August 9, 1979.

Mr. Tammachart Sirivadhanakul,
Director of Regulatory Division,
National Energy Administration.

Dear Mr. Tammachart,

Re: LPG PRODUCTION FROM NATURAL GAS

I study LPG production from 100% of natural gas (from well head), and whether Thailand can export LPG to Japan or not.

I do not use computor, but the calculation is based on Fluor's report and Chiyoda's estimation, so the result is not so much different.

When LPG is manufactured from 100% of natural gas (from well head), the dew point control unit is unnecessary. Therefore, the cost of dew point control operation must be minused from the cost of LPG unit. I suppose that the cost of dew point control unit is 15 -30% on the cost of LPG unit. In my report, I apply for 15% of that.

I LPG PRODUCTION QUANTITY IN THAILAND

Natural Gas Production		LPG Production T/Y		
		C_3 LPG	C_4 LPG	Total
350 MMscf/D (in 1983)		196.2	107.8	304.0
500 MMscf/D (after 1984)	In 1984	272.5	150.0	422.5
700 MMscf/D (after 1988)	In 1988	360.0	199.1	559.1
LPG From Refinery	In 1979			181.0

I suppose that LPG production from the refinery after the expansion and new refinery completion, LPG from these refineries is excess for domestic requirement, because these refineries will

have a lot of cracking units. Thai LPG demand in 1982 will be 244 MT, so Thailand could not export before the completion of the expansion and new refinery.

Accordingly, the most of LPG from natural gas should be exported to Japan (Japan is the best LPG market for Thailand), to obtain foreign currency, but after the completion of the expansion and new refinery.

After 1983, Thailand will be available to export for 300×10^3T/Y and after 1988 for 560×10^3T/Y.

II LPG USAGE

Every countries are saving crude oil, therefore, they are going to substitute petroleum products (from crude oil) to natural gas and LPG.

New usage of LPG for Thailand

1. Motor car
2. Gas turbine fuel for electric generators of EGAT in province.
3. Others (such as refrigerator)

III. MARKETING RESEARCH IN JAPAN

Thai LPG Production from Natural Gas

in 1983	304×10^3 T
after 1988	559×10^3 T

Japanese LPG Domestic Production and Import

Domestic in 1983	$5,917 \times 10^3$T	33.8 %
Import in 1983	$11,589 \times 10^3$T	66.2 %
Total	$17,506 \times 10^3$T	100.0 %

Japan is very good LPG market for Thailand.

IV FEASIBILITY STUDY

FOB Price of C_3 LPG and C_4 LPG

	C_3 LPG $/T	C_4 LPG $/T
1979 Jan.	133	111
1989 Jan.	125.5	115.50
1989 April	126.50	127.50
1989 July	160.00	180.00
Price on Spot		
1989 July	200.00	300.00

Latest FOB price of C_3 LPG is 160 $/T and C_4 LPG is 180 $/T (before the 2nd oil crisis), the price up is according to tight of all over the world LPG market.

The FOB price of them will be going up very rapidly.

THAI LPG COST VS LPG FOB PRICE   Unit: ฿.

Natural Gas Price (from pipeline) $/MMBTU	C_3 LPG $/T 160	168	177	187	192
	C_3 LPG $/T 180	189	199	210	216
1.50	+12.26	+20.16	+30.16	+40.16	+45.16
1.70*1	+ 1.96	+ 9.86	+19.86	+29.86	+84.86
1.78	- 9.11	- 1.21	+ 8.79	+18.79	+23.79
2.06*2	-30.70	-22.80	-10.80	- 0.8	+ 4.2

Note: *1 1.70 $/MMBTU may be current natural gas price including transportation fee.

*2 Fuel oil 1,200" equivalent price on calorific value.

Natural gas production is 500 MMscf/D.

From the above mentioned table, at present status, if C_3 LPG FOB price is 192 $/T and C_4 LPG FOB price is 216 $/T, the profit is nearly zero. In other word, FOB LPG price should be higher than equivalent price of fuel oil 1,200". Anyhow, C_3 and C_4 FOB price will be immediately going up.

So, NGOT should watch a movement of LPG FOB price.

V SALES NATURAL GAS IS DECREASED ACCORDING TO LPG PRODUCTION INCREASE

When LPG production is 100% from natural gas (from well head), the sales natural gas is decreased. Fluor LPG production is not from 100% of natural gas (from well head).

Unit : MMSCF/D

	1981	1982	1983	1984	1985
Decreased Sales Natural Gas	18.20	31.91	36.00	52.02	46.42
Sales Natural Gas For Existing Industry (50%)	8.77	18.55	30.57	42.66	55.23
	1986	1987	1988	1989	1990
Decreased Sales Natural Gas	52.64	46.16	51.61	44.45	36.97
Sales Natural Gas For Existing Industry (50%)	58.17	59.17	62.13	64.47	66.80

VI LOCATION OF NATURAL GAS PROCESSING UNIT

Thailand has many water ways. LPG transportation cost by water is very cheap. And Thailand has possibility to export LPG to Japan. Therefore, the location of natural gas processing unit should not be far from sea-shore.

If LPG is increased production, NGOT can not supply sales natural gas to the existing industry even if 50% on total consumption,

because sales natural gas is decreased according to LPG production increase.

I appreaciate if my report is useful for you.

Sincerely yours,

Y. Kawase

LPG PRODUCTION FROM NATURAL GAS

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LPG PRODUCTION FROM NATURAL GAS

I FOREWORD

I study LPG production from natural gas. Flour Ocean Services International Inc.. reported LPG production from natural gas but not 100% of the gas from pipeline, only 61% in 1990. LPG production from refineries which will be included LPG from the expansion and new refinery is guessed larger than domestic requirement, but nobody can estimate because plants of the expansion and new refinery are not decided. It is evident that the expansion and new refinery should have much cracking units, so LPG production should be large.

Accordingly, whole or mostly of LPG which will be produced from natural gas should be exported, to get foreign currency, but LPG production should make much profit.

Another way to utilize LPG must be developed to increase domestic consumption, such as (1) motor car fuel (2) industrial use (3) small gas turbine of EGAT in province.

II DEFINITION OF LPG

C_3 LPG is liquefied propane and propene, dnd C_4 LPG is liquefied butanes and butenes, and ordinary LPG is mixutee of C_{3s} and C_{4s} which is propene, propene . butanes and butenes. Actually,, C_3s and C_4s cuts can not be perfectly separated to pure C_{3s} and C_{4s}, always mixed a small quantity of before and after cuts. For instance, C_3 LPG is mainly C_{3s} and a small quantity of C_2 and C_4 cut are mixed.

III PHYSICAL PROPERTY OF LPG

Physical property of LPG must be very important, when composition of LPG is changed. TABLE-1 (ATTACH.1) shown the physical property of LPG for recalculation.

Vapor pressure of LPG is very important, because pressure test of LPG vessel is very important when components are changed. Vapor pressure of C_2, C_3, C_4, C_5 mixture is calculated by vapor-liquid

equivalent calculation. This calculation takes long time without computer, but from Fig.1 VAPOR PRESSURE OF PROPANE AND PROPYLENE (ATTACH.2) and Fig.2 VAPOR PRESSURE OF BUTANES AND BUTENES (ATTACH.3), we can know outline.

When highest temperature of Thailand is 44.5 ^{o}C at Uttradit province on April 27, 1960, C_{3s} and C_{4s} vapor pressure at 44.5 ^{o}C is as follows:

44.5 ^{o}C	=	112.1 ^{o}F
		Vapor Pressure at 44.5 ^{o}C
Propene		17.8 atm.
Propane		14.5 atm.
i-Butane		5.6 atm.
c-Butane		3.5 atm.

When C_3 percentage of C_3 and C_4 mixed LPG is high, LPG vapor pressure is closed to 17.8 atm., and if C_4 percentage of C_3 and C_4 mixed LPG is high, LPG vapor pressure is closed to 3.5 atm. Maximum vapor pressure difference which is according to composition of C_3 and C_4 is nearly 17.8 - 3.5 atm. And when C_4 LPG is used, heating for vaporisation is needed, so vapor pressure of C_4 vapor pressure is higher than ordinal temperature.

The LPG specification of Thailand is 30% propane and 70% butanes, but LPG composition from natural gas is about 35.5% butanes and about 64.5% propane, thus vapor pressure of natural gas LPG is very higher than it of refinery LPG, but difference of vapor pressure is less than 14.3 atm. the pressure test of LPG vessel must be checked.

IV LPG SPECIFICATION

Thai industrial specification of LPG is shown in TABLE-2 (ATTACH.4). And Japanese industrial specification is shown in TABLE-3 (ATTACH.5).

Difference of LPG (C_3 and C_4 mixed LPG for household) between Thailand and Japan is big. Rate of C_3 and C_4 component in Thailand is 30 : 70, in Japan 80 : 20 in winter and 70 : 30 in summer.

Standard specification of LPG imported in Japan is shown in TABLE-4 (ATTACH.6).

V LPG DEMAND FORECAST

LPG demand forecast in Thailand (NEA), JAPAN (MITI) are shown in TABLE-5 (ATTACH.7). And it of Mitsui's estimation is shown in TABLE-6 (ATTACH.8).

In Japanese statistics (TABLE-5 and 6. ATTACH.7 and 8),LPG demand forecast and each service as break-down are shown. As TABLE-5 (ATTACH.7) LPG demand in Thailand is very small compared with Japan. Moreover in Japan, town gas which is very similar to LPG consumption is very big, but Thailand has no town gas. So, Thailand must be developed the utilization of LPG for household, commerce and industry.

VI LPG USAGE

LPG usage in Japan is shown in Japanese specification of TABLE-3 (ATTACH.5) and LPG demand forecast of TABLE-5 and 6 (ATTACH.7 and8). I explain the use of LPG more detail as follows :

VI.1 Household and Commerce

LPG is used as room heating, cooking, hot water and refrigerator for household and commerce.

VI.2 Industry

Butane utilization for industry has been increased recently.

Fuel of coal, fuel oil (kerosene, gas oil,fuel oil) have been replaced by LPG because of an economical point, preventing air pollution (low sulfur content) and no ash and soot (products are not contaminated by ash and soot), moreover, heating value is high, temperature control and handling are very easy.

- Metal industry (melting decarbonizing, gas reforming, hardening, quenching, annealing, cutting and scarfing forging)

- Ceramic industry (pottery, tile, whetstone, lime calcining, glass melting and molding work)

- Textile industry (gassed thread, plastic thread, plastic treating and dyeing)

- Foodstuffs (cake, ham, bread).

- Printing and Painting

VI.3 Agriculture Industry (drying of tobacco leaf, grain, pasture, and ageing of fluts, and green house, and poultry farming and pig raising)

VI.4 Town Gas

C_3 and C_4 are mixed with coal gas to increase calorific value.

VI.5 Internal Combustion Engine

- Taxis in big city are using LPG, octane number of C_3 is 96, and it of C_4 is 90.

- Tractor
- Forklift

VI.6 Petrochemical

Raw material of ethylene, ammonia, hydrogen and synthetic gas.

polyethylene (resin)
stylene butadiene (rubber)
polystylene (resin)
Tetoron (polyester fiber)
polyester (resin)
surface active gent (detergent)
Ethand -------- ethanol (solvent, raw material)
polyvinyl chloride (resin)
polyvinylidene resin & fiber

4-ethyl lead (additive)
dioctyl phthalate (plasticizer)
buthyl acetate (solvent)
acetic acid (raw material)
ethyl acetate (solvent, raw material)
pentacrythritol (resin)
higher alcolols (detergent, plasticizer)

Propylene ------

iso propyl alcohol (solvent)
aceton (solvent)
methacrylic resin
epoxy resin
urethane foam
acrylic fiber
detergent
butyl rubber
polypropylene glutamic acid (ajinomoto)

C_4 cuts — n-butene, butadiene, isobutene

methylethylketon (solvent)
polyester resin
polybutene (rubber)
stylene butadiene rubber
nitrile butadiene rubber
polybutene 1 (rubber)
polybutadiene (rubber)
Nylon 66 (fiber)
butyl gum
polyisoprene rubber

VII MARKETING RESEARCH IN JAPAN

VII.1 Japanese LPG Import by Supply Sources

Japan imported LPG from Middle East (Saudi Arabia, Kuwait, Iran), Australia, Canada and Venezuela as TABLE-7 (ATTACH.9) and about a half of total import is from Saudi Arabia which is shown in FIG.3 (ATTACH.10).

VII.2 LPG Import Quantity of Each Company in Japan

LPG import quantity of each company in Japan is shown in TABLE-8 (ATTACH.11), and share of LPG import in Japan is shown in FIG.4 (ATTACH.12).

VII.3 Import Terminal Capacity in Japan

LPG import terminal in Japan is spreaded in mainland and Kyushu Island which is shown in FIG.5 (ATTACH.13).

LPG import terminal capacity by area is shown in TABLE-9 (ATTACH.14) and by company in TABLE-10 (ATTACH.15).

VII.4 LPG Sales Quantity of Each Company in Japan

LPG sales quantity of each company in Japan is shown in TABLE-11 (ATTACH.16), and share of LPG sales in Japan is shown in FIG.6 (ATTACH.17).

VII.5 LPG Supply and Demand Forecast in Japan

LPG supply and demand forecast was shown in TABLE-6 (ATTACH.8). In Japan, LPG demand is very big but domestic production is small.

		1978	1979	1980	1981	1982	1983
Supply							
Domestic	%	36.2	34.7	35.8	34.3	34.4	33.8
Import	%	63.8	65.3	64.2	65.7	65.6	66.2
Total		100.0	100.0	100.0	100.0	100.0	100.0

Japan is big LPG importing country, and LPG domestic production is growing up corresponding to crude oil throughput but LPG demand is growing up year by year more than LPG domestic production. Thus, domestic production percentage was 36.2% on demand in 1978 and will be 33.8% in 1983.

VII.6 Japan Petroleum Development Corporation (JPDC)

Japanese Government has 100% share of JPDC, he assists a half of investment for exploratory drilling in country and foreign countires. And when crude oil and natural gas is discovered and commercial production is commenced, the fund is returned to JPDC, and if well is dry, the fund is not necessary returned to JPDC. But, the fund is tax from nation thus if Thailand excess product from natural gas and wants to export, Japanese Government expects that Thailand export them to Japan in proportion to share hold.

