NATURAL GAS UTILIZATION AND PETROLEUM REFINING IN THAILAND

No. 3

FROM AUG 1977 TO AUG 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

I N D E X

A

August 20, 1979.

Mr. Pravit Ruyabhorn,
Secretary-General,
National Energy Administration.

Dear Mr. Pravit,

As promised, attached please find all the reports and conclusion covering two years of my service as an adviser to the National Energy Administration.

I would like to express my sincere thank, especially to your staffs and all concerns who provided me necessary data and informations which made my reports possible in time.

I will leave Bangkok on August 23, 1979. However, if you need any informations regarding the above, please do not hesitate to write or telex to me as following address :

Y. KAWASE
UNICO INTERNATIONAL CORP.
KONISHI BLDG. (7TH FLOOR)
2-2, 2-CHOME, HON-CHO, NIHONBASHI,
CHUO-KU, TOKYO, JAPAN

TEL : (03) 661-7733
CABLE : ADD. "CONSULT UNICO"
TELEX NO : 0252-2107
ANSWER BACK CODE : "INTO J"

Thank you very much again for your good co-operation.
I remain,

Sincerely yours,

Y. Kawase

Encl. 1. List of Report
2. List of Memorandum
3. CONCLUSION

cc: Mr. Athorn
Mr. Tammachart
Dr. Itti

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(02)	CONSUMPTION OF NATURAL GAS AND ELECTRICITY FOR MAJOR INDUSTRY PROJECT PART I . FERTILIZER PART II CHEMICAL	November 21, 1977
(03)	FEASIBLE STUDY OF AMMONIA	December 19,1977
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(3)	SECURE NATURAL GAS FOR 40 YEARS	September 18, 1978
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(5)	PETROLEUM PRODUCTS DEMAND FORECAST No.2 LPG RECOVER FOR NATURAL GAS	October 18, 1978
(6)	PETROLEUM PRODUCTS DEMAND FORECAST No.3 PETROLEUM PRODUCTS DEMAND FORECAST AND NEW REFINERY CAPACITY	October 25, 1978

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CONCLUSION

I FOREWORD

I.1 1ST ONE YEAR (AUGUST 24, 1977 - AUGUST 23, 1978)

During the 1st one year, I was adviser of Technical Division.

I reported (1) the review of SOFREGAZ interim and final report (2) new project of ammonia, soda ash, integrated flat steel, and (3) natural gas demand and forecast of the industry.

In this stage, natural gas production, price and others were unknown. So, these reports must be reviced. Some of them I reviced in the 2nd on year.

II.2 2ND ONE YEAR (AUGUST 24, 1978 - AUGUST 23, 1979)

During the 2nd one year, I was adviser of the Regulatory Division.

I would like to explain the conclusion of the 2nd one year to you, of course, the renort of the 1st one year is related the report of the 2nd one year.

II PETROLEUM PRODUCT DEMAND INCLUDING NATURAL GAS

Crude oil throughput is always changed when energy source is changed. For the time being, natural gas production from Siam Gulf is changed, crude oil throughput should be changed.

In future, Thai energy source should be changed; not only crude oil and natural gas but as following energy

(1) Atomic Energy

(2) Coal (lignite)

(3) Oil Shale

(4) Solar Energy

(5) Others

I presented two reports of crude throughput in case of 500 MMscf/D natural gas production and 700 MMscf/D natural gas production.

III CONCLUSION

III.1 PETROLEUM REFINING AND NATURAL GAS

The petroleum refining pattern is entirely different after natural gas production.

Petroleum and natural gas flow is shown in FIG.1.

III.1.1 Refinery

1. Refining Capacity in 1983

The expansion and new refinery will be completed in 1983 at earliest.

Existing Capacity	184,000 BPSD (Nominal 165,000 BPSD)	
Minimum Capacity	369,000 BPSD	
Excess Capacity*	50,000 BPSD	The year of 1983
Necessity Capacity	419,000 BPSD	

Note: Excess capacity must be needed for petroleum products demand increase of 2.5 years.

The expansion and new refinery capacity is as follows:

Expansion and New (Minimum)	185,000 BPSD	
Excess	50,000 BPSD	
Total	235,000 BPSD	- 1.4 times for nominal capacity 1.3 times for existing capacity

Of course, fuel oil is substitueed by natural gas, so fuel oil which is equivalent of natural gas on calorific value should be grade up to lighter fractions, for this purpose many cracking units should be installed.

2. Optimum Refinery

During my vacation, I asked for the computor calculation of the optimum refinery to some Japanese refining company and Unico without fee. The companies calculated by computor for 5 cases, actually more than 100 cases must be needed. So, I could not get conclusion of the optimum refinery.

The best way from 5 cases calculation for the expansion and new refinery are as follows :

(1) Residues of existing 3 refineries must be gathered and cracked.

(2) Diesel oil must be imported. (Note: Diesel oil import is very difficult).

(3) Cracking units must be necessary, but gasoline fraction is over production.

3. Crude Evaluation

I presented some company's crude evaluation which was calculated by computor.

Conclusion of crude evaluation is as follow :

a. Lighter crude and high gasoline yield crude are profitable instead of high price.

b. Low sulfur crude is profitable instead of high price.

As you know the crude in all over the world is getting heavier, and production of low sulfur crude is very difficult to get it.

CRUDE EVALUATION IS NEEDED TO CARRY AS FOLLOWING CASES :

(1) Refining company wants to buy new crude.

(2) Revamping, expansion and new refinery

- 1st

  Available crudes must be selected.

- 2nd

  Optimum refinery must be calculated for available crudes, and same time crude evaluation can be carried.

Crude evaluation can not carried before units selection, and ev·luation of unavailable crude is no meaning.

3. Construction Cost and Financing

Construction cost/barrie /day of big size is less than small size.

For Example:

	50,000 BPSD (MM $)	115,000 BPSD	150,000 BPSD
Construction Cost*	260.9	461.6	554.6
$/B/D	5,218	4,014	3,679
Rate	1	0.77	0.71

Note: * including off-site

Thus, small expansion and new refinery are big loss of money, but when one company installs big refinery, financing is very difficult.

Three refining companies are planning to revamp and expand for existing refineries. If the revamping is possible, installation cost may be cheap. In any event, comparison of case 1 three refineries expansion and expansion (no new refinery), case 2 combination of three refineries expansion and new refinery, and case 3 only new refinery, should be carried by computor calculation.

In Japan, it is said that the most profitable capacity is 300,000 BPSD and minimum size is 150,000 BPSD capacity.

4. Thai Petroleum Requirement Pattern

The refinery pattern after natural gas production is so-called abnomal, but it is very similar to W. Germany and France (see FIG.1). Refinery which is high yield of diesel oil is called DIESEL OIL REFINERY.

5. Bottle Neck

I surveyed the bottle neck of SUMMIT Bangchak Refinery. 3 refining companies already revamped, so I suspended a study of bottle neck of 3 refineries.

6. Tank Capacity

Thailand should be installed tanks before the expansion and new refinery completion may be the year of 1983, because he should import petroleum products before the year of 1983 about same quantity of domestic production in 1983.

Tank capacity must be needed 90 days storage for domestic refining and import petroleum products.

Existing tank capacity for 3 refineries is not satisfactory.

	1977	1978	1979	1980	1981	1982
(1) Existing Tank Capacity 10^3Kl	2,639	2,639	2,639	2,639	2,639	2,639
(2) Crude Thruput 10^3Kl/D	29.3	29.3	29.3	29.3	29.3	29.3
(3) Storage Days *1 For refinery	90	90	90	90	90	90
(4) Demand 10^3Kl/D	33.7	36.5	43.2	48.1	50.0	53.4
(5) Storage Days *2 For Demand	78.3	72.3	61.1	54.9	52.8	49.9
(6) Running Capacity Days *3	39.3	36.2	30.6	27.5	26.4	24.7

Note: *1 Storage days for refinery (crude throughput)
(1) - (2) = days (3)

*2 Storage days for demand (1) - (4) = days (5)

*3 Storage days for running capacity (5) x ½

In 1982	necessity of tank capacity	$4,806 \times 10^3$Kl
At present	tank capacity	$2,639 \times 10^3$Kl
New	tank capacity (newly install)	$2,167 \times 10^3$Kl

If tanks are not sufficient, petroleum products can not be imported.

III.1.2 Natural Gas

Natural gas production will be commenced in October, 1981.

When Bang Pakong Power Station will be completed, natural gas requirement for the power station will be 382 MMscf/D. 700 MMscf/D natural gas production is not enough to supply it to the existing industry. So, at first, natural gas should be supplied to EGAT and new products. If natural gas production will be over than 700 MMscf/D, then NGOT will supply natural gas to existing industry. At that time, NGOT should be guarantee a quantity of natural gas, and supplying term.

Natural gas supplying to existing industry need much money such as natural gas pipeline laying, boiler modification, but no merit.

Bang Pakong Power Station is not good location, it is better to move to very close to refinery, and aslo good place for coal firing.

At present, Thai Government is planning the new project of flat steel and soda ash project. In future, when natural gas production will be increased, he must study petrochemical, such as ammonia (fertilizer), and C_2, C_3 C_4 and C_5 delivertibes. And if natural gas will be enough more than 700 MMscf/D. The new project should be expanded.

III.1.3 LPG Production

LPG from refineries are supposed to enough for domestic requirement after the completion of the expansion and new refinery.

So, LPG from natural gas will be exported to get foreign currency, but LPG FOB price must be higher than fuel oil 1,200" on calorific value.

	C_3 LPG	C_4 LPG
Current FOB Price	160 $/T	180 $/T
Expected FOB Price	more than 192 $/T	more than 216 $/T

Note: * C_3 LPG 192 $/T, C_4 LPG 216 $/T are costs of Thai LPG from natural gas, and costs of them are equivalent to fuel oil 1,200" on calorific value.

The current FOB price is very low, but LPG FOB price is going up rapidly, in near future LPG FOB price will be up to feasible price because of worldwide LPG market tight.

Therefore, NGOT should be watch a movement of LPG price.

Japan is very good LPG market for Thailand.

Thai LPG production from natural gas (from pipeline)

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

Japanese LPG Domestic Production and Import

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

The natural gas processing unit must be moved to near sea-shore for LPG export and LPG delivery by ship.

Decrease of natural gas production according to LPG production increase is 18.20 MMscf/D in 1981, 46.42 MMscf/D in 1985 and 36.97 MMscf/D in 1990. The decrease of natural gas supply is nearly equal to natural gas for the existing industry, therefore, NGOT can not

supply natural gas to the existing industry.

III.3 ENERGY CONSERVATION

I presented 2 reports for energy conservation. I requested to send materials of energy conservation to Japan and I got many of them, but I have no time to report to you.

Energy conservation in the refinery is as follows :

(1)	Air fuel ratio	O_2 meter for flue gas necessary.
(2)	Insulation	Change to thick insulator former insulator price is higher than curde oil.
(3)	Heatexchanger	Change or rearrange, former heatexchanger price is higher than crude oil
(4)	Reflux and stripping Steam	Reduce
(5)	Waste pressure and heat	Recover
(6)	Vapor loss from storage corn roof tank	Recover

Some refining company's energy conservation target is 20%.

