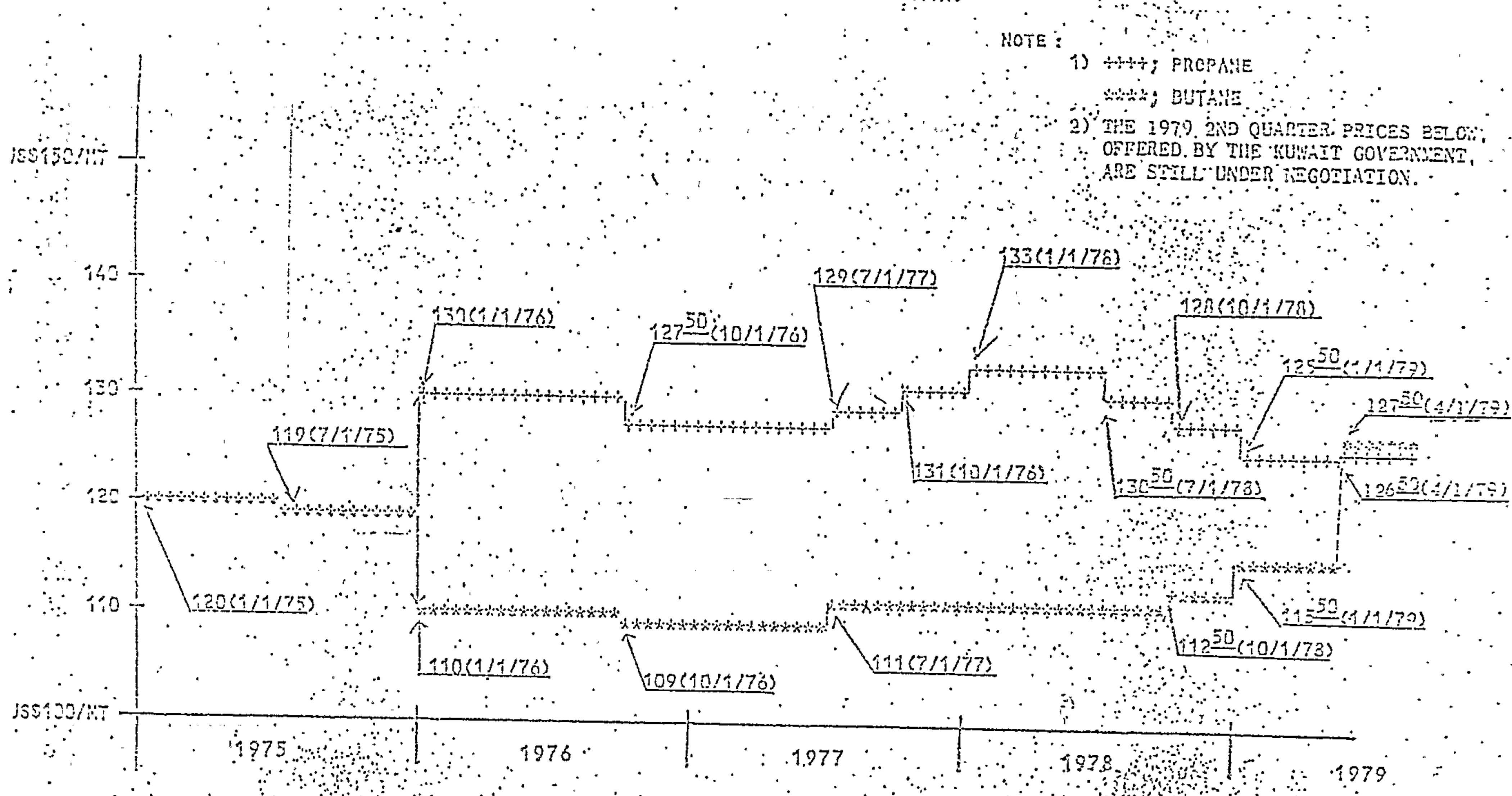
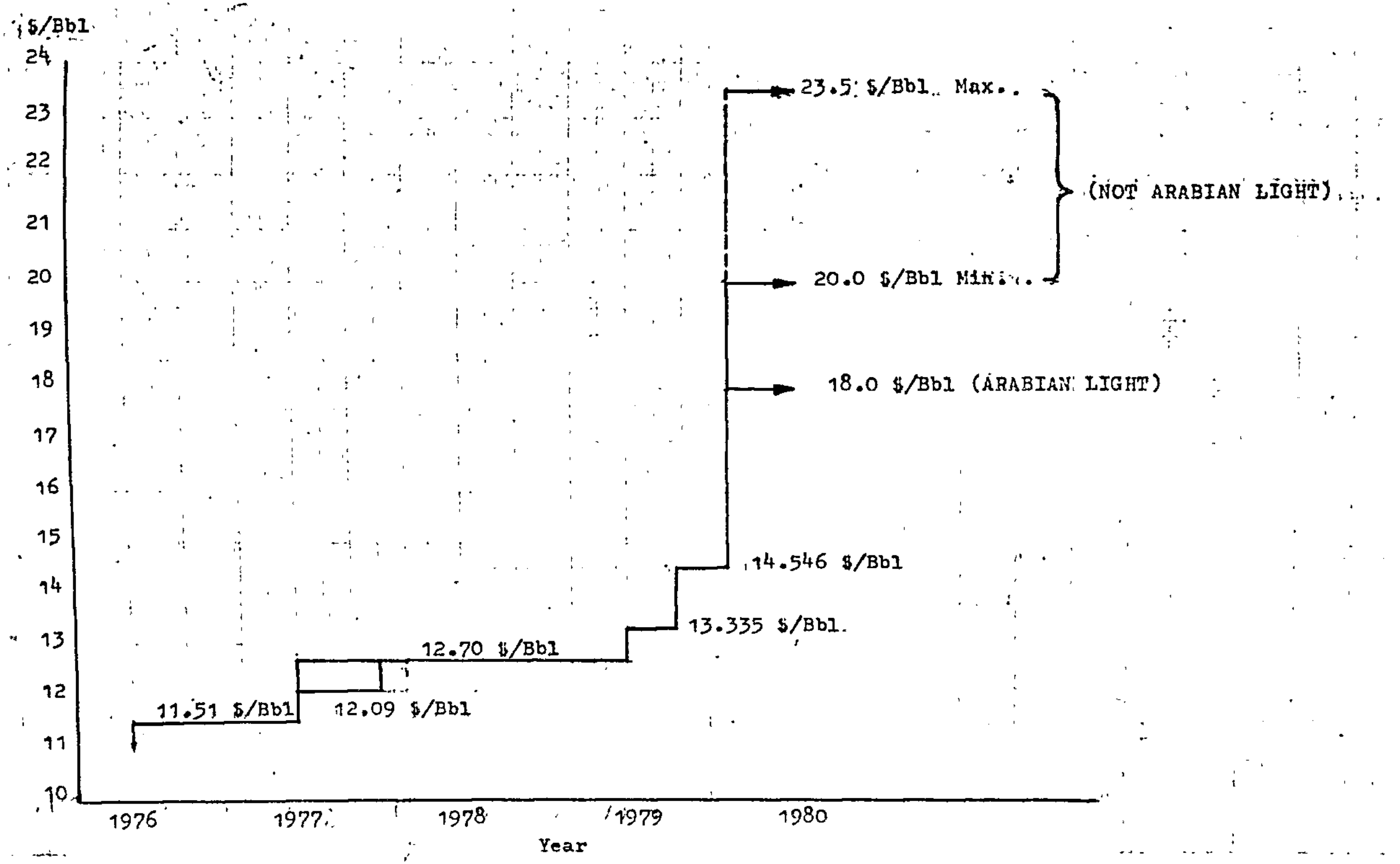
ATTACH. 23


(UNIT : US$/MT)
NOTE :
1) ++++; PROPANE
****; BUTANE
2) THE 1979 2ND QUARTER PRICES BELOW, OFFERED BY THE KUWAIT GOVERNMENT, ARE STILL UNDER NEGOTIATION.
US$150/MT
140
130
120
110
US$100/MT
1975
1976
1977
1978
1979
120(1/1/75)
119(7/1/75)
130(1/1/76)
110(1/1/76)
127 50 (10/1/76)
109(10/1/76)
129(7/1/77)
111(7/1/77)
131(10/1/76)
133(1/1/78)
130 50 (7/1/78)
128(10/1/78)
112 50 (10/1/78)
125 50 (1/1/79)
115 50 (1/1/79)
127 50 (4/1/79)
126 50 (4/1/79)

ATTACH.24

(MARKET PRICE, ARABIAN LIGHT, PER BBL)



	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:% or
	(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) C_3LPG 10^3 lb/H*1	(2) (1)x24 10^3 lb/D	(3) (2)x3.65*2 10^6 lb/Y	(4) (3)x21,647*3 BTU/lb Gross 10^6 BTU/H	(5) (2)x21,647 BTU/lb Gross 10^6 BTU/D	(6) (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