VIII MATERIAL BALANCE OF C_3 AND C_4 LPG (FROM NATURAL GAS)

C_3 and C_4 cuts in the gas from pipeline is shown in TABLE-12 (ATTACH.18). As was noted previously, C_3 and C_4 cuts separation (yield) must be estimated by computer, and 100% of them can not be recovered, so, I assume that C_3 yield is 90% on total C_3 in natural gas, and C_4 yield is 98% on total C_4 in natural gas (see TABLE-12, ATTACH.18).. These yields are based on Chiyoda's information.

I calculate material balance and heat balance of C_3 and C_4 LPG which are met the standard of specification of LPG imported in Japan (see TABLE-4, ATTACH.6), are shown in TABLE-13-1 and-2, (ATTACH.19-1 and -2). (13)-(19) of TABLE-13-2 shows calculation of heating value of C_3 LPG and C_4 LPG. These physical data are applied from TABLE-14-1 and -2 (ATTACH.20-1 and -2). SOURCE: DATA BOOK ON HYDROCARBONS), afterward I will use data from same tables.

Then, I calculate production of C_3 and C_4,LPG, and show in TABLE-15 (ATTACH.21) as Lb/H.

C_3 and C_4 LPG production is shown in TABLE-16 (ATTACH.22) as ton.

C_3 and C_4 LPG value and their average value are shown in TABLE-17 (ATTACH.25).

Note: When I calculated heating value, it is gross heating value not net heating value, because natural gas price is based on gross heating value. And T means MT and $ means US$.

IX LPG FOB BANGKOK PRICE (EXPORT LPG)

LPG price in Thailand (domestic LPG price) is very high, so LPG from natural gas is to make much profit according to Mr. Shishido's report last year.

LPG (CIF) price which was imported to Japan about 2 months ago was $143/T, if freight rate between Thailand and Japan is assumed as about $15/T, FOB Thailand might be $128/T.

FOB price of Kuwait D/D LPG is shown in FIG.7 (ATTACH.23) C_3 price was higher than C_4 price, but recently both prices have been closed, because C_4 LPG demand has been grown up.

o The Nippon Economic Newspaper reported as following :

Dated on June 24, 1979

Kuwait FOB Price (price in April - June in 1979)

C_3 LPG	126.5 $/T	Note: See the above mentioned $128/T.
C_4 LPG	127.5 $/T	

Price on spot at Houston, USA

C_3 LPG	150 $/T
C_4 LPG	300 $/T

o The same newspaper
Dated on July 5, 1979

Kuwait FOB Price (in July 1979)

C_3 LPG	160 $/T
C_4 LPG	180 $/T

Price on spot

C_3 LPG	200 $/T
C_4 LPG	300 $/T

o FOB Persian Gulf (Mitsui & Co.estimated)

April - June in 1979		July - Sept. in 1979	
C_3 LPG	C_4 LPG	C_3 LPG	C_4 LPG
125 - 126.5	123 - 127.5	159 - 160	177 - 180

Freight of Persian Gulf to Japan may be 22 - 25 $/T. Freight of Siam Gulf to Japan may be 15 $/T.

All over the world, LPG is very tight, because C_4 is mixed in gasoline and used as petrochemical raw material (substituted naphtha).

The LPG price is risen in July 1979, being caused by LPG shortage not by crude oil price up. Change of crude oil standard price is shown in FIG.8 (ATTACH.24).

I calculate average price of C_3 and C_4 LPG produced from Siam Gulf natural gas (the gas from pipeline), and show it in TABLE-17 (ATTACH.25).

Ratio of C_3 LPG and C_4 LPG of produced from the gas from pipeline is 64.5 : 35.5 (wt), and average price is 167.1 $/T when C_3 LPG price is 160 $/T and C_4 LPG price is 180 $/T.

According to Mr. Shishido's report (in 1978), exrefinery price of LPG in Thailand is as follows : (For your reference)

Exrefinery Price 3.1397 ฿/Kg*
= 154.096 $/T

Note: * Exrefinery price of LPG was not changed before July 1979.

The price of LPG in Thailand (in June 1979) was higher than the LPG of FOB Kuwait price (April and June 1977).

X CASE-1 EXPENDITURE AND REVENUE IN CASE OF NATURAL GAS PRICE 1.50$/MMBTU, C_3 LPG PRICE 160$/T AND C_4 LPG PRICE 180 $/T (500 MMscf/D)

X.1 Operation Cost

X.1.1 Production

In Mr. Shishido's report "THE PRELIMINARY ECONOMIC STUDY OF LPG RECOVERY FROM NATURAL GAS", LPG production was estimated as follows :

C_3	220,000	T/Y
C_4	160,000	T/Y
Total	380,000	T/Y

My calculation of LPG production (in case of 500 MMscf/D natural gas production schedule) is as follows: (in 1987)

C_3 LPG	272.52	MT/Y
C_4 LPG	149.88	MT/Y
Total	422.40	MT/Y

(see TABLE-16, ATTACH.22)

X.1.2 Construction Cost of LPG Production

Construction cost was estimated by Chiyoda Chemical Engineering and Construction Company based on 380,000 T/Y LPG production.

Designed recovery ratio is as follows:

C_3 : more than 90%

C_4 : more than 98%

CO_2 removal unit is necessary when natural gas charge to LPG plant, CO_2 content must be less than 1%, because turboexpand is applied :

	Chiyoda Estimate	Correction of Production rate	Correction 1979 Plant Cost	Plant Cost per Ton
	MM $	MM $	MM $	$/T
LPG Unit	70			
CO_2 Removal Unit	16			
Total	86	92.610*1	98.112	232.27*3

Note: *1 $86.000 \text{ MM\$} \times \left(\frac{422,400 \text{ T/Y}}{380,000 \text{ T/Y}} \right)^{0.7} = 92.610 \text{ MM\$}$

*2 92.610 MM$ x 1.07 % = 98.112 MM$

7% up/year of construction cost

*3 98.112 MM$ ÷ 422.40 MT = 232.27 $/T

Fluor's estimation of gas plant (the end of 1979)

200 MMscf/D	68,301 MM$
500 MMscf/D	x

$x = 68,301 \text{ M\$} \times \left(\frac{500}{200} \right)^{0.7} = 129,714$

$129,714 \text{ M\$} \times \left(1 + \frac{0.07}{2}\right) = 134,254$

$\frac{134,254 \text{ M\$}}{98,112 \text{ M\$}} = 1.37$ (37% higher than Japan)

The difference could not be clarify, it might be caused by different process and price of machine and equipment. And it is contained the cost of the dew point control unit.

X.1.3 Dew Point Control Unit

When LPG recovery is from 100% natural gas (the gas from pipeline), the dew point control unit is unnecessary. Thus, LPG recovery acts as dew point control duty, the duty is not for LPG production. Thus, the operation cost of dew point control must be eliminated from the cost of LPG production.

The cost of dew point control can not calculate at this stage. I assumed for 15% of total operation cost of LPG production.

X.1.4 Operation Cost $/T of LPG Production

Expense

A. Natural gas price is 1.5 $/MMMBTU

		% on Construction Cost	$/T
(1)	Depreciation (20 years)	5	11.61
(2)	Interest for Construction Cost	5	11.61
(3)	Tax and Insurance	2	4.65
(4)	Maintenance	3	6.97
(5)	Administration	2	4.65
(6)	Overhead	2	4.65
	Total	19	44.14

Note: Construction cost is 232.27 $/T

B. Interest of working capital

C_3 and C_4 LPG average price is 167.1 $/T (from TABLE-17, ATTACH.25)

167.1 $/T x 422,400 T/Y = 70.58 MM $/Y

70.58 MM $/Y x $\frac{1.5 \text{ Mon.}}{12 \text{ Mon.}}$ = 8.82 MM $/Y

8.82 MM $/T x 8% = 0.71 MM $/Y

∴ 8% is interest.

0.71 MM $/Y ÷ 422,400 T/Y = 1.68 $/T

C. Utility

Natural gas consumption is :

For LPG plant	9 MMscf/D
Cor CO_2 plant	18 MMscf/D
Total	27 MMscf/D

(Heating value of the natural gas was assumed as 1,050 BTU/scf by Mr. Shishido).

	Natural Gas Price
Mr. Shishido's Estimation	1.555 \$/MMBTU (compressor station at off-shore)
	1.544 \$/MMBTU (compressor station at on-shore)
Fluor's Report	1.50 \$/MMBTU
In the report, 2 natural gas prices were applied	1.75 \$/MMBTU
My Calculation	1.50 \$/MMBTU

The price is not included the transportation charge from the natural gas processing unit to end user. So, I apply for 1.50 \$/MMBTU of natural gas charge.

$$27 \text{ MMscf/D} \times 1{,}050 \text{ BTU/scf} \times \frac{1.50\ \$}{1\ \text{MMBTU}} = 42.525\ \$/\text{D}$$

$$= 15.52\ \text{MM\$/Y}$$

$$15.52\ \text{MM\$/Y} \times \frac{422{,}400\ \text{T/Y}}{380{,}000\ \text{T/Y}} \div 422{,}400 = 40.84\ \$/\text{T}$$

D. Labor cost

15 persons x 4 shifts = 60 persons

Salary and other expense is assumed as 200 \$/Mon. Month

200 \$/Mon month x 60 persons x 12 months = 0.144 MM\$/Y

0.144 MM\$/Y ÷ 422,400 T/Y = 0.34 \$/T

E. Operation cost

		\$/T
(1)	Expense	44.14
(2)	Interest for Working Capital	1.68
(3)	Utility	40.84
(4)	Labor Cost	0.34
	Total	87.00

F. Operation cost minus the cost of dew point control unit

87.00 $/T x (100 - 15)% = 73.95 $/T

X.2 Cost of Natural Gas Charge

50.92 MMBTU/T* x $\frac{1.5 \$}{MMBTU}$ = 76.38 $/T

Note: * is come from TABLE-20 (ATTACH.28).
TABLE-20 (ATTACH.28) is calculated from TABLE-18 and -19 (ATTACH.26 and 27).

X.3 Expenditure

	$/T
Cost Natural Gas Charge	76.38
Operation Cost	73.95
Total	150.33

Selling charge (including shipping) is assumed as 3% on total expenditure.

Expenditure is as follows :-

150.33$/T x (1 + 0.03) = 154.84 $/T

X.4 Revenue

C_3 and C_4 LPG average FOB Bangkok price is 167.1 $/T which is from TABLE-17-7 (ATTACH.25).

X.5 Profit or Loss

167.1 $/T - 154.84 $/T = +12.26 $/T

12.26 $/T - 154.84 $/T x 100 = + 7.9%

In this case, profit is 12.26 $/T.

(see TABLE-21, ATTACH.29)

X' CASE-1' EXPENDITURE AND REVENUE IN CASE OF NATURAL GAS PRICE 1.70 $/MMBTU, C_3 LPG PRICE 160 $/T AND C_4 LPG PRICE 180 $/T (500 MMSCF/D)

In X, I applied 1.50 $/MMBTU of natural gas, but actual natural gas price in 1979 may be 1.70 $/MMBTU, so I calculate in case of 1.70 $/MMBTU as follows :

X'.1 Utility

$$27 \text{ MMscf/H} \times 1{,}050 \text{ BTU/scf} \times \frac{1.70\ \$}{1\text{MM}} = 48{,}195\ \$/\text{D}$$

$$= 17.59\ \text{MM\$/Y}$$

$$17.59\ \text{MM \$/Y} \times \frac{422{,}400\ \text{T/Y}}{380{,}000\ \text{T/Y}} \div 422{,}400\ \text{T/Y} = 46.29\ \$/\text{T}$$

X'.2 Operation Cost

		$/T	
(1)	Expense	44.14	no change
(2)	Interest for Working Capital	1.68	no change
(3)	Utility	46.29	
(4)	Labor Cost	0.34	no change
	Total	92.45	

$$92.45\ \$/\text{T} \times (100 - 15)\% = 78.58\ \$/\text{T}$$

X'.3 Cost of Natural Gas Charge

$$50.92\ \text{MMBTU/T} \times \frac{1.7\ \$}{\text{MMBTU}} = 86.56\ \$/\text{T}$$

X'.4 Expenditure

	$/T
Cost of natural gas charge	86.56
Operation cost	78.58
Total	165.14

X'.5 Profit and Loss

167.1 \$/T - 165.14 \$/T = + 1.96 \$/T
1.96 \$/T ÷ 165.14 \$/T = + 1.2%

In this case, profit is 1.96 \$/T.

XI CASE-2 EXPENDITURE AND REVENUE IN CASE OF NATURAL GAS PRICE EQUIVALENT TO FUEL OIL PRICE (2.063 \$/MMBTU) (500 MMSCF/D)

XI.1 Natural Gas Price Equivalent to Fuel Oil 1,200"

Fuel Oil 1,200" 1.6157 Ø/lit (May 1, 1978)

1.6157 Ø/lit = 0.0792 \$/lit

1\$ = 20.4 Ø

Heating value (Gross)

400" 9,371 Kcal/lit
1,500" 9,826 Kcal/lit
1,200" 9,675 Kcal/lit (assumed)

9,675 Kcal/lit = 38,392.86 BTU/lit

1 Kcal = 3.96825 BTU

0.0792 \$/lit - 38,392.86 BTU/lit x MMBTU = 2.063 \$/MMBTU

XI.2 Utility

$$27 \text{ MMscf/D} \times 1{,}050 \text{ BTU/scf} \times \frac{2.063\ \$}{\text{MMBTU}} = 58{,}486\ \$/\text{D}$$

$$= 21.35\ \text{MM\$/Y}$$

$$21.35\ \text{MM\$/Y} \times \frac{422{,}400\ \text{T/Y}}{380{,}000} \div 422{,}400\ \text{T/Y} = 56.18\ \$/\text{T}$$

XI.3 Operation Cost

	\$/T	
(1) Expense	44.14	no change
(2) Interest for Working Capital	1.68	no change
(3) Utility	56.18	
(4) Labor Cost	0.34	no change
Total	102.34	

Total operation cost minus the cost of dew point control unit.

