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Summary of Energy Planning Technical Support to the Government of Liberia

Garland Samuels

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MARTIN MARIETTA ENERGY SYSTEMS, INC.
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Energy Division

SUMMARY OF ENERGY PLANNING TECHNICAL SUPPORT TO THE GOVERNMENT OF LIBERIA

Garland Samuels

Prepared for
U.S. Agency for International Development (AID)

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ABSTRACT

Subsequent to a general assessment of energy options for Liberia, the principal activities of this program were (1) an assessment of the economics of wood energy in Liberia, (2) a study of the potential for energy conservation in government buildings, (3) assistance in completing the 1982 Liberian energy balance, and (4) assistance in preparing the National Energy Plan. This report discusses the first three of these activities. A draft of the National Energy Plan was submitted in January 1985 to member agencies of the Liberian National Energy Committee for their review and comments.

Liberia used the equivalent of 13.2 million barrels of crude oil in 1982— 67% from fuel wood, 4% from hydro, and 29% from imported petroleum. The wood was used almost entirely (~99%) by the residential sector. Iron ore mining operations accounted for about 60% of domestic consumption of petroleum products. The transportation sector accounted for another 25%. The energy consumed by the agriculture and forestry sector was less than 2% of domestic consumption and was used primarily for operations of the large rubber plantations and timber concessions. Very little energy was used for food production.

Significant energy savings in government buildings would require a major remodeling effort, including replacement of the louvered windows; extensive repairs to close large gaps around windows, air conditioners, and doors; and extensive caulking. The payback period from energy savings would be long.

The assessment of the economics of wood energy indicates that wood can probably be delivered to a small rural power plant at costs that make this feedstock highly competitive for some and perhaps most of Liberia's rural electric stations.

1. INTRODUCTION

In March 1982 the U.S. Agency for International Development (AID) and the U.S. Department of Energy (DOE) entered into an agreement through which the Oak Ridge National Laboratory (ORNL) provided energy planning assistance to the Government of Liberia (GOL). This initial agreement was to fund a one-year project to help in conducting a National Energy Assessment[1] and to provide professional development support to upgrade the energy planning capabilities of GOL agencies and staffs. The assessment was intended to help identify energy options for Liberia and to serve as a basis for eventual development of a National Energy Plan.

Following the completion of the initial energy assessment, AID contracted with ORNL (1) under the auspices of AID's Energy Initiatives in Africa program to provide a resident energy advisor to the GOL for a two-year period to help the GOL continue data collection and policy analysis activities and to aid in developing a National Energy Plan and (2) as part of AID's Energy Policy Development and Conservation Project (Office of Energy, Bureau of Sciences and Technology) to provide short-term technical support to the GOL and to the national energy advisor to carry out these activities.

This report summarizes the work performed under the agreement to provide short-term technical support. Personnel engaged in this effort were T. J. Wilbanks, R. D. Perlack, G. D. Pine, and G. Samuels. The resident energy advisor to the GOL was W. F. Barron.

The principal activities of the program were (1) an assessment of the economics of wood energy in Liberia, (2) a study of the potential for energy conservation in government buildings, (3) assistance in completing the 1982 Liberian energy balance, and (4) assistance in preparing the National Energy Plan. The following sections discuss the results of the first three of these activities. A draft report of the National Energy Plan for Liberia has been submitted (January 1985) to the member agencies of the Liberian National Energy Committee. The Table of Contents for the National Energy Plan is shown in Appendix A.

2. 1982 LIBERIAN ENERGY BALANCE

One of the primary objectives of the initial Liberian National Energy Assessment and the follow-up work was to compile a data base of energy flows within the Liberian economy. The initial energy balance for 1981 was completed in early 1983, near the end of the first phase of the National Energy Assessment.[1,2] The 1982 energy balance, shown in Table 1, was completed in early 1984.[3]

Although data collection continued throughout 1983 on several specific topics, a shortage of staff and a lack of response from several key private sector organizations to data requests from the National Energy Committee hampered attempts to collect 1982 data in the same detail as that collected for 1981. Thus, in a number of cases, the 1982 energy balance is based on 1981 data or 1981 data adjusted to reflect changes in economic activity.

