POLICY OPTIONS FOR FUTURE ENERGY USE IN SIERRA LEONE

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ABSTRACT

The paradox in Africa is that the continent does not lack energy sources but has failed to demonstrate proper energy management and planning regarding the exploitation and utilisation of these resources. This paper discusses the various policy options for the future energy use in Sierra Leone. The current energy balance sheet is presented. This provides the basis for predicting future consumption up to the year 2000 using socio-economic, political, institutional and demographic factors. Various policy options are investigated that match the computed future demand. This analysis provides concrete suggestions for policy formulation relating to future consumption, source exploitations and utilisation in Sierra Leone. Results obtained can be applied to other African countries.

INTRODUCTION

Oil-importing developing countries of Africa are plagued with huge balance of payment deficits, mounting external debts, dwindling export figures, and foreign exchange scarcity. To this is added the severe implications on the social fabric of their societies as the rate of utilisation of the most important traditional energy source, fuelwood increases.

This situation will persist unless drastic policy changes are made. The most plausible line of approach in securing an adequate energy supply both for survivial and development is to formulate a comprehensive energy policy. Such a policy requires not only baseline information regarding resources, consumption patterns, pricing structure etc., but also the predicted demand and various policy options to satisfy this demand. The latter aspect will be the focus of this paper discussed in relation to Sierra Leone.

The energy sources are briefly outlined to provide the background to the present consumption and future supply. Various policy options are analysed from which concrete suggestions are made to satisfy the future demand.

ENERGY SOURCES

Sierra Leone does not have a detailed energy source map at present. But certain ad hoc studies provide preliminary estimates for the various energy sources in the country. These studies form the basis for the discussion in this section.

The energy sources of Sierra Leone can be classified into renewable and non-renewable sources. The former are hydro, direct solar, biomass and to a limited extent wind. The latter are lignite and crude oil.

Lignite deposits are found 70 km from the capital and the north eastern part of the country. Though there are no precise estimates, UNDP (1980) suggests a figure of 740,000 tons of proven and indicated quantities. These deposits have significant clay with them. The south western coastal areas of the country are presently being prospected for crude oil. Though work has been going on for the past two years there has been no government report regarding their findings.

Due to the geographical position of the country, solar energy is a very attractive energy source. Sherriff (1982) computed the horizontal radiation for various areas of the country for the different months of the year. The country average was estimated to be 395 cal/m^2/day. Wind energy is less attractive. Proximity to the equator results in very low average wind speeds.

Hydro sources are the greatest energy resource. Present potential is estimated at over 600 MW of both large and mini units. Inadequate funds and source data have prohibited the exploitation of this source. Another problem is the major seasonal variation in water levels. These fall to as low as 10% of the maximum during the dry season.

Biomass is a major energy source in the country. Forms available include fuelwood, ethanol from a sugar refinery, and agricultural and animal wastes. Atlanta (1979) estimated the high forests to be 5% and secondary forests 4% of the total land area of 72,000 km^2. Up to 90% of the total wood used in Sierra Leone is for fuelwood. Agricultural wastes include groundnut shells, coconut husks, sawdust etc. In addition to human waste, there are significant quantities of cattle waste in selected regions of the country.

ENERGY CONSUMPTION

The inadequacy of data and poor quality data collection makes it difficult to evaluate the energy consumption levels in Sierra Leone. Data regarding non-commercial energy are non-existent and those for commercial energy are not properly organised. The situation is improving. Davidson (1983) conducted a nation-wide survey of all the energy consuming sectors for the year 1982. Data from this study forms the basis for computing the current energy balance sheet below.

Survey

The energy economy was divided into sub-sectors that were classified as follows:

- residential, households of urban and rural areas
- commercial, operations and premises of commercial centres
- industrial, all formal and informal activities, mining, manufacturing, factories etc.
- agriculture, directly farming and indirect activities
- transportation, all modes of transport passengers and freight
- services, government institutions, hospitals, schools and public corporations.