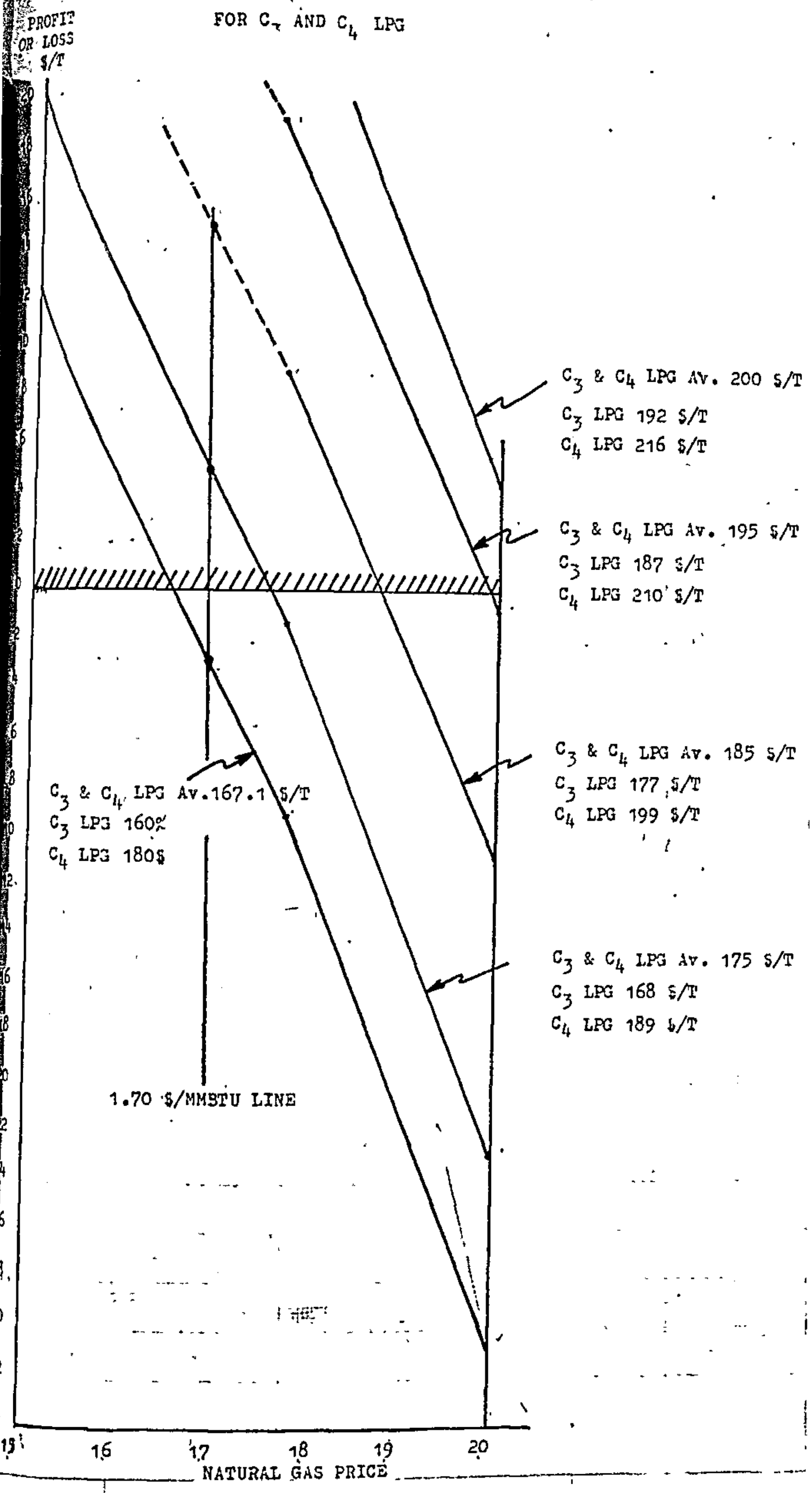
			\$/T
Charge Natural Gas	50.92 MMBTU/T	1.5 \$/10^6BTU	76.38
Operation Cost	(Investment 93.253 MM\$ - 385,090 T = 242,158 \$/T)		
Depreciation	5% on Investment		11.61
Interest for Investment	5% on Investment		11.61
Tax and Insurance	2% on Investment		4.65
Maintenance	3% on Investment		6.97
Administration	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

ATTACH.30

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



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PETROLEUM STATISTICS IN 1978

CONFIDENTIAL

June 11, 1979.

CONTENT

	page
CRUDE OIL IMPORTED BY COUNTRY OF ORIGIN 1978	1
PRODUCTION OF TOTAL FOUR REFINERIES IN 1978	2
FANG REFINERY PRODUCTION (1960-1969)	2[1]
PETROLEUM PRODUCTS IMPORTS IN 1978	3
PETROLEUM PRODUCT CONSUMPTION 1978	4
WHOLESALE PRICE OF PETROLEUM PRODUCTS AT REFINERIES AS CONTROLLED BY GOVERNMENT (INCLUDING TAX) (EXREFINERY PRICE)	5
RETAIL PRICE OF PETROLEUM PRODUCTS IN THE MUNICIPALITY OF BANGKOK	5
EXREFINERY PRICE WAS CHANGED ON MAY 1ST 1979	5[1]
PETROLEUM IMPORT PRICE (CIF PRICE)	6
PETROLEUM PRODUCT IMPORTS BY CO INTRY	7
PETROLEUM STOCK PILING BY LEGAS	8
SUBSIDY FOR SALES COMPANY	8
TANK CAPACITY	9
TANK INSTALLATION PLANNING	10
CRUDE OIL IMPORT VALUE	11
PETROLEUM PRODUCT IMPORT VALUE	11

CRUDE OIL IMPORTED BY COUNTRY OF ORIGIN 1978

	1978											
	Jan.	Feb	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Qatar	160	165	158	186	305	276	-	339	322	242	306	157
Kuwait	59	26	125	-	186	-	71	47	66	54	61	165
Abu Dhabi	-	81	-	117	-	157	105	234	84	88	81	-
Saudi Arabia	550	472	499	246	203	81	223	83	169	361	437	70
China	-	-	-	-	-	17	76	-	93	71	104	87
Iran	-	37	-	-	-	148	46	-	-	-	-	-
Iraq	-	-	-	-	-	105	-	-	-	-	-	-
Brunie	58	-	64	61	145	-	161	-	176	59	60	90
Darius	-	-	-	44	-	-	-	-	-	-	-	-
Singapore	-	-	-	-	-	-	-	8	11	-	-	-
Indonesia	-	-	-	-	-	-	-	-	-	-	-	-
Total	827	781	846	654	839	784	682	711	921	875	1,049	569

CRUDE OIL IMPORTED BY COUNTRY OF ORIGIN 1978

Unit : 10^3Kl

	1978													1979		
	Jan.	Feb	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Jan.	Feb.	Mar.
Qatar	160	165	158	186	305	276	-	339	322	242	306	157	2,616	386	92	257
Kuwait	59	26	125	-	186	-	71	47	66	54	61	165	860	55	111	183
Abu Dhabi	-	81	-	117	-	157	105	234	84	88	81	-	713	31	144	-
Saudi Arabia	550	472	499	246	203	81	223	83	169	361	437	70	3,545	229	299	381
China	-	-	-	-	-	17	76	-	93	71	104	87	531	83	55	94
Iran	-	37	-	-	-	148	46	-	-	-	-	-	231	-	-	-
Iraq	-	-	-	-	-	105	-	-	-	-	-	-	105	-	-	-
Brunie	58	-	64	61	145	-	161	-	176	59	60	90	874	66	65	64
Darius	-	-	-	44	-	-	-	-	-	-	-	-	44	-	-	-
Singapore	-	-	-	-	-	-	-	8	11	-	-	-	19	-	--	18
Indonesia	-	-	-	-	-	-	-	-	-	-	-	-	-	[illegible]	-	14
Total	827	781	846	654	839	784	682	711	921	875	1,049	569	9,538	850	766	1,011

data of 1979 are preliminary, subject to change.

PRODUCTION OF TOTAL FOUR REFINERY IN 1978

UNIT : KL

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
LPG	21,981	16,610	20,049	15,627	19,516	21,452	18,771	11,069	18,549	22,052	15,799	19,586	221,106
Gasoline Premium	116,313	97,194	93,036	79,324	110,896	101,071	100,552	92,497	107,845	103,741	90,370	87,163	1,180,007
Regular	80,289	72,369	77,079	79,186	69,468	71,593	74,766	58,371	75,060	64,932	83,073	81,924	888,110
Jet Fuel JP-1	50,806	50,580	57,749	63,181	65,818	67,967	63,493	43,231	69,776	77,216	49,528	61,483	720,828
JP-4	2,252	4,206	2,353	4,339	2,191	2,098	2,148	1,890	2,180	2,156	4,214	4,341	34,368
Kerosene	24,688	17,579	14,979	22,753	21,518	19,069	29,460	19,569	16,929	20,798	17,748	33,389	258,479
Diesel Oil HSD	246,734	229,567	167,883	138,315	229,933	[illegible]5,446	188,486	166,889	201,999	207,166	182,692	207,057	2,382,167
LSD.	10,291	9,323	11,898	14,919	9,114	10,191	12,241	6,546	15,990	10,950	12,[illegible]01	5,526	129,990
Fuel Oil	198,619	22[illegible],733	261,208	259,745	252,254	165,596	194,504	187,436	239,158	227,908	244,710	283,104	2,743,025
Bitumen	12,706	1[illegible],[illegible]15	13,534	12,251	14,942	2,389	2,881	2,306	2,116	2,886	706	1,267	81,301
Total	764,679	73[illegible],726	719,813	689,640	795,650	676,872	687,302	589,804	749,602	739,807	701,641	784,845	8,639,381

FANG REFINERY PRODUCTION (1960-1969)

Unit : 10^3 Kl

Year	Benzine	Kerosene	Diesel	JP-4	JP-1	Fuel Oil		LPG	Total
						Heavy	Light		
1960	0.4	-	-	-	-	1.4	4.1	-	5.9
1961	0.1	-	0.2	-	-	2.7	-	-	3.0
1962	0.1	-	-	-	-	0.4	1.1	-	1.6
1963	-	-	0.2	-	-	1.4	0.2	-	1.8
1964	18.1	19.4	138.1	7.3	74.2	121.9	0.001	1.5	380.5
1965	202.9	22.0	534.3	35.4	182.5	308.7	2.9	4.9	1,293.6
1966	327.2	33.2	733.9	64.1	163.4	591.3	9.6	9.5	1,932.2
1967	468.8	91.3	796.1	47.6	156.2	618.9	-	17.2	2,195.1
1968	480.9	152.7	888.8	4.9	185.4	866.7	-	34.6	2,614.0
1969	547.6	159.2	1,027.1	18.6	232.3	1,005.6	-	49.7	3,040.1

Note: In this period, Thailand had only one refinery.

