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## **An Evaluation of the Liberian Petroleum Refining Company Operations: Crude Oil Refining vs Product Importation**

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Energy Division

AN EVALUATION OF THE LIBERIAN PETROLEUM REFINING COMPANY  
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## ABSTRACT

This report is one of a series of project papers providing background information for an assessment of energy options for Liberia, West Africa. It presents information on a controversial recommendation of the energy assessment--that the only refinery in the country be closed and refined products be imported for a savings of approximately \$20 million per year.

The report reviews refinery operations, discusses a number of related issues, and presents a detailed analysis of the economics of the refinery operations as of 1982. This analysis corroborates the initial estimate of savings to be gained from importing all refined products.

## INTRODUCTION

This report is one of a series of project papers prepared as part of the joint Government of Liberia/U.S. Agency for International Development National Energy Assessment for Liberia. These papers, which provide background information on various aspects of the Liberian economy and energy consumption, were intended as appendices to the main project report.<sup>1</sup> However, because of their length, they were not included with the project report but are being issued as six topical reports.

The Liberian Energy Assessment Project included an examination of current energy use by sector and fuel type, projections of future energy demands, and a preliminary evaluation of alternative energy resource and technology options for Liberia. This report (originally Appendix 17 of the main project report) presents information on a controversial recommendation of the energy assessment--that the only refinery in the country be closed and refined products be imported for a savings of approximately \$20 million per year.

In December 1982, an Ad Hoc Working Group on Energy Conservation composed of members of the Energy Assessment Team and members of the Technical Subcommittee of the National Energy Committee (NEC) concluded that the existing arrangements between the Liberia Petroleum Refining Company (LPRC) and its "concessionaire" customers resulted in subsidization of those large-volume customers to the detriment of all other consumers. This does not mean that the concessionaires are receiving "unfair" price advantages. It does mean, however, that a disproportionate amount of LPRC's current operating costs and losses is placed solely on nonconcessionaire customers.

The Ad Hoc Working Group recommended that the existing arrangements be modified to place more of the cost of refinery operation on the concessionaires or, alternatively and more appropriately, that the refinery be closed and refined petroleum products be imported. Although

the group had access only to limited data at the time, it concluded that the latter move would save Liberia roughly \$17 million to \$24 million annually.\* LPRC rejected both proposals and submitted tabulations showing that little or no gain was likely from closing the refinery and that raising concessionaire prices was not possible.

The following sections of this report review the refinery operations, discuss a number of related issues, and present a detailed analysis of the economics of the refinery operation as of 1982; this analysis corroborates the initial estimate of savings to be gained from importing all refined products.

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\* After this analysis was performed in the latter part of 1982, the refinery was shut down, and Liberia is currently importing refined petroleum products.

## 2. REFINERY OPERATION

Liberia imports about 4 million bbl/year of crude oil from Saudi Arabia and processes the crude oil in the Monrovia refinery of the government-owned LPRC. LPRC has the exclusive rights for petroleum processing in Liberia, and essentially all production is sold within the country.

The Monrovia refinery was constructed in the 1960s by Sun Oil Corporation of the United States. The refinery is relatively small, having a sustainable capacity of approximately 13,500 bbl/d. The refinery was operated by Sun Oil until late 1976, when a major fire occurred and the refinery was shut down completely. In 1978, the refinery was purchased by the government corporation LPRC and was refurbished to its present condition and throughput. The refinery averages a throughput of between 3 million and 4 million bbl/year of crude oil.

The LPRC refinery is essentially a crude oil distillation unit with one additional plant, a catalytic reforming (platforming) unit, which is needed to obtain the octane quality of the gasoline required for motor gasoline use. There is also a small hydrotreater, which treats kerosene/jet fuel material to remove sulfur. In addition to these processing units, the refinery has the necessary peripheral facilities: tankage, steam generation, air compressors, standby electrical power facilities, and a cooling water system. The refinery operates in a harsh environment, including high humidity, high temperatures, and salt-laden air from the nearby ocean, and appears to have been operated with minimal maintenance. Consequently, there appears to be significant deterioration of some of the equipment, such as piping, pumps, and electrical motors. Since a relatively high-sulfur crude oil is being processed in the salt-containing atmosphere, the distillation columns, piping, and vessels handling the oil products are corroding. Currently, caustic is being injected into the crude oil to neutralize the acidic component in the oil and alleviate the corrosion problem. The refinery has a minimal amount of effective pipe insulation, much of which is damaged and has not been repaired. Other

evidences, such as oil spills, leakage, and open flowing water lines for cooling, indicate that the plant has deteriorated from its original condition and has received minimal maintenance.

The refinery has no catalytic cracking, coking facilities, alkylation, thermal cracking, hydrocracking, or similar sophisticated processing capabilities. These processes are used in modern refineries because of the necessity to minimize the yield of the heavier, higher boiling fractions of the crude oil and convert them into more valuable products such as jet fuel and gasoline. Consequently, the Monrovia refinery produces a very low yield of gasoline and a very high yield of residual (heavy) fuel oil.

Among the alternatives being examined by LPRC is the possibility of importing Nigerian crude instead of Saudi Arabian crude. Nigerian crude oil is a lighter material and would result in a slightly higher yield of gasoline and a lower yield of heavy fuel oil. However, the heavy fuel oil from Nigerian crude oil has more paraffinic material and has a higher pour point than the heavy fuel oil from Saudi Arabian crude. As a consequence, the heavy fuel oil from Nigerian crude would not meet the specifications of the finished fuel oil product. For this reason, LPRC is considering the installation of a vis-breaker process unit in the refinery. This unit would thermally treat the residual oil to achieve a molecular rearrangement and thereby produce residual fuel oil with lower viscosity and a lower pour point. The cost of the vis-breaker would be about \$8 million according to a study made by Lummus Corporation, the consulting engineers to LPRC.

The yield structure of the Monrovia refinery when processing the present mixture of Saudi Arabian crude oil results in the production of approximately 51% (by volume) residual fuel oil. The other products are gas oil--22%, kerosene/jet fuel--8%, gasoline--15%, and a small amount of liquefied petroleum gases (LPG) and asphalt. Between 5 and 6% of the energy content of the crude oil processed is consumed internally for fuel or wasted (flared). This yield of products may be compared with that from a typical modern competitive refinery where more than 45% of the crude oil

input comes out as gasoline (the high-value product), and only about 20% appears as heavy fuel oil, the lowest value product. In the present world market, motor gasoline sells for about \$6.00 to \$8.00 more per barrel than crude oil, whereas heavy fuel oil sells for about \$6.00 to \$8.00 per barrel less than crude oil. Obviously, if products are priced according to their world market value, profitable refinery operation requires conversion of substantially more than half of the crude oil into the more valuable gasoline and distillate products. The LPRC Monrovia refinery is not equipped to accomplish this without substantial investment.