102.34 \$/T x (100 - 15)% = 86.99 \$/T

XI.4 Cost of Natural Gas Charge

$50.92 \text{ MMBTU/T} \times \frac{2.063 \$}{\text{MMBTU}} = 105.05 \$/T$

XI.5 Expenditure

	\$/T
Cost Natural Gas Charge	105.05
Operation Cost	86.99
Total	192.04

Selling charge (including shipping) is assumed as 3% on total expenditure.

192.04 \$/T x (1 + 0.03)% = 197.80 \$/T

XI.6 Revenue

C_3 and C_4 LPG average FOB Bangkok price is 167.1 \$/T which is come from TABLE-17 (7) (ATTACH.25).

XI.7 Profit and Loss

167.1 \$/T - 197.80 \$/T = -30.7 \$/T
-30.7 \$/T ÷ 197.80 \$/T = -15.5%

In this case, loss is 30.7 \$/T.

XII CASE-3 EXPENDITURE AND REVENUE IN CASE OF NATURAL GAS PRICE IS MIDDLE OF CASE-1 AND CASE-2 (1.78 \$/MMBTU) (500 MMscf/D)

XII.1 Natural gas price

CASE-1	1.50	\$/MMBTU
CASE-2	2.063	\$/MMBTU
CASE-3	1.78	\$/MMBTU

Average of CASE-1 and CASE-2 is 1.78 \$/MMBTU.

XII.2 Utility

$$27 \text{ MMscf/D} \times 1{,}050 \text{ BTU/scf} \times \frac{1.78\ \$}{\text{MMBTU}} = 50{,}463\ \$/\text{D}$$

$$= 18.42 \text{ MM } \$/\text{Y}$$

$$18.42 \text{ MM\$/Y} \times \frac{422{,}400 \text{ T/Y}}{380{,}000 \text{ T/Y}} \div 422{,}400 \text{ T/Y} = 48.47$$

XII.3 Operation Cost

		$/T	
(1)	Expense	44.14	no change
(2)	Interest for Working Capital	1.68	no change
(3)	Utility	48.47	
(4)	Labor Cost	0.34	no change
	Total	94.63	

Total operation cost minus the cost of dew point control unit

$$94.63\ \$/\text{T} \times (100 - 15)\% = 80.44\ \$/\text{T}$$

XII.4 Cost of Natural Gas Charge

$$50.92 \text{ MMBTU/T} \times \frac{1.78\ \$}{\text{MMBTU}} = 90.64\ \$/\text{T}$$

XII.5 Expenditure

Cost Natural Gas Charge	90.64 $/T
Operation Cost	80.44 $/T
Total	171.08 $/T

Selling charge (including shipping) is assumed as 3% on total expenditure.

$$171.08 \times (1 + 0.03)\% = 176.21\ \$/\text{T}$$

XII.6 Revenue

C_3 and C_4 LPG average FOB Bangkok price is 167.1 \$/T which is come from TABLE-17 (7) (ATTACH.25). -

XII.7 Profit and Loss

167.1 \$/T - 176.21 \$/T = -9.11 \$/T

-9.11 \$/T ÷ 176.21 \$/T = -5.2 %

In this case, loss is 9.11 \$/T.

XIII RESULT OF CASE-1, CASE-1', CASE-2 AND CASE-3 (500 MMSCF/D)

When C_3 LPG price is 160 \$/T and C_4 LPG price is 180 \$/T, average 167.1 \$/T, natural gas price must be 1.66 \$/T at profit zero point which is shown in FIG.9 (ATTACH.30). These calculations are based on 272.52 x 10^3 T/Y of C_3 LPG production, and 149.88 x 10^3 T/Y of C_4 LPG production in 1984 (see TABLE-16, ATTACH.22).

In FIG.9 (ATTACH.30) another 4 lines of 175 \$/T, 185 \$/T, 195 \$/T, 200 \$/T for C_3 and C_4 LPG average price are as following :

Natural gas price vs C_3 and C_4 LPG average price is as under :

Natural gas production 500 MMscf/D

NATURAL GAS PRICE \$/MMBTU		C_3 and C_4 LPG AVERAGE PRICE (\$/T)*				
		167.1	175	185	195	200
		PROFIT OR LOSS (\$/T)				
CASE-1	1.50	+12.26	+20.16	+30.16	+49.16	+45.16
CASE-1'	1.70	+ 1.96	+ 9.86	+19.86	+29.86	+34.86
CASE-2	2.063	-30.7	-22.80	-10.80	- 0.80	+ 4.2
CASE-3	1.78	- 9.11	- 1.21	+ 8.79	+18.79	+23.79

Note: * FOB Bangkok price

When C_3 and C_4 LPG price is 167.1 \$/T and natural gas price is 1.50 \$/MMBTU (CASE-1), profit is 12.26 \$/T, but when these are 1.78 \$/T (CASE-3) and 2.063 \$/MMBTU (CASE-2) of natural gas price, all are loss. Namely, even if fuel oil equivalent 2,063 \$/MMBTU and C_3 and C_4LPG 1.95S/T, profit is still not so big (see FIG.9, ATTACH.30).

In the above table, C_3 and C_4 average price is indicated, their average prices are breakdown as follows but approximately.

		C_3 LPG	C_4 LPG
Line	165.9 \$/T	160 \$/T	180 \$/T
Line	175 \$/T	168 \$/T	189 \$/T
Line	185 \$/T	177 \$/T	199 \$/T
Line	195 \$/T	187 \$/T	210 \$/T
Line	200 \$/T	192 \$/T	216 \$/T

Note: Data of calculated. above number are approximately.

Natural gas price is 2.063 \$/MMBTU which is equivalent to fuel oil 1,200", when C_3 LPG and C_4 LPG prices are going up to 192 \$/T and 216 \$/T individually (price is going up about 40 \$/T higher than the present price of C_3 LPG and C_4 LPG), but it is almost no profit and loss.

As a consequence, NGOT will not able to produce C_3 and C_4 LPG at present price, but C_3 and C_4 LPG price will be going up rapidly in near future according to C_3 and C_4 LPG market is becoming tight.

XIV CASE-4 EXPENDITURE AND REVENUE IN CASE OF NATURAL GAS PRICE 1.50 \$/MMBTU, C_3 LPG PRICE 160 \$/T C_4 LPG PRICE 180 \$/T (700 MMSCF/D)

LPG production which was noted above is from 500 MMscf/D, LPG production from bigger size is cheaper than from smaller size.

XIV.1 Construction Cost

380,000 T/Y   86 MM$

$$86 \text{ MM\$} \times \left(\frac{559.15^{*} \text{ T/Y}}{380{,}000 \text{ T/Y}} \right)^{0.7} = 112.70 \text{ MM\$}$$

= 120.59 MM$ 7% up

120.59 MM$ - 559.15 T = 215.67 $/T

Note: * come from TABLE-15 (ATTACH.21)

63.83 Kg/H x 24 h x 365 days = 559.15 T/Y

XIV.2 Operation Cost

XIV.2.1 Natural gas price 1.5 $/MMBTU

	% on Construction Cost	$/T
1) Depreciation (20 years)	5	10.78
2) Interest for Construction	5	10.78
3) Tax and Insurance	2	4.31
4) Maintenance	3	6.47
5) Administration	2	4.31
6) Overhead	2	4.31
Total	19	40.96

Note: Construction cost is 215.67 $/T

XIV.2.2 Interest of working capital

Same as X.1.4, B

Namely, it is 1.68 T/Y.

XIV.2.3 Utility

Same as X.1.4, C

Namely, it is 40.84 $/T.

XIV.2.4 Labor cost

16 persons x 4 shifts = 64 persons

Salary and other expense is assumed as 200 $/Man.Month.

200 $/Man. Month x 64 persons x 12 months ÷ 559.150 T/Y = 0.27 $/T

XIV.2.5 Operation cost

		$/T	
(1)	Expense	40.96	(change)
(2)	Interest for Working Capital	1.68	
(3)	Utility	40.84	
(4)	Labor Cost	0.27	(change)
	Total	83.75	

XIV.2.6 Total operation cost minus the cost of the dew point control unit

83.75 $/T x (100 - 15)% = 71.19 $/T

XIV.3 Cost of Natural Gas Charge

50.94^{*} MMBTU/T x $\frac{1.5\ \$}{MMBTU}$ = 76.41

Note: * come from TABLE-20 (ATTACH.28)

XIV.3 Expenditure

	$/T
Cost of Natural Gas Charge	76.41
Operation Cost	71.19
Total	147.6

Selling charge (including shipping) is assumed as 3% on total expenditure.

Expenditure is as follows :

$147.6\ \$/T \times (1 + 0.03)\% = 152.03\ \$/T$

XIV.5 Revenue

Same as X.5

Namely, it is 167.1 \$/T

XIV.6 Profit and Loss

$167.1\ \$/T - 152.03\ \$/T = 15.07\ \$/T$

$15.07\ \$/T \div 152.03\ \$/T = 9.0\%$

In this case, profit is 15.07 \$/T,

XV COMPARISON OF LPG PRODUCTION FROM 500 MMSCF/D AND 700 MMSCF/D (NATURAL GAS PRICE 1.50 \$/MMBTU)

	Expenditure \$/T	Revenue \$/T	Profit \$/T	Profit %
From 500 MM/D Natural Gas	155.59	167.1	+10.31	6.6
From 700 MM/D Natural Gas	152.20	167.1	+15.07	9.9

LPG from 700 MMscf/D natural gas is 4.59 \$/T more profit, but LPG production unit can not be bigger than 700 MMscf/D unit.

XVI CONCLUSION

(1) Export LPG State

When LPG is exported, LPG must be separate C_3 LPG and C_4 LPG. And LPG state is not high pressure and atmospheric temperature must be low.

(2) Expected LPG Production and LPG to Export to Japan

When Thailand intends to export the products and by products (energy) from Siam Gulf natural gas, Japan expects to import the products and by products on proportion to the share hold.

Thai natural gas production from 700 MMscf/D natural gas from pipeline and quantity of imported LPG in Japan are as follows :

Thai LPG Production from Natural Gas (from pipeline)

in 1983	$3{,}040 \times 10^3$T
(after 1988	$5{,}590 \times 10^3$T)

Japanese LPG Domestic Production and Import

Domestic in 1983	$5{,}917 \times 10^3$T	33.8 %
Import in 1983 (forecast)	$11{,}589 \times 10^3$T	66.2 %
Total	$17{,}506 \times 10^3$T	100.0 %

Japanese import LPG will be grown up every year.

Japanese LPG market is good for Thailand.

(3) LPG price

I estimate the Thai LPG cost from natural gas as of 1979 before the 2nd oil crisis.

Calculation conditions of Thai LPG cost from natural gas CASE-2 are as follows :

Natural gas production	500 MMscf/D
Natural gas price	2.063 $/MMBTU
C_3 LPG price	160 $/T
C_4 LPG price	180 $/T
C_3 LPG : C_4 LPG	64.5 : 35.5

Results are as follows :

C_3 LPG and C_4 LPG average FOB price	167.1 $/T
Thai LPG selling price (cost) from natural gas	197.8 $/T
Loss	30.7 $/T

Note: *1 come from XI.7

*2 come from TABLE-17 (7) (ATTACH.25)

According to the above table, the price of natural gas from pipeline is very high compared with other natural gas produced country, so Thai LPG cost from natural gas is very high.

In accordance with circumstances of Thai economics, the export LPG price must be higher than fuel oil price based on calorific power. If export LPG price is lower than fuel oil price, LPG can not export, because of big loss money.

As the above table, at present status, Thailand can not produce and export LPG from natural gas.

(4) Possibility of LPG export

LPG FOB Kuwait price has been going up rapidly.

in 1979

	April - June	July	on Spot
C_3 LPG	126.5 $/T	160 $/T	150 - 200
C_4 LPG	127.5 $/T	180 $/T	300

The above mentioned price up is not according to crude oil price up, to tight of LPG market.

Therefore, it seems that LPG price will be going up more than 200 $/T in very near future.

(5) Export port condition

In case of Japan, the port condition and vessel are as follows :

1. Port condition

   75,000 M^3 cargo is acceptable.

2. Tanker size

   50,000 DWT

   LOA (length over all) 225 M

   Draft 12 M

3. Cargo lot : about 43,000 T

43,000 T of one LPG lot is following days production.

in 1982	62 days
in 1984	37 days
in 1990	28 days

4. Fleight from Bangkok

Bangkok to Japan 15 $/T

Comments

(1) If NGOT exports LPG to Japan, he negotiates export port conditions with Japanese importer to fit production scale and port condition of Thailand.

(2) According to NGOT plan, the gas processing unit is about 20 Km far from sea-shore. It is too far for low temperature and very low pressure LPG transportation by pipeline. It is better that the gas processing unit is very close to sea-shore.

Even if, LPG is not exported, LPG must be transported by tanker in inland, tanker transportation fee is cheaper than other way.

(3) C_4 LPG export price is higher than C_3 LPG export price, so C_4 LPG from the refineries is exported and C_3 LPG from natural gas is back to the refineries on same heating value. Therefore, Thai LPG specification is needed to change when more C_4 LPG is exported.

(4) I assumed that the cost of dew point control is 15% on LPG production expense, it has big influence on LPG cost, so the cost of dew point control must be calculated exactly.

Summary

(1) Present LPG FOB price is not feasible for Thai LPG production from natural gas, but in near future LPG FOB price would be going

up and it will become feasible. NGOT should be watched a movement of LPG FOB price.

(2) Natural gas processing unit should be moved to sea-shore.

end.

