UNITED NATIONS

A

United Nations Conference on New and Renewable Sources of Energy

Nairobi, Kenya
10-21 August 1981

Distr.
GENERAL

A/CONF.100/NR/36 *

21 April 1981

ENGLISH ONLY

NATIONAL REPORT SUBMITTED BY

KENYA **

* National reports are reproduced by photo-offset and issued in the languages of submission only. This document will receive full distribution at Headquarters. Only two copies per delegation will be available at the Conference site.

** The designations employed, the presentation of material and the views expressed in this paper are those of the submitting Government and do not necessarily reflect the practices and views of the Secretariat of the United Nations in any of these respects.

81-10831

1.0 PREAMBLE

1.1. Kenya which is situated in eastern Africa has a land area of approximately 580,000 sq. km., 70 per cent of which is semi arid and arid. It has a population of 15.7 million with an annual growth rate of nearly 4 per cent which is one of the highest in the world. About 70 per cent of this population i.e. 11 million people, live on 30 per cent of the land area and the per capita income in 1979 was US $242 at 1976 prices, which is among the lowest in the world.

1.2 One indication of socio-economic progress made since the country attained independence in 1963 is the success achieved in expanding the nation's output of goods and services. The average GDP annual growth rate between 1964 and 1977 was 5.8 per cent. The growth rate of the manufacturing sector over the same period was remarkable, i.e. 12 per cent at constant prices despite the fact that its contribution to the national income (GDP) has been rather modest, about 17 per cent of the total in 1979, at constant prices. Agriculture which is the backbone of the country's economy, as it accounts for about 33 per cent of GDP, had an annual average growth rate at constant prices of 4.3 per cent, between 1976 and 1979, despite the fact that this sector suffered from declining output of 0.8 per cent and 3.9 per cent in 1979 and 1980 respectively, at 1976 prices.

1.3 The disappointing record, in GDP performance, in recent years reflects the disorder which has characterised, international economic relations since the 1973/74 oil crisis. The international economic order has undergone a series of recessions which coupled with inflation and ever rising prices of petroleum have led to escalation in prices of manufactured goods. Due to these external factors over which Kenya, being a net importer of production technology and energy, has no control, the country has had to revise downwards its development targets, set in the 1979/83 Development Plan. This was done in "Sessional Paper No. 4 of 1980 on Economic Policies and Prospects" in which the projected annual GDP growth rate in real terms was reduced from 6.3 per cent to 5.4 per cent during the Plan period. This growth rate is rather optimistic as evidenced by the fact that in 1979 GDP grew by only 3 per cent which was 2.3 per cent below the revised rate. The paper further, indicates that, as a result of the poor external factors, there will be reduction in anticipated employment opportunities, decline in projected government revenues, and, deterioration in balance of payments problems as the country will have to borrow funds from external sources, from time to time, in order to sustain a balanced demand of essential commodities and services such as oil, capital goods and spare parts, medical stores, etc.

1.4 An official report published by Kenya's Bureau of Statistics in 1977 indicated that 41 per cent of families engaged in small-holder agriculture - a group that represents about 80 per cent of Kenya's total population - had incomes including subsistence production, of less than KShs.2,000/- (US $244) per family in the year 1974/75. Another 14 per cent of these families had incomes in the range of US $244 to 366. Incomes of this order of magnitude are not sufficient to provide the basic necessities of life such as food, energy, water, shelter, health and clothing. It has been estimated that since 1974/75 the per family annual incomes of the group under reference have, in real terms, not changed due to the factors outlined above.

...../2

1.5 In order to uplift the standard of living of both rural and urban poor, and hence make advances in all aspects of social-economic development, the country will require increased quantities of energy in all sectors of the economy and in particular agriculture and manufacturing.

1.6 In realisation of the importance of energy as one of the key factors of production, the Government of Kenya through its Ministry of Energy has decided to prepare a comprehensive energy policy with the following major objectives:

1. Increasing the supply of energy to meet the requirements of economy;

2. Rationalizing the use of imported petroleum;

3. Lessening dependence on imported fuels through vigorous conservation measures, aimed at increasing productivity of such fuels and utilization of new and renewable sources of energy to the extent possible, and;

4. Developing indigenous energy resources.

In this connection, the government has already begun to introduce appropriate conservation measures, in a step by step fashion, and has prepared and provided funds for projects and programmes aimed at extensive rural afforestation for energy production and for development of new and renewable energy sources of hydropower, solar, wind geothermal and biomass. These topics are covered in the later chapters of this paper. The Ministry of Energy is also investigating possibilities of substituting coal for oil for both industrial and household consumption since coal is in more abundant supply and is more widely distributed than oil, not to mention the well known fact that it is much cheaper than oil in BTU terms.

1.7 Kenya's critical energy and development issues are rooted in two sets of circumstances, first, a pattern of land use, lifestyle and economy structure rooted in 80 years of colonial rule and limited endowment in natural resources. Thble I, gives a sectional breakdown of end use of petroleum products. Transportation sector which accounts for some 62.37 per cent of all petroleum used in the country is well developed throughout with the exception of a few remote areas in the countryside.

1.8 In order to facilitate general development and in particular the remote areas, additional fuels will be required although, with the projected switch from petrol to diesel and the development of mass transit systems, it is expected that switching from the current patterns of petroleum energy use will substantially result in oil savings of between 10 per cent and 15 per cent per annum.

1.9 Over 22 per cent of petroleum products are used in the commercial sector. A relatively high income market and developed urban infrastructure have attracted substantial amounts of foreign investment, although industry in Kenya tends to be located in a few areas spreading the benefits unevenly and exacerbating problems of rural to urban migration. However, the drive to decentralise industry which is now part of Government policy in industrial

PROSPECTS FOR NEW AND RENEWABLE SOURCES OF ENERGY: DEVELOPMENT AND UTILIZATION IN KENYA

TABLE OF CONTENTS

development requires the provision of basic infrastructure, including energy, in increasing order of magnitude in order to reduce the extremely large gap that now exists between the rural and urban sectors of the economy.

