are broken out from the overall oil company data; where possible we indicate (Table 3) how much total energy goes to various sectors.

We have gone further by using estimates of building energy use for key kinds of buildings; major hotels, office buildings, schools, hospitals. Some of these buildings are described in Table 4. In the case of one major hotel, we found that overall electric power use per guest per year had been decreased substantially from 1976 to 1978, in part due to the recent initiation of a conservation campaign.

On the other hand, energy use in large structures in Kenya depends critically on the building shell design. Most, but not all, of the new office buildings in Nairobi, for example, exhibit elaborate systems of shading to keep direct sunlight off the windows. Energy conserving buildings have their axes oriented east-west, with few windows on the east-west ends and shading on the north-south sides. This design maximizes free (day) light, minimizes cooling needs (if any) and only sometimes requires the use of small electric heaters in some rooms during cold months. We have not yet surveyed lighting levels in offices but we found no evidence of the overlighting common in the U.S.

II.C Homes

Commercial energy use in the residential sector is characterized by extreme concentration into a small fraction of all households. As the figures in Table 5 suggest, only 6% of the population in Nariobi, and less elsewhere, was "connected" to the EAPL grid. Complementing this picture is the relatively minor but growing use of kerosene for lighting and cooking and for somewhat greater use of gas cylinders. For cooking the majority of Kenyans, of course, use charcoal for firewood for domestic purposes. Openshaw (in 1) estimates this as great as 5 times the sum of all commercial energy use!

We have been able to break down electricity use further, using data from EAPL. The largest residential consumers register their hot-water electricity consumption on a special tariff (with an electronic signal interrupter). In 1976 there were 27,000 hot water customers, 51,000 regular residential customers (including the hot water) and 56,000 customers using very little electricity, most living in rural areas or in low-income estates. Typical figures for consumption in these groups are given in Table 6. It should be noted that the designated income group for each housing tract does not always reflect the incomes of the people who actually live there, due to subleasing. Similarly figures of wealthy households include use of energy in servants' quarters.

What is missing from this electricity use picture is the complementary use of fuels. While electric cooking probably dominates in those homes with Tariff 1 or 6, it is clearly absent from those on Tariff 2, charcoal or in some cases gas being more important. One house we visited had switched from gas to charcoal since the gas stove exploded. We obtained estimates of country wide kerosene and LPG consumption from Kenya Shell. This estimate includes sales of small lots of packaged kerosene and bulk kerosene sold for resale, as well as lots of small gas cylinders. We may have overestimated consumption in the residential sector of these two fuels since small stores or restaurants may use small quantities of these fuels as well.

The prospects for solar water heating in Kenya are bright. We examined the records of one of the major assemblers and suppliers of solar water heaters. Using an estimate of 2000 M^2 of collector he has installed thus far, each M^2 providing about 9000 BTU/day of hot water, we find that installed residential and commercial hot water systems save Kenya about 1.5×10^6 kWh/yr that would have been required in the form of electricity (more if gas or oil) for heating this water. Moreover, a great deal of this electricity would be under normal commercial tariff, being used in schools or hospitals. The total investment cost for these collectors has been approximately 3×10^6 KS. If normal tariff electricity cost 50 K-cents/kWh in 1979, then the yearly savings to Kenya from this investment is approximately 750,000 KS.* The manufacturer we interviewed pointed out that business was booming, and provided us with the examples of new projects (a school, a hospital, a condominium) that he expected to complete soon. (Table 7).

