MINISTRY OF ENERGY
Republic of the Philippines

INDUSTRIAL ENERGY PROFILES

- LUBE REFINING
- TOBACCO
- RUBBER AND TIRE
- DOMESTIC MARINE
- FERTILIZER

VOLUME III

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INDUSTRIAL ENERGY PROFILES

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MESSAGE

In aide of the Ministry's policy formulation exercises for energy demand management, this document comes out as a timely source of information particularly as we begin to expand our span of attention from mere provision of cost-effective energy alternatives towards ultimately the more-efficient utilization of energy fuels through improved industrial energy technology.

I, therefore, congratulate the Ministry's Planning Service for again breaking new ground in its continuing initiatives at generating reliable baseline data that constitute the necessary building blocks of sound policy legislation.

I trust that Executives as well as Energy Managers of firms engaged in these industry sectors will find in these volumes a useful and wealthy repository of energy-related industrial statistics and hopefully, be guided towards a more rational ethic of energy access.

GERONIMO Z. VELASCO
Minister of Energy

FOREWORD

Undertaken for the first time, the following volumes detail the energy consumption profiles of selected industry sectors in the economy, tracing the energy flows from the raw supply source to its embodied form in the final product. The cover design, appropriately baptized in the trade as the "spaghetti diagram", symbolizes the main output of this massive effort.

Inevitably, therefore, the document also delves into a discussion of the process technologies applicable in each particular industry and from there attempts projections of future energy options available to the industry. The main instrument used to gather data was a survey questionnaire and whenever possible the consolidated figures were cross-checked against aggregates available from secondary government sources. Thus, much of the work is to be acknowledged as submissions from the cooperating respondents themselves.

This work represents the second in a series of surveys, designed to continually upgrade the quality of baseline energy information in the country. It proceeds, albeit peripherally, to discuss financial implications of industrial energy inputs on the sector's total cost structure.

The Planning Service shares the conviction that there is no substitute for hard empirical statistics as the starting point of public policy deliberations. Only then can we begin to quantify the relevant social dividends of any given policy thrust. This 4-volume document was completed as an initial step in that direction.

PLANNING SERVICE
MINISTRY OF ENERGY

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ENERGY PROFILE OF THE LUBE REFINING INDUSTRY

SUMMARY

The lube refining industry is relatively young. Its development only gained momentum with the entry of the Philippine Petroleum Corporation in 1974. Since then, the production level increased from a low 536,000 barrels of lube basestock in that year to a high 969,860 barrels in 1978. Because of the influence of its market, however, the experienced growth was characterized by fluctuations. In 1979, production decreased by 9.6 percent to a level of 876,330 barrels. In order to be free from such a constraint, exportation is being foreseen.

In the manufacture of lube, fuel oil is also produced as a by-product. Aside from generating income from the sales of this by-product, the industry is able to save in its fuel expenses as 20 percent of the fuel oil produced is plowed back for refinery use. Considering the amount of fuel oil used in the operations, the savings can be seen to be quite substantial.

Energy Requirements

The total energy consumption of the lube refining industry in 1979 amounted to 716.63 thousand barrels-of-oil equivalent (MBOE). Petroleum fuels, namely: fuel oil, diesel and liquefied petroleum gas accounted for 89 percent with purchased electricity contributing 11 percent.

A substantial amount of the energy input (87.56 percent) is utilized primarily for process heating. Mechanical power drive using electric motors and internal combustion engines use up about 10.79 percent. The manufacturing process also involves inert gas generation which consumes 100 percent of the liquefied petroleum gas or 1.63 percent of the aggregate energy. The remaining 0.02 percent is used for transport, lighting and air conditioning.

Energy Losses

In the process of converting the energy input to its various uses, energy losses are incurred in the form of electro/thermodynamic losses. Of the total input in 1979, about 57 percent was fully utilized and 43 percent was rendered lost in the process of conversion.

Energy Input Per Barrel

The refining process, as of 1979, requires a total of 0.8178 BOE of energy to produce a barrel of lube basestock. Of this figure, 0.0882 BOE is in the form of electricity and 0.7296 BOE in the form of petroleum. Historically, the energy utilization ratio ranged from a low 0.7415 BOE per barrel of lube in 1977 to a high 0.9509 BOE in 1975. Variations in this respect may be attributed to the nature of processing, i.e., higher grades requiring higher temperature, as well as the shutdowns – scheduled and unscheduled.