LPRC sells most of its heavy fuel oil and much of its gas oil to three iron ore mines and the Liberia Electricity Corporation (LEC). These four large customers, classified as "concessionaires" by LPRC, receive a separate and substantially lower price schedule. Contracts between LPRC and the concessionaires specify that the price of heavy fuel oil and gas oil which they purchase will be held to "fair world market value" plus transportation to Liberia. If LPRC charged more, the concessionaires would have the contractual right to import directly. Without the local market for heavy fuel oil, LPRC would need to find expanded export markets for its product. Generally, heavy fuel oil is in a surplus worldwide and even during tight oil markets is typically a difficult item to export.

Currently, these conditions force LPRC to sell essentially all of its heavy fuel oil at prices below the cost of imported crude. Gas oil is also sold to the concessionaires at a relatively low price. These losses, as well as all operating expenses and any potential profit, must be recouped through the administered prices charged by LPRC to nonconcessionaire customers. The nonconcessionaire customers are mostly Liberian and foreign firms operating in Liberia who are consumers of gas oil, gasoline, kerosene, and LPG. Since the refinery yields less than 50% of these lighter products, the cost penalty to such customers is substantial. Changes in the relative prices for imported crude oil and refined products could alleviate the problem slightly for the nonconcessionaire users but would not, under plausible circumstances, substantially alter the situation.

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In addition to its refinery operations, LPRC imports refined products as needed. At the present time, gas oil is the significant import item.

### 3. PROPOSAL FOR CLOSING THE REFINERY

The original calculations used by the Ad Hoc Working Group to recommend closing the refinery were based on the following arguments:

1. The concessionaires can import their own refined oil products at little or no cost penalty; some minor adjustments would be needed, but nothing major.
2. The cost of importing refined lighter products is substantially below prices currently charged by LPRC to its nonconcessionaire users (e.g., gasoline savings of \$1 to \$1.50 per gallon and gas oil savings of \$0.80 to \$1.25 per gallon).
3. LPRC could close down the refinery and import directly the product mix needed by the nonconcessionaire users, LEC, and the National Iron Ore Company (NIOC).
4. LPRC could keep the existing price structure and absorb the difference as revenue to be passed on to the Government of Liberia. At about 20 million gal/year of gasoline and 12 million to 17 million gal/year of gas oil consumed by taxable users, the gain would be roughly \$30 million to \$35 million per year. Allowing for certain costs, the net annual gain would probably still be \$20 million or more.
5. Keeping LPRC at its current staff level to avoid increasing unemployment would cost roughly \$3 million to \$4 million per year leaving a minimum a net annual gain of \$17 million and probably much more.
6. Since LPRC needs as much payment "offshore" as possible to avoid payment bottlenecks due to liquidity problems within Liberia, LPRC should urge foreign customers (e.g., Firestone, foreign oil distributors) to pay offshore. Alternately, LPRC could remain as the importer of refined products for the foreign concessionaires and thus retain whatever advantages there are to their offshore payment ability.

In essence, LPRC argues that the profits from importing refined products will be eroded by operating costs. LPRC further argues that its current refining operations with limited imports is potentially highly profitable (\$31 million annually). It is LPRC's position that only the problem of bad debts is keeping the refinery from making such a profit.

#### 4. REVIEW OF OTHER POINTS RAISED BY LPRC

##### 4.1 CUSTOMER NONPAYMENT

LPRC currently suffers major liquidity problems because of nonpayment by some customers and thereby incurs substantial interest and demurrage charge penalties. Conversion of LPRC into strictly an importer of refined products would not eliminate this problem, but neither would it worsen it. The gains calculated in the following section would be affected in only a minor way so long as the scale of nonpayment did not increase. The projected increase in profits is largely from customers who generally do pay (e.g., transport fuel users).

##### 4.2 NATIONAL SECURITY

National security in energy supplies is related to the degree of dependence on imported energy and the national energy storage capacity. Storage of crude oil is no more safe, and indeed is probably less safe, than storage of refined products (i.e., the refinery may be vulnerable to sabotage). The amount of stored energy and its location are the issue. We propose that LPRC convert its current crude oil storage into storage of refined petroleum products. We believe this cost would not be a major problem. LPRC should also consider establishing larger storage facilities for refined products at key points in the country (e.g., Voinjama, Gbarnga, Zwedru, Greenville, Harper).

The types of weather-related ocean transport problems pointed out by LPRC should be minor and could readily be handled by a moderate increase in storage. With regard to longer term cutoffs, the historical disruptions in oil supply have been in crude oil trade, not directly in trade in refined products. Overall, we believe that Liberia's national security will be improved by closing the refinery and switching to refined products.

#### 4.3 IMPROVE REFINERY OPERATION THROUGH PROCESS IMPROVEMENTS

While refinery operational efficiency could be improved by upgrading the present mix and condition of the physical plant, we believe that such investments do not effectively address the structural problems of refinery financing (i.e., concessionaire prices). Further, such investments are risky in light of the uncertain future for iron ore mine operation. If one of the mines should close and the Guinean and Wologezi mines fail to open soon, the new and improved refinery probably could not market its heavier products at a profit. Given the current tight financial situation at LPRC, undertaking a risky investment at this time should be considered with some hesitation even if it were required. As we demonstrated, not only are these unnecessary, they preclude the move toward a basic structural improvement--that of switching to importation of refined products.

## 5. ANALYSIS OF THE LPRC REFINERY OPERATIONS

The purpose of this section is to clarify and provide insight into claims that shutting down the LPRC refinery would save about \$20 million per year. Although the actual savings are sensitive to price assumptions for both crude oil and finished products, reasonable assumptions for these items show the annual savings to be in the range of \$15 million to \$30 million. This section presents some ground rules for the analysis and arguments for this range of savings, and also an analysis of the LPRC results that show a much smaller or negligible savings from shutting down the refinery. The LPRC results are presented in Appendix A.

### 5.1 GROUND RULES

Studying the merits of closing the LPRC refinery necessitates

- (1) establishing a set of values for crude oil and finished products,
- (2) determining the typical product yield from a barrel of crude oil,
- (3) minimizing or eliminating any effects of inventory changes, and
- (4) determining the percentage of sales to various classes of customers.

One of the more difficult items to determine is the actual cost of crude oil to the LPRC. During our energy assessment work in Liberia we heard that costs were \$40 to \$42 per barrel including very high financing charges [letter of credit (L/C) charges]. Rather than attempt to arrive at an independent crude oil cost, we will use the cost reported by LPRC (and shown in Table A.1) with demurrage and L/C charges added. Thus, the cost of crude oil used in this analysis is \$37.35/bbl.

The LPRC study reports two different sets of prices for finished products delivered to Liberia. The higher set of prices (identified as prices for average conditions) is listed in Table A.2. A lower set of prices (identified as favorable product prices) is shown in Table A.6. The higher product prices of Table A.2 are used for this report. However, because of an error in Table A.2 for jet fuel/kerosene, the cost of this

item was reduced from \$49.16 to \$46.49 per barrel. Using the lower or favorable prices would increase the savings from closing the refinery by about \$5 million per year.

The prices charged to the various classes of customers for finished products are also taken from the LPRC study and are shown in Tables A.4–A.6.

The product yield from the refinery is derived from LPRC historical operations data collected during the Liberian Energy Assessment. These data, shown in Table B.1, are based on the LPRC Marketing Department Monthly Production and Import Summaries. The methodology for determining product yields from these data is discussed later. This methodology also resolves difficulties with inventory changes.