Competing with commercially sold energy, as we pointed out above, is the use of wood, charcoal, and other renewable fuels for cooking and possibly water heating. Unlike electricity, these fuels (and gas cylinders) are available in the rural regions; thus the choice between them and electricity tends to be biased because of the cost of electrifying villages. That is, both non-commercial fuels _and_ electricity (or gas plus the necessary stove) are _scarce resources,_ if for different reasons. This means that the choice between them, if there is to be a policy favoring one or the other, is difficult. However, sales of kerosene by the largest oil company have increased much over the past few years, suggesting that the scarcity of charcoal is indeed putting pressure on use of commercial fuels. **

II.D Transportation

Statistics on transportation are often well known in the aggregate, because motor vehicles are registered, traffic is often surveyed, and most motor fuels are taxed in one way or another. On the other hand there are many ways in which sales of fuels do not correspond uniquely to one class of vehicles, or where types of vehicles may provide two kinds of service. Light Diesel fuel, called Gasoil, can fuel automobiles or light trucks; heavy diesel fuel can fuel trucks, railway, or some busses. Matatus usually run on motor gasoline, but ordinary trucks

---

*This calculation assumes no standby losses for either system. We count only the hot water actually made available by solar systems. If all this were produced from the low cost interruptible tariff the savings would be considerably less, on the order of 300,000 /year. Either way the rate of return is greater than 10%.

** D. French, USAID, points out that the increase in commercial fuel use may also be a result of higher incomes.

can be used as matatus. Thus it is difficult to assign fuel use to specific tasks, and therefore difficult to analyze the fuel efficiency of each vehicle or service.

Nevertheless we give the breakdown of fuels used for transportation, and their end uses, in Table 1. In Table 7a we present another view of transportation, the share of vehicles in each class and the share of vehicle miles in each class as estimated from actual road surveys.* In general the following rules apply relating vehicle type to fuel:

Private Cars - Up to nine-passenger vehicles except Landrovers and minibusses: Using premium fuel

Medium Commercial Vehicles - Two-axled goods vehicles weighing more than 1524 KG with more than one tire in each axle: Regular fuel

Light Commercial - As above, but less than 1525 KG: Regular fuel

Heavy Commercial - More than two axles: Using diesel fuel

Bus - Other passenger vehicles including minibusses, including dual purpose vehicles: Using diesel fuel (except matatus)

Note that the share of vehicles in each class roughly corresponds to the share of vehicle miles in each class. That commercially motivated vehicle miles exceed that classification's share of vehicles, when compared with private vehicles is not surprising; owners of capital, such as vehicles, try to maximize the utilization of their often substantial investments. On the other hand, most developed countries reveal clear patterns of growth: use of private automobiles rises somewhat faster to much faster than private incomes, while use of commercial vehicles, particularly for freight, tends to scale only with total output. Armed

---

*These figures do not truly represent vehicle miles, but we use them as a proxy for the rough division of traffic into various classes or modes.

with more detailed fuel sales statistics we could closely couple fuel and efficiency to transportation services.

Now we couple to the greatest extent possible the use of energy to the activities of transportation. In Table 7b some of these relationships are shown. First we show the number of passengers actually embarking from Nairobi International Airport for international destinations, and the amount of fuel loaded there. While this measure of efficiency, fuel use per passenger, is crude, its decrease over a period when additional transcontinental flights from Europe and Africa were being added to schedules, thus lengthening the average trip away from Nairobi, suggests conservation. In fact, the 1973-77 era saw the replacement of most narrow bodied aircraft by jumbo-jets and an increase in charter flights from Europe. These changes increase energy efficiency. On the other hand, emergency conditions often dictate that planes cannot take on a full load of fuel in Nairobi, but must bring in fuel. Therefore our figures must be seen as provisional until surveys are arranged to show the exact amount of fuel used in Kenya to transport a passenger--whether a Kenyan or a tourist returning home--to an overseas destination.

In the case of private autos, we give amounts of gasoline sold to autos as well as the number of autos registered. This gives an approximate measure of intensity of use, though not efficiency, since we have not obtained data on actual miles traveled, nor on auto weight or load factor. Moreover, we suspect that a few surveys among auto dealers, registration statistics, and fuel sales records would reveal many of these measures. We hardly need to point out the phenomenal growth in the ownership of autos.