Two methodological procedures should be noted here. In certain cases data are available on the consumption of fuel and in other cases only on the sales of fuel. Whenever available, consumption values are used because these values provide a better picture of energy used to meet given levels of economic activity. Since sales figures are the only available information in certain cases, the data are not entirely consistent.

For sectors in which direct 1982 energy values are unavailable and indicators of economic activity are available, the 1982 value for energy use is based on a simple scaling of the 1981 value by the ratio of 1982 to 1981 economic activity. Where both energy data and economic activity data are unavailable, 1981 energy values are used unchanged for 1982.

The data of Table 1 include a number of assumptions and procedures. All forms of energy are expressed as equivalent barrels of crude oil (BCOE) with the conversion factors listed in Appendix B. Hydroelectric output is equated to the quantity of oil that would be required to generate the electricity. The conversion factor (1 BCOE per 575 kWh) is based on the efficiency of the large, low-speed diesels operated by the Liberia Electricity Corporation (LEC).

The first two rows of Table 1 show total domestic energy production and those imports handled or recorded by the Liberia Petroleum Refining Company (LPRC). There are discrepancies between the sum of these two rows and total consumption that are accounted for in the third row of the table (stock drawdown/other imports). For example, 2,595,000 bbl of crude oil were refined in 1982 compared to imports of 2,558,000 bbl (see Appendix C). Thus, 37,000 bbl were drawn from inventory. For gasoline, total LPRC sales exceeded the sum of imports plus refining output by 26,000 bbl. The largest value shown for stock drawdown/other imports is for fuel oil. This value was derived from the difference between known or estimated consumption of the largest consumers

Table 1. 1982 Liberian energy balance (10^3 BCOE)

	Fuel wood	Hydro	Crude oil	Charcoal	Electricity	Fuel oil	Gas oil	Gasoline	Kerosene	Jet fuel	Other petroleum*	Total energy	Total petroleum
Production	8900	518										9418	0
Imports			2558			158	358	54		41		3169	3169
Stock drawdown/other imports			37			361	183	26	3	−6	20	624	624
Total available	8900	518	2595			519	541	80	3	35	20	13211	3793
Charcoal production	−2350			2350									
Charcoal production losses				−1880								−1880	
Petroleum refining			−2595			1368	550	411	32	160	74		
Petroleum refining losses						−95	−12	−2			−58	−167	−167
Exports**						−192	−15	−23		−181	−29	−440	−440
Domestic consumption	6650	518	0	470		1600	1064	466	35	14	7	10724	3186
LEC generation		−481			775	−110	−184						−294
LEC generation losses					−537							−537	
LEC transmission and distribution losses					−36							−36	
Sectoral consumption	6650	37	0	470	202	1490	880	466	35	14	7	10151	2892
Transportation							−351	−446		−14	−4	−815	−815
Road							−246	−441			−4	−691	−691
Rail							−99					−99	−99
Sea/air							−6	−5		−14		−25	−25
Mines end use					−368	−361	−216					−945	−577
Mines generation					1303	−1122	−181						−1303
Mines generation losses					−886							−886	
Industry	−15				−18	−7	−15					−55	−22
Residential	−6490			−460	−139		−3		−25		−3	−7120	−31
Commercial end use	−15			−10	−76		−5		−10			−116	−15
Commercial generation					35		−35						−35
Commercial generation losses					−26							−26	
Government					−23							−23	
Agriculture and forestry	−30				−23		−50	−20				−123	−70
Agriculture and forestry generation		−37			61		−24						−24
Agriculture and forestry generation losses					−42							−42	

*Other petroleum includes naphtha, liquid petroleum gas, asphalt, and fuel gas.

**Exports include fuel for international commerce.

and sales reported by LPRC. For example, one of the three iron ore mining companies, Bong Mining Company (BMC), reported the consumption of 1,190,476 bbl (1,290,500 BCOE) compared to reported sales by LPRC to BMC of 1,060,848 bbl (1,150,000 BCOE). Thus, BMC accounted for 140,500 of the 361,000 BCOE shown. The 20,000 BCOE of other petroleum is the difference between LPRC exports and production of naphtha (see Appendix C).