1.10 Conservation measures have begun to be implemented by many industrial concerns. However, multi-national firms, with easier access to capital and technology, are more efficient users of energy strengthening their position against local producers. Energy audits of existing industry are being undertaken to emphasize the possibilities of conservation and fuel switching.

1.11 Agriculture which is the backbone of the country's economy consumes relatively little petroleum products whereas Kenya's modern sector depends for over 80 per cent of its energy requirements on imported petroleum. Small rural industries, informal urban industry, small farmers, and pastoralists rely mainly on wood and charcoal for their energy needs. Hydro-electric power is limited in supply. Table II, shows the production trade and consumption of commercial energy, in general.

1.12 Although great efforts have been made to increase the role of Kenyan manufactured and other processed products in international trade, Kenya still depends heavily on sales of coffee and tea for its export earnings. These two commodities like other primary products, are subject to wide international price swings which in turn create a volatile foreign exchange position. However, as the price of oil continues to escalate, (Table III) to some 37 per cent of the value of total exports in 1979 even as the quantity imported remains constant, it has become absolutely necessary to devise an energy policy that moves towards increased pace of development and utilization of hydropower, geothermal energy and other new and renewable sources of energy. In realization of such an energy policy, a number of projects and programmes in the field of new and renewable sources of energy have been undertaken and continue to be undertaken by the government alone or in partnership with the private enterprise. These projects and programmes include, among others, power alcohol industry whose prime objective is to achieve 20 per cent alcohol replacement of gasoline in volume by 1985, development of mini hydropower potential, the investigation of which is currently being carried out in Western Kenya with the help of donor assistance, etc. As indicated in paragraph 1.6, detailed treatment of these vital sources of new and renewable sources of energy is covered elsewhere in this paper.

2.0 WOODFUEL ENERGY

2.1 Woodfuel (fuelwood and charcoal) is the most important energy source in Kenya accounting for about 75 per cent of all its requirements. This energy source is indigenous, mainly coming from the natural woodlands and forests, with only a small proportion being supplied from government owned plantations. These natural forest areas are being depleted, firstly to make more land available for agriculture and secondly, because in many areas more than the equilibrium supply of wood is removed thus eating into the

forest capital. Clearly, Kenya cannot go on using woodfuel as it does at present, without making adequate arrangements to renew this energy source. The only practical alternatives to woodfuel are oil products, including LPG and electricity: these require considerable foreign exchange to import or produce and Kenya, like most other developing countries, has an acute shortage of foreign exchange. Therefore, the guaranteeing of an adequate wood supply to meet Kenya's future energy requirements is an essential part of this country's energy strategy.

2.2. The principal use of woodfuel in Kenya is in the household, fuelwood being used in rural areas and charcoal mainly in towns. Cooking is the most important application accounting for between 60 and 75 per cent of total household use. Space heating and water heating are the next two important uses, and together with cooking, they account for about 95 per cent of total household energy use. The remaining 5 per cent of woodfuel is used for ironing and lighting. Non-household uses of woodfuel including cottage industries, account for about 15 per cent of total consumption, with agricultural crop-drying - tea and tobacco and beer brewing being the most important use for this fuel. Other uses include brick and pottery firing, fish smoking and cooking in restaurants, canteens, butchers shops, schools, and hospitals, etc. Estimates of current annual consumption of woodfuel is of the order of 30 million m^3 (22 million tonnes of air dry wood) or approximately 7 million tonnes of oil equivalent and is saving in terms of foreign exchange an estimated K£200 million (US $485 million) per year.

2.3 If present use patterns continue, after making due allowance for people switching to more convenient fuels, and also taking into account the new uses of woodfuels and transfers to its use, the potential demand for woodfuel by the year 2000 may be of the order of 55 million m^3. However, if more efficient cooking stoves are fully accepted, and on the production side, more efficient charcoal production methods introduced, then it may be possible to reduce projected demands to the current demand level of 30 million m^3. However, in practice the potential demand will most likely be somewhere between these two limits. But on examining the supply side of the supply/demand equation, the tree capital is already being depleted and there is insufficient growing stock to meet the current needs on a sustained basis. If nothing is done about this state of affairs then the forest estate will diminish rapidly, the price of woodfuel will increase both in actual monetary terms and in the time taken to collect it, imported fuels will be substituted and perhaps just as important the removal of the tree cover will have adverse effects on water flow, dam life, agricultural production and even local climate.

2.4 The only practical solution that is open to the government, and a solution that will create rural employment, save foreign exchange, and be the cheapest in terms of total expenditure, is to encourage the farmers to plant trees on their farms and establish village woodlots and fuelwood plantations. To this end, a Presidential directive has been issued to the effect that every administrative location

in Kenya should have at least one tree seedlings nursery, to supply seedlings to local population. It has also been decreed that for every tree cut down, there must be a replacement.

2.5 An area equivalent to about 3 million hectares may have to be planted with tree species between now and the turn of the century assuming an average growth rate of 15 m^3 (11 tonnes) per hectare if Kenya's woodfuel requirements are to be met, to say nothing of the area needed to meet the requirements of other wood users.

2.6 The common plantation woodfuel species eucalyptus is not suitable for growing in fields for it allows no competition, is demanding on both surface nutrients and water and its leaves do not break down readily. On the other hand there are many trees species, that are ideal for farming areas, such as species of Acacia, Leucaena, Cassia, Azadirachta, Mimosa, Prosopis, Grevilla and Gmelina, for many of these trees fix nitrogen, produce food and fodder, and do not compete with agricultural crops.