Finally we give a measure of the use of trucks and buses in the Table, showing also fuel used. Here we take the sales of gasoil as reported by Kenya Shell, since the official statistical abstract lists "light diesel fuel" that is also used for some stationary applications. We give this figure separately but warn against any strict interpretation of these figures.

There are other important uses of fuel that we have not covered here but show in Table 1. Among those are inland and overseas shipping, passenger and freight rail, busses, matatus. The most significant development is the switch, by Kenyan Railway Corp, from heavy fuel oil to lighter diesel oil, which reduces markedly the consumption of fuel per unit of output. Taken together, all this transportation data, combined with economic and demographic projections of incomes, mobility, and location of people, would provide an excellent base for a careful forecast of energy demands for future transportation in Kenya.

III Energy Prices

The increase in world energy prices was felt in Kenya. First, the EAOR which used to turn a foreign exchange profit by reselling oil products amounting to about half of the throughput of the refinery, saw foreign demand drop off somewhat, the domestic share increasing. Worse, the gross profit margin on a unit of product became very small in relation to the price of crude. Thus the situation after 1974 was very different than in 1973 and earlier.

In Table 8 we present some representative energy prices in Kenya, from data gathered by Bikro Consult, Kenya, and from the Bureau of Statistics. We have converted all amounts to units of 10^6 BTU or kilowatt hours. We remind readers that transportation charges for fuel, and demand charges for heavy electric power users must be added to these figures.

The data presented are in current KS. While the price increases seem dramatic, the GNP deflator for the period 1974-77 inclusive is approximately 1.6, according to the difference between the monetary GDP in constant and current dollars as given in the 1978 Economic Survey. We give the approximate value of these fuels in 1974 pices, and the change is dramatic. While basic fuel prices, with the exception of LPG, have increased considerably, electricity prices have not, due of course to the dominance of hydropower in the supply picture. On the other hand, preliminary data from 1978 indicate that substantial price increases over 1977 occurred, and a new billing system and tariff was introduced in 1979.

Two factors determine the use of energy from an economic point of view. Energy prices determine in part the marginal cost of using certain equipment or enjoying certain amenities, provided the users processes the capital equipment in the first place. Prices also play an important role in the choice of equipment particularly where solar water heating or most industrial uses are concerned. On the other hand, incomes and income growth play a great role both in affordability of equipment and the ability to use that equipment. In Europe, for example, gasoline use is climbing steadily because family incomes are increasing and they are buying their first or second autos. Accordingly gasoline use will be rising there for some time in spite of high prices, though not as fast as the increase in autos, because new autos in Europe may become more energy efficient now. In Kenya, however, the use of autos by expatriates and diplomats as well as the Kenyan upper class, is fully saturated. Growth in the future depends on the rate of increase of the middle class. This kind of analysis must be performed on all sectors of energy use in Kenya in order for us to be able to derive meaningful price-income-intensity of use relationships. Moreover, we must be able to measure use of commercially sold fuels compared to non-commercial fuels, capital intensive renewables like solar hot water, and of course the non-market income of many Kenyans.

IV Conservation in Kenya?

We noted in several places that sites we visited indicated that energy conservation programs were in progress. In every case the person responsible cited higher prices for fuels and electricity as the primary motivation. As to our pessimism over the lack of interest on the part of some firms, it is well known from economic observations that the response to a price increase, be it steady or on-time, takes between a few and tens of years, to take effect. The reason is simply that the greatest changes in energy use take place with the least cost when new equipment is built. Thus the evidence we have seen so far indicates conservation is beginning to take place in Kenya. But we found many opportunities worth investigation.

We noticed several buildings that could be retrofitted to reduce solar gain and hence air conditioning, including the building housing the American Embassy, the Hilton Hotel, and even the Kenyatta Center. We mention of names of these buildings not to single out their owner/managers but to show that a wide variety of enterprises could take part in energy conservation as energy pices climb. We also note that homeowners can add insulation to hot water heaters (in the United States some utilities now provide this as a service), shade windows, keep refrigerator coils clean, and make a conscious effort to reduce the number of miles driven.