Methods employed included examination of existing records, personal interviews and observation, and administration of questionnaires. Various sampling techniques depending on the sub-sector studies. In several cases new techniques to extract information had to be introduced.

Energy balance sheet

The overall energy balance is shown in Table 1. Over 50% of the commercial energy is used by the transportation sector. For non-commercial sources, the domestic sector becomes dominant. This is mainly due to the prominence of fuelwood which is used mostly for cooking. The relatively low efficiency of the devices in domestic use account for the high energy used by the domestic sector. There is greater diversity in fuel sources used in urban households than rural households. Travel by road is significant because of the volume of cars and the absence of a rail system. Sea transport is very limited and not as organised as road. The high value for sea transport is mainly due to the high value for bunkering. Industrial activities are quite low in Sierre Leone. Mining, which produces its own electricity, is by far the most important industrial activity.

These results now form the basis for future energy use to be computed.

FUTURE ENERGY USE

The national economies of most developing countries are weak national economies. This reduces their control over future trends. Usually their policies are largely dictated by outside forces. This increases their vulnerability to the pitfalls of the international economic system. This makes it difficult to predict energy use since there is a strong interaction between economic development and energy use. The local factors such as erratic performance and disorder normally experienced in various sectors of the national economy only reinforces this point.

Ideally to make reliable forecasts for future energy use demands the development of techno-economic computer models based on consistent and realistic assumptions of the various consuming sectors of the energy. Presently, we are developing a computer model that will be capable of predicting future energy use in LDC's. However, using currently available data a set of consistent and realistic assumptions have been used here to evaluate the future energy use. These assumptions can be summarised as:

- economic - income, trade patterns, global trends, debt involvements, etc.
- political - policy change, structural change, etc.
- technological - technology imports, local capability, technical changes, etc
- institutional - social systems, infrastructure etc.
- demographic - population change and distribution, household size, urbanisation etc.

Since these factors are not entirely independent they will not be discussed separately. This work is concentrated on the end-use of energy hence the analysis will be discussed in terms of demand by the various sub-sectors. Though not the only way of looking at future use, this provides one approach to evaluating future demand.

Using the present consumption as the baseline the future energy demand is predicted up to the end of the century using 1990 as the intermediate point.

Apart from various assumptions for the specific sub-sectors, some general ones were made regarding the factors outlined above. These assumptions were arrived at after discussions with the relevant government authorities, the assessment and observation by the author in specific areas, and government records.

The most important economic factor used in this analysis is the gross domestic product (GDP) and an annual rate of 4.1% is used. The effect of the parallel market due to smuggling was also considered. It was assumed that with time smuggling will decline and the GDP will be more reflective of the national economy.

The expected major shift in policy calls for more efficient management of the country's resources. This will show up as an overall improvement of the economy. Due to foreign exchange restrictions the country will be forced to increase local production of basic equipment using local materials as best as possible. This will assist in improvement in domestic appliances.

The trend for technical changes in global perspective will also affect the technology imports and better energy efficient devices will be used in various industries. There will be a time lag between the development of technology and its use in developing countries.

The expected changes in demographic factors will have serious implications on the total energy use. The population is growing at 2.8% per year. But with the present campaign for family planning, increased urbanisation, better health facilities, and literacy improvements population growth is expected to fall to about 2.6% per year. Improvement in the overall development of a nation reduces the rate of population increase. Rates were also assumed for shift between the urban and rural population. The fact that as humans become economically better off they move to more energy intensive activities was considered by looking at the movement between income groups at both urban and rural sectors. A summary of the demographic and economic assumptions made in analysis are given in Table 2.

Sectoral assumptions

The differences in the energy demands of the various sub-sectors necessitates that they are discussed separately.

Household

The projected household profile is shown in Table 3 for the years 1990 and 2000. Estimates are given for the various income groups as identified by Davidson (1983). The various end-uses were considered as significant changes are expected to occur for the different end-uses. Though there are likely to be substantial changes in cooking it is expected that more efficient devices will be introduced. This will have more impact on the people using firewood and charcoal. The change in the distribution between the different income groups in rural and urban areas is expected to change in the 1990s and 2000. This will also affect energy demand. The expected drift in population from rural to urban explains the reduction seen in Table 3 for rural areas.