PETROLEUM PRODUCTS IMPORTS IN 1978

Unit : Kl

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
LPG	9,442	2,052	1,552	1,053	-	2,173	6,419	4,954	7,639	8,759	9,351	18,069	71,463
Gasoline Premium	1,761	11,007	18,781	18,185	9,719	8,536	3,353	15,460	-	6,486	17,606	25,951	136,845
Regular	9,364	429	337	20,117	6,041	13,669	6,688	5,398	3,754	23,773	12,630	9,130	111,330
Jet Fuel JP-1	2,127	3,810	6,352	2,512	-	810	-	300	-	3,234	3,720	9,198	32,063
JP-4	-	-	-	-	-	-	-	-	-	-	-	-	-
Kerosene	253	206	236	236	201	280	-	227	478	469	268	-	2,854
Diesel Oil HSD.	66,134	87,079	125,313	44,560	167,574	100,100	41,774	214,437	95,087	131,438	120,196	145,012	1,338,701
LSD	-	-	-	-	-	-	-	-	-	-	-	4,790	4,790
Fuel Oil	63,514	57,646	84,709	79,255	125,483	184,866	67,314	55,007	70,590	14,870	31,442	18,069	852,765
Bitumen	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	152,595	162,229	237,280	165,918	309,018	310,434	125,545	295,783	177,548	189,029	195,213	230,219	2,550,811

PETROLEUM PRODUCT CONSUMPTION IN 1978
(Page 3 import plus page 2 production)

Unit : Kl

		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
LPG	Imp.	9,442	2,052	1,552	1,053	-	2,173	6,419	4,954	7,639	8,759	9,351	18,069	71,463
	Prod.	21,981	16,610	20,094	15,627	19,516	21,452	18,771	11,069	18,549	22,052	15,799	19,586	221,106
	Total	31,428	18,662	21,646	16,680	19,516	23,625	25,190	16,023	26,188	30,811	25,150	37,655	292,569
Gasoline Premium	Imp.	1,761	11,007	18,781	18,185	9,719	8,536	3,353	15,460	-	6,486	17,606	25,951	136,845
	Prod.	116,313	97,194	93,036	79,324	110,896	101,071	100,552	92,497	107,845	103,741	90,370	87,168	1,180,007
	Total	118,074	108,201	111,817	97,509	120,615	109,607	103,905	107,957	107,845	110,227	107,976	113,119	1,316,852
Regular	Imp.	9,364	429	337	20,117	6,041	13,669	6,688	5,398	3,754	23,773	12,630	9,130	111,330
	Prod.	80,289	72,369	77,079	79,186	69,468	71,593	74,766	58,371	75,060	64,932	83,073	81,924	888,110
	Total	89,653	72,798	77,416	99,303	75,509	85,262	81,454	63,769	78,814	88,705	95,703	91,054	999,440
Jet Fuel JP-1	Imp.	2,127	3,810	6,352	2,512	-	810	-	300	-	3,234	3,720	9,198	32,063
	Prod.	50,806	50,580	57,749	63,181	65,818	67,967	63,493	43,231	69,776	77,216	49,528	61,483	720,828
	Total	52,933	54,390	64,101	65,693	65,818	68,777	63,493	43,531	69,776	80,450	53,248	70,681	752,891
JP-4	Imp.	-	-	-	-	-	-	-	-	-	-	-	-	-
	Prod.	2,252	4,206	2,353	4,339	2,191	2,098	2,148	1,890	2,180	2,156	4,214	4,341	34,368
	Total	"	"	"	"	"	"	"	"	"	"	"	"	"
Kerosene	Imp.	253	206	236	236	201	280	-	227	478	469	268	-	2,854
	Prod.	24,688	17,579	14,979	22,753	21,518	19,069	29,460	19,569	16,929	20,798	17,748	33,389	258,479
	Total	24,941	17,785	15,215	22,989	21,719	19,349	29,460	19,796	17,407	21,267	18,016	33,389	261,333
Diesel Oil HSD	Imp.	66,134	87,079	125,313	44,560	167,574	100,100	41,771	214,437	95,087	131,438	120,196	145,012	1,338,701
	Prod.	246,734	229,567	167,883	138,315	229,933	215,446	188,486	166,889	201,999	207,166	182,692	207,057	2,382,167
	Total	312,868	316,646	293,196	182,875	397,507	315,546	230,257	381,326	297,086	338,604	302,888	352,069	3,720,868
LSD	Imp.	-	-	-	-	-	-	-	-	-	-	-	4,790	4,790
	Prod.	10,291	9,523	11,898	14,919	9,114	10,191	12,241	6,546	15,990	10,950	12,801	5,526	129,990
	Total	10,291	9,523	11,898	14,919	9,114	10,191	12,241	6,546	15,990	10,950	12,801	10,316	134,780
Fuel Oil	Imp.	63,514	57,646	84,709	79,255	125,483	184,866	67,314	55,007	70,590	14,870	31,442	18,069	852,765
	Prod.	198,619	228,783	261,208	259,745	252,254	165,596	194,504	187,436	239,158	227,908	244,710	283,104	2,743,025
	Total	262,133	286,429	345,917	339,000	377,737	350,462	261,818	242,443	309,748	242,778	276,152	301,173	3,595,790
Bitumen	Imp.	-	-	-	-	-	-	-	-	-	-	-	-	-
	Prod.	12,706	13,315	13,534	12,251	14,942	2,389	2,881	2,306	2,116	2,828	706	1,267	81,301
	Total	"	"	"	"	"	"	"	"	"	"	"	"	"
Total	Imp.	152,595	162,229	237,280	165,918	309,018	310,434	125,545	295,783	177,548	189,029	195,213	230,219	2,550,811
	Prod.	764,679	739,726	719,813	689,640	795,650	676,872	687,302	589,804	749,602	739,807	701,641	748,845	8,639,361
	Total	917,274	901,955	957,093	855,558	1,104,668	987,306	812,847	885,587	927,150	928,836	896,854	1,015,064	11,190,192

WHOLESALE PRICE OF PETROLEUM PRODUCTS AT REFINERIES AS CONTROLLED BY GOVERNMENT (INCLUDING TAXES)

(EXREFINERY PRICE)

Unit : ฿/lit

	1978												1979		
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
LPG (฿/kg)	3.3235	3.3235	3.3235	3.3235	3.3255	3.3255	3.3255	3.3255	3.3255	3.3255	3.3255	3.3255	3.3255	3.4018	3.4018
asoline Premium	3.6898	3.6898	4.4533	4.4533	4.4533	4.4533	4.4533	4.4533	4.4533	4.4533	4.4533	4.4533	4.4533	4.9599	4.9599
Regular	3.4389	3.4389	4.2024	4.2024	4.2024	4.2024	4.2024	4.2024	4.2024	4.2024	4.2024	4.2024	4.2024	4.5179	4.5179
et Fuel JP-1	2.4557	2.4557	2.4557	2.4557	2.4557	2.4557	2.4557	2.4557	2.4557	2.4557	2.4557	2.4557	2.4557	2.4733	2.4733
JP-4	2.2892	2.2892	2.2892	2.2892	2.2892	2.2892	2.2892	2.2892	2.2892	2.2892	2.2892	2.2892	2.2892	2.3160	2.3160
erosene	2.3971	2.3971	2.3971	2.3971	2.3971	2.3971	2.3971	2.3971	2.3971	2.3971	2.3971	2.3971	2.3971	2.5900	2.5900
iesel Oil HSD	2.3520	2.3520	2.3520	2.3520	2.3520	2.3520	2.3520	2.3520	2.3520	2.3520	2.3520	2.3520	2.3520	2.5018	2.5018
LSD	2.3097	2.3097	2.3097	2.3097	2.3097	2.3097	2.3097	2.3097	2.3097	2.3097	2.3097	2.3097	2.3097	2.4737	2.4737
uel Oil 450"	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
600"	1.6722	1.6722	1.6722	1.6722	1.6722	1.6722	1.6722	1.6722	1.6722	1.6722	1.6722	1.6722	1.6722	1.6966	1.6966
1,200"	1.6314	1.6314	1.6314	1.6314	1.6314	1.6314	1.6314	1.6314	1.6314	1.6314	1.6314	1.6314	1.6314	1.6356	1.6356
1,500"	1.6157	1.6157	1.6157	1.6157	1.6157	1.6157	1.6157	1.6157	1.6157	1.6157	1.6157	1.6157	1.6157	1.6157	1.6157
itumen (฿/kg)	1.2266	1.2266	1.2266	1.2266	1.2266	1.2266	1.2266	1.2266	1.2266	1.2266	1.2266	1.2266	1.2266	1.2724	1.2724

data of 1979 are preliminary, subject to change.