V Foreign Trade and Embodied Energy

An extremely important source of energy often omitted from national data is the energy bound up in imports and exports. That is, a unit of goods or services required energy for its fabrication, including the process energy use to make the raw materials and so on. Elsewhere we examined the balance of trade for this embodied energy and found that while the United States imported a small amount (about 1% of its 1973 gross energy use), Sweden and other countries in Europe were significant exporters. That is, significant quantities of the oil imported by many nations leave their borders bound up in steel, paper, and other energy intensive goods. Agricultural products tend not to be as energy intensive on an energy/ton or energy/monetary-unit basis when compared with raw materials. One important energy intensive export from Kenya is refined oil products, energy for which is consumed at the EA Refinery. This embodied energy amounts to nearly 5% of the actual heat content of the fuels exported. Another may soon be paper.

We have not evaluated specific energy intensities for the many materials and products that Kenya deals with. However, we note that three significant categories besides trade in actual fuels show a great import surplus: These are industrial supplies besides food, machinery and other capital equipment, and transport equipment. These are listed here in the approximate order of greatest to least energy intensity. In 1974 these goods amounted to 240 x 10^6 KSh imports, 85 x 10^6 KSh exports, and in 1977 (deflated by 1.6 to 1974 currency) 212 x 10^6 KSh imports and 56 x 10^6 exports. Estimating average energy intensity for these kinds of products at about 100,000 BTU/1974 US $ ($1 - 7 KSh approximately) this amounts to about 40 x 10^{12} BTU in 1974 and a similar amount in 1977. These figures appear to be greater than half of the recorded energy use in Kenya. While our estimate is rough, this hidden energy is known to form a significant fraction of energy use in other countries, as much as 20% in Denmark. We expect that our estimate is correct to within a factor of two, and point out that the major export from Kenya, food products, tends to be far less energy intensive than the goods we have considered here. However, it would be useful for Kenyan energy planners to look carefully into this hidden energy flow since by any account it is significant in the overall energy balance, particularly as rising world energy prices push up the costs of energy-intensive materials and products.

Units Used: (See also Ref. a)

1 Kilowatt-hour (kWh) of heat or electricity contains 3412 British Thermal Units. 1 kilocalorie (Kcal) contains 4.18 kJ.

Oil energy content is often measured in metric tonnes of oil equivalent, which is given an arbitrary value of 10^7 Kcal, or 11.63 thousand kWh. We have used an average value for all oil products, since true values vary by only about 10% except for LPG. One barrel contains by definition 42 U.S. gallons or about 160 liters, and as a standard of oil contains 5.8 X 10^6 BTU.

We count electricity at its direct thermal content, 3412 BTU, rather than include fictitious losses in thermal powerplants for hydropower, as is often done.

BIBLIOGRAPHY

1) See the forthcoming proceedings of the workshop "Energy and Environment in East Africa," Nairobi, 5-11 May, 1979, to be published by the UN Environmental Program and the Beijer Institute of Energy and Human Ecology.

Other references for this work include:

a) Central Bureau of Statistics, 1978. _Statistics of Energy and Power 1969-77._ Nairobi, Kenya.

b) Schipper, L. and Lichtenberg, A., 1976. Efficient Energy Use and Well Being: The Swedish Example. _Science_ 194, p. 1001, Dec. 3, 1976.

c) Central Bureau of Statistics, 1974, 77. _Directory of Industries_, Nairobi, Kenya. See also _Economic Survey, 1978_.

d) Estimates of industrial energy intensities from other countries taken from Schipper and Lichtenberg (Ref. 2b); Schipper, L., 1978 _Energy Use and Conservation in Industrialized Countries_, published in 1979 in _Energy Conservation and Public Policy_, J. Sawhill, editor, New York; Prentice Hall; and private communications with other researchers and firms interviewed. In each case we obtained energy intensities of firms listed directly. Sample energy intensities of goods in foreign trade are found in Schipper, L., 1976. _Ann. Rev. En. 1._ Palo Alto: Ann. Revs. Inc.