3.0 HYDRO POWER

3.1 The earliest application of hydro energy in Kenya was in connection with the running of water mills for grinding cereals like maize, wheat and millet. This technology was introduced in the early part of this century, and reached a relatively high plateau of utilization in the late fifties.

3.2 The hydraulic ram is another device which has found wide utilization in the country. The device is basically a water driven pump which can be used for water supply and irrigation in the rural areas.

3.3 On average hydro electricity generation accounts for 70 per cent of the total electricity supply. The most important application of hydro energy in Kenya is in the generation of electrical energy. Hydro electric power generation is well established in Kenya. The main potential is concentrated on the River Tana which has an estimated total energy potential of about 15,000 GWh/year. However, only 4,000 - 5,000 GWh/year (i.e. between 500 - 600 MW of electric power) can be economically exploited, which approximates the total forecasted load for the year 1990 The total installed hydro electric capacity is about 410 MW; and this is expected to rise to 450 MW with the commissioning of a multipurpose project before the end of 1991.

3.4 As indicated in the preamble, exploration for mini hydro-power potential is being carried out in Western Kenya. In total, the hydropower potential is estimated at 1200 MW out of which 750 MW can be harnessed economically at today's market prices.

3.5 Kenya's rapid socio-economic development has resulted in electricity demand growth rate of 8 per cent per annum, on average, since Independence. This rate of growth is expected to continue up to and including year 2000.

...../6

Translated in other words, this simply means that the total hydropower potential if harnessed exclusively for generation of electricity, will not meet the country's electricity demand by the year 1993. However, with the finalization of the national master water plan, the picture of the estimated total hydropower potential may change, i.e. either rise or decrease accordingly.

3.6 Feasibility studies on Kiambere hydro electric power in the Tana River basin have been finalised. To this end, construction work for this project which has a power potential of 130 Mw will soon commence, and is expected to come on stream by 1988. Another hydro electric power project in the Rift Valley province of Kenya, Turkwell Gorge, whose estimated power potential is 120 Mw will be implemented as soon as detailed feasibility studies, which among other things include seccimic studies, are finalised. It is anticipated that if the feasibility studies are satisfactory, this project will come on stream in or before 1990.

4.0 GEOTHERMAL ENERGY EXPLORATION AND DEVELOPMENT

4.1 Geothermal areas in Kenya are mostly located within the Rift Valley, which runs South-North from Lake Magadi near the Kenya/Tanzania to Ethiopia Border. The Rift Valley has a nearly constant width, between 30 - 60 km., and a total length of approximately 800 km. The Valley is considered to reflect on incomplete breaking up of a "Continental Plate"; normally resulting in the formation of a new ocean floor. The resultant Geological structures presents a remarkable graben. Generally, Eastern-Africa except for the coastal regions, if topographically characterized by plateaus and mountains higher than 1,200 m. above sea level partly due to regional doming of the crust and partly due to the development of the Kenya volcanic dome and the central volcanoes. Also, micro-earthquakes are recorded in and around the Rift-Valley. Recent geophysical work by several universities has observed a mantle dome under the Rift Valley reducing the crust thickness by about a half. In the Rift Valley, as already indicated, there are many areas of active geothermal manifestations, but only three of these areas have been well surveyed. These are: Olkaria, Eburru and Lake Bogoria. Olkaria and Eburru geothermal fields are limited mainly to widespread fumalore activity. At Eburru, the fumalores have been used to supply the local settlements with water condensing the steam in sloping aluminium pipes and collecting the water in tanks before distribution. The steam is used by farmers also as a source of heat for drying pyrethrum flowers.

4.2 Geothermal exploration in Kenya started early in 1950's with Olkaria geothermal area chosen for exploratory drilling because the other sites selected had neither suitable access roads nor, more importantly, adequate sources of water supply. In May 1956 a well designated X-1 was spudded using a percussion rig. Temperatures recorded during percussion drilling reached 120°C at 370 m (but apparently were lower during notary drilling - well X-1 was eventually abandoned in January 1958 at a depth of 592 m. Prior to the abandonment of well X-1, work with the percussion rig started in August 1957 on a second well, designated X-2

2 km north of X-1 at an elevation of 1975 m. At this site, using rotary drilling mostly, the well reached 942 m in July 1959, but similar problems to those of X-1 were experienced. Inspite of many efforts to bring X-2 to production by air-lifting, the well was unproductive and operations stopped in March 1959.

4.3 Interest in further geothermal exploration work revived in 1967 when a wenner configuration restivity survey was carried out in the Rift Valley between Olkaria in the South and Lake Bogoria in the North. The survey identified a number of anomalies and recommended exploration drilling. Flow tests were conducted using lip-pressure pipes with different diameters to obtain flow-back pressure characteristics. Initially, when operating at a well-head pressure of 6 bars (abs), the well produced about 50 tonnes of steam per hour which is equivalent to about 5 Mw.

Today, drilling at Olkaria is still going on and so far 16 wells have been drilled at depths varying from 900 M to 1,685 M. From the 16 wells drilled the majority are potentially productive and some of the latter yielded as much as 90 per cent dry steam. Spacing between wells is 200 - 250 m and the equivalent output varies from zero to 3 - 3.5 Mw. Calculations determined that 1.5 Mw per well, compared to other energy sources, was still economical under Kenyan conditions. The average subsurface temperature at the geothermal locations currently being developed in Kenya (1 x 1 Km) was 280°C (maximum 304°C), dry steam wells yielded a temperature range of 235°C - 245°C.