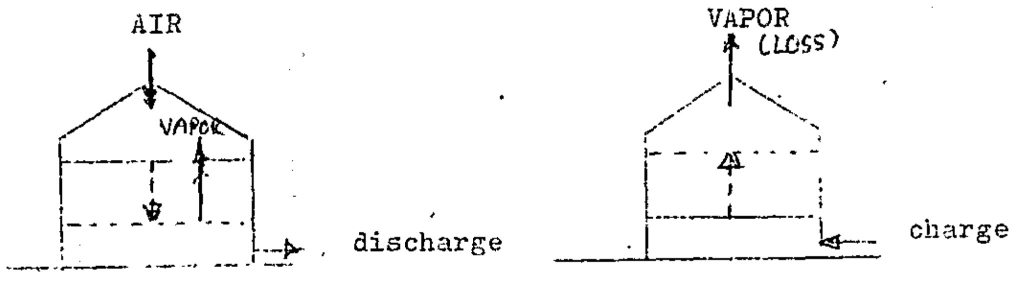
About energy saving in the refinery, my calculation is as follows:

(1)	Renewal of used lube oil	0.37% on crude
(2)	Flare gas	0.03% on crude
(3)	Vapor loss	0.31% on crude

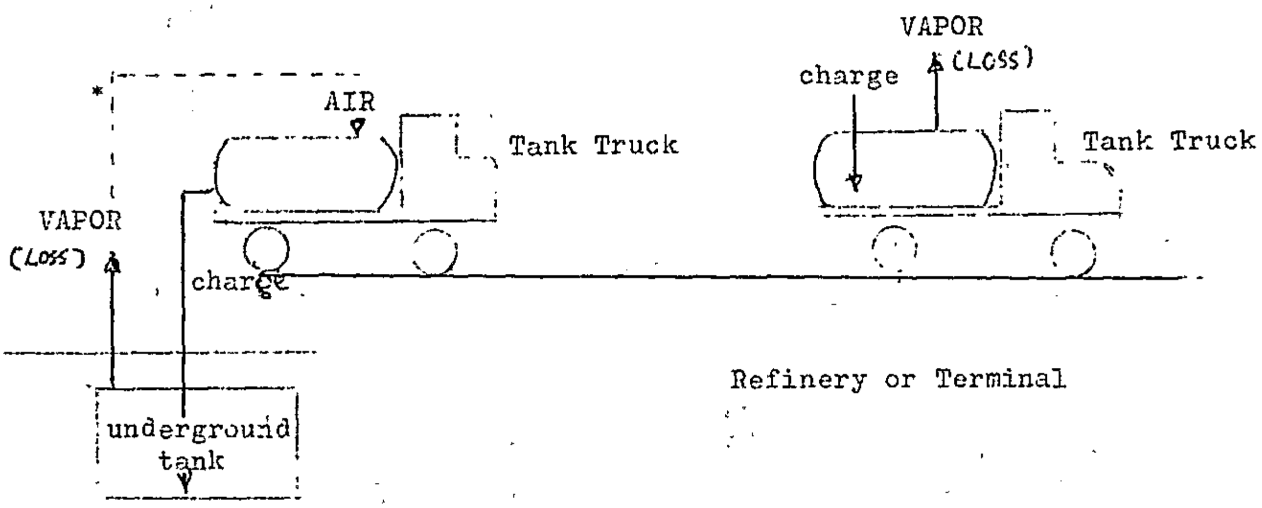
Vapor loss is very big, so in USA, Japan and other countries have recovered gasoline vapor.

In refinery	crude oil and gasoline tank (cone roof tank), and tank truck and car.

In terminal (depot)	Gasoline tank and tank truck
In gasoline service station	Underground tank and tank truck



Cone Roof Tank (Crude oil and gasoline tank)

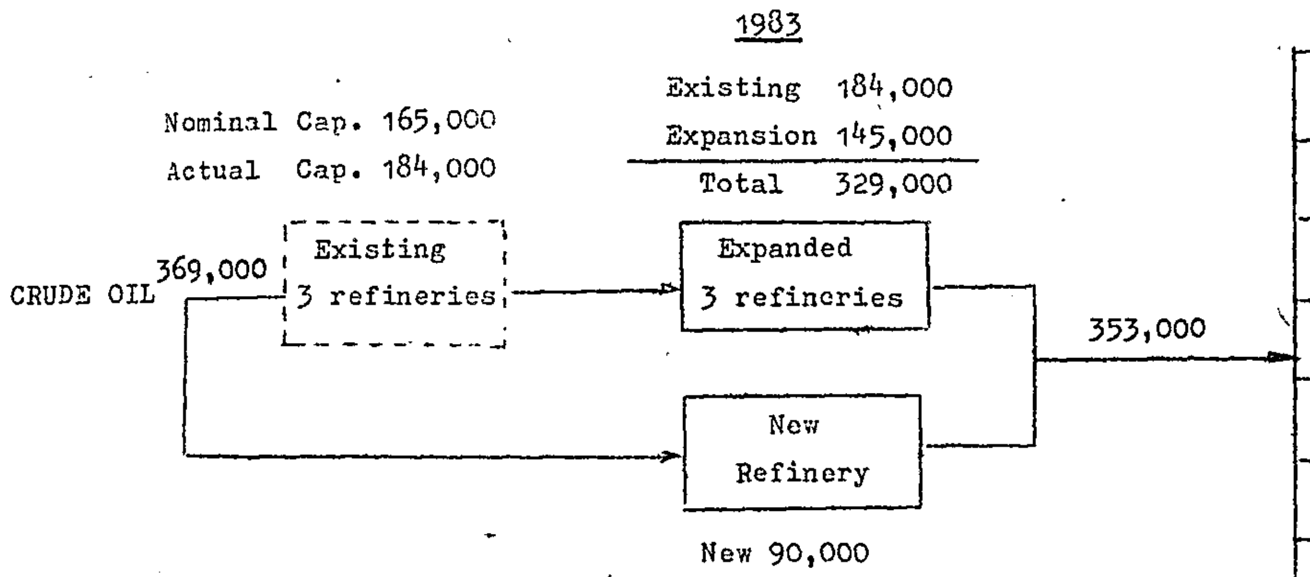


Gasoline Service Station

Note: * Tank is connected underground tank and gasoline vapor loss is prevented.

FIG.1 CRUDE FLOW

Note: No mark is BPSD



	1983	1978
LPG	2.4 %	2.1 %
BENZINE	21.5 %	19.1 %
JET FUEL	7.5 %	6.6 %
KEROSENE	2.8 %	2.5 %
DIESEL OIL	36.1 %	31.9 %
FUEL OIL	21.6 %	30.6 %
OTHERS	3.8 %	2.4 %
LOSS & OWN FUEL	4.3 %	4.8 %

CRUDE THRUPUT (IN 1983)

	Existing	Expansion	Expanded (Total)
SUMMIT	63,000	45,000	108,000
TORC	74,500	65,000	139,000
ESSO	46,500	35,000	81,500
	184,000	145,000	329,000
NEW	-	Newly 90,000	Newly 90,000
	184,000	235,000	419,000

Expansion and New Refinery

Minimum Cap.	369,000
Extra	50,000
	419,000

PETROLEUM PRODUCTION % OF MAIN COUNTRIES AS OF 1976

	Japan	USA	W.Germany	France
BENZINE	11.1 %	44.4 %	15.6 %	15.6 %
NAPHTHA	10.7	4.0	2.5	5.1
JET FUEL	1.4	6.5	1.4	3.1
KEROSENE	9.8	1.2	nil	0.1
DIESEL OIL	15.5	22.1	41.0	25.8
FUEL OIL	45.3	13.0	24.1	32.5
OTHERS	6.1	8.4	13.4	7.5

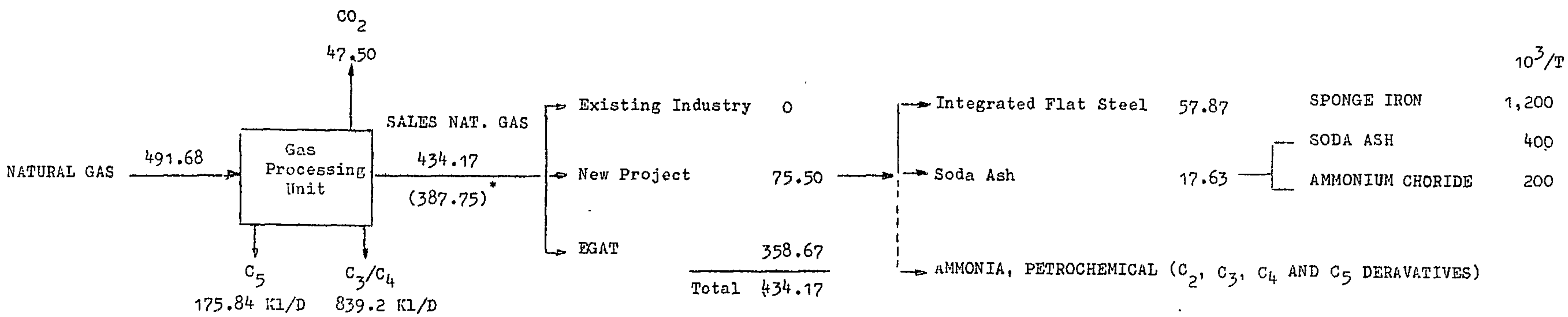
TABLE-1 FUEL OIL BALANCE

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	N.G. Prod. Sched.	Fuel Oil N.G. Equi.		(2)÷(1)	Total Product	(2)÷(4)	Fuel Oil	
							(Incl. N.G.)	(Excl.N.G.)
	MMscf/D	10^3Kl/y	10^3Kl/y	%	10^3Kl/y	%	% on crude	% on crude
1981	150	5,726	1,189	20.8	16,723	7.1	32.6	25.8
1982	300	6,413	2,141	33.4	17,960	11.9	34.2	22.8
1983	350	6,699	2,529	37.8	18,489	13.7	34.7	21.6
1984	500	6,913	3,578	51.8	18,155	19.7	36.4	17.6
1985	500	7,549	3,527	46.7	20,251	17.4	35.7	19.0
1986	600	8,256	4,106	49.7	21,896	18.8	36.1	18.1
1987	600	8,958	4,038	45.1	24,174	16.7	35.5	19.5
1988	700	9,592	4,634	48.1	25,576	18.1	35.9	18.5
1989	700	10,199	4,577	44.9	27,546	16.6	35.4	19.5
1990	700	10,818	4,506	41.7	29,566	15.2	35.0	20.4

FIG.2 NATURAL GAS FLOW

Note: No mark is MMscf/D

1985



Note: * Natural gas volume when LPG is produced from 100% natural gas from well head.

(1) Bang Pakong Power Station's natural gas requirement 382 MMscf/D. So, NGOT can not supply natural gas to the existing industry.

(2)

Thai LPG Production	in 1983	304 x 10^3T
	in 1988	559 x 10^3T
Japanese LPG	in 1983	5,917 x 10^3T
	in 1988	11,589 x 10^3T
		17,506 x 10^3T

Japan is good LPG market for Thailand.

TABLE-2 NATURAL GAS BALANCE (NO EXISTING INDUSTRY)

	FLUOR REPORT			100% LPG Prod.		Sales N.G. FLUOR REPORT			100% LPG Production		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	N.G. Prud. Sched.	LPG Prod.	Sales N.G.	LPG Prod.	Sales N.G.	Consumption New Proj.	Consumption EGAT	Total	(5)-(6) For EGAT	Bang Pakong Requirement	Total
	MMscf/D	10^3T	MMscf/D	10^3T	MMscf/D	MMscf/D	MMscf/D	(6)+(7)=(3)	MMscf/D	MMscf/D	(6)+(9) =(15)
1981	150	48.94	134.16	150.93	115.96	-	134.16	Same as (3)	115.96	110	Same as (5)
1982	300	74.56	267.01	253.60	235.10	-	267.01		235.10	110	
1983	350	102.28	309.05	303.97	273.05	-	309.05		273.05	246	
1984	500	130.95	444.94	422.40	392.92	17.63	427.21		375.29	382	
1985	500	162.35	434.17	422.40	389.75	75.50	358.67		314.25	382	
1986	600	195.73	512.88	490.56	460.24	75.50	437.38		384.74	382	
1987	600	232.01	499.57	490.56	453.41	75.50	424.07		377.91	382	
1988	700	270.13	578.43	559.15	526.82	75.50	502.93		451.32	382	
1989	700	310.20	562.32	559.15	517.87	75.50	486.82		442.37	382	
1990	700	352.07	546.35	559.15	509.38	104.44	441.91		404.94	382	

Note: Sales natural gas is not enough for Bang Pakong Power Station, so LPG production must be controlled.

ATTACH. 28 R-21

April 30, 1979.

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

Dear Mr. Tammachart,

Re: PETROLEUM PRODUCT DEMAND FORECAST
NO.4 - REVISION OF NO.2 AND NO.3 REPORT

Previous report of PETROLEUM PRODUCT DEMAND FORECAST was in case of 500 MM scf/D maximum natrual gas production schedule, afterwards National Gas Organization of Thailand changed the natural gas production schedule from 500 MM scf/D to 700 MM scf/D. Therefore, petroleum product demand forecast is recalculated because fuel oil production in the refinery is changed.

The calculation and consideration way are very similar to my experience when I was used to work for Koa Oil Co. (joint venture with Caltex) and Kyokuto Oil Co. (joint venture with Mobile). NEA must establish own procedure of calculation and consideration of expansion and/or new refinery.

When the expansion and/or new refinery is studied and planned, the petroleum products demand is foundation of study, planning and basic engineering. Therefore, bases of petroleum product demand are changed, it must be recalculated.

1. LPG production from refinery might be exceeded LPG demand, so LPG from natural gas must be exported.

2. Condensate from well head and natural gas process plant must be export as petrochemical raw material. Because light naphtha might be exceeded the requirement from refineries, accordingato this reason, refineries must have much cracking units. But, the decision should be made after computor calculation.

3. Lube oil should be manufactured in near future, because lube oil p oduction makes much profit as well as it contributes to Thai economy.

4. Crude oil selection and crude oil import are very difficult after the oil crisis.

Petroleum stockpiling is necessary and crude oil import source must be enlarged.