Energy Cost

In 1979, the cost per barrel-of-oil equivalent to the industry was ₱150, a 50 percent increase from the cost in 1975 of ₱101. The relatively low increase is caused by the fact that the energy utilized is fuel-oil based. In the same period, the price of fuel oil only reflected a 60 percent increase.

In spite of the upward trend of the cost, total expenditure on energy reflected a fluctuating trend due to the level of production, the amount, as well as the price, of the energy consumed.

BACKGROUND

Lube refining is the processing of reduced crude[1] to produce lubricants. At present, the firm that is virtually the only one engaged in this type of manufacturing is the Philippine Petroleum Corporation (PPC). Of course, there are also a number of small firms in the industry, but these only undertake the "re-refining" of spent lubricants. Previous to the entry of PPC into the industry in 1974, the country's supply of lubes was mostly imported. It was only since then that the industry started to develop. Considering the annual production of the industry (Table 11.1 and Figure 11.1), the aggregate performance reflected an upward movement. From 1975 to 1979, the year-to-year growth rate averaged 4.22%. However, the average year-to-year growth rate of 8.40% from 1976 to 1979 would be the more recent trend.

Table 11.1

HISTORICAL PRODUCTION OUTPUT

YEAR	'000 BARRELS OF BASE STOCK
1974	536.70
1975	782.09
1976	716.97
1977	726.31
1978	969.86
1979	876.33

Average year to year growth rate:

1976 - 1979 8.40%

1/ This is the heavier fraction of crude oil left after petroleum refining.

Table 11.2

OUTPUT PER METRIC TON OF FEEDSTOCK

Lubricating Oil Basestock		0.2100
Fuel Oil		
Refinery Fuel Oil	0.5130*	
Fuel Oil to NPC	0.6153	0.7683
Refinery Loss		0.0017
Total		1.0000

* Used in refinery operations.

It can be noticed that the growth trend was not a mere upward movement because it fluctuated widely, especially in the period covering 1977 to 1979. Such fluctuations could be attributed to the dependence of production on the demands of the industry's market.[2] The substantial increase of production in 1978, for instance, was due to the rise in the market's requirements to stock up its inventory as a means to hedge the then anticipated price increase. However, the consequent inventory surtax levied on the market discouraged the continuance of such action. This would explain the subsequent decrease in 1979. As a means to be free from the constraints of the domestic market, exportation is envisioned by PPC. Although the company had previously exported in accordance with an earlier contract agreement with the supplier, such a provision was no longer included upon renewal of this contract.

2/ The market of the industry is not the "end users" of the product but rather the dealers who add their own additives to the product to meet their specifications and then package it for selling to the "end users".

As regards the product mix, the manufacturing process also had fuel oil as a by-product, together with other secondary by-products (Table 11.2). Of the fuel oil produced, roughly 80% was sold to the National Power Corporation and 20% was plowed back to the refinery to operate fuel-oil-powered equipment. As a result, fuel oil no longer had to be purchased.

Other factors that affected production were the availability of feedstock supply and when the plants were shutdown for maintenance. There were also the unscheduled shutdowns.

ENERGY PROFILE[3]

Historical Energy Consumption

Total Energy Consumption

The historical energy consumption of the lube refining industry, which is essentially that of PPC, is seen in Table 11.3 and Figure 11.1. The figures[4], as a whole show an average year-to-year growth rate of 9.44%. In comparison to the production trend, the industry's energy consumption shows quite a similar movement. This can be explained by the direct relationship of the two, i.e., the amount of energy consumed being a function of the amount of lubes to be produced.

3/ It will be recalled in the earlier discussion that the principal raw material used is reduced crude — an input which is itself an energy source. For the sake of consistency, only the portion used as an energy source is considered in the succeeding discussions.

4/ As in the derivation of the production growth rates, the 1974 and 1975 figures have been discarded.