4.4 The Olkaria geothermal field has been proved to be a large one. Indeed anomalously low resistivity values extend over 100 km^2, with surface thermal activity scattered over an area of 36 km^2. Based on exploration data obtained and certain geological assumptions made, the estimated geothermal energy potential of the Olkaria field range from a conservative 4200 Mw year's to an optimistic figure of 1250 Mw years. Stated in another way, this potential is equivalent to between 170 Mw and 500 Mw, available over a period of 25 years. However, there is a likelihood of some of the wells being non-productive and hence the estimated upper limit capacity will correspondingly be lower. Construction work has already begun for the installation of two geothermal electricity plants of 15 Mw. each. The first plant is expected to come on stream by July, 1981 and the second plant by 1982. Exploration work on the other two geothermal fields, namely: Eburru and Lake Bogoria which have been identified as potential sources of geothermal energy will be undertaken in the very near future.

5.0 ENERGY CROPS FOR SEED OIL AND IN PARTICULAR POWER ALCOHOL PRODUCTION

5.1 The country's power alcohol programme is aimed at achieving some of the national energy policy goals. It is government policy to encourage investments, either from within the country or from external sources, and development of resources pertaining to production of power alcohol while at the same time maintaining harmony with other government policies in respect to land use and utilisation of all

important resources. Clearly due to the heavy capital investments involved, incentives must given. Such incentives may take the form of government partnership, waiving of import duty, subsiding price of power alcohol vis-a-vis gasoline price, sales tax exemption, accelerated depreciation, machinery resulting in an actual income tax rebate commensurate with total income, guaranteeing foreign loans and providing the necessary infrastructure including land for power alcohol projects.

5.2 Availability of fertile land is a major issue to be considered in the development of power alcohol. There is a clear indication that Kenya must initiate and plan power alcohol projects and address other renewable energy resources, away from the existing fertile land so as to avoid competition between food and energy crops. This means that energy crops will be assigned especially to poorer lands such as low-rainfall areas. There is also an urgent need to diversify primary resources for power alcohol production in order to minimize the need to base projects only on sugarcane. If sugarcane should remain as the major power alcohol resource, however, then new draught resistant sugarcane strains will have to be developed which could be cultivated on marginal lands. However, with good sugarcane husbandry, it should be possible initially to increase cane yields without necessarily requiring more land.

5.3 The existing power alcohol resources are of only one type namely, sugarcane. Sugarcane is grown in the Nyanza Belt (Kano Plains and adjoining areas), Awendo in South Nyanza, Ramisi, at the Coast and in Mumias and Nzoia in Western Province. The areas under cane cultivation is estimated at 70,000 ha and it is estimated that Kenya produced 400,000 tonnes of plantation white sugar in 1980. Production of sugar requires expansion of the cane area to over 105,000 hectares if the target of 650,000 tonnes of white plantation sugar is to be achieved by 1990. A further 120,000 tonnes of sugar could be produced when the Yala Swamp and Busia Sugar projects are implemented.

5.4 Today, there exist two on-going power alcohol projects, namely, the Kenya Chemical and Food Corporation (KCFC) in Kisumu which will come on stream in July 1981 and the Agro-Chemical and Food Corporation (ACFC) in Muhoroni which is expected to come on stream in 1983. The design capacity of each of the two distilleries is 60,000 litres/day. The Riana Ethanol Project, already proposed, is the first ethanol project planned to use direct sugarcane juice, at a production rate of 150,000 litres/day. It is also expected to come on stream in 1984/85.

5.5 KCFC and ACFC projects are designed to use molasses as feedstock. Molasses is produced in seven sugar mills. Table 4 gives the corresponding yield per year. It is evident from Tables 4 and 5 that the demand for molasses is greater than the supply. In view of this, Kenya has already started looking for the production of power alcohol without the use of molasses. The only alternative to molasses at present is sugarcane juice. However, the Kenya Government is also aware that in choosing among alternatives, a balance must be established between sugarcane productions for white sugar and for power alcohol.

Miana Ethanol project is conceived as a possible resolution of this dilemma. It will be based on the use of direct cane juice.

5.6 Some research geared towards production of power alcohol and seed soils from energy crops and fast growing trees is currently taking place under the general direction of the Ministries of Agriculture, as well as Environmental and Natural Resources. The Ministry of Energy coordinates these activities and will soon itself be engaged in active research, development and demonstration of all energy crops for production of both power alcohol and oils. These two energy sources are meant to partially replace petroleum based fuels.

5.7 Research, development and production needs, as relating to power alcohol, will be dictated largely by the degree of Kenya's determination to be self-sufficient in energy. Logically new energy crops will have to be identified for basic and applied research. Of greater interest to Kenya's energy policy are the crops which could be cultivated for immediate use in the production of power alcohol and oils.

5.8 Improvement of sugarcane currently in use in Kenya's Sugar Belt, may lead to increases of sugar content and therefore to an increase in power alcohol production per tonne of cane. Although many types of cane are grown in the Sugar Belt, the following varieties have been recommended: CO 331, CO 421, and B 351. Of all varieties, CO 421 is the most suitable for Western Kenya.

5.9 Research geared towards development of complementary crops will be quite significant towards reducing the pressure of fertile lands. Cassava will form an important crop in respect to this goal. Also, "power alcohol" sugar beets could be intercropped between food crop seasons and be used to provide supplies for distilleries.

5.10 Kenya's needs for expansion of power alcohol and seed oils production will be dictated largely by the following factors: (a) duration, and extent to which prices of petroleum - based liquid fuels will remain competitive with prices of power alcohol and substitute oils; (b) need of using power alcohol and seed oils projects as nuclei for the development of arid and semi-arid (marginal) regions or under-developed lands; (c) use of power alcohol and related industries to create job opportunities in rural areas, and (d) rate of utilization of industrial and automotive fuels.