TABLE-1 PHYSICAL PROPERTY OF LPG

	Propane	(Propylene) Propene	n-Butane	i-Butane	(i-Butylene) i-Betane	J-But. ne	t-Butene	c-Butene
Molecular Formular	C_3H_8	C_3H_6	C_4H_{10}	C_4H_8	C_4H_8	C_4H_8	C_4H_8	C_4H_8
Molecular Weight	44.1	42.1	58.1	56.1	56.1	56.1	56.1	56.1
Boiling Point (1 atm) (°C)	-42.1	-47.1	-0.5	-11.7	-6.3	-6.9	0.9	3.7
Melting Point (1 atm) (°C)	-187.7	-185.3	-138.4	-159.6	-185.4	-140.4	-105.6	-138.9
Specific Gravity Liquid (15 °C) (g/ml)	0.508	0.523	0.585	0.563	0.601	0.601	0.610	0.627
Gas (15 °C) (Kg/m³)	1.895	1.805	2.538	2.529	2.443	2.442	-	2.442
Vapor Pressure (37.8 °C) (Kg/cm²A)	13.4	15.9	3.6	5.0	4.4	4.4	3.5	3.2
Gross Heating Value (25 °C) (Kcal/Kg)	12.020	11,690	11,830	11,800	11,580	11,510	11,530	11,550
(15.6 °C) (Kcal/m³)	22,830	21,120	30,050	29,850	28,300	28,110	28,170	28,210
(60 °F) (BTU/lb)	21,650	21,040	21,290	21,240	20,840	20,720	20,750	20,780
Net Heating Value (25 °C) (Kcal/Kg)	10,930	10,940	10,890	10,840	10,830	10,760	10,780	10,800
(15.6 °C) (Kcal/m³)	21,000	19,750	27,730	27,540	26,450	26,260	26,330	26,360
(60 °F) (BTU/Kg)	19,930	19,690	19,670	19,610	19,490	19,370	19,400	19,430
Latent Heat (B.P. 1 atm) (Kcal/Kg)	101.8	104.6	92.1	87.6	93.4	94.2	96.9	99.5
Sensible Heat Gas) (25 °C) (Kcal/Kg °C)	0.399	0.368	0.401	0.398	0.365	0.380	0.374	0.336
Sensible Heat Liquid (25 °C) (Kcal/Kg °C)	0.602	0.611	0.575	0.582	0.549	0.558	0.544	0.537
Explosion Limit (in air) (vol %)	2.1 - 9.5	2.0 - 10.0	1.8 - 8.4	1.8 - 8.4	1.6 - 9.3	-	-	-
Ignition Temperature (in air) (°C)	481	548	441	544	443	443		
Gas Specific Gravity (15.6 °C, 1 atm) (air = 1)	1.550	1.477	2.076	2.068	1.998	1.997	-	1.997

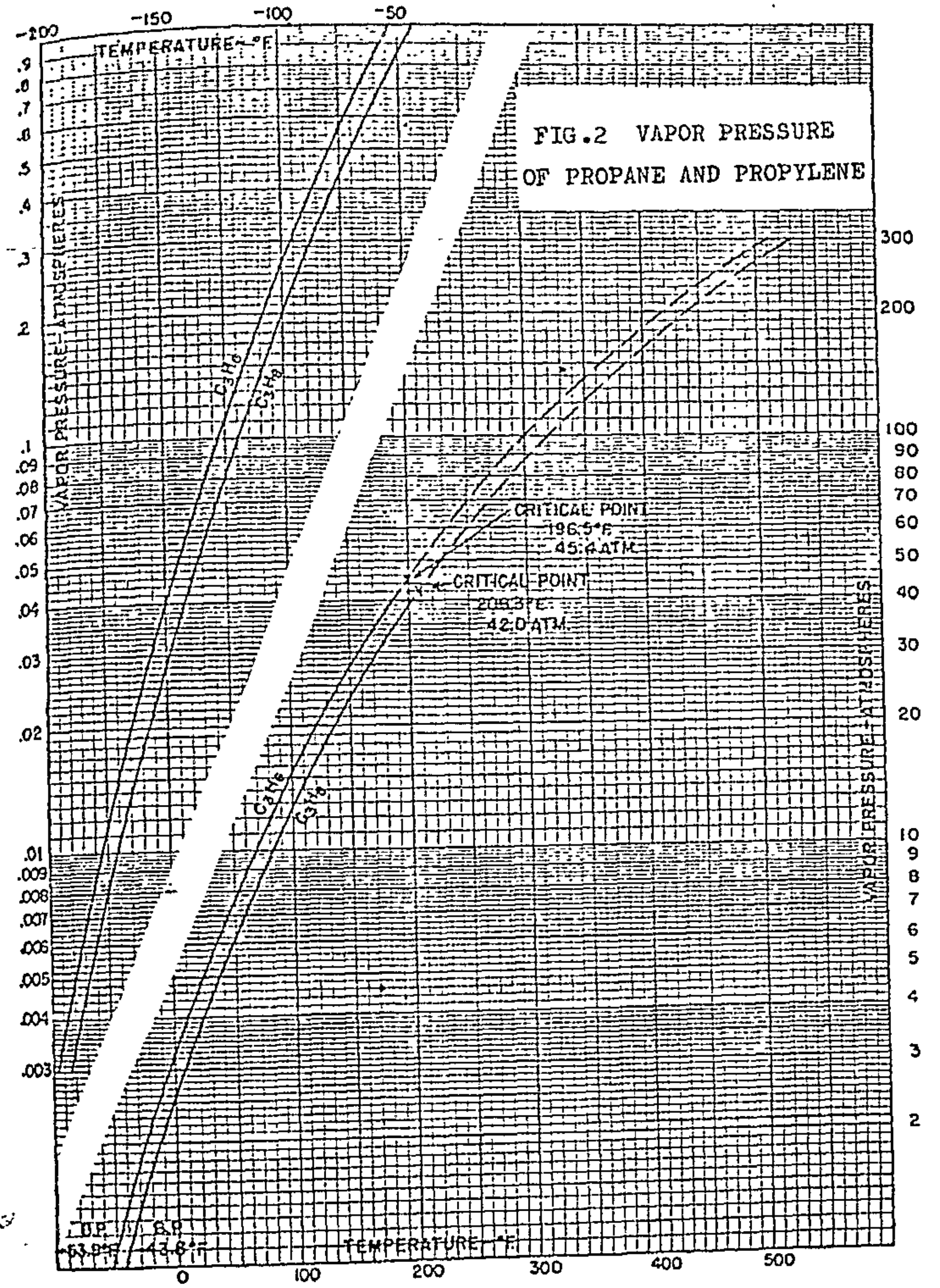


FIG.2 VAPOR PRESSURE OF PROPANE AND PROPYLENE

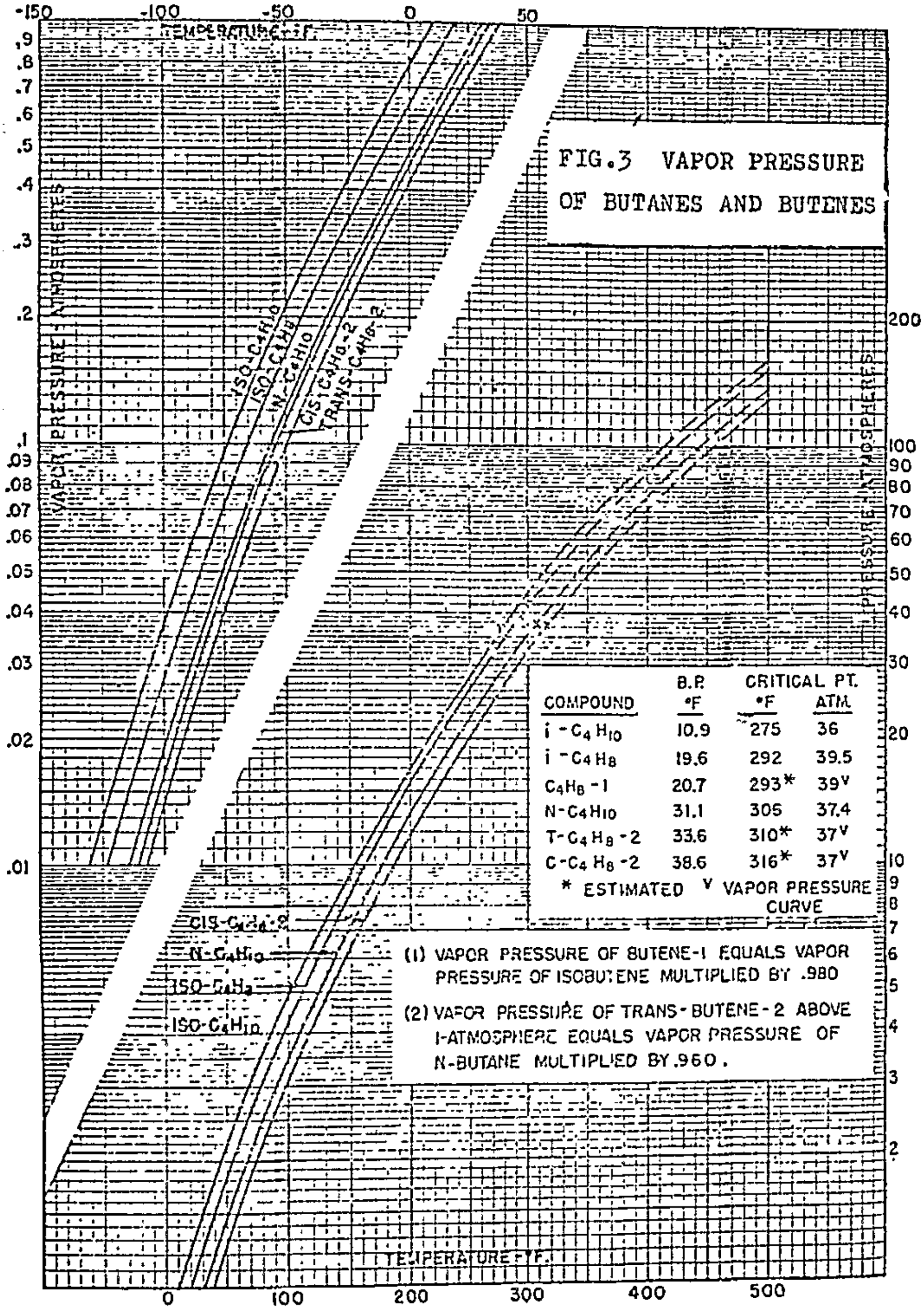


FIG.3 VAPOR PRESSURE OF BUTANES AND BUTENES

TABLE-2 THAI INDUSTRIAL SPECIFICATION OF LPG

LIQUEFIED PETROLEUM GAS		LIMITS	TEST METHODS
VAPOR PRESSURE @ 37.8°C	MIN	4.22	ASTM-D-1267
95% BOILING POINT °C	MAX	2.2	ASTM-D-1837
PENTANE AND HEAVIERS VOL % (VAPOR)	MAX	2	ASTM-D-2163
COPPER STRIP CORROSION	MAX	COPPER NO.1	ASTM-D-1838
TOTAL SULPHUR GRAINS/m^3	MAX	0.05	ASTM-D-1266
RESIDUE AFTER EVAPORATION 100 ml	MAX	0.05	ASTM-D-2158
NO WATER			
ODOR		MARKETABLE	

$C_{3s} : C_{4s} = 3 : 7$ (by volume)

ATTACH.5

TABLE-3

LIQUEFIED PETROLEUM GAS
JIS K2240 - 1972

No. \ Item	Vapor Pressure (40 °C) (Kg/cm²)	Sulfur wt.%	Component (Mol %)				Usage
			Ethane + Ethylene	Propane + Propylene	Butanes + Butenes	Butadienes	
1	15.8 Max.	0.02 Max.	-	90 Min.	-	-	Industry, Motor car, and Others.
2	15.8 Max.	0.02 Max.	-	50 Min. 90 Max.	-	-	
3	12.7 Max.	0.02 Max.	-	-	40 Min. 90 Max.	-	Industry, Motor car, and Others.
4	5.3 Max.	0.02 Max.	-	-	90 Min.	-	
R	15.6 Max.	0.015 Max.	8 Max.	60 Min. 80 Max.	-	2 Max.	Household (general use)
C	15.6 Max.	0.015 Max.	8 Max.	80 Min.	-	2 Max.	Household (for very cold weather area in winter)

TABLE-4 STANDARD OF SPECIFICATION OF LPG IMPORTED TO JAPAN

	C_3 LPG Mol%	C_4 LPG Mol%
C_2	2.0 Max.	-
C_3	96.0 Min.	-
C_4	2.5 Max.	95.0 Min.
C_5		2.0 Max.