Table 11.3

HISTORICAL ENERGY CONSUMPTION

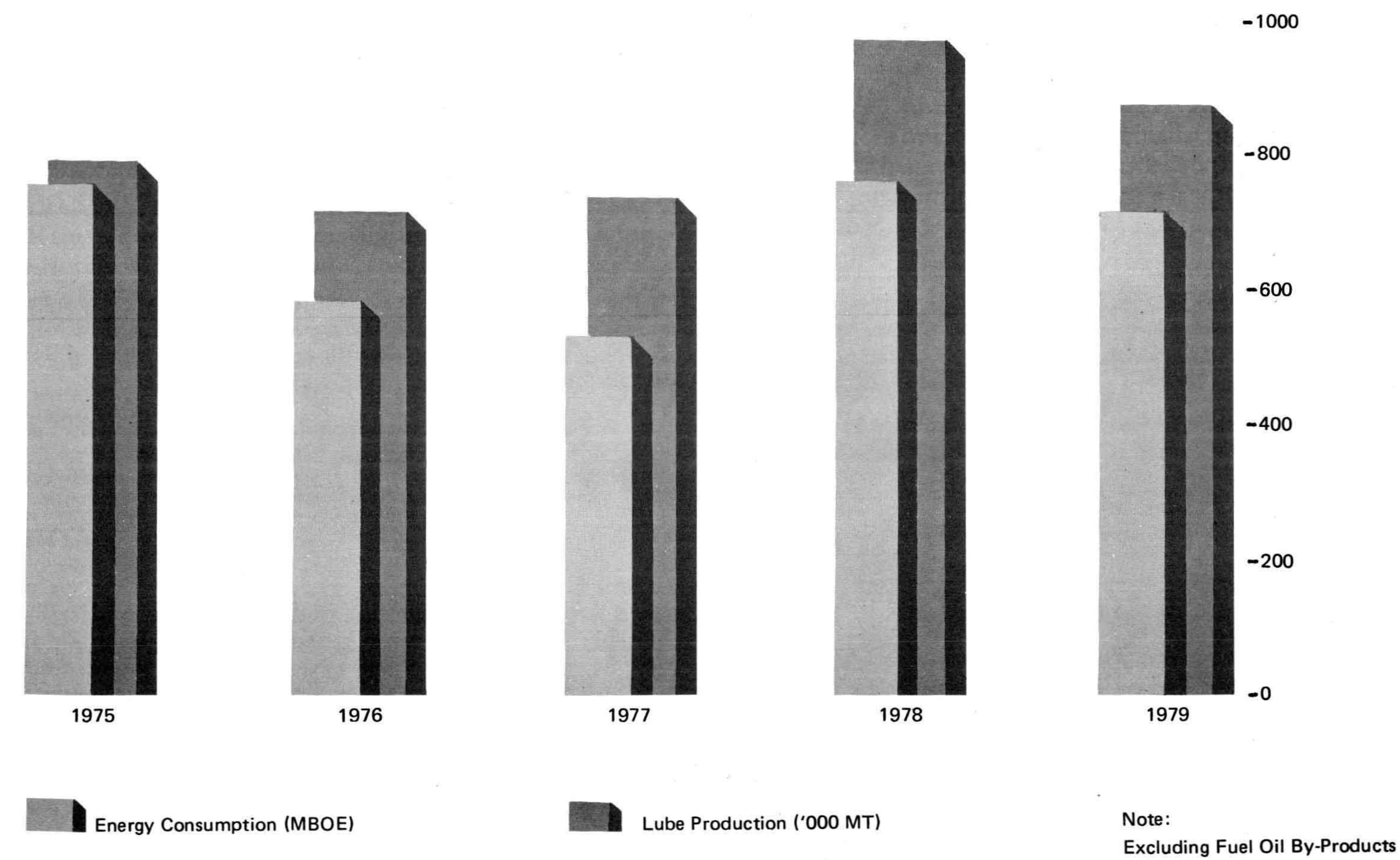
YEAR	MBOE
1975	743.66
1976	577.02
1977	538.53
1978	752.83
1979	716.63

Average year to year growth rate:
1976 - 1979 9.44%

The difference, however, can be seen in their growth rates: the energy consumption increasing at a slightly higher rate. This may be attributed to a number of factors, one of which is the increase in unscheduled shutdowns due to power interruptions within the last three years. Such would require the plant to start up all over again bringing about non-productive periods. Consideration must also be given to the grades of lube oil basestock to be produced. Higher grades require longer heating periods. Thus, although there is no physical increase in production, there is an increase in energy consumption.

