FEASIBILITY STUDY REPORT

ON

REFINERY PROJECT

IN

THE REPUBLIC OF GUATEMALA

AUGUST 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to the request of the Government of the Republic of Guatemala, the Government of Japan decided to conduct a feasibility study on the Refinery Plant Establishment Project and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to Guatemala a survey team headed by Mr. Susumu Sato from November 12 to December 4, 1983.

The team exchanged views with the officials concerned of the Government of Guatemala and conducted a field survey in the Project-related areas including El Rancho and Puerto Santo Tomás de Castilla. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I with to express my deep appreciation to the officials concerned of the Government of the Republic of Guatemala for their close cooperation extended to the team.

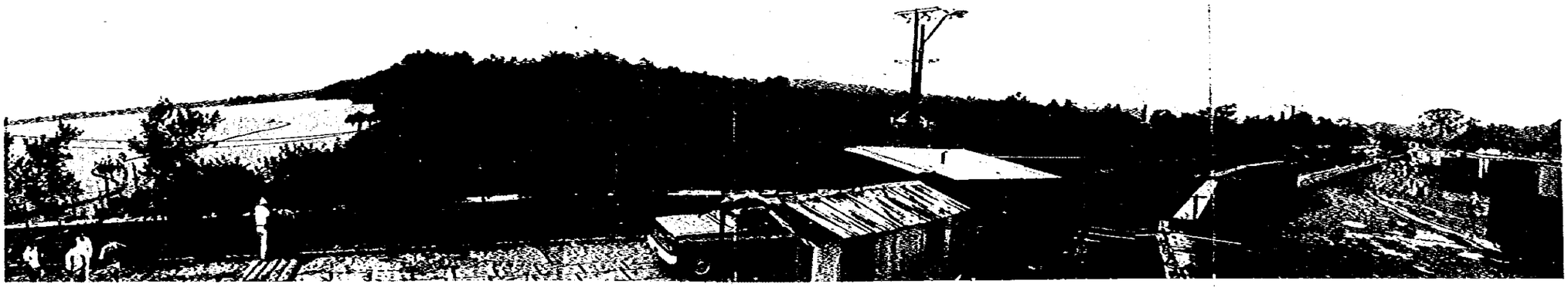
Tokyo, August 1984

Keisuke Arita
President
Japan International cooperation Agency

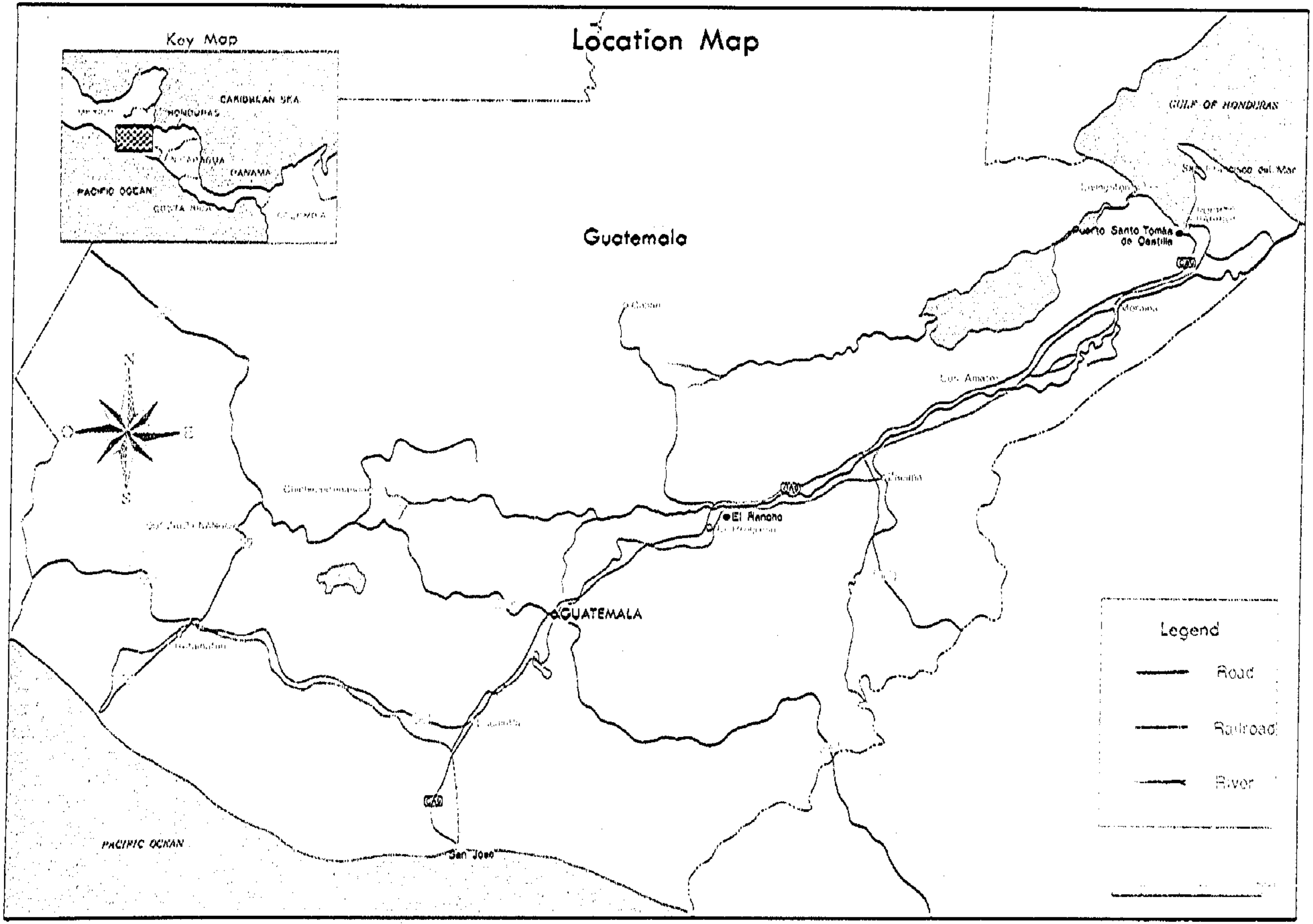
Selected Refinery Site

"Area C"

Selected Terminal Site



Location Map



ABSTRACT

ABSTRACT

1. Outline of This Project

(1) General

1) Total capital requirement
Construction of the refinery, terminal and pipeline costs about 673 million quetzales and about 121 million quetzales are required for other expenses. The total capital requirement amounts to about 794 million quetzales.

2) Schedule
It takes three years to construct the above.

3) Time of starting a commercial operation
A commercial operation starts in January, 1989.

(2) Outline of refinery facilities

1) Crude oil processing capacity
40,000 bbl/d

Guatemalan crude oil	10,000 bbl/d
Mexican Maya crude oil	15,000 bbl/d
Mexican Isthmus crude oil	15,000 bbl/d

2) Processes to be used
Because crude oil available is heavy and the demand for petroleum products centers on light products, the ebullated-bed hydrocracking process and fluid catalytic cracking process are used as heavy oil cracking process.

3) Location
El Rancho

4) Construction cost
About 510 million quetzales

(3) Outline of terminal facilities

1) Total tank capacity
200,000 kl

2) Location
Puerto Santo Tomas de Castilla

3) Construction cost
About 67 million quetzales

(4) Outline of pipeline facilities

1) Pipeline length and pipe diameter
Pipeline length : 220 km
Pipe diameter : 16 inches

2) Construction cost
About 95 million quetzales

2. Financial Evaluation

The financial internal rate of return on investment is 11.2% and indicates that this project pays, although its profitability is not very high. The financial internal rate of return on equity is 17.6% and exceeds the loan interest of 9%.

3. Economic Evaluation

The economic internal rate of return is 8.6%. The economic value of this project is not very high but economically rewarding.

4. Overall Evaluation

According to financial and economic evaluation, this project is rather feasible, although its profitability is not so high. However, the profitability of this project is greatly influenced by costs of crude oil and prices of petroleum products according to the results of sensitivity analysis. This project might lose its appeal, depending on the above costs and prices, for example in such a case as the costs of crude oil will rise abnormally, while the prices of petroleum products are not high enough to cover such costs.

The Guatemalan economy at present depends for 40% of its total exports on coffee, cotton and other agricultural products and its economic structure is easily influenced by weather and market conditions of crops, and Guatemala is therefore, oriented for industrialization. Taking the above into account, it would be preferable to implement and execute this project.

However, in implementing the project, it should be necessary to study and examine the project from a national macro-economic standpoint, since it requires a vast amount of funds amounting to about 794 million quetzales.

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(1) Unit and Conversion

o Length

mm	Millimeter
cm	Centimeter
m	Meter
km	Kilometer
in	Inch (1 in = 2.54 cm)
ft	Foot (pl. feet) (1 ft = 0.305 m)

o Area

cm^2	Square centimeter
m^2	Square meter
ha	Hectare (1 ha = 10,000 m^2)
ft^2	Square foot (1 ft^2 = 0.0929 m^2)

o Volume

m^3	Cubic meter
Nm^3	Normal cubic meter
l	Liter
kl	Kiloliter
bbl	Barrel (1 bbl = 159 l)
gal	Gallon (1 U.S. gallon = 3.785 l)
ft^3	Cubic foot (1 ft^3 = 0.0283 m^3)

o Weight

g	Gram
kg	Kilogram
t	Metric ton
lb	Pound (1 lb = 0.0454 kg)

o Time

sec	Second
min	Minute
h, hour	Hour
d, day	Day
m	Month
y, year	Year

o Temperature

°C	Degrees centigrade
°F	Degrees fahrenheit

o Others

Kcal	Kilocalorie
Btu	British thermal unit (1 Btu = 0.252 kcal)
g/Nm³	Gram per normal cubic meter
g/cm³	Gram per cubic centimeter
lb/gal	Pound per gallon
lb/ft³	Pound per cubic foot
°API	American petroleum institute gravity
kg/cm²	Kilogram per square centimeter
lb/in² (psi)	Pound per square inch
mm Aq	Millimeter aqua
St	Stokes (cm²/s)
P	Poise (g/cm.s)
A	Ampere
V	Volt
W	Watt
kVA	Kilo volt ampere
kWh	Kilo watt hour
Hp	Horse power (1 Hp = 746 W)
%	Percent
vol %	Volume percent

wt %	Weight percent
ppm	Parts per million
pH	Hydrogen ion concentration
t/d	Tons per day
t/y	Tons per year
CD	Calender day
SD	Stream day
BPSD	Barrel per stream day

(2) Exchange Rate

Yen, ¥	Japanese yen (1 U.S.$ = 235 yen)
U.S.$	U.S. dollar
Q.	Quetzal (1 U.S.$ = 1 Q.)

(3) Market, Finance and Economy

IRR	Internal rate of return
EIRR	Economic internal rete of return
FIRR	Financial internal rate of return
ROI	Return investment
GDP	Gross domestic product
GNP	Gross national product
CIF	Customs insurance and freight
FOB	Free on board

(4) Organization and Company

MEM	Ministerio de Energía y Minas
INDE	Instituto Nacional de Electriticación
TEXACO	Texas Petoroleum Co.
GUATCAL	Guatemala California Oil Co.
JICA	Japan International Cooperation Agency

VOLUME I

INTRODUCTION

I INTRODUCTION

1. Outline of Guatemala

1.1 Nature and Geography

(1) Geography and topography

The Republic of Guatemala is located at the western end of the Central America that connects the South and North American continents, and its geographical position is between N.L. 14° and N.L. 18°. Guatemala borders with Mexico at the north and west and with Honduras and El Salvador at the southeast, and it faces the Caribbean Sea towards the east and Pacific Ocean towards the south.

The Sierra Madre runs from the northwest to southeast of the country and there are many active volcanos and crater lakes. Accordingly, earthquakes are frequent in Guatemala and several earthquakes occurred in Capital Guatemala City and surrounding area.

The land size of Guatemala is 131,800 km², out of which about 60% are mountainous. The central plateau, having an average altitude of 1,000 to 1,500 m, has a mild climate and the soil is fertile. Therefore, the majority of the population concentrate in the central plateau, and Capital Guatemala City is located at a height of 1,502 m above the sea level.

The El Peten district in the north, which occupies about one third of the country land, is a limestone platform covered by a vast jungle.

The Caribbean coastal area is low and there are many swamps.

(2) Population

The total population of Guatemala is 6,044,000 according to the census of 1981. However, the 1983 edition of the International Financial Statistics Year Book reports that the population of Guatemala in 1981 is about 7,480,000, much greater than the result of census, and it is said the report of the year book is closer to the actual.

About 22% (1,307,000) of the population live in the Department of Guatemala, making a population distribution type of heavy in urban zone.

The population of Guatemala is increasing at a very high rate of average 3% per year since 1950.

(3) Climate

A characteristic point of the climate in Guatemala is that the temperature greatly varies by the altitude although the whole land is located in the tropical zone.

Table I-1 shows the meteorological data of some representative districts of Guatemala.

Table I-1 Meteorological Data

Location	Temp. (Annual Av. °C)		Rainfall (mm)		Height (m)
	Max.	Min.	Annual	Monthly, Max.	
El Progreso	35.0	19.5	773.5	155.1 (Sep.)	280
Puero Barrios	30.0	21.9	2,989.6	377.9 (Oct.)	0 - 10
Guatemala City	24.9	15.1	895.1	192.7 (Sep.)	1,500

In the El Peten district in the north, Caribbean coastal area and hilly areas up to 800 m above the sea level, the climate is tropical with the temperature kept at a high level through the year, hardly dropping below 23°C.

The highland including Guatemala City, in the altitude range of 800 to 1,800 m, belongs to a mild climate zone with the temperature kept at about 20°C, providing a pleasant area for living as well as for agriculture.

The rainfall varies by districts but is seasonally constant. The Pacific coastal area has two seasons of rainy (June through September) and dry (November through May). Other areas have rainfall through the year although the quantity varies by areas.

1.2 Outline of Economy

(1) General situation of economy

The first oil crisis (1973-'74) and second oil crisis (1978-'79) that occurred in succession after the dollar shock gave a grave impact to the whole world and caused a substantial change to the economic structure of the world. As a result, each country began to have a difficulty in smoothly managing the national economy and the high rate economic growth as had before cannot be expected any longer.

Naturally, Guatemala was affected by the oil crises, as other countries were, but the influence of the oil crises to Guatemala was not as grave as other countries since Guatemala has no industries that consume a large quantity of energy and the commercial energy consumption per capita is extremely low, or 185 kg in 1981 as the petroleum equivalent.

Table I-2 shows the gross national product (GNP), GNP growth rate, population and others as major indicators of Guatemala's economic trend in the past ten years. As the table indicates, the GNP growth rate in the period of 1972 through 1974 was sound at an annual average of 7.1%. The high growth rate after the first oil crisis is attributable to the following favorable conditions, in addition to the fact that Guatemala's economy is less dependent on petroleum:

1) Income increase due to favorable price change (35% price hike in 1973 over the price of preceding year) on the coffee, a very important export item.

2) Increase of export to the Central American Common Market during 1972 through 1974.

3) Smooth growth of income on tourism.

Table I-2 Guatemala's Basic Economic Indicators (1972 – 1982)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Gross National Product at 1980 Prices (in million quetzales)	5047	5410	5774	5864	6310	6879	7240	7598	7809	7782	N.A
GNP Growth Rate (%)	7.4	7.2	6.7	1.6	7.6	9.0	5.2	4.9	2.8	-0.3	N.A
Population (in million people)	5.58	5.74	6.05	6.24	6.43	6.63	6.84	7.05	7.26	7.48	7.70
Per Capita GNP at 1980 Prices (in quetzales)	904	943	954	940	981	1038	1058	1078	1076	1040	N.A

Source: International Financial Statistics Year Book, 1983

In 1975, however, the GNP growth rate dropped to 1.6%, the lowest since early 1950's. This is due to the slow export activities affected by the worldwide depression and stagnation of domestic consumption caused by high rate inflation of annual average 15%.

In the successive two years of 1976 and 1977, in spite of the serious disaster of the big earthquake occurred in February 1976, the GNP growth marked high rates of 7.6% and 9.0% respectively. The economy has remarkably recovered and the trade balance which had been in the deficit trend changed to surplus in 1977. The prominent expansion of demand both domestic and international and capital flow into Guatemala, as outlined in the following, contributed to this economy recovery:

1) Substantial expansion of domestic damands on all industrial fields of manufacturing, agriculture, in addition to the construction industry, owning to the economy reconstruction plan enforced after the earthquake disaster.

2) Extraordinary high rate of price hike for two successive years (65% increase in 1976 and 96% increase in 1977) on the coffee, a major foreign currency earner, and resultant large increase of income on the export.

3) Financial aids from overseas for reconstruction from the earthquake disaster.

4) Increase of capital investments from overseas

After marking the highest GNP growth rate of 9.0% in 1977, the growth of production on the agriculture and manufacturing industries gradually dropped. Accordingly, the GNP growth rate went on the decrease trend since 1978 as shown in Table I-2, marking -0.3%, which is the first recession ever occurred in the past 50 years. The causes for the recession are as follows:

1) Stagnation of international demands as the result of worldwide depression caused by the first and second oil crises.

2) Decrease of income on coffee export, a major export item, caused by inactive international coffee market.

3) Poor domestic demand affected by increased pressure of inflation.

4) Decrease of income on tourism resulting from sharp decrease of tourists from foreign countries since 1980 (The number of Americans who visited Guatemala in 1982 dropped to about 30% of that in 1979.)

(2) Trade activities and trade balance

The structure of trade of Guatemala is that it exports primary products like coffee, raw cotton, sugar, banana, beef, nickel alloy and imports capital goods and consumers' durables like machinery, chemicals, automobiles, fuel and petroleum products from foreign countries, a pattern typical of advancing countries.

As Table I-3 shows, the share of coffee and raw cotton, major export crops, in the total export amount is about 28% and 12%, respectively, that is, the two items account for about 40% of the total export, indicating that the economy of Guatemala is greatly subjected to the natural conditions which cannot be controlled by human being.

Since 1956, the government of Guatemala has been making efforts to diversify the export items from the aforementioned agricultural crops to cardamom (spice), tobacco, sesame, and cacao and concurrently promoting such industries as fermentation, nickel, fertilizer, lumbering, cement, paper making, petroleum development and refining, hydraulic power generation and development of telecommunications network. However, the trade pattern of Guatemala is still exporting agricultural products and importing industrial products.

Table I-3 Proportion of Principal Export Goods (1980, 1981)

	1980 (%)	1981 (%)
Coffee	30.5	25.0
Cotton	10.9	13.1
Sugar	4.6	6.6
Banana	2.9	3.8
Nickel	3.9	0
Cardamom	3.7	2.6
Meat	1.9	2.3
Petroleum	1.6	1.7
Export to Central America	29.0	29.2
Miscellaneous	11.0	15.7

Source: Estudio Economico & Memoria de Labores 1981.

Table I-4 Proportion of Prinipal Import Goods (1980, 1981)

	1980 (%)	1981 (%)
Primary Goods	32.8	32.4
Consumer Goods	21.3	20.4
Petroleum Goods	21.2	22.1
Construction Materials	5.8	6.0
Capital Goods	17.9	17.9
Miscellaneous	1.0	1.2

Source: Estudio Economico & Memoria de Labores 1981.

As shown in Table I-4, the share of crude oil and petroleum products in the total import is about 22%, which is not a high value. Also, the degree of dependence of foreign trade of Guatemala (ratio of total CIF values of import to GNP) is about 20% and this trend is fairly constant since 1975.

As to the opposite countries in foreign trade, the United States of America ranks at the top on both of export and import, and this is followed by the Central American Common Market (CACM) especially El Salvador, as shown in Tables I-5 and I-6. In this respect, Guatemala's economy is easily affected by the US economy, as other Latin American countries are.

As Table I-7 shows, the trend of total inport in the last 10 years (1972 - 1981) is on a mild increase of annual average growth rate of 20% as a whole, although there is a sharp increase of 64% in 1974 (from 427.4 million quetzales of 1973 to 701.3 million quetzales).

On the other hand, the total export amount is unsteady indicating a high correlation with the international market situation of coffee, which is the largest export item of Guatemala.

Table I-5 Imports by Principal Countries (percentage of total value)

	1978 (%)	1979 (%)
U.S.A.	30.2	34.8
CACM	16.5	15.2
(El Salvador)	(9.0)	(7.7)
Japan	10.3	9.2
Germany	8.5	7.8
Venezuela	6.9	1.2
Mexico	4.2	4.1
Miscellaneous	23.4	27.7

Source: 1981 Yearbook of International Trade Statistics

Table I-6 Exports by Principal Countries (percentage of total value)

	1978 (%)	1979 (%)
U.S.A.	30.5	26.6
CACM	22.9	25.4
(El Salvador)	(10.8)	(12.7)
Germany	12.4	8.8
Japan	6.5	8.1
Netherlands	4.7	5.1
Italy	4.5	3.6
Miscellaneous	18.5	22.4

Source: 1981 Yaerbook of International Trade Statistics

Table I-7 Main Foreign Trade Indicators
(1972 — 1982, in million quetzales)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Total Import (CIF)	349.7	427.4	701.3	732.4	838.4	1,052.5	1,260.7	1,449.4	1,559.1	1,673.5	1,388.0
Total Export (FOB)	328.1	436.2	572.1	623.6	760.3	1,160.2	1,111.6	1,217.1	1,472.8	1,226.1	1,119.8
Export of Coffee (FOB)	105.3	145.6	172.9	164.2	243.0	525.9	477.4	430.3	469.8	294.8	358.8
Export of Cotton (FOB)	40.9	47.9	68.3	74.1	85.0	152.1	139.1	182.8	166.5	130.9	78.7

Sources: (1) Boletin Estadistico, JUL., AGO., SEP., 1975 by Banco de Guatemala
(2) Anuario de Comercio Exterior, 1980 by D.G.E
(3) Boletin Estadistico, ABR., MAY, JUN., 1983 by Banco de Guatemala

As Table I-8 shows, the deficit on the current account of international balance of payment in Guatemala is generally covered by the surplus of capital account, thereby maintaining a surplus as total balance. However, after 1979, with unfavorable factors, such as, substantial deficit on the current account balance caused by poor international coffee market (the deficit of current account balance for 1981 reached as high as 559 million quetzales), and deficit on the capital account in 1980 (65 million quetzales) because of flow-out of capitals into foreign countries affected by the money crisis of the year overlapping, the total balance has had to show a deficit. The deficit on the total balance of 1980 reached as large a sum of 250 million quetzales.