TABLE-5 LPG DEMAND FORECAST IN THAILAND AND JAPAN (MITI ESTIMATION)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
IN THAILAND											
10^3Kl	147	195	188	197	223	240	292	317	356	396	444
10^3T	84*	112	108	123	128	138	167	182	204	227	254
IN JAPAN 10^3T											
Household	4,208	4,616	4,833	4,990	5,265	5,275	5,453	5,690	5,937	6,195	6,461
Industry	1,586	2,009	2,131	2,438	2,750	3,067	3,627	4,093	4,328	4,592	4,853
Town gas	407	401	493	563	692	674	777	981	1,070	1,163	1,345
Motor Car	1,506	1,495	1,448	1,558	1,655	1,677	1,707	1,736	1,753	1,769	1,786
Petrochemical Raw Material	1,087	1,194	1,069	866	806	932	977	1,030	1,034	1,038	1,041
Export	30	50	10	8	5	1	8	8	8	8	8
Total	8,824	9,765	9,990	10,423	11,173	11,626	12,549	13,538	14,130	14,765	15,494

Note: * Specific gravity

C_{3s} 0.5155 x 30% = 0.15465

C_{4s} 0.5978 x 70% = 0.41846

0.573

147 x 0.573 = 84

ATTACH.8

TABLE-6 LPG SUPPLY/DEMAND PLAN (1979-1983)
(ESTIMATED BY MITI)

(UNIT: 1,000 M/T)

SUPPLY/DEMAND \ YEAR	1978	1979			1980	1981	1982	1983
		1st half	2nd half	Total				
SUPPLY								
DOMESTIC	4,668	2,320	2,610	4,930	5,244	5,483	5,735	5,917
IMPORT	8,232	4,545	4,714	9,259	9,413	10,486	10,922	11,589
TOTAL	12,900	6,865	7,324	14,189	14,657	15,969	16,657	17,506
DEMAND								
HOUSEHOLD USE	5,340	2,404	3,128	5,532	5,712	5,898	6,090	6,288
INDUSTRIAL FUEL	3,316	1,765	1,853	3,618	3,798	4,010	4,218	4,438
ELECTRIC POWER	344	330	135	465	508	966	1,243	1,486
TOWN GAS	942	451	726	1,177	1,344	1,438	1,597	1,623
AUTOMOBILE FUEL	1,721	849	876	1,725	1,748	1,776	1,796	1,814
CHEMICAL FEEDSTOCK	1,271	614	750	1,364	1,471	1,522	1,553	1,576
EXPORT	41	20	20	40	40	40	40	40
TOTAL	12,975	6,433	7,488	13,921	14,621	15,630	16,537	17,265
INVENTORY	970	1,402	1,238	1,238	1,274	1,593	1,713	1,954

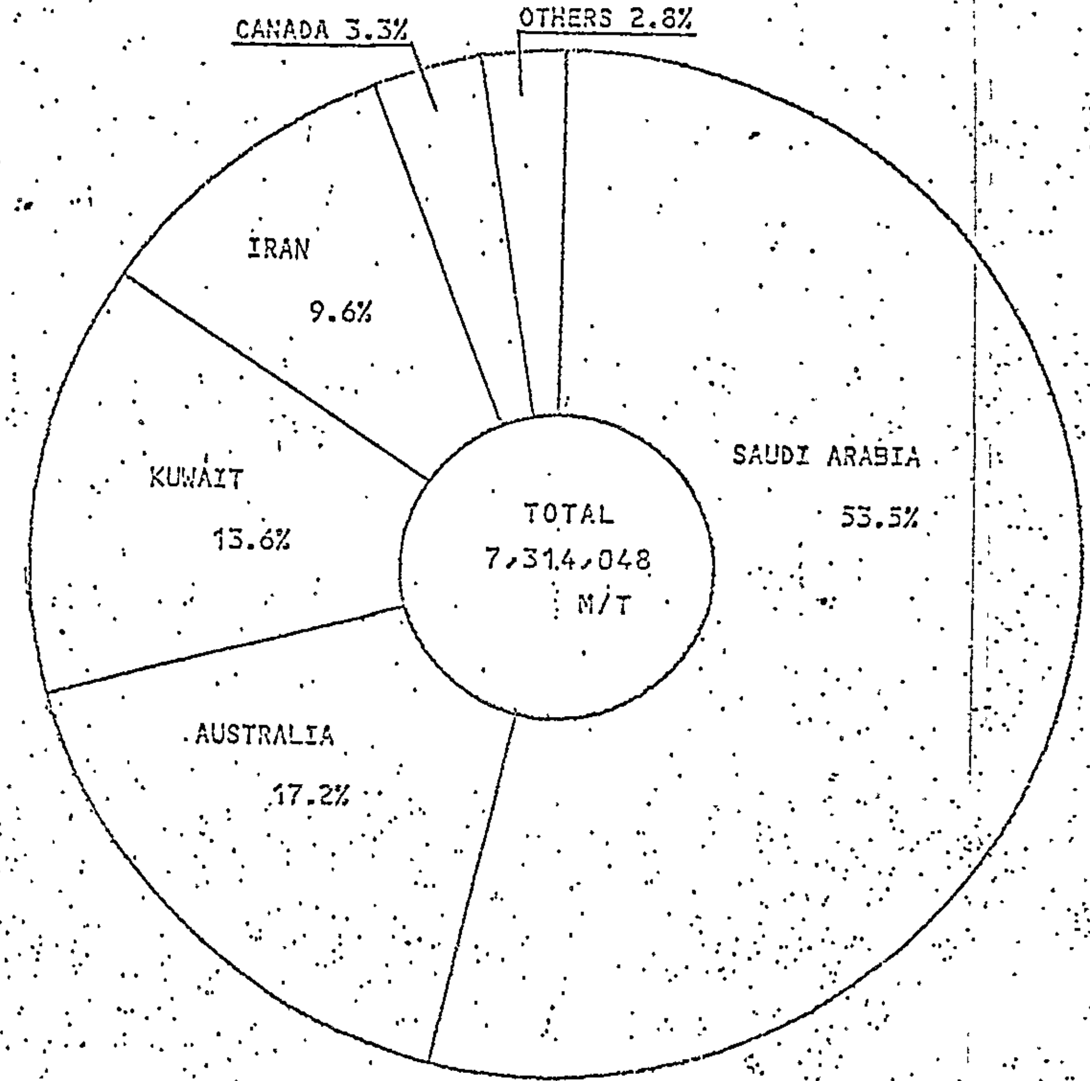
ATTACH.9

TABLE-7 JAPANESE LPG IMPORT BY SUPPLY SOURCES

(UNIT: 1,000M/T)

YEAR / COUNTRY	1971	1972	1973	1974	1975	1976	1977
SAUDI ARABIA	1,003	1,101	1,750	2,654	2,799	3,464	3,911
AUSTRALIA	553	741	1,029	1,008	1,097	1,084	1,255
KUWAIT	1,158	1,249	1,303	929	823	853	997
IRAN	575	678	771	767	703	708	704
CANADA	250	267	224	223	232	249	241
VENEZUELA	71	259	103	27	25	-	26
OTHERS	11	130	34	70	232	212	180
TOTAL	3,621	4,425	5,214	5,678	5,911	6,570	7,314

FIG.3 SHARE OF JAPANESE LPG IMPORT BY SUPPLY SOURCES (AS OF 1977)



ATTACH.10

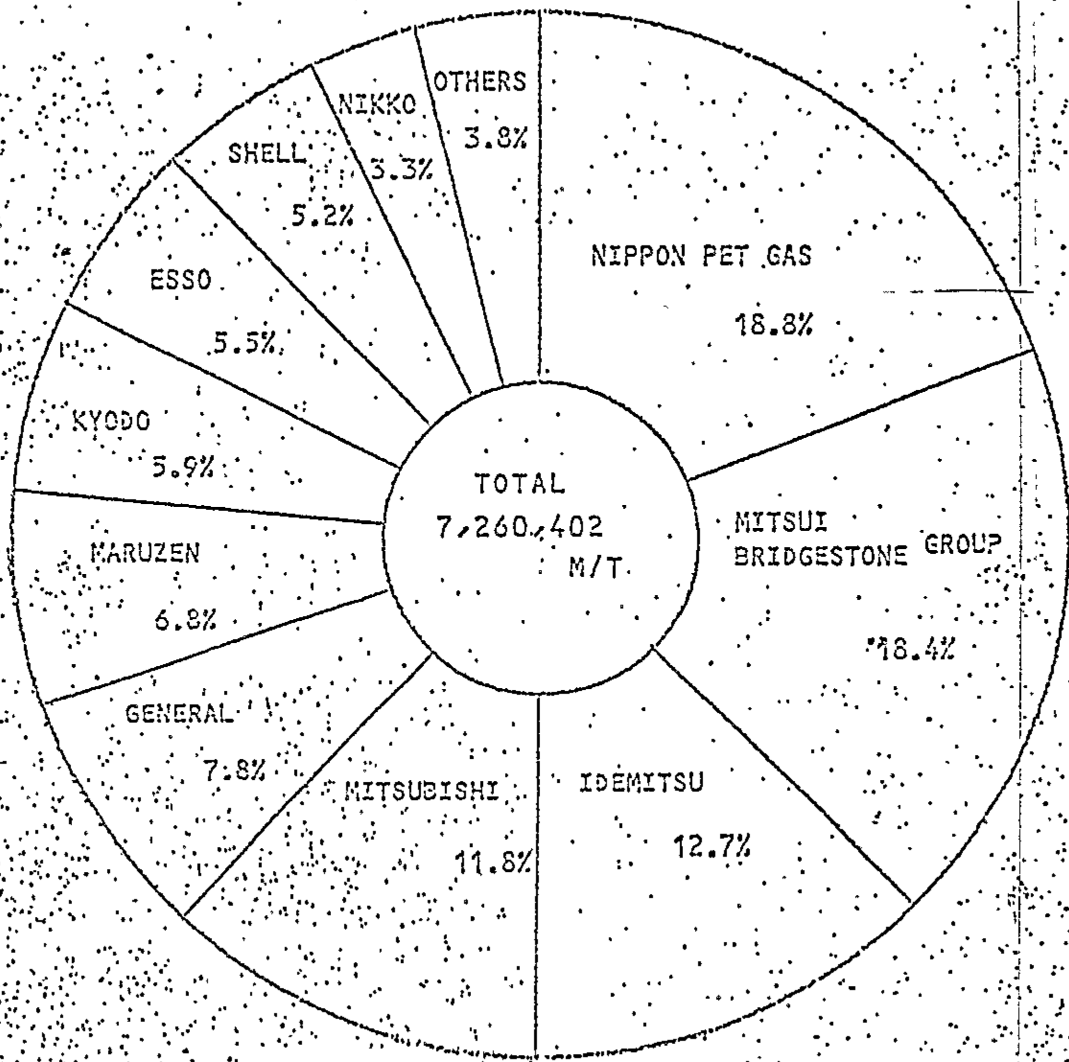
ATTACH:11

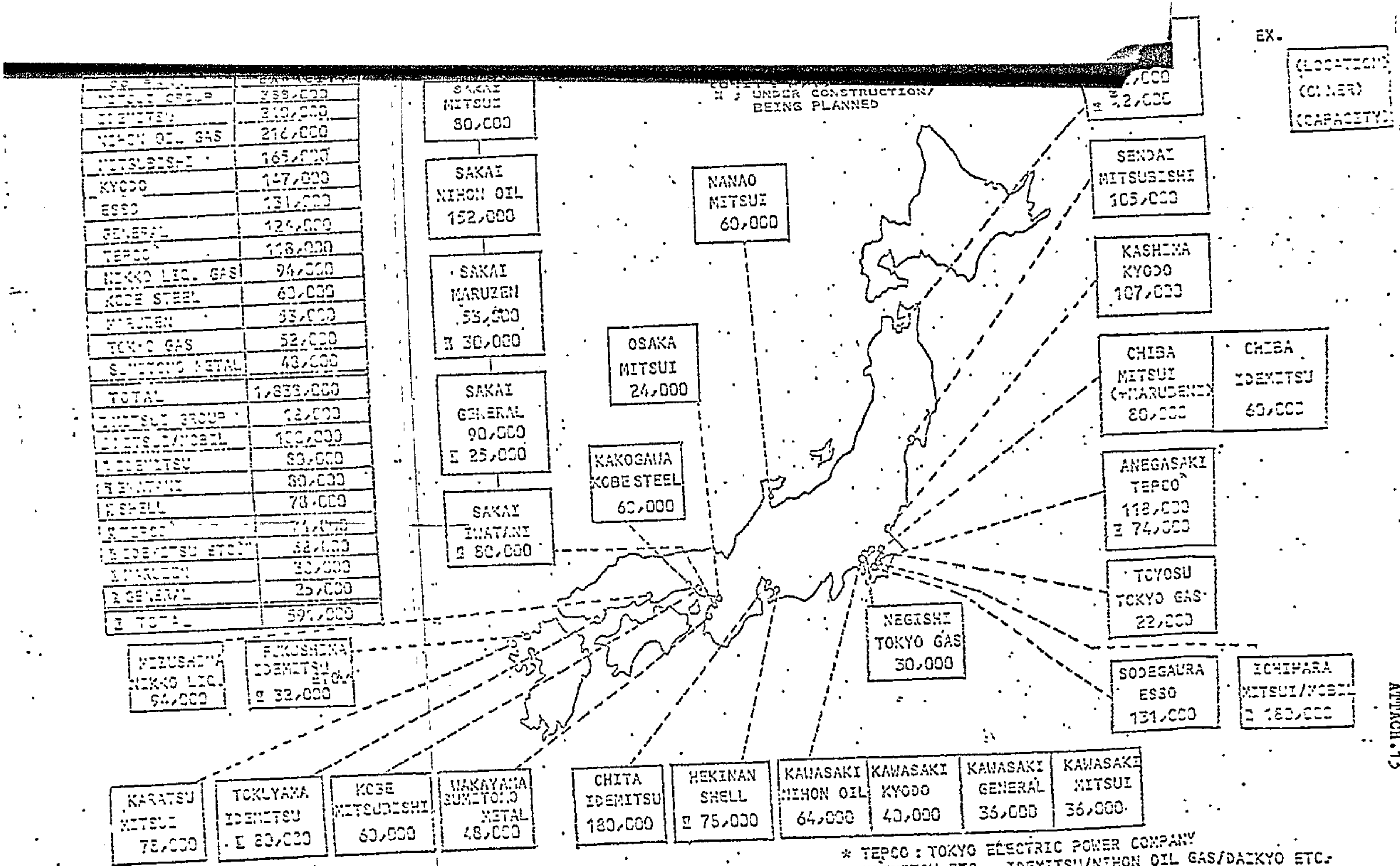
(UNIT: [illegible])

COMPANY	1972	1973	1974	1975	1976	1977
NIPPON PET. GAS	681	771	1,135	1,332	1,385	1,363
MITSUI & BRIDGESTONE LIQ. GAS GROUP	1,326	1,464	1,473	1,146	1,297	1,338
IDEMITSU SEKIYU	293	372	652	638	673	919
MITSUBISHI LIQ. GAS	511	598	494	432	572	859
GENERAL SEKIYU	191	227	335	348	530	565
MARUZEN SEKIYU	217	181	278	468	501	495
KYODO SEKIYU	455	616	543	474	411	429
ESSO	150	201	147	286	364	397
SHELL	119	225	200	227	307	379
NIKKO LIQ. GAS	283	311	286	252	250	242
OTHERS	195	212	237	328	398	274
TOTAL	4,421	5,178	5,720	5,911	6,688	7,260

ATTACH.12

FIG.4 SHARE OF LPG IMPORT IN JAPAN (AS OF 1977)





[illegible]	CAPACITY
MITSUI GROUP	233,000
IDEMITSU	210,000
NIHON OIL GAS	216,000
MITSUBISHI	165,000
KYODO	147,000
ESSO	131,000
GENERAL	124,000
TEPCO*	118,000
NIKKO LIQ. GAS	94,000
KOBE STEEL	60,000
MARUZEN	53,000
TOKYO GAS	52,000
SUMITOMO METAL	48,000
TOTAL	1,833,000
Ξ MITSUI GROUP	12,000
Ξ MITSUI/MOBIL	180,000
Ξ IDEMITSU	83,000
Ξ IWATANI	80,000
Ξ SHELL	75,000
Ξ TEPCO*	74,000
Ξ IDEMITSU ETC.**	32,000
Ξ MARUZEN	30,000
Ξ GENERAL	25,000
Ξ TOTAL	597,000

* TEPCO : TOKYO ELECTRIC POWER COMPANY
** IDEMITSU ETC. IDEMITSU/NIHON OIL GAS/DAIKYO ETC.