5. Petroleum Products import and export must be consider after marketing research.

6. The minimum and desirable capacity of total refineries, and additional capacity are as follows:

	Total Minimum Capacity BPSD	Additional Capacity BPSD	Total Desirable Capacity BPSD	Remark
1977	184,000	-		Actual crude through-put in 1977
1982	ditto	-		
1983	369,000 (184,000+185,000)	+50,000 (185,000+50,000)	419,000	New installation 235,000 BPSD
1984	362,000			
1985	404,000			
		+100,000	519,000	
1986	437,000			
1987	482,000			
1988	510,000	+125,000	644,000	
1989	550,000			
1990	590,000			
		+150,000	794,000	
1991	644,000			
1992	699,000			
1993	757,000			
		+150,000	944,000	
1994	820,000	⋮	⋮	
⋮	⋮			
1999	1,177,000	⋮	⋮	
		+150,000	1,394,000	
2000	1,257,000			

Note: The minimum capacity is same as products demand plus loss and own fuel.

Total Japanese crude oil through-put was about 6,000,000 BPSD in 1977.

89	toppers	average	66,000 BPSD
49	refineries	average	121,000 BPSD
	biggest		330,000 BPSD

If the expansion and/or new refinery is completed in 1983, newly installation should be 235,000 BPSD, total capacity is 419,000 BPSD.

Recalculation data are one of the input data of computor calculation.

I appreciated if it would be useful for you.

Sincerely yours,

Y. Kawase

CONTENTS

FIGURE AND TABLE LIST

NO.4 PETROLEUM PRODUCTS DEMAND FORECAST

I FOREWORD

I reported PETROLEUM PRODUCTS DEMAND FORECAST NO.1 NATURAL GAS on September 30, 1978, NO.2 LPG RECOVERY FROM NATURAL GAS on October 18, 1978, NO.3 PETROLEUM PRODUCTS DEMAND FORECAST AND NEW REFINERY CAPACITY on October 25, 1978.

These calculations were based on 500 MM scf/D maximum natural gas production schedule, afterwards Natural Gas Organization of Thailand disclosed on 700 MM scf/D maximum natural gas production schedule. Therefore, I revice previous No.1, No.2 and No.3 report.

My recalculation of the report is used the petroleum demand forecast which was made by Regulatory Division of NEA as same as previous report, and natural gas supply schedule is used Fluor Ocean Services International Inc.'s report which was presented to NGOT.

I recalculated the minimum and desirable refinery capacities from 1981 to 2000, according to the above mentioned change.

In 1977, actual crude oil through-put was 184,000 BPSD. When the existing refineries is expanded or revamped and the grass roots refinery will be installed in 1983, total crude oil through-put will be minimum 369,000 BPSD and additional crude oil through-put will be 185,000 BPSD (actual crude oil through-put of existing refineries is 184,000 BPSD). It is just twice of present crude oil through-put. Crude oil through-put in 2000 will be 1,257,000 BPSD.

Total refinery capacity must be always bigger than minimum crude oil through-put which is same as products demand plus loss and own fuel. Desirable refinery capacity must be bigger than minimum refinery capacity, because petroleum products import is more difficult then crude oil import and foreign currency is lost and a niew point of national security.

The recalculation is based on the under conditions.

1. Petroleum product forecast was made by Regulatory Division of NEA in 1978.

2. Natural gas production schedule is NGOT's schedule and used data are Fluor Ocean Services International's report which was presented to NGOT.

3. The capacity of expansion and/or new refinery is based on 1977's result of three refineries. When 1978's result of three refineries crude oil through-put is summerized, re-calculation should be necessary again.

4. The expansion and/or new refinery is concerned no petroleum products import and export.

5. The expansion and/or new refinery is assumed to be completed in 1983.

   So, the recalculation of refinery capacity is from 1983 to 2000.

6. LPG production is assumed same as its demand.

   Deficit of LPG in 1981 and 1982 will be covered by LPG from natural gas.

   After 1983, whole LPG demand will be produced in refineries. Therefore,,LPG from natural gas should be exported.

7. Lube oil production is assumed to be manufactured from 1983.

   If a start-up of lube oil production is delayed, the crude oil through-put must be minused about 2%.

8. Loss and own fuel in assumed as 3.8% or 4% on crude oil through-put.

   This should be recalculated after decision of units of expansion and/or new refinery.

When the above mentioned bases and assumptions are changed, recalculation should be carried. Because data of petroleum demand forecast are foundamental of study, planning and basic engineering for the expansion and/or new refinery.

II HEAT VALUE AND FULE OIL EQUIVALENT OF SALES NATURAL GAS

Heat value and fuel oil equivalent of sales natural gas are calculated from Fluor's report. In Fluor's report, the Gas Processing

Plant is installed and it provides a source of high quality sales gas with low CO_2 content, provides LPG and provides pentanes plus heavier hydrocarbons.

Fluor said pentanes plus heavier hydrocarbons make an excellent gasoline precursor, but lighter gasoline (light naphtha) fractions are excess because expansion and new refinery should have much cracking units. So, the fraction from natural gas must be exported as petrochemical raw material or used as own fuel.

The PROCESS PLANT BLOCK FLOW DIAGRAM is shown in Figure on the next page.

In Fluor's report, heating value is shown as high heating valve (HHV), so low heating valve (LHV) is calculated, then fuel equivalent is calculated. The calculations are shown in TABLE 1 - 10 (ATTACH. 1 - 10).

III LPG PRODUCTION

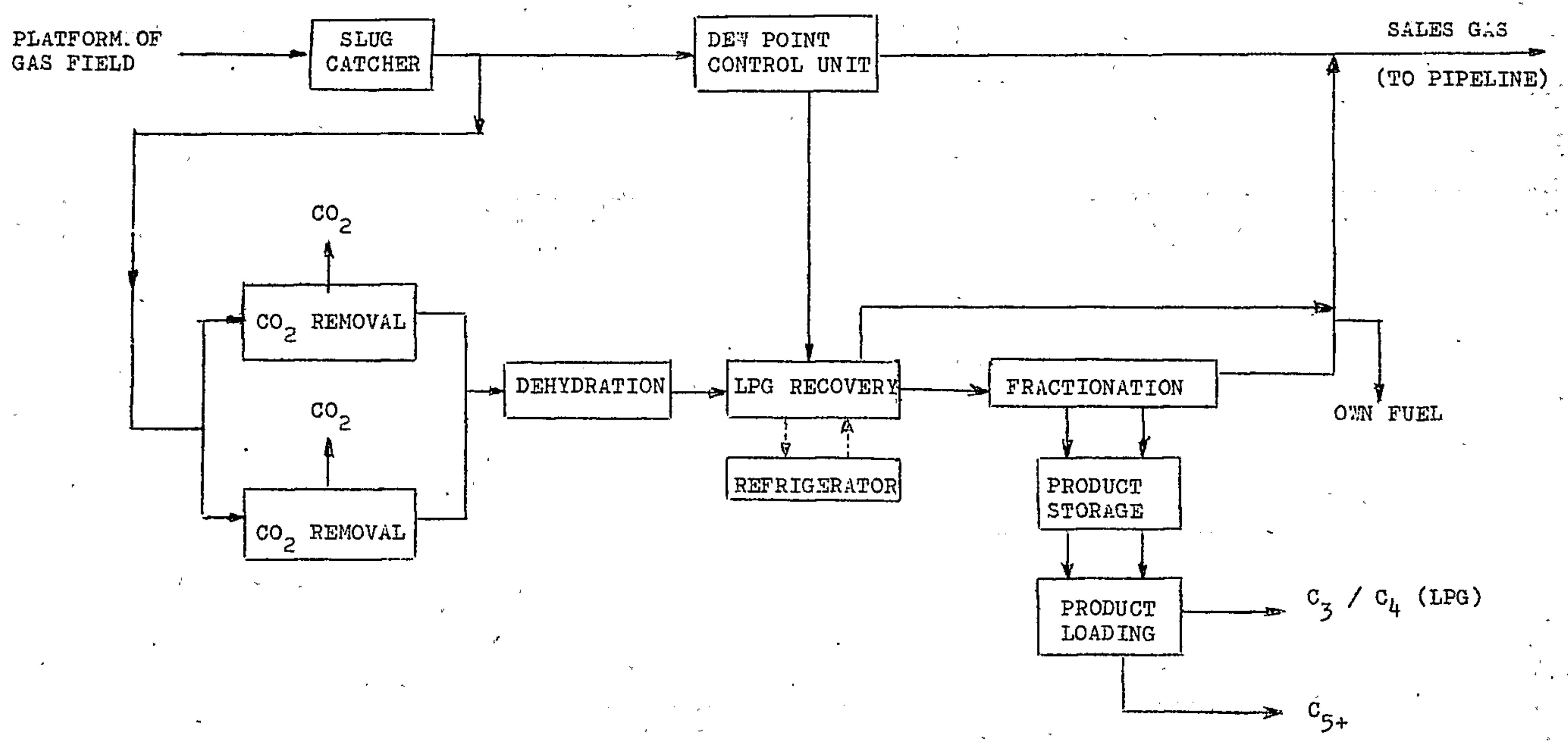
In Fluor's report, LPG production is shown as LB-Moles/Hr, LBS/HR, and GMP, so Kl/y is calculated, and TABLE 11 -20 (ATTACH. 11 - 20) shows LPG production in Kl/y.

When the minimum crude oil through-put is recalculated, LPG production is assumed as same as its demand.

LPG production of the expansion and new refinery can not estimate because new installed units are not decided. So, the above mentioned LPG production is assumed.

If plants of the expansion and new refinery are same as existing refineries, LPG production can be assumed as upper table of page 5. Actually LPG production from refineries is bigger than the demand of LPG which is shown in the table, after the expansion and/or new refinery will be completed. Accordingly, LPG from natural gas will not be needed except 1981 and 1982 for domestic use, thus LPG from natural gas should be exported.

PROCESS PLANT BLOCK DIAGRAM



LPG PRODUCTION (ASSUMED) AND DEMAND

	Production (assumed) 10^3Kl/y		Demand 10^3Kl/y	
1977	240	Actual		
78	240	Actual	294	Deficit of LPG will be imported.
79	240	Actual	317	Deficit of LPG will be imported.
80	240	Actual	356	Deficit of LPG will be imported.
1881	240	Actual	396	Deficit of LPG will be make up from LPG from natural gas.
82	240	Actual	444	Deficit of LPG will be make up from LPG from natural gas.
83	481*		464	Actual production will be more than the demand because cracking plants will be more than at present.
84	472		479	
85	527		523	
:	:		:	
2000	1,640		1,483	

Note: * $240 \times 10^3 Kl/y \times \frac{369,000}{184,000} = 481$

LPG production of 1983 ~ 2000 is assumed.

When LPG from natural gas is exported, LPG production schedule must be changed, namely LPG is produced from whole natural gas instead of some part of natural gas.

LPG PRODUCTION FROM WHOLE NATURAL GAS

	(1) N.G. Production MMscf/D	(2) Fluor's LPG Production Schedule 10^3Kl/y	(3) N.G. Product 10^3LBS/Hr	(4) Gas Plant Feed 10^3LBS/Hr	(5) $(2)\times\frac{(3)}{(4)}$ 10^3Kl/y	(6) (5)x 0.53* 10^3t/y	(7) (6)÷365 t/D
1981	150	92	365	107	314	166	455
82	300	141	826	227	513	272	745
83	350	193	954	299	616	326	893
84	500	247	1,376	400	850	451	1,236
85	500	306	1,376	500	842	446	1,222
86	600	369	1,669	637	967	513	1,405
87	600	438	1,669	757	966	512	1,403
88	700	509	1,963	914	1,093	579	1,586
89	700	585	1,963	1,051	1,093	579	1,586
1990	ditto	664	1,963	1,194	1,092	ditto	ditto
2000	:	:	:	:	:	:	:

Note: (1) is EGAT schedule.

(2), (3), (4) are from TABLE 11 - 20 (ATTACH.11 -20), and from Fluor's report.

* is average specific gravity of LPG.

IV SCHEDULE OF EXPANSION AND NEW REFINERY PLANNING

When the existing refineries are expanded or revamped and new refinery is installed, generally follwoing procedure should be carried.

Products demand is very important to decision of capacity of the expansion and new refinery, so when products demand and natural gas production is changed, petroleum products demand should be recalculated.

IV.1 Products Demand

IV.1.1 Products From Natural Gas

At first, petroleum products which is not considering natural gas products, demand must be made. Then following items must be considered.

(a)	LPG	LPG production from natural gas.
(b)	Gasoline	Condensate from well head and natural gas pressing plant.
(c)	Fuel Oil	Sales gas which is fuel oil equivalent.

For (a), LPG production from refineries will be exceeded LPG demand as the above mentioned III. So, LPG production from natural gas is not considered in the recalculation, LPG from natural gas must be exported.

(b) Condensates of natural gas is light gasoline (light naphtha), it would be excess because the expansion and new refinery must have cracking units. So, condensates from natural gas is not considered in the recalculation, condensates must be exported.