Additional information on energy use and the economy can be found in the paper by House and Killick; on urban and residential energy use in the paper by McGranahan, et al.; both are presented in Ref. 1. See also "Basic Energy Statistics and Energy Balances for LDC's"; Paris, International Energy Agency, January 1978 (with updates for 1977 for Kenya supplied by the IEA).

Notes for Table 1: 1977 KENYAN ENERGY BALANCE

We have given here the approximate allocation of various energy forms to various end use sectors. Figures in parentheses should not be added to row or column totals as they are composite figures. Information from EAPL, the Bureau of Statistics, the oil companies, and the International Energy Agency was not always easy to reconcile, particularly in view of the many different units, both energy and quantity, employed by various organizations. We counted the contribution of hydro power at its direct thermal equivalent, rather than counting it as if made in thermal powerplants, the IEA convention. We used an average value for the energy content of a ton of oil product, typically there should be a 15% variation from this average at the most. For LPG (Liquid Petroleum Gas), however, we took its true energy value per KG, 13.4 kWh or about 4×10^6 BTU/barrel.

Note that we have accounted for the use of electricity by refining under "industry" while crude oil lost in refining appears under losses. Losses of oil in the conversion to electricity appear under the "other" column.

Unfortunately the various statistics provided by the government do not break down oil use satisfactorily for us to be able to allocate each type of product to each use. Thus "industrial and commercial uses" of oil products as given by the 1978 survey of energy use by the Bureau of Statistics does not tell which kinds of oils were used for which activities. Dotted lines indicate where the allocation of energy over sectors is uncertain.

All Units GWh = 10^6 KWh

PRIMARY SUPPLIES		TRANSFORMATIONS		USES							
		Losses*	Net Available	Res.	Bldgs., Sm. Indus.	Lg. Indus.	Auto	Truck, Bus	Rail	Air	Marine, other
Electricity											
Hydro, Incl. Import	1060	200 El □1450·oil	1210	305	310	640^{++}					
Thermal Elec.	350										
Coal	360										
Other (Bagasse)	700										
Oil											
Crude & Prod.	34500										
Exports, Stock	15800										
Net	18700	1200	17425								
Lighting, Cooking Kerosene			750	405	345						
LPG (Bulk)				(--90------)							
(Cylinders)			185		(--95-----------)						
Motor Spirit Reg. Prem.			3145				3145				
Diesel Fuel Gas Oil			3550			1920	(--1440-------)				
Diesel Fuel Heavy			380					(---570-----)			
Jet Fuels, Av Gas			3440							3440	
Heavy Oils			6020		(---3520---------)				1050		1450□ El. GE
TOTALS (Do Not Add Vertically)											

* Losses: 1,200 GWh oil (used in EAOR); 200 GWh transmission losses, + unaccounted from Elec. Sectors; 1450□ GWh oil consumed to produce 350 GWh Thermal Electricity; $^{++}$50 GWh Self generation not included.

TABLE 2

SOME INDUSTRIAL INTENSITIES

TYPE	PLACE	ELECTRICITY	FUEL	OUTPUT UNIT	YEAR
LORRIES	KENYA	173.4 KWH	1.85 x 10^6 BTU	LORRY	1978
BEER	KENYA	.12 KWH	2200 BTU	LITRE	1978
TYRES	KENYA	1.09 KWH	15000 BTU	POUND OF TYRE	1975
	KENYA	.74 KWH	9650 BTU		1978
	WORLD AVERAGE, SAME COMPANY	13,400 BTU (TOTAL)			
	U.K., SAME COMPANY	19,000 BTU (TOTAL)			
	S. AMERICA,	11,100 BTU (TOTAL)			
OIL REFINING	KENYA	16 KWH	1.48 x 10^6 BTU	TON	1977
		11.5 KWH	1.37 x 10^6 BTU	TON	1973
	TYPICAL REFINERY, 20% GASOLINE 3.75 x 10^6 T/YR	1.75 x 10^6 BTU/TON			