Because LPRC has different fuel oil and gas oil prices for different customers, it is necessary to determine the sales of these products to different customers in order to determine the income derived from these products. The distribution of sales is shown in Table B.2. This table is also based on LPRC historical data (sales statistics 1971 through 1981) collected during the Liberian Energy Assessment.

## 5.2 METHODOLOGY AND RESULTS

This section presents two methods of analyzing the refinery operating economics. Both methods, using 1981 conditions, show savings of about \$20 million from closing the refinery.

The first method compares the cost of refining a barrel of crude oil in the LPRC refinery with the value of the products produced from each barrel of crude oil processed. The second method analyzes a complete typical year of LPRC operations, which includes both refining operations and the purchase and sale of imported finished products. This second method compares the net income for the case in which the refinery continues operations with that for the case in which the refinery is closed and the market is supplied by imported finished products. Both of these methods require a knowledge of the energy consumed in refining crude oil (which

for LPRC is between 5 and 6% of the energy content of the crude oil processed) and the yield of finished products per barrel of crude oil processed (which can be determined from LPRC operating records).

The basic data required for both of these methods are shown in Table 1 for 1981 operating conditions. The second column shows the actual net refinery production of finished products (from Table B.1). All fuel gas production shown in Table B.1 and 87,000 bbl of fuel oil listed in Table B.2 as plant use are part of the energy required to process the crude oil and are not included in the net refinery production.

Because of our lack of refinery inventory data, the quantity of crude oil required to produce the products shown in column 2 of Table 1 is calculated from an energy balance. This energy balance is illustrated in column 3, in which the energy content of each product is expressed as barrels of crude oil equivalent (BCOE). The refinery losses shown in this column are the energy required to process the crude oil and are equal to 5.5% of the energy content of the crude oil processed, or 173,000 bbl. Thus, the total quantity of crude oil required to produce the reported finished products is 3,153,000 bbl. We have two reported values for 1981 crude oil imports--3,136,000 and 2,844,000 bbl. The first value (3,136,000) agrees very well with the total requirements, and the lower value (2,844,000) is within one tanker load of the total requirements and thus within possible inventory changes. The last column of Table 1 gives the net product yield of each product per barrel of crude oil processed. This value is equal to the net production of column 2 divided by the total crude oil required (3,153,000 bbl).

Columns 4 and 5 show the finished products imported and the total finished products made available for sale--refinery production plus imports.

The simplest way to check the profitability of the refinery is to compare the value of the products produced with the cost of their production. This comparison is shown in Table 2. The total value of the products is \$34.42 per barrel of crude oil processed. The cost of producing the products is the cost of the crude oil (\$37.35/bbl) plus the

Table 1. 1981 petroleum operations

Product	Net refinery production <sup>a</sup> (10 <sup>6</sup> bbl)	BCOE <sup>b</sup> (10 <sup>6</sup> bbl)	Finished products imported (10 <sup>6</sup> bbl)	Total finished products (10 <sup>6</sup> bbl)	Net product yield <sup>c</sup>
Fuel oil	1.463	1.586	0	1.463	0.464
Gas oil	0.682	0.685	0.260	0.942	0.216
Gasoline	0.459	0.416	0.085	0.544	0.146
Jet fuel	0.184	0.180	0.005	0.189	0.058
Kerosene	0.058	0.057	0	0.058	0.018
LPG	0.003	0.002	0	0.003	0.001
Asphalt	<u>0.047</u>	<u>0.054</u>	0	0.047	0.015
Total	2.896	2.980			
Refining losses <sup>d</sup>		<u>0.173</u>			
Crude oil		3.153			

<sup>a</sup>Net refinery production excludes in-plant use of  $0.087 \times 10^6$  bbl of fuel oil that is included in the refining losses.

<sup>b</sup>BCOE (barrels of crude oil equivalent) is the energy content of the product expressed as barrels of crude oil.

<sup>c</sup>The product yield is the yield of each product as a fraction of the crude oil input.

<sup>d</sup>Refining losses are 5.5% of crude oil energy input.

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Table 2. Value of refinery products vs cost of production  
(1981 conditions)

Product	Value of product		
	Quantity per barrel of crude (bbl)	Value <sup>a</sup> (\$/bbl)	Total value (\$)
Fuel oil	0.464	29.70	13.78
Gas oil	0.216	45.21	9.77
Gasoline	0.146	44.75	6.53
Jet fuel	0.058	46.49	2.70
Kerosene	0.018	46.49	0.84
LPG	0.001	50 <sup>b</sup>	0.05
Asphalt	0.015	50 <sup>b</sup>	<u>0.75</u>
Total			34.42

Cost of processing a barrel of crude oil

Cost of crude	37.35
Production cost	<u>4.22</u>
Total	41.57

<sup>a</sup>The value of the products for this comparison is the cost of importing these products into Liberia.

<sup>b</sup>Assumed values.

processing cost. The processing cost is the production cost of \$13,315,000 (from Table A.3) divided by the crude oil processed (3,153,000 bbl) or \$4.22/bbl. The cost of the products is then \$41.57 per barrel of crude oil processed. This represents a loss of \$7.15/bbl. For a total of 3,153,000 bbl, the total loss is about \$22,500,000. The unit value used for the products is the higher set of values used in the LPRC study (Table A.2). If the lower favorable imported cost of fuel oil, gas oil, and gasoline (see Table A.6) had been used, the loss would have been increased by \$6,800,000. These losses would be reduced by the cost of handling imported products.

To show that the production or product mix for 1981 did not lead to abnormal results, we made a similar analysis for 1979 and 1980 LPRC operations. For these cases, the same product costs and values are used--only the quantities processed or imported are changed. Tables similar to Tables 1 and 2 are shown in Appendix C (Tables C.1 and C.2 for 1979 and C.6 and C.7 for 1980). The processing cost for these two years was assumed to be the same as for the 1981 case (\$13,315,000) even though the quantity of crude processed was greater. The processing cost per barrel decreases to \$3.57 and \$3.10 in 1979 and 1980 respectively, and the refinery loss per barrel decreases to \$6.67 and \$6.15. However, because of increased refinery throughput, total losses increase to \$24,900,000 and \$26,500,000 in 1979 and 1980 respectively. Thus, the larger the refinery throughput, even with processing costs held constant, the larger the loss.

The reason LPRC does not show these large losses is that many of the products are sold at prices far above the cost of imported products (see Tables A.4-A.6). To analyze petroleum operations under actual price conditions, we will use a procedure similar to that used in the LPRC study. This analysis assumes that if the refinery were closed, LPRC would continue to supply all markets with imports, except fuel oil and gas oil to bunker users, the Liberian American-Swedish Minerals Company (LAMCO), and the Bong Mining Company (BMC). This differs from the LPRC study only in that LPRC would continue to supply the jet fuel and kerosene market. The LPRC argument that imports for the domestic kerosene market would be too small

to be profitable does not appear to be valid. Considering that most jet fuel today is a special grade of kerosene, LPRC could supply both the jet fuel and domestic kerosene market. The total market for these products during 1979-81 has ranged from 250,000 to 400,000 bbl/year.