Accordingly, the foreign currency reserves of Guatemala is gradually decreasing since 1979, after the peak of 790 million quetzales of 1978.

The international indebtedness of Guatemala is on the way of increase, reaching to 1,409 million as of the end of 1981.

Table I-8 International Balance of Payment in Guatemala
(1972 — 1982, in million quetzales)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Total Balance	44.2	83.3	-14.3	105.7	221.3	178.7	68.8	-15.1	-249.6	-197.8	-10.9
Current Account Balance	-9.5	11.1	-99.4	-62.3	-70.6	-35.2	-262.1	-196.4	-176.4	-559.0	-375.4
Capital Account	62.3	66.1	88.4	178.0	311.1	202.1	342.0	197.4	-64.9	393.1	361.2
Net International Reserves	148.2	230.6	213.3	318.4	538.0	720.7	789.5	776.1	526.9	346.8	N.A
External Debt	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	1,053.4	1,409.4	N.A

Sources:
(1) Anuario Estadistico, 1974 by D.G.E
(2) Boletin Estadistico, JUL., AGO., SEP., 1975 by Banco de Guatemala
(3) Anuario Estadistico, 1980 by D.G.E
(4) Estudio Economico & Memoria de Labores 1981 by Banco de Guatemala
(5) Anuario Estadistico, 1982 by SMHEN

(3) Industrial structure

As table I-9 shows, the contribution of agricultural sector to the gross domestic product (GDP) is as high as about 25%, and agriculture is the basic industry of Guatemala. The number of people working in agriculture accounts for about 55% of the whole working population, and agriculture is a major field of employing people.

The contribution of industrial sector to GDP is only about 16%, indicating a delay on industrial development.

The contribution of tertiary industries (commerce sector) is very high, or about 27%, and plumpness of this sector is extremely noticeable.

Table I-9 Sectoral Contribution to GDP (1980/1981)

Sector	Contribution to GDP (%)	
	1980	1981
Agriculture	24.8	24.2
Industry	16.7	15.6
Commerce	27.0	26.1
Construction	3.2	3.5
Transportation & Communication	6.9	6.6
Miscellaneous	21.4	24.0

Source: Estudio Economico & Memoria de Labores, 1981

As mentioned earlier, the government of Guatemala is making efforts to diversify the agriculture crops for export to cardamom (spice), tobacco, sesame, and cacao in order to avoid heavily relying on coffee, raw cotton, sugar and banana. At the same time, the government is promoting industrialization of cement, fertilizer, nickel, paper, lumbering and petroleum development, and improvement of the industrial structure is being realized although at a slow pace.

On the plantation, Guatemala is blessed with favorable climatic conditions and fertile soil. Also, it has rich water resources, forest resources, and it also is a petroleum producing country. Furthermore, it has many scenic resources for tourism (volcanic scenery and Maya remains). When all these favorable environmental factors are taken into consideration, we can say that Guatemala has good possibilities of development for the future.

1.3 Industry Development Plan

The government of Guatemala once established a National Development 5-year Plan (1971-1975) and made public investments amounting to about 59 million Quetzales, giving priorities to the development of power generation, transportation network and telecommunications network.

Also, a development plan was implemented during 1975 to 1979, which included revision of the preceding 5-year plan.

At present, however, there is no medium to long term development plan similar to the preceding 5-year plans.

2. Energy Situation of Guatemala

2.1 Energy Supply and Demand

(1) Trend of energy demand

Table I-10 shows the comparisons of the total energy demand, which is a sum of the primary energy (domestic production and imported energy) and imported seconday energy, and commercial energy demand, with GNP growth rate. This table indicates that there is practically no correlation between the growth of total energy demand and GNP growth rate. We consider that the reason for this is that fuelwood, which is non-commercial (self-consuming) fuel that is not influenced by changes of the economic situation, accouts for more than 50% of the total energy demand.

On the other hand, the commercial energy demand is very closely related with the economic situation as described in the following:

Table I-10 Trend of Energy Demand v.s. GNP Growth Rate

	1975	1976	1977	1978	1979	1980	1981
GNP Growth Rate (%)	1.6	7.6	9.0	5.2	4.9	2.8	-0.3
Total Energy Demand ($\times 10^3$ TPE)	3,086.1	3,270.8	3,505.6	3,621.1	3,751.1	4,373.0	3,643.5
Growth Rate (%)		6.0	7.2	3.3	3.6	16.6	-16.7
Total Commercial Energy Demand ($\times 10^3$ TPE)	1,052.8	1,157.0	1,362.5	1,468.1	1,588.3	1,580.7	1,382.7
Growth Rate (%)	N.A	9.9	17.8	7.8	8.2	-0.5	-12.5
Comm. Ener. (KGPE) Demand per Capita	169	180	206	215	225	218	185

Sources: (1) Anuario Estadistico, 1980, 1981, 1982 published by SNHEN

(2) International Financial Statistics Year Book 1983

1) Growth of commercial energy demand

The GNP growth rate was very high in the two years of 1976 and 1977 (7.6% in 1976 and 9.0% in 1977) for two major reasons of the construction rush as the result of economy reconstruction plan enforced after the big earthquake and increase of income on export due to abnormally high price of coffee which is a very important foreign currency earner of Guatemala. Reflecting this active economic state, the demand of commercial energy (energy of all types except non-commercial use energy like fuelwood and bagasse) increased at a high rate, resulting in 9.9% in 1976 and 17.8% in 1977. However, the GNP growth rate started to slow down in 1978, affected by the worldwide depression, and the growth rate of commercial energy also started to slow down. In 1981, the growth ended at -12.5%.

The commercial energy consumption per capita in Guatemala is about 185 kg in the petroleum equivalent in 1981, indicating that there is a much space left for industrialization.

(2) Structure of total energy demand

Table I-11 shows the structure of total energy demand.

Table I-11 Energy Demand Structure in Guatemala (1978 – 1981)
(x 10^3 TPE: in thousand tons of petroleum equivalent)

Sector	1978		1979		1980		1981	
	x 10^3 TPE	Percent	x 10^3 TPE	Percent	x 10^3 TPE	Percent	x 10^3 TPE	Percent
Crude Petroleum & Natural Gas	858.5	23.7	880.3	23.5	829.5	19.0	835.5	22.9
Fuelwood	1955.6	54.0	1981.3	52.8	2599.2	59.5	2005.2	55.0
Bagasse	197.4	5.5	181.5	4.8	193.1	4.4	255.6	7.0
Hydro	23.9	0.6	23.1	0.6	23.9	0.5	29.6	0.9
Geothermal	0	0	0	0	0	0	0	0
Uranium	0	0	0	0	0	0	0	0
Sub-total	3035.4	83.8	3066.2	81.7	3645.7	83.4	3125.9	85.8
Imported Petroleum Products	585.7	16.2	684.9	18.3	727.3	16.6	517.6	14.2
Total Energy Demand	3621.1	100.0	3751.1	100.0	4373.0	100.0	3643.5	100.0
Total Commercial Energy Demand	1468.1	-	1588.3	-	1580.7	-	1382.7	-
Domestic Energy Production	2252.4	-	2306.4	-	3070.1	-	2567.5	-
Domestic Commercial Energy Production	54.6	-	102.4	-	234.0	-	248.6	-
Self-sufficiency of Energy	-	62.2	-	61.5	-	70.2	-	70.5
Self-sufficiency of Commercial Energy	-	3.7	-	6.4	-	14.8	-	18.0
Petroleum Dependability of Commercial Energy	-	98.4	-	98.5	-	98.5	-	97.9

Source: Anuario Estadistico, 1980, 1981, 1982 published by SNHEN

As described earlier, about 50% or more of the total energy demand is shared by fuelwood, followed by the petroleum energy as a total of crude petroleum, natural gas and imported petroleum products, accounting for about 40%.

However, the petroleum energy occupies about 98% of the whole commercial energy demand, indicating high dependency upon petroleum.

The government of Guatemala has been constructing large hydraulic power generating plants, including the Chxoy Hydraulic Power Plant, by utilizing the rich water resources that the country is blessed with in order to secure the commercial primary energy source besides petroleum.

The government is also studying on the construction of a geothermal power plant but this has not been yet realized in the form of actual project.

(3) Energy self-sufficiency

As Table I-11 shows, 50% or more of the total energy demand in Guatemala is covered by fuelwood which is self-consuming fuel. For this reason, the energy self-sufficiency from the viewpoint of total energy demand is extremely high (70.5% in 1981).

On the other hand, the self-sufficiency of commercial energy is rather low (18.0% in 1981). However, there is a tendency of the self-sufficiency of commercial energy getting higher as Guatemala will be producing more petroleum domestically.

(4) Structure of secondary energy demand

Table I-12 shows the consumption and shares of consumption of the secondary energy by fields of industry.

Among all industries the transportation sector consumes the largest amount of energy, occupying about 45% of the total consumption, followed by industry sector, consuming about 30%. These two sectors consume about 75% of the total.

As industrialization develops in Guatemala and the number of energy-consuming industries increases in the future, undoubtedly there will be a shift from transportation to industry sector in the largest energy consumption.

Table I-12 Sectoral Shares of Secondary Energy Consumption (1978 – 1981)
($\times 10^3$ TPE: in thousand tons-of-petroleum equivalent)

Sector	1978		1979		1980		1981	
	$\times 10^3$ TPE	Percent	$\times 10^3$ TPE	Percent	$\times 10^3$ TPE	Percent	$\times 10^3$ TPE	Percent
Industry	362.1	31.6	412.4	33.8	352.4	30.4	266.3	25.9
Transportation	504.7	44.0	524.5	43.0	504.6	43.6	513.7	50.0
Agriculture	76.5	6.7	80.6	6.6	85.1	7.4	63.2	6.2
Residential Commercial & Public	162.5	14.2	166.1	13.6	175.4	15.1	181.9	17.7
Miscellaneous	40.4	3.5	36.8	3.0	40.8	3.5	1.6	0.2
Total	1146.2	100.0	1220.4	100.0	1158.3	100.0	1026.7	100.0

Source: Anuario Estadistico, 1980, 1981, 1982 published by SIGEN.

3. Outline of Study

3.1 Background and Purpose of Study

The Republic of Guatemala started the production of crude petroleum in 1976 and the production scale reached to two million bbl/y. The produced crude petroleum is exported except for consumption by power generation.

As to the petroleum products, although there are two oil refineries in Guatemala, only a refinery owned by Texas Petroleum Co. is operating at present, and Guatemala depends on importation for more than half of the petroleum products.

Under such circumstances, the government of Guatemala planned to construct a national refinery and made a request to the Japanese government in November 1982 to conduct a feasibility study on the construction of a refinery including a pipeline and crude oil terminal.

Upon receiving the request, the related ministries of the Japanese government and the Japan International Cooperation Agency dispatched a Pre-survey team headed by Mr. Iwaguchi, in July 1983, for the purpose of grasping the concrete contents of the project and conferring on basic matters necessary for the Study. A Scope of Work (hereinafter referred to as S/W) was concluded, dated as of July 19, 1983, on the study of the construction of a refinery in Guatemala, by and between the Pre-survey Team and La Secretaries de Mineria, Hidrocarburos and Energia Nuclear (which was reorganized to be Ministerio de Energia y Minas, which is hereinafter referred to as MEM).

The field survey was conducted from November 12 to December 4, 1983, based on the S/W of July 19. This report has been worked out as a result of the field survey conducted in Guatemala and home study conducted in Japan.

3.2 Study Methods and Procedures

A field survey is conducted first, and the results of the field survey are studied in Japan.

3.2.1 Items of field survey

Below listed are the items to be investigated during the filed survey:

(1) Background of planning oil refinery

1) Guatemala economy

The trend of major Guatemala economic indices, such as, population, growth of GNP, trade balance and balance of payment, etc. in the past 10 years are investigated.

2) Industry development policies

The current situation of industry development in Guatemala and incentive measures taken by the Government are investigated.

An investigation is made on the nature of projects being planned or implemented for expansion of the economical infrastructure, if any, with emphasis placed on the investigation of infrastructure related to this project.

3) Current situation of supply and demand of petroleum products

The current situation of supply and demand of petroleum products is investigated as in detail as possible.

4) Relationship with existing oil refineries (Texas Petroleum Co. and Guatecal Co.)

The cause for a low operation rate of the existing refineries is thoroughly investigated and the results is reviewed in detail.

(2) Study of petroleum products market and sales channels

1) Trend of demand for petroleum products in the past

The trend of demand on petroleum products, such as, liquefied petroleum gas, automobile gasoline, kerosene and jet fuel, aviation gasoline, gas oil, fuel oil and asphalt in the past ten years is investigated.

2) Costs and sales channels of petroleum products

Guatemala is dependent on importation for about half of the necessary petroleum products, and petroleum products are mainly imported by private concerns of international petroleum capitals and are sold under their brand names. Since petroleum products, if domestically produces, are expected to be distributed through these existing channels, the current situation of these channels and costs are investigated in detail.

3) Petroleum product prices

Price determining mechanism of petroleum products in Guatemala is that standard prices are set based on domestic production costs (including profit), which are at a fairly high level, and the ex-terminal prices of imported products set at the same level are as that of domestic production costs. Whole sale and consumer prices are determined by adding a controlled tax and profit to the unified standard prices. Investigation is made on this price determining mechanism for each petroleum product, being weighed against CIF prices of imported products.

(3) Study of crude oil availability

1) Crude oil produced in Guatemala

(a) Forecast of crude oil production

Expansion plans in the future on crude oil production and its facilities for each oil field are investigated. Oil fields to be investigated are Rubel Santo, Chinaja-Oeste, Caribe, Yalpemech, San Diego and XAN.

(b) Crude oil price

The price of Guatemalan crude oil is calculated by using the weighted ratio set for each crude oil on FOB prices of Arabian Lgiht, Tia Juana Light and Maya crude oil, CIF Houston prices, and estimated CIF prices at Guatemalan Atlantic ports. This price determining mechanism is investigated.

2) Imported crude oil

(a) Types of imported crude oil

Since the quantity of crude oil produced in Guatemala is insufficient for the oil refinery under this project for the time being, import of crude oil is taken into account from Mexico, Venezuela and Ecuador having similar nature to Guatemalan crude oil. Also taken into consideration is import of light crude oil in view of the demand on petroleum products. A thorough investigation is made on applicability as feedstock and possibility of importing crude oil for the oil refinery project.

(b) Crude oil prices

Current prices of crude oil to be imported from Mexico, Venezuela and Ecuador are investigated.

(4) Survey on proposed sites for oil refinery, crude oil terminal and pipeline route

The sites proposed by the Government of Guatemala are El Rancho area for oil refinery, Puerto Santo Tomas de Castilla area for crude oil terminal and a pipeline route connecting the refinery with the terminal. The following surveys are made on these proposed sites:

1) Natural conditions

(a) Climatic conditions

Statistical data on temperature, humidity, wind direction, wind velocity, rainfall and earthquake are obtained.

(b) Geology and topography

Availability of boring data on the proposed sites for oil refinery and crude oil terminal are investigated. However, soil bearing stress is measured by means of a portable cone in case such boring data are not available.

Whether or not site preparation is necessary on the proposed sites is studies by referring to maps and conducting a field survey. On the pipeline route, maps are obtained and an investigation is made on an optimal route through field inspection by car.

2) Social and economic conditions

(a) Population, labor supply and wage level survey is made on wage level, working conditions and labor supply in the surrounding areas of the proposed refinery and terminal.

(b) Local industries

Investigation is made on machinery and equipment manufacturers, construction

contractors and maintenance shops in the districts of the proposed refinery and terminal, whereby study is made on the range or scope of equipment, materials, and services available in Guatemala for the construction of oil refinery, pipeline and terminal.

Also are investigated organizations of existing refineries and the results are reflected to the proposed plant organization of this project.

(c) District development plan

Investigation is made on regional development plans in the surrounding area of the proposed sites for refinery and terminal, and their relationship with this project is studied.

3) Utility availability and public facilities

(a) Electricity

Necessary information on availability of an electric power to operate the oil refinery and terminal is obtained from INDE (Instituto Nacional de Electrificación).

(b) Water

While water to be used for the refinery is in principle to be taken from River Motagua, the use of well water is also studied in the event of the river water not being sufficient to satisfy plant need.

For the operation of the oil terminal, the use of well water is bas cally studied.

(c) Transportation

To study means of transporting products from the oil refinery, survey is conducted on roads and railways situation in the surrounding area of the refinery. Since heavy machinery and equipment have to be transported to construct the oil refinery, pipeline and terminal, transportation routes are surveyed in detail.

(d) Port

At present, Guatemala crude oil is stocked in Puerto Santo Tomas de Castilla, which is supposed to be a supply source of domestically produced crude oil in the future.

On the other hand, since the shortage of domestic oil has to be covered with imported oil, port facilities are essential. Accordingly, port facilities near the proposed terminal site are carefully surveyed and the results are reflected to the selection of the terminal site.

(e) Telecommunications

The situation of telecommunications at the proposed sites for oil refinery and terminal is investigated.

(f) Land cost

Land costs in the surrounding area of the proposed refinery and terminal is investigated and the results are applied to the construction cost.

4) Selection of sites for oil refinery, terminal and pipeline route

(a) Oil refinery

The study of oil refinery location at the first stage is comparison of El Rancho area with Puerto Santo Tomas de Castilla area on the Atlantic coast.

At the second stage, an exact location of the refinery is determined in consideration of various factors, such as, site preparation cost, soil bearing stress and easiness in transporting heavy machinery and equipment. Final location is to be clearly indicated on a map.

(b) Crude oil terminal

The study of crude oil terminal location at the first stage is comparison of two proposed areas, Puerto Santo Tomas de Castilla/Puerto Barrios with San Francisco del Mar area.

At the second stage, an exact location of the crude oil terminal is determined in consideration of various factors, such as, availability of land, site preparation cost,

relationship with port facilities and the existing terminals of domestically produced crude oil. Final location is to be clearly indicated on a map.

(c) Pipeline route

On the selection of pipeline route to connect the oil refinery with crude oil terminal, study is to be made on various cases to determine the route in consideration of construction cost and others.

5) Study of related laws and regulations

(a) Old and new petroleum laws

The old petroleum law stipulates that oil field development shall be conducted based on contracts on exploration and drilling concluded by and between the government of Guatemala and oil developing and producing companies and that the government of Guatemala shall share 55% of produced crude oil. However, in order to stimulate crude oil exploration and exploitation in Guatemala, the law is said to be revised to make such conditions more favorable to oil developing and producing companies.

In reviewing contents of the new law, study is made on how much impact the new law will have on exploration of crude oil in Guatemala leading to increase of oil production in the future.

(b) San Jose Agreement

Study is made on the possibility of applying the San Jose Agreement to this project. Under the agreement finance facility at a low interest rate shall be provided by oil exporting countries to consuming countries for latters' crude oil facilities, if crude oil is used as energy source.

(c) Other related laws and regulations

Laws and regulations applicable to oil refinery, pipeline and terminal facilities are investigated with regard to safety, environmental protection and working conditions.

6) Investigation for the purpose of working out basic and conceptual design of oil refinery, terminal and pipeline

(a) Design codes and standards to be applied to oil refinery

Codes and Standards being applied to existing oil refineries are investigated to determine design standards oil refinery under this project.

(b) Organization and required number of personnel for oil refinery and crude oil terminal

Organization and number of personnel of existing oil refineries are investigated with

an aim to reflect the results to the plan of this project.

7) Financial analysis

Investigation is conducted on the project life, financing plan, financing conditions (interest rate and repayment period), tax, insurance, incentives, depreciation period etc. required as preconditions for financial analysis.

8) Economic analysis

The project life, shadow prices and so on required as preconditions for economic analysis are investigated.

3.2.2 Home works conducted in Japan

Home work is conducted in Japan based on the field survey results.

The work is outlined in the following.

(1) Basic and conceptual design of oil refinery, terminal and pipeline

1) Determination of product mix and production scale

The product mix, production scale and product quality are determined based on the demand forecast on petroleum products and product quality required in Guatemala.

2) Determination of curde oil to be processed and processing capacity

The crude oil to be processed and processing capacity are determined based on the quantity of each production scale of the product mix as determined in Item 1) above.

The use of imported crude oil is taken into account in case domestically produced oil is not sufficient enough to satisfy the quantity of oil to be processed.

3) Studies on unit process for refinery and alternatives

A basic flow pattern for refinery is studied based on the quantity and properties of crude oil to be processed, product mix and quantity and quality of products. Process units constituting the basic flow pattern are to include distillation, vacuum distillation, catalytic reforming, catalytic cracking, hydrogenation cracking, thermal cracking, hydrogenation purification of naphtha, kerosene and gas oil, and fuel oil desulfurization, etc. and the basic flow pattern is studied based on the results of review on necessity and combination of these units.

Particularly close attention and consideration are paid to the fact that the crude oil to be processed seems a heavier curde oil and of a high sulfur content while demand on heavy oil is expected to decline in the future due to completion of a hydraulic power plant.

With regard to the study of process units of refinery, and conducted case study is conducted in addition to a basic plan.

4) Determination of process units of refinery

An optimal constitution of process units is determined from a technical and economical standpoint.