TABLE 2, CONTINUED

		ELECTRICITY	FUEL	UNIT	YEAR
CEMENT	(1)	90 KWH +	6.0×10^6 BTU (SAME PLANT)	TON	1975
	(1)	90 KWH +	5.3×10^6 BTU		1977
3 PROCESSES IN 2 PLANTS	(2)	105 KWH +	3.1×10^6 BTU		1977
	(3)	95 KWH +	3.6×10^6 BTU (SAME PLANT, DIFFERENT KILN)		1977
OTHER COUNTRIES	SOUTH AMERICA	4.5×10^6 BTU TOTAL			1978
	SWEDEN	4.8×10^6 BTU TOTAL			1975
PAPER (COGENERATION)	KENYA	5.1×10^7 BTU TOTAL			1977
	SWEDEN	3×10^7 BTU TOTAL			1973
KENYA PIPELINE	KENYA	10 KWH OR		CUBIC METER OF OIL	DATA
		870 BTU		10^6 BTU OF OIL	
	LORRY MOMBASSA-NAIROBI	15,400 BTU		10^6 BTU	ESTIMATE

NOTE: THESE FIGURES WERE OBTAINED DIRECTLY FROM REPRESENTATIVE FIRMS. WHERE POSSIBLE, WE GIVE THE ELECTRICITY-FUEL BREAKDOWN. THE COMPARATIVE FIGURES HAVE ELECTRICITY FIGURED IN, IN THE CASE OF TIRES ELECTRICITY IS COUNTED AT 10000 BTU/KWH.

TABLE 3

PROVISIONAL BREAKDOWN OTHER ELECTRICITY USES

	CUSTOMERS	PRICE/KWH KE CENTS	TOTAL SECTOR KWH	REMARKS
COMMERCIAL				
SMALL[a] (T3)	20,000	55	132×10^6	1976
LARGE[b] (T4)	400	55	140×10^6	1976
LARGE INDUSTRY (T5)	490	27.3	356×10^6	1976
AGRICULTURE[c] NAIROBI (LARGE ESTATES)	50	40	13×10^6	
ELSEWHERE	50			
NAIROBI ONLY				
TOTAL T4	251	-	95×10^6	1977
	270		103×10^6	1978
AMONG WHICH . .				
HOTELS	24	35	19.6×10^6	1977
	25	45	14.4×10^6	1978
(COASTAL REGION)	40	-	23.9×10^6	1978
HOSPITALS			15.7×10^6	1977
OFFICES, BANKS (EXCLUDING GOV'T)	22	50	11.4×10^6	1977
	22	60	12.6×10^6	1978
(NEW CUSTOMERS ONLY)	3	60	1.9×10^6	1978
KENYATTA CENTER			2.7×10^6	1977
			2.2×10^6	1978

a. MOSTLY SHOPS

b. MOSTLY LARGE BUILDINGS, SCHOOLS, SOME LIGHT MANUFACTURING

c. AGRICULTURE INCLUDES FARMS AND ESTATES; TOTALS INCLUDED IN T4 AND T5

TABLE 4

MAJOR HOTEL, NAIROBI, AIR CONDITIONED

	ELECTRICAL, KWH/GUEST	OIL BTU GUEST	GAS BTU/ GUEST
1976	37.5	3×10^5	-
1977	35.5	2.9×10^5	2×10^2
1978	29.4	2.9×10^5	2×10^2

TABLE 5

RESIDENTIAL ENERGY, 1978

	Customers	Price, KeC	Use/yr kWh	
Regular Electricity	51,000	33	3,000 per customer	
Small Users (Elect.)	56,000	125	250	
Hot Water (Elect.)	22,000	18	4,815	
Gas Cylinders (Total Country)	-	-	90 GWH	77
			103 GWH	78
Cooking and Lighting Oil (Total Country)	-	-	405 GWH	77
			645 GWH	78

---

*Shell estimates 1 liter/week/family for lighting, cooking. Fuel estimates subject to revision.