To simplify the analysis, we will first determine the average price received for fuel oil and gas oil sold to various classes of customers. Table 3 shows these average prices. With refinery operations, the average prices received are \$27.85/bbl for fuel oil and \$54.43/bbl for gas oil. Concessionaires receiving the favorable prices for this case are LEC, NIOC, LAMCO, and BMC.

Without refinery operations, the average price received becomes \$29.62/bbl for fuel oil and \$64.89/bbl for gas oil. The only concessionaires being supplied by LPRC are the government-owned operations--the LEC and the NIOC.

Sales, costs, and income, with and without refinery operations, are compared in Tables 4 and 5. With refinery operations (Table 4), sales exceed costs by \$18,800,000. About \$7,500,000, or 40% of this "profit," is obtained from the small portion (11%) of products that are imported. Without refinery operations (Table 5), sales exceed costs by \$39,360,000--an increase of \$20,560,000. The handling cost for refined products used in Table 5 (\$5,350,000) is far less than that used in the LPRC study (\$10,041,305).

The LPRC production or handling costs for both cases are shown in Table A.3. These data indicate that closing the refinery would make no change in such costs as utilities, outside services, travel, general local expenses, or training. Furthermore, the reduction shown for other costs such as wages and salaries (a reduction of only 17%) appears to be too small. The LPRC costs shown for terminalling only amounts to more than \$7/bbl for handling imports. With the refinery in operation, the total production cost of importing 350,000 bbl of products and importing and refining 3,153,000 barrels of crude oil was given as \$13,314,178. This is equivalent to \$3.80/bbl of imports (both crude oil and finished products) and includes the cost of refining the crude oil. The \$5,350,000 used in Table 5 was calculated by multiplying the quantity of finished products

Table 3. Average prices for fuel oil and gas oil  
(1981 conditions)

	Sales %	Price (\$/bbl)	Total
<u>With refining operations</u>			
Fuel oil			
Retail	0.3	57.96	0.17
Concessionaires	86.8	28.56	24.79
Bunker	10.7	22.26	2.38
Export	<u>2.2</u>	22.96	<u>.51</u>
Total	100.0		27.85
Gas oil			
Retail	35.9	78.12	28.05
Concessionaires	<u>64.1</u>	41.16	<u>26.38</u>
Total	100.0		54.43
<u>Without refining operation</u>			
Fuel oil			
Retail	3.6	57.96	2.09
Concessionaires	<u>96.4</u>	28.56	<u>27.53</u>
Total	100.0		29.62
Gas oil			
Retail	64.2	78.12	50.15
Concessionaires	<u>35.8</u>	41.16	<u>14.74</u>
Total	100.0		64.89

Table 4. Sales and costs with refinery operations  
(1981 conditions)<sup>a</sup>

Product	Price (\$/bbl)	Refinery production (10 <sup>6</sup> bbl)	Product imports (10 <sup>6</sup> /bbl)	Total \$10 <sup>6</sup>
<u>Sales</u>				
Fuel oil	27.85	1.463	0	40.74
Gas oil	54.43	0.682	0.260	51.27
Gasoline	104.58	0.459	0.085	56.89
Jet fuel	46.20	0.184	0.005	8.73
Kerosene	84.42	0.058	0	4.90
LPG	52.50	0.003	0	0.16
Asphalt	63.00	<u>0.047</u>	0	<u>2.96</u>
Total				165.65
<u>Costs</u>				
Crude oil	37.35		3.153	117.76
Gas oil	45.21		0.260	11.75
Gasoline	44.75		0.085	3.80
Jet fuel	46.49		0.005	0.23
Production				<u>13.31</u>
Total				146.85
Income				18.80

<sup>a</sup>Based on LPRC prices.

Table 5. Sales and cost without refinery operations  
(1981 conditions)<sup>a</sup>

Product	Price (\$/bbl)	Quantity (10 <sup>6</sup> bbl)	Total (\$10 <sup>6</sup> )
<u>Sales</u>			
Fuel oil	29.62	0.107	3.17
Gas oil	64.89	0.510	33.09
Gasoline	104.58	0.544	56.89
Jet fuel	46.20	0.189	8.73
Kerosene	84.42	0.058	<u>4.90</u>
Total			106.78
<u>Costs</u>			
Fuel oil	29.70	0.107	3.18
Gas oil	45.21	0.510	23.06
Gasoline	44.75	0.544	24.34
Jet fuel	46.49	0.189	8.79
Kerosene	46.49	0.058	2.70
Handling			<u>5.35</u>
Total			67.42
Income			39.36

<sup>a</sup>Based on LPRC prices

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imported by \$3.80/bbl; that is, the cost per barrel of importing products was assumed to be almost the same as the cost of handling and refining crude oil. This value should be more than sufficient to cover these costs.

Similar analyses were also made for 1979 and 1980 operating conditions (see Tables C.4 and C.5 for 1979 and C.9 and C.10 for 1980). For 1979 conditions the gain from shutting down the refinery is \$18,550,000. The reason this value is less than for 1981 is that more finished products were imported in 1979. For 1979, 57% of the income with refinery operations (Table C.4) is from imported finished products. For 1980 conditions the gain from shutting down the refinery is \$28,050,000. The reason for this larger gain is that more crude oil was processed and less finished product imported. Imported finished product for this case accounted for only 14% of the income with refinery operations (Table C.9).

### 5.3 LPRC STUDY RESULTS

With all of these analyses showing savings of \$15 to \$30 million from closing the refinery, why the rather small savings of only \$2 million shown in the LPRC study (the difference between the incomes shown in Tables A.4 and A.5)? The main problem with the LPRC results is that they are based on data for only 1 month with these results multiplied by 12 to obtain annual values. Apparently, for the month considered, there were significant inventory changes that are not accounted for in the analysis.

To illustrate this inventory change, we will assume that the 235,485 bbl of crude oil imported during the 1 month of the LPRC analysis (see cost of sales in Table A.4) is also the amount processed by the refinery. The product yields per barrel of crude oil shown in Table 2 for 1981 conditions are used to determine the products produced (column 2 of Table 6). Column 3 (products imported) and column 4 (products sold) of Table 6 are from the LPRC study. Columns 5 and 6 show the inventory changes for the various products and the value of the products added to or drawn from inventories. For example, for fuel oil the total quantity produced and imported is 109,265 bbl while sales were only 91,180 bbl.

Table 6. Inventory changes for LPRC study conditions

Product	Net refinery output (bbl)	Product imports (bbl)	Products sold (bbl)	Inventory change (bbl)	Value of inventory change (\$)
Fuel oil	109,265	0	91,180	+18,085	+506,561
Gas Oil	50,865	35,000	88,980	-3,115	-166,092
Gasoline	34,381	0	44,742	-10,361	-1,083,553
Jet Fuel	13,658	0	17,193	-3,535	-163,317
Kerosene	4,239	0	3,015	+1,224	+103,330
LPG	235	0	331	-96	-5,040
Asphalt	3,532	0	324	+3,208	+202,104
Total					-606,007

Thus 18,085 bbl with an average retail value of \$28.01/bbl (total value of \$506,561) were added to inventory. The retail value was determined from the sales income and quantity sold listed in Table A.5. For gas oil the total of that produced and imported (85,865 bbl) is 3,115 bbl less than sales. This quantity, with an average retail value of \$53.52/bbl and total value of \$166,092 must be drawn from inventory. In addition, sales of gasoline exceed that produced and imported by 10,361 bbl. This again requires drawing on inventories with a retail value of \$104.58/bbl and a total value of \$1,083,553. In Table 6 a plus sign indicates products added to inventory and a minus sign indicates products drawn from inventory. The overall effect of the inventory changes is to overstate the income for the refining case by \$606,000/month or \$7,272,000/year.