Tokyo Area (Kei-Yo Area)

Chiba (Mitsui + Marubeni)	80,000	
Chiba (Idemitsu)	60,000	
Anegasoki (Tokyo Electric Power Co.)	74,000	(under construction)
Toyosu (Tokyo Electric Power Co.)	22,000	
Ichihara (Mitsui/Mobil)	180,000	(under construction)
Sodegaura (ESSO)	131,000	
Negishi (Tokyo Gas)	30,000	
Kawasaki (Mitsui)	36,000	
" (General)	36,000	
" (Kyodo)	40,000	
" (Nihon Oil)	64,000	
Total	753,000	

Nagoya Area (Chukyo Area)

Hekinan (Shell)	78,000	(under construction)
Chita (Idemitsu)	180,000	
Total	258,000	

Osaka Area (Ken-Hanshin Area)

Osaka (Mitsui)	24,000	
Kakegawa (Kobe Steel)	60,000	
Sakai (Mitsui)	80,000	
" (Nihon Oil)	152,000	
" (Maruzen)	53,000	
	30,000	(under construction)
" (General)	90,000	
	25,000	(under construction)
" (Iwatani)	80,000	(under construction)
Wakayama (Sumitomo Metal)	48,000	
Kobe (Mitsubishi)	60,000	
Total	702,000	

Others	716,000
Grand Total	2,429,000

ATTACH.15

TABLE-10 L G IMPORT TERMINAL CAPACITY BY COMPANY

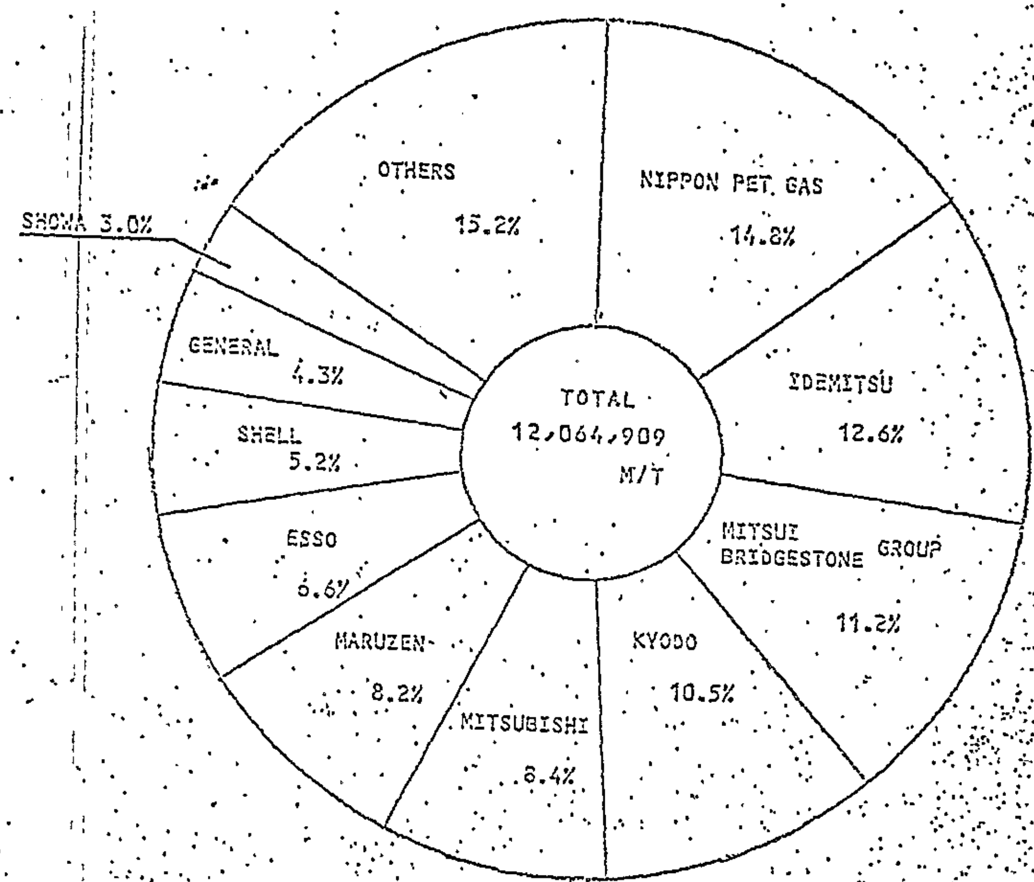
	T	
Mitsui Group	388,000	
	12,000	(under construction)
Mitsui/Mobil	100,000	(" ")
Idemitsu	240,000	
	80,000	(under construction)
Idemitsu etc.	32,000	(" ")
Nohon Pet Gas	216,000	
Mitsubishi	165,000	
Kyodo	147,000	
ESSO	131,000	
General	126,000	
	25,000	(under construction)
Tokyo Electric Power Co.	118,000	
	74,000	(under construction)
Nikko Liq. Gas	94,000	
Kobe Steel	60,000	
Maruzen	53,000	
	30,000	(under construction)
Tokyo Gas	52,000	
Sumitomo Metal	48,000	
Iwatani	80,000	(under construction)
Shell	78,000	(" ")
Total	2,429,000	

ATTACH.16

(UNIT: 1,000 M/T)

COMPANY	1972	1973	1974	1975	1976	1977
NIPPON PET GAS	1,031	1,178	1,416	1,612	1,790	1,783
IDEMITSU	1,193	1,209	1,219	1,214	1,345	1,521
MITSUI BRIDGESTONE GROUP	1,298	1,437	1,326	1,174	1,157	1,348
KYODO	815	999	1,092	1,092	1,317	1,273
MITSUBISHI	767	775	793	832	912	1,012
MARUZEN	740	761	788	921	975	986
ESSO	761	851	814	783	712	794
SHELL	360	422	463	561	602	631
GENERAL	422	400	422	488	490	523
SHOWA	205	205	200	250	303	365
OTHERS	1,794	1,940	1,978	1,642	1,851	1,829
TOTAL	9,385	10,177	10,511	10,769	11,454	12,065

FIG.6 SHARE OF LPG SALES IN JAPAN
(AS OF 1977)



ATTACH.17

	C_3					C_4				
	(1)	(2)	(3)	(4)	(5)	(1')	(2')	(3')	(4')	(5')
	Gas From Pipeline	(1)x379÷10^3	(2)x90%*3	(3)÷379x44.094*2	(4)÷2.2	Gas From Pipeline	(1')x379÷10^3	(2')x98%	(3')÷379x58.12*2	(4')÷2.2
	Lb-Mol/H	10^3scf/H	10^3scf/H	10^3Lb/H	T/H	Lb-Mol/H	10^3scf/H	10^3scf/H	10^3Lb/H	T/H
1981	595.7	225.8	203.2	23.6	10.7	239.3	90.7	88.9	13.6	6.2
1982	993.4	376.5	338.9	39.4	17.9	404.9	153.5	150.4	23.1	10.5
1983	1,191.6	451.6	406.4	47.3	21.5	484.8	183.5	179.8	27.6	12.5
1984	1,655.7	627.5	564.8	65.7	29.9	674.8	255.7	250.6	38.4	12.9
1985	1,655.7	627.5	564.8	65.7	29.9	674.8	255.7	250.6	38.4	12.9
1986	1,920.6	727.9	655.1	76.2	34.6	785.0	297.5	291.6	44.7	20.3
1987	1,920.6	727.9	655.1	76.2	34.6	785.0	297.5	291.6	44.7	20.3
1988	2,186.2	828.6	745.7	86.8	39.5	895.4	339.4	332.6	51.0	23.2
1989	2,186.2	828.6	745.7	86.8	39.5	895.4	339.4	332.6	51.0	23.2
1990	2,186.2	828.6	745.7	86.8	39.5	895.4	339.4	332.6	51.0	23.2

Note: *1 Fluor's report

*2 Molecular Weight

*3 Yield of C_3 and C_4 recovery

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Specification	Adjusting	Molecular Weight	(2) x (3)	(4) x 0.4536*1	(2) x 379*2	(6)x0.0267*3		(4) x (8)	(9) ÷ (6)x10^6
	Mol %	Mol %	lb	lb	Kg	scf	NM^3	BTU/lb (Gross)	MM BTU	BTU/scf (Gross)
C_3 LPG	C_2 2.0 Max.	1.8	30.068	54.12	24.55	682.2	18.2	22,300	1.21	
	C_3 96.0 Min	96.0	44.094	4,233.02	1,920.10	36,384.0	971.4	21,650	91.64	
	C_4 2.5 Max.	2.2	58.120	127.86	58.00	833.8	22.3	21,265*4	2.72	
Total		100.0		4,415.00	2,002.65	37,900.0	1,011.9		95.57	2,522
C_4 LPG	C_4 95.0 Min.	98.0	58.120	5,695.76	2,583.60	37,142.0	991.7	21,265*4	121.12	
	C_5 2.0 Max.	2.0	72.146	144.29	65.45	758.0	20.2	21,020*5	3.03	
Total		100.0		5,840.05	2,649.05	37,900.0	1,011.9		151.15	3,988

Note: data from TABLE-14-1 and-2 (ATTACH.20-1 and-2).

*1 1 lb = 2.2046

*2 1 lb mal = 379 ft^3

*3 1 scf = $0.0283 \times \frac{460}{460+(60-32)} = 0.0267$

*4 Butanes (21,290 + 21,240) ÷ 2 = 21,265

*5 Pentanes (21,070 + 21,030 + 20,960) ÷ 3 = 21,020

TABLE-13-1 MATERIAL AND HEAT BALANCE OF C_3 AND C_4 LPG (FROM NATURAL GAS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Specification Mol %	Adjusting Mol %	Molecular Weight lb	(2) x (3) lb	(4) x 0.4536*1 Kg	(2) x 379*2 scf	(6)x0.0267*3 NM^3	BTU/lb (Gross)	(4) x (8) MM BTU	(9) ÷ (6)x10^6 BTU/scf (Gross)
C_3 LPG	C_2 2.0 Max.	1.8	30.068	54.12	24.55	682.2	18.2	22,300	1.21	
	C_3 96.0 Min	96.0	44.094	4,233.02	1,920.10	36,384.0	971.4	21,650	91.64	
	C_4 2.5 Max.	2.2	58.120	127.86	58.00	833.8	22.3	21,265*4	2.72	
	Total	100.0		4,415.00	2,002.65	37,900.0	1,011.9		95.57	2,522
C_4 LPG	C_4 95.0 Min.	98.0	58.120	5,695.76	2,583.60	37,142.0	991.7	21,265*4	121.12	
	C_5 2.0 Max.	2.0	72.146	144.29	65.45	758.0	20.2	21,020*5	3.03	
	Total	100.0		5,840.05	2,649.05	37,900.0	1,011.9		151.15	3,988

Note: data from TABLE-14-1 and-2 (ATTACH.20-1 and-2).

*1 1 lb = 2.2046

*2 1 lb mal = 379 ft^3

*3 1 scf = $0.0283 \times \frac{460}{460+(60-32)}$ = 0.0267

*4 Butanes (21,290 + 21,240) ÷ 2 = 21,265

*5 Pentanes (21,070 + 21,030 + 20,960) ÷ 3 = 21,020

TABLE-13-2 MATERIAL AND HEAT BALANCE OF C_3 AND C_4 LPG (FROM NATURAL GAS)

(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
BTU/lb (Net)	(4) x (11) MMBTU	(12)÷(6)x10^9 BTU/scf (Net)	(9)÷(4) BTU/lb (Gross)	(12)÷(4) BTU/lb (Net)	(14)x0.5556*8 Kcal/Kg (Gross)	(15)x0.5556*8 Kcal/Kg (Net)	(16)x0.5083*9 Kcal/lit (Gross)	(17)x0.1746*9 Kcal/lit (Net)
C_2 20,420	1.11							
C_3 19,930	84.36							
C_4 19,640*6	2.51							
Total	87.98	2.321	21,647	19,928	12,027	11,072	6,113	6,362
C_4 19,640*6	111.86							
C_5 19,429*7	2.80							
Total	114.66	3,025	25,882	19,634	14,308	10,909	7,309	5,545

Note: *6 Butanes (19,670 + 19,610) = 19,640 BTU/Lb. *7 Pentanes (19,500 + 19,450 + 19,330) ÷ 3 = 19,427 BTU/Lb