5) Processing capacity of refinery

The processing capacity is determined for each process unit.

6) Preparation of production flow diagram including material balance

Process flow diagram containing material balance is worked out based on the determined constitution of process units and capacity of each unit.

7) Preparation of conceptual design

A basic policy is established for the design of refinery, pipeline, crude oil terminal and all related facilites to prepare process flow diagram and list of major equipment. Also, established is a basic policy for the design of off-site facilities that are essential for a safe and smooth operation of the refinery, such as, water, steam, electricity and cooling water facilities, locally consumed fuel facility, blowdown flare facility, waste water treating facility and fire prevention and extinguishing facilities to determine the outline of equipment.

8) Plot plan of oil refinery and related facilities

Plot plans of oil refinery (including related facilities), pipeline and crude oil terminal are studied.

9) Proposal on transportation of construction materials

A proposal on methods of unloading and transportation up to the construction site of heavy machinery and equipment is prepared.

10) Preparation of construction schedule

A time schedule for the construction of oil refinery, pipeline and crude oil terminal is prepared.

11) Preparation of organization and personnel plan for construction and operation on a commercial basis

The number of personnel required for the construction of refinery, pipeline and terminal is roughly estimated, while organization and personnel deployment plans are proposed on a commercial basis operation of refinery, pipeline and crude oil terminal.

12) Proposal on commercial basis operation plan

A proposal is prepared on a rate of operation of the refinery in connection with demands.

A proposal is also prepared on training programs

for plant employees, including training in foreign countries, to be conducted prior to starting up the operation.

13) Study on environmental protection measures

A proposal on environmental protection measures on air pollution, waste water and noise produced by the refinery is prepared with reference to related laws and regulations in Japan.

(2) Financial analysis

The purpose of financial analysis is to determine the return on investment of this project by setting expenditure against revenue, i.e., all income from product sales less the sum of total capital costs consisting of the production equipment and production cost, using an enterprise model while interpreting this project as being an enterprise.

In order to analyze this project financially, profit and loss statements, balance sheets and cash flow table are prepared for the project life based on appropriate initial conditions and necessary assumptions on expected sales proceeds, raw material costs, repayment plan of loaned operation fund, depreciation, various tax rates, dividend policy, etc. The project is also evaluated financially by calculating the internal rate of return based on the cash flow table.

The following summarized financial analysis methods to be applied.

1) Estimate of total capital required

The total capital required consists of fixed capital (land cost, plant construction cost, pre-operation expenses, interest on loan during construction) and operation fund.

o Fixed capital

Land and plant construction costs are calculated based on the result of conceptual design, plant equipment costs, and cost information as collected in Guatemala. The pre-operation expenses are calculated based on data obtained at the time of constructing a refinery by Mitsubishi Petroleum Co. and information obtained in Guatemala. The fixed capital is estimated on the basis of these costs and interest during the construction period based on the interest rate available in Guatemala.

o Working capital

Working capital necessary to start up the plant is calculated. The working capital needed is the balance after deducting account payable from the sum of cash on hand and accounts receivable plus costs equivalent to a proper stock on hand of raw materials, fuel, intermediate products and products.

o Repayment plan

A repayment plan is worked out based on the information obtained in Guatemala and accumulated in the Study Team.

2) Financing

A proposal is prepared on a capital/loans ratio, a short/long term loand ratio, sources of loans and their conditions (interest rate and period). The ratio of capital is determined upon consultation with the Guatemalan side.

3) Production cost

The production cost consists of variable cost (raw materials, auxiliary raw materials and utilities), fixed cost (labor cost, insurance, fixed asset tax, and plant overhead), depreciation and interest. The production cost is calculated based on data obtained from the conceptual design, data accumulated in the Mitsubishi group, and information collected in Guatemala.

4) Profit and Loss Statement

Sales proceeds are estimated by setting production plans and product prices based on the results of the field survey in Guatemala. A Profit and Loss Statement is prepared for each year of the project life by calculating the profit from estimated sales proceeds and the production cost as obtained in Item 3) above and in consideration of income tax.

5) Balance Sheet

A Balance Sheet is prepared for each year of the project life while taking the information collected in Guatemala into consideration.

6) Preparation of financial statements

The financial statements consist of three tables; profit and Loss Statement, Balance Sheet and Cash Flow Table. A Cash Flow Table is prepared based on total capital required and Profit and Loss Statement. Tables for cost analysis, debt service ratio and break-even-point are also prepared.

7) Calculation of internal rate of return

An internal rate of return means a discount rate by which incoming and outgoing cash for each year is discounted until making the sum of all discounts zero. The internal rate of return is calculated to quantitatively evaluate a financial profitability of this project, based on the Cash Flow Table.

8) Sensitivity analysis

Major fluctuating factors in financial analysis are investment cost, crude oil prices and product sales prices. Accordingly, a sensitivity analysis is conducted by calculating the internal rates of return using different values on these factors. In order to evaluate this project properly, a sensitivity analysis is also made by fluctuating other factors such as rate of operation,

production cost, and interest rate as occasion demands.

(3) Economic and social evaluation

The purpose of economic evaluation is to clarify the importance of this project to Guatemala by drawing merits and demerits measured as quantitatively as possible from an economic viewpoint, in consideration of the impact which this project will have on Guatemala, into comparison with the cost.

1) National economic evaluation

Economic expenses and benefit which would be brought in by implementing this project are analysed. The economic internal rate of return is calculated by applying shadow prices checking and processing transfer items between the government and private enterprises like taxes and governmental subsidies. The quantitative economic evaluation is conducted by estimating the national economic profitability and efforts on foreign trade balance. The national economic evaluation is also made by taking qualitative benefits into account that cannot be measured quantitatively, such as, increase of employment, technology transfer and effect on other industries.

2) Influence on industry development plans

The coordination of this project with and its effects on the industry development plans are studied.

3) Sensitivity analysis

A sensitivity analysis is conducted on the economic internal rate of return by fluctuating economic merits and expenses.

4) Overall evaluation and recommendation

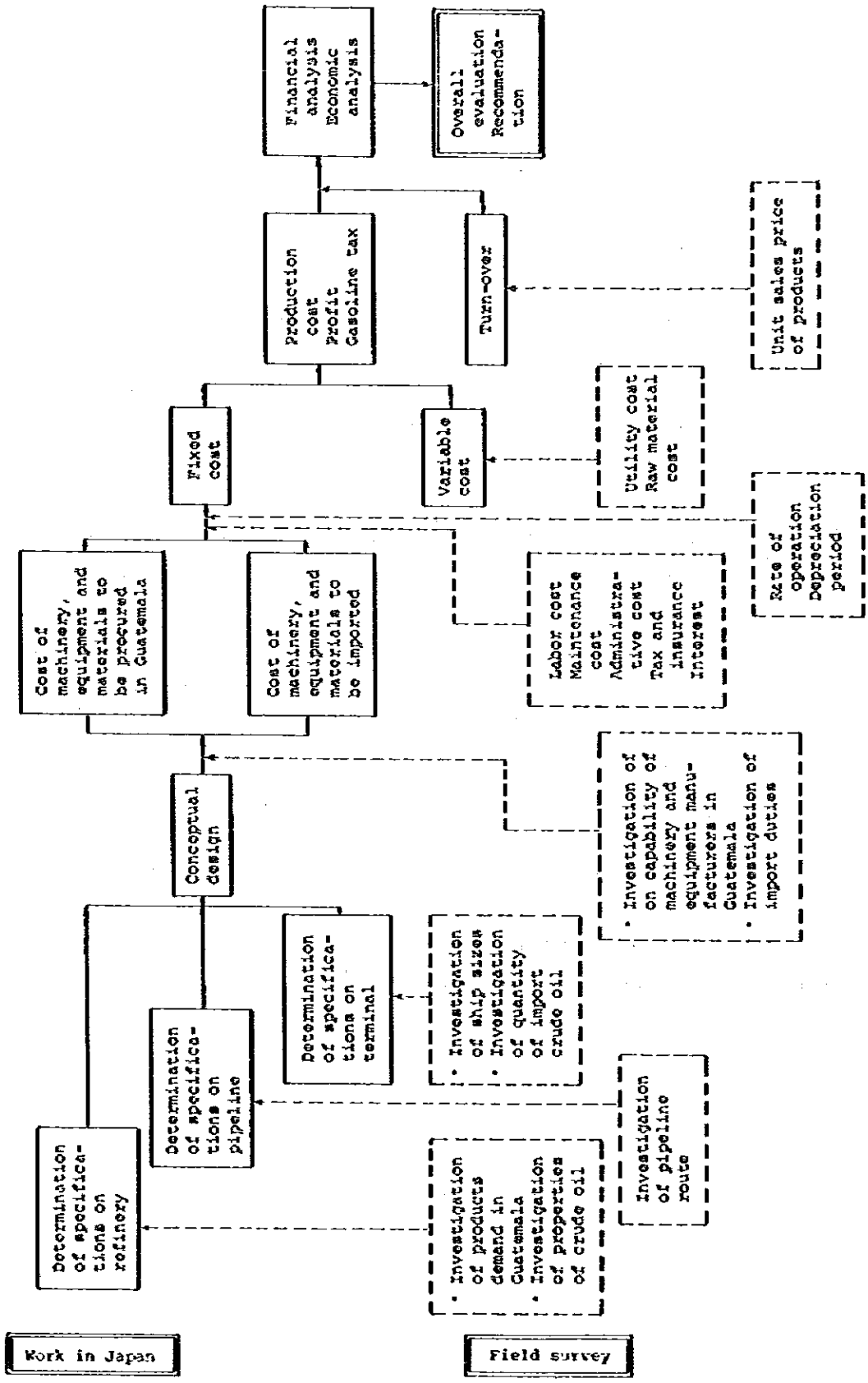
The project is evaluated from technical and economical viewpoints by making overall judgement of the survey results.

A proposition is to be made on which seems necessary to implement the project in the event that the project is found feasible.

In case the realization of this project seems endangered due to internal or external problems, these problems are to be clarified, with measures to be taken to solve them proposed, and evaluation will be made on feasibility of this project assuming that the problems had been solved.

The major points of the field survey and home work conducted in Japan are summarized in Fig. I-1, in order of the work.

Fig. I-1 Outline of Survey Procedure



3.3 Framework and Schedule of the Study

Based on the S/W, the schedule of this study is set as shown below:

o	Preparatory work in Japan	Sep. 1983 - Nov. 1983
o	Field survey	Nov. 1983 - Dec. 1983
o	Home work in Japan	Dec. 1983 - Jun. 1984
o	Submission of final report draft and discussion	Jun. 1984
o	Submission of final report	Aug. 1984

VOLUME Ⅱ

FIELD SURVEY REPORT

II FIELD SURVEY REPORT

1. Purpose of Field Survey

The field survey was conducted from November 12, 1983 to December 4, 1983. The major purposes of the field survey are as follows:

- o Collection of data necessary for home work in Japan
- o Conference with MEM concerning the method of this study

2. Organization of Field Survey Team

The Field survey team was organized as shown in Table II-1.

Table II-1 Field Survey Team

Team leader	Mr. S. Satoh	Project manager
Engineer	Mr. Y. Suzuki	Pipeline
Engineer	Mr. S. Nishiyama	Oil refinery plant
Engineer	Mr. H. Sekiguchi	Terminal facility
Engineer	Mr. S. Kobayashi	Oil refinery process
Engineer	Mr. M. Itagaki	Civil and architecture
Economist	Mr. E. Sugiyama	Marketing
Economist	Mr. A. Hashimoto	Finance and economy
Economist	Mr. K. Koike	Marketing system

3. Field Survey Schedule

The field survey team tried to obtain necessary information through conference with the personnel representing the Guatemalan side during field survey. Also, the team obtained a lot of information through inspection tours to the proposed sites of oil refinery and crude oil terminal and the surrounding areas.

The schedule of the field survey team is as shown in Table II-2.

Table II-2 Field Survey Schedule

DATE		AM/PM	SCHEDULE
NOV. 12	SAT.		Arriving at Guatemala (PA-022)
13	SUN.		Preparation for field survey
14	MON.	AM PM	Visit to Japanese Embassy Meeting with MEM
15	TUE.		Meeting with MEM
16	WED.		Visit to El Rancho (Proposed site of oil refinery) Survey of pipeline route
17	THU.		Visit to proposed site of terminal Survey of oil refinery (Guatecal Co.)
18	FRI.		Visit to San Francisco del Mar Survey on equipment transportation
19	SAT.		Report preparation
20	SUN.		Report preparation
21	MON.		Visit to San Jose Port

DATE		AM/PM	SCHEDULE			
22	TUE.		Studies of national policies on industry development	Collection of data related to pipeline (map and others)	Investigation of natural conditions	Investigation of major economic indices
23	WED.		Investigation of quantity and price of Guatemalan crude oil	Visit to Puerto Santo Tomas de Castilla	Studies of laws and regulations on oil refinery	Investigation of financial analysis preconditions
24	THU.		Investigation of quantity and price of imported crude oil	Investigation of pipeline route	Survey of local industries	- ditto -
NOV. 25	FRI.		Investigation of supply and demand of petroleum products	- ditto -	- ditto -	Investigation of economic analysis preconditions
26	SAT.		Report preparation	Report preparation	Report preparation	Report preparation
27	SUN.		- ditto -	- ditto -	- ditto -	- ditto -
28	MON.		Visit to oil refinery (Texas Petroleum Co.)		Meeting with local industries	
29	TUE.		Investigation of petroleum product distribution	Meeting with local industries		Investigation of labor situation
30	WED.		Meeting with MEM			
DEC. 1	THU.	AM	Meeting with MEM (Signing interim report)			
		PM	Visit to Japanese Embassy			
2	FRI.		Leaving Guatemala (NX-908)			

4. Main Attendants of Meetings

1) Ministerio de Energía y Minas (MEM)

Minister	Tte. Cnl. e Ing. Sigfrido Alejandro Contreras Bonilla
Director	Ing. Marco Tulio Espinoza
Vice-Director	Lic. Augusto Estrada
Department Head	Ing. Jorge L. Huertas
Engineer	Mario R. Cáceres
Engineer	Ing. Roberto Chacón
Engineer	Ing. José Arturo Estrada
Engineer	Ing. Luis G. Paredes

2) Técnica de Pulpa y Papel, S.A.

Engineer	Ing. Enrique Ruiz Girola

3) San Agustín Municipality Office

Mayor	Oliverio Ayala Juárez

4) Guatcal Oil Co.

Engineer	Julio Rafael Colón R,
Engineer	Carlos A. Gómez

5) Crude Oil Terminal

Supervisor	Richrad White

6) Insivumeh (Meteorological Agency)

Engineer	Estuadro Velásquez
Engineer	Eddy Sánchez

7) Puerto Barrios Municipality Office

Mayor	Luis A. Solís

8) Instituto Nacional de Electrificación (INDE)

Director	José L. Terrón

9) Transformadora Industrial Pittsburgh

Des Moines y Cía. S.A. (TIPIC)

Director	Fidelino Javier

10) Banco de Guatemala

Director	Gabriel R. Castellanos

11) Texas Petroleum Co.

Engineer	Héctor F. De León G.
Engineer	Julio F. Martínez

5. Field Survey Report

5.1 Mutual Agreement Items

5.1.1 Study methods and procedures

The field survey team explained the study methods and procedures described in Clause 3.2 of Section 3, Volume I, to MEM and MEM agreed to them.

5.1.2 Time schedule of study and the number of copies of report

The field survey team confirmed the study time schedule and the number of copies of report with MEM based on the S/W, and MEM agreed to them.

5.1.3 Site selection

For the home work to be conducted in Japan, the field survey team had to select the site of oil refinery and crude oil terminal. Based on field survey results and existing reports, the field survey team selected El Rancho for oil refinery and Puerto Santo Tomas de Castilla for crude oil terminal.

The reasons for selecting these sites are as follows:

(1) Oil refinery

El Rancho and Puerto Santo Tomas de Castilla were proposed as a site for the oil refinery. As a result of comparison of two sites on annual costs co-related with investment cost and annual transportation costs, the field survey team found El Rancho more economical. Accordingly,

the field survey team selected El Rancho as the site for oil refinery.

(2) Imported crude oil terminal

Puerto Santo Tomas de Castilla and San Francisco del Mar were compared as a site for the crude oil terminal. In the case of San Francisco del Mar, an access road would have to be constructed to transport machinery and equipment for the terminal. According to the information obtained from MEM and municipal officers, there were a lot of suitable areas for the terminal in Puerto Santo Tomas de Castilla and an access road was already existing. The filed survey team, therefore, selected Puerto Santo Tomas de Castilla as a site for the imported crude oil terminal.

5.1.4 Capacity of proposed oil refinery

MEM wanted the target capacity of the proposed oil refinery to be 40,000 to 50,000 bbl/d. The field survey promised MEM to study the capacity of the oil refinery based on future demands on petroleum products in Guatemala, while taking the target capacity wanted by MEM into consideration.

5.1.5 Importing crude oil

MEM plans to import crude oil from Venezuela or Mexico to fill a shortage of domestically produced crude oil. The field survey team requested to the Guatemalan side to select only a kind of imported crude oil that would have the highest possibility of importation for the purpose of establishing a conceptual design. MEM indicated Mexican Maya as the most probable imported crude oil. MEM also suggested that, should the use of Mexican Maya crude oil

only be impossible for a reason of processing oil, the Maya crude oil might be mixed with Isthmus crude oil.

5.2 Field Survey Results

5.2.1 Background of planning an oil refinery

There are two oil refineries in Guatemala; one owned by Guatcal Oil Co. and the other owned by Taxas Petroleum Co. The oil refinery of Guatcal Co. has stopped operation since 1975 for an economical reason, while that of Texas Petroleum is operating at a lower operation rate since the product mix of Texas Petroleum does not necessarily meet or match demands on oil products in Guatemala.

On the other hand, the production of Guatemalan crude oil is expected to increase because of incentive measures given to oil producers by the enactment of new petroleum law.

5.2.2 Survey on market and distribution channels for petroleum products

The filed survey team collected data on the trend of demands on petroleum products in the past eight years from 1975 through 1982. The field survey team requested MEM for the data of 1973 and 1974, to make it ten years-data, but the data for these years were not available except for a certain products.

The field survey team also collected data on prices and distribution channels for petroleum products.

5.2.3 Survey of Guatemalan crude oil

The price of Guatemalan crude oil is calculated with reference to the CIF prices of Arabian Light, Tia Juana Light and Maya crude oil.

The field survey team obtained the data on current prices of Guatemalan crude oil from MEM but was unable to obtain the price determining formula for the reason of the formula being strictly confidential.

5.2.4 Survey of proposed sites for oil refinery, crude oil terminal and pipeline

The field survey team conducted field surveys of El Rancho, the proposed site of oil refinery, Puerto Santo Tomas de Castilla, the proposed site of crude oil terminal, and the pipeline route connecting the oil refinery with the crude oil terminal. The surveyed items are as follows:

(1) Natural conditions

The Team collected statistical data of these areas for the past ten years on temperature, humidity, rainfall and wind velocity from the Weather Bureau.

(2) Geology and topography

Since boring data were not available for these areas, we measured soil bearing stresses by means of a portable corn brought from Japan. The Team obtained maps of 1/50,000 scale for related areas.

(3) Utility, public facilities and infrastructure

We had a meeting with INDE with regard to the availability of electricity at the oil refinery and crude oil terminal. The result is that the electric power is available at both places but that the supply fails frequently and its reliability is rather low.

The Team conducted detailed investigations on both routes from Santo Tomas de Castilla to El Rancho and from San Jose to El Rancho, to transport heavy machinery and equipment.

The Team investigated unloading facilities and piers on two ports, Puerto Santo Tomas de Castilla and San Jose.

Besides the above stated, the Team surveyed land prices at the proposed sites for oil refinery and terminal.

5.2.5 Study of related laws and regulations

(1) New and old petroleum laws

The fieled survey team studied the new and old petroleum laws and investigated how much exploration and development of oil fields in Guatemala would be encouraged and activated in future.

(2) San Jose Agreement

According to the comment made by MEM staff, contents of San Jose Agreement were modified with respect to credit conditions in August 1983. The Team obtained detailed information on the modification.

(3) Other related laws and regulations

According to MEM, the laws and regulationss applicable to oil refineries and crude oil terminals with regard to the safety and environmental protection have not been legislated yet. Accordingly, the Team has decided to apply the laws and regulations of Japan or the United States when working on a conceptual design.

5.2.6 Survey for conceptual design of oil refinery, crude oil terminal and pipeline

The Team investigated on organization, the number of personnel and design standards of the existing oil refineries, Guatcal Co. and Texas Petroluem Co.

5.2.7 Financial and economic analysis

Based on the conferences with MEM, premises preconditions for financial and economic analysis have been set forth as follows:

(1) The unit of currency is expressed in Quetzal, the Guatemalan currency.

All foreign currency values are converted to the Quetzal value.

(2) Exchange rate

1 Quetzal = 1 US$
1 Quetzal = 235 Yen

(3) Financial and economic analysis are based on the value as of December 1983 with no escalation taken into account. However, financial analysis will be conducted for a case with escalation as a reference.

(4) The year of plant startup is 1989.

(5) The project life for financial and economical analysis is 20 years.

(6) Stream factor

With technical viewpoints such as operator's familiarization with operation, demands on products and etc. taken into consideration, the stream factor is determined to be as follows;

First year	70%
Second year	90%
Third year and onward	100%

The number of operating days is 330 days a year.

(7) Conditions for financial and economical analysis

- o Debt equity ratio 90:10
- o Source of equity Government
- o Long term loan conditions

Interest rate	9% per annum
Installment	15 times
Repayment	15 years
Grace period	3 years

- o Short term loan condition

  Interest rate 12% per annum

- o The interest during the construction period is capitalized.