(c) Fuel oil of demand must be excluded fuel oil equivalent of natual gas. (see TABLE 21 and 22, ATTACH. 21 and 22)

Natural gas production schedule is as follows.

NATURAL GAS PRODUCTION SCHEDULE

	MMscf/D		MMscf/D
1981	150	1986	600
1982	300	1987	700
1983	350	1988	700
1984	500	⋮	⋮
1985	500	⋮	⋮
		2000	

IV.1.2 Lube Oil Production

Lube oil is added in the petroleum products demand as shown on TABLE 21 and 22, (ATTACH.21 and 22), a lube oil production is about 2% on crude oil through-put. The reason of lube oil including in products demand, TORC has had lube oil production plan. Lube oil production makes much profit as well as its contribute to Thai economy.

Lube oil production capacity is as follows in 1983.

369,000 BPSD x 0.017 = 6,237 BPSD Lube oil demand in 1983.

Note: 0.017 means lube oil demand is 1.7% on crude oil through-put in 1983.

6,273 BPSD ÷ 0.65 = 9,651 BPSD Lube oil material in 1983

Note: Lube oil yield % on lube oil material is 65%.

10,000 BPSD lube oil plant is economical size. Lube oil production would be commenced in 1983, the minimum lube oil capacity is as follows.

LUBE OIL MINIMUM CAPACITY IN THAILAND

Year	Lube Oil Minimum Capacity BPSD	
1983	9,651	Desirable lube oil capacity is 15,000 BPSD
84	11,138	
85	13,674	
86	14,791	
87	15,572	Desirable lube oil capacity is 20,000 BPSD (install 5,000 BPSD more)
88	17,262	
89	17,769	
1990	19,062	

If lube oil production is postponed for several years, crude oil through-put which is shown in TABLE 21 and 22 (ATTACH. 21 and 22) must be minus 2% for the same years.

IV.1.3 Loss and Own Fuel

Loss and own fuel percentage of TABLE 21 and 22 (ATTACH. 21 and 22) is different, TABLE 21 is calculated 4.5% and TABLE 22 is 3.8% on crude oil through-put, but these are not including diesel oil for big electric power generator in the refinery, but including small electric power generator for emergency. At this stage loss and own fuel can not be calculated exactly, but approximately estimation of them is needed for calculation of refinery capacity.

IV.1.4 Petroleum Products Production Pattern

Thai Petroleum products production pattern seems unusual after natural gas utilization. But, it is not unusual, petroleum products production of main countries are shown.

PETROLEUM PRODUCTS PRODUCTION OF
MAIN COUNTRIES AS 1976

UNIT : 1,000t,( )is %

	Japan	USA	UK	West Germany	France	Thailand (1985) 10^3 Kl
Motor Gasoline	12,019 (11.1)	299,832 (44.4)	15,232 (16.9)	17,346 (15.6)	18,187 (15.6)	4,692 (22.1)
Naphtha	21,248 (10.7)	27,185 (4.0)	4,538 (5.1)	2,490 (2.5)	5,822 (5.1)	-- --
Aviation Fuel	2,777 (1.4)	44,005 (6.5)	4,402 (4.9)	1,350 (1.4)	3,549 (3.1)	1,637 (7.7)
Kerosene	19,615 (9.8)	7,879 (1.2)	2,458 (2.7)	49 (-)	120 (0.1)	612 (2.9)
Diesel Oil	30,952 (15.5)	149,255 (22.1)	24,198 (26.8)	40,473 (41.0)	40,954 (35.8)	7,851 (37.1)
Fuel Oil	90,371 (45.3)	87,948 (13.0)	32,695 (36.2)	23,783 (24.1)	37,123 (32.5)	4,022 (19.0)
Others	12,255 (6.1)	60,037 (8.4)	6,716 (7.4)	13,195 (13.4)	8,547 (7.5)	2,348 (11.2)
Total	199,237 (100)	676,138 (100)	90,284 (100)	98,686 (100)	114,302 (100)	21,162 (100)

As above mentioned table, Thai petroleum products production is very similar with West Germany, fuel oil of USA production is less than Thai and diesel oil production of France is similar to Thai.

IV.2 Crude Oil

Crude oil selection is restricted after the oil crisis, especially after Iranian revolution.

When the expansion and/or new refinery is installed in 1983, crude oil import is being very difficult, because crude oil import is jumped up from 184,000 BPSD to 369,000 BPSD, it is about twice. If such big quantity of crude oil is not able to import, petroleum products should import, but its import is more difficult than crude oil import, therefore Thailand must be produced petroleum products by domestic refinery, a view point of national security. Every country produces petroleum products in his own refineries.

Petroleum stockpiling is very important, main countries' stockpiling is as follows.

PETROLEUM STOCKPILING OF EACH COUNTRIE

	Days		
Japan	85	(April, 1979)	(90 days the end of 1979)
UK	89	(April, 1977)	
Sweden	79	"	
Belgium	115	"	
France	101	"	
W. Germany	105	"	
Italy	112	"	
Switzerland	128	"	

Every country endeavor to enlarge crude oil import source.

Comparison of crude oil source between Thailand and Japan is shown in Table.

(1) Japan has more import sources than Thailand.

(2) Thailand is depended more on Middle East than Japan.

(3) Japan desires to import Red Chinese crude oil, but he can not more import, because he has not enough cracking unit for treating it. It is said that crude oil reserves of Gulf of Pohai (Chili) is as same as Saudi Arabia.

Recently, Japanese Government approaches with Petroleos Maxicanoe to import his crude oil, and his crude oil reserves is 40.2×10^9 Bbl (including natural gas) this of Saudi Arabia is 150×10^9 Bbl in 1977.

CRUDE OIL IMPORT SOURCE OF THAILAND AND JAPAN

	Thailand (10^3 Kl)		Japan (10^3 Kl)	
	1977		1976	
	Quantity	%	Quantity	%
Middle East				
Saudi Arabia	4,568	47.15	86,536	31.4
Kuwait	95	0.98	17,618	6.4
Neutral Zone	668	6.90	11,374	4.1
Qatar	2,815	29.05	494	10.2
UEA	411	4.24	31,741	11.5
Oman	-	-	9,458	3.4
Iran	-	-	53,832	19.5
Iraq	190	1.96	8,344	3.0
Others	53	0.55	-	-
Sub Total	8,255	90.83	219,397	79.5
ASIA PACIFIC				
Bruni & Malaysia	719	7.42	12,571	4.5
Indonesia	-	-	33,494	12.1
Australia	-	-	133	0.1
Sub Total	719	7.42	46,198	16.7
Communist Country				
Taching	170	1.75	7,268	2.6
USSR	-	-	93	0.1
America (USA, Brazil, Venezuela)	-	-	333	0.1
Africa	-	-	2,537	1.0
Total	9,689	100	75,826	100

Big different of Thailand is that Japan has many exploitation companies.

Conclusion of crude oil is as follows.

(1) It is very difficult to selection of crude oil.

(2) It is very difficult to get more crude oil when the expansion and/or new refinery will be completed.

(3) Crude oil import source must be enlarged.

(4) For calculation of optimum refinery, crude oil is selected among available crudes and at least two of lighter and heavier crude oil are selected for design. But special heavy crude such as Red China and Infonesia crude oil are ordinary distillated separate topper.

IV.3 Petroleum Products Import and Export

IV.3.1 Import

When import price of petroleum products is cheaper than domestic refined petroleum products, petroleum products can be import. In this case, petroleum products will be imported by long range contract. Recently, Middle East countries and Singapore are under construction or planning of export refinery. So in future, it is easy to import petroleum products. But, in principle rule whole petroleum products must be produced by own refineries, according to national security.

If export refinery is shut-down, petroleum products can not be imported from others.

Import market must be surveyed.

IV.3.2 Export

Thai petroleum demand is inclined to light fraction, so, Thai refinery has to have much cracking unit. Accordingly gasoline fraction yield is going up, thus condensates from well head and natural gas processing plant, and some part of virgin naphtha might be exported as petrochemical raw material. Japan is importing much naphtha as under tabel.

Thai can export naphtha to Japan, but fuel oil is very difficult to export. Export market must be surveyed.

IMPORT AND EXPORT IN JAPAN IN 1977

UNIT : 10^3 Kl

	Import	Export
Gasoline	-	-
Naphtha	8,528 (24.4%)[*2] (34,928)[*1]	-
Jet Fuel	-	1,496
Kerosene	5	150
Diesel Oil	-	176
A Fuel	1,379	887
B Fuel	-	54
C Fuel	7,781	9,276
Total A,B,C Fuel	9,160 (7.8%)[*2] (117,880)[*1]	10,217
Total	17,693	12,039

Note: *1 Consumption of naphtha and fuel oil
*2 % on each (naphtha and fuel oil) consumption

V MINIMUM CAPACITY OF EXPANSION AND NEW REFINERY

At first, the demand, loss and own fuel for each year must be estimated for decision of the minimum refinery capacity. The minimum refinery capacity muct be decided by the following 3 items.

(1) Petroleum product demand
(see IV.1)

(2) Possibility crude oil import
(see IV.2)

(3) Petroleum products import and export
(see IV.3)

Initial stage, condensates and petroleum import and export can not be in consideration. These matters are studied by consultant.

Accordingly, the minimum refinery capacity of each year might be as well petroleum product demand and plus loss and own fuel.

VI DESIRABLE CAPACITY OF EXPANSION AND NEW REFINERY

When the expansion and new refinery is constructed, the refinery capacity should be bigger than the minimum capacity. The products demand is going up every year, so 1 - 3 years after completion of expansion and/or new refinery of 50,000 - 150,000 BPSD capacity must be installed. But, when additional refinery capacity is installed with cracking unit, small cracking is not economical, so desirable additional capacity would be 100,000 - 150,000 BPSD.

TABLE 23 (ATTACH. 23) shows an example of construction schedule from 1983 to 2000, it is made from FIG. 1 (ATTACH. 24). CASE-1 of TABLE 23 is the minimum size of additional refinery and CASE-2 of it is the maximum (desirable) size of additional refinery, but total additional must be same. New No.1 - No.3 refinery may be possible the second refinery of existing oil refinery.

FIG.1 (ATTACH.24) and FIG.2 (ATTACH.25) show 2 cases, CASE-1 shows 50,000 BPSD – 75,000 BPSD minimum size of additions, and CASE-2 shows 100,000 ~ 150,000 BPSD desirable size of additions. In practice, additional capacities will be between CASE-1 and CASE-2, but total of additions must be equal.

Summarized desirable additional capacity is shown in table of page 14. FIG.1 and 2, and the table are depend on TABLE 21 (ATTACH.).

When additional capacity is installed, capacity of one train must be considered, thus when the capacity is smaller than one train, plant must be always expandable to one train.

The most favorable capacity of one train may be 150,000 BPSD and one refinery may be 300,000 BPSD.

In Japan every company is made expansion schedule when operation rate is going up to 85%.

Japanese government guide line of the minimum capacity of refinery is 300,000 BPSD, and Japanese companies consider that 150,000 BPSD refinery is border line whether make pro it or not.

DESIRABLE ADDITIONAL CAPACITY

	(1) MINIMUM Capacity BPSD	(2) Desirable Additional Capacity BPSD	
1983	369,000	419,000	(+ 50,000)
84	362,000		
85	404,000		
86	437,000	519,000	(+100,000)
87	482,000		
88	510,000	644,000	(+125,000)
89	550,000		
1990	590,000		
91	644,000	794,000	(+150,000)
92	699,000		
93	757,000		
94	820,000	944,000	(+150,000)
95	888,000		
96	960,000	1,094,000	(+150,000)
97	1,028,000		
98	1,100,000	1,244,000	(+150,000)
99	1,177,000		
2000	1,257,000	1,394,000	(+150,000)

Note: From FIG.1 (ATTACH.24) and TABLE 23 (ATTACH.23)

VII CONCLUSTION

Capacity of expansion and/or new refinery is calculated by ordinal procefure.

1. The minimum capacity of expansion and/or new refinery must be same as demand plus loss and own fuel. The expansion and/or new refinery will be completed in 1983 at the earliest.

   The minimum capacity of expansion and/or new refinery will be 185,000 BPSD in 1983, actual crude oil through-put is 184,000 BPSD in 1977 (nominal capacity is 165,000 BPSD), so, 369,000 BPSD of total capacity in 1983 will be twice of 1977. In 2000, total capacity will be 1,257,000 BPSD.

2. It would be very difficult to import big quantity of crude oil such as just twice of present import in 1983. Crude oil import source must be enlarged.

3. Import and export of petroleum products will be consider after marketing survey.

4. Capacity of revamp and/or new refinery after 1983 can be considered as 50,000 BPSD, but small capacity such as 50,000 BPSD is not economical because construction cost per barrel is high, especially small cracking unit is very expensive. So, disirable capacity of revamp and/or new refinery will be 100,000 ~ 150,000 BPSD after 1983.