For charcoal production, Table 1 shows 2,350,000 BCOE transferred from the fuel wood column to the charcoal column (without any energy used). The average efficiency of the conversion of wood to charcoal is assumed to be 20%; thus, charcoal production losses are 1,880,000 BCOE, with 470,000 BCOE available for domestic consumption. A similar procedure is used for petroleum refining and LEC generation. In each case the sum of the values in each row is zero, with the losses shown in the following row. For LEC generation, the total energy consumption is 775,000 BCOE—481,000 from hydro, 110,000 from fuel oil, and 184,000 from gas oil. The gas oil consumption includes that reported by LEC for the central grid (123,000 BCOE) plus an estimated 61,000 BCOE for the rural generating stations. Generation losses were 537,000 BCOE, leaving an electrical output equivalent to 238,000 BCOE, or 405 GWh. Transmission and distribution losses were about 15% of generation—36,000 BCOE—leaving 202,000 for sectoral consumption.

Electrical generation by the mining, commercial, and agriculture and forestry sectors is presented in the same manner as for LEC. However, part of the generation at the mining sites is supplied to their associated towns. Of the 1,303,000 BCOE consumed at the mines for generation, 886,000 was lost in generation, leaving a net output of 417,000 BCOE. In addition, BMC has an exchange agreement with LEC whereby BMC receives 1.3 units of electricity from LEC's hydroelectric output during the rainy season in exchange for 1 unit during the dry season. Under this agreement BMC received the equivalent of 6000 BCOE over that supplied to LEC. Thus, total electricity used by the mines and their associated communities was 423,000 BCOE. Mining operations used 368,000 BCOE, and 55,000 BCOE was supplied to the towns, which are included in Table 1 in the residential and commercial sectors—80% to the residential sector and 20% to the commercial sector.

The residential sector accounted for about 9,300,000 BCOE, or 71% of all energy available. Direct energy use was 6,490,000 BCOE of fuel wood, 460,000 of charcoal, 139,000 of electricity, and 31,000 of petroleum products. In addition, charcoal conversion losses were 1,840,000 BCOE, and electrical generation, transmission, and distribution losses were 363,000. Although total primary energy use was about 9,300,000 BCOE, only 305,000 BCOE was from petroleum products—31,000 of direct use and 274,000 used for the electricity supplied.

The iron ore mining companies accounted for over half of all domestic consumption of petroleum products. Direct end use was 577,000 BCOE, with another 1,134,000 BCOE used for the electricity supplied. Also, the 99,000 BCOE shown for rail transportation was for the three railroads operated by the mining companies to haul ore.

The other major energy-consuming sector is transportation, which accounted for about 25% of domestic consumption of petroleum products—mostly for highway transport. The reason for the small value shown for sea/air is that fuels used for international commerce are included in exports.

In summary, of the 13,200,000 BCOE of energy available in 1982, 67% was fuel wood, 4% hydro, and 29% petroleum. The fuel wood was used almost entirely (~99%) by the residential sector. The mining operations, including their associated communities, accounted for about 60% of the domestic consumption of petroleum products. Transportation accounted for another 25%. The energy consumption in the agriculture and forestry sector was primarily for operation of the large rubber plantations and timber concessions. Very little energy was used for food production. Most industrial operations in the country are in the mining or agriculture and forestry sectors.

3. POTENTIAL FOR CONSERVATION IN GOVERNMENT BUILDINGS IN LIBERIA

One area identified for additional study during the initial Liberian National Energy Assessment was the obviously inefficient use of energy for air conditioning in government buildings. Although the methods of record-keeping often make it difficult to identify energy use by government-owned corporations, total electricity used by these corporations and other government ministries and agencies is about 20% of the total demand on the LEC. Futhermore, most of the government building electricity demand is for air conditioning, which reaches a peak during the dry season when most of LEC's electricity output is derived from petroleum and when the LEC has been forced to resort to rolling blackouts to restrict demand to match operable generating capacity.

The study of the potential for conservation in government buildings consisted of an inspection and collection of selected information from six buildings and a detailed analysis of one.[4] The building selected for detailed analysis was considered typical in regard to conditions of the building, lack of general maintenance, and the relative importance of the various air conditioning loads.