6.0 SOLAR ENERGY

6.1 Solar energy is one such source that is renewable and has relatively great potential, as Kenya lies approximately 4.5 degrees noth and south of the Equator. Due to its geographical location, therefore, Kenya has an undisputed opportunity for utilization of solar energy to enhance its socio-economic development. The solar radiation data already collected indicate that, on average, some parts of the country have solar insolation of between 30 to 45 watts per square centimetre. The Department of Meteorology of the University of Nairobi, recently published a map which indicates solar insolation of the various parts of Kenya.

..../10

6.2 The most widespread solar energy application in Kenya is in drying of agricultural commodities and miscellaneous other things such as wet clothes. This application of solar energy has been in use since time immemorial. The method most commonly employed in drying is simply that of spreading crops either on the ground or on special drying beds raised some height above the ground, depending on user requirements. This traditional method has some limitations in that products tend to take a longer period to dry and are also exposed to pests and contamination. Some crops such as maize and groundnuts, which require relatively short drying periods, when subjected to longer drying periods result in aflatoxin contamination and such contamination makes the crops unfit for human consumption since aflatoxin has been proved to be carcinogenic.

6.3 The second most widespread application of solar energy in Kenya is domestic and commercial water heating. Solar hot water systems, flat plate collectors of varying sizes and qualities, are being manufactured and/assembled by several local firms in the Country. On the average, about 1,000 units of flat plate solar systems are sold each year.

6.4 Depending on quality of material used, the cost ranges from US $500 for 1.4 square metre galvanized steel flat plate collector with a 140 litre storage tank. Mass production could possibly bring down the costs due to economies of scale, even though the solar hot water systems are both material and labour intensive and therefore their total costs are not expected to decrease proportionately with production costs. Nearly all the solar hot water systems' that are being manufactured or in use are of thermosyhon type.

6.5 Despite the fact that solar hot water systems being marketed in Kenya have useful life spans ranging between 15 to 20 years, the high production costs have limited their extensive application. Fiscal incentives, by the Government in the form of tax rebates, could make their application more attractive.

6.6 The pay back period of the flat plate hot water systems, that takes into account time value of money and escalation of prices of energy commodities, has not been assessed with any degree of accuracy and the available information is simply a guestimate. As is argued by some of the local manufacturers depending on the application to which a system is being put, the pay back period without taking the time value of money into account varies between 3 and 8 years.

6.7 Industrial solar water heating systems dedicated to deliver process energy, depending on use, may supply water which has to be heated further to require temperatures by conventional energy systems. They have not gained any popularity; and this is an area in which the Government will in the near future provide information on possible benefits and appropriate incentives so as to make the application attractive to the potential users.

6.8 Other types of solar water heaters such as parabolic and evacuated tube concentrators, which are capable of attaining extremely high temperatures, are unlikely to find any market in Kenya in the near future for two major reasons:

(i) Their technology is still in the developmental stage and completion of this phase will take at least a couple of years; and

(ii) Even if the technological barriers were overcome the question of manufacturing such systems and commercialisation at competitive prices before the turn of this century is highly doubted by many experts.

6.9 Photovoltaic electricity generation has barely been tried in Kenya, even though expert thinking is that in countries in which villages are remotely located from the national grid and other forms of conventional energy supply infrastructure is lacking or is grossly inadequate, photovoltaic electric power at today's market price is between 6 and 10 US$ per watt for water pumping, and even for electricity generation or other purposes, is highly competitive with conventional systems such as diesel powered water pumps and electric generators.

6.10 Because of the high sophistication of the technology for the manufacture of photovoltaic cells, which is both labour and energy intensive, the possibility of manufacturing commercially viable photovoltaic cells in Kenya in the near future is rather remote, even though this is one of the solar energy sources that have a potentially wide scale application in rural Kenya in the near future.

7.0 WIND POWER UTILISATION

7.1 A survey carried out throughout Kenya in May, 1980 to collect information on the present use of wind energy indicated that this technology has been used for almost 100 years in Kenya. The wind machines were imported from Southern Cross of Australia, Aeromotor and Dampester of the United States of America and Climax of England. However, the existing installations of these windmills are very few, because, as a certain point in time they were abandoned in favour of cheap diesel engines which, hitherto, have continued to dominate in water pumping application and electricity generation in various parts that are inaccessible by the national grid.

7.2 Efforts by various parties, including the government, to re-introduce the wind power technology have met with little success due to the following:

(a) Data on wind regimes characteristics which are essential, as the application of this technology is site specific, are inadequate. However, the Meteorological Department of the Government of Kenya and the Department of Meteorology of the University of Nairobi have been collecting wind data based on user needs - the former has been collecting data for both the civil aviation and the national air force while the latter has been collecting data for academic pursuits. These data have, nevertheless, not been analysed for their suitability as source of wind energy;

(b) Available windmills (imported and locally fabricated) have not been tested for their suitability as regards durability and performance with any degree of accuracy and as such some of the financially able potential buyers are somewhat reluctant to invest their money in this field. It also goes without saying that there is gross inadequacy of skilled manpower country-wide to maintain this renewable technology;

(c) The windmills, currently available in the market, are too expensive for the target group to afford, i.e. the rural population. The available windmills for shallow well water pumping cost US $1800, on average, whereas the household income of 80% of the rural population which account for 90 % of Kenya's population have household incomes of between US $244 and 365 per annum.

7.3 As part of the Kenya Government's policy in developing indigeneous energy sources and in lessening the country's dependence on imported energy, plans are being implemented for country-wide collection of wind data as well as for development of cheap but reliable windmills that are affordable by the target group.

8.0 BIOGAS UTILIZATION

8.1 The biogas technology was first used in Kenya about 30 years ago by Messrs Hutchingson, who subsequently started manufacturing biogas digesters in 1950. Apparently not much interest developed among farmers, partly because of abundance of alternative sources of energy and a relatively small population. With the present energy crunch in the country's rural areas, interest has been shown by both the private enterprise and Government to develop and commercialize this technology as an alternative fuel to wood fuel and other biomass materials that are burned directly, to provide primarily cooking energy and to a lesser extent energy for space heating.