ETAIL PRICE OF PETROLEUM PRODUCTS IN THE MUNICIPALITY OF BANGKOK Unit : ฿/lit.

	Mar. 10, 1978	Jan. 31, 1979
soline Premium	4.98	5.60
Regular	4.69	5.12
rosene	2.68	3.06
esel Oil HSD	2.64	3.03
LSD	2.50	2.93
l Oil :		
400"	-	-
600"	1.66	1.86
1,200"	1.62	1.79
1,500"	1.61	1.77

June 1, 1979.

EXREFINERY PRICE WAS CHANGED ON MAY 1ST 1979

		No Tax	Excise Tax	Municipal Tax % on Excise Tax	฿/L Exrefinery Price
Gasoline	Premium	3.1528	2.2960	1	5.7418
	Regular	2.9047	2.0992	1	5.0249
Jet Fuel	JP-1	no price control			
	JP-2				
Kerosene		2.9284	0.2754	1	3.2066
Diesel Oil	HSD	2.7845	0.2727	1	3.0599
	LSD	2.7547	0.2637	1	3.0210
Fuel Oil	600"	2.0798	0.001	-	2.0808
	1,200"	1.9975	0.001	-	1.9985
	1,500"	1.9707	0.001	-	1.9717
LPG	฿/L	2.717	0.001	-	
	฿/Kg	4.6828	$\frac{(2.717 + 0.001) \times 4.9628}{2.719}$		4.9646
Bitumen	฿/Kg	1.74850	-	-	1.7485

RETAIL PRICE

The retail price was changed on January 31, 1979 (effective on February 1, 1979). Exrefinery price went up on May 1, 1979, but retail price did not change, so retail price is lower than exrefinery price. So, Thai Government decided to subsidize retail price since May 1, 1979, but now not yet enforced.

PETROLEUM IMPORT PRICE (CIF PRICE)

Unit : ฿/lit.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
LPG (฿/kg)	1.990	2.141	2.144	2.196	-	1.916	1.985	2.152	2.109	2.005	2.017	2.039
Gasoline Premium	2.545	2.514	2.513	2.483	2.481	2.417	2.443	2.487	-	2.404	2.486	2.531
Regular	2.328	2.294	2.282	2.187	2.203	2.156	2.147	2.660	2.165	2.395	2.124	2.166
Jet Fuel JP-1	2.385	2.264	2.236	2.230	-	1.981	-	3.523	-	2.277	2.253	2.266
JP-4	-	-	-	-	-	-	-	-	-	-	-	-
Kerosene	2.269	2.272	2.292	2.297	2.299	2.290	-	2.304	2.268	2.330	2.295	-
Diesel Oil HSD.	2.138	2.109	2.133	2.084	2.108	2.099	2.026	2.169	2.057	2.209	2.128	2.124
LSD.	-	-	-	-	-	-	-	-	-	-	-	2.247
Fuel Oil	1.555	1.577	1.613	1.549	1.586	1.549	1.541	1.529	1.471	1.493	1.491	1.489
Bitumen	-	-	-		-	-	-	-	-	-	-	-

PETROLEUM PRODUCT IMPORTS BY COUNTRIES 1978年

Unit : Kl

Petroleum Prod. \ Countries	Singapore	Taiwan	China	Indonesia	Srilanka	Hongkong	Japan	Korea	Australia	Bahrain	Kuwait	Iran	Yemen	South AFC	Total
LPG	46.306							3.394	2.893					1.829	54.422
Gasoline Premium	72.325	33.940					5.402								111.667
Regular	9.986	56.645													66.631
Jet Fuel JP-1	24.260														24.260
Diesel Oil HSD	547.485	284.593	3.808			3.150	7.180		23.253	119.510	72.984				1,061.963
Fuel Oil	474.313			108.327	27.118						19.825	83.949	54.666	19.936	788.134
Total	1,174.675	375.178	3.808	108.327	27.118	3.150	12.582	3.394	26.146	119.510	92.809	83.949	54.666	21.765	2,107.077
	55.7%	17.8%	0.2%	5.1%	1.3%	0.2%	0.6%	0.2%	1.2%	5.7%	4.4%	4.0%	2.6%	1.0%	100%

June 8, 1979.

I PETROLEUM STOCK PILING BY LEGAL.

Buying : Crude Oil and Product 5% - 20%

Refining Products : 5% - 20%

Petroleum products for [redacted] are 20%, other are 5%.

The refinery submit the document for petroleum stock piling to the Ministry of Commerce and have to get approval from him.

II SUBSIDY FOR SALES COMPANY (see page 5 and 5[1])

Reduce ↓ / Extra ↓

Gasoline tax 0.125 ฿/lit <u>For refinery</u>

↓ Subsidy for other products

<u>Sales Company</u>

Subsidy 0.088 ฿/lit for domestic refined products except gasoline. Subsidy for import products except gasoline has to change depend on import price.

TANK CAPACITY (As May 1979)

Refinery	Crude Oil 10^3Kl	Gasoline 10^3Kl	Jet Fuel 10^3Kl	Kerosene 10^3Kl	Diesel Oil 10^3Kl	Fuel Oil 10^3Kl	Total 10^3Kl	%
TORC	530	103	55	11	134	67	900	34.1
SUMMIT	675	78	1	49	178	255	1,249	47.3
ESSO	361	-	15	10	60	44	490	18.6
10^3Kl	1,566	181	84	70	372	366	2,639	
%	59.3	6.9	3.2	2.6	14.1	13.9		100%

TANK INSTALLATION PLANNING

	(1) Crude Thruput Kl/SD	(2) Import Products Kl/CD	(3) Total (1)+(2) Kl/D	(4) Total Tank Capacity Kl	(5) Holding Days (4) ÷ 3 days	(6)** Petroleum Stock Piling (5) ÷ 2 days	(7) Petroleum Stock Piling By Law days	(8) Deficit Stock Piling days	(9) New Instration Tank Kl	Remark: New Tank Installation Expected Schedule			
										100,000 Kl or Tank	50,000,Kl or Tank	30,000 Kl or. Tank	10,000 Kl Tank
1977	29,269	4,456	33,725	2,639,000	78	39	60	21	-				
1978	29,545	6,989	36,534	"	72	36	60	24	-				
1979	29,269	13,896	43,165	"	61	30	60	30	-				
1980	29,269	18,877	48,146	3,852,000*	80	40	60	20	1,213,000	12	24	40	121
1981	29,269	20,693	49,962	4,996,000	100	50	60	10	1,144,000	11	23	38	114
1982	29,269	24,082	53,351	6,402,000	120	60	60	0	1,406,000	15	28	47	140
1983	58,548	-	58,548	7,611,000	130	65	65 } Assume	0	1,209,000	12	24	40	121
1984	57,491	-	57,491	8,049,000	140	70	70 } Assume	0	438,000	4	9	15	44
1985	64,127	-	64,127	9,619,000	150	75	75 } Assume	0	1,570,000	16	31	52	157
1986	69,881	-	69,881	10,482,000	150	75	75 } Assume	0	860,000	9	17	29	86

Note : * Thailand can install tanks from 1980, in 1979 can not.

** Petroleum stock piling is average inventry, so (5) devided 2.

June 7, 1979.

CRUDE OIL IMPORT VALUE

Unit: 10^6 ฿

	1978													1979		
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Jan.	Feb.	Mar.
Value	1,422	1,351	1,456	1,127	1,452	1,333	1,136	1,194	1,555	1,474	1,770	953	16,222	1,524	1,402	1,820

PETROLEUM PRODUCT IMPORT VALUE

Unit: 10^6 ฿

	1978												
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Value	252	316	470	314	590	551	211	580	329	195	380	439	4,627

(F)

April 1, 1979.

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

Dear Mr. Tammachart,

Re: OIL SHALE

(TRANSLATED INTO ENGLISH FROM "PETROTECH"
OF THE JAPAN PETROLEUM INSTITUTE)
AUTHOR: MR. MINORU ENOMOTO
NATIONAL RESEARCH INSTITUTE
FOR POLLUTION AND RESOURCES

I present you Mr. Minoru Enomoto's paper subjected "OIL SHALE" which I translated into English during the holiday. Some engineers in NEA and Ministry of Industry have interested in oil shale, so I want to deliver this translated paper to the above gentlemen. I request your permission.

(1) Oil shale reserves in Thailand

800,000 Bbl (Equivalent crude oil)

When Thai refinery capacity is 1,000,000 BPSD, and 20% of crude oil is replaced by shale oil, Thailand can be used 11 years.

800,000,000 Bbl ÷ (1,000,000 BPSD x 20%) = 4,000 days
= 11 years

1,000,000 BPSD crude thruput will be in 2000.

(2) Quality of Thai oil shale is very high.
(see ATTACHED information)

	Colorado	Thailand
Oil Recovery	10.7	20.1

I appreciate if it would be useful for you.