The building analyzed most thoroughly is a two-story office building constructed during the 1960s. It is of concrete block wall construction with 3-ft exterior overhangs approximately 1 ft above both the first- and second-floor windows. The windows are single-pane louvered windows with aluminum frames. The roof is a concrete slab with an additional built-up wood layer of 2 x 4s and a galvanized, corrugated steel top layer. The floor of the building is a concrete slab. All lighting is fluorescent, and air conditioning is provided by individual wall units in the offices.

The inefficient use of energy within the building was apparent from even a casual inspection. Nearly every office had an air conditioner whose compressor ran constantly without cycling on a typical dry season day. Windows in the air-conditioned offices typically were poorly sealed and often were actually opened from ½ to 6 in. while the air conditioners operated. Many of these windows would not close because the crank mechanisms to shut the windows had become inoperable, and the window panes themselves were quite frequently impossible to move at all because of corrosion of the frames. Some windows were missing large pieces of glass. The corrugated metal roof was once shiny and a good reflector of solar radiation, but after two years in the hot, humid environment, it had become rusty and absorbed solar heat, adding to the heat load inside the building. Although the walls were in better condition than the windows or roof, they had received a coat of paint infrequently and so absorbed more solar radiation than they might have. In short, the building had received inadequate maintenance except for air conditioners, which were occasionally repaired or replaced.

It was concluded that repairing windows and painting the roof and walls would have little effect on electricity consumption, especially during the critical dry season between November and April. Even with the louvered windows repaired to the point that they would close and with missing glass sections replaced to reduce the number of air changes per hour to two, calculations indicate that the building load would exceed the capacity of the air conditioners much of the time. The analysis suggests that with the above improvements the air conditioners would still run essentially constantly during the dry season, although these measures would improve the comfort level of the building. The improvements would have little effect during the rainy season because air conditioning is used much less frequently during that time. Some benefits might be achieved during the months of transition between the rainy and dry seasons, but electricity shortages are generally not a problem at those times. Electricity is supplied by the Mt. Coffee hydroelectric station at those times, and the marginal cost of power is not high nor is the supply of electricity inadequate. Therefore, the above improvements, while desirable to improve the comfort of the occupants of the building and undoubtedly beneficial in the long term in preserving the existing buildings infrastructure of the government, will have an insignificant impact on electricity consumption in the building.

Significant energy savings in these buildings would require a major remodeling effort, including complete replacement of the louvered windows; extensive repairs to close large gaps around windows, air conditioners, and doors; and extensive caulking. The payback period from energy savings for a major remodeling would be long.

4. COSTS OF FUEL WOOD FOR POWER PLANTS IN RURAL LIBERIA

In Liberia, as in many developing countries, electrification of towns and cities throughout the country has long been a major development goal. Yet, in recent years, the quality of "rural" electric services in Liberia has been declining, and the future economic viability of these power stations is a growing concern.[1,5,6] Each of the nine operating and each of the planned rural power stations is designed to operate exclusively on gas oil (diesel fuel). Fuel expenditures by the LEC for the rural public stations represent a major and growing burden on the financially hard-pressed utility.[5,6]

Wood-fired electric power plants are operating in many parts of the world, including West Africa. Such plants have been proposed in Liberia as a means of reducing costs, utilizing domestic resources, and stimulating local economic development in the areas served by the rural electric power plants in Liberia.[1,7,8] A major determinant of the economic viability of wood electric power plants is the cost of the wood feedstock. This section summarizes an analysis made of the economics of wood supply under Liberian conditions in order to develop a better understanding of the viability of converting part (and perhaps eventually the greater part) of Liberia's rural electric system to wood fuel.[9]

This analysis estimated the cost of wood energy for four different wood supply systems and for power plants with three levels of wood requirements. The four wood supply systems were retired or abandoned rubber trees; secondary growth forests (removed as part of the slash and burn cultivation system after five to seven years of growth); wood energy plantations with the land returned to agriculture for one or two years after each cutting; and wood energy plantations without agricultural development. The major difference between the two plantation systems is that the latter would rely on coppicing to regenerate the stand after cutting, whereas the first would require replanting for each cutting.

The upper bound (Case 1) on the feedstock requirements for this analysis was set by a 1.5-MW, wood-fired steam plant operating at an annual average capacity factor of 60%. Assuming 190 harvest days per year for operation of the wood delivery system, a plant efficiency of 15%, and wood delivered with a wet-basis moisture content of 25%, about 70 tonnes/day would be harvested. Total annual requirements would be 13,250 tonnes.