(8) Depreciation and amortization

- o Pipeline 15 years
- o Machinery and equipment 10 years
- o Plant construction 10 years
- o Buildings and structures 10 years
- o Interest during construction 15 years
- o Pre-operation expenses 5 years

(9) Taxes

All taxes are to be exempted in consideration that the project is executed by a governmental organization. However, a financial analysis is made as a reference, for a case with taxes taken into account.

(10) Prices of raw materials and products

- o Raw materials

  Guatemalan crude oil 26.89 US$/bbl

  Imported crude oil as of end 1983

- Products

LPG	0.6797 US$/gallon
Premium gasoline	1.146 US$/gallon
Regular gasoline	1.109 US$/gallon
Kerosene	1.165 US$/gallon
Jet fuel	1.165 US$/gallon
Diesel oil	1.081 US$/gallon
Fuel oil	0.6627 US$/gallon
Asphalt	(0.9056 US$/gallon)

(11) Production cost

The production costs are broken down into raw materials cost, utilities cost, checmicals and catalysts cost, labor cost, plant overhead, maintenance expenses, insurance, land rent, and others.

(12) Major incentives

The following incentives are provided in making a financial analysis as a reference case of paying taxes:

- Carry-over of loss
- Exemption from paying import duties on imported machinery and equipment
- Exception from paying income tax for two years or eight years

(13) Items for sensitivity analysis

- Investment cost
- Crude oil price
- Product sales price
- Others

VOLUME Ⅲ

CRUDE OIL

III CRUDE OIL

1. Guatemalan Crude Oil

The following describes on the new and old petroleum laws, production, properties, and price of Guatemalan crude oil.

1.1 New and Old Petroleum Laws

The government of Guatemala enacted a new petroleum law in 1983, superseding the old petroleum law. The old petroleum law stipulated that petroleum development companies succeeding in drilling petroleum should share 45% of the production, while the Government of Guatemala taking the balance 55%.

The major revisions made on the new petroleum law are as follow:

(1) For the period until petroleum development companies have recovered costs and expenses invested in the development:

1) The Guatemalan government's share is 20% in case of crude oil having an API scale of 30 degrees. The government's share increases or decreases by 1% for an increase or decrease of one degree of API scale respectively.

2) The minimum rate of the government's share is 5%.

(2) For the period after petroleum development companies have recovered costs and expenses invested in the development:

1) The Guatemalan government's share is 20% + α.

The α value varies by the quantity of production as listed below:

Production	α value
0 - 5,000 bbl/d	80% x 30% = 24%
5,000 - 10,000 bbl/d	80% x 35% = 28%
10,000 - 20,000 bbl/d	80% x 40% = 32%
over 20,000 bbl/d	80% x 50% = 40%

For petroleum development companies, the new petroleum law makes their development work easier since the government's share is now substantially decreased to 20% from 55%.

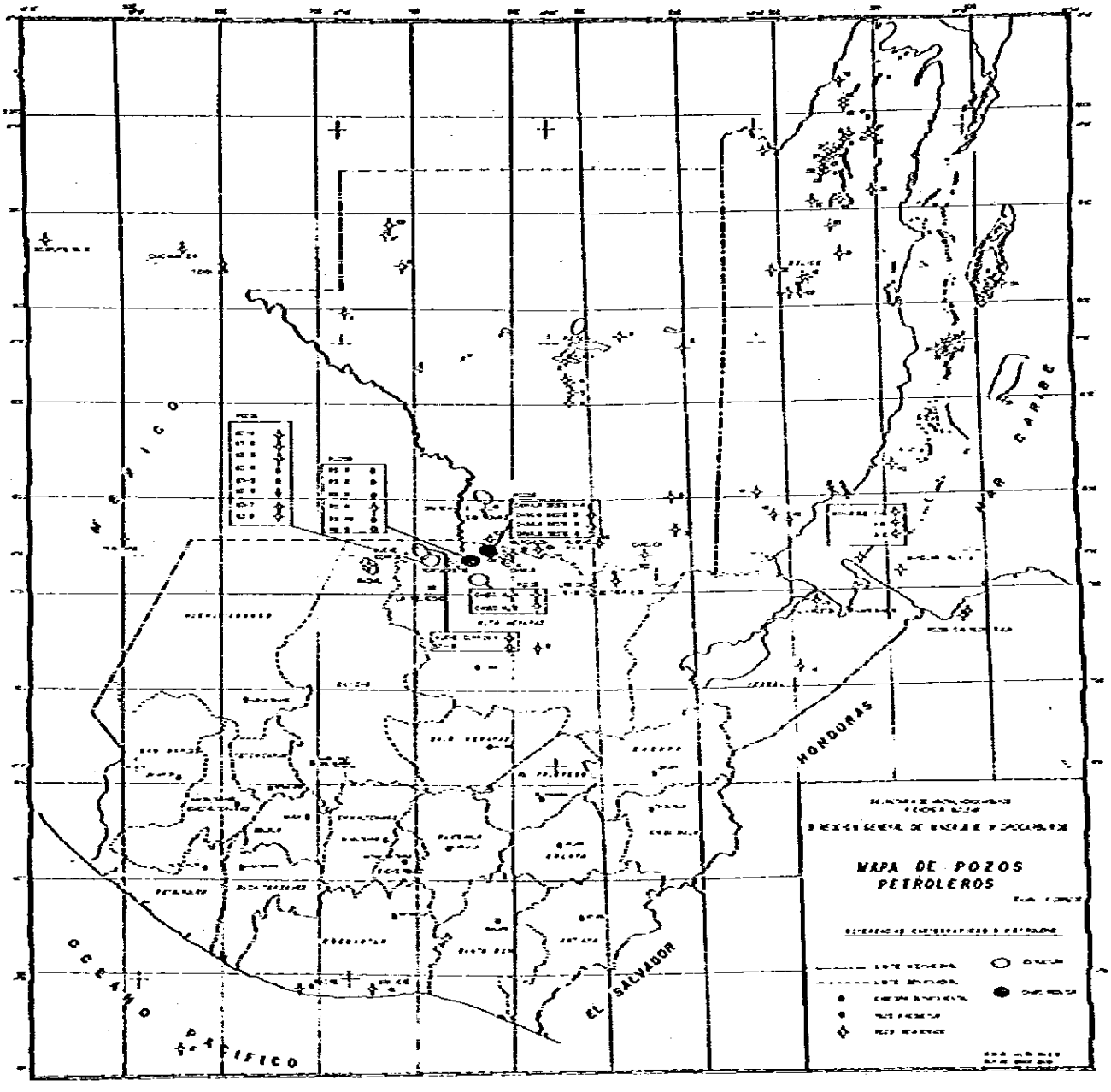
1.2 Crude Oil Production

1.2.1 Crude oil reserves

Guatemalan oil fields are distributed over such departments as Alta Verapaz, Peten and Quiche, which are in the north of Guatemala City and close to Mexico. This distribution is shown in Fig. III-1.

At present in Guatemala two companies, Elf Aquitaine Guatemala & Basic Resources International (Bahamas) Ltda and HISPANOIL are producing crude oil from four oil feilds of Rebelsanto, Chinaja-Oeste, Caribe and Yalpemech in two concessions of I and A-A. No production is under way in the San Diego oil field, although reserves there have been appraised.

Fig. III-1 Distribution of Oil Fields in Guatemala



(Source: MEM Anuario Estadastico)

Also Texas Petroleum Co. has confirmed petroleum reserves in the XAN oil field of the concession D in Peten Department.

Table III-1 summarizes original oil contain of resources, ultimately recoverable oil resources and actual production of each oil field.

Table III-1 Reserves and Production by Oil Fields

(Unit: 10^3 bbl)

Oil Field	Original oil contain of resources	Ultimately recoverable oil resources	Production
Rubelsanto	39,300	11,790	3,264
Chinajá-Oeste	27,600	8,380	3,831
Caribe	13,200	3,960	405
Yalpemech	17,000	5,100	116
San Diego	14,000	4,200	-
XAN	48,000	7,000	
Total	159,100	40,430	7,616

Note: Production is actual as of June, 1983.
(Source: MEM)

As Table III-1 shows, Guatemala has about 159 million bbl original oil contain of resources and about 40 million bbl of ultimately recoverable oil resources.

1.2.2 Crude oil production

The crude oil production in Guatemala started in 1976, and Table III-2 shows an annual production in the past. The production sharply increased in 1980 when Chinaja oil field started production and the pipeline from Rubelsanto oil field to the crude oil shipment terminal in Puerto Santo Tomas de Castilla was completed. According to the forecasts by the Guatemalan government the production would reach about 4 million bbl/y in 1984.

Table III-2 Guatemalan Crude Oil Production

(Unit: 10^3 bbl/y and %)

Year/month	Production	Ratio to prec. yr.	Production (Cumulative)	Export	Domestic
1978	220.7			-	215.2
1979	571.4	258.9	792.1	-	568.7
1980	1,513.3	264.8	2,305.4	781.5	530.2
1981	1,493.6	98.7	3,799.0	661.7	755.2
1982	2,291.1	153.5	6,091.1	1,546.0	730.1
1983 Jan.	208.0	-	-	140.0	40.6
Feb.	200.7	-	-	144.8	44.3
Mar.	211.9	-	-	144.8	45.9
1984	(4,000)	Estimation			

(Source: 1983 Edition of Actualidad Petrolera en Guatemala)

1.3 Crude Oil Properties

Unable to obtain detailed analysis data on the Guatemalan crude oil (Coban Blend), the Survey Team obtained crude oil samples from MEM to analyse in detail. Table III-3 shows results of analysis. However, in view of the current crude oil production and its active development expected for the future, it is to be recommended that the crude oil should be analyzed again to check up its properties finally constructing a new oil refinery.

Results of analysis conducted by the Team indicate that the Guatemalan crude oil is a heavy crude oil with high sulfur content, exceptionally high sulfur contained especially in light crude oil fraction. Therefore, a close attention would have to be given to the selection of unit processes in planning an oil refinery. It should also be pointed out that much more closer attention is to be paid to the design and selection of materials for the distillation column since an extremely large volume of H_2S is generated, when heated, from the crude oil.

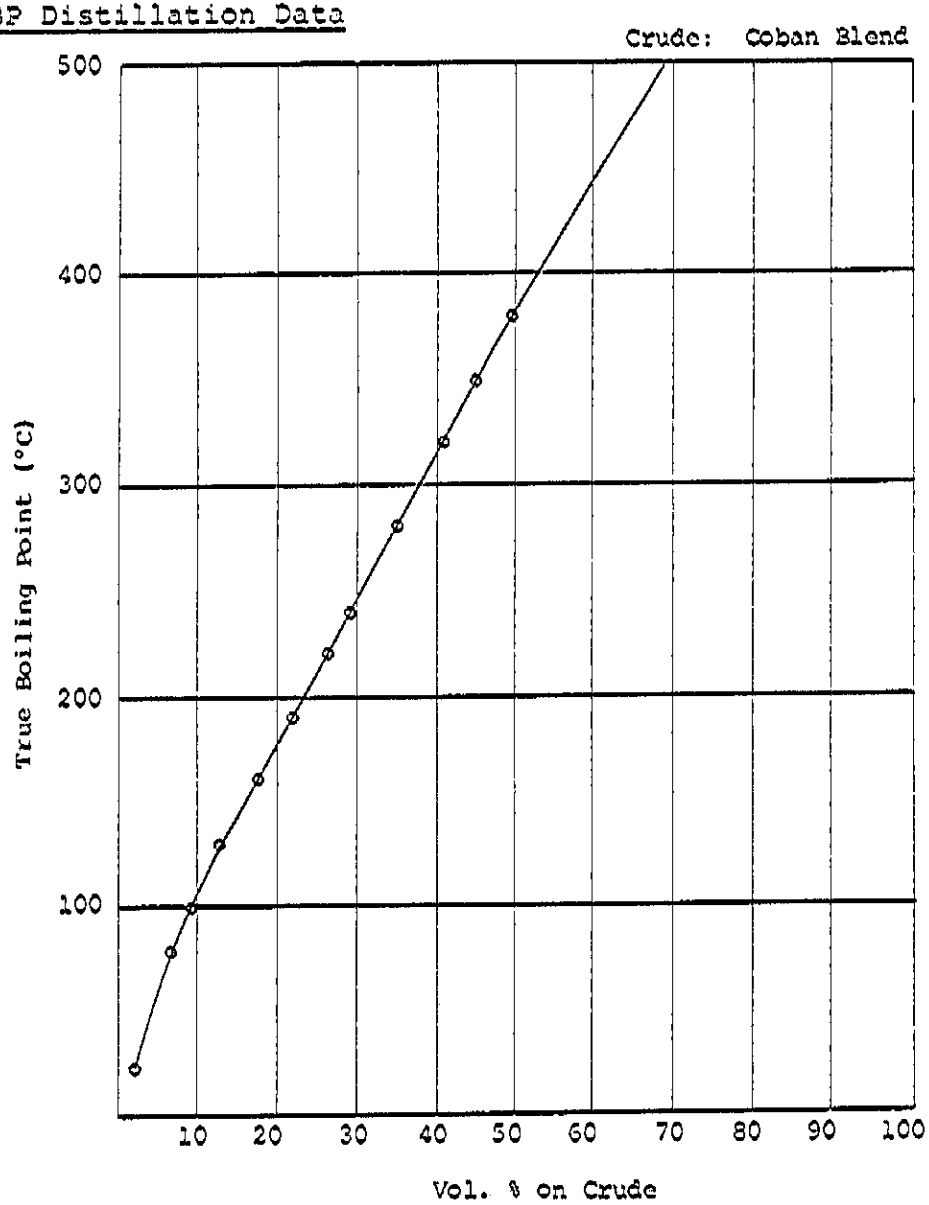
Table III-3 Crude Assay of Coban Blend

(1) Summary of Crude Oil

Crude Source		Coban Blend
Specific Gravity, (15/4°C)		0.8964
API Gravity, (60°F)		26.27
Characterization Factor		11.8
Total Sulfur Content, wt.%		2.93
H_2S Dissolved, g/kl		0
H_2S Total Evolution, g/kl		2,000
Total Nitrogen Content, wt.ppm		1,190
Copper Corrosion,		1a
Viscosity, cSt at 30°C		40.52
	at 40°C	20.50
	at 50°C	14.71
Pour Point, °C		+10
Carbon Residue, wt.%		7.47
Acidity, mg KOH/g		0.01
Ash Content, wt.%		0.00
Water, vol.%		0.00
Water & Sediment, vol.%		0.01
Salt Content, g/kl		4.5
Metal	Vanadium, wt.ppm	5.1
	Nickel, wt.ppm	16.4
	Iron, wt.ppm	0.2

TEMP. (°C)	WT.%	VOL.%	VOL. %	TEMP. (°C)
24	1.16	1.84	IBP	24.0
80	4.46	6.31	5	63.6
100	6.45	8.82	10	109.2
140	10.93	14.22	15	145.0
160	13.59	17.33	20	178.6
180	16.10	20.20	25	213.4
200	18.63	23.08	30	246.4
220	21.19	25.95	35	281.8
240	24.03	29.10	40	315.0
260	26.65	31.92	45	352.8
280	29.28	34.73	50	384.5
300	32.15	37.74	55	416.3
320	35.01	40.76	60	448.1
350	38.73	44.56	65	479.9
400	46.69	52.44		
450	54.91	60.30		
500	63.13	68.16		

TBP Distillation Data



(2) Basic Breakdown

1) Summary

	Distillation Cut Range (°C)	Yield on Crude (vol.%)
LPG	C_1 - C_4	0.71
L't Naphtha	C_5 - 80	4.71
H'y Naphtha	80 - 170	11.99
Kerosene	170 - 240	10.28
Gas Oil	240 - 340	14.45
At. Residual Oil	340^+	57.86
Vacuum Gas Oil	340 - 500	23.73
Vac. Residual Oil	500^+	34.13

2) Light End Product

	Yeild on Crude (vol.%)
Propane and Lighter	0.18
i - Butane	0.15
n - Butane	0.66
i - Pentane	0.72
n - Pentane	1.21
Cyclo-Pentane	0.13

3) Light Naphtha Fraction

Cut Range, °C		C_5 - 80
Specific Gravity, (15/4°C)		0.6637
Appearance		Colorless
Total Sulfur Content, wt.%		0.50
Mercaptan Sulfur Content, wt.ppm		4,070
Hydrocarbon Types P, vol.%		89.42
N, vol.%		9.31
A, vol.%		1.27
Copper Corrosion,		2a
Research Octane Number F-1 Clear		61.8
Hydrocarbon Composition, vol.%		
C_3		0.01
C_4	normal paraffin	1.65
	iso paraffin	0.12
C_5	normal paraffin	22.31
	iso paraffin	11.76
	cyclo pentane (5N)	1.68
C_6	normal paraffin	24.73
	iso paraffin	21.34
	cyclo hexane (6N)	2.25
	methylcyclopentane (5N)	4.08
	benzene (AB)	1.08
C_7	normal paraffin	2.63
	iso paraffin	4.88
	methylcyclohexane (6N)	0.43
	5N	0.87
	Toluene (AB)	0.20

4) Heavy Naphtha Fraction

Cut Range, °C		80 - 170
Specific Gravity, (15.4 °C)		0.7482
Appearance		Colorless
Total Sulfur Content, wt.%		0.48
Mercaptan Sulfur Content, wt.ppm		3,130
Hydrocarbon Types	P, vol.%	65.85
	N, vol.%	20.77
	A, vol.%	13.37
Copper Corrosion		4a
Research Octane Number F-1 Clear		44.1
Aniline Point, °C		51.2
ASTM Distillation, °C		
	IBP	94.5
	5 vol.%	107.5
	10	110.5
	20	115.5
	30	119.5
	40	125
	50	131
	60	136
	70	141
	80	148
	90	156.5
	95	164
	EP	169
	Recovery,vol.%	98.0
	Residue, vol.%	1.0
	Loss , vol.%	1.0

5) Kerosene Fraction

Cut Range, °C		170 - 240
Specific Gravity, (15/4°C)		0.7975
Appearance		Colorless
Total Sulfur Content, wt.%		0.73
Mercaptan Sulfur content, wt.ppm		2,790
Hydrocabon Types P+N, vol.%		77.1
A, vol.%		22.9
Copper Corrosion		3b
Viscosity, cSt at 30°C		1.467
at 50°C		1.114
Flash Point, °C		57
Smoke Point, mm		20.8
Aniline Point, °C		57.8
Freezing Point, °C		-42.5
Saybolt Color		+27
ASTM Distillation, °C		
	IBP	174.5
	5 vol.%	185.5
	10	187
	20	191
	30	193.5
	40	197
	50	200.5
	60	205
	70	209
	80	215
	90	223
	95	229
	EP	235.5
	Recovery, vol.%	98.0
	Residue, vol.%	1.5
	Loss, vol.%	0.5

6) Gas Oil Fraction

Cut Range, °C		240 - 340
Specific Gravity, (15/4°C)		0.8483
Appearance		Yellow
Total Sulfur Content, wt.%		1.71
Viscosity, cSt at 30°C		4.254
at 50°C		2.760
Flash Point, °C		118
Aniline Point, °C		67.0
Cetane Index		53.3
Pour Point, °C		-7.5
Acidity, mg KOH/g		0.03
ASTM Distillation, °C		
	IBP	253
	5 vol.%	264
	10	265.5
	20	270
	30	273.5
	40	277.5
	50	281.5
	60	287.5
	70	294
	80	300.5
	90	310
	95	318
	EP	321
	Recovery, vol.%	98.5
	Residue, vol.%	1.0
	Loss, vol.%	0.5

7) Atmospheric Residual Oil Fraction

Cut Range, °C	340+
Specific Gravity, (15/4°C)	0.9713
Appearance	Black
Total Sulfur Content, wt.%	4.01
Total Nitrogen Content, wt.ppm	1,850
Viscosity, cSt at 50°C	752.6
at 100°C	60.92
Flash Point, °C	220
Pour Point, °C	+30
Carbon Residue, wt.%	12.5
Ash Content, wt.%	0.00
Metal Vanadium, wt.ppm	8
Nickel , wt.ppm	26
Iron , wt.ppm	0.4
ASTM Distillation, °C	
IBP	356
5 vol.%	396
10	408
20	436
30	468
40	494
50	540

8) Vacuum Gas Oil Fraction

	Fraction-1	Fraction-2
Cut Range, °C	340 - 500	340 - 550
Specific Gravity, (15/4°C)	0.9099	0.9169
Appearance	Brown	Brown
Total Sulfur Content, wt.%	2.57	2.65
Total Nitrogen content, wt.ppm	420	-
Viscosity, cSt at 50°C	20.64	28.39
at 100°C	5.194	6.361
Flash Point, °C	212	-
Aniline Point, °C	78.8	80.4
Pour Point, °C	+30	+32.5
Carbon Residue, wt.%	0.11	-
Acidity, mg KOH/g	0.03	-
Ash Content, wt.%	0.00	-

9) Vacuum Residual Oil Fraction

	Fraction-1	Fraction-2
Cut Range, °C	500^{+}	550^{+}
Specific Gravity, (15/4°C)	1.0164	1.0308
Appearance	Brack	Brack
Total Sulfur Content, wt.%	4.51	4.68
Total Nitrogen content, wt.ppm	2,730	-
Viscosity, cSt at 75°C	4,955	22,770
at 100°C	1,066	4,122
Carbon Residue, wt.%	20.2	23.4
Ash Content, wt.%	0.01	-
Metal Vanadium,wt.ppm	13.0	15.5
Nickel, wt.ppm	42.2	50.5
Iron , wt.ppm	0.6	0.8
Softening Point, °C	-	50.5
Penetration	-	56

(3) Asphalt Production

Straight Asphalt produced from Coban Blend has been tested and proved to meet all the specifications specified by ASTM D 946 as follows:

1) Adjustment of Penetration

To adjust penetration of asphalt at a level between 85 and 100, asphalt is produced with the following blending ratio:

Vacuum Residue (530°C$^+$)	94 wt.%
Cut Back Oil (500-530°C)	6 wt.%

2) Analysis

	Coban Blend Straight Asphalt	ASTM D 946 85-100
Penetration at 77°F (25°C), 100g, 5sec.	92	85-100
Flash Point, (C.O.C.), °F (°C)	644(340)	450 (232.2) min.
Ductility at 77°F (25°C), 5cm/min., cm	>150	150 min.
Retained penetration after thin-film oven test, %	63	47 min.
Solubility in trichloro-ethylene, %	99.89	99.0 min.
Ductility at 77°F (25°C), 5cm/min., cm after thin film oven test	>150	75 min.
Specific Gravity	1,0229	-
Softening Point, °C	47.5	-

1.4 Crude Oil Price

Forecasts of Guatemalan crude oil are conducted in comparison with that of Arabian light. While the current price is basically used in conducting financial analysis, the prices above forecasted are applied to sensitivity analysis to be conducted as a case with escalation taken into account.