Industrial

Table 4 presents predicted changes in energy demand within the industrial sector. Mining, the most important industrial activity is expected to increase in the coming years. It is assumed that a second bauxite company will start and that kimberlite mining in the present diamond mining site will be on-stream. Intense gold mining activity and rutile and iron ore mines will continue. these activities account for the increase observed in the mining section. Food processing is also expected to increase significantly due to the growth in agro-based industries and the present call for food processing in the country. Construction is expected to increase due to improvements in infrastructure especially road building.

Transportation

Only moderate growth is expected in the transportation sector based on expected improvement in the economy (Table 4). The expected shift to high income earners will contribute to the increase in car travel. Government participation and also congestion in urban travel will force more people to travel by mini-buses.

Agriculture

An increase in mechanised agriculture is expected due to the current food shortages and the involvement of more sophisticated business operators in farming. Also the fruits of the various government projects are expected to have yielded results. Hence, agriculture and its support services will become more energy intensive (Table 4).

Only moderate growth is expected in the commercial and services sector. They are very dependent on the nature of the economy (Table 4).

Table 5 summarises the predicted changes in energy consumption within all the sectors including the percentage contribution to total consumption.

POLICY OPTIONS

The summary of the future use of energy shows that a 7.5% increase is expected by the year 1990 and 12.0% by the end of the century. The existing source of supply cannot support such requirements. This section discusses various policy options that are aimed at solving this problem using as much locally available resources as possible.

Four possible policy options are:

- increased fuelwood
- improved fuelwood stoves and kilns
- introduction of new and renewable energies
- conservation measures.

They are interdependent but will be discussed separately.

Increased fuelwood supply

There is a high demand for fuelwood which will escalate unless measures are taken to counteract this. People especially in rural areas, do not have alternative to fuelwood. Therefore it is very important that adequate arangements are made to assure the supply of wood.

Agroforestry, ie combining selected tree species with existing food crops, is an attractive option for many reasons. It is estimated that 50% of present fuelwood comes from land preparation for farming. Selected trees can be intercropped with certain food crops and this means fuelwood is close to the farm. An added advantage is that trees help to prevent soil erosion. Davidson (1985) recommends Albizzia adianthifolia and A. zygia. They have calorific values over 4000 kcal/kg and are high yielding and fast growing.

Another method of increasing fuelwood supply is by plantation programmes to replant depleted forest areas, and develop plantation farms in forest or periurban areas. Trees for such programmes would include Albizzia and Luceana. An added advantage of these trees is that they fix nitrogen in the soil as well.

The expected potential of this supply option: **Tree yields of 10-15 tonnes/ha in 2000-5000 ha producing 39000 tonnes/ha by 1990 and twice that in 2000.**

Improved fuelwood stoves and kilns

One method of conserving fuelwood is to introduce improved stoves that can use both charcoal and firewood. Efficiency of existing stoves are under 15% and the three stone stoves is as low as 9%. Improved stoves are now available with efficiencies up to 25% (Davidson 1985).

The inefficiency of charcoal production in which 75% of useful heat is lost (Davidson 1983), compounds the problem. Metal kilns or pyrolysis in industrial process can improve the situation. More convenient cooking does not necessarily save fuel and large scale introduction will definitely have an effect.

Expected potential: **Using 25% efficient stoves and more efficient charcoal will reduce energy demand for cooking by 10-15%.**

New and renewable sources

New and renewable energy sources in Sierra Leone are likely to have an impact on the overall energy picture and include:

- Biogas for rural application in individual houses
- Biogas for selected industrial activities
- Producer gas for selected industrial purposes
- Direct solar for water heating, water pumping, crop drying, and to a limited extent communications
- use of ethanol both as a fuel or as additive in the transport sector
- agricultural wastes in improved stoves, ovens, smokers etc.