Sincerely yours,

Y. Kawase

OIL SHALE

TRANSLATED INTO ENGLISH FROM "PETROTECH"
OF THE JAPAN PETROLEUM INSTITUTE
(PUBLISHED ON SEPTEMBER 1978)

AUTHOR: MR. MINORU ENOMOTO
NATIONAL RESEARCH INSTITUTE
FOR POLLUTION AND RESOURCES

CONTENTS

I HISTORY OF OIL SHALE 1

II OIL SHALE RESOURCE 1

III THE SITUATION OF DEVELOPMENT 5

III.1 Mining 5

III.2 In Situ Retorting 6

III.3 Distillation on The Ground 7

III.3.1 TOSCO II retort system 9

III.3.2 Paraho retort 10

III.3.3 Petrosix process 12

III.3.4 GGS (Gas Generator Shaft) 13

IV CHARACTERIZATION OF SHALE OIL 14

V REFINING OF SHALE OIL 15

VI THE POINT AND PROSPECT OF DEVELOPMENT 16

ATTACHMANT ATTACH.1

Fig.1 Oil Shale Ore 2

TABLE 1 COMPOSITION OF OIL SHALE ORE 3

TABLE 2 RESERVES OF MAJOR PRODUCTION COUNTRY 4

TABLE 3 FEATURE OF TYPICAL RETORT 8

Fig.2 Tosco II process 10

Fig.3 Paraho retort 11

Fig.4 Petrosix and process flow diagrams 12

Fig.5 Gas generator with the cross-flow heat carrier 13

TABLE 4 CHARACTERIZATION OF PRODUCED OIL AND BY-PRODUCT GAS ... 14

TABLE 5 EXAMPLE OF SYNTHETIC CRUDE 16

CONTENTS

ATTACHMENT ATTACH.1

I HISTORY OF OIL SHALE

Fig.1 Oil Shale Ore 2

II Oil SHALE RESOURCE

TABLE 1 COMPOSITION OF OIL SHALE ORE 3

III THE SITUATION OF DEVELOPMENT

TABLE 2 RESERVES OF MAJOR PRODUCTION COUNTRY 4

TABLE 3 III.1 NATURE FEATURE OF TYPICAL RETORT 5 8

III.2 In Situ Retorting 9

Fig.2 Tosco II process

III.3 Distillation on the Ground 10

Fig.3 Paraho retort

III.3.1 TOSCO II retort system 11

Fig.4 III.Petrosix and process flow diagrams 12

Fig.5 III.3.2 Petrosix process

Gas generator with the cross-flow heat carrier 12 13

III.3.4 GGS (Gas Generator Shaft) 13

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VI THE POINT AND PROSPECT OF DEVELOPMENT 16

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II

OIL SHALE

TRANSLATED FROM "PETROTECH" OF THE JAPAN PETROLEUM INSTITUTE

AUTHOR: MINORU ENOMOTO
National Research Institute
for Pollution and Resource

I HISTORY OF OIL SHALE

History of oil shale is very old and for the first, the patent which shale oil is recovered by heating was submitted in England in 1964. Shale oil was recovered by improved process of English patent in France in 1938, then in Scotland in 1850. They had been operated before the crude oil discovery in USA in 1859. Then small scale of shale oil production is commenced in Australia in 1865, Brazil in 1881, New Zealand in 1900, Switzerland in 1915, Sweden in 1921 and Estonia in 1921.

But these countries suspended shale oil production, because oil fields were discovered in all over the world and cheap oil was produced according to the promotion technics of exploitation and production especially in USA. But shale oil production has been continued in Estonia (USSR) and Fushun (Red China).

As well-known fact, in 1973, crude oil price was increased for 3 eimes in advance, so promoted countries faced the crisis. For the reason, development of substituted resources for crude oil has been accelerated. It is possible to compete with utilization of coal and oil shale which are placed at a disadvantage in cost compared with crude oil. Especially, USA abounded of crude oil resource, but in present state of affairs crude oil reserves are going down, a stand point of self-supply energy, SNG production from coal and synthetic oil from oil shale are highlighted again.

Japan has not a lot of energy source himself, so a view point of having various energy source, Japan is studying about coal, solar energy, subterranean heat, tar sand and oil shale (but Japan has no tar sand and oil shale).

II OIL SHALE RESOURCE

According to Duncan's definition[2] of the oil shale, the oil shale

[illegible]

is shale which has minute structure and contains of organic matter which is much different by region, and oil is produced from shale by pyrolysis. The origin is various according to produced areas, but mostly remains of fresh-water weed and seaweed would be pile up in the mud, and formed oil shale.

Color of oil shale is black, brown, grey, yellow or orange according to production area, in many cases thin layers are heaped up and constructed accumulated layer. Photograph of Fig.1 shows Thailand oil shale in the right hand side and American oil shale in the left hand side.

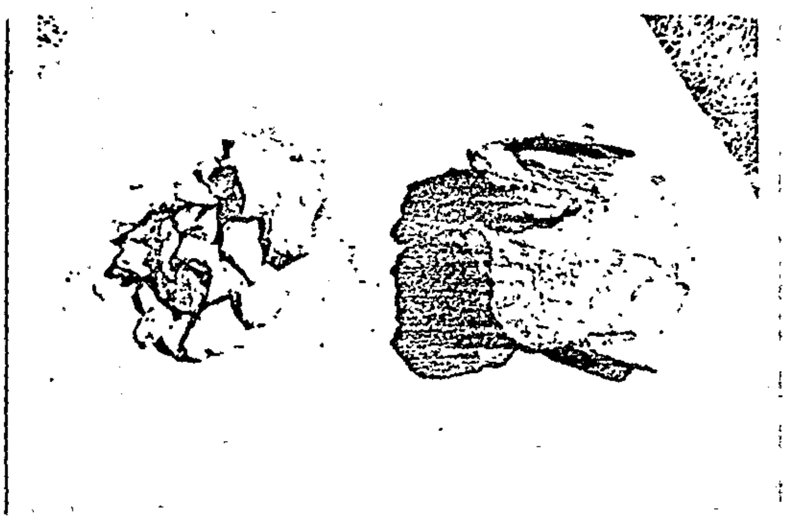

Fig.1 Oil Shale Ore

As shown on TABLE 1, kerogen (organic matter) content is big different[3] in accordance with production area. A stand point of the industry, shale which 10~15 gal/ton oil can be produced by pyrolysis is regard as oil shale. C/H ratio of kerogen is 7~8 and bituminous coal is 13~15, so kerogen has double hydrogen compared with bituminous coal. It means that oil production from oil shale is easier than from coal by pyrolysis.

Reserves of oil shale are not perfectly investigated, and its reserves is big changed with oil content range which would be considered as oil shale. TABLE 2 shows Bureau of Mines data which was presented in 1965[4].

TABLE 1 COMPOSITION OF OIL SHALE ORE

	Oil Shale Raw Ore (wt%)					Kerogen (wt%)				
	Organic Carbon	Total Nitrogen	Total Sulfur	Ash	Inorganic CO_2	Oil gal/t	Organic Carbon	Organic Hydrogen	Ash	C/H
Alaska	53.86	0.30	1.50	34.1	0.1	139.0	83.28	11.48	1.5	7.3
Argentina	8.88	0.26	0.48	82.6	4.5	14.2	51.66	6.60	34.9	7.8
Australia	81.44	0.83	0.49	4.4	0.1	200.0	83.58	10.69	1.7	7.8
Brazil	12.79	0.41	0.84	75.0	0.6	17.8	64.88	8.52	12.5	7.6
Canada	7.92	0.54	0.70	84.0	2.4	9.4	54.78	5.57	33.4	9.8
Colorado (USA)	12.43	0.41	0.63	65.7	18.9	27.7	66.38	8.76	12.9	7.6
France	22.25	0.54	2.32	66.3	8.4	25.0	70.47	6.45	17.7	10.9
New Zealand	45.69	0.78	4.79	32.7	0.1	66.2	63.89	7.48	9.9	8.5
Oregon (USA)	25.83	0.51	2.20	48.3	0.2	48.0	47.32	6.00	36.2	7.9
Scotland	12.33	0.46	0.73	77.8	3.2	22.2	67.61	7.62	18.6	8.9
South Africa	52.24	0.84	0.74	33.6	0.9	99.8	81.14	9.12	1.3	8.9
Spain	26.01	0.55	1.68	62.8	2.3	46.9	61.08	7.04	26.0	8.7

TABLE 2 RESERVES OF MAJOR PRODUCTION COUNTRIES

Countries or Region	Equivalent Crude Oil (MM Bbl)
Argentina	400
Australia (inc. Tasmania)	270
Brazil	800,000
Balkan and Middle Europe	340
Burma	2,000
Canada	50,000
Chile	20
China	28,100
England	1,000
France	425
West Germany	2,000
Israel	20
Jordan	45
Sicily	35,000
Luxembourg	700
New Zealand	560
Congo	100,000
Republic South Africa	130
Scotland	580
Spain	280
Sweden	2,500
Thailand	800
USA	2,200,000
USSR	,
Estonia and Leningrad	22,000
Other European Russia	13,000
Siberia	80,000
Total	3,340,000
	(658,193)*

Note:* Crude oil reserves as Jan. 1, 1976.