The second system considered (Case 2) was also a 1.5-MW steam system, but in this case it was operating in combination with a small run-of-the-river hydroelectric plant. The steam plant was assumed to operate as a base load plant five months each year at a plant capacity factor of 60%, to operate as an interseason intermediate load plant for five months at a capacity factor of 30%, and to be idle at the height of the rainy season for two months. Peak harvest requirements were 60 tonnes/day, with 30 tonnes/day required during the intermediate load period. Total annual wood demand was 8280 tonnes.

The last plant system (Case 3) was a 400-kW gasifier engine system assumed to generate with an average annual load factor of 50%. This engine would, at least initially, probably be operated on charcoal to reduce operating and maintenance problems. With a wood-to-charcoal thermal efficiency of 30%, a gasifier engine operating efficiency from combustion to thermal electric output of 20%, and a 25% wet-basis moisture content for the wood, requirements for wood supply would be 20 tonnes/day. Total annual wood requirements would be 3750 tonnes. To keep this analysis focused on the cost of supplying the wood feedstock, we assume that the charcoal kilns are on the grounds of the electric power plant and the responsibility of the plant operator (not of the wood supplier). Likewise, under each of the three cases, storage facilities for the wood are assumed to be the responsibility of the plant operator and not of the wood supplier.

The results of the analysis for each of the four wood supply systems are shown in Tables 2–5. Table 6 summarizes the data for the four systems and shows the cost of diesel fuel delivered to rural power stations. These results indicate that the use of wood to fuel rural station electric power plants in Liberia is a viable economic option. The cost advantages of systems utilizing currently existing biomass stand out sharply in comparison with those requiring the growing of trees. Clearly, wood suppliers will prefer to utilize the standing biomass resource base as long as it is available within acceptable transport distances. The cost disadvantages of wood energy plantations relative to the "mining" of existing resources must be evaluated in view of the transport cost advantages and security of supply considerations.

Table 2. Annual costs of retired rubber trees

	Case 1	Case 2	Case 3
Cost component			
Stumpage*	$34,700	$21,700	$9,800
Harvesting	$54,400	$34,000	$15,400
Transportation**	$69,800	$47,400	$23,200
Margin for risk	$31,800	$20,600	$9,700
Total annual costs	$190,700	$123,700	$58,100
Annual harvest (in tonnes)	13,250	8,280	3,750
Average annual cost ($/tonne)	14.40	14.90	15.50
Average annual cost ($/GJ)***	1.01	1.04	1.08

*An average stumpage cost of $2.62 per tonne is used.

**Average round trip transport distance for use of retired rubber trees is assumed to be 20 km.

***Energy content of wood is assumed to be 14.3 GJ/tonne.

Table 3. Annual costs of secondary growth forests

	Case 1	Case 2	Case 3
Cost component*			
Harvesting	$57,700	$36,300	$16,300
Transportation**	$95,400	$79,700	$37,500
Margin for risk	$30,600	$23,200	$10,800
Total annual costs	$181,700	$130,800	$64,700
Annual harvest (tonnes)	13,250	8,280	3,750
Average annual cost ($/tonne)	13.90	16.80	17.20
Average annual cost ($/GJ)***	0.97	1.18	1.20

*Stumpage cost is assumed to be zero in this case. In practice some charges may occur, but these are expected to be low.

**Average round trip transport distance for use of secondary forest is assumed to be 40 km.

***Energy content of wood is assumed to be 14.3 GJ/tonne.

Table 4. Annual costs of short-rotation wood energy plantations with shifting agriculture

	Case 1	Case 2	Case 3
Cost component			
Production	$137,500	$85,900	$38,900
Harvesting	$101,500	$63,700	$28,700
Transportation*	$95,400	$79,700	$37,500
Margin for risk	$66,900	$45,900	$21,000
Total annual costs	$401,300	$275,200	$126,100
Annual harvest (tonnes)	13,250	8,280	3,750
Average annual cost ($/tonne)	30.30	33.20	33.60
Average annual cost ($/GJ)**	2.12	2.32	2.35

*Average round trip transport distance for this case is assumed to be the same as for use of secondary forest.