5. In 1983, crude oil through-put, additional and total capacity are as follows.

Crude oil through-put will be	369,000 BPSD
Existing capacity is	184,000 BPSD
Additional capacity will be	235,000 BPSD
Total capacity will be	419,000 BPSD

end.

TABLE 1 HEAT VALUE AND FUEL OIL EQUIVALENT OF SALES NATURAL GAS IN 1981 ATTACH.1

	(1)	(2)*1	(3)	(4)*2	(5)	(6)	(7)	(8)	(9)	(10)	(11)*2	(12)	(13)
			(1)x(2) x24÷10^3		(3)x(4) ÷10^3	(5)x365 ÷10^3	(6) ÷ 3.968254*3	(7)÷9,826*4 x10^3	(1)x379*5 x24÷10^6	(5)÷(9)		(3)x(11) ÷10^3	(2)÷(9)
	Net Gas To Pipeline lb-Mols/Hr.	Molecular Weight lb	10^3 lb/D	H.V.Net 10^9 BTU/Y	H.V.Net 10^6 BTU/D	H.V.Net 10^9 BTU/Y	H.V.Net 10^9 Kcal/Y	(Fuel Equiv.) 10^3 Kl/Y	H.V.Net 10^6 scf/D	H.V.Net BTU/scf	H.V.Gross BTU/lb	H.V.Gross 10^6 BTU/D	H.V.Gross BTU/scf
NITROGEN	35.3	28.013	23.7	0	0	0			0.32		0	0	
METHANE	10,821.9	16.042	4,166.5	21,500	89,580	32,697			98.44		23,860	99,413	
CARBON DIOXIDE	1,764.4	44.01	1,863.6	0	0	0			16.05		0	0	
ETHANE	1,497.9	30.068	1,080.9	20,420	22,072	8,056			13.62		22,300	24,104	
PROPANE	428.0	44.094	452.9	19,930	9,026	3,294			3.89		21,650	9,805	
ISOBUTANE	88.5	58.120	123.4	19,610	2,420	883			0.80		21,240	2,621	
N-BUTANE	71.9	58.120	100.3	19,670	1,973	720			0.65		21,290	2,135	
ISOPENTANE	20.8	72.146	36.0	19,390	698	255			0.19		20,995	756	
N-PENTANE	11.8	72.146	20.4	19,500	398	145			0.11		21,070	430	
HEXANES	15.7	86.172	32.5	19,206	624	228			0.14		20,746	674	
HEPTANES	4.9	100.198	11.8	19,129	226	82			0.06		20,639	244	
OCTANES	0.9	114.224	2.5	19,074	48	18			0.01		20,564	51	
WATER	1.7	18.015	0.7	0	0	0			0.02		0	0	
TOTAL	14,763.7	———	7,915.2	———	127,065	46,378	11,687	1,189	134.28	946	———	140,233	1,044

Note: *1 molecular weight from the book. *2 DATA BOOK ON HYDROCARBONS *3 Kcal = 3.968254 BTU *4 heat value of fuel oil *5 1 lb-mol = 379 scf

ATTACH.2

TABLE 2 HEAT VALUE AND FUEL OIL EQUIVALENT OF SALES NATURAL GAS IN 1982

	(1)	(2)*1	(3)	(4)*2	(5)	(6)	(7)	(8)	(9)	(10)	(11)*2	(12)	(13)
			(1)x(2) x24÷10³		(3)x(4) ÷10³	(5)x365 ÷10³	(6) ÷ 3.968254*3	(7)÷9,826*4 x10³	(1)x379*5 x24÷10⁶	(5)÷(9)		(3)x(11) ÷10³	(2)÷(9)
	Net Gas To Pipeline lb-Mols/Hr	Molecular Weight lb	10³lb/D	H.V.Net 10⁹BTU/Y	H.V.Net 10⁶BTU/D	H.V.Net 10⁹BTU/Y	H.V.Net 10⁹Kcal/Y	(Fuel Equiv.) 10³Kl/Y	H.V.Net 10⁶scf/D	H.V.Net BTU/scf	H.V.Gross BTU/lb	H.V.Gross 10⁶BTU/D	H.V.Gross BTU/scf
NITROGEN	160.7	28.013	108.0	0	0	0			1.46		0	0	
METHANE	20,206.4	16.042	7,779.6	21,500	167,261	61,050			183.80		23,860	185,621	
CARBONDIOXIDE	5,576.6	44.01	5,890.2	0	0	0			50.72		0	0	
ETHANE	2,303.1	30.068	1,662.0	20,420	33,938	12,387			20.95		22,300	37,063	
PROPANE	732.6	44.094	775.3	19,930	15,452	5,640			6.66		21,650	16,785	
ISOBUTANE	151.3	58.120	211.0	19,610	4,138	1,510			1.38		21,240	4,482	
N-BUTANE	137.1	58.120	191.2	19,670	3,761	1,373			1.25		21,290	4,071	
ISOPENTANE	42.8	72.146	74.1	19,390	1,437	525			0.39		20,995	1,556	
N-PENTANE	26.1	72.146	45.2	19,500	881	322			0.24		21,070	952	
HEXANES	31.1	86.172	64.3	19,206	1,235	451			0.28		20,746	1,334	
HEPTANES	10.5	100.198	25.2	19,129	482	176			0.10		20,639	520	
OCTANES	2.4	114.224	6.6	19,074	126	46			0.02		20,564	136	
WATER	3.5	18.015	1.5	0	0	0			0.03		0	0	
TOTAL	29,384.2	———	16,834.2	———	228,711	83,480	21,037	2,141	267.28	856	———	252,520	945

Note: *1 molecular weight from the book. *2 DATA BOOK ON HYDROCARBONS *3 Kcal = 3.968254 BTU *4 heat value of fuel oil *5 lb-mol = 379 scf.

TABLE 3 HEAT VALUE AND FUEL OIL EQUIVALENT OF SALES NATURAL GAS IN 1983

ATTACH.3

	(1)	(2)*1	(3)	(4)*2	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
			(1)x(2) x24÷10^3		(3)x(4) ÷10^3	(5)x365 ÷10^3	(6) ÷ 3.968254*3	(7)÷9,826*4 x10^3	(1)x379*5 x24÷10^6	(5)÷(9)		(3)x(11) ÷10^3	(2)÷(9)
	Net Gas To Pipeline	Molecular Weight		H.V.Net	H.V.Net	H.V.Net	H.V.Net	(Fuel Equiv.)	H.V.Net	H.V.Net	H.V.Gross	H.V.Gross	H.V.Gross
	lb-Mols/Hr	lb	10^3lb/D	10^9BTU/Y	10^6BTU/D	10^9BTU/Y	10^9Kcal/Y	10^3Kl/Y	10^6scf/D	BTU/scf	BTU/lb	10^6BTU/D	BTU/scf
NITROGEN	173.0	28.013	116.3	0	0	0			1.57		0	0	
METHANE	23,882.0	16.042	9,194.8	21,500	197,688	72,156			217.23		23,860	219,388	
CARBON DIOXIDE	5,858.3	44.01	6,187.8	0	0	0			53.29		0	0	
ETHANE	2,809.3	30.068	2,027.3	20,420	41,397	15,110			25.55		22,300	45,209	
PROPANE	834.7	44.094	883.3	19,930	17,604	6,425			7.59		21,650	19,123	
ISOBUTANE	171.9	58.120	239.8	19,610	4,702	1,716			1.56		21,240	5,093	
N-BUTANE	153.0	58.120	213.4	19,670	4,198	1,532			1.39		21,290	4,543	
ISOPENTANE	47.5	72.146	82.2	19,390	1,594	582			0.43		20,995	1,726	
N-PENTANE	28.7	72.146	49.7	19,500	969	354			0.26		21,070	1,047	
HEXANES	34.8	86.172	72.0	19,206	1,383	505			0.32		20,746	1,494	
HEPTANES	11.6	100.198	27.9	19,129	534	195			0.11		20,639	576	
OCTANES	2.5	114.224	6.9	19,074	132	48			0.02		20,564	142	
WATER	3.9	18.015	1.7	0	0	0			0.04		0	0	
TOTAL	34,011.2	——	19,103.1	——	270,201	98,623	24,853	2,529	309.36	873	——	298,341	964

Note: *1 molecular weight from the book. *2 DATA BOOK ON HYDROCARBONS *3 Kcal = 3.968254 BTU *4 heat value of fuel oil *5 lb-mol = 379 scf

ATTACH.4

TABLE 4 . HEAT VALUE AND FUEL OIL EQUIVALENT OF SALES NATURAL GAS IN 1984

	(1)	(2)*1	(3)	(4)*2	(5)	(6)	(7)	(8)	(9)	(10)	(11)*2	(12)	(13)
			(1)x(2) x24÷10³		(3)x(4) ÷10³	(5)x365 ÷10³	(6) ÷ 3.968254*3	(7)÷9,826*4 x10³	(1)x379*5 x24÷10⁶	(5)÷(9)		(3)x(11) ÷10³	(2)÷(9)
	Net Gas To Pipeline lb-Mols/Hr.	Molecular Weight lb	10^3lb/D	H.V.Net 10^9BTU/Y	H.V.Net 10^6BTU/D	H.V.Net 10^9BTU/Y	H.V.Net 10^9Kcal/Y	(Fuel Equiv.) 10^3Kl/Y	H.V.Net 10^6scf/D	H.V.Net BTU/scf	H.V.Gross BTU/lb	H.V.Gross 10^6BTU/D	H.V.Gross BTU/scf
NITROGEN	269.5	28.013	181.2	0	0	0			2.45		0	0	
METHANE	33,869.8	16.042	13,040.1	21,500	280,362	102,332			308.08		23,860	311,137	
CARBON DIOXIDE	9,107.6	44.01	9,619.8	0	0	0			82.84		0	0	
ETHANE	3,859.1	30.068	2,784.9	20,420	56,868	20,757			35.10		22,300	62,103	
PROPANE	1,198.2	44.094	1,268.0	19,930	25,271	9,224			10.90		21,650	27,452	
ISOBUTANE	246.9	58.120	344.4	19,610	6,754	2,465			2.25		21,240	7,315	
N-BUTANE	223.6	58.120	311.9	19,670	6,135	2,239			2.03		21,290	6,640	
ISOPENTANE	69.8	72.146	120.9	19,390	2,344	856			0.63		20,995	2,538	
N-PENTANE	42.6	72.146	73.8	19,500	1,439	525			0.39		21,070	1,555	
HEXANES	50.8	86.172	105.1	19,206	2,019	737			0.46		20,746	2,180	
HEPTANES	17.1	100.198	41.1	19,129	786	287			0.16		20,639	848	
OCTANES	4.0	114.224	11.0	19,074	210	77			0.04		20,564	226	
WATER	5.7	18.015	2.5	0	0	0			0.05		0	0	
TOTAL	48,964.7	———	27,904.7	———	382,188	139,499	35,154	3,578	445.38	858	———	421,994	947

Note: *1 molecular weight from the book. *2 DATA BOOK ON HYDROCARBONS *3 Kcal = 3.968254 BTU *4 heat value of fuel oil *5 lb-mol = 379 scf

TABLE 5 HEAT VALUE AND FUEL OIL EQUIVALENT OF SALES NATURAL GAS IN 1985

ATTACH.5

	(1)	(2)*1	(3)	(4)*2	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
			(1)x(2) x24÷10³		(3)x(4) ÷10³	(5)x365 ÷10³	(6) ÷ 3.968254*3	(7)÷9,826*4 x10³	(1)x379*5 x24÷10⁶	(5)÷(9)		(3)x(11) ÷10³	(2)÷(9)
	Net Gas To Pipeline lb-Mols/Hr.	Molecular Weight lb	10³lb/D	H.V.Net 10⁹BTU/Y	H.V.Net 10⁶BTU/D	H.V.Net 10⁹BTU/Y	H.V.Net 10⁹Kcal/Y	(Fuel Equiv.) 10³Kl/Y	H.V.Net 10⁶scf/D	H.V.Net BTU/scf	H.V.Gross BTU/lb	H.V.Gross 10⁶BTU/D	H.V.Gross BTU/scf
NITROGEN	268.7	28.013	180.7	0	0	0			2.44		0	0	
METHANE	33,774.2	16.042	13,003.3	21,500	279,571	102,043			307.21		23,860	310,259	
CARBON DIOXIDE	8,213.3	44.01	8,675.2	0	0	0			74.71		0	0	
ETHANE	3,843.1	30.068	2,773.3	20,420	56,631	20,670			34.96		22,300	61,845	
PROPANE	1,086.9	44.094	1,150.2	19,930	22,923	8,367			9.89		21,650	24,902	
ISOBUTANE	221.8	58.120	309.4	19,610	6,067	2,214			2.02		21,240	6,572	
N-BUTANE	200.8	58.120	280.1	19,670	5,510	2,011			1.83		21,290	5,963	
ISOPENTANE	62.7	72.146	108.6	19,390	2,106	769			0.57		20,995	2,280	
N-PENTANE	38.2	72.146	66.1	19,500	1,289	470			0.35		21,070	1,393	
HEXANES	45.6	86.172	94.3	19,206	1,811	661			0.41		20,746	1,956	
HEPTANES	15.4	100.198	37.0	19,129	708	258			0.14		20,639	764	
OCTANES	3.6	114.224	9.9	19,074	189	69			0.03		20,564	204	
WATER	5.2	18.015	2.2	0	0	0			0.05		0	0	
TOTAL	47,779.5	——	26,690.3	——	376,805	137,532	34,658	3,527	434.61	867	——	416,138	957