1.4.1 Current crude oil price

Table III-4 shows comparison of the price of Coban Blend, Guatemalan crude oil, based on FOB Puerto Santo Tomas de Castilla as of 1983 with that of Arabian light, base on CIF Houston, USA which is used as standard price.

The Guatemalan crude oil price was 26.89 US$/bbl at the period of field survey held in November 1983. However, the price with 26.48 US$/bbl, which is the price is July - September 1983, is applied to the Study, since the petroleum product prices applied are that in July - September 1983.

Table III-4 Crude Oil Prices (Part 1)

Crude Oil	°API	S (%)	Price (US$/bbl)
Guatemalan (Coban Blend)	28	3.17	26.48
Arabian light	34	1.70	30.41

Source: MEM

As seen from the Table, the price of Guatemalan oil is the lower than that of Arabian light, because the former is heavier and contains more sulfur than the latter.

1.4.2 Future crude oil price

Forecasts are made for future prices of Guatemalan crude oil and Arabian light. The price hereunder referred to is a nominal price.

The premises for the price forecast are as follow;

(1) Forecast of Arabian light price

Out of forecasts made by the World Bank and International Energy Association on prices of Arabin light, the forecast made by the former has been adopted.

Real price of Arabian light in 1990 US$37.0/bbl
Real price of Arabian light in 2000 US$41.0/bbl

(2) Rate of escalation on Guatemalan crude oil and Arabian light

Assuming that the escalation rate on prices of both crude oils would be the same as that of wholesale prices in the United States, the Team has adopted a rate of 5% per year for the increase of US wholesale prices as forecasted by Japan Economic Research Center.

(3) Differential between Guatemalan crude oil and Arabian light

Since the differential between the two crude oils shown in Table III-4 seems appropriate, reflecting the difference of quality between the two, such differential is assumed to continue henceforth.

Based on the premises assumed in (1) through (3) results of the forecast on prices of Guatemalan crude oil and Arabian light over the period of 1989 through 2008 are shown in Table III-5.

Table III-5 Forecast on Crude Oil Prices (Part 1)

(Unit: US$/bbl)

Year	Guatemalan Crude Oil	Arabian Light
1989	37.01	42.50
1990	40.66	46.70
1991	43.54	50.00
1992	46.59	53.50
1993	47.81	57.20
1994	53.29	61.20
1995	57.04	65.50
1996	61.04	70.10
1997	65.31	75.00
1998	69.84	80.20
1999	74.80	85.90
2000	80.02	91.90
2001	85.60	98.30
2002	91.60	105.20
2003	98.05	112.60
2004	104.84	120.40
2005	112.24	128.90
2006	120.08	137.90
2007	128.44	147.50
2008	137.49	157.90

Source: Estimate by Study Team

According to the forecasts shown in Table III-5, the rate of an average annual price increase of the Guatemalan crude oil and Arabian light is about 6.8%. Since an escalation rate of 5.0% is assumed, the real increase rate of the crude oil price is about 1.8%.

2. Imported Crude Oil

The new oil refinery project is planned on the basis of processing the Guatemalan crude oil of which production is expected to increase substantially. However, the quantity of Guatemalan crude oil will be expected to fall short at the time of the start-up of the proposed refinery. The shortage will have to be filled by importing crude oil from neighboring countries. The following describes the kinds, properties and prices of the crude oil to be imported.

2.1 Kinds of Imported Crude Oil

MEM proposed the possibility of importing Maya crude oil from Mexico in view of future trend of crude oil available getting heavier. However, Maya crude oil is a heavy crude oil with API scale of 22° to 23°, which does not fit in with the Guatemalan market where the demand is strong on gasoline and gas oil. Should such market demand be filled by processing only Guatemalan crude oil, the capacity of the cracking facility would have to be large for the proposed processing capacity, and the project would accordingly become very uneconomical.

The existing oil refinery of Texas Petroleum Co. in Escuintla is processing Maya and Isthmus crude oil produced in Mexico and Oritupano crude oil produced in Venezuela based on the agreements between the Government of Guatemala and Mexico/Venezuela. Since Maya crude oil is heavy and of a high viscosity, the transportation through a pipeline seems also a problem. Therefore, it is said to be sent to the refinery, after being mixed with Isthmus crude oil at the crude oil terminal for adjustment of the viscosity.

Therefore, in compliance with the suggestion made by MEM during the field survey, it has been concluded to consider the import of light crude oil, Isthmus, in addition to Maya, i.e. the shortage of Guatemalan crude oil will be filled by the 50:50 blend of Maya and Isthmus.

2.2 Properties of Imported Crude Oil

The Maya and Isthmus crude oil produced in Mexico have been selected as the imported crude oil to be adopted in the basic plan for the new oil refinery project, and their properties are shown in Table III-6.

2.3 Prices of Imported Crude Oil

Forecasts are made on the prices of Maya and Isthmus crude oil which have been selected as the imported crude oil. The prices forecasted hereunder are applied to the financial analysis for a case study with escalation taken into consideration.

2.3.1 Current crude oil prices

Table III-7 Curde Oil Prices (Part 2) compares CIF prices as of 1983 of Arabian light, and Maya and Isthmus crude oils produced in Mexico. The prices of Arabian light and Maya crude oil are based on CIF prices at Houston port, USA. Since the CIF price at the same port of Isthmus crude oil is not available, it has been set at the same price as that of the Arabian light from the point of the quality.

Table III-6 Assay of Maya & Isthmus

Maya, Mexico

Pajaritos, Veracruz and Salina Cruz (Pacific), Oaxaca

Crude
Gravity, °API @ 60°F.: 22.0
Sulfur, wt %: 3.32
Pour test, °F.: 0
Vis., SUS @ 70°F.: 1,024.57
Vis., SUS @ 100°F.: 333.62
Rvp, psi @ 100°F.: 6.7
Hydrogen sulfide, ppm: 199
NC_4 & lighter, vol %: 1.5

Light straight run
Range, °F.: 60-200
Yield, vol %: 5.2
Total sulfur, wt %: 0.025
RON clear: 57.7
RON + 3 ml TEL/gal: 80.9

Naphtha
Range, °F.: 60-400
Yield, vol %: 19.7
Paraffins, vol %: 69.60
Naphthenes, vol %: 27.03
Aromatics, vol %: 12.37
Total sulfur, wt %: 0.213
RON clear: 38.1
RON + 3 ml TEL/gal: 57.6

Kerosene
Range, °F.: 400-500
Yield, vol %: 9.6
Gravity, °API: 39.6
Freezing pt, °F.: -29
P/N/A, vol %: 45.4/33.7/20.9
Total sulfur, wt %: 1.16
Aniline pt. °F.: 142.2
Smoke pt. mm: 20

Light gas oil
Range, °F.: 500-650
Yield, vol %: 12.8
Gravity, °API: 30.6
Pour pt. °F.: + 30
P/N/A, vol %: 36.9/38.1/29.1
Total sulfur, wt %: 2.17
Carbon residue, Rams., wt %: 0.08
Aniline pt. °F.: 152.8
Cetane index: 51.0

Topped crude
Range, °F.: 650 +
Yield, vol %: 56.4
Gravity, °API: 7.7
Vis., SUS @ 210° F.: 3,370.63
Vis., SUS @ 122° F.: 23,755.00
Pour pt. °F.: +115
Total sulfur, wt %: 5.04
Carbon residue Rams., wt %: 17.83
Nitrogen, %: 0.4245
Ni/V, ppm: 87.0/535.0

Vacuum gas oil
Range, °F.: 650-1,100+
Yield, vol % (of crude): 25.2
Gravity, °API: 18.3
Aniline pt. °F.: 167.4
Vis., SUS @ 130°F.: 270.11
Pour pt. °F.: +105
Sulfur, wt %: 3.14
Carbon residue, Rams., wt %: 0.63
Ni/V, ppm: 0.9/1.9

Vacuum residue
Range, °F: 1,100+
Yield, vol % (of crude): 31.2
Gravity, °API: 0.5
Vis., SUS @ 275° F.: Too hard
Sulfur, wt %: 5.78
Carbon residue, Rams., wt %: 26.2
Ni/V, ppm: 143/913

Isthmus, Mexico

Pajaritos, Veracruz, and Salina Cruz (Pacific), Oaxaca

Crude
Gravity, °API @ 60°F.: 32.8
Sulfur, wt %: 1.51
Pour test, °F.: -15
Vis., SUS @ 70°F.: 65.53
Vis., SUS @ 100°F.: 43.91
Rvp, psi @ 100°F.: 6.4
Hydrogen sulfide, ppm: 102
NC_4 & lighter, wt %: 1.2

Light straight run
Range, °F.: 60-200
Yield, vol %: 9.1
Total sulfur, wt %: 0.046
RON clear: 62.6
RON + 3 ml TEL/gal: 82.4

Naphtha
Range, °F.: 60-400
Yield, vol %: 23.9
Paraffins, vol %: 64.40
Naphthenes, vol %: 21.02
Aromatics, vol %: 14.58
Total sulfur, wt %: 0.054
RON clear: 48.5
RON + 3 ml TEL/gal: 67.0

Kerosene
Range, °F.: 400-500
Yield, vol %: 12.5
Gravity, °API: 41.2
Freezing point, °F.: -36
P/N/A, vol %: 47.4/30.9/21.7
Total sulfur, wt %: 0.23
Aniline pt. °F.: 143.2
Smoke pt. mm: 22

Light gas oil
Range, °F.: 500-650
Yield, vol %: 16.0
Gravity, °API: 32.3
Pour pt. °F.: + 25
P/N/A, vol %: 41.2/33.3/25.5
Total sulfur, wt %: 1.19
Carbon residue, Rams., wt %: 0.01
Aniline pt. °F.: 156.3
Cetane index: 52.5

Topped crude
Range, °F.: 650+
Yield, vol %: 40.4
Gravity, °API: 15.5
Vis., SUS @ 210° F.: 145.47
Vis., SUS @ 122° F.: 143.53
Pour pt. °F.: +55
Total sulfur, wt %: 2.94
Carbon residue, Rams., wt %: 8.08
Nitrogen, %: 0.2065
Ni/V, ppm: 14.8/67.1

Vacuum gas oil
Range, °F.: 650-1,100+
Yield, vol % (of crude): 28.5
Gravity, °API: 19.7
Aniline pt, °F.: 181.1
Vis., SUS @ 130° F.: 207.09
Pour pt. °F.: +110
Sulfur, wt %: 2.45
Carbon residue, Rams., wt %: 0.97
Ni/V, ppm: 4.3/-

Vacuum residue
Range, °F.: 1,100+
Yield, vol % (of crude): 11.9
Gravity, °API: 4.2
Vis., SFS @ 27.5° F.: 235.8
Sulfur, wt %: 4.18
Carbon residue, wt %: 23.08
Ni/V, ppm: 37/210

Source: Oil & Gas Journal

Table III-7 Crude Oil Prices (Part 2)

Crude Oil	°API	S (%)	Price (US$/bbl)
Arabian Light	34	1.7	30.41
Mexican Oil (Maya)	22	3.3	23.49
Mexican Oil (Isthmus)	33	1.5	30.41

2.3.2 Future crude oil prices

Forecasts are conducted for future prices of Arabian light, Maya and Isthmus crude oils produced in Mexico. The prices hereunder referred to are nominal prices. The premises set forth for this price forecasting are as follow:

(1) Forecast of Arabian light price

The forecast made by the World Bank has been adopted as the forecast of Arabian light future price.

Real price of Arabian light in 1990 US$37.0/bbl
Real price of Arabian light in 2000 US$41.0/bbl

(2) Rate of escalation on Arabian light and Mexican crude oils

Assuming that the escalation rate on the prices of Arabian light and Mexican crude oils would be the same as that of wholesale prices in the United States, as mentioned in Clause 1.4, the Study Team has adopted a rate of 5% per year for the increase of US wholesale prices as forecasted by Japan Economic Research Center.

(3) Differential between Arabian light and Mexican Maya

Since the differential between Arabian light and Maya shown in Table III-7 seems appropriate, reflecting the difference of quality between the two, such differential is assumed to continue henceforth.

Based on the premises assumed in (1) through (3), results of the forecast on prices of Arabian light, Maya and Isthmus crude oils over the period of 1989 through 2008 are as shown in Table III-8, Forecast on Crude Oil Prices (Part 2).

The average annual price increase in the rear table is 6.8%, same as in Clause 1.4, and since an escalation rate of 5% is assumed, the real increase rate of the crude oil price is about 1.8%.

Table III-8 Forecast on Crude Oil Prices (Part 2)

Year	Arabian Light	Maya Crude Oil, Mexican	Isthmus Crude Oil, Mexican
1989	42.50	32.83	42.50
1990	46.70	36.07	46.70
1991	50.00	38.62	50.00
1992	53.50	41.33	53.50
1993	57.20	44.18	57.20
1994	61.20	47.27	61.20
1995	65.50	50.60	65.50
1996	70.10	54.15	70.10
1997	75.00	57.93	75.00
1998	80.20	61.95	80.20
1999	85.90	66.35	85.90
2000	91.90	70.99	91.90
2001	98.30	75.93	98.30
2002	105.20	81.26	105.20
2003	112.60	86.98	112.60
2004	120.40	93.00	120.40
2005	128.90	99.57	128.90
2006	137.90	106.51	137.90
2007	147.50	113.94	147.50
2008	157.90	121.97	157.90

Source: Estimate by Study team

VOLUME IV

DEMAND FORECAST ON PETROLEUM PRODUCTS

IV DEMAND FORECAST ON PETROLEUM PRODUCTS

1. Methods of Demand Forecast

To forecast demands on petroleum products, both methods by means of input-output analysis and econometric model are generally used.

While the former is a method to analyze and forecast a far-reaching effect of productions and prices of various industries, the latter is one to simulate economic trends by combining consumption functions and production functions.

Since, in this study, the demand forecasts are required over a long period of 20 years from 1989 to 2009 of project life, it has been decided to forecast the demands for all petroleum products by means of the elasticity analysis using the econometric model generally applied to demand forecasts from a macroscopic viewpoint. The regression analysis has been used as a means for elasticity calculation.

The forecast has been conducted in the following sequence:

- o Past trend of demands and prices
- o Demands structure and economic indices
- o Analysis of demands trend
- o Demands forecast

2. Past Trend of Demands and Prices

The trend of demands for petroleum products in Gautemala in the past ten years is summarized in Table IV-1, and the trend of prices is summarized in Table IV-2.

The trend of demands as shown in Table IV-1 indicates that while the demands for LPG and kerosene grew smoothly during the period from 1975 through 1982, the demands for gasoline, jet fuel, gas oil, fuel oil and others were on the decline from 1980 through 1982 after a smooth growth up to 1979. The reasons for this are assumed that the prices of gasoline, jet fuel, gas oil, fuel oil and others went up in the wake of price hike of the crude oil and that the Guatemalan economy has been somewhat stagnant since 1980.

According to the trend of petroleum product prices as shown in Table IV-2 the prices of all petroleum products such as LPG, gasoline, kerosene, gas oil, fuel oil and others went up from 1973 through 1981, but they dropped slightly in 1982. The reason for this is to be presumed that the prices of the petroleum products change in linkage with the price of crude oil.

Table IV-1 Trend of Demands for Petroleum Products

(Unit: 10^3 bbl)

	LPG	Premium Gasoline	Reg. Gasoline	Kerosene	Jet Fuel	Gas Oil	Fuel Oil	Others	Remarks
1972	—	626.9	996.2	—	—	1,775.2	—	—	
1973	—	698.6	1,090.3	—	—	1,905.7	—	—	
1974	—	580.6	1,221.9	—	—	1,672.4	—	—	
1975	385.5	690.0	1,263.6	358.3	211.5	1,943.2	1,942.6	337.1	
1976	390.4	802.4	1,350.8	363.8	234.2	2,262.8	2,291.4	344.9	
1977	462.0	1,006.0	1,481.6	391.7	264.7	3,087.8	2,738.8	363.3	
1978	457.6	1,179.5	1,379.4	417.8	313.1	3,579.2	2,695.1	386.7	
1979	513.1	1,077.6	1,478.6	424.4	359.8	3,562.4	3,162.8	351.6	
1980	509.4	967.4	1,263.2	483.6	251.7	3,661.8	3,313.7	293.8	
1981	543.7	944.4	1,064.4	562.2	212.6	3,409.1	2,314.8	260.1	
1982	572.0	921.0	976.8	534.3	176.0	3,047.8	1,817.8	262.7	

Source: Primarily the 1983 edition of Actualidad Petrolera en Guatemala, with partial additions.

Note 1: "Others" include such products as asphalt, lubrication oil and aviation gasoline.

Table IV-2 Trend of Prices of Petroleum Products

(Unit: Q/100 lbs for LPG, Q/gal. for others)

	LPG	Premium Gasoline	Reg. Gasoline	Kerosene	Gas Oil	Fuel Oil	Gasoline AV. Price	Remarks
1973	10.500	0.513	0.460	0.250	0.370	0.108	0.481	
1974	10.500	0.742	0.703	0.514	0.535	0.256	0.716	
1975	12.500	0.782	0.743	0.543	0.559	0.303	0.757	
1976	12.500	0.782	0.743	0.543	0.559	0.303	0.758	
1977	17.738	0.969	0.926	0.550	0.562	0.346	0.943	
1978	17.738	0.969	0.926	0.550	0.562	0.346	0.946	
1979	19.472	1.390	1.330	0.680	0.723	0.457	1.355	
1980	20.400	1.895	1.850	0.860	0.965	0.616	1.870	
1981	20.400	2.078	2.029	1.042	1.292	0.929	2.052	
1982	20.375	2.002	1.935	1.120	1.210	0.861	—	

Source: The 1983 edition of Actualidad Petrolera en Guatemala

Note 1: The gasoline average prices listed for reference are the average prices of premium gasoline and regular gasoline, each being multiplied by the quantity and divided by the total quantity.

3. Demands Structure and Economic Indices

Table IV-3 shows how petroleum products are mainly used in Guatemala. The following outlines uses classified by the kind of petroleum products and economic indices correlated with them.

- o LPG

  Use for residence occupies 89%. Therefore, the personal consumption seems proper as a correlating economic index.

- o Gasoline (Premium gasoline and regular gasoline)

  Use for transportation accounts for 95%. This is presumed to correlate with the number of passenger cars owned. The personal consumption seems proper as the index correlating with the number of passanger cars owned.

- o Kerosene

  Kerosene is used for many purposes covering uses for residence, transportation, industries and agriculture, but the consumption by residence occupies 57%, the largest portion. Therefore, a porper economic index seems the personal consumption.

- o Jet fuel

  The aviation use occupies the total consumption. Accordingly, the personal consumption index seems proper.

- Gas oil

  Use for transportation occupies 63%. Since gas-oil-driven vehicles are used for industrial and commercial purposes, Guatemalan GNP seems a proper correlating economic index.

- Fuel oil

  Industrial use accounts for 87%, out of which the majority is consumed by thermal power generation. Accordingly, fuel oil consumption seems to correlate with power generation, and a proper economic correlating index seems GNP.

- Others (Asphalt, lubrication oil, aviation gasoline)

  GNP seems a proper correlating economic index.

Table IV-3 Consumption Ratios of Petroleum Products

Product	Use	Ratio (%)	Related Item	Macroscopic Economic Index
LPG	Residence	89		Personal consumption
	Transportation	3		
	Industry	8		
Gasoline	Transportation	95	Number of passenger cars owned	Personal consumption
	Industry	5		
Kerosene	Residence	57		Personal consumption
	Transportation	21		
	Agriculture	5		
	Industry	15		
	Others	2		
Jet Fuel	Aviation	100		Personal consumption
Gas Oil	Transportation	63		GNP
	Agriculture	12		
	Industry	25		
Fuel Oil	Industry	87	Power generation	GNP
	Agriculture	7		
	Residence	4		
	Transportation	2		
Others				GNP

Source: Anuario Estadistico, 1982 edition

4. Analysis of Demands Trend

The Study Team has analyzed the demands for each petroleum product in Guatemala. The correlating economic indices have been selected based on the uses of the product. Each petroleum product indicates a close correlation with the selected economic index respectively. The details of demands analysis for each product are as follows.

4.1 LPG

Since LPG and kerosene are commonly used as fuel for residence, the Team studied the relationship between the calorific value equivalent of LPG and kerosene and the real personal consumption. As a result, the correlation coefficient was 0.97 in accordance with the following formula. Generally, it is said that a coefficient of 0.95 and over means an extremely close correlation.

$$\log (DLK) = -2.900 + 1.182 \times \log (DPRC) \quad \ldots\ldots \quad (1)$$

DLK : Calorific value equivalent of LPG and kerosene (10^6 Kcal/y)

DPRC: Real personal consumption (10^6 Quetzales/y)

The real personal consumption is a value of a nominal personal consumption divided by a deflator, and is shown in Table IV-4.