8.2 In an effort to alleviate the rural population's total dependence on wood fuel and other biomass as the prime source of energy whose continued consumption are posing serious ecological problems such as destruction of water catchment areas with obvious results of destabilization of water table, deforestation leading to desertification, siltation of rivers and dams, etc., the Government is promoting and fostering the use of biogas as an alternative fuel for use in the rural areas.

8.3 The Government through the Ministry of Energy has begun to look into the existing worldwide biogas technology, mainly of Chinese and Indian designs with a view to producing at the least cost possible designs that are suitable for use in Kenya.

8.4 Parallel to the effort indicated in 8.3, studies on socio-economic and cultural implications will soon be commenced so as to overcome any such barriers that may hinder faster acceptability of the biogas technology. A small survey carried out by the Ministry of Energy, as

part of Kenya's preparations for a position paper on the UNRSE, in 1990 covering 195 people in certain administrative districts indicated that there was need for an extensive and intensive dissemination of information on biogas technology. Tables VI and VII give a breakdown of people interviewed by economic activity and administrative area, and the likely benefits derivable from biogas vis-a-vis other energy sources.

8.5 The summary of the survey's results indicate that:

(i) farmers and more especially the agricultural officers felt that more information should be availed to help in the adoption of biogas technology;

(ii) there is need for reliable performance data and a source that listed the range of options and equipment available as widespread talk about the biogas technology is not a sufficient mechanism to effectively propagate the technology;

(iii) farmers require clarification in respect to comparative performances and, of course, the side effects of the technology, as well as cultural beliefs and practices;

(iv) the imbalance between the capital cost of the digester and the benefits derived, was a problem common to most of the farmers interviewed. While the main concern focused on capital cost, the farmers were also concerned with operating costs, especially in areas where water for mixing the raw materials in an acceptable form, was far away from the site of biogas digester; and

(v) there is need to give loans for purchase and installation of biogas digesters as part of farm development credit that the Government gives to farmers through its agricultural credit finance institutions i.e. Agricultural Finance Corporation (AFC) and Agricultural Development Corporation (ADC);

8.6 It was a general feeling that biogas could alleviate the hitherto common place problems in some parts of the country where women have to walk long distances in search of firewood, agricultural wastes as well as other vegetable wastes that are barely enough to meet cooking energy needs for more than a day; and

8.7 Finally, the farmers and agricultural officers agreed that the biogas digester spent slurry could be a good fertilizer and that the only problem that will hinder large scale use of the slurry was the enormous effort that is required to transport it to farms.

9.0 EDUCATION AND TRAINING

9.1 At the moment there is no well organised training programmes for solar, wind and biogas energy personnel in Kenya; and the sooner we make a start the better it is for us. However, the University of Nairobi and its constituent College, Kenyatta University College,

have planned for inclusion of these renewable energy sources in their teaching programmes at both undergraduate and post-graduate levels. Nevertheless, there are financial constraints that may hinder faster implementation of the training programmes.

9.2 As regards training in hydropower, the University of Nairobi offers three year courses in electrical, mechanical and civil engineering and it is from graduate in these fields that the electrical power industry recruits its high level personnel. The East African Power and Lighting Company, which is the only electricity utility trains its engineers and technicians both on-the-job and its training school. Despite the availability of the training facilities in this field, there is still a shortage of both professional and technical manpower.

9.3 The Forestry Department of the University of Nairobi is now incorporating into its courses methods and practices of agro-forestry and the Forest Training School, Ministry of Environment and Natural Resources is also training students in extension work in both forestry and agro-forestry. These training facilities are however, inadequate to meet the country-wide afforestation programme which is now being undertaken.

9.4 At present, there are no local training facilities in the field of geothermal energy and as such professional manpower has been and continue to be, trained overseas. With regard to sub-professional and skilled manpower there are no formal training facilities both in Kenya and overseas and as such, such manpower has to be trained on-the-job. However, there is need to train more personnel in this area so as to cope with expanding geothermal development programmes. Creation of a regional geothermal training and research centre for Africa will go a long way in reducing the training problems at all manpower levels.

10.0 INFORMATION FLOWS

10.1 A mechanism for a national information service capability aimed at education of prospective buyers on the most appropriate new and renewable sources of energy that have reached commercialization stage is at the moment lacking. However, the Ministry of Energy is considering setting up a data bank/library which, inter alia, will deal with information flow from the Government to both the consumer and the manufacturing sector. The main energy resources that will receive high priority are afforestation, solar hot water systems, biogas digesters and windmills. The question of standardization and quality control will be addressed so as to protect consumers from exploitation by unscrupulous salesmen.

10.2 In the field of afforestation, simple information brochures will be published in various local languages to inform the farmers about suitable types of trees for their particular area, seed and seedling source, how to grow and tend these trees and what they can be used for besides woodfuel, pole and sawn timber. On the consumption side stoves models that are efficient and cheap enough for the rural poor to afford will be demonstrated.

10.3 The national political machinery and the country's provincial administration will be used to promote and foster the development and utilization of new and renewable sources of energy as far as possible.

10.4 Information exchange between and among countries should be encouraged and propagated through publication of papers and journals in new and renewable sources of energy as regards research and any break throughs.

11.0 RESEARCH AND DEVELOPMENT

11.1 Like training, research and development as a whole is yet unco-ordinated even though it has been undertaken by the University of Nairobi in solar and wind energy and by the Ministries of Agriculture, and Environment and Natural Resources in Energy crops such as sugarcane and suitable tree seedlings for growing on marginal lands. The role of the Ministry of Energy in this respect will, inter alia, include co-ordination of research and development of new and renewable sources of energy.