Note: *1 molecular weight from the book. *2 DATA BOOK ON HYDROCARBONS *3 Kcal = 3.968254 BTU *4 heat value of fuel oil *5 lb-mol = 379 scf

TABLE 6 HEAT VALUE AND FUEL OIL EQUIVALENT OF SALES NATURAL GAS IN 1986

	(1)	(2)	(3)	(4)*1	(5)	(6)	(7)	(8)	(9)	(10)	(11)*2	(12)	(13)
			(1)x(2) x24÷10³		(3)x(4) ÷10³	(5)x365 ÷10³	(6) ÷ 3.968254*3	(7)÷9,826*4 x10³	(1)x379*5 x24÷10⁶	(5)÷(9)		(3)x(11) ÷10³	(2)÷(9)
	Net Gas To Pipeline lb-Mols/Hr.	Molecular Weight lb	10³lb/D	H.V.Net 10⁹BTU/Y	H.V.Net 10⁶BTU/D	H.V.Net 10⁹BTU/Y	H.V.Net 10⁹Kcal/Y	(Fuel Equiv.) 10³Kl/Y	H.V.Net 10⁶scf/D	H.V.Net BTU/scf	H.V.Gross BTU/lb	H.V.Gross 10⁶BTU/D	H.V.Gross BTU/scf
NITROGEN	349.8	28.013	235.2	0	0	0			3.18		0	0	
METHANE	39,671.0	16.042	15,273.7	21,500	328,385	119,861			360.85		23,860	364,430	
CARBON DIOXIDE	10,173.0	44.01	10,745.1	0	0	0			92.53		0	0	
ETHANE	4,335.1	30.068	3,128.3	20,420	63,880	23,316			39.43		22,300	69,761	
PROPANE	1,232.1	44.094	1,303.9	19,930	25,987	9,485			11.21		21,650	28,229	
ISOBUTANE	250.7	58.120	349.7	19,610	6,858	2,503			2.28		21,240	7,428	
N-BUTANE	231.3	58.120	322.6	19,670	6,346	2,316			2.10		21,290	6,868	
ISOPENTANE	73.5	72.146	127.3	19,390	2,468	901			0.67		20,995	2,673	
N-PENTANE	45.4	72.146	78.6	19,500	1,533	560			0.41		21,070	1,656	
HEXANES	52.1	86.172	107.7	19,206	2,068	755			0.47		20,746	2,234	
HEPTANES	18.0	100.198	43.3	19,129	828	302			0.16		20,639	894	
OCTANES	4.5	114.224	12.3	19,074	235	86			0.04		20,564	253	
WATER	6.0	18.015	2.6	0	0	0			0.05		0	0	
TOTAL	56,442.5	———	31,730.3	———	438,588	160,085	40,341	4,106	513.38	854	———	484,426	944

Note: *1 molecular weight from the book. *2 DATA BOOK ON HYDROCARBONS *3 Kcal = 3.968254 BTU *4 heat value of fuel oil *5 lb-mol = 379 scf

TABLE 6 HEAT VALUE AND FUEL OIL EQUIVALENT OF SALES NATURAL GAS IN 1986

	(1)	(2)	(3)	(4)*1	(5)	(6)	(7)	(8)	(9)	(10)	(11)*2	(12)	(13)
			(1)x(2) x24÷10^3		(3)x(4) ÷10^3	(5)x365 ÷10^3	(6) ÷ 3.968254*3	(7)÷9,826*4 x10^3	(1)x379*5 x24÷10^6	(5)÷(9)		(3)x(11) ÷10^3	(2)÷(9)
	Net Gas To Pipeline	Molecular Weight		H.V.Net	H.V.Net	H.V.Net	H.V.Net	(Fuel Equiv.)	H.V.Net	H.V.Net	H.V.Gross	H.V.Gross	H.V.Gross
	lb-Mols/Hr.	lb	10^{3}lb/D	10^{9}BTU/Y	10^{6}BTU/D	10^{9}BTU/Y	10^{9}Kcal/Y	10^{3}Kl/Y	10^{6}scf/D	BTU/scf	BTU/lb	10^{6}BTU/D	BTU/scf
NITROGEN	349.8	28.013	235.2	0	0	0			3.18		0	0	
METHANE	39,671.0	16.042	15,273.7	21,500	328,385	119,861			360.85		23,860	364,430	
CARBON DIOXIDE	10,173.0	44.01	10,745.1	0	0	0			92.53		0	0	
ETHANE	4,335.1	30.068	3,128.3	20,420	63,880	23,316			39.43		22,300	69,761	
PROPANE	1,232.1	44.094	1,303.9	19,930	25,987	9,485			11.21		21,650	28,229	
ISOBUTANE	250.7	58.120	349.7	19,610	6,858	2,503			2.28		21,240	7,428	
N-BUTANE	231.3	58.120	322.6	19,670	6,346	2,316			2.10		21,290	6,868	
ISOPENTANE	73.5	72.146	127.3	19,390	2,468	901			0.67		20,995	2,673	
N-PENTANE	45.4	72.146	78.6	19,500	1,533	560			0.41		21,070	1,656	
HEXANES	52.1	86.172	107.7	19,206	2,068	755			0.47		20,746	2,234	
HEPTANES	18.0	100.198	43.3	19,129	828	302			0.16		20,639	894	
OCTANES	4.5	114.224	12.3	19,074	235	86			0.04		20,564	253	
WATER	6.0	18.015	2.6	0	0	0			0.05		0	0	
TOTAL	56,442.5	———	31,730.3	———	438,588	160,083	40,341	4,106	513.38	854	———	484,426	944

Note: *1 molecular weight from the book. *2 DATA BOOK ON HYDROCARBONS *3 Kcal = 3.968254 BTU *4 heat value of fuel oil *5 lb-mol = 379 scf

ATTACH.7

TABLE 7 HEAT VALUE AND FUEL OIL EQUIVALENT OF SALES NATURAL GAS IN 1987

	(1)	(2)*1	(3)	(4)*2	(5)	(6)	(7)	(8)	(9)	(10)	(11)*2	(12)	(13)
			(1)x(2) x24÷10³		(3)x(4) ÷10³	(5)x365 ÷10³	(6) ÷ 3.968254*3	(7)÷9,826*4 x10³	(1)x379*5 x24÷10⁶	(5)÷(9)		(3)x(11) ÷10³	(2)÷(9)
	Net Gas To Pipeline lb-Mols/Hr	Molecular Weight lb	10^3 lb/D	H.V.Net 10^9 BTU/Y	H.V.Net 10^6 BTU/D	H.V.Net 10^9 BTU/Y	H.V.Net 10^9 Kcal/Y	(Fuel Equiv.) 10^3 Kl/Y	H.V.Net 10^6 scf/D	H.V.Net BTU/scf	H.V.Gross BTU/lb	H.V.Gross 10^6 BTU/D	H.V.Gross BTU/scf
NITROGEN	348.8	28.013	234.5	0	0	0			3.17		0	0	
METHANE	39,556.0	16.042	15,229.4	21,500	327,432	119,513			359.80		23,860	363,373	
CARBON DIOXIDE	9.048.9	44.01	9,557.8	0	0	0			82.31		0	0	
ETHANE	4,316.8	30.068	3,115.1	20,420	63,610	23,218			39.27		22,300	69,467	
PROPANE	1,104.2	44.094	1,168.5	19,930	23,288	8,500			10.04		21,650	25,298	
ISOBUTANE	221.9	58.120	309.5	16,610	5,141	1,876			2.02		21,240	6,574	
N-BUTANE	204.6	58.120	285.4	19,670	5,614	2,049			1.86		21,290	6,076	
ISOPENTANE	65.0	72.146	112.5	19,390	2,181	796			0.59		20,995	2,362	
N-PENTANE	40.1	72.146	69.4	19,500	1,353	494			0.36		21,070	1,462	
HEXANES	46.0	86.172	95.1	19,206	1,826	666			0.42		20,746	1,973	
HEPTANES	15.9	100.198	38.2	19,129	731	267			0.14		20,639	788	
OCTANES	4.0	114.224	11.0	19,074	210	77			0.04		20,564	226	
WATER	5.3	18.015	2.3	0	0	0			0.05		0	0	
TOTAL	54,977.5	———	30,228.7	———	431,386	157,456	39,679	4,038	500.07	863	———		985

Note: *1 molecular weight from the book. *2 DATA BOOK ON HYDROCARBONS *3 Kcal = 3.968254 BTU *4 heat value of fuel oil *5 lb-mol = 379 scf

TABLE 8 HEAT VALUE AND FUEL OIL EQUIVALENT OF SALES NATURAL GAS IN 1988

ATTACH.8

	(1)	(2)*1	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)*2	(12)	(13)
			(1)x(2) x24÷10³		(3)x(4) ÷10³	(5)x365 ÷10³	(6) ÷ 3.968254*3	(7)÷9,826*4 x10³	(1)x379*5 x24÷10⁶	(5)÷(9)		(3)x(11) ÷10³	(2)÷(9)
	Net Gas To Pipeline lb-Mols/Hr.	Molecular Weight lb	10^3 lb/D	H.V.Net 10^9 BTU/Y	H.V.Net 10^6 BTU/D	H.V.Net 10^9 BTU/Y	H.V.Net 10^9 Kcal/Y	(Fuel Equiv.) 10^3 Kl/Y	H.V.Net 10^6 scf/D	H.V.Net BTU/scf	H.V.Gross BTU/lb	H.V.Gross 10^6 BTU/D	H.V.Gross BTU/scf
NITROGEN	431.5	28.013	290.1	0	0	0			3.92		0	0	
METHANE	45,716.7	16.042	17,601.3	21,500	378,428	138,126			415.84		23,860	419,967	
CARBON DIOXIDE	10,755.4	44.01	11,360.3	0	0	0			97.83		0	0	
ETHANE	4,838.0	30.068	3,491.3	20,420	71,292	26,022			44.01		22,300	77,856	
PROPANE	1,234.6	44.094	1,306.5	19,930	26,039	9,504			11.23		21,650	28,286	
ISOBUTANE	247.0	58.120	344.5	16,610	5,722	2,089			2.25		21,240	7,317	
N-BUTANE	231.3	58.120	322.6	19,670	6,346	2,316			2.10		21,290	6,868	
ISOPENTANE	73.9	72.146	128.0	19,390	2,482	906			0.67		20,995	2,687	
N-PENTANE	46.2	72.146	80.0	19,500	1,560	569			0.42		21,070	1,686	
HEXANES	52.0	86.172	107.5	19,206	2,065	754			0.47		20,746	2,230	
HEPTANES	17.8	100.198	42.8	19,129	819	299			0.16		20,639	883	
OCTANES	5.0	114.224	13.7	19,074	261	95			0.05		20,564	282	
WATER	6.1	18.015	2.6	0	0	0			0.06		0	0	
TOTAL	63,655.5	———	35,091.2	———	495,014	180,680	45,531	4,634	579.01	855	———	548,062	947

Note: *1 molecular weight from the book *2 DATA BOOK ON HYDROCARBONS *3 Kcak = 3.968254 BTU *4 heat value of fuel oil *5 lb-mol = 379 scf