Figure 11.1

HISTORICAL PRODUCTION OUTPUT AND ENERGY CONSUMPTION OF THE LUBE REFINING INDUSTRY



Energy Application

In the production of several grades of lube oil basestock, the reduced crude feedstock is processed in four process units; namely, vacuum distillation, propane deasphalting, furfural refining and solvent dewaxing. (See Figure 11.2 for the process flow diagram). These units are designed to turn out lube basestocks that meet certain specifications such as viscosity and pour point.

Vacuum Distillation Unit

At the start of the process, the raw material is fed into a vacuum tower operated at a temperature of 740°F and an absolute pressure of 80 mm.Hg. with the use of a fuel-oil-powered furnace and an electric process pump. This step is necessary to produce the required boiling range in lube distillates. A relatively large number of fractionating trays in the tower allows for the required split between the distillate cuts.

The distillate streams which evolve are subsequently refined in furfural refining and solvent dewaxing units. On the other hand, the bottom products of the tower or the vacuum residue containing very high boiling and high viscosity lubes and asphaltic materials are processed in another unit for further separation.

Other equipment used in this process are transfer pumps and chemical injection facilities both of which are powered by electricity.

As regards energy consumption, this process unit accounts for 10 percent of the total fuel oil consumption and 6 percent of electricity; a combined total 9.4 percent of the aggregate energy consumption in 1979.

Propane Deasphalting Unit

As a vacuum residue contains very high temperature lube and asphaltic materials, separation cannot be done by fractional distillation but rather by a combined process of extraction and precipitation. Liquid propane is introduced into the system and it extracts the paraffinic constituent suitable for lube oil. It also precipitates the high molecular weight/highly aromatic asphalt. Depending on the propane-to-fuel ratio and the extractor temperature conditions, two grades of deasphalted oil can be produced. These are subsequently processed in furfural refining and solvent dewaxing units.

Similar to the previous process unit, propane deasphalting utilizes a fuel oil-fired furnace, and electric process and transfer pumps. Added to these are compressors and blowers which are also powered by electricity. However, due to the higher temperatures involved, this process takes up 20 percent of the fuel oil and 25 percent of the electricity. A total of 144.83 MBOE or 20.21 percent of the total energy consumed in 1979 is accounted for in this process unit.

Furfural Refining Unit

The furfural is a solvent possessing the property of recovering the undesirable constituents from the lubricating oil fraction by way of a selective solvent action, leaving the high quality oil undissolved.

This unit consists primarily of an extractor tower, a section for the recovery of the furfural from the raffinate phase and a section for the recovery of furfural from the extract phase.

In the refining operation, the raw lubricating oil fraction is introduced into an electric rotating disc extractor wherein