11.2 The Ministry of Energy will soon establish an Energy Technology Institute whose prime role will be testing, development, adaptation and adoption of new and renewable sources of energy technologies that have surpassed basic research levels.

12.0 TECHNOLOGY TRANSFER

12.1 At the moment, Kenya lacks the machinery for transferring energy technology to manufacturers and end-users of new and renewable sources of energy. The Ministry of Energy hopes to set up in the near future, an extention service network through out the country to cater for the transfer of all forms of appropriate renewable and new sources of energy to both manufacturers and end-users. There is also a need to set up a machinery at sub-regional, regional and international levels for transfer of technology between countries and among countries at a nominal fee.

13.0 FINANCING

13.1 Financing is an important aspect in the development and utilization of new and renewable sources of energy. Consumers could get soft loans from Government financial institutions. Manufacturers could also benefit from the existing quasi-government financial institutions to get appropriate financing to set up munufacturing plants. There is also a need to explore the possibility of tapping bilateral and multilateral financing, on very reasonable terms, for developing new and renewable sources of energy.

14.0 RURAL ENERGY SUPPLY

14.1 At the moment there is only one major government activity that caters for rural energy supply, i.e. the rural electrification programme whose projects implementation are hampered by lack of adequate funds. As regards the supply of woodfuel, solar and wind energy, the Ministry of Energy is embarking on country-wide programmes to meet the rural energy requirements. Such a programme calls for

...../16

huge capital out-lay that cannot be met in full from Government revenue and as such efforts will be made to tap bilateral and multilateral financial and technical assistance.

15.0 INSTITUTIONAL INFRASTRUCTURE

15.1 The Ministry of Energy is the prime government authority charged with the responsibility for energy development. In order to cater for the country's energy needs which are as important as classical factors of production, the Ministry has set up:-

(1) A Policy, Planning and Monitoring Division which is charged with the responsibility for preparing policies, programmes and strategies associated with energy activities.

(2) A Technical Division which is charged with the responsibility of all aspects of development of energy resources as well as providing appropriate relevant infrastructure.

15.2 In addition to these two divisions, an energy development fund has been set up to help promote and foster harnessing of biomass energy as well as other new and renewable sources of energy. It is expected that the Energy Development Fund would benefit from both bilateral and multilateral financial resources and as time goes on the Fund is expected to be self-financing and autonomous - i.e. it is expected to eventually become an energy development bank.

16.0 REGIONAL CO-OPERATION

16.1 Kenya would like to develop regional ties with other African countries in setting up appropriate training facilities in the new and renewable energy sector, as well as foster institutional and financial mechanisms for harnessing new and renewable sources of energy such as biomass, hydropower and geothermal energy. Of particular interest to Kenya is a machinery for setting up an African Energy Commission which, inter alia, would help in information flows between and among countries, training of high level manpower, dissemination of research and development results, etc., for the benefit of all mankind.

17.0 RECOMMENDATION

Subject to the foregoing, it is recommended that:-

(1) Top priority be given to development of solar water heaters, cookers, and wind and solar electricity generators to mainly meet the energy requirements of the rural people.

(2) A mechanism for the transfer, adaptation and acquisition of new and renewable sources of energy technology within the framework of United Nations programmes be established.

.../17

(3) In order to provide essential financing for development of new energy technologies in developing countries, a special fund be created to which both developing and developed countries would contribute on terms to be determined by the United Nations Conference.

(4) Regional co-operation be encouraged among neighbouring countries to address the development of new and renewable sources of energy in common areas of interest.

(5) In order to reduce the presently high cost of photovoltaic and windmill systems, which potentially have a very bright future in electricity generation, water pumping, etc., in Africa, and tropical countries elsewhere, consideration should be given to setting up regional manufacturing plants so as to fully realize the benefit of economies of scale. The funds for establishing such plants should be borne by member countries; and political differences between and among countries should not be allowed to interfere with such co-operative projects.

TABLE I PETROLEUM PRODUCT SALES - 1978 IN '000'LITRES

SECTOR / COMPANY	AGRICULTURE	ROAD RETAIL	RAIL	MARINE	POWER	COMMERCIAL INDUSTRIAL	GOVERNMENT	AVIATION	TOTAL
Caltex	12,390	103,882	74,574	40,078	6,053	72,643	9,823	130,269	449,712
Total	4,221	72,979	92	-	-	51,649	7,052	27,085	163,178
Mobil	14,440	57,943	-	35,946		29,791	11,588	52,553	202,261
Kenya Oil	2,540	2,503	530	-	-	9,167	6,941	-	21,681
Esso	-	83,459	20,584	35,081	-	62,662	10,859	28,794	241,439
Agip	6,681	47,584	-	-	-	59,019	-	-	113,284
Shell-BP	39,695	195,856	17,934	1,147	118,449	133,874	29,415	154,201	690,571
Total	79,967	564,206	113,814	112,252	124,502	418,805	75,678	392,902	1,882,126
Percent of Total	4.25%	29.98%	6.05%	5.96%	6.61%	22.25%	4.02%	20.88%	

ORIGINAL DATA IN METRIC TONS, CONVERSION ASSUMES 1,163 LITRES/METRIC TONNE)

Table IV CURRENT AND PROJECTED SUPPLY OF MOLASSES IN 000's TONNES

Sugar Mill		Y E A R					
	1979	1980	1981	1982	1983	1984	1985
	ACTUAL	E S T I M A T E D					
Miwani	12.9	14.0	18.0	20.0	22.0	23.0	25.0
Chemilil	15.7	17.0	17.0	17.0	17.0	18.0	21.0
Muhoroni	20.6	17.8	20.2	24.0	24.0	26.0	26.0
Mumias	27.7	48.0	48.0	48.0	48.0	48.0	48.0
Nzoia	12.9	11.0	16.7	19.5	20.0	24.0	24.0
Ramisi	6.9	8.5	10.5	12.1	13.0	15.0	17.0
Sony	-	14.4	16.0	20.0	24.0	24.0	24.0
Others	0.5	1.0	1.5	2.0	2.0	2.0	2.0
Total	97.2	131.7	147.9	162.6	170.0	180.0	187.0