ATTACH.9

TABLE 9 HEAT VALUE AND FUEL OIL EQUIVALENT OF SALES NATURAL GAS IN 1989

	(1)	(2)*1	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)*2	(12)	(13)
			(1)x(2)		(3)x(4) ÷10^3	(5)x365 ÷10^3	(6)÷ 3.968254*3	(7)÷9,826*4 x10^3	(1)x379*5 x24÷10^6	(5)÷(9)		(3)x(11) ÷10^3	(2)÷(9)
	Net Gas To Pipeline lb-Mols/Hr.	Molecular Weight lb	10^3lb/D	H.V.Net 10^9BTU/Y	H.V.Net 10^6BTU/D	H.V.Net 10^9BTU/Y	H.V.Net 10^9Kcal/Y	(Fuel Equiv.) 10^3Kl/Y	H.V.Net 10^6scf/D	H.V.Net BTU/scf	H.V.Gross BTU/lb	H.V.Gross 10^6BTU/D	H.V.Gross BTU/scf
NITROGEN	430.1	28,013	289.2	0	0	0			3.91		0	0	
METHANE	45,572.6	16,042	17,545.8	21,500	377,235	137,691			414.53		23,860	418,643	
CARBON DIOXIDE	9,434.3	44.01	9,964.9	0	0	0			85.81		0	0	
ETHANE	4,816.4	30.068	3,475.7	20,420	70,974	25,906			43.81		22,300	77,508	
PROPANE	1,093.4	44.094	1,157.1	19,930	23,061	8,417			9.95		21,650	25,051	
ISOBUTANE	215.3	58.120	300.3	19,610	5,889	2,149			1.96		21,240	6,378	
N-BUTANE	201.4	58.120	280.9	19,670	5,525	2,017			1.83		21,290	5,980	
ISOPENTANE	64.3	72.146	111.3	19,390	2,158	788			0.58		20,995	2,337	
N-PENTANE	40.2	72.146	69.6	19,500	1,357	495			0.37		21,070	1,466	
HEXANES	45.2	86.172	93.5	19,206	1,796	656			0.41		20,746	1,940	
HEPTANES	15.5	100.193	37.3	19,129	714	261			0.14		20,639	770	
OCTANES	4.3	114.224	11.8	19,072	225	82			0.04		20,564	243	
WATER	5.3	18.015	2.3	0	0	0			0.05		0	0	
TOTAL	61,938.3	———	33,340	———	488,934	178,462	44,972	4,577	563.39	868	———	540,316	959

Note: *1 molecular weight from the book. *2 DATA BOOK ON HYDROCARBONS *3 Kcal = 3.968254 BTU *4 heat value of fuel oil *5 lb-mol = 379 scf

TABLE 10 HEAT VALUE AND FUEL OIL EQUIVALENT OF SALES NATURAL GAS IN 1990

ATTACH.10

	(1)	(2)*1	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)*2	(12)	(13)
			(1)x(2) x24÷10^3		(3)x(4) ÷10^3	(5)x365 ÷10^3	(6) ÷ 3.968254*3	(7)÷9,826*4 x10^3	(1)x379*5 x24÷10^6	(5)÷(9)		(3)x(11) ÷10^3	(2)÷(9)
	Net Gas To Pipeline	Molecular Weight		H.V.Net	H.V.Net	H.V.Net	H.V.Net	(Fuel Equiv.)	H.V.Net	H.V.Net	H.V.Gross	H.V.Gross	H.V.Gross
	lb-Mols/Hr.	lb	10^{3}lb/D	10^{9}BTU/Y	10^{6}BTU/D	10^{9}BTU/Y	10^{9}Kcal/Y	10^{3}Kl/y	10^{6}scf/D	BTU/scf	BTU/lb	10^{6}BTU/D	BTU/scf
NITROGEN	428.6	28.013	288.2	0	0	0			3.90		0	0	
METHANE	45,409.9	16.042	17,483.2	21,500	357,889	137,199			413.05		23,860	417,149	
CARBON DIOXIDE	8,050.1	44.01	8,502.8	0	0	0			73.22		0	0	
ETHANE	4,792.5	30.068	3,458.4	20,420	70,621	25,777			43.59		22,300	77,122	
PROPANE	945.3	44.094	1,000.4	19,930	19,938	7,277			8.60		21,650	21,659	
ISOBUTANE	182.1	58.120	254.0	19,610	4,981	1,818			1.66		21,240	5,395	
N-BUTANE	170.0	58.120	237.1	19,670	4,664	1,702			1.55		21,290	5,048	
ISOPENTANE	54.2	72.146	93.8	19,390	1,819	644			0.49		20,995	1,969	
N-PENTANE	33.9	72.146	58.7	19,500	1,145	418			0.31		21,070	1,237	
HEXANES	38.1	86.172	78.7	19,206	1,513	552			0.35		20,746	1,635	
HEPTANES	13.0	100.198	31.3	19,129	599	219			0.12		20,639	646	
OCTANES	3.6	114.224	9.9	19,072	189	69			0.03		20,564	204	
WATER	4.5	18.015	1.9	0	0	0			0.04		0	0	
TOTAL	60,125.8	——	31,498.5	——	481,358	175,695	44,275	4,506	546.91	880	——	532,064	973

Note: *1 molecular weight from the book. *2 DATA BOOK ON HYDROCARBONS *3 Kcal = 3.968254 BTU *4 heat value of fuel oil *5 lb-mol = 379 scf

TABLE 11 LPG PRODUCTION IN 1981

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			(1)x(2)	(3)÷2.20462	(4)x24÷10^3	(5)x365÷10^3		(6)÷(7)
	LPG Product lb-Mols/Hr	Molecular Weight lb	LPG Weight lb/Hr	LPG Weight Kg/Hr	LPG Weight t/D	LPG Weight 10^3t/Y	Specific Quantity $60^{\circ}F/60^{\circ}F$	LPG Volume 10^3Kl/Y
ETHANE	8.3	30.068	249.6	113.2	2.72	0.99	0.374	2.65
PROPANE	165.9	44.094	7,315.2	3,318.1	79.63	29.06	0.508	57.20
BUTANE (ISO+N)	77.0	58.120	4,475.2	2,029.9	48.72	17.78	0.584	30.45
PENTANE (ISO+N)	3.7	72.146	266.9	121.1	2.91	1.06	0.631	1.68
HEXANE	0.1	86.172	8.6	3.9	0.09	0.03	0.664	0.05
TOTAL	255.0		12,315.5	5,586.2	134.07	48.94		92.03

TABLE 12 · LPG PRODUCTION IN 1982

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			(1)x(2)	(3)÷2.20462	(4)x24÷10^3	(5)x365÷10^3	[illegible]	(6)÷(7)
	LPG Product lb-Mols/Hr	Molecular Weight lb	LPG Weight lb/Hr	LPG Weight Kg/Hr	LPG Weight t/D	LPG Weight 10^3t/Y	Specific Quantity $60^oF/60^oF$	LPG Volume 10^3Kl/Y
ETHANE	12.3	30.068	369.8	167.7	4.02	1.47	0.374	3.93
PROPANE	258.9	44.094	11,415.9	5,178.2	124.28	45.36	0.508	89.29
BUTANE (ISO+N)	113.6	58.120	6,602.4	2,994.8	71.88	26.24	0.584	44.93
PENTANE (ISO+N)	5.1	72.146	367.9	166.9	4.01	1.46	0.631	2.31
HEXANE	0.1	86.172	8.6	3.9	0.09	0.03	0.664	0.05
TOTAL	390.0		18,764.6	8,511.5	204.28	74.56	2.761	140.51

TABLE 13 LPG PRODUCTION IN 1983

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			(1)x(2)	(3)÷2.20462	(4)x24÷10^3	(5)x365÷10^3		(6)÷(7)
	LPG Product lb-Mols/Hr	Molecular Weight lb	LPG Weight lb/Hr	LPG Weight Kg/Hr	LPG Weight t/D	LPG Weight 10^3t/Y	Specific Quantity 60°F/60°F	LPG Volume 10^3Kl/Y
ETHANE	17.0	30.068	511.2	231.9	5.57	2.03	0.374	5.43
PROPANE	354.8	44.094	15,644.6	7,096.3	170.31	62.16	0.508	122.36
BUTANE (ISO+N)	156.1	58.120	9,072.5	4,115.2	98.76	36.05	0.584	61.73
PENTANE (ISO+N)	7.0	72.146	505.0	229.1	5.50	2.01	0.631	3.19
HEXANE	0.1	86.172	8.6	3.9	0.09	0.03	0.664	0.05
TOTAL	535.0		25,741.9	11,676.4	280.23	102.28		192.76

TABLE14 LPG PRODUCTION IN 1984

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			(1)x(2)	(3)÷2.20462	$(4)\times24\div10^3$	$(5)\times365\div10^3$		(6)÷(7)
	LPG Product lb-Mols/Hr	Molecular Weight lb	LPG Weight lb/Hr	LPG Weight Kg/Hr	LPG Weight t/D	LPG Weight 10^3t/Y	Specific Quantity $60^\circ F/60^\circ F$	LPG Volume 10^3Kl/Y
ETHANE	21.6	30.068	649.5	294.6	7.07	2.58	0.374	6.90
PROPANE	455.1	44.094	20,067.2	9,102.3	218.46	79.74	0.508	156.97
BUTANE (ISO+N)	199.4	58.120	11,589.1	5,256.7	126.16	46.05	0.584	78.85
PENTANE (ISO+N)	8.9	72.146	542.1	291.3	6.99	2.55	0.631	4.04
HEXANE	0.1	86.172	8.6	3.9	0.09	0.03	0.664	0.05
TOTAL	685.1		32,956.5	14,948.8	358.77	130.95		246.81

TABLE 15 LPG PRODUCTION IN 1985

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			(1)x(2)	(3)÷2.20462	$(4)\times24\div10^3$	$(5)\times365\div10^3$		(6)÷(7)
	LPG Product lb-Mols/Hr	Molecular Weight lb	LPG Weight lb/Hr	LPG Weight Kg/Hr	LPG Weight t/D	LPG Weight 10^3t/Y	Specific Quantity 60°F/60°F	LPG Volume 10^3Kl/Y
ETHANE	26.9	30.068	808.8	366.9	8.81	3.22	0.374	8.61
PROPANE	566.0	44.094	24,957.2	11,320.4	271.69	99.17	0.508	195.22
BUTANE (ISO+N)	246.2	58.120	14,309.1	6,490.5	155.77	56.86	0.584	97.36
PENTANE (ISO+N)	10.7	72.146	772.0	350.2	8.40	3.07	0.631	4.87
HEXANE	0.1	86.172	8.6	3.9	0.09	0.03	0.664	0.05
TOTAL	349.9		40,855.7	18,531.9	444.76	162.35		306.11

TABLE 16 LPG PRODUCTION IN 1986

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			(1)x(2)	(3)-2.20462	(4)x24÷10^3	(5)x365÷10^3		(6)÷(7)
	LPG Product lb-Mols/Hr	Molecular Weight lb	LPG Weight lb/Hr	LPG Weight Kg/Hr	LPG Weight t/D	LPG Weight 10^3t/Y	Specific Quantity 60°F/60°F	LPG Volume 10^3Kl/y
ETHANE	32.0	30.068	962.2	436.4	10.47	3.82	0.374	10.21
PROPANE	684.3	44.094	30,173.5	13,686.5	328.48	119.90	0.508	236.02
BUTANE (ISO+N)	295.8	58.120	17,191.9	7,798.1	187.15	68.31	0.584	116.97
PENTANE (ISO+N)	12.8	72.146	923.5	418.9	10.05	3.67	0.631	5.82
HEXANE	0.1	86.172	8.6	3.9	0.09	0.03	0.664	0.05
TOTAL	1,025.0		49,259.7	22,343.8	536.24	195.73		369.07

TABLE 17 LPG PRODUCTION IN 1987

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			(1)x(2)	(3)÷2.20462	(4)x24÷10^3	(5)x365÷10^3		(6)÷(7)
	LPG Product lb-Mols/Hr	Molecular Weight lb	LPG Weight lb/Hr	LPG Weight Kg/Hr	LPG Weight t/D	LPG Weight 10^3t/Y	Specific Quantity $60^oF/60^oF$	LPG Volume 10^3Kl/Y
ETHANE	38.0	30.068	1,142.6	518.3	12.44	4.54	0.374	12.14
PROPANE	811.9	44.094	35,799.9	16,238.6	389.73	142.25	0.508	280.02
BUTANE (ISO+N)	350.0	58.120	20,342.0	9,227.0	221.45	80.83	0.584	138.41
PENTANE (ISO+N)	15.2	72.146	1,096.6	497.4	11.94	4.36	0.631	6.91
HEXANE	0.1	86.172	8.6	3.9	0.09	0.03	0.664	0.05
TOTAL	1,215.2		58,389.7	26,485.2	635.65	232.01		437.53

TABLE 18 LPG PRODUCTION IN 1988

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			(1)x(2)	(3)÷2.20462	(4)x24÷10^3	(5)x365÷10^3		(6)÷(7)
	LPG Product lb-Mols/Hr	Molecular Weight lb	LPG Weight lb/Hr	LPG Weight Kg/Hr	LPG Weight t/D	LPG Weight 10^3t/Y	Specific Quantity $60^{\circ}F/60^{\circ}F$	LPG Volume 10^3Kl/Y
ETHANE	43.7	30.068	1,314.0	596.0	14.30	5.22	0.374	13.96
PROPANE	946.6	44.094	41,739.4	18,932.7	454.38	165.85	0.508	326.48
BUTANE (ISO+N)	407.0	58.120	23,654.8	10,729.6	257.51	93.99	0.584	160.94
PENTANE (ISO+N)	17.6	72.146	1,269.8	576.0	13.82	5.04	0.631	7.99
HEXANE	0.1	86.172	8.6	3.9	0.09	0.03	0.664	0.05
TOTAL	1,415.0		67,986.6	30,838.2	740.10	270.13		509.42