Expected impact: **Biogas will have greatest impact mainly in northern provinces; ethanol could save 15% of transport costs; other sources would provide for 5% of domestic demand.**

Conservation measures

This option will prove very useful for the industrial sector in two ways. Firstly by achieving very low running costs and in certain cases no costs at all by improving performance of existing equipment through proper auditing and close monitoring. This might involve introducing some retrofitting but at cost that can be afforded by the industries. Secondly introducing more efficient devices. Technology presently available in developing countries can cut production energy consumption by a factor of 5 to 10 (Davidson 1985). It will be very useful because of the stage of industrialisation of many developing countries means they need to purchase new machines.

Expected gains: **10% of industrial needs by 1990 and 20% by 2000.**

All these policy options call for strong political will and a comprehensive study on energy pricing. This mechanism can also be used to stabilise the energy situation but this issue is not considered here.

CONCLUSIONS

This study shows that significant savings can be made by taking certain policies. These are:

- Increase fuelwood supply by adopting measures suggested
- Subsidise programmes to introduce stoves and kilns in both urban and rural areas
- Create schemes for utilising biogas in the northern province. Use tax incentives for industrial purposes. Producer gas can be utilised as well. Encourage solar water heating for urban areas and crop dryers for rural areas
- Encourage fuel switching in transportation sector between diesel and petrol. Use ethanol produced locally as additive
- Encourage intense conservation programmes
- Existing programme for electricity by hydro should be intensified.

These policies along with political will can go a great way to solving the imminent energy crisis.

ACKNOWLEDGEMENTS

The author wishes to express his sincere thanks to the various government and other agencies in providing information for this work. The funds from the University and the International Development Research Centre (IDRC) of Canada are deeply appreciated. The work of the research team is acknowledged.

REFERENCES

Atlanta (1979) Forest resource development in Sierra Leone. UNECA Study.

Davidson O R (1983) Energy use patterns, Sierra Leone. IDRC Project Report 3-P-80-011.

Davidson O R (1985) Fuelwood use in Sierra Leone. Procs of OAU Energy Expert Meeting, Lome, Togo, February, 1985.

O'Keefe P, Raskin P, Bernows (1984) Energy, environment and development in Africa, Kenya. Beijer Institute and SIDA, Sweden.

Sherrif A Y (1982) Prediction of solar radiation in Sierra Leone (Dissertation. B. Eng) University of Sierra Leone.

UNDP (1980) The availability and possible uses of lignite deposits in Sierra Leone 1980. Sierra Leone 178-005.

TABLE 1: Energy consumption by sectors 1982 (TJ)

Source	Domestic	Commercial	Industrial	Agriculture	Transportation	Services	Electricity Production
Gasoline	-	-	-	-	1988.0	-	-
Diesel	-	7.0	1236.35	8.04	1992.0	7.9	1.96
Kerosene	1263.0	-	37.97	-	592.0	-	-
Fuel oil	-	-	106.79	-	1499.0	-	1134.8
LPG	377.5	-	0.14	-	-	-	-
Lignite	-	-	0.55	-	-	-	-
Sub-total	**1640.5**	**7.0**	**1678.75**	**8.04**	**5971.0**	**7.9**	**1136.76**
Commercial (%)	(16.6)	(0.07)	(17.03)	(0.08)	(54.6)	(0.08)	(11.5)
Firewood	31,588.0	84.51	76.9	-	-	4.43	-
Charcoal	4441.0	13.03	103.5	-	-	-	-
Agric. waste	12.1	-	88.6	-	-	-	-
TOTAL ENERGY	**37,681.0**	**104.5**	**1947.75**	**8.04**	**5971.0**	**12.17**	**1136.76**
(%)	**(81.4)**	**(0.2)**	**(4.2)**	**(0.02)**	**(11.6)**	**(0.03)**	**(2.5)**