The relationship between the quantity of LPG and calorific value equivalents of LPG and kerosene is shown in Formula (2) below. The coefficient is 0.98, also indicating a very close correlation.

$$\log (DLPG) = -0.6351 + 0.9282 \times \log (DLK) \quad \ldots\ldots \quad (2)$$

DLPG: Quantity of LPG consumption (10^3 bbl/y)

DLK : Calorific value equivalent of LPG and kerosene (10^6 Kcal/y)

Table IV-4 Trend of Real Personal Consumption

(Unit: 10^6 Quetzales, Index)

Year	Nominal Personal Consumption Expenditure	Deflator	Real Personal Consumption Expenditure
1972	1,682	40.7	4,133
1973	2,034	46.6	4,365
1974	2,470	53.9	4,583
1975	2,875	61.0	4,713
1976	3,396	68.0	4,994
1977	4,127	79.2	5,211
1978	4,675	83.5	5,599
1979	5,432	90.7	5,989
1980	6,217	100.0	6,217
1981	7,037	110.0	6,397

Source: International Financial Statistics Year Book, 1983

4.2 Gasoline (Premium Gasoline and Regular Gasoline)

The survey Team has analyzed the total quantity of premium gasoline plus regular gasoline in analyzing the demand for gasoline. Since gasoline is generally used for passenger cars, the number of passenger cars owned and real gasoline price are supposed to influence on demands.

The result of having studied this correlation is shown in Formula (3). The coefficient is 0.97, indicating a very close correlation.

$$\log (DGAL) = -1.538 + 1.433 \times \log (AUT) - 0.7730 \times \log \left(\frac{PGAL\ (-1) \times PGAL}{DF} \right) \quad \ldots (3)$$

DGAL: Total quantity (10^3 bbl/y) of premium gasoline plus regular gasoline

AUT : Number of passenger cars owned (10^3 unit)

PGAL (-1): Average gasoline price (Quetzal/l) as of a year before the current year

PGAL : Average gasoline price (Quetzal/l) as of the current year

DF : Deflator (Index based on 100 for 1980)

For the total quantity of gasoline, the values shown in Table IV-1 are used. The trend of number of passenger casr owned is shown in Table IV-5. The reason for adding the price of the current year to that of a year before and dividing the sum by a deflator for the average gasoline price is that prices are generally supposed to have effect on demands with about half a year lag, while dividing the sum by a deflator is for the purpose of obtaining the real price.

The values shown in Table IV-2 are used for the average gasoline price, while the values shown in Table IV-4 are used for deflators.

Table IV-5 Trend of Number of Passenger Cars Owned

(Unit: 10^3 cars)

Year	No. of Passenger Cars Owned
1971	43.0
1972	54.1
1973	65.5
1974	70.8
1975	76.1
1976	82.7
1977	83.7
1978	90.5
1979	96.1
1980	99.7

Source: Statistical Yearbook, 1979/80, United Nations

4.3 Kerosene

As described in Clause 4.1, the calorific value equivalent of LPG and kerosene indicates a very close correlation with real personal consumption.

The relation between the quantity of kerosene and the calorific value equivalents of LPG and kerosene is shown in Formula (4) below. The coefficient is 0.97, indicating a very close correlation.

$$\log (DKER) = -1.955 + 1.097 \times \log (DLK) \quad \ldots\ldots \quad (4)$$

DKER : Kerosene consumption (10^3 bbl/y)
DLK : Calorific value equivalent (10^6 Kcal/y) of LPG and kerosene

4.4 Jet Fuel

Jet fuel is used completely for aviation. It is supposed that the flight distance and jet fuel price are influential on the demand. Since data on flight distances were not available, the index of per capita real personal consumption was substituted for flight distances to study the correlation. As shown in Formula (5) below, the correlation coefficient is 0.88 with a fairly good result.

$$\log (DTUR) = -12.52 + 1.836 \times \log (DPRC/POP) - 1.195 \times \log (PKER/DF) \quad \ldots\ldots (5)$$

DTUR: Jet fuel consumption (10^3 bbl/y)
DPRC: Real personal consumption (10^6 Quetzales/y)
POP : Population (10^6 persons)
PKER: Kerosene price (Quetzal/l)
DF : Deflator

The values used are obtained: for DTUR from Table IV-1, for DPRC from Table IV-4, for PKER from Table IV-2 and for DF from IV-4. The trend of population is summarized in Table IV-6.

Table IV-6 Trend of Population in Guatemala

(Unit: 10^6 persons)

Year	Population
1971	5.42
1972	5.58
1973	5.74
1974	6.05
1975	6.24
1976	6.43
1977	6.63
1978	6.84
1979	7.05
1980	7.26
1981	7.48
1982	7.70

Source: International Financial Statistics Year Book, 1983

4.5 Gas Oil

The consumption of gas oil is 63% for transportation and 25% for industrial use. It is estimated that the real GNP (Gross National Product) and kerosene price are the economic indices that affect the demand. The correlation is shown as Formula (6) below, resulting in a coefficient of 0.99, an extremely close correlation.

$$\log (DGAS) = -15.39 + 2.408 \times \log (DGNP) - 0.4314 \times \log (PGAS/DP) \quad \ldots\ldots (6)$$

DGAS: Gas oil consumption (10^3 bbl/y)
DGNP: Real GNP (10^6 Quetzales/y) in Guatemala
PGAS: Gas oil price (Quetzal/l)
DP : Deflator

The DGAS value is taken from Table IV-1, the PGAS value from IV-2 and DF from Table IV-4. The trend of the real GNP in Guatemala is summarized in Table IV-7.

Table IV-7 Real GNP of Guatemala

(Unit: 10^6 Quetzales/y)

Year	Real GNP
1972	5,047
1973	5,410
1974	5,774
1975	5,864
1976	6,310
1977	6,879
1978	7,240
1979	7,598
1980	7,809
1981	7,782

Source: International Financial Year Book, 1983

4.6 Fuel Oil

87% of fuel oil is consumed by industry (thermal power generation), and accordingly, its correlation with the quantity of power generation is expected.

The result of having studied the correlation is shown in Formula (7) below. The coefficient is 0.97, indicating an extremely close correlation.

$$\log (DFUL) = 1.203 + 0.9073 \times \log (DEL) \quad \ldots\ldots \quad (7)$$

DFUL: Fuel oil consumption (10^3 bbl/y)
DEL : Quantity of generated power (10^6 kWh)

The DFUL value is obtained from Table IV-1. The power generation is summarized in Table IV-8.

Table IV-8 Power Generation in Guatemala

(Unit: 10^6 kwh)

Year	Power Generation
1975	1,167
1976	1,275
1977	1,564
1978	1,726
1979	1,914
1980	1,970

Source: Statistical Yearbook, 1979/80 United Nations

4.7 Others (Asphalt, Lubrication Oil, Aviation Gasoline)

The demands for asphalt, lubrication oil and aviation gasoline have been analyzed as a whole under group titled "Others". The study has been made on the correlation with the real GNP of Guatemala and prices of fuel oil. The result is shown in Formula (8). The coefficient is 0.98.

$$\log (DOTH) = 1.406 + 0.1595 \times \log (DGNP) - 0.5678 \times \log (DFUL/DF) \quad \ldots\ldots (8)$$

DOTH: Consumption of "Others" (10^3 bbl/y)
DGNP: Real GNP of Guatemala (10^6 Quetzales/y)
PFUL: Fuel oil price (Quetzal/l)
DF : Deflator

The DOTH value was taken from Table IV-1, DGNP from Table IV-7, PFUL from Table IV-2 and DF from Table IV-4.

4.8 Summary of Demands Analysis

The results of demands analysis on all petroleum products, as described in Clauses 4.1 to 4.7, are shown in Fig. IV-1 through Fig. IV-7, while comparing theoretical values calculated from formulae (1) through (8) with the actual consumption in the past.

All these figures show a good matching of theoretical and actual values.

Studying of formulae (1) through (8) also indicates that demands for LPG, kerosene and fuel oil are hardly affected by the price, while demands for gasoline, gas oil, jet fuel and others is very sensitive to price fluctuation.

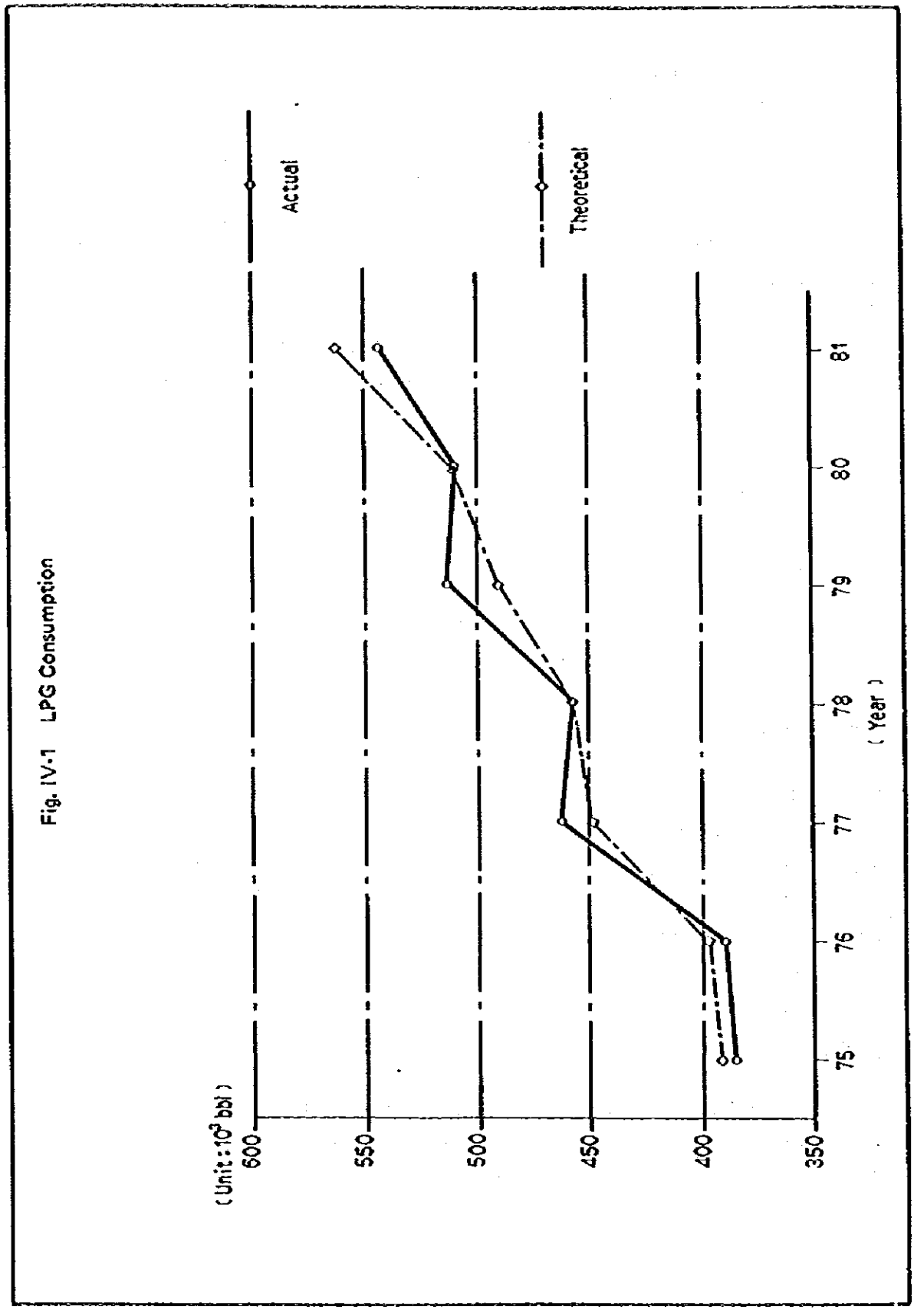


Fig. IV-1 LPG Consumption

Fig. IV-2 Gasoline Consumption

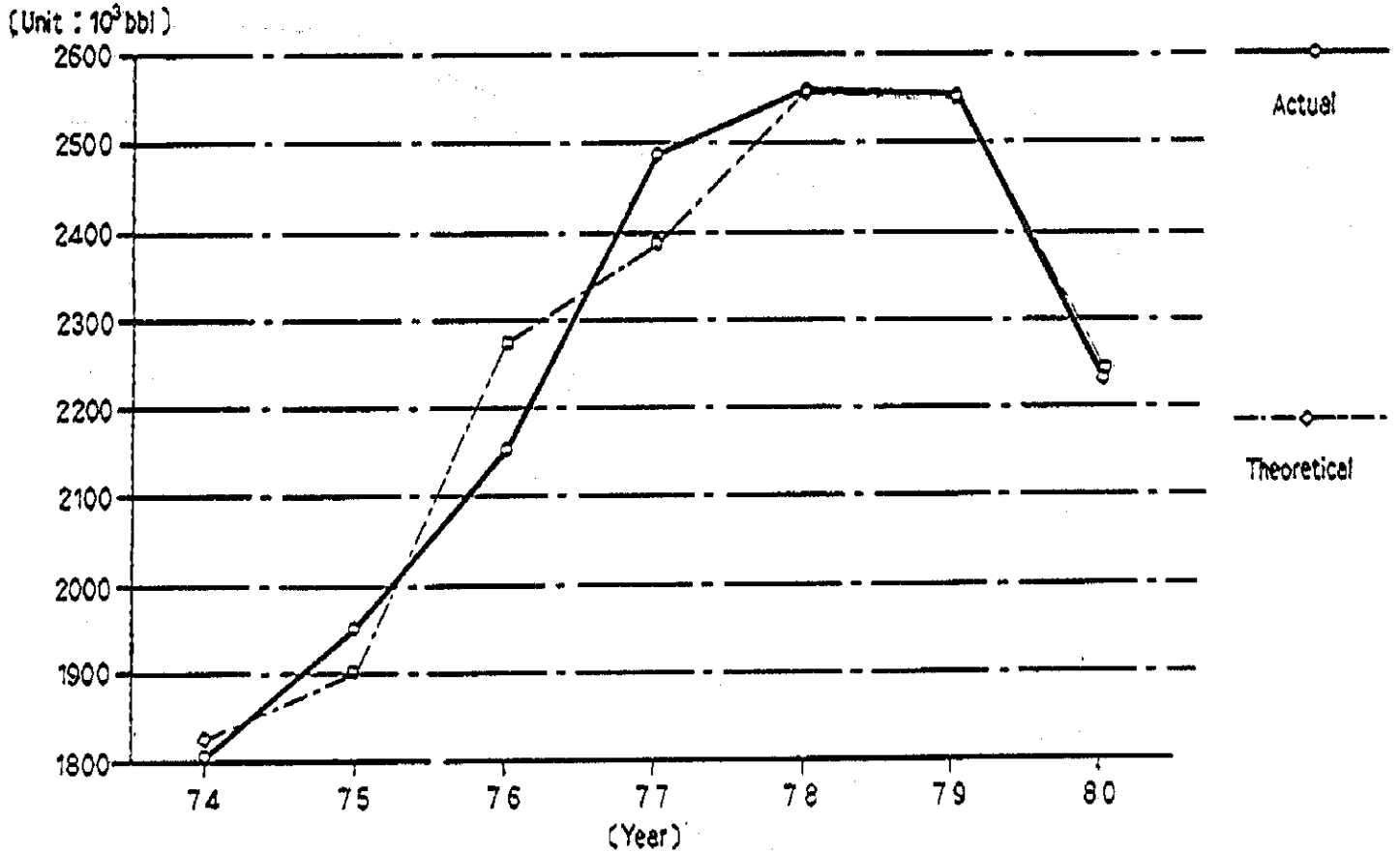
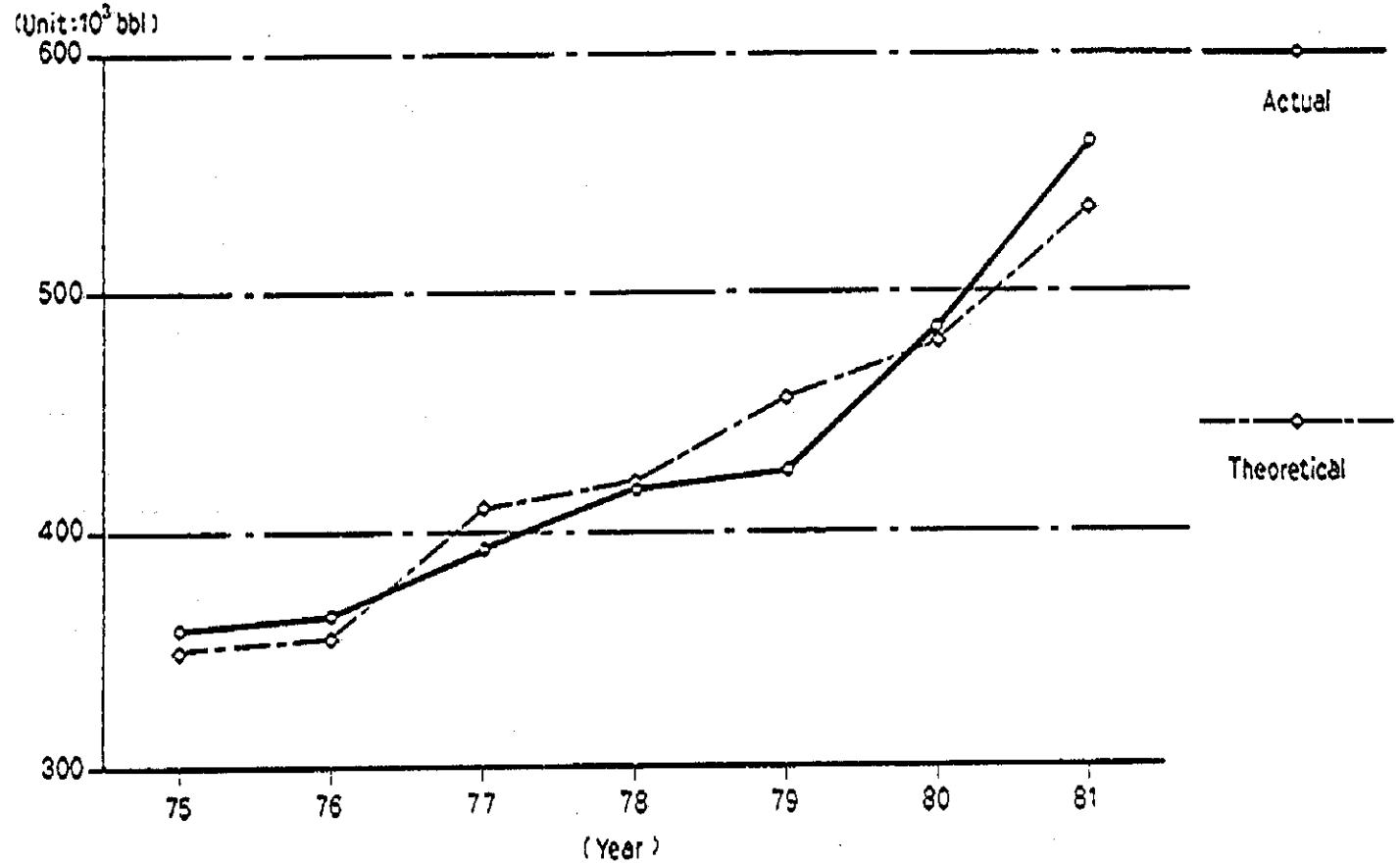