TABLE19 LPG PRODUCTION IN 1989

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			(1)x(2)	(3)÷2.20462	(4)x24÷10^3	(5)x365÷10^3		(6)÷(7)
	LPG Product lb-Mols/Hr	Molecular Weight lb	LPG Weight lb/Hr	LPG Weight Kg/Hr	LPG Weight t/D	LPG Weight 10^3t/Y	Specific Quantity $60^oF/60^oF$	LPG Volume 10^3Kl/Y
ETHANE	50.2	30.068	1,509.4	684.7	16.43	6.00	0.374	16.04
PROPANE	1,087.4	44.094	47,947.8	21,748.8	521.97	190.52	0.508	375.04
BUTANE (ISO+N)	457.2	58.120	27,153.7	12,316.7	295.60	107.89	0.584	184.74
PENTANE (ISO+N)	20.1	72.146	1,450.1	657.8	15.79	5.76	0.631	9.13
HEXANE	0.1	86.172	8.6	3.9	0.09	0.03	0.664	0.05
TOTAL	1,625.0		78,069.6	35,411.9	849.88	310.20		585.00

TABLE 20 LPG PRODUCTION IN 1990

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			(1)x(2)	(3)÷2.20462	(4)x24÷10^3	(5)x365÷10^3		(6)÷(7)
	LPG Product lb-Mols/Hr	Molecular Weight lb	LPG Weight lb/Hr	LPG Weight Kg/Hr	LPG Weight t/D	LPG Weight 10^3t/Y	Specific Quantity 60°F/60°F	LPG Volume 10^3Kl/Y
ETHANE	57.0	30.068	1,713.9	777.4	18.66	6.81	0.374	18.21
PROPANE	1,234.9	44.094	54,451.7	24,698.9	592.56	216.28	0.508	425.75
BUTANE (ISO+N)	530.2	58.120	30,815.2	13,977.6	335.46	122.44	0.584	209.66
PENTANE (ISO+N)	22.7	72.146	1,637.7	742.8	17.83	6.51	0.631	10.32
HEXANE	0.1	86.172	8.6	3.9	0.09	0.03	0.664	0.05
TOTAL	1,844.9		88,627.1	40,200.6	964.60	352.07		663.99

YEAR	(1) LPG 10³Kl/y	(2) % of (1) on Crude (23)	(3) Benzine 10³Kl/y	(4) % of (3) on Crude (23)	(5) Jet Fuel 10³Kl/y	(6) % of (5) on Crude (23)	(7) Kerosene 10³Kl/y
	Production						
1977	240		2,117		752		280
	Demand						
78	292	2.1	2,625	19.1	916	6.6	342
79	317	2.1	2,843	19.0	992	6.6	371
1980	356	2.1	3,200	19.0	1,116	6.6	417
81	396	2.2	3,559	20.3	1,241	7.1	464
82	444	2.4	3,986	21.2	1,390	7.4	520
83	464	2.4	4,163	21.5	1,452	7.5	543
84	479	2.5	4,297	22.6	1,499	7.9	560
85	523	2.5	4,692	22.1	1,637	7.7	612
86	571	2.5	5,131	22.4	1,790	7.8	669
87	620	2.5	5,567	22.0	1,942	7.7	726
88	664	2.5	5,961	22.3	2,079	7.8	777
89	706	2.5	6,339	22.0	2,211	7.7	826
1990	749	2.4	6,723	21.8	2,345	7.6	877
91	808	2.4	7,257	21.5	2,531	7.5	946
92	868	2.4	7,799	21.3	2,720	7.4	1,017
93	933	2.4	8,374	21.1	2,921	7.4	1,092
94	1,003	2.4	9,002	21.0	3,140	7.3	1,174
95	1,077	2.3	9,671	20.8	3,373	7.3	1,261
96	1,156	2.3	10,382	20.6	3,621	7.2	1,354
97	1,232	2.3	11,060	20.5	3,858	7.2	1,442
98	1,311	2.3	11,774	20.4	4,107	7.1	1,535
99	1,395	2.3	12,528	20.3	4,370	7.1	1,633
2000	1,483	2.2	13,321	20.2	4,646	7.1	1,737

Note: *1 Unfinished products is only including in 1977.

*2 The crude oil thru- put of 3 existing refineries, this is conceiva

*3 (25) minus *2 (1,840 B/SD), it is the capacity of the new refiner

TABLE 21 REQUIREMENT OF EACH PRODUCT AND TOTAL CRUDE OIL THRU-PUT (EXISTING, EXPANSION AND/OR NEW REFINERY) AND EXPANSION AND/OR NEW REFINERY CRUDE OIL THRU-

3) … de	(5) Jet Fuel 10^3Kl/y	(6) % of (5) on Crude (23)	(7) Kerosene 10^3Kl/y	(8) % of (7) on Crude (23)	(9) Diesel Oil 10^3Kl/y	(10) % of (9) on Crude (23)	(11) Fuel Oil (Incl. N.G.) 10^3Kl/y	(12) N.G. Equi. Fuel Oil 10^3Kl/y	(13) (11)-(12) Fuel Oil(Excl. N.G.) 10^3Kl/y	(14) % of (13) on Crude (23)	(15) Lube Oil 10^3Kl/y	(16) % of (15) on Crude (23)	(17) Bitumen 10^3Kl/y	(18) % of (17) on Crude (23)	(19) Petroleum Product Total 10^3Kl/y
	752		280		2,797		2,828						156	1.6	9,170
	916	6.6	342	2.5	4,392	31.9	4,223			30.6	128	0.9	205	1.5	13,123
	992	6.6	371	2.5	4,757	31.8	4,574			30.6	152	1.0	236	1.6	14,242
	1,116	6.6	417	2.5	5,354	31.7	5,149			30.5	187	1.1	281	1.7	16,060
	1,241	7.1	464	2.6	5,954	33.9	5,726	1,189	4,537	25.8	225	1.3	347	2.0	15,723
	1,390	7.4	520	2.8	6,669	35.5	6,413	2,141	4,272	22.8	291	1.5	388	2.1	17,960
	1,452	7.5	543	2.8	6,966	36.1	6,699	2,529	4,170	21.6	325	1.7	406	2.1	18,489
	1,499	7.9	560	3.0	7,189	37.9	6,913	3,578	3,335	17.6	377	2.0	419	2.2	18,155
	1,637	7.7	612	2.9	7,851	37.1	7,549	3,527	4,022	19.0	457	2.2	457	2.2	20,251
	1,790	7.8	669	2.9	8,585	37.5	8,256	4,106	4,150	18.1	500	2.2	500	2.2	21,896
	1,942	7.7	726	2.9	9,315	36.9	8,958	4,038	4,920	19.5	543	2.1	543	2.1	24,174
	2,079	7.8	777	2.9	9,975	37.3	9,592	4,634	4,958	18.5	581	2.2	581	2.2	25,576
	2,211	7.7	826	2.9	10,606	36.9	10,199	4,577	5,622	19.5	618	2.1	618	2.1	27,546
	2,345	7.6	877	2.9	11,250	36.4	10,818	4,506	6,312	20.4	655	2.1	655	2.1	29,566
	2,531	7.5	946	2.8	12,143	36.0	11,677	4,506	7,171	21.3	707	2.1	707	2.1	32,270
	2,720	7.4	1,017	2.8	13,049	35.6	12,548	4,506	8,042	22.0	760	2.1	760	2.1	35,015
	2,921	7.4	1,092	2.7	14,011	35.3	13,473	4,506	8,967	22.6	816	2.1	816	2.1	37,930
	3,140	7.3	1,174	2.7	15,063	35.1	14,484	4,506	9,978	23.2	877	2.0	877	2.0	41,114
	3,373	7.3	1,261	2.7	16,183	34.8	15,561	4,506	11,055	23.8	943	2.0	943	2.0	44,506
	3,621	7.2	1,354	2.7	17,372	34.6	16,705	4,506	12,199	24.3	1,011	2.0	1,011	2.0	48,106
	3,858	7.2	1,442	2.7	18,507	34.3	17,796	4,506	13,290	24.7	1,078	2.0	1,078	2.0	51,545
	4,107	7.1	1,535	2.7	19,701	34.2	18,945	4,506	14,439	25.0	1,147	2.0	1,147	2.0	55,161
	4,370	7.1	1,633	2.6	20,963	34.0	20,158	4,506	15,652	25.4	1,221	2.0	1,221	2.0	58,983
	4,646	7.1	1,737	2.6	22,289	33.9	21,433	4,506	16,927	25.7	1,298	2.0	1,298	2.0	62,999

ly including in 1977.

f 3 existing refineries, this is conceivabled the maximum capacity of existing 3 refineries.

), it is the capacity of the new refinery.

...-PUT (EXISTING, EXPANSION AND/OR NEW REFINERY). AND EXPANSION AND/OR NEW REFINERY CRUDE OIL THRU-PUT

ATTACH. 21

	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)*1	(21)	(22)	(23)	(24)	(25)	(26)
...ui. ...il ...y	(11)-(12) ...uel Oil(Excl. ...N.G.) 10^3Kl/y	% of (13) on Crude (23)	Lube Oil 10^3Kl/y	% of (15) on Crude (23)	Bitumen 10^3Kl/y	% of (17) on Crude (23)	Petroleum Product Total 10^3Kl/y	Loss and Own Fuel % on Products	Loss and Own Fuel 10^3Kl/y	% of (21) on Crude (23)	Total Crude Oil Thru-put 10^3Kl/y	Total %	(23)÷330x6.3 Crude Oil Thru-put B/SD	Expan.and/or New Ref. Crude Oil Thru-put B/SD
					156	1.6	9,170	9.5	488	5.1	9,658			184,000*2
		30.6	128	0.9	205	1.5	13,123	5.0	656	4.8	13,779	100	263,000	
		30.6	152	1.0	236	1.6	14,242	5.0	712	4.8	14,954	100	285,000	
		30.5	187	1.1	281	1.7	16,060	5.0	803	4.8	16,863	100	322,000	
	4,537	25.8	225	1.3	347	2.0	16,723	5.0	836	4.8	17,559	100	335,000	151,000*3
	4,272	22.8	291	1.5	388	2.1	17,960	4.5	808	4.3	18,768	100	358,000	174,000
	4,170	21.6	325	1.7	406	2.1	18,489	4.5	832	4.3	19,321	100	369,000	185,000
	3,335	17.6	377	2.0	419	2.2	18,155	4.5	817	4.3	18,972	100	362,000	178,000
	4,022	19.0	457	2.2	457	2.2	20,251	4.5	911	4.3	21,162	100	404,000	220,000
	4,150	18.1	500	2.2	500	2.2	21,896	4.5	985	4.4	22,881	100	437,000	253,000
	4,920	19.5	543	2.1	543	2.1	24,174	4.5	1,088	4.3	25,262	100	482,000	298,000
	4,958	18.5	581	2.2	581	2.2	25,576	4.5	1,151	4.3	26,727	100	510,000	326,000
	5,622	19.5	618	2.1	618	2.1	27,546	4.5	1,240	4.3	28,786	100	550,000	366,000
	6,312	20.4	655	2.1	655	2.1	29,566	4.5	1,330	4.3	30,896	100	590,000	406,000
	7,171	21.3	707	2.1	707	2.1	32,270	4.5	1,452	4.3	33,722	100	644,000	460,000
	8,042	22.0	760	2.1	760	2.1	35,015	4.5	1,576	4.3	36,591	100	699,000	515,000
	8,967	22.6	816	2.1	816	2.1	37,930	4.5	1,707	4.3	39,637	100	757,000	573,000
	9,978	23.2	877	2.0	877	2.0	41,114	4.5	1,850	4.3	42,964	100	820,000	636,000
	11,055	23.8	943	2.0	943	2.0	44,506	4.5	2,003	4.3	46,509	100	888,000	704,000
	12,199	24.3	1,011	2.0	1,011	2.0	48,106	4.5	2,165	4.3	50,271	100	960,000	776,000
	13,290	24.7	1,078	2.0	1,078	2.0	51,545	4.5	2,320	4.3	53,865	100	1,028,000	844,000
	14,439	25.0	1,147	2.0	1,147	2.0	55,161	4.5	2,482	4.3	57,643	100	1,100,000	916,000
	15,652	25.4	1,221	2.0	1,221	2.0	58,983	4.5	2,654	4.3	61,637	100	1,177,000	993,000
	16,927	25.7	1,298	2.0	1,298	2.0	62,999	4.5	2,835	4.3	65,834	100	1,257,000	1,073,000