There are several other problems with the LPRC study. For example, the cost of L/C charges and demurrage are not included in the cost of crude oil and gas oil for the refining case but are included in the terminalling (without refinery operation) case. Adding these charges (\$1.73/bbl for crude oil and \$1.87/bbl for gas oil) would reduce the net income for the refining case by another \$5,406,000/year.

Another major problem is the relative production costs given in the LPRC study for the two cases. For the refining case, production costs are given as about \$4.30/bbl, which includes the cost of handling imports, refining the crude, and then handling the finished products. For the terminalling case, production costs are given as \$6.90/bbl of imported finished products without any refining operations. This grossly overstates the cost for the terminalling case.

Another problem with the LPRC results is that the monthly data shown represent only 65 to 90% of the average monthly crude oil throughput for the years 1979-81. A higher crude oil throughput would increase the advantage of closing the refinery.

## 6. SUMMARY

There is little doubt that closing the LPRC refinery and importing finished products would save \$15 million to \$30 million per year. Any profit actually shown for the refinery is the result of very high prices (compared with world market prices) for gasoline (\$2.49/gal without taxes), kerosene (\$2.01/gal) and the non-subsidized price of gas oil to retail consumers (\$1.86/gal). These higher prices, which are paid by retail consumers, are used to offset refinery losses and subsidies for fuel oil and gas oil sold to the concessionaires, for bunker fuel, and for export. In effect, closing the refinery could either reduce the price of products to the general public or provide additional revenues to the Liberian government. Considering the serious financial conditions of the Liberian government and the need to reduce petroleum imports, closing the refinery could provide the government an additional \$15 million to \$30 million in revenues without any price increases to consumers.

Although these savings depend on the difference or spread between the cost of crude oil and finished products that may vary over time, the difference used in this analysis is based on the higher costs of imported products used in the LPRC study. Using the more favorable prices of imported products reported in the LPRC study would increase the annual savings from closing the refinery by about \$5 million.

There are three major reasons that the LPRC study showed only a modest annual savings (less than \$2 million) from closing the refinery. First, the analysis did not account for inventory changes that add \$7,272,000/year to the savings from closing the refinery. Furthermore, because the cost of imported crude oil and gas oil used in the LPRC analysis did not include demurrage or L/C charges, the cost of operating the refinery is underestimated by \$5,406,000/year. The third reason is that the savings in production costs from closing the refinery (used in the LPRC study) appear to be at least \$5 million too low. These alone would increase the savings from closing the refinery by \$17 million or \$18 million per year.

Appendix A

LPRC ECONOMIC ANALYSIS

Tables A.1–A.6 present input data and results from the LPRC study of its operations.

Table A.1. Arab light spot crude cost<sup>a</sup>

Cargo size, LT	42,000
Degrees API	34.0
Cargo size, bbl	314,664
C&F price, \$/bbl	34.90
C&F cost, \$	10,981,773.60
Insurance, \$	15,099.94
C.I.F. cost, \$	10,996,873.54
Consular fee, \$	164,953.10
Port expense, \$	12,500.00
NPA tariff, \$	31,500.00
Inspection, \$	1,470.00
Total cost <sup>b</sup>	11,207,296.64
Unit cost, \$/bbl	35.617

<sup>a</sup>Based on information provided by the Liberia Petroleum Refining Company.

<sup>b</sup>Here we left out the demurrage charge of approximately \$145,617.62, the L/C costs (when applicable) of approximately \$400,000, or bank guarantee costs (when applicable) of approximately 60,000 U.S. dollars.

Table A.2. Import Product Prices<sup>a</sup>  
(Average Conditions)

	Gasoline	Jet/kerosene	Gas oil	Fuel oil
Cargo size, MT	5,000	2,000 <sup>b</sup>	10,000	20,000
Cargo size, bbl	44,000	15,000	76,000	134,000
C&F price, \$/MT	373.4	326.3 <sup>b</sup>	326.4	189.2
C&F cost, \$	1,867,000	692,600 <sup>b</sup>	3,264,000	3,784,000
Insurance, \$	2,324	1,048	4,937	5,723
C.I.F. cost, \$	1,869,324	693,648	3,268,937	3,789,723
Consular fee, \$	28,647	10,405	49,034	56,846
Throughput fees, \$	6,500	2,293	11,400	0
NPA tariff, \$	6,500	2,600	13,000	26,000
Inspection, \$	400	160	800	1,600
Demurrage, \$	11,000	11,000	11,000	11,000
L/C charges, \$	<u>46,675</u>	<u>17,315</u>	<u>81,600</u>	<u>94,600</u>
Total cost, \$	1,969,046	737,420	3,435,771	3,979,769
Unit cost, \$/bbl	44.75	49.16 <sup>b</sup>	45.21	29.70

<sup>a</sup>Based on information provided by the Liberia Petroleum Refining Company.

<sup>b</sup>For 2000 MT and \$326.3/MT, the C&F cost should be \$652,600 and the unit cost 46.49 \$/bbl.

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Table A.3. Operating Costs<sup>a</sup>

	Annual costs, (\$)			
	Private sector	Gov't. agencies	Overseas payments	Total costs
<u>Costs for refining</u>				
Wages, salaries	3,404,000	630,370		4,034,370
Benefits	76,922			76,922
Repairs	30,000	600,000	1,000,000	1,630,000
Supplies	350,200	625,875	1,043,125	2,019,200
Utilities		564,000		564,000
Outside services	1,744,300	0	2,306,036	4,050,336
Rentals, leases	270,000	9,000		279,000
Travel	206,500			206,500
Gen. local expense	54,400			54,400
Training			400,000	400,000
Totals	6,136,322	2,429,245	4,749,161	13,314,728
<u>Costs for terminalling</u>				
Wages, salaries	2,840,760	526,067		3,366,827
Benefits	42,482			42,482
Repairs	30,000	168,750	281,250	480,000
Supplies	240,600	180,810	301,350	722,760
Utilities		564,000		564,000
Outside services	1,744,300		2,306,036	4,050,336
Rentals, leases	145,000	9,000		154,000
Travel	206,500			206,500
Gen. local expense	54,400			54,400
Training			400,000	400,000
Totals	5,304,042	1,448,627	3,288,636	10,041,305
<u>Reductions due to terminalling</u>				
Totals	832,280	980,618	1,460,525	3,273,423

<sup>a</sup>Based on information provided by the Liberia Petroleum Refining Company.