**Energy content of wood is 14.3 GJ/tonne.

Table 5. Annual costs of short-rotation wood energy plantations without shifting agriculture

	Case 1	Case 2	Case 3
Cost component*			
Production	$95,800	$59,900	$27,100
Harvesting	$101,500	$63,700	$28,700
Transportation*	$66,800	$45,500	$22,300
Margin for risk	$52,800	$33,800	$15,600
Total annual costs	$316,900	$202,900	$93,700
Annual harvest (tonnes)	13,250	8,280	3,750
Average annual cost ($/tonne)	23.90	24.50	25.00
Average annual cost ($/GJ)**	1.67	1.71	1.75

*Average round trip transport distance for the plantation is assumed to be 10 km.

**Energy content of wood is assumed to be 14.3 GJ/tonne.

Table 6. Summary of costs of alternative fuel supply systems

Supply system	Unit	Case 1	Case 2	Case 3
Retired rubber trees	$/tonne	14.40	14.90	15.50
	$/GJ	1.01	1.04	1.08
Secondary forests	$/tonne	13.90	16.80	17.20
	$/GJ	0.97	1.18	1.20
Plantation w/agriculture	$/tonne	30.30	33.20	33.60
	$/GJ	2.12	2.32	2.35
Plantation w/o agriculture	$/tonne	23.92	24.50	25.00
	$/GJ	1.67	1.71	1.75
Gas oil (diesel fuel)*	$/GJ		8.10 to 12.20	

*Prices of delivered fuel vary by location in Liberia, with prices rising with increasing distance from Monrovia; LEC receives fuel at the "concession" price, which reflects landed import costs (roughly $1/U.S. gal). This price is well below that paid by nonconcession customers (i.e., about $2.30/gal in Monrovia). To the concession price LEC must add transport charges of $0.10 to $0.40/gal) and take into account the substantial losses in diesel fuel due to theft at the rural stations.

Over time, Liberia's still low but gradually mounting population pressure will tend to reduce the availability of underutilized standing biomass to meet industrial-scale energy applications. The retired rubber tree resource, in particular, will likely be "mined" locally near wood-burning power plants within a few years, even if the emerging boom in the planting of new rubber trees continues for some time into the future. Likewise, it is probable that the length of the fallow period for shifting agriculture will shorten as population pressure increases. This will reduce the amount (and possibly the quality) of the wood available from this resource. In the longer term, it seems likely that some form of tree planting will be required to provide a substantial wood supply within an acceptable transport distance from the power plants. The cost penalties associated with the planting of trees are clear from the preceding analysis, but even these higher-cost wood systems offer major price advantages over petroleum-based fuels in Liberia.

Within each of the wood resource systems, the economies presented in the higher demand situation (Case 1) reduce average costs by 4% to 24% compared to those in the lowest demand situation (Case 3). The greater fractional reduction occurs with the secondary forest resources, where transport costs represent a larger share of total delivered costs than they do in the tree planting system.

The diseconomies associated with seasonal variation in wood demand or supply ability raise costs for Case 2 by 3% to 21% compared to those for Case 1. Again, the secondary forest resources show the greater sensitivity to changes in demand, because this is reflected primarily in the change in average transport costs, which represent a larger share of delivered costs for this system.

To conclude, our analysis indicates that wood can probably be delivered to small, rural power plants at costs that make this feedstock highly competitive for some and perhaps most of Liberia's rural electric stations. Furthermore, the wood supplier has at least four resource base alternatives to choose from and will probably have the ability to shift over time from one to another to ensure the reliability of supply and the competitiveness of his prices.

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Appendix A

TABLE OF CONTENTS FOR THE NATIONAL ENERGY PLAN FOR LIBERIA

Appendix B

ENERGY CONVERSION FACTORS

The following table lists the factors used to convert different fuels to barrels of crude oil equivalent (BCOE). One BCOE is equal to 5.8×10^6 Btu or 6.12×10^{12} J.