TABLE 6

RESIDENTIAL ELECTRICITY BY INCOME, 1977

DESCRIPTION	SAMPLE SIZE	AVERAGE FOR SIX MONTHS		TARIFF
"LOWER CLASS ESTATE"	20	10 KWH/MO.		T2
"MIDDLE CLASS ESTATE"	12	258 KWH/MO.		T1
EXECUTIVE HOUSING	12	565 KWH/MO.	NORMAL	T1
	11	444 KWH/MO.	HOT WATER	T6
LARGE ESTATES	18	752 KWH/MO.	NORMAL	T1
	17	462 KWH/MO.	HOT WATER	T6

SAMPLE OF ELECTRICITY BILLING DATA. THE DESCRIPTION OF THE HOUSING ARE ONLY APPROXIMATE AND REFLECT THE OUTWARD APPEARANCE OR PURPOSE OF THE HOUSING PROJECT. NOTE THAT THE LAST TWO SAMPLES REFLECT HOT WATER AND COOKING FOR SERVANTS. IN NAIROBI, ROUGHLY HALF OF ALL CUSTOMERS RECEIVE TARIFF ONE AND OR SIX, THE NORMAL AND HOT WATER TARIFFS, WHILE HALF RECEIVE TARIFF T2. THE AVERAGE FOR "MIDDLE CLASS ESTATE" PROBABLY SHOULD BE USED FOR FORECASTING PURPOSES. DATA SOURCE: EAPL. SEE ALSO MC GRANAHAN, ET AL., ELSEWHERE IN THIS CONFERENCE.

FOR PRICES, SEE TABLE 5 AND 8.

TABLE 7

SOLAR WATER HEATING*

TYPE OF BUILDING	INVESTMENT	M^2	ELECTRICITY REPLACED YEARLY	COST**
GROUP OF 42 FLATS	360,000 KS	112	4000 KWH/ FLAT	32¢
LUXURY CONDOMINIUM, 104 UNITS	510,000 KS	250	3000 KWH/ FLAT	25¢
SCHOOL, 300 STUDENTS	100,000 KS	38		(50 KS/ STUDENTS)
MEDICAL CENTER (80% SOLAR)	330,000 KS	128		

*BEASLEY COLLECTORS PRODUCE ABOUT 17,000 BTU/DAY/M^2 HOT WATER (32 LITRES/DAY WITH 80°F TEMPERATURE RISE). OTHER SUPPLIES IN KENYA HAVE NOT BEEN SURVEYED. DATA FROM K. MOUSLEY, INSTRUMENTATION LTD., NAIROBI AND BEASLEY, LTD., AUSTRALIA, FACT SHEETS.

**COST ESTIMATED AS RATIO OF 15%/ANNUM FIXED CHARGE TO ELECTRICITY PRODUCED, I.E., ¢/KWH.

TABLE 7A

AMOUNT OF TRAVEL BY CLASS OF ROAD AND VEHICLE TYPE, 1978

CLASS OF ROADS	% OF TOTAL NETWORK[1]	AVERAGE YEARLY VEHICLE TRAFFIC PER KILOMETER OF ROAD CALSS (VEH/KM.)						
		CARS	LIGHT COMMERCIAL VEHICLES	MEDIUM COMMERICAL VEHICLES	HEAVY COMMERCIAL VEHICLES	BUSES	TOTAL (VEH/KM)	(%)
TRUNK	13	1,185	501	501	178	220	2,970	(62)
PRIMARY	18	339	533	300	12	71	1,275	(27)
SECONDARY	23	71	258	95	1	53	278	(10)
MINOR	46	1	8	2	-	-	11	(10)
ALL ROADS	100	1,596	1,705	878	191	344	4,734	(100)
PER CENT VEH/KM	-	(34)	(36)	(19)	(4)	(7)	(100)	