Table A.4. Refining profitability<sup>a</sup>

	Price (\$/bbl)	Quantity (bbl/month)	Monthly Receipts		
			Local	Overseas	Total
<u>Sales income:</u>					
LPG	52.50	331.4	17,400	0	17,400
Gasoline	104.58	44,742.1	4,211,200	467,900	4,679,100
Kerosene	84.42	3,014.6	254,500	0	254,500
Jet fuel	46.20	17,192.7	0	794,300	794,300
Gas oil					
Retail	78.12	29,274.3	2,286,900	0	2,286,900
LEC	41.16	21,355.1	879,000	0	879,000
LAMCO	41.16	20,554.3	0	846,000	846,000
NIOC	41.16	7,296.3	300,300	0	300,300
BMC	41.16	10,499.6	0	432,200	432,200
Plant	.00	1,000.0	0	0	0
Fuel oil					
Retail	57.96	266.9	15,500	0	15,500
BMC	28.56	57,125.0	0	1,631,500	1,631,500
LAMCO	28.56	6,139.6	0	175,300	175,300
LEC	28.56	18,151.9	518,400	0	518,400
Plant	.00	7,400.0	0	0	0
Bunkers	22.26	7,296.3	0	162,400	162,400
Asphalt	63.00	324.0	20,400	0	20,400
<b>Total income</b>	<b>51.647</b>	<b>251,964.1</b>	<b>8,503,600</b>	<b>4,509,600</b>	<b>13,013,200</b>
<u>Cost of sales:</u>					
Crude	35.617	235,485.0	156,400	8,230,900	8,387,300
Gas oil imports	43.339	23,057.4	18,606	980,690	999,296
Fuel oil exports	22.956	(2,200.0)	0	(50,503)	(50,503)
<b>Total C.O.S.</b>	<b>36.420</b>	<b>256,342.4</b>	<b>175,006</b>	<b>9,161,087</b>	<b>9,336,093</b>
Monthly gross margin			8,328,594	(4,651,487)	3,677,107
Annual gross margin			99,943,128	(55,817,844)	44,125,284
Production costs			(8,565,567)	(4,749,161)	(13,314,728)
Income before finance charges			91,377,561	(60,567,005)	30,810,556

<sup>a</sup>Based on information provided by the Liberia Petroleum Refining Company.

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Table A.5. Terminalling Profitability<sup>a</sup>  
(Average imported product prices)

	Price (\$/bbl)	Quantity (bbl/month)	Monthly receipts		
			Local	Overseas	Total
<u>Sales income:</u>					
LPG	52.50	0.0	0	0	0
Gasoline	104.58	44,742.1	4,211,200	467,900	4,679,100
Kerosene	84.42	0.0	0	0	0
Jet fuel	46.20	0.0	0	0	0
Gas oil					
Retail	78.12	29,274.3	2,286,900	0	2,286,900
LEC	41.16	21,355.1	879,000	0	879,000
LAMCO	41.16	0.0	0	0	0
NIOC	41.16	7,296.3	300,300	0	300,300
BMC	41.16	0.0	0	0	0
Plant	.00	0.0	0	0	0
Fuel oil					
Retail	57.96	266.9	15,500	0	15,500
BMC	28.56	0.0	0	0	0
LAMCO	28.56	0.0	0	0	0
LEC	28.56	18,151.9	518,400	0	518,400
Plant	.00	0.0	0	0	0
Bunkers	22.26	0.0	0	0	0
Asphalt	63.00	0.0	0	0	0
Total income	71.678	121,086.6	8,211,200	467,900	8,679,200
<u>Cost of sales:</u>					
Gasoline imports	44.751	44,724.1	53,431	1,948,869	2,002,300
Gas oil imports	45.207	57,925.7	64,934	2,553,666	2,618,600
Fuel oil imports	29.618	18,418.8	11,613	533,887	545,500
Total C.O.S.	42.667	121,086.6	129,978	5,036,422	5,166,400
Monthly gross margin			8,081,222	(4,568,522)	3,512,800
Annual gross margin			96,974,664	(54,822,264)	42,153,600
Production costs			(6,752,669)	(3,288,636)	(10,041,305)
Income before finance charges			90,221,995	(58,110,900)	32,112,295

<sup>a</sup>Based on information provided by the Liberia Petroleum Refining Company.

Table A.6. Terminalling profitability  
(favorable imported product prices)

	Price (\$/bbl)	Quantity (bbl/month)	Monthly receipts		
			Local	Overseas	Total
<u>Sales income:</u>					
LPG	52.50	0.0	0	0	0
Gasoline	104.58	44,742.1	4,211,200	467,900	4,679,100
Kerosene	84.42	0.0	0	0	0
Jet fuel	46.20	0.0	0	0	0
Gas oil					
Retail	78.12	29,274.3	2,286,900	0	2,286,900
LEC	41.16	21,355.1	879,000	0	879,000
LAMCO	41.16	0.0	0	0	0
NIOC	41.16	7,296.3	300,300	0	300,300
BMC	41.16	0.0	0	0	0
Plant	.00	0.0	0	0	0
Fuel oil					
Retail	57.96	266.9	15,500	0	15,500
BMC	28.56	0.0	0	0	0
LAMCO	28.56	0.0	0	0	0
LEC	28.56	18,151.9	518,400	0	518,400
Plant	.00	0.0	0	0	0
Bunkers	22.26	0.0	0	0	0
Asphalt	63.00	0.0	0	0	0
<b>Total income</b>	<b>71.678</b>	<b>121,086.6</b>	<b>8,211,200</b>	<b>467,900</b>	<b>8,679,200</b>
<u>Cost of sales:</u>					
Gasoline imports	37.954	44,724.1	31,200	1,666,900	1,698,100
Gas oil imports	43.339	57,925.7	46,700	2,463,700	2,510,400
Fuel oil imports	28.069	18,418.8	11,200	505,800	517,000
<b>Total C.O.S.</b>	<b>39.027</b>	<b>121,086.6</b>	<b>89,100</b>	<b>4,636,400</b>	<b>4,725,600</b>
Monthly gross margin			8,122,100	(4,168,500)	3,953,600
Annual gross margin			97,465,200	(50,022,000)	47,443,200
Production costs			(6,752,669)	(3,288,636)	(10,041,305)
Income before finance charges			90,712,531	(53,310,636)	37,401,895

<sup>a</sup>Based on information provided by the Liberia Petroleum Refining Company.

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Appendix B

LPRC PRODUCTION, IMPORTS AND SALES FOR RECENT YEARS

Tables B.1 and B.2 provide data for LPRC refinery production, finished product imports, and product sales for recent years.