*8 1 BTU/Lb = 0.5556 Kcal/Kg

*9 Specific Gravity

Ethylene 0.374

Propane 0.508

C_2 24.55 x 0.374 = 9.182

C_3 1,920.10 x 0.508 = 975.441

C_4 58.00 x 0.5735 = 33.263

2,002.65 mean 0.5083

Butanes 0.584

0.563

0.5735

C_4 2,583.60 x 0.5735 = 1,481.695

C_5 65.45 x 0.6177 = 40.428

2,649.05 mean 0.5746

Pentanes 0.631

0.625

0.577

0.6177

TABLE-14-1 PHYSICAL CONSTANTS OF HYDROCARBONS

	FORMULA	MOLEC. WT.	BOILING POINT °F	MELTING POINT °F	DENSITY			CRITICAL CONSTANTS			HEAT OF COMBUSTION @ 60°F—BTU/lb	
					°API	Sp Gr 60°/60°	Lb/gal	t °F	P Atm	D G/ml	Gross	Net
NORMAL PARAFFINS												
Methane	CH_4	16.0	−258.9	−296.5	340	0.30	2.50	−116.3	45.8	0.162	23,860*	21,500*
Ethane	C_2H_6	30.1	−128.0	−297.8	247	.374	3.11	+ 90.1	48.2	.203	22,300*	20,420*
Propane	C_3H_8	44.1	− 43.8	−305.7	147	.508	4.23	206.3	42.0	.226	21,650*	19,930*
Butane	C_4H_{10}	58.1	+ 31.1	−216.9	111	.584	4.86	306	37.4	.225	21,290*	19,670*
Pentane	C_5H_{12}	72.1	96.9	−201.5	92.7	.631	5.25	386.5	32.0	.232	21,070*	19,500*
Hexane	C_6H_{14}	86.2	155.7	−139.5	81.6	.664	5.53	455.0	29.4	.234	20,760	19,240
Heptane	C_7H_{16}	100.2	209.2	−131.1	74.2	.688	5.73	512.5	26.8	.234	20,670	19,160
Octane	C_8H_{18}	114.2	258.2	− 70.3	68.6	.707	5.89	565	24.6	.233	20,590	19,100
Nonane	C_9H_{20}	128.2	303.4	− 64.5	64.5	.722	6.01	612*	23*	—	20,530	19,050
Decane	$C_{10}H_{22}$	142.3	345.2	− 21.5	61.3	.734	6.11	651*	22*	—	20,480	19,020
Undecane	$C_{11}H_{24}$	156.3	384.4	− 14.1	58.7	.744	6.19	695*	20*	—	20,450	19,000
Dodecane	$C_{12}H_{26}$	170.3	421.3	+ 14.7	56.4	.753	6.27	731*	18*	—	20,420	18,960
ISO-PARAFFINS												
Isobutane	C_4H_{10}	58.1	10.9	−255.0	120	.563	4.69	275	36	.234	21,240*	19,610*
2-Methylbutane (Isopentane)	C_5H_{12}	72.1	82.2	−255.5	94.9	.625	5.20	369.5	32.4	.234	21,040*	19,450*
2,2-Dimethylpropane (Neopentane)	C_5H_{12}	72.1	49.0	+ 2.1	105	.597	4.97	329*	35*	—	20,960*	19,330*
2-Methylpentane (Isohexane)	C_6H_{14}	86.2	140.5	−245	83.5	.658	5.48	437*	31*	—	20,750	19,210
3-Methylpentane	C_6H_{14}	86.2	145.9	−180	80.0	.669	5.57	443*	30*	—	20,760	19,220
2,2-Dimethylbutane (Neohexane)	C_6H_{14}	86.2	121.5	−147.6	84.9	.654	5.44	415*	31*	—	20,700	19,160
2,3-Dimethylbutane (Diisopropyl)	C_6H_{14}	86.2	136.4	−198.8	81.0	.666	5.54	441	31	.241	20,740	19,200
2-Methylhexane (Isoheptane)	C_7H_{16}	100.2	194.1	−180.8	75.7	.683	5.68	496	28*	—	20,650	19,140
3-Methylhexane	C_7H_{16}	100.2	197.5	−182.9	73.0	.692	5.76	504	28.5*	—	20,660	19,150
3-Ethylpentane	C_7H_{16}	100.2	200.2	−181.5	69.8	.703	5.85	508*	28.5	—	20,670	19,160
2,2-Dimethylpentane	C_7H_{16}	100.2	174.0	−190.6	77.2	.678	5.64	475*	28.5	—	20,600	19,090
2,3-Dimethylpentane	C_7H_{16}	100.2	193.6	—	70.6	.700	5.83	498*	29	—	20,640	19,130
2,4-Dimethylpentane	C_7H_{16}	100.2	176.9	−183.1	77.2	.678	5.64	477	28.5*	—	20,620	19,110
3,3-Dimethylpentane	C_7H_{16}	100.2	186.9	−211.0	71.2	.698	5.81	467*	28*	—	20,620	19,110

TABLE-14-2 PHYSICAL CONSTANTS OF HYDROCARBONS

2,2,3-Trimethylbutane (Triptane)	C_7H_{16}	100.2	177.6	−13.0	72.1	0.695	5.78	480[c]	29.5	—	20,620	19,110
2-Methylheptane (Isoöctane)	C_8H_{18}	114.2	243.8	−165.1	70.1	.702	5.84	549[c]	26[b]	—	20,570	19,080
3-Ethylhexane	C_8H_{18}	114.2	245.4	—	65.6	718	5.98	551[c]	25[b]	—	20,570	19,080
2,5-Dimethylhexane (Diisobutyl)	C_8H_{18}	114.2	228.4	−130	71.2	.698	5.81	530	25	0.237	20,550	19,060
2,2,4-Trimethylpentane ("Isoöctane")	C_8H_{18}	114.2	210.6	−101.2	71.8	.696	5.79	515[c]	27[b]	—	20,540	19,050
OLEFINS												
Ethylene	C_2H_4	28.0	−154.7	−272.5	273	.35	2.91	50	51	.22	21,640[a]	20,290[a]
Propylene	C_3H_6	42.1	−53.9	−301.4	140	.522	4.35	196.5	45.4	.233	21,040[a]	19,690[a]
Butene-1	C_4H_8	56.1	20.7	—	104	.601	5.00	293[c]	39[b]	—	20,840[a]	19,490[a]
Cis-Butene-2	C_4H_8	56.1	38.6	−218.0	94.2	.627	5.22	316[c]	37[b]	—	20,780[a]	19,430[a]
Trans-Butene-2	C_4H_8	56.1	33.6	−157.7	100	.610	5.08	310[c]	37[b]	—	20,750[a]	19,400[a]
Isobutene	C_4H_8	56.1	19.6	−220.6	104	600	4.99	292.5	39.5	.234	20,720[a]	19,370[a]
Pentene-1 (Amylene)	C_5H_{10}	70.1	86.2	−216.4	87.2	.647	5.38	385[c]	36[b]	—	20,710[a]	19,360[a]
Cis-Pentene-2	C_5H_{10}	70.1	98.6	−290.2	82.6	661	5.50	396[c]	35[b]	—	20,660[a]	19,310[a]
Trans-Pentene-2	C_5H_{10}	70.1	96.8	−211.0	84.0	654	5.44	396[c]	35[b]	—	20,640[a]	19,290[a]
2-Methylbutene-1	C_5H_{10}	70.1	88.0	—	84.5	655	5.45	387[c]	36[b]	—	20,610[a]	19,260[a]
3-Methylbutene-1 (Isoamylene)	C_5H_{10}	70.1	68.4	−292.0	92.0	.633	5.27	363[c]	37[b]	—	20,660[a]	19,310[a]
2-Methylbutene-2	C_5H_{10}	70.1	101.2	−207.0	80.6	667	5.55	401[c]	35[b]	—	20,570[a]	19,220[a]
Hexene-1	C_6H_{12}	84.2	146.4	−218.0	77.2	678	5.64	463[c]	34[b]	—	20,450	19,100
Cis-Hexene-2	C_6H_{12}	84.2	155.4	−231.0	73.9	689	5.73	473[c]	34[b]	—	20,420	19,070
Trans-Hexene-2	C_6H_{12}	84.2	154.2	−207.0	75.7	683	5.68	472[c]	34[b]	—	20,400	19,050
Cis-Hexene-3	C_6H_{12}	84.2	153.7	−211.0	75.4	654	5.69	472[c]	34[b]	—	20,420	19,070
Trans-Hexene-3	C_6H_{12}	84.2	154.6	−171	76.0	682	5.68	473[c]	34[b]	—	20,400	19,050
DIOLEFINS												
Propadiene	C_3H_4	40.1	−30.1	−213.0	108	.595	4.95	249	70	—	20,880[a]	19,930[a]
Butadiene-1,2	C_4H_6	54.1	+50.5	—	83.5	.658	5.48	343[c]	—	—	—	—
Butadiene-1,3	C_4H_6	54.1	24.1	−164.0	94.2	.627	5.22	308	45	—	20,230[a]	19,180[a]
Pentadiene-1,2	C_5H_8	68.1	112.8	−85.0	71.5	.697	5.80	420[c]	—	—	—	—
Cis-Pentadiene-1,3	C_5H_8	68.1	111.0	—	71.8	.696	5.79	420[c]	—	—	20,150[a]	19,040[a]
Trans-Pentadiene-1,3	C_5H_8	68.1	108.1	—	70.0	.682	5.68	415[c]	—	—	20,150[a]	19,040[a]
Pentadiene-1,4	C_5H_8	68.1	78.9	−234.0	81.3	.665	5.53	350[c]	—	—	20,320[a]	19,210[a]
3-Methylbutadiene-1,2	C_5H_8	68.1	101	−184.0	82.9	.685	5.70	410[c]	—	—	—	—
2-Methylbutadiene-1,3 (Isoprene)	C_5H_8	68.1	93.3	−231.0	74.8	.680	5.71	395[c]	—	—	20,060[a]	18,950[a]

[a] Heat of combustion as a gas—otherwise as a liquid.
[b] Estimated.
[c] Critical temperature-boiling point correlation.
[d] Vapor pressure curve or correlation
[e] Mixture of cis- and trans isomers.
** Sublimes.

TABLE-15 C_3 AND C_4 LPG PRODUCTION (LB/H) OF EACH YEAR

	C_3 LPG				C_4 LPG			Total				
	C_2 10^3Lb/H	C_3 10^3Lb/H	C_4 10^3Lb/H	Total 10^3Lb/H	C_4 10^3Lb/H	C_5 10^3Lb/H	Total 10^3Lb/H	C_2 10^3Lb/H	C_3 10^3Lb/H	C_4 10^3Lb/H	C_5 10^3Lb/H	Total 10^3Lb/H
1981 *1 (Kg/H)	0.44	23.6 *1	0.54	24.58 *3 (11.17)	13.06 *2	0.27	13.33 *4 (6.06)	0.44	23.6	13.6	0.27	37.91 (17.23)
1982 (Kg/H)	0.74	39.4	0.90	41.04 (18.65)	22.20	0.45	22.65 (10.30)	0.74	39.4	23.1	0.45	63.69 (28.95)
1983 (Kg/H)	0.89	47.3	1.08	49.27 (22.40)	26.52	0.54	27.06 (12.30)	0.89	47.3	27.6	0.54	76.33 (34.70)
1984 (Kg/H)	1.23	65.7	1.51	68.44 (31.11)	36.89	0.75	37.64 (17.11)	1.23	65.7	38.4	0.75	106.08 (48.22)
1985 (Kg/H)	1.23	65.7	1.51	68.44 (31.11)	36.89	0.75	37.64 (17.11)	1.23	65.7	38.4	0.75	106.08 (48.22)
1986 (Kg/H)	1.43	76.2	1.75	79.38 (36.08)	42.95	0.88	43.83 (19.92)	1.43	76.2	44.7	0.88	123.21 (56.00)
1987 (Kg/H)	1.43	76.2	1.75	79.38 (36.08)	42.95	0.88	43.83 (19.92)	1.43	76.2	44.7	0.88	123.21 (56.00)
1988 (Kg/H)	1.63	86.8	1.99	90.42 (41.10)	49.01	1.00	50.01 (22.73)	1.63	86.8	51.0	1.00	140.43 (63.83)
1989 (Kg/H)	1.63	86.8	1.99	90.42 (41.10)	49.01	1.00	50.01 (22.73)	1.63	86.8	51.0	1.00	140.43 (63.83)
1990 (Kg/H)	1.63	86.8	1.99	90.42 (41.10)	49.01	1.00	50.01 (22.73)	1.63	86.8	51.0	1.00	140.83 (63.83)

Note: *1 come from TABLE-12 (4) (ATTACH.18)

*2 TABLE-12 (4') (ATTACH.18) minus C_4 in C_3 LPG of this Table
13.6 - 0.54 = 13.06