In TABLE 2, total shale oil which would be produced from more than 10 gal/t contained oil shale. Oil shale reserves are existed all over the world, but crude oil and oil sand reserves are omnipresent. USA has the biggest reserves of oil shale, the next is Brazil and the third is USSR. Total oil shale reserves is 530,000 MM KL equivalent crude oil, as compared with 90,000 MM KL crude oil reserves, it is almost 6 times. The literature[5] said that oil shale reserves which is including undiscovery but anticipatory resource of oil shale is 54,000,000 MM KL equivalent crude oil all over the worl. In any event, enormous resource of oil shale is distributed certainly all over the world.

III THE SITUATION OF DEVELOPMENT

III.1 Mining

According to oil shale deposit, there are the surface and the underground mining and moreover an in situ retorting has been studied mainly in USA.

Green River formation which stretches over Colorado, Utah and Wyoming is 44,000 Km^2, and has oil shale deposit which can be produced 600,000 MM bbl equivalent crude oil.[6), 7)] Mahogany zone which is along the famous Colorado Valley has deposit of 30 gal/t, and the deposit being in existence above 500 m depth from the ground surface, so experimental digging which is the room and pillar method has been operated from 1946.[8)]

It was reported that 2,730 t oil shale was produced in Estonia region of USSR in 1967, and a half of them was produced by the surface mining, and another half by the room and pillar method.[9)]

At Irati formation which is located in Parana Province, Brazil, is covered by 30 m thickness soil, so after covered soil is taken off, the surface mining is carried out and 2,200 t/day shale is retorted by Petrosix process.

In fusion (China) of former Manchuri, the surface mining of coal was carried out, but 5,400 MM t oil shale is accumulated above the coal layer. For the coal surface mining, oil shale must be taken off. The oil content of oil shale is only 6%, so it is poor ore, but the cost of oil shale mining must be included in the cost of coal mining, consequently the cost of

oil shale mining is for nothing, furthermore spent oil shale can be used as filler for hole of coal mining.[11] Just after the 2nd world war, Manchuri was taken over by China, and China continues the oil shale mining.

In USA, oil shale deposit is comparatively deep from the surface of the earth, hence the cost of mining is high and the restoration of minining hole by the spent oil shale is required much money. And a stand point of environment destruction the in situ retorting would be advantage if efficiency of oil recovery was going on effective. In USA, Bureau of Mines, Sinclair oil and other companies have been developed the in situ retorting about 20 years ago.

III.2 In Situ Retorting

The oil shale deposit is artificially fractured by high pressure air,[12] hydrolic power,[13] electric current,[14] detonator,[15] and nuclear explosion,[13] and fractures is successful in opening passages for gas flow, then dry distillation is carried within fractures by combustion of fuel gas or heated hot gas. Sinclair[39] process which was developed in 1953 was fractured by high pressure air, but gradually passages of gas flow was becoming difficult.[12] Bureau of Mines study many processes[38] how to make good passages for gas flow, the study carried out by using oil shale deposit model from nearly 1960. As the result of the study, the best way is that at first the deposit was drilled, then cracks along the oil shale formation were made by electric current, then cracks are expanded by high pressure air, after that explosive compound was filled up in cracks and passages for gas were made by explosion.[16] Study of nuclear explosion is the cheapest way for huge scale fracture but radio-active contamination of the earth and water is indispensable and kerogen may be decomposed into hydrogen and carbon according to very high temperature.[17]

Recently, the most powerful process is RISE PROCESS. At first, a conventional horizontal tunnel is made and volume of the tunnel is about 20% of the ore deposit, then the ore bed of above tunnel is crushed by explosion, according to explosion 20% of passages for gas are made.[18] In this case, oil shale which is come out by digging the tunnel is dry distillated on

the ground. Nevertheless 6 ~ 9 $/Bbl oil is expected to produce from oil yield 20 gal/t ore which is in 400 ft thickness ore deposit. Occidental Petroleum Company has conducted similar RISE PROCESS[19] since 1972. Other process, Equity Oil[37] has made field test of the in situ retorting by using steam through natural passages of gas since 1968, and Bureau of Mines has made the field test[20] of same way since 1970, but there are still experimental stage. Till the in situ distillation is commercial operation, technics of making uniform size of oil shale and uniform passages of gas should be developed, and improvement of product yield by the in situ distillation and effective rate of mining of reserves resource and other technics should be desolved.

III.3 Distillation on The Ground

Until a recent date, reliable oil recovery process from oil shale is pyrolysis of ore on the ground. Experiments of kerogen extraction by solvent was tested. For instance, Thomas used 14 Kg/cm^2.G CO_2 for elimination of Ca, Mg, Fe, Al and other matals from Colorado oil shale, and kerogen was concentrated, ash was decreased to 3%.[21] Same purpose, acetic acid, HCI, HF and etc. were used.[22] Vitorovic and others tested an extraction of kerogen by using several organic solvents from Yugoslavian oil shale, and they reported that the most effective solvents were cyclohexanol (extraction rate 38.6%), aniline (52.6%), tetraline (32.1%).[23] But, the solvent which can extract 98% yield has not been discovered at present, so the best way for recovery of organic matter from ore is pyrolysis for the time being.

Guthrie[24] enumerated that retort fulfils as following conditions: (1) continuous operation (2) bigger retorting capacity (3) Process energy should be self-supplied by perfectly recovery of waste heat and chemical energy (4) initial cost should be lower (5) operation should be more simple and easier (6) consumption water should be smaller (7) wide range of ore grain diameter could be used efficiently (8) no pollution. Among these conditions, (7) is expecially important, the most suitable size to be retorted is selected from crushed oil shale for the purpose of stable operation, hence the smaller size grain must be retorted by another way. When process of powdered oil shale retorting is applied, cost of energy for

TABLE 3 FEATURE OF TYPICAL RETORT

		Country	Retort Type	Heat Carrier	Diameter of Grain	Pyrolysis Temp. °C	Operation	t/day/unit	Reference
1	NTU retort	USA	Vertical Cylinder	Flue Gas	-	-	-	-	16)
2	U.S.B.M gas combustion retort	"	"	"	1/4 in.	ca 800	1940 ~ 1950	150	16), 35)
3	Union Oil retort								16)
	a) "A"	"	"	"	1/8 in.	-	1957 ~ 1958	1,200	16)
	b) "B"	"	"	Circulation Gas	"	"	"	-	16)
	c) SGR retorting system	"	"	"	"	"	1975 ~	1,500 (schedule)	16)
4	Paraho retorting process	"	"	Fuel Gas (and Circulation Gas)	1/2~3in.	-	1973 ~ 1975	400	6), 26)
5	TOSCO II retorting system	"	Rotary	Ceramic Ball	~1/2 in.	510 - 640	1972	1,000	25), 6)
6	Lurgi-Ruhrgas process	Germany	Screw	Waste Shale	1/4~1/3in.	ca 550	1963	20	16)
7	Petro SIX process	Brazil	Vertical Cylinder	Circulation Gas	-	< 400	1970 ~	2,200	28), 29)
8	GGS retort	USSR	"	(Flue Gas Producer Gas)	-	ca 800	New Operating	20 ~ 185	30), 9)
9	Chamber oven	"	Vertical Chamber	Flue Gas (Shell heating)	-	ca 800	"	500~1,000	30), 9)
10	UTT retort	"	Rotary	Waste Shale	Powder-Grain	Oil 470-520	1960 ~	500	9)
11	Fushun dry distillation Furnace	China	Vertical Cylinder	(Flue Gas Producer Gas)	20 ~ 50 (mm)	ca 550	1939 ~	200	11)

crusher would be higher, and when spent oil shale is thrown away, it is the problem that spent oil shale is scattered.

Types of retort are (1) vertical cylindrical vessel type (2) rotary kiln type (3) screw furnace type (4) chamber oven type. And heating methods are (a) internal combustion method (b) external combustion method (c) combination of (a) and (b). And heat carriers for heating are classified into: (A) flue gas (B) circulation gas (C) solid heat carrier. At present, more than 10 kinds of retort which are combination of the above mentioned retort type, heating method and heating carrier are used as commercial size plant or test plant. These retorts are listed up in TABLE 3. Four kinds of typical retort which have actual result are explained as follows:

III.3.1 TOSCO II retort system[6), 16), 25)]

After Oil Shale Corp. tested for 24 t/day pilot plant, Standard Oil and other one company organized Colony Development, and he installed 1,000 t/day plant at Parachute Creek of Piceance Basin, and operated till 1967. Then Atlantic Richfield joined with him and 1,000 t/day field test had been carried out till 1972. Fig.2 shows flowsheet of field test.

A rotary kiln utilizing ceramic balls heated in external equipment accomplished the retorting. Conventionally mined oil shale is crushed to ½ in or less, and is preheated and pneumatically conveyed through vertical pipes by hot flue gases from the ball heater. The preheated shale enters the retort (rotary kiln) simultaneously with the heated balls, retorting the oil shale at a temperature of about 900°F (482°C). The mixture is then passed over a trommel screen to separate the balls for recycling through the ball heater, and the processed oil shale is cooled and compacted as a land fill with subsequent revegetation. Compared to the other above surface processes, the TOSCO II process is highly developed and offeres advantages of high oil yield and a product gas undiluted by products of combustion.