Fig. IV-3 Kerosene Consumption



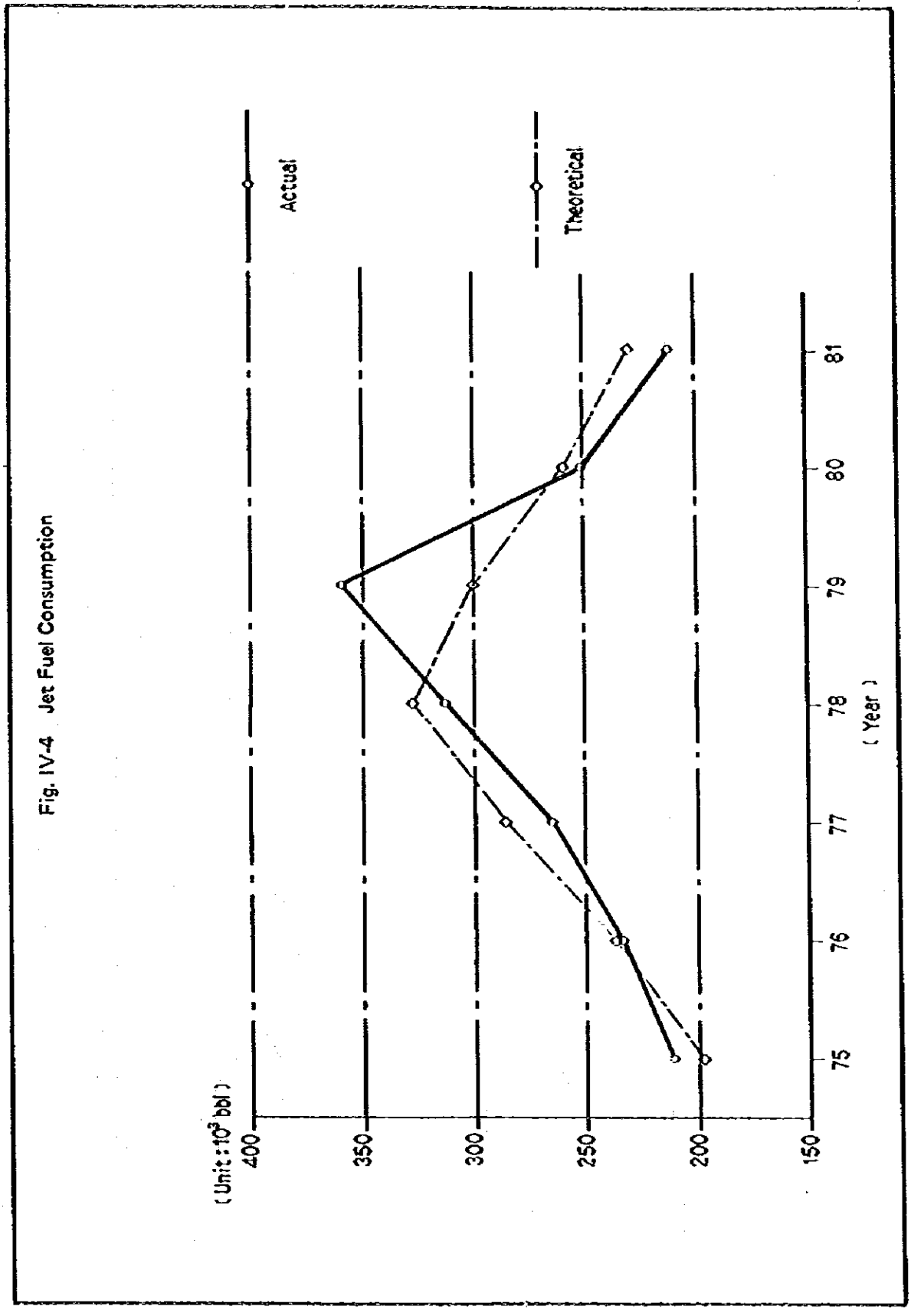


Fig. IV-4 Jet Fuel Consumption

Fig. IV-5 Gas Oil Consumption

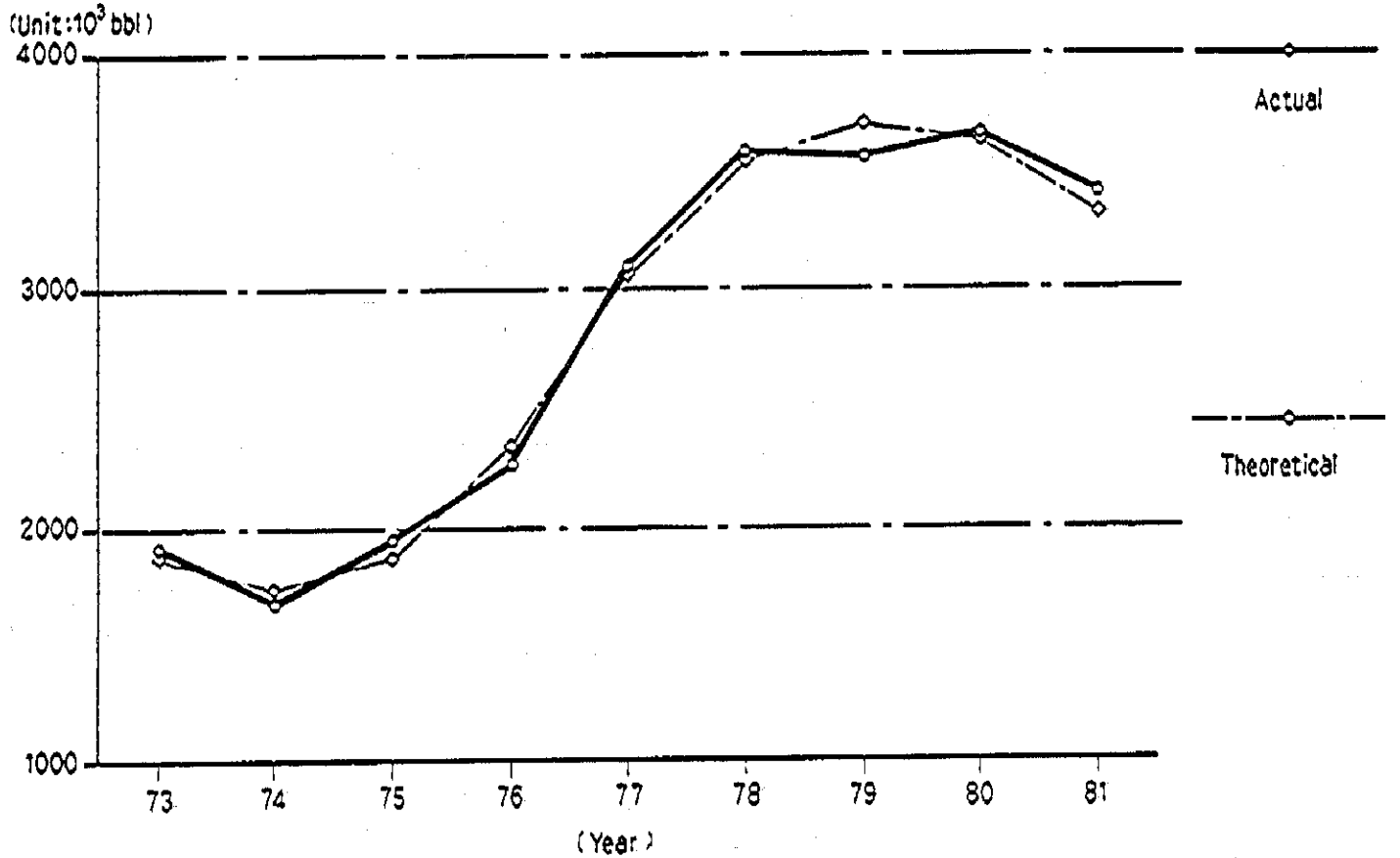
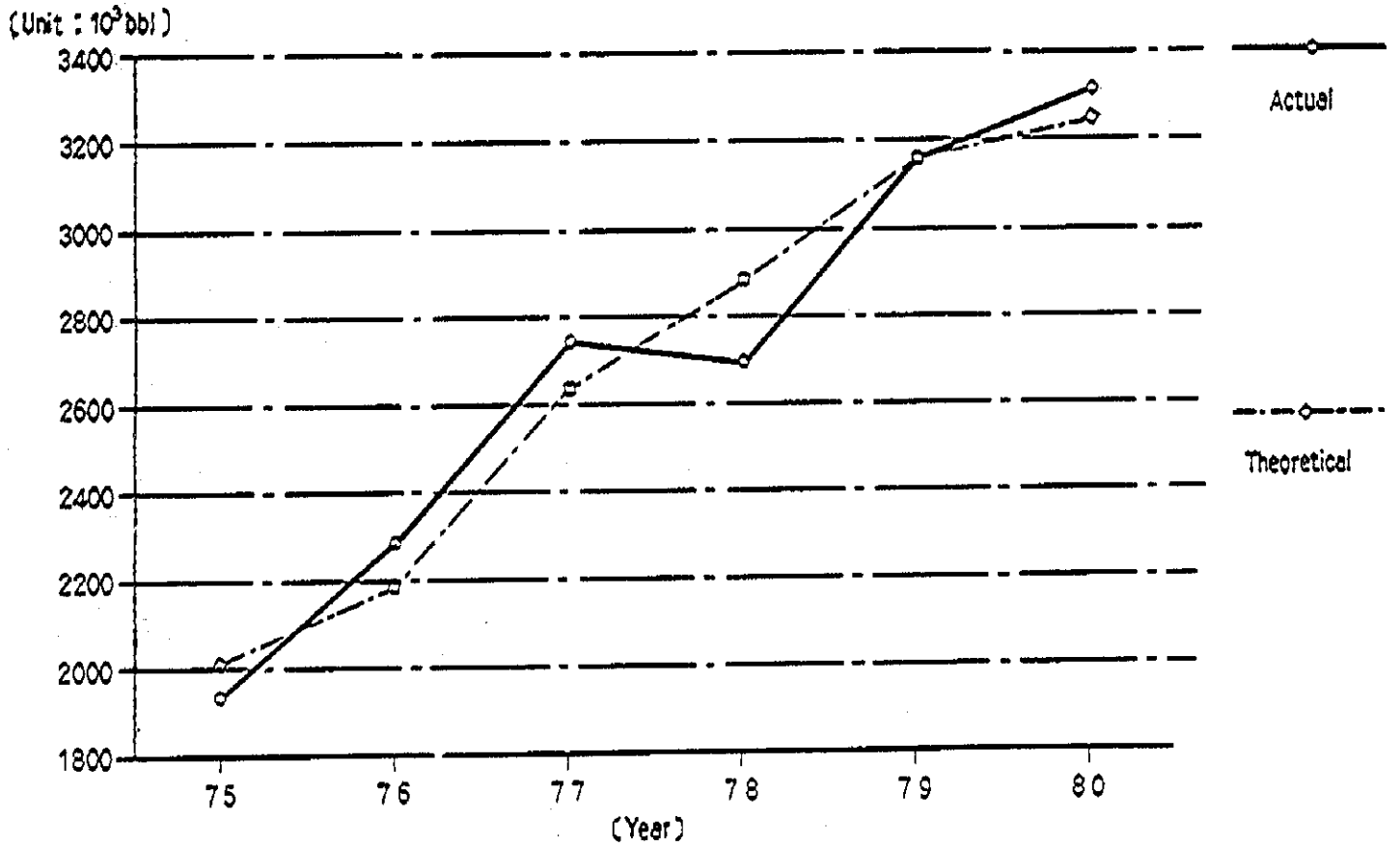


Fig. IV-6 Fuel Oil Consumption



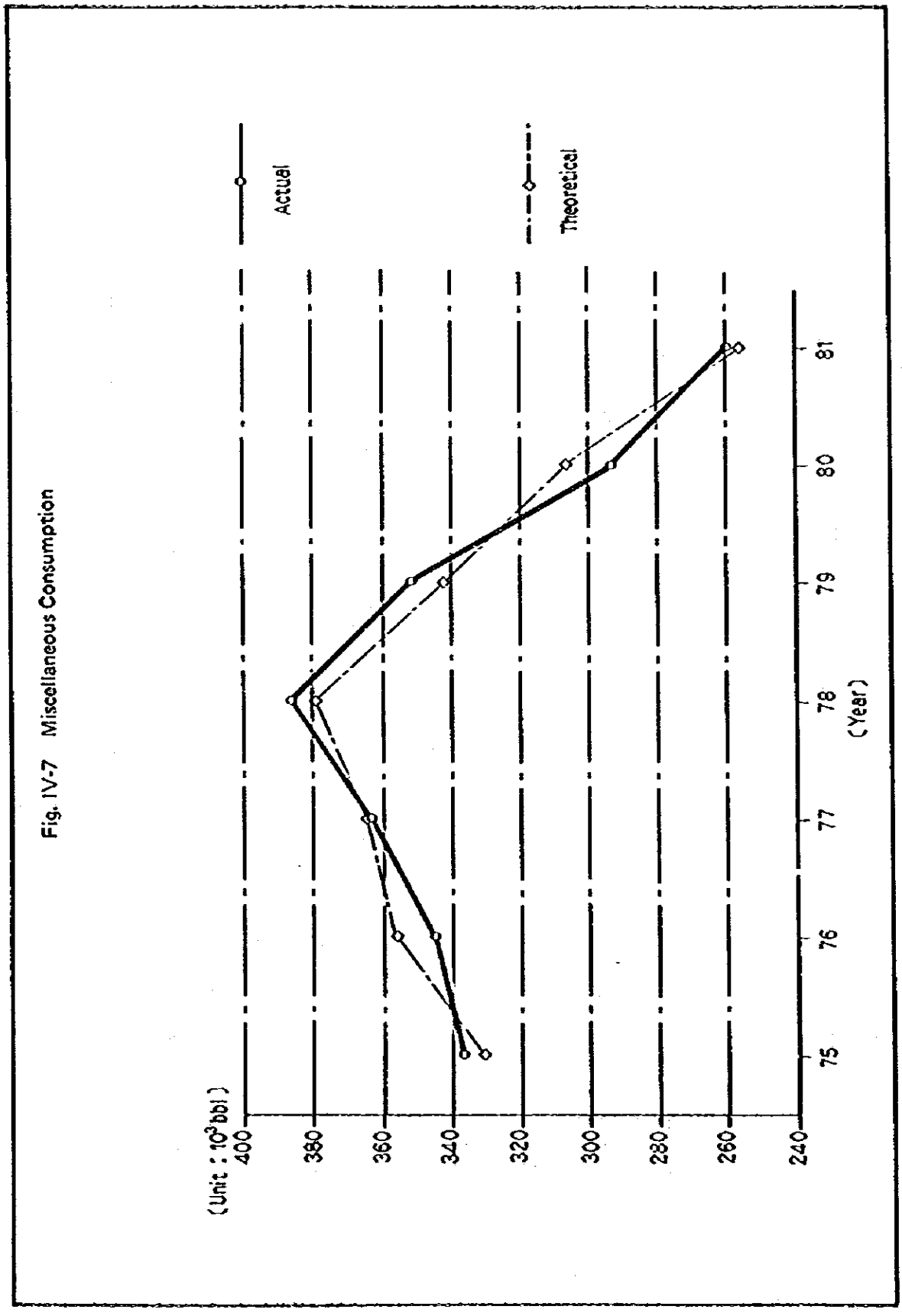


Fig. IV-7 Miscellaneous Consumption

5. Demands Forecast

Demands forecast is conducted for petroleum products in Guatemala, using the results of demands analysis studied in Chapter 4. In other words, in spite of the fact that a very close correlation has been obtained between the petroleum products and various economic indices as seen from the formulae (1) through (8), it is required to study on whether such past data are applicable to future demands forecast. Therefore, formulae for future demands forecast are to be established after a careful examination of such applicablity.

5.1 LPG

Demands for LPG are obtained from the following formulae (1) and (2) in accordance with those set forth in Clause 4.1;

$$\log (DLK) = -2.900 + 1.182 \times \log (DPRC) \quad \ldots\ldots \quad (1)$$

$$\log (DLPG) = -0.6351 + 0.9282 \times \log (DLK) \quad \ldots \quad (2)$$

DLK : Calorific value equivalent (10^6 Kcal/y) of LPG and kerosene
DPRC: Real personal consumption (10^6 Quetzales/y)
DLPG: LPG consumption (10^3 bbl/y)

(1) Study on formulae to estimate the demands

Formula (1) indicates that in the event that the real personal consumption increases by 1%, the calorific value equivalent of LPG and kerosene increases by 1% x 1.18 times (1.18%), and seems to be applicable to future demands forecast. In other words, "1.182" in Formula (1) is a so called "elasticity".

Formula (2) also indicates that in the event that the calorific value equivalent of LPG and kerosene increases by 1%, the LPG consumption increases by 1% x 0.93 times (0.93%), and also seems to be applicable to future demands forecast.

(2) Preconditional economic indices to establish demands forecasting formulae

Formula (1) contains DPRC, that is, the real personal consumption in Guatemala, and what this value would be in future has to be forecasted.

Therefore, the Study Team has studied the relationship between the real personal consumption and real GNP in Guatemala in the past.

$$\log (DPRC) = 0.2219 + 0.9486 \times \log (DGNP) \quad \ldots (9)$$

DPRC: Real personal consumption (10^6 Quetzales/y)
DGNP: Real GNP (10^6 Quetzales/y)

The correlation coefficient of formula (9) is 0.99, indicating an extremely close correlation.

It is known from formula (9) that in order to forecast the growth of real personal consumption in Guatemala, the growth of real GNP has only to be forecasted.

The Survey Team tried to obtain forecasts on the growth of real GNP of Guatemala during the field survey, but they were not available even at the Ministry of Economy. Since Guatemala depends on U.S. economy to a great extent especially in exporting coffee and cotton, the relationship of real GNP between Guatemala and USA has been studied.

$$\log (DGNP) = -2.339 + 1.432 \times \log (DUGNP) \quad \ldots (10)$$

DGNP: Real GNP (10^6 Quetzales/y) of Guatemala
DUGNP: Real GNP (10^6 US$/y) of the United States

The correlation coefficient of Formula (10) is 0.99, indicating an extremely close correlation. The formula (10) indicates that if the real GNP of USA increases by 1%, the real GNP of Guatemala increases by about 1.4%. The past data of real GNP of the United States are shown in Table IV-9.

Table IV-9 Real GNP of USA

(Unit: 10^9 US$/y)

Year	Real GNP, USA
1971	2,002.6
1972	2,115.9
1973	2,237.9
1974	2,223.7
1975	2,197.4
1976	2,316.3
1977	2,443.8
1978	2,566.8
1979	2,639.6
1980	2,631.7
1981	2,700.9
1982	2,650.3

Source: International Financial Statistics Year Book, 1983

It has been made clear from the above stated that forecasts on the real personal consumption of Guatemala can be obtained, if the real GNP of the United States can be forecasted.

There are various reports available concerning the future growth of the real GNP of the United States:

2.5%/y forecasted by Economic Council of the Japanese Government
3.6%/y forecasted by Chase Econometrics
2.7%/y forecasted by Japan Economic Research Center

In this study, 2.5%/y has been adopted with reference to the actual values of the United States in recent years.

LPG demands can accordingly be forecasted using formulae (1), (2), (9), and (10).

5.2 Gasoline (Premium Gasoline and Regular Gasoline)

In accordance with Clause 4.2, the formula to determine the quantity of gasoline (total of premium gasoline and regular gasoline) is as follows:

$$\log(DGAL) = -1.538 + 1.433 \times \log(AUT) - 0.7730 \times \log \frac{PGAL(-1) + PGAL}{DF} \quad \ldots (3)$$

DGAL: Total quantity (10^3 bbl/y) of premium gasoline and regular gasoline
AUT : Number of passenger cars owned (10^3 unit)
PGAL (-1): Average gasoline price (Quetzal/l) of one year before the current year

PGAL : Average gasoline price (Quetzal/l) of the current year

DF : Deflator

(1) Study on formula to calculate the demand

Formula (3) indicates that the elasticity of gasoline consumption to the number of passenger cars owned is 1.433 and that when the number of passenger cars owned increases by 1%, gasoline consumption increases by about 1.4%. Since the traveling milage per passenger car is expected to increase because of the improvement of road conditions, this formula seems considered applicable to the future. Also, the elasticity of the price indicating that the consumption decreases by about 0.8% when the average gasoline price rises by 1% seems appropriate.

(2) Preconditional economic indices to establish forecasting formula

Formula (3) contains the AUT factor, that is, the number of passenger cars owned, of which value for the future must be forecasted.

Study has been made on the past relationship between the number of passenger cars owned and real personal consumption.

$$\log (AUT) = -5.236 + 1.128 \times \log (DPRC) \quad \ldots\ldots \quad (11)$$

AUT : Number of passenger cars owned (10^3 Unit)

DPRC: Real personal consumption (10^6 Quetzales/y)

The coefficient of formula (11) is 0.98, with a extremely close correlation.

As a result of the above study and in accordance with the formulae (9) and (10) described in Clause 5.1, 2.5%, the estimated growth of the real GNP of the United States, can be substituted.

PGAL, the third item in Formula (3), that is the gasoline price, must be forecasted.

Since the price of gasoline is correlated with that of crude oil, their correlation has been studied using data in the past.

$$\log (PGAL) = -2.310 + 0.8796 \times \log (CRD) \quad \ldots (12)$$

PGAL: Average gasoline price (Quetzal/l)
CRD : Price of Arabian light (US$/bbl)

The correlation coefficient of Formula (12) is 0.98, indicating an extremely close correlation.

The World Bank and International Energy Association have forecasted future crude oil prices. In this study, are used the following values forecasted by the World Bank:

Real Arabian light price in 1990 US$37.0/bbl
Real Arabian light price in 2000 US$41.0/bbl

On the deflator of Guatemala that is contained in the third item of formula (3), the correlation with the past indices of US wholesale prices has been studied.

$$\log (DF) = -0.6281 + 1.145 \times \log (UDF) \quad \ldots (13)$$

DF : Guatemala deflator
UDF : Wholesale price index of USA

The correlation coefficient of formula (13) is 0.99, indicating an extremely close correlation.

As to the forecast on the wholesale price index of the United States, a rise of 5%/y has been assumed to continue in accordance with the information in "Japanese Economy in the World" published by Japan Economic Research center.

The past trend of US wholesale price index is given in IV-10, while the past and future forecasted prices of Arabian light, the standard price of crude oil, being given in Table IV-11.

Table IV-10 Wholesale Price Index, USA

(Unit: 1980 = 100)

Year	US Wholesale Price Index
1972	44.3
1973	50.1
1974	59.6
1975	65.1
1976	68.1
1977	72.3
1978	77.9
1979	87.7
1980	100.0
1981	109.1

Source: International Financial Statistics Year Book, 1983

Table IV-11 Crude Oil Nominal Price

(Unit: US$/bbl)

Year	Price	Year	Forecasted Price
1976	11.510		Figures in parentheses are real prices forecasted.
1977	12.395		
1978	12.700	1990	46.700 (37.0)
1979	17.259		
1980	28.667	2000	91.900 (41.0)
1981	32.500		
1982	34.000		

Source: World Bank

As a result of the above studies, the total demand of gasoline (premium gasoline plus regular gasoline) can be forecasted by formulae (3), (9), (10), (11), (12) and (13).

The sharing ratio between premium and regular gasoline has to be reviewed. Table IV-12 shows the proportion of premium gasoline to the whole gasoline in Guatemala in the past.

Table IV-12 Ratio of Premium Gasoline

Year	Premium Gasoline/Whole Gasoline
1973	0.391
1974	0.322
1975	0.353
1976	0.373
1977	0.404
1978	0.461
1979	0.422
1980	0.434
1981	0.470

Source: Actualidad Petrolera en Guetemala, 1983

As Table IV-12 shows, the ratio of premium gasoline in the whole gasoline is rising every year, recording the highest rate of 47% in 1981. Therefore, the ratios of premium and regular gasoline have been assumed to be 50% : 50% in forecasting the future demand.