Calculation way

*3 C_3 LPG
23.6 Lb/H÷0.96

	%	Lb/H
C_2	1.8	0.44
C_3	96.0	23.60
C_4	2.2	0.54
	100.0	24.58

*4 C_4 LPG
13.06 Lb/H÷0.98

	%	Lb/H
C_4	98	13.06
C_5	2	0.27
	100	13.33

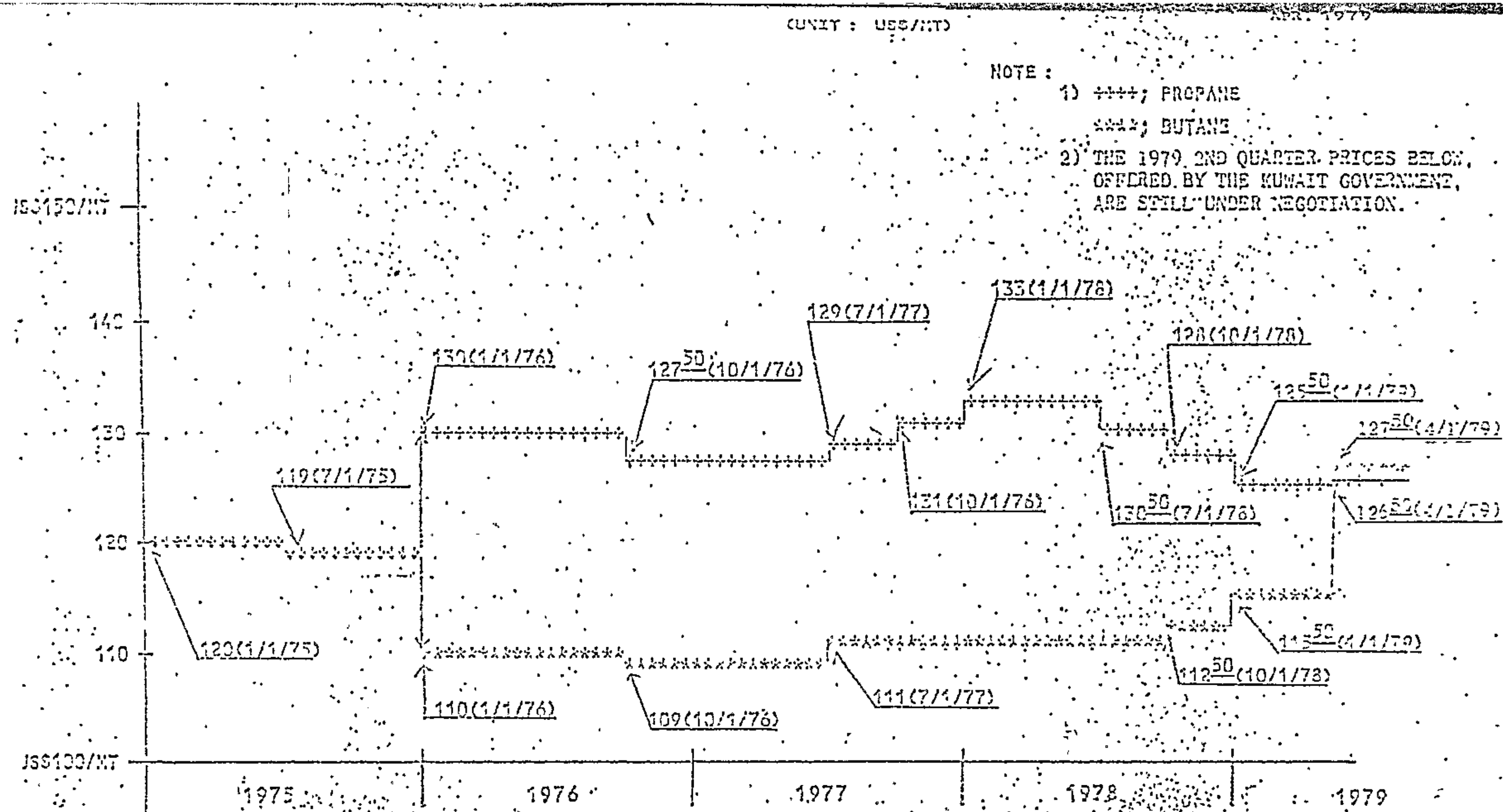
TABLE-16 C_3 AND C_4 LPG (T/H, T/D, T/Y) PRODUCTION OF EACH YEAR

	C_3 LPG			C_4 LPG			Total			REMARK NATURAL GAS PRODUCTION MM scf/D
	T/H*	T/D	10^3T/Y	T/H*	T/D	10^3T/Y	T/H*	T/D	10^3T/Y	
1981	11.17	268.08	97.85	6.06	145.44	53.08	17.23	413.52	150.93	150
1982	18.65	447.6	163.39	10.30	247.20	90.23	28.95	694.80	253.60	300
1983	22.40	537.6	196.22	12.30	[illegible]	107.75	34.70	883.80	303.97	350
1984	31.11	746.64	272.52	17.11	410.64	149.88	48.22	1,157.28	422.40	500
1985	31.11	746.64	272.52	17.11	410.64	149.88	48.22	1,157.28	422.40	500
1986	36.08	865.92	316.06	19.92	478.08	174.50	56.00	1,344.00	490.56	600
1987	36.08	865.92	316.06	19.92	478.08	174.50	56.00	1,344.00	490.56	600
1988	41.10	986.40	360.04	22.73	545.52	199.11	63.83	1,531.92	559.15	700
1989	41.10	986.40	360.04	22.73	545.52	199.11	63.83	1,531.92	559.15	700
1990	41.10	986.40	360.04	22.73	545.52	199.11	63.83	1,531.92	559.15	700

Note: * from TABLE-15 (ATTACH.21)

APR. 1979

ATTACH. 25



(MARKET PRICE, ARABIAN LIGHT, PER BBL)

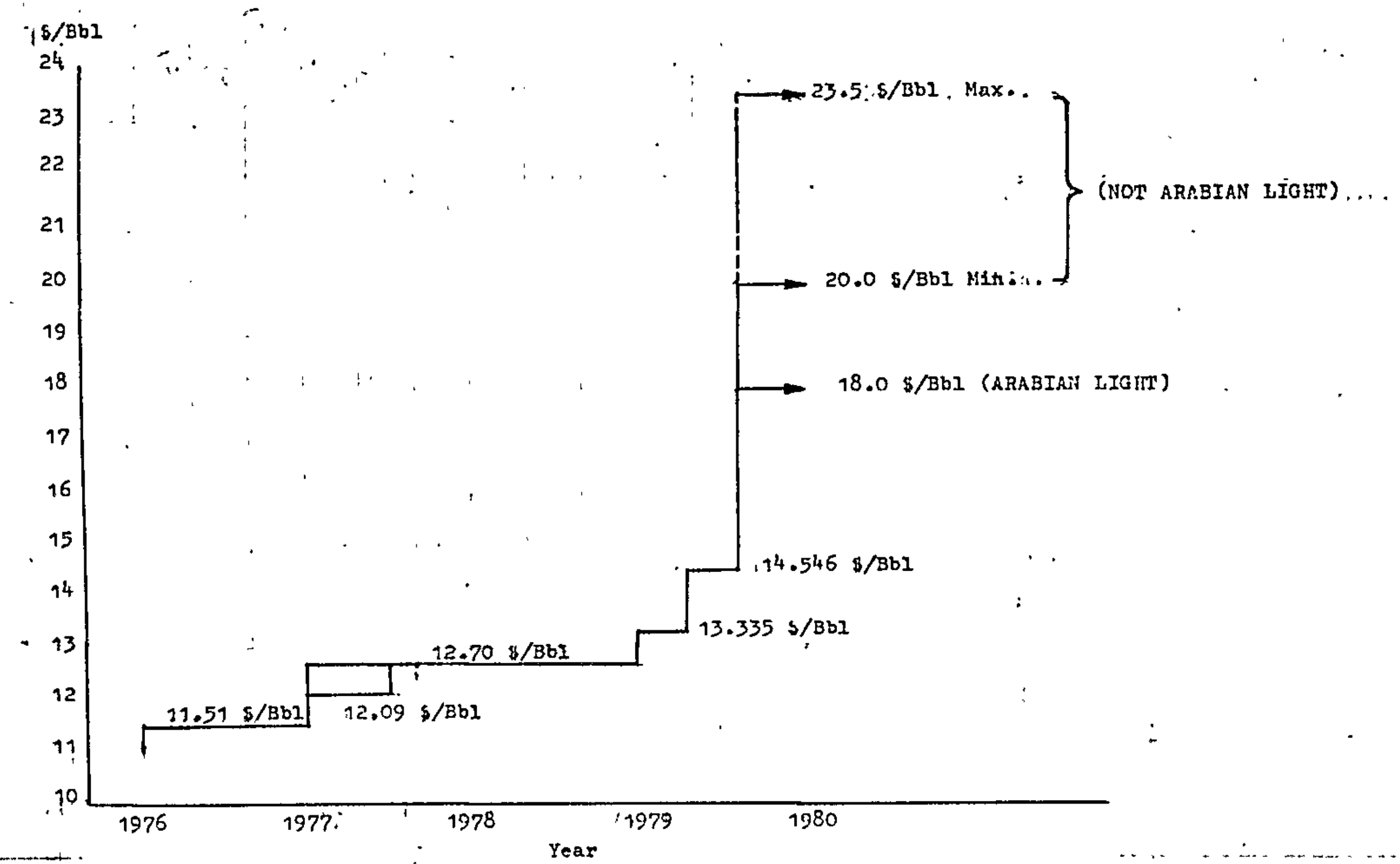


TABLE-17 AVERAGE VALUE OF C_3 AND C_4 LPG

	C_3 LPG		C_4 LPG		C_3 and C_4 LPG	C_3 and C_4 LPG	C_3 and C_4 LPG	C_3 LPG:% on Total
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	C_3 LPG [*1] 10^3 T/Y	(1)x160 \$/T 10^3 \$/Y [*2]	C_4 LPG [*1] 10^3 T/Y	(3)x180 \$/T 10^3 \$/Y [*2]	(2) + (4) 10^3 \$/Y	(1) + (3) 10^3 T/Y	(5) ÷ (6) 10^3 \$/T	(1) ÷ (6) %
1981	97.85	15,656	53.06	9,551	25,207	150.91	167.1	64.8
1982	163.37	26,139	90.23	16,241	42,380	253.60	167.1	64.4
1983	196.22	31,395	107.75	19,395	50,790	303.97	167.1	64.5
1984	272.52	43,603	149.88	26,978	70,581	422.41	167.1	64.5
1985	272.52	43,603	149.88	26,978	70,581	422.40	167.1	64.5
1986	316.06	50,570	174.50	31,410	81,980	490.56	167.1	64.4
1987	316.06	50,570	174.50	31,410	81,980	490.56	167.1	64.4
1988	360.04	57,664	199.11	35,840	93,504	559.15	167.2	64.4
1989	360.04	57,664	199.11	35,840	93,504	559.15	167.2	64.4
1990	360.04	57,664	199.11	35,840	93,504	559.15	167.2	64.4
							Average 167.1	64.5

Note: *1 are come from TABLE-16 (ATTACH.22).

*2 C_3 LPG 160 \$/T, C_4 LPG 180 \$/T

	(1)	(2)	(3)	(4)	(5)	(6)
	C_3LPG 10^3 lb/H[*1]	(1)x24 10^3 lb/D	(2)x3.65[*2] 10^6 lb/Y	(3)x21,647[*3] BTU/lb Gross 10^6 BTU/H	(2)x21,647 BTU/lb Gross 10^6 BTU/D	(3)x21,647 BTU/lb 10^6 BTU/Y
1981	24.58	589.92	215.32	532.08	12,770.00	4,661.03
1982	41.04	984.96	359.51	888.39	21,321.43	7,782.31
1983	49.27	1,182.48	431.61	1,066.55	25,597.14	9,343.06
1984	68.44	1,642.56	599.53	1,481,52	35,556.50	12,978.03
1985	68.44	1,642.56	599.53	1,481.52	35,556.50	12,978.03
1986	79.38	1,905.12	695.37	1,718.34	41,240.13	15,052.67
1987	79.38	1,905.12	695.37	1,718.34	41,240.13	15,052.67
1988	90.42	2,170.08	792.08	1,957.32	46,975.72	17,146.16
1989	90.42	2,170.08	792.08	1,957.32	46,975.72	17,146.16
1990	90.42	2,170.08	792.08	1,957.32	46,975.72	17,146.16

Note: *1 come from TABLE-15 (ATTACH.21).

*2 LPG production can not be changed because heating value of sales natural gas should be maintained constant.

*3 come from TABLE-13-2 (14) (ATTACH.19-2).

	(1)	(2)	(3)	(4)	(5)	(6)
		(1) x 24 H	(2) x 365 *2	(1) x 25,882 *3 BTU/Lb Gross	(2) x 25,882 BTU/Lb Gross	(3) x 25,882 BTU/Lb Gross
	10^3Lb/H *1	10^3Lb/D	10^6Lb/Y	10^6BTU/H	10^6BTU/D	10^9BTU/Y
1981	13.33	319.92	116.77	345.01	8,280.17	3,022.24
1982	22.65	543.60	198.41	586.83	14,069.46	5,115.25
1983	27.06	649.44	237.05	700.37	16,808.81	6,135.33
1984	37.64	903.36	329.73	974.20	23,380.76	8,534.07
1985	37.64	903.36	329.73	974.20	23,380.76	8,534.07
1986	43.83	1,051.92	383.95	1,134.41	27,225.79	9,937.39
1987	43.83	1,051.92	383.95	1,134.41	27,225.79	9,937.39
1988	50.01	1,200.24	438.09	1,294.36	31,064.61	11,338.65
1989	50.01	1,200.24	438.09	1,294.36	31,064.61	11,338.65
1990	50.01	1,200.24	438.09	1,294.36	31,064.61	11,338.65

Note: *1 come from TABLE-15 (ATTACH.21).

*2 LPG production can not be changed because heating value of sales natural gas should be maintained constant.

*3 come from TABLE-13-2 (14)(ATTACH.19-2)

TABLE-20 AVERAGE C_3 AND C_4 LPG HEATING VALUE

	(1)	(2)	(3)	(4)	(5)
	C_3 LPG Gross 10^9BTU/Y	C_4 LPG Gross 10^9BTU/Y	C_3+C_4 LPG Gross 10^9BTU/Y	C_3+ C_4 LPG Production 10^3 T/Y	(3) ÷ (4) Gross 10^6BTU/T
1981	4,661.03	3,022.24	7,682.27	150.93	50.91
1982	7,782.31	5,115.06	12,897.37	253.60	50.86
1983	9,343.06	6,135.33	15,478.39	303.97	50.92
1984	12,978.03	8,534.07	21,512.10	422.40	50.92
1985	12,978.03	8,534.07	21,512.10	422.40	50.92
1986	15,052.67	9,937,39	24,990.06	490.56	50.94
1987	15,052.67	9,937.39	24,990.06	490.56	50.94
1988	17,146.16	11,338.65	28,484.81	559.15	50.94
1989	17,146.16	11,338.65	28,484.81	559.15	50.94
1990	17,146.16	11,338.65	28,484.81	559.15	50.94

Note: (1) TABLE-18 (6) (ATTACH.26)

(2) TABLE-19 (6) (ATTACH.27)

(4) TABLE-16 (ATTACH.22)

TABLE-21 COST SUMMATION

Production 385,010 T/Y

			$/T
Charge Natural Gas	50.92 MMBTU/T	1.5 $/$10^6$BTU	76.38
Operation Cost	(Investment 93.253 MM$ - 385,090 T = 242,158 $/T)		
Depreciation	5% on Investment		11.61
Interest for Investment	5% on Investment		11.61
Tax and Insurance	2% on Investment		4.65
Maintenance	3% on Investment		6.97
Administration	2% on Investment		4.65
Over-head	2% on Investment		4.65
Interest of Working Capital			1.68
Sub-Total			45.82
Utility			40.82
Labor Cost	15x4 = 60 persons 200 $/mon x 60 persons x 12 mon ÷ 385,090 T/Y		0.34
Sub-Total			86.98
	Minus 15% for dew point control		73.93
Total			150.31
	plus 3% for selling charge		154.82

OUTLET (INCOME)

C_3 and C_4 LPG		167.1

FIG.9 PROFIT OR LOSS VS. NATURAL GAS PRICE FOR C_3 AND C_4 LPG