Oxygen does not come in the retort, so oxydized products are very small, and liquified hydrocarbon yield is 99%. Whole oil shale which is less than ½ in size can be retorted, but

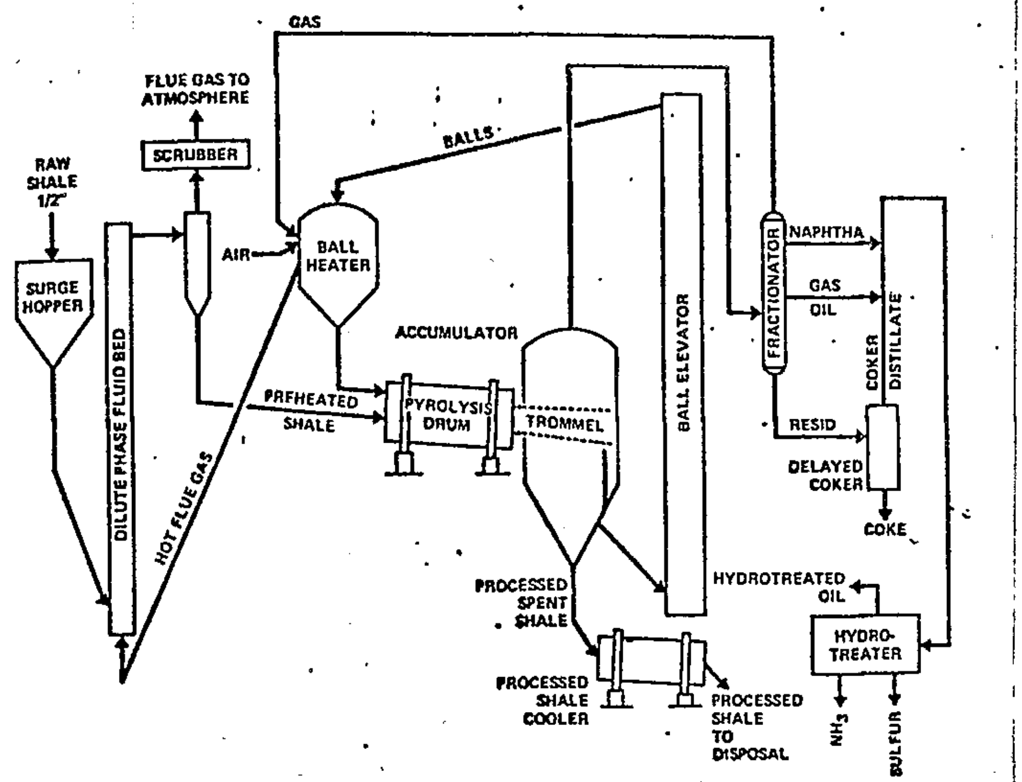

Fig. 2—Tosco II process.

it has a defect of very high cost of crushing, and the plant is very complicated and movable parts are too much so many troubles are come out and ceramic balls are worn out.

III.3.2 Paraho retort[6), 26)]

In USA, oil shale retortings on the ground were developed by individual organization for several years ago. Afterward, the Paraho project, a joint venture with 17 industry sponsors of energy and engineering companies, has been formed to test a modified vertical kiln retorting technics at the government Anvil Points experimental facilities in 1974 and the test plant capacity is 400 t/day.

The novel feature of the Paraho patented technology is the injection of combustion air at more than one level within the bed of shale in a counter-flow vertical kiln (Fig.3). This feature is said to permit control of the time-temperature relationship during retorting and also permits lower maximum bed temperatures than would otherwise be necessary. Except for the multiple zones for combustion, the process closely

resembles the gas combustion process developed by the US Bureau of Mines.

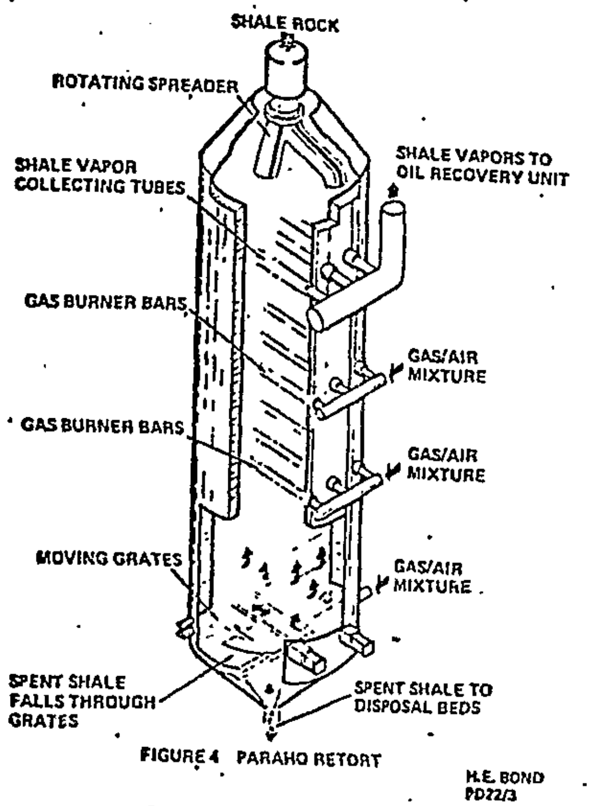

Fig. 3—Paraho retort.

Fig.3 shows that gas and air mixture is sent to the retort from separated three spots which are located below the middle of kiln and flue gas is contacted with shale counter current as the above mentioned. The upper gas burner produce high temperature combustion gas for pyrolysis, the middle gas burner is for recovery chemical energy of burning carbon which is produced in pyrolysis zone, gas and air mixutre which is injected to lower is recovered latent heat of spent shale. Grates of bottom for discharge of spent shale and separated into 3 gas burners system are patents of Paraho, but detail mechanisms are unknown. Shale size is wide range of ⅜ – 3 in, but powder which is less than ⅜ in can not be retorted, so it must be retorted by another process. The process is the internal combustion, thus heat value of by-product gas is very low. The gas is only used as own (processing) fuel. Therefore, the external combustion process is studying at the same time. It is said that 11,500 t/day test plant which is based on the result of 400 t/day plant is planning.

III.3.3 Petrosix process[28), 29)]

Petrobras, Brazil, installed and is operating the semicommercial plant of 2,200 t/day. The charge stock of oil shale is produced from Irati formation near state of Parana, Brazil. From the semicommercial plant 1,000 bbl/day oil, 36,500 m^3/day of fuel gas, 17 t/day of sulfur and ammonia are produced. Fig.4 is shown the process flow diagrams. The process is very similar to Paraho retort construction but it is different that circulating gas is heated outside. The feature of external combustion process is that pyrolysis is carried out in reducing atmosphere so good quality of oil which is not contained oxydized products is available, and by-product gas has high alorie, but carbon on the spent shale is not recovered and powdered oil shale is difficult to retorting.

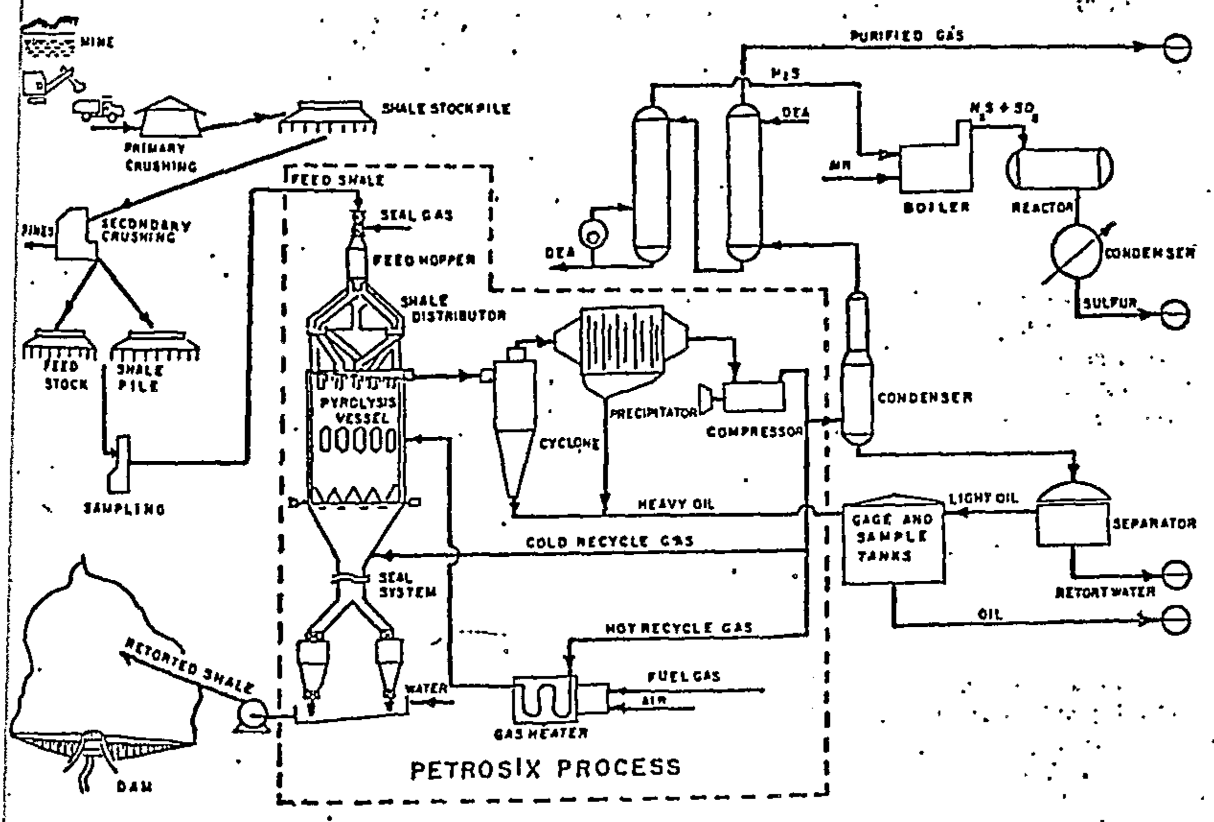

Fig.4—Petrosix and process flow diagrams.