Table B.1. LPRC production and imports<sup>a</sup>  
(10<sup>6</sup> bbl)

Product	CY 1978			CY 1979			CY 1980			CY 1981		
	Refinery production	Finished product imports	Total	Refinery production	Finished product imports	Total	Refinery production	Finished product imports	Total	Refinery production	Finished product imports	Total
Fuel oil	0.339	0.122	0.461	1.920	0.116	2.036	2.117		2.117	1.550		1.550
Gas oil	0.179	0.422	0.601	0.776	0.704	1.480	1.004	0.176	1.180	0.682	0.260	0.942
Gasoline	0.109	0.094	0.203	0.530	0.160	0.690	0.547	0.028	0.575	0.459	0.085	0.544
Jet fuel	0.022	0.144	0.166	0.252	0.073	0.325	0.204	0.017	0.221	0.184	0.005	0.189
Kerosene	0.035		0.035	0.072		0.072	0.057		0.057	0.058		0.058
Fuel gas	0.028		0.028	0.096		0.096	0.104		0.104	0.119		0.119
LPG	0.002		0.002	0.006	0	0.006	0.004		0.004	0.003		0.003
Subtotal	0.714	0.782	1.496	3.652	1.053	4.705	4.037	0.221	4.258	3.055	0.350	3.405
Asphalt	0.001		0.001	0.017	0.002	0.019	0.011		0.011	0.047		0.047
Naphtha	0.014		0.014	0.033		0.033	0.129		0.129			
Kerosene Slop												
Total	0.729	0.782	1.511	3.702	1.055	4.757	4.177	0.221	4.398	3.102	0.35	3.452

<sup>a</sup>Based on information provided by the Liberia Petroleum Refining Company.

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Table B.2 LPRC 10-year product sales history<sup>a</sup>  
(10<sup>3</sup> bbl)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
<b>Fuel oil</b>											
Retail	32.1	32.4	55.4	40.5	19.1	13.0	14.5	22.7	5.0	5.3	3.9
BMC	517.7	640.8	812.5	775.8	832.9	830.6	553.1	146.4	1,273.2	1,341.9	963.8
LAMCO	835.2	678.1	738.2	679.1	693.3	591.1	188.4		111.3	159.4	174.4
LEC									26.3	99.2	103.4
Bunker	186.9	34.1	42.9	12.3	22.9	79.0		5.3	46.8	270.4	152.6
Plant	67.1	32.8	79.2	52.3	61.4	65.7	16.5	8.4	126.0	98.4	86.8
Export								520.3	166.7	31.9	
Subtotal	1,639.0	1,418.2	1,728.2	1,578.0	1,629.6	1,579.4	772.5	182.8	2,108.9	2,131.3	1,516.8
<b>Gas oil</b>											
Retail	342.0	361.5	359.0	383.8	453.3	475.5	454.8	450.9	505.5	469.1	327.4
LEC	278.6	224.7	436.8	419.4	259.8	294.9	378.4	314.1	352.2	192.1	102.6
LAMCO	262.1	303.3	266.7	279.1	283.9	255.3	295.0	294.7	274.2	311.3	284.0
NIOC	117.6	118.5	118.2	122.3	120.2	119.2	120.4	118.7	116.2	98.8	79.6
BMC	61.2	63.3	82.2	62.6	75.1	83.1	93.2	87.4	102.8	102.7	106.9
LMC	71.9	56.9	60.7	58.8	42.9	42.4	49.4	43.9	53.6	37.8	
Bunker	30.1	33.8	16.6	13.3	22.6	33.0	15.7	24.4	19.9	20.2	10.7
Plant	18.9	19.5	18.5	16.7	15.4	17.6	4.8	9.5	15.7	16.6	
Subtotal	1,182.6	1,181.5	1,358.7	1,356.0	1,273.6	1,321.0	1,411.7	1,343.6	1,440.1	1,248.6	911.2
Gasoline	478.9	470.3	502.7	507.1	561.2	559.7	600.5	636.5	663.5	617.1	540.2
Kerosene	87.5	92.4	92.0	81.0	75.5	77.9	75.1	80.3	68.1	62.3	52.9
Jet fuel	89.5	135.5	199.3	241.5	281.7	250.8	266.6	316.2	313.9	223.2	200.6
LPG	7.6	8.1	10.7	12.3	13.5	12.0	2.8	0.5	4.1	3.9	3.5
Naphtha									14.3	146.4	31.8
Asphalt	7.6	16.6	10.9	15.4	16.2	10.1	17.8	5.4	18.4	13.8	3.0
Total	3,492.7	3,322.6	3,902.5	3,791.3	3,850.9	3,810.9	3,147.0	2,565.0	4,631.3	4,446.6	3,260.0
Totals from Table B.1									4,757.0	4,398.0	3,452.0

<sup>a</sup>Based on information provided by the Liberia Petroleum Refining Company.

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## Appendix C

## ANALYSIS RESULTS FOR 1979 AND 1980 OPERATING CONDITIONS

Tables C.1-C.10 present the results of this study for 1979 and 1980 operating conditions. These tables are analogous to those for 1981 presented in Tables 1-5 in the main body of this report.

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Table C.1. 1979 petroleum operations

Product	Net refinery production <sup>a</sup> (10 <sup>6</sup> bbl)	BCOE <sup>b</sup> (10 <sup>6</sup> bbl)	Finished products imported (10 <sup>6</sup> bbl)	Total finished products (10 <sup>6</sup> bbl)	Net product yield <sup>c</sup>
Fuel oil	1.794	1.945	0.116	1.910	0.481
Gas oil	0.760	0.763	0.704	1.464	0.204
Gasoline <sup>d</sup>	0.530	0.480	0.160	0.690	0.142
Jet fuel	0.252	0.246	0.073	0.325	0.068
Kerosene	0.072	0.070	0	0.072	0.019
LPG	0.006	0.004	0	0.006	0.002
Asphalt	0.017	<u>0.019</u>	0.002	0.019	0.005
Total		3.527			
Refining losses <sup>e</sup>		<u>0.205</u>			
Crude Oil		3.732			

<sup>a</sup>Net refinery production excludes in-plant use of  $0.098 \times 10^6$  bbl of fuel oil and  $0.017 \times 10^6$  bbl of gas oil that are included in the refining losses.

<sup>b</sup>BCOE (barrels of crude oil equivalent) is the energy content of the product expressed as barrels of crude oil.

<sup>c</sup>The product yield is the yield of each product as a fraction of the crude oil input.

<sup>d</sup>Includes naphtha production.

<sup>e</sup>Refining losses are 5.5% of crude oil energy input.

Table C.2. Value of refinery products vs cost of production  
(1979 conditions)

Product	Value of product		
	Quantity per barrel of crude (bbl)	Value (\$/bbl)	Total value (\$)
Fuel oil	0.481	29.70	14.29
Gas oil	0.204	45.21	9.22
Gasoline	0.142	44.75	6.35
Jet fuel	0.068	46.49	3.16
Kerosene	0.019	46.49	0.88
LPG	0.002	50 <sup>a</sup>	0.10
Asphalt	0.005	50 <sup>a</sup>	<u>0.25</u>
Total			34.25
<u>Cost of processing a barrel of crude oil</u>			
	Cost of crude	37.35	
	Production cost	<u>3.57</u>	
	Total	40.92	

<sup>a</sup> Assumed values.