Figure 11.2
PROCESS FLOW DIAGRAM

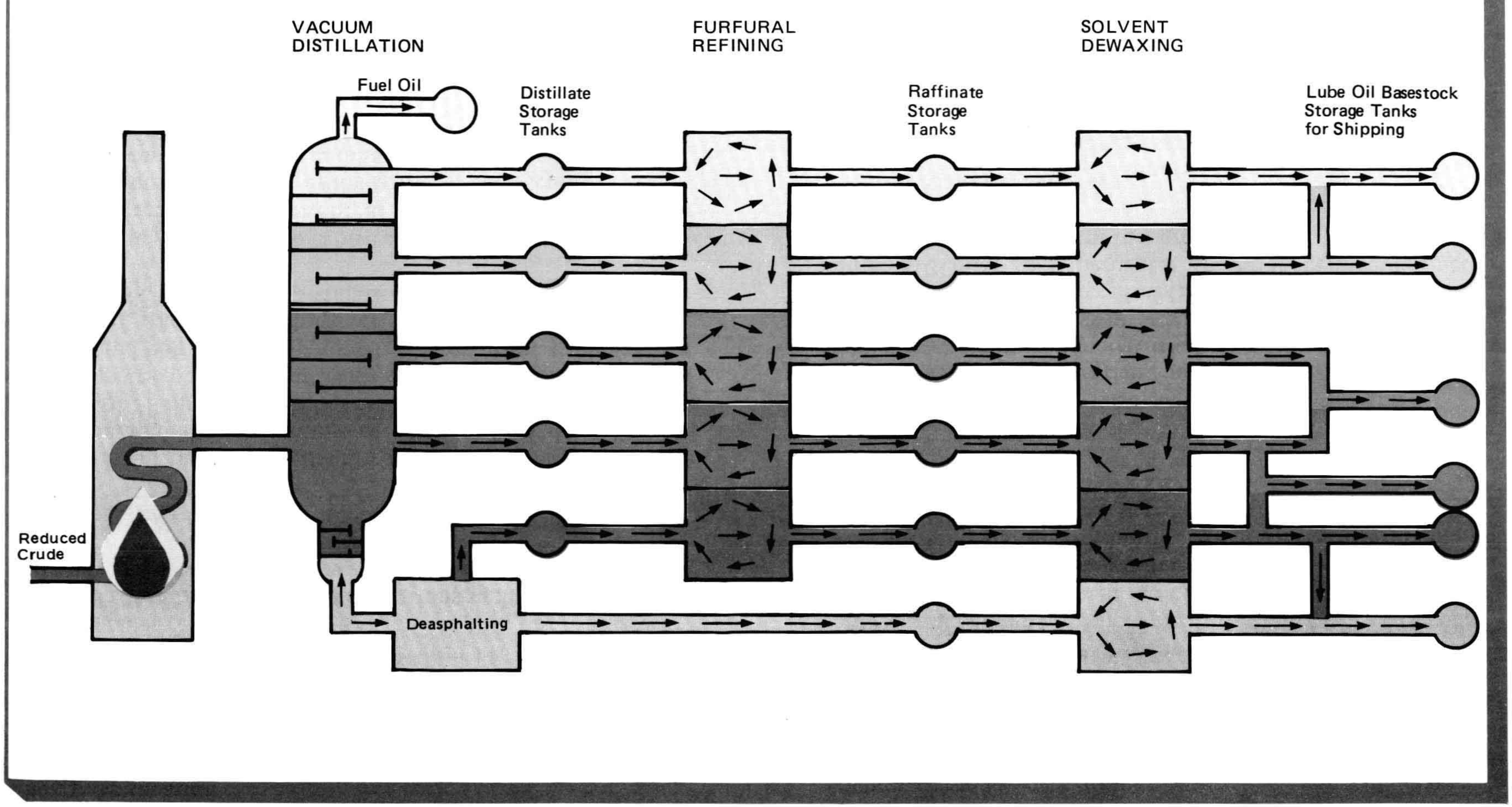


Table 11.4

EQUIPMENT USED AND CONSUMPTION (1979)

PROCESS UNIT	EQUIPMENT	TYPE OF FUEL	CONSUMPTION MBOE	CONSUMPTION % of Total ENERGY CONSUMPTION
Vacuum Distillation	Furnace	Fuel Oil	62.75	8.76
	Process pumps Transfer pumps Chemical Injection Facilities	Electricity	4.63	0.65
		SUB-TOTAL	67.38	9.40
Propane Deasphalting	Furnace	Fuel Oil	125.50	17.50
	Process pumps Transfer pumps Compressors Blowers	Electricity	19.32	2.70
		SUB-TOTAL	144.82	20.21
Furfural Refining	Furnace	Fuel Oil	62.75	8.76
	Process pumps Transfer pumps Blowers Compressors	Electricity	5.41	0.75
		SUB-TOTAL	68.16	9.51
Solvent Dewaxing	Furnace	Fuel Oil	62.75	8.76
	Process pumps Transfer pumps Compressors Scoopers Mechanical filters	Electricity	31.68	4.42
	Inert gas generator	L P G	11.69	1.63
		SUB-TOTAL	106.12	14.81
Utilities	Boilers	Fuel Oil	313.76	43.78
	Process pumps Transferal Project pumps Tank, mixers Chemical injection pumps FDF Motors	Electricity	16.23	2.26
	Diesel Engines	Diesel	0.07	0.01
	Others Lighting, airconditioning	Electricity	0.04	0.01
		Diesel	0.05	0.01
		SUB-TOTAL	330.15	46.07
		GRAND TOTAL	716.63	100.00

counter-current flowing contact of oil and furfural takes place and the undesirable components of the raw oil are selectively dissolved. The raffinate and extract phase pass from the top and bottom of the tower respectively to separate systems for recovery of the furfural.