[1] EXCLUDES SPECIAL PURPOSE ROADS

SOURCE: DEVELOPMENT PLAN 1979-1983.

TABLE 7B

SOME TRANSPORTATION ENERGY USES

JET AVIATION (NAIROBI ONLY)	ACTIVITY PASSENGERS	GROSS ENERGY	INTENSITY KWH/PASSENGER	
1923	730,000	3570 GWH	48.2	
1924	790,000	3540	44.2	
1975	920,000	4020	43.1	
1976	960,000	4140	42.5	
1977	-	3860	≤ 42.5	ASSUMING INCREASE IN TRAFFIC
1978	-	3800	≤ 42.5	

SOURCE: STATISTICAL ABSTRACT, KENYA SHELL

PRIVATE AUTOS	REGISTRATIONS[A]	[A]GROSS ENERGY		
1973	70,000	2710 GWH	3106 GWH	-
1974	78,000	2625 GWH	3015 GWH	-
1975	83,680	2730 GWH	3145 GWH	-
1976	88,700	2800 GWH	3230 GWH	-
1977		3150 GWH		
1978		3250 GWH		

SOURCE: BUREAU OF STATISTICS, "STATISTICS OF ENERGY AND POWER" FOR (A) STATISTICAL ABSTRACT FOR REGISTRATIONS, GROSS ENERGY (B) WHICH MAY INCLUDE GASOIL.

OTHER VEHICLES TRUCKS, BUSES	REGISTRATIONS[A]	GROSS ENERGY (A)	(C)	(B)	
1973	67,750	2950 GWH		3250 GWH	-
1974	76,460	2910 GWH	1220 GWH	3120 GWH	-
1975	83,825	2965 GWH	1250 GWH	3260 GWH	-
1976	91,790	3350 GWH	1360 GWH	3660 GWH	-
1977		3550 GWH	1490 GWH		-
1978					-

SOURCE; AS ABOVE - (C) KENYA SHELL GASOIL FIGURES. DIFFERENCES DUE TO DEFINITION OF PRODUCT; DO NOT ALWAYS RECONCILE WITH TABLE 1.

TABLE 8

ENERGY PRICES

UNITS - KENYA SHILLINGS/10^6 BTU OR kWh

FUELS (KS/10^6BTU)	1973	1974	1977	1977 AT 1974 PRICES	REMARKS
FUEL OIL	14.6		39.0	24.4	FOB NAIROBI
DIESEL OIL (HEAVY)	17.0		46.3	28.9	"
GAS OIL (LIGHT MOTOR DIESEL)	24.3		61.0	38.7	"
LPG, 15 KG CYLINDERS	55.8		97.6	61.0	"
LPG, BULK	65.5		87.8	54.9	"
MOTOR GASOLINE	40.8	64.9	72.3		AVERAGE OF SUPER/REGULAR

ELECTRICITY ¢/kWh	1974	1976	1977	1977 AT 1974 PRICES	
REGULAR DOMESTIC	25.8	35.4			
SPECIAL DOMESTIC	112.5	128.9	36.4	22.8	1977 IS AVERAGE FOR ALL 3 TARIFFS
INTERRUPTIBLE DOMESTIC	22.6	18.6			
SMALL COMMERCIAL	41.5	54.8	60.0	37.5	
LARGE COMMERCIAL	24.6	34.0	40.0	25.0	
INDUSTRIAL	17.8	27.3	31.0	19.31	