5.3 Kerosene

As described in Clause 4.3, formulae to calculate the demand for kerosene are as follows:

$$\log (DLK) = -2.900 + 1.182 \times \log (DPRC) \quad \ldots\ldots (1)$$
$$\log (DKER) = -1.955 + 1.097 \times \log (DLK) \quad \ldots\ldots (4)$$

DLK : Calorific value equivalent (10^6 Kcal/y) of LPG and kerosene
DPRC: Real personal consumption (10^6 Quetzales/y)
DKER: Kerosene consumption (10^3 bbl/y)

(1) Study on formulae to calculate the demand

As studied in Clause 5.1, formula (1) can be considered proper.

Formula (4) indicates that, if the calorific value equivalent of LPG and kerosene increases by 1%, the kerosene consumption increases by about 1.10%, and seems proper to be applied to the future.

(2) Preconditional economic indices to establish forecasting formula

As explained in Clause 5.1, the following correlations have been established.

$$\log (DPRC) = 0.2219 + 0.9486 \times \log (DGNP) \quad \ldots \quad (9)$$

DPRC : Real personal consumption (10^6 Quetzales/y)
DGNP : Real GNP (10^6 Quetzales/y)

$$\log (DGNP) = -2.339 + 1.432 \times \log (DUGNP) \quad \ldots \quad (10)$$

DGNP : Real GNP (10^6 Quetzales/y) of Guatemala
DUGNP: Real GNP(10^6 US$/y) of USA

Therefore, the future demand for kerosene in Guatemala can be forecasted out of formulae (1), (4), (9) and (10) by substituting a rise of 2.5%/y, an estimated value of the real GNP of the United States in the formula (10).

5.4 Jet Fuel

As described in Clause 4.4, the formula to calculate the demand for jet fuel is as follows:

$$\log (DTUR) = -12.52 + 1.836 \times \log (DPRC/POP) - 1.195 \times \log (PKER/DF) \quad \ldots\ldots \quad (5)$$

DTUR: Jet fuel consumption (10^3 bbl/y)
DPRC: Real personal consumption (10^6 Quetzales/y)
POP : Population (10^6 persons)
PKER: Kerosene price (Quetzal/l)
DF : Deflator

(1) Study on formula to calculate the demand

Formula (5) indicates that the jet fuel consumption increases by about 1.8% if the real personal consumption per capita increases by 1%, while the jet fuel consumption decreases by about 1.2% if the real price of jet fuel rises by 1%, and seems applicable to forecast the future demand.

(2) Economic indices to establish corecasting formula

Clause 5.1 has established the following formulae with regard to DPRC, that is, real personal consumption:

$$\log (DPRC) = 0.2219 + 0.9486 \times \log (DGNP) \quad \ldots (9)$$

DPRC: Real personal consumption (10^6 Quetzales/y)
DGNP: Real GNP (10^6 Quetzales/y)

$$\log (DGNP) = -2.339 + 1.432 \times \log (DUGNP) \quad \ldots (10)$$

DGNP : Real GNP (10^6 Quetzales/y) of Guatemala
DUGNP: Real GNP (10^9 US$/y)

The real personal consumption can be forecasted by substituting a growth of 2.5%/y, an estimated value of the real GNP of the United States, in Formula (10).

As to the forecast on POP, that is, the growth of Guatemalan population, an average growth rate of 3.0%/y has been presumed to continue also in the future in accordance with Table IV-6 indicating the above figure for the past 12 years.

The future of PKER, the kerosene price, must be forecasted. The kerosene price is car related with the crude oil price, and their correlation has been studied with past data.

$$\log (PKER) = -2.210 + 0.6412 \times \log (CRD) \quad \ldots (14)$$

PKER : Kerosene price (Quetzal/l)
CRD : Crude oil price (US$/bbl)

The correlation coefficient of Formula (14) is 0.99, showing an extremely close correlation. The future kerosene price can accordingly be forecasted by incorporating the future crude oil price, as explained in Clasue 5.2

The future Guatemalan deflator can be forecasted by incorporating an estimated rise of 5%/y for the wholesale price index of the United States in the following formula;

$$\log (DF) = -0.6281 + 1.145 \times \log (UDF) \quad \ldots (13)$$

DF : Guatemalan deflator
UDF : Wholesale price index of the United States

The future demand for jet fuel in Guatemala can be forecasted by calculating formulae (5), (9), (10), (13) and (14).

5.5 Gas Oil

As described in Clause 4.5, the formula to calculate the demand for gas oil is as follows:

$$\log (DGAS) = -15.39 + 2.408 \times \log (DGNP) - 0.4314 \times \log (PGAS/DF) \quad \ldots\ldots (6)$$

DGAS : Gas oil consumption (10^3 bbl/y)
PGAS : Gas oil price (Quetzal/l)
DF : Deflator

(1) Study on formula to calculate the demand

Formula (6) indicates that, if real GNP increases by 1%, the gas oil consumption increase by about 2.4%. Since the elasticity of energy consumption to real GNP is gene-

rally close to 1.0, using this formula for the future is considered to be problematic. In other words, the statistics show that the increase of the gas oil consumption in Guatemala was about 2.4 times the growth of real GNP during the past 10 years. It is highly doubtful that this high rate of growth is possible in the future.

Accordingly, elasticity of 2.408 has been assumed to decline as follows:

up to 1985	2.0
from 1986 to 2009	1.4

On the other hand, there is a report in "Tratado General de Integracion Economica Centroamericana" to the effect that the future gas oil demand will decrease as follows, affected by the operation start-up of the Hydraulic Power Station in Chixoy:

in 1983	Decrease of 235 x 10^3 bbl/y
1984 onward	Decrease of 380 x 10^3 bbl/y.

With the above information taken into consideration, the quantity above estimated is to be deducted from the value obtained from formula (6) for the relevant years.

As to the price of gas oil, formula (6) indicates that if the price increases by 1%, the demand decreases by about 0.4%, and seems applicable to future forecast.

Based on the above studies, following formulae have been selected respectively to calculate future demands for gas oil:

From present to 1985

$$\log (DGAS) = -15.39 + 2.0 \times \log (DGNP) - 0.4314 \times \log (PGAS/DP) \quad \ldots\ldots \quad (15)$$

[However, DGAS -235 is applied to 1983, while DGAS -380 is applied to 1984 and 1985.]

From 1986 to 2009

$$\log (DGAS) = -15.39 + 1.4 \times \log (DGNP) - 0.4314 \times \log (PGAS/DP) \quad \ldots\ldots \quad (16)$$

[DGAS -380 is used.]

(2) Preconditional economic indices to establish forecasting formula

As explained in Clause 5.1, the real GNP can be calculated by substituting an estimated rate of 2.5%/y, growth of the real GNP of the United States in the formula (10).

$$\log (DGNP) = -2.339 + 1.432 \times \log (DUGNP) \quad \ldots \quad (10)$$

DGNP : Real GNP (10^6 Quetzales/y) of Guatemala
DUGNP: Real GNP (10^9 US$/y) of the United States

PDIS, that is the price of gas oil, must be forecasted for thefuture. Since the gas oil price is closely correlated with the crude oil price, correlation has been studied by means of past data as follows:

$$\log (PGAS) = -2.474 + 0.7566 \times \log (CRD) \quad \ldots \quad (17)$$

PGAS: Gas oil price (Quetzal/l)
CRD : Crude oil price (US$/bbl)

The correlation coefficient of formula (17) is 0.99, indicating an extremely close correlation.

Therefore, as explained in Clasue 5.2, the future gas oil price can be forecasted by incorporating the future crude oil price.

The deflator (DF) can be forecasted by incorporating 5%/y, an estimated rate of increase on wholesale price index of the United States in Formula (13) shown below:

$$\log (DF) = -0.6281 + 1.145 \times \log (UDF) \quad \ldots (13)$$

DF : Deflator in Guatemala
UDF : Wholesale price index of the United States

Therefore, the future demand for gas oil in Guatemala can be forecasted using formulae (10), (13), (17) and (15) or (16).

5.6 Fuel Oil

As described in Clause 4.6, the formula to calculate the demand for fuel oil is as follows:

$$\log (DFUL) = 1.203 + 0.9073 \times \log (DEL) \quad \ldots (7)$$

DFUL : Fuel oil consumption (10^3 bbl/y)
DEL : Power generation (10^6 kWh)

(1) Study on formula to calculate the demand

Formula (7) indicates that, if the power generation increases by 1%, the fuel oil consumption increases by about 0.9%, and seems applicable to the future demand.

However, since the "Tratado General de Intergracion Economica Centroamericana" reports that the future fuel oil consumption will decrease by 425 x 10^3 bbl/y in and after 1984 because of the operation start-up of Hydraulic Power Station in Chixoy, the above quantity is to be deducted from the value calculated with formula (7).

(2) Preconditional economic indices to establish forecasting formula

DEL (power generation) contained in formula (7) must be forecasted. Since power generation correlates with real GNP, such correlation has been studied as follows:

$$\log (DEL) = 9.731 + 1.933 \times \log (DGNP) \quad \ldots (18)$$

DEL : Power generation (10^6 kWh)
DGNP: Real GNP (10^6 Quetzales/y)

The correlation coefficient of formula (18) is 0.99, indicating an extremely close correlation.

Real GNP (DGNP) can be forecasted, as explained in Clause 5.1, by incorporating 2.5%/y, an estimated growth rate of real GNP of the United States in the formula (10).

$$\log (DGNP) = -2.339 + 1.432 \times \log (DUGNP) \quad \ldots (10)$$

DGNP : Real GNP (10^6 Quetzales/y) of Guatemala
DUGNP: Real GNP (10^9 US$/y) of the United States

Accordingly, the future demand for fuel oil in Guatemala can be forecasted by deducting 425 x 10^3 bbl/y from the result of calculating formulae (7), (10) and (18) for the relevant years.

5.7 Others (Asphalt, Lubrication Oil, Aviation Gasoline)

As described in Clause 4.7, the formula to calculate the demand for Others is as follows:

$$\log (DOTH) = 1.406 + 0.1595 \times \log (DGNP) - 0.5678 \times \log (PFUL/DF) \quad \ldots (8)$$

DOTH : Consumption on Others (10^3 bbl/y)
DGNP : Real GNP (10^6 Quetzales/y)
PFUL : Fuel oil price (Quetzal/l)
DF : Deflator

(1) Study on formula to calculate the demand

Formula (8) indicates that, if the real GNP increases by 1%, the demand for Others increases by about 0.2%. Although the elasticity of demand to real GNP seems a bit two low, it is determined to use formula (8) to calculate the future demand, since the demand for lubrication oil, etc. is considered not to be influenced too much by the growth of real GNP. With the prices of other products unknown the fuel oil price is used instead, while its elasticity of about 0.57 seems appropriate.

Accordingly, to use formula (8) seems appropriate to forecast the demand for others, as a whole.

(2) Preconditonal economic indices to establish forecasting formula

DGNP (real GNP) used in formula (8) has already been explained in Clause 5.1 as follows:

$$\log (DGNP) = -2.339 + 1.432 \times \log (DUGNP) \quad \ldots (10)$$

DGNP : Real GNP (10^6 Quetzales/y) of Guatemala
DUGNP: Real GNP (10^9 US$/y) of the United States

The real GNP can be forecasted by incorporating 2.5%/y, an estimated growth rate of real GNP of the United States into formula (10).

The future prices of fuel oil (PHEV) must be forecasted. The fuel oil price is correlated with the crude oil price. Their correlation has been studied based on past data.

$$\log (PFUL) = -3.434 + 0.9283 \times \log (CRD) \quad \ldots (19)$$

PFUL : Fuel oil price (Quetzal/l)
CRD : Crude oil price (US$/bbl)

The coefficient of formula (19) is 0.98, indicating an extremely close correlation. Accordingly, the fugure fuel oil price can be forecasted by incorporating the future crude oil price into formula (19), as explained in Clause 5.2.

The Guatemalan deflator can be forecasted by incorporating an estimated rise rate of 5%/y of the wholesale price index of the United States into the formula (13).

$$\log (DP) = -0.6281 + 1.145 \times \log (UDF) \quad \ldots (13)$$

DP : Deflator of Guatemala
UDF : Wholesale price index of the United States

Accordingly, the demand for others in Guatemala can be forecasted by calculating formulae (8), (10), (13) and (19).

6. Summary of Results of Demands Forecast

The results of forecasting demands for petroleum products described in Chapter 1 through 5 are collectively shown in Table IV-13.

The bottom column of Table IV-13 shows for reference the total demand of LPG, kerosene, premium gasoline, regular gasoline, jet fuel, gas oil, fuel oil and asphalt in terms of bbl/day. The quantity indicated here is the total of forecasted demands, and can be basic data to determine plant capacity of the proposed new oil refinery.

From figures of Table IV-13, an average growth rate of demands for each major petroleum product during the period from 1989 through 2008 as follows:

o	LPG	About 3.7%/y
o	Gasoline	About 4.3%/y
o	Kerosene	About 5.0%/y
o	Gas oil	About 5.4%/y
o	Fuel oil	About 6.8%/y

Formulae (1) through (19) which have been used heretofore to estimate demands for petroleum products are listed in the following.

Table IV-13 Summary of Forecasted Demands for Petroleum Products

(Unit: 10^3 bbl/y)

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
LPG	617.100	640.190	664.143	688.993	714.772	741.516	769.261	798.043	827.903	858.880	891.016	924.354
Premium G.	1535.313	1632.459	1685.269	1739.687	1792.078	1848.347	1925.087	2022.528	2125.918	2234.608	2348.045	2467.016
Regular G.	1535.313	1632.459	1685.269	1739.687	1792.078	1848.347	1925.087	2022.528	2125.918	2234.608	2348.045	2467.016
Kerosene	674.945	704.024	734.346	765.963	798.930	833.305	869.147	906.518	945.483	986.110	1028.469	1072.634
Jet Fuel	309.784	309.313	310.943	310.598	310.647	311.177	317.984	325.096	332.567	340.022	347.561	355.275
Gas Oil	4827.589	5017.854	5261.037	5499.221	5750.772	6017.291	6352.272	6706.229	7080.714	7473.138	7885.366	8319.319
Fuel Oil	2566.400	2758.427	2962.740	3180.124	3411.416	3657.507	3919.341	4197.928	4494.339	4809.713	5145.265	5502.285
Asphalt	118.111	116.373	115.198	113.534	111.993	110.590	110.718	110.883	111.094	111.264	111.415	111.568
Total	12184.560	12811.102	13418.948	14037.811	14682.690	15368.084	16188.901	17089.758	18043.939	19048.346	20105.185	21219.470
bbl/day	36922.911	38821.523	40663.480	42538.822	44493.000	46569.951	49057.278	51787.146	54678.604	57722.261	60924.804	64301.424

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
LPG	958.940	994.819	1032.041	1070.656	1110.716	1152.275	1195.388	1240.115	1286.515	1334.651	1384.589	1436.394
Premium G.	2592.318	2724.763	2862.850	3007.529	3160.920	3321.749	3489.999	3667.884	3854.436	4049.851	4256.475	4472.621
Regular G.	2592.318	2724.763	2862.850	3007.529	3160.920	3321.749	3489.999	3667.884	3854.436	4049.851	4256.475	4472.621
Kerosene	1118.680	1166.688	1216.741	1268.925	1323.330	1380.050	1439.184	1500.833	1565.104	1632.107	1701.958	1774.777
Jet Fuel	363.246	371.548	379.565	388.096	396.877	405.697	414.668	424.163	433.463	443.214	453.251	463.219
Gas Oil	8776.976	9260.378	9763.912	10297.734	10860.362	11450.639	12071.348	12728.910	13415.607	14141.720	14907.012	15708.247
Fuel Oil	5882.147	6286.312	6716.336	7173.872	7660.680	8178.634	8729.727	9316.077	9939.942	10603.721	11309.968	12061.401
Asphalt	111.740	111.943	112.050	112.226	112.413	112.569	112.718	112.926	113.061	113.239	113.429	113.570
Total	22396.367	23641.218	24946.349	26326.569	27786.222	29323.367	30943.035	32658.796	34462.568	36368.359	38383.160	40502.852
bbl/day	67867.781	71640.055	75594.997	79777.483	84200.675	88858.688	93766.774	98966.048	104432.025	110207.149	116312.607	122735.917

$$\log (DLK) = -2.900 + 1.182 \times \log (DPRC) \quad \ldots\ldots\ldots\ldots (1)$$

$$\log (DLPG) = -0.6351 + 0.9282 \times \log (DLK) \quad \ldots\ldots\ldots\ldots (2)$$

$$\log (DGAL) = -1.538 + 1.433 \times \log (AUT) - 0.7730 \times \log \left(\frac{PGAL\ (-1) + PGAL}{DF} \right) \quad \ldots\ldots (3)$$

$$\log (DKER) = -1.955 + 1.097 \times \log (DLK) \quad \ldots\ldots\ldots\ldots (4)$$

$$\log (DTUR) = -12.52 + 1.836 \times \log \left(\frac{DPRC}{POP} \right) - 1.195 \times \log \left(\frac{PKER}{DF} \right) \quad \ldots\ldots\ldots\ldots\ldots (5)$$

$$\log (DGAS) = -15.39 + 2.408 \times \log (DGNP) - 0.4314 \times \log \left(\frac{PGAS}{DF} \right) \quad \ldots\ldots\ldots\ldots\ldots (6)$$

$$\log (DFUL) = 1.203 + 0.9073 \times \log (DEL) \quad \ldots\ldots\ldots\ldots (7)$$

$$\log (DOTH) = 1.406 + 1.1595 \times \log (DGNP) - 0.5678 \log \left(\frac{PFUL}{DF} \right) \quad \ldots\ldots\ldots\ldots\ldots (8)$$

$$\log (DPRC) = 0.2219 + 0.9486 \times \log (DGNP) \quad \ldots\ldots\ldots\ldots (9)$$

$$\log (DGNP) = -2.339 + 1.432 \times \log (DUGNP) \quad \ldots\ldots\ldots\ldots (10)$$

$$\log (AUT) = -5.236 + 1.128 \times \log (DPRC) \quad \ldots\ldots\ldots\ldots (11)$$

$$\log (PGAL) = -2.310 + 0.8796 \times \log (CRD) \quad \ldots\ldots\ldots\ldots (12)$$

$$\log (DF) = -0.6281 + 1.145 \times \log (UDF) \quad \ldots\ldots\ldots\ldots (13)$$

$$\log (PKER) = -2.210 + 0.6412 \times \log (CRD) \quad \ldots\ldots\ldots\ldots (14)$$

$$\log (DGAS) = -15.39 + 2.0 \times \log (DGNP) - 0.4314 \times \log \left(\frac{PGAS}{DF} \right) \quad \ldots\ldots\ldots\ldots\ldots (15)$$

$$\log (DGAS) = -15.39 + 1.4 \times \log (DGNP) - 0.4314 \times \log \left(\frac{PGAS}{DF} \right) \quad \ldots\ldots\ldots\ldots\ldots (16)$$

$$\log (PGAS) = -2.474 + 0.7566 \times \log (CRD) \quad \ldots\ldots\ldots\ldots (17)$$

$$\log (DEL) = -9.731 + 1.933 \times \log (DGNP) \quad \ldots\ldots\ldots\ldots (18)$$

$$\log (PFUL) = -3.434 + 0.9283 \times \log (CRD) \quad \ldots\ldots\ldots\ldots (19)$$

DLPG : LPG consumption (10^3 bbl/y)

DLK : Calorific value equivalent (10^6 Kcal/y) of LPG and kerosene

DGAL : Total (10^3 bbl/y) of premium gasoline and regular gasoline

AUT : Number of passenger cars owned (10^3 unit)

PGAL (-1) : Average gasoline price (Quetzal/l) one year before the current year

PGAL : Average gasoline price (Quetzal/l) of the current year

DF : Deflator (Index based on 1980 being 100)

DKER : Kerosene consumption (10^3 bbl/y)

DTUR : Jet fuel consumption (10^3 bbl/y)

DPRC : Real personal consumption (10^6 Quetzales/y)

POP : Population (10^6 persons)

PKER : Kerosene price (Quetzal/l)

DGAS : Gas oil consumption (10^3 bbl/y)

DGNP : Real GNP (10^6 Quetzales/y) of Guatemala

DFUL : Fuel oil consumption (10^3 bbl/y)

DEL : Power generation (10^6 kWh)

DOTH : Consumption (10^3 bbl/y) of other petroleum products

PFUL : Fuel oil price (Quetzal/l)

DUGNP : Real GNP (10^9 US$/y) of the United States

CRD : Arabian light crude oil price (US$/bbl)

UDF : Wholesale price index of the United States

7. Distribution of Petroleum Products

The production and distribution flow of crude oil and petroleum products in Guatemala is shown in Fig. IV-8.

The demands for petroleum products are filled with the petroleum products produced by the only oil refinery operating in Guatemala owned by Texas Petroleum Co. and imports from foreign countries. The quantity of production and import of the petroleum products is given in Table IV-14.

Table IV-14 Production and Import of Petroleum Products

(Unit: 10^3 bbl/y)

	1980		1981		1982	
	Prod.	Imp.	Prod.	Imp.	Prod.	Imp.
LPG	19	600	22	599	25	560
Premium Gasoline	402	539	421	518	405	545
Regular Gasoline	518	704	502	538	440	539
Kerosene, Jet Fuel	536	186	482	305	419	305
Gas Oil	1,751	1,883	1,602	1,675	1,476	1,598
Fuel Oil	2,070	1,165	2,211	131	1,627	147
Others	-	292	-	289	-	238
Total	5,296	5,369	5,240	4,055	4,392	3,932

Source: MEM

Table IV-14 shows that the domestic production and import share about half and half respectively in Guatemala.

As shown in Fig. IV-8, petroleum products are being imported and distributed by multinational major oil companies from the terminal at Puerto Barrios, Puerto Santo Tomas de Castilla and San Jose under their trademarks.

Fig. IV-8 Production and Distribution Flow of Crude Oil and Petroleum Products in Gatemala