The resulting raffinate product is completely free of furfural and is suitable for lube oil from the point of view of oxidation stability. However, the pour point of the raffinate is in general more than 100°F, and thus not suitable for use as crankcase oil. To get an oil that is fluid at low temperature, high pour-point waxy compounds are removed from the raffinate in the solvent dewaxing unit.

Aside from the rotating disc extractor, a furnace, process and transfer pumps, compressors and blowers are again utilized in this stage in the refinery process. A total of 68.16 MBOE or 9.51 percent of the total energy is consumed in this process.

Solvent Dewaxing Unit

With the use of methyl ethyl ketone and toluene as solvents, this solvent dewaxing unit processes the raffinate. The methyl ethyl ketone causes the wax to crystallize and toluene dissolves the oil.

The waxy oil charge containing initial dilution solvent is cooled down in the scrapped surface heat exchanger and then chilled to 0°C in the scrapped chiller. The chilled solution is introduced into the rotary vacuum filter where wax is separated from the oil mix.

The subsequent stages of the operation consists of solvent recovery from the wax and the wax-face oil mix.

As regards consumption of energy, 14.81 percent of the total consumption is covered by this process with the furnace, consuming 10 percent of total fuel oil, the various electric motors utilizing 41 percent of total electricity. Liquified Petroleum Gas (LPG) is used exclusively in the inert gas generator for cooling.

Besides the various equipment used in the four process units, the refinery operations employ auxillary utilities required in operating the production facility. Auxillary equipment use up a total of 48.32 percent of total energy consumed. (See Table 11.4, previous page).

Energy Source Mix

The lube refining industry derives its energy requirements from two sources: from petroleum, namely, industrial fuel oil, diesel and LPG; and from purchased electricity. Table 11.5 shows the energy mix. Out of the total energy input of 704.94 MBOE in 1979, 89% was in the form of petroleum and only 11% in electricity form. Such a mix has remained fairly constant through the years of operation.

Table 11.5

ENERGY SOURCE MIX OF THE LUBE REFINING INDUSTRY, 1979 (In Percent)

	%
Electricity-Purchased	10.79
Petroleum	
Fuel Oil	87.56
Liquified Petroleum Gas	1.63
Diesel	0.02
TOTAL	100.00%

Most of the energy consumed by the industry is utilized mainly for heat generation, as process heat is very essential in the manufacturing process. In 1979, this alone accounted for 627.51 MBOE of the total petroleum consumed which is 87.6% of the total energy consumption (Table 11.6).

Table 11.6

CURRENT APPLICATION OF ENERGY IN LUBE REFINING

	MBOE	%
1. Mechanical Power Drive		
a. Electric Motors	77.27	10.78
b. Internal Combustion Engines	0.07	0.01
2. Process Heating		
a. Low Temperature	313.75	43.78
b. High Temperature	313.76	43.78
3. Material Handling/Transport	0.05	0.01
4. Others		
a. Lighting, Airconditioning, etc.	0.04	0.01
b. Process Cooling	11.69	1.63
TOTAL	716.63	100.00

Table 11.7 shows the equipment used in the industry as well as their rated capacities and estimated utilization.

Of the total energy input, about 57% was fully utilized. The balance of 43% represents the electro/thermodynamic losses inherent to the conversion and utilization of energy (Figure 11.3).

Table 11.7

RATED CAPACITIES AND ESTIMATED UTILIZATION OF ENERGY CONSUMING EQUIPMENT AND FACILITIES IN A LUBE REFINING PLANT

	Rated Capacity	Estimated % Utilization
Equipment Facilities		
1. Steam Generation	3.12×10^8 Btu/hr.	100.00
2. Electric Motors Aggregate Output	19,532.3 KW	82.07
3. Land Transport Vehicles	2,490.0 HP	78.00
4. Other Mechanical Equipment	4,592.0 HP	87.93
5. Process Heat Equipment (Other than those using Steam)	3.00×10^8 Btu/hr.	83.33

Figure 11.3

ESTIMATED ENERGY FLOW AND INHERENT LOSSES IN A LUBE REFINING PLANT (1979 figure in '000 BOE)