TABLE 2: Summary of demographic and economic assumptions used in the analysis

Variable	1982 base year	1990	2000	Average Annual Growth (%)
Population (Millions)				
Total	3.356	4.124	5.341	2.6
Urban	0.839	1.32	2.136	7.0
Rural	2.517	2.804	3.205	2.1
Persons/Household				
Total	7.94	7.4	7.0	
Urban	7.0	6.6	6.1	
Rural	8.3	7.9	7.5	
Income Distribution %				
Urban				
Group 1	56	49	40	
" 2	24	27	31	
" 3	15	17	19	
" 4	5	7	10	
Rural				
Group 1	100	95	90	
" 2	negl.	5	10	
Gross Domestic Product (Lem)	1264.5	1743.8	2606.1	4.1
GDP/Capita (Le)	376.8	422.8	487.9	1

TABLE 3: Household end-use energy predictions

Income Group	End Use	Energy Demand TJX10^3 1982	1990	2000
URBAN				
1	Cooking/heating	3.35	3.39	4.03
	Lighting	0.37	0.38	0.46
	Ironing	1.19	1.21	1.44
	Others	0.07	0.08	0.08
	Sub-Total	**4.98**	**5.05**	**6.01**
2	Cooking/heating	2.25	2.66	4.45
	Lighting	0.20	0.24	0.39
	Ironing	0.62	0.73	1.23
	Others	0.06	0.06	0.11
	Sub-Total	**3.13**	**3.69**	**6.18**
3	Cooking/heating	1.06	1.69	2.76
	Lighting	0.12	0.20	0.32
	Ironing	0.32	0.51	0.83
	Others	0.05	0.07	0.12
	Sub-Total	**1.55**	**2.47**	**4.03**
4	Cooking/heating	0.31	0.72	1.50
	Lighting	0.04	0.07	0.18
	Ironing	0.09	0.20	0.42
	Others	0.02	0.05	0.42
	Sub-Total	**0.46**	**1.06**	**2.21**
	TOTAL	**10.12**	**12.27**	**18.43**
RURAL				
1	Cooking	25.48	24.00	17.88
	Ironing	1.85	1.74	1.3
	Lighting	0.68	0.68	0.47
	Sub-Total	**28.01**	**26.42**	**19.65**
2	Cooking	-	1.09	2.24
	Ironing	-	0.22	0.45
	Lighting	-	0.14	0.30
	Sub-Total	**negl.**	**1.45**	**2.99**
	TOTAL	**28.01**	**27.87**	**22.64**

TABLE 4: Energy demand for other sub-sectors

Sub-Sector		DEMAND (TJ) 1982	1990	2000
Industrial				
	Mining	1193.65	1392.96	1851.26
	Construction	152.30	197.99	251.39
	Eng. metal	98.70	138.18	193.45
	Food Procs	53.73	73.85	159.69
	Others	449.87	494.86	544.34
Transportation				
	Cars	1100.20	1613.40	2218.40
	Buses	814.10	932.40	1242.10
	Freight	1189.70	1308.67	1439.54
	Air	592.00	651.20	716.32
	Sea	2135.68	2345.25	2584.17
	Others	139.32	153.25	168.57
Agriculture				
	Machines	8.02	16.04	24.06
	Services	0.74	1.11	1.55
Services Commercial		116.67	128.37	141.21

TABLE 5: Summary of energy productions

	1982		1990		2000	
Sub-Sector	**TJ**	**%**	**TJ**	**%**	**TJ**	**%**
Domestic	38,130.00	81.40	40,140.00	78.90	41,070.00	77.30
Industrial	1947.75	4.20	2297.84	4.50	3000.13	5.70
Transportation	5971.00	11.10	7008.17	13.8	7482.10	14.10
Agriculture	8.76	0.02	17.15	0.03	25.61	0.03
Services & Commercial	116.67	0.23	128.37	0.28	141.21	0.27
Electricity Production	113.00	2.50	1250.31	2.50	1375.34	2.60
TOTAL	**47,310.89**	**100**	**50,841.80**	**100**	**53,094.39**	**100**