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Table C.3. Average price for fuel oil and gas oil  
(1979 conditions)

	Sales (%)	Price (\$/bbl)	Total
<u>With refining operations</u>			
Fuel oil			
Retail	0.3	57.96	0.17
Concessionaires	71.1	28.56	20.31
Bunker	2.4	22.26	.53
Export	<u>26.2</u>	22.96	<u>6.02</u>
Total	100.0		27.03
Gas oil			
Retail	35.5	78.12	27.72
Concessionaires	<u>64.5</u>	41.16	<u>26.55</u>
Total	100.0		54.27
<u>Without refining operations</u>			
Fuel oil			
Retail	100.0	57.96	57.96
Concessionaires	<u>0</u>		<u>0</u>
Total	100.0		57.96
Gas oil			
Retail	51.9	78.12	40.54
Concessionaires	<u>48.1</u>	41.16	<u>19.80</u>
Total	100.0		60.34

Table C.4. Sales and costs with refining operations  
(1979 conditions)

Product	Price (\$/bbl)	Refinery production (10 <sup>6</sup> bbl)	Product imports (10 <sup>6</sup> /bbl)	Total (\$10 <sup>6</sup> )
<u>Sales</u>				
Fuel oil	27.03	1.794	0.116	51.63
Gas oil	54.27	0.760	0.704	79.45
Gasoline	104.58	0.530	0.160	72.16
Jet fuel	46.20	0.252	0.073	15.02
Kerosene	84.42	0.072	0	6.08
LPG52.50	0.006	0	0.32	
Asphalt	63.00	0.017	0.002	1.20
Total				225.86
<u>Costs</u>				
Crude oil	37.35		3.732	139.39
Fuel oil	29.70		0.116	3.45
Gas oil	45.21		0.704	31.83
Gasoline	44.75		0.160	7.16
Jet fuel	46.49		0.073	3.39
Production				13.31
Total				198.53
Income				27.33

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Table C.5. Sales and cost without refining operations  
(1979 conditions)

Product	Price (\$/bbl)	Quantity (10 <sup>6</sup> bbl)	Total (\$10 <sup>6</sup> )
<u>Sales</u>			
Fuel oil	57.96	0.005	0.29
Gas oil	60.34	0.474	28.60
Gasoline	104.58	0.690	72.16
Jet fuel	46.20	0.325	15.02
Kerosene	84.42	0.072	6.08
Total			122.15
<u>Costs</u>			
Fuel oil	29.70	0.005	0.15
Gas oil	45.21	0.474	21.43
Gasoline	44.75	0.690	30.88
Jet fuel	46.49	0.325	15.11
Kerosene	46.49	0.072	3.35
Handling			5.35
Total			76.27
Income			45.88

Table C.6. 1980 petroleum operations

Product	Net refinery production <sup>a</sup> (10 <sup>6</sup> bbl)	BCOE (10 <sup>6</sup> bbl)	Finished products imported (10 <sup>6</sup> bbl)	Total finished products (10 <sup>6</sup> bbl)	Net product yield <sup>c</sup>
Fuel oil	2.019	2.189	0	2.019	0.469
Gas oil	0.987	0.991	0.176	1.163	0.229
Gasoline <sup>d</sup>	0.676	0.612	0.028	0.704	0.157
Jet fuel	0.204	0.200	0.017	0.221	0.047
Kerosene	0.057	0.056	0	0.057	0.013
LPG	0.004	0.003	0	0.004	0.001
Asphalt	0.011	<u>0.013</u>	0	0.011	0.003
Total		4.064			
Refining losses <sup>e</sup>		<u>0.237</u>			
Crude Oil		4.301			

<sup>a</sup>Net refinery production excludes in-plant use of  $0.126 \times 10^6$  bbl of fuel oil and  $0.016 \times 10^6$  bbl of gas oil that are included in the refining losses.

<sup>b</sup>BCOE (barrels of crude oil equivalent) is the energy content of the product expressed as barrels of crude oil.

<sup>c</sup>The product yield is the yield of each product as a fraction of the crude oil input.

<sup>d</sup>Includes naphtha production.

<sup>e</sup>Refining losses are 5.5% of crude oil energy input.

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Table C.7. Value of refinery products vs cost of production  
(1980 conditions)

Product	Value of Product		
	Quantity per barrel of crude	Value (\$/bbl)	Total value (\$)
Fuel oil	0.469	29.70	13.93
Gas oil	0.229	45.21	10.35
Gasoline	0.157	44.75	7.03
Jet fuel	0.047	46.49	2.19
Kerosene	0.013	46.49	0.60
LPG	0.001	50 <sup>a</sup>	0.05
Asphalt	0.003	50 <sup>a</sup>	<u>0.15</u>
Total			34.30

Cost of processing a barrel of crude oil

Cost of crude	37.35
Production cost	<u>3.10</u>
Total	40.45

<sup>a</sup>Assumed values.

Table C.8. Average price for fuel oil and gas oil  
(1980 conditions)

	Sales (%)	Price (\$/bbl)	Total
<u>With refining operations</u>			
Fuel oil			
Retail	0.3	57.96	0.17
Concessionaires	78.7	28.56	22.48
Bunker	13.3	22.26	2.96
Export	<u>7.7</u>	22.96	<u>1.77</u>
Total	100.0		27.38
Gas oil			
Retail	38.1	78.12	29.76
Concessionaires	<u>61.9</u>	41.16	<u>25.48</u>
Total	100.0		55.24
<u>Without refining operations</u>			
Fuel oil			
Retail	5.1	57.96	2.96
Concessionaires	<u>94.9</u>	28.56	<u>27.10</u>
Total	100.0		30.06
Gas oil			
Retail	61.7	78.12	48.20
Concessionaires	<u>38.3</u>	41.16	<u>15.76</u>
Total	100.0		63.96

Table C.9. Sales and costs with refining operations  
(1980 conditions)

Product	Price (\$/bbl)	Refinery production (10 <sup>6</sup> bbl)	Product imports (10 <sup>6</sup> bbl)	Total (\$10 <sup>6</sup> )
<u>Sales</u>				
Fuel oil	27.83	2.019	0	55.28
Gas oil	55.24	0.987	0.176	64.24
Gasoline	104.58	0.676	0.028	73.62
Jet fuel	46.20	0.204	0.017	10.21
Kerosene	84.42	0.057	0	4.81
LPG	52.50	0.004	0	0.21
Asphalt	63.00	0.011	0	<u>0.69</u>
Total				209.06
<u>Costs</u>				
Crude oil	37.35		4.301	160.64
Gas oil	45.21		0.176	7.96
Gasoline	44.75		0.028	1.25
Jet Fuel	46.49		0.017	0.79
Production				<u>13.31</u>
Total				183.95
Income				25.11

Table C.10. Sales and cost without refining operations  
(1980 conditions)

Product	Price (\$/bb1)	Quantity (10 <sup>6</sup> bb1)	Total (\$10 <sup>6</sup> )
<u>Sales</u>			
Fuel oil	30.06	0.105	3.16
Gas oil	63.96	0.760	48.61
Gasoline	104.58	0.704	73.62
Jet fuel	46.20	0.221	10.21
Kerosene	84.42	0.057	<u>4.81</u>
Total			140.41
<u>Costs</u>			
Fuel oil	29.70	0.105	3.12
Gas oil	45.21	0.760	34.36
Gasoline	44.75	0.704	31.50
Jet fuel	46.49	0.221	10.27
Kerosene	46.49	0.057	2.65
Handling			<u>5.35</u>
Total			87.25
Income			53.16

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