Fuel	BCOE
Crude oil (1 bbl)	1.000
Fuel oil (1 bbl)	1.084
Gas oil (1 bbl)	1.004
Gasoline (1 bbl)	0.906
Liquefied petroleum gas (1 bbl)	0.634
Kerosene (1 bbl)	0.978
Asphalt (1 bbl)	1.144
Hydroelectric (1 MWh)	1.74
Wood (1 tonne)	2.45
Charcoal (1 tonne)	4.64

Appendix C

SELECTED DATA FROM THE LIBERIA PETROLEUM REFINING COMPANY, BONG MINING COMPANY, AND LIBERIA ELECTRICITY CORPORATION

From LPRC

Crude oil imported (bbl)	2,558,000
Crude oil processed (bbl)	2,595,000
Products exported (bbl)	
Fuel Oil	113,670
Gasoline	25,623
Naphtha	31,936
Products produced at LPRC refinery (bbl)	
Fuel oil	1,261,709
Gas Oil	547,743
Gasoline	453,564
Kerosene	32,640
Jet fuel	163,786
LPG	4,318
Fuel gas	68,675
Naphtha	10,340
Asphalt	3,945
Refinery consumption (bbl)	
Fuel oil	87,220
Gas oil	12,355
Gasoline	2,007
Fuel gas	68,676
Total sales by LPRC (apparently including exports) (bbl)	
Fuel oil	1,406,761
Gas oil	753,715
Gasoline	540,127
Kerosene	35,749
Jet fuel	200,132
LPG	4,064
Naphtha	31,936
Asphalt	3,659

Sales by LPRC to Major Customers (bbl)

	BMC	LAMCO	NICO	LEC
Fuel oil	1,060,848	64,381		95,162
Gas oil	113,296	106,080	75,125	118,899

From BMC

Fuel use (bbl)

	Fuel oil	Gas oil	Gasoline
Operations		88,095	
Transport		14,286	12,857
Elec. gen.	857,143	7,143	
Processing	333,333		

From LEC

	Output (GWh)	Fuel consumption (bbl)	
		Fuel oil	Gas oil
LEC Monrovia generation			
Mt. Coffee hydro	277		
Slow speed diesels	63	101,886	
Medium speed diesels	6		11,730
Gas turbines	32		110,719

LEC Monrovia customer sales distribution (GWh)

Residential	86.009
Commercial	86.156
Industrial	34.079
Government	21.672
Street lighting	13.091

Internal Distribution

1–5. W. F. Barron
6. D. J. Bjornstad
7. J. M. Bownds
8. M. A. Brown
9. R. M. Davis
10. W. Fulkerson
11. D. L. Greene
12. L. J. Hill
13. E. L. Hillsman
14. D. W. Jones
15. S. I. Kaplan
16. R. Lee
17. H. A. McLain
18. J. W. Michel
19. H. Perez-Blanco
20. R. D. Perlack
21. A. M. Perry
22. C. H. Petrich
23. S. F. Rayner
24–33. G. Samuels
34. R. B. Shelton
35. J. H. Sorensen
36. R. A. Stevens
37–41. T. J. Wilbanks
42. Central Research Library
43. Document Reference Section
44. Laboratory Records (RC)
45–46. Laboratory Records Department
47. ORNL Patent Section
48–57. Energy Division Office

External Distribution

58. R. H. Bonczek, Krannert Graduate School of Management, Purdue University, West Lafayette, Indiana 47907
59. P. L. Baldwin, U.S. Agency for International Development, Office of Energy, Room 509, SA-18, Washington, DC 20523
60. S. M. Gillis, Economics and Public Policy, Department of Economics, Duke University, Durham, NC 27706
61. F. R. Kalhammer, Vice President, Electric Power Research Institute, P.O. Box 10412, Palo Alto, CA 94303
62. R. E. Kasperson, Graduate School of Geography, Clark University, Worcester, MA 01610
63. P. Koshel, U.S. Agency for International Development, Office of Energy, Room 509, SA-18, Washington, DC 20523
64. M. Lessen, 12 Country Club Drive, Rochester, NY 14618
65. Office of the Assistant Manager for Energy Research and Development, Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN 37831
66–67. United Nations Distribution, #1 United Nations Plaza, Room DCL/876, New York, NY 10017
68–72. World Bank Distribution-World Bank, 1818 H Street, NW, Washington, DC 20433
73–152. Liberia Distribution, c/o D. Klein, U.S. AID Liberia, APO, New York, NY 09155
153–179. Technical Information Center, U.S. Department of Energy, P.O. Box 62, Oak Ridge, TN 37831