Table V: CURRENT AND PROJECTED DEMAND OF MOLASSES

Utilization	1979	1980	1981	1982	1983	1984	1985
Miwani distillery	5.7	6.0	6.0	6.0	6.0	6.0	6.0
Export	74.6	60.3	0.7	-	-	-	-
Animal feeds	29.6	30.14	31.1	31.1	33.7	33.7	34.6
KCFC	-	-	110.0	110.1	110.0	110.0	110.0
ACFC	-	-	-	50.4	63.0	63.0	63.0
Total	109.9	131.7	147.9	198.5	211.8	212.8	213.6

TABLE 11

PRODUCTION, TRADE AND CONSUMPTION OF ENERGY EXPRESSED IN TERMS OF PRIMARY SOURCES, 1974 AND 1979 IN TONNES OF OIL EQUIVALENT AND AS PERCENT OF TOTAL

	1974		1979	
PRIMARY ENERGY BY TYPE	000 tons oil equivalent	% of Total	'000 tons Oil equiva lent.	% of Total
Coal and Coke imports	46.6	2.9	11.3	0.5
Imports of Crude Oil	2,902	-	2,471.5	-
Net Exports of Petroleum Fuels	1,458.8		713.4	
Stock changes and balancing Items	91.4		80.6	
Total consumption of liquid fuels - Local	1,352.1	84.5	1,677.5	79.7
Hydro energy local production of hydropower	131.3		314.0	
Imports of hydropower	71.0		38.4	
Total consumption of hydro energy	202.3	12.6	352.4	17.3
Total local energy produced	131.3		314.0	
Total Imports	1,561.7	97.5	1,807.8	88.5
Use of stock and balancing item	91.4		80.6	
Total Energy consumption	1,601.6	100.0	2,041.2	100.0
Local energy production as percent of Total	8.2		15.4	
Per capita consumption in terms of kilogram oil equivalent	123		133	

SOURCE: GOVERNMENT OF KENYA Economic Surveys, 1979 and 1980

TABLE III

TOTAL EXPORTS OF COMMODITIES INCLUDING OIL PRODUCTS AND OIL CRUDE & IMPORTS OF CRUDE OIL AND PRODUCTS.

YEAR	TOTAL EXPORTS K£'000'	IMPORTS OF PETROLEUM CRUDE AND PRODUCTS K£'000'	EXPORT OF PETROLEUM PRODUCTS K£'000'	OIL IMPORTS AS % TOTAL EXPORTS
1973	161,388	22,325	21302	13.83
1974	211,282	82,105	45614	38.82
75	215,125	96,125	58,552	44.68
76	318,657	103,830	68,966	32,58
77	480,259	117,343	83,759	24.43
78	369,965	117,658	69,463	31.80
79	393,700	145,714	76,859	37.01

CRUDE OIL AND PETROLEUM PRODUCTS IN '000' TONNES

TABLE III B

YEAR	IMPORT OF CRUDE & PETROLEUM PRODUCTS	EXPORTS OF PETROLEUM CRUDE AND PRODUCTS	NETT IMPORT
73	2,881	1,682	1,199
74	3,134	1,652	1,482
75	2,920	1,380	1,540
76	2,508	1,431	1,167
77	2,730	1,417	1,313
78	2,693	1,213	1480
79	2808	1,040	1,768

SOURCE: Government of Kenya Annual Statistical Report and Annual Economic Surveys.

TABLE VI BREAKDOWN BY INDIVIDUALS

AREA	KERICHO	KISII	NYANZA	KAKAMEGA	BUNGOMA	BARINGO	NYERI	TRANS-NZOIA	TOTAL
Farmers	15	10	25	20	18	6	5	12	111
Manufactures	-	-	1	-	1	-	-	1	3
Agricultural	3	5	4	9	7	3	3	5	39
Others	7	4	9	14	9	0	2	7	52
TOTAL:	25	19	39	33	35	9	10	25	195

The responses were analysed in terms of groups rather than individuals, as it is difficult to separate individual attitudes for most of the interviews, there frequently being more than one person. Moreover, there was strong inter-action between people in the group situation, with each person often provoking responses from others, usually in the form of agreeing with a proposition by expanding on details of problem causes and effects.

TABLE VII

PERCENTAGE OF GROUPS MENTIONING A FACT OR TREND

Facts or trends	All Groups	Farmers	Agricu. Officers	Manufactures
1. Sources of energy for heating and cooking:				
Charcoal	16	8	51	21
Firewood	31	44	5	-
Sisal leaves	22	30	-	-
Maize stalks	10	12	-	-
Bagasse	5	6	-	-
Paraffin stoves	4	-	34	35
Electricity	3	-	9	45
2. Benefit of biogas as an alternative energy source	43	34	54	42
3. Knowledge of biogas technology	37	19	80	67
4. Functional knowledge of biogas digesters	51	34	68	32
5. Availability of raw materials; number of animals owned by an individual (more than five heads)	56	43	13	9
6. Technical guidance on biogas technology; design, construction and maintenance	27	17	45	8
7. Availability of capital for installation of biogas digesters	17	28	14	33
8. Systems analysis of different combinations of energy sources and different techniques of management, consequences on the environment, weather effects, etc.	41	50	64	17
9. Energy crisis, studies and acceptance of fuel economy.	5	3	27	-