III.3.4 GGS (Gas Generator Shaft)[9), 30)]

In Estonia, USSR, there have been industries which are utilized oil shale for long years ago. Oil shale is still used for town gas manufacturing and electric power generation. Oil shale utilization in Estonia side was 18,000,000 t and in Soviet side was 5,500,000 t in 1970.[9)] As the retort is mainly GGS chamber oven type and 60% of total oil shale is retorting by GGS. Contents of organic matter in Estonia oil shale is 31-36%, therefore powdered oil shale is directly fired for boiler of electric power station, and fly ash is utilized for cement and building materials.

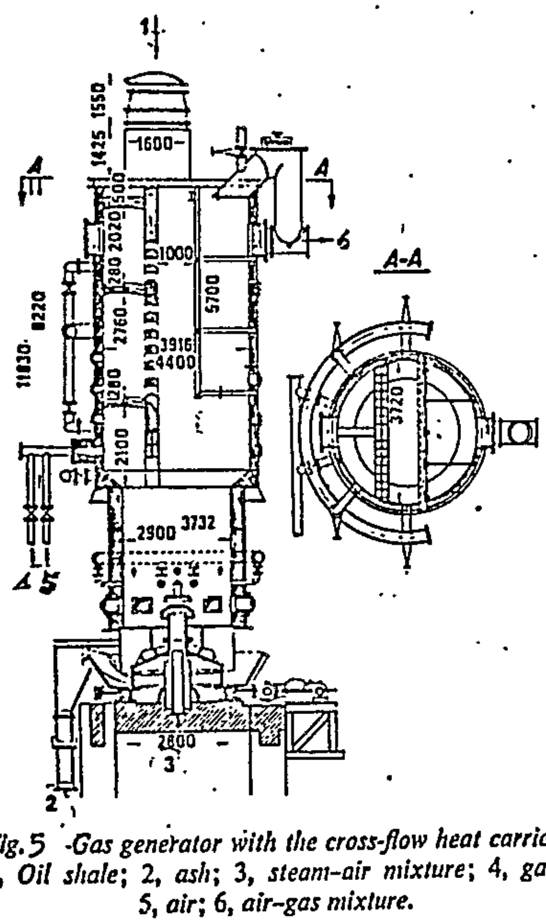

Fig.5 -Gas generator with the cross-flow heat carrier. 1, Oil shale; 2, ash; 3, steam-air mixture; 4, gas; 5, air; 6, air-gas mixture.

GGS process is shown in Fig.5. Oil shale is continously charged from the top, and spent oil shale is discharged from the bottom. Air and fuel gas mixture burns in combustion chamber which is located in the middle, and the flue gas is sent to 2 parts of retort, and the flue gas and oil shale are cross-flow, and the pyrolysis is carried out at about 800°C. Carbon on high temperature spent ash is recovered as water gas by air and steam. The process is very similar with Fushun retort

(in red China) which was installed by Japan. This process is internal combustion process, so heating value of gas is low about 1,000 Kcal/m^3 and oil yield is 15 - 16% on charged oil shale and 26 ~ 31% of oil is phenols.

IV CHARACTERIZATION OF SHALE OIL

Characterizations of produced oil and by-product gas from 2 kinds of retort are shown in TABLE 4.

TABLE 4 CHARACTERIZATION OF PRODUCED OIL AND BY-PRODUCT GAS

	B.M. Gas Combustion Process[36)]	TOSCO II[34)]
Oil		
Specific Gravity ($60^{\circ}F/60^{\circ}F$)	0.927	0.927
Pour Point ($^{\circ}C$)	29.4	27
Viscosity (cSt)($38^{\circ}C$)	18.5 ($54^{\circ}C$)	22
Elementary Analysis wt%		
C	—	85.1
H	—	11.6
N	2.11	1.9
O	-	0.8
S	0.68	0.9
Oil Recovery %	86.2	100
ASTM Distillation		
IBP $^{\circ}C$	184	<93
10 %	258	135
30 %	352	260
50 %	431	
Gas		
Composition vol%		
O_2	0.2	—
N_2	62.2	—
CO	2.6	2.88
CO_2	25.2	14.33
H_2	4.3	33.65
H_2S	-	2.50
Hydrocarbon	5.5	46.63
Heating value (Kcal/Nm^3)	1,089	7,275

Characterization of produced oil and gas are changed according to dry distillation temperature, atmosphere of heat carrier and different kinds of oil shale. In case of internal combustion process, oxygen comes in the system so phenols and oxidized organic matters are much, and polymerization is carried out accordingly produced oil is heavier (Bureau of Mine Gas Combustion Process). In case of external heating of circulation gas, it is in reducing atmosphere so oxygen and nitrogen is small in the produced oil but carbon on the spent ash and latent heat of it are difficult to recover (TOSCO II).

Characteristics of Khafji crude are as follows: specific gravity is 0.886, pour point is -12.5°C, viscosity is 12.4 cSt (50°C), ASTM distillation test is Initial Boiling Point (IBP) 26°C, 10% 114°C, 30% 239°C and sulfur content 2.9%. Comparison with Khafji crude and produced oil from oil shale is as follows: Produced oil from oil shale is (1) high pour point (-4 ~ 34°C), (2) high nitrogen content (1 ~ 2%), (3) high oxygen content (about 1%), (4) high IBP (100°C), (5) low metal content (example of USA[9]: Ni 6.4%, V 6.0%, Fe 108.0 ppm).

V REFINING OF SHALE OIL

Produced shale oil is distillated by atmospheric distillation unit (topping unit), but sulfur content of each distillate is very high, because sulfur content of shale oil is very high, for instant USSR shale oil is contained of 2-3% sulfur and about 1% nitrogen,[32] so sulfur and nitrogen must be eliminated. The retorting of oil shale must be carried out near the oil shale deposit, but it is benefit that produced shale oil is sent to refinery which is closed to consumption region, therefore pour point and viscosity of shale oil must be reduced.

Recently, shale oil refining process which is considering by USA, USSR and Brazil is the separation of light fraction by the atmospheric distillation unit (topping unit) at first, then residue of topping unit is cracked into light fractions and coke by coker. 50,000 BPD synthetic crude and by-products of 850 t/day ammonia and 43 t/day sulfur are produced by Bureau of Mines'process from 52,000 BPD shale oil. Characterization of synthetic crude which is produced by topping unit and coking unit is shown in TABLE 5,[9] but example only. Metal contents of coke are very low, but more

effective production process of synthetic crude manufacture such as hydrocracking (as well as denitrogenation, desulfurization) must be developed.

TABLE 5 EXAMPLE OF SYNTHETIC CRUDE

	Crude Shale Oil	Synthetic Crude
°API	28.0	46.2
Pour Point °C	24	10
S Content wt %	0.8	0.005
N_2 Content wt %	1.7	0.035
Viscosity (SUS 38°C)	120	40

VI THE POINT AND PROSPECT OF DEVELOPMENT

It should be pointed out that the manufacture of shale oil, processing of mining, crushing, dry distillation, refining and spent ash disposal are necessary. Ratio of energy for processing and energy content in products on TOSCO II process was estimated.[33] Necessity energy fro processing is consisted of research and development, plant election, capital cost of wear and tear (consumption) relacted production. Output energy divided by input energy is 8.8 when 35 gal/ton shale is mining by the room and pillar process, capacity is 100,000 BPCD and 20 years operation. The ratio is compared with other energy production processes as TABLE 6, the developing of oil shale has a good possibility.

TABLE 6 ENERGY PRODUCTIVITY OF REFINING PROCESSES

Process	Out-put/In-put
Oil Production from Off-shore	14.9
Oil Shale Dry-distillation	
above ground	8.8
under ground	15.0
Tar Sand	15.9
Coal (USA Eastern Coal)	55
Coal Gasification	1.4
Secondary Recover in Oil Field	1.9

[illegible]

As the above mentioned, oil shale development is worth and progressed technology is practicable, inspite of USSR and China have commercial plants, West European country has not yet commercial plants, the reason is because of the high production cost and environment assessment.

Production cost of pipeline grade of synthetic crude and initial investment are as follows: (Paraho is based on data of 200 BPD test plant).

TABLE 7 PRODUCTION COST AND INITIAL INVESTMENT

Process	Capacity BPD	Production Cost $/bbl	Initial Investment $10^9$$	Remark
Paraho[27)]	100,000*	11.5	1.2	in 1976
TOSCO	48,000	9.26**	1.0	in 1975
ERDA	300,000	-	***	planning completion in 1985

* pipeline grade

** excluding profit

*** Estimated initial investment of 50,000 BPD plant was $0.4 \times 10^9$$, but 3 years later it was going up $1.2 \times 10^9$$.

Production cost of shale oil would compete with 13 - 15 $/bbl crude oil, but initial investment is very high, thus there are big risk concerning with crude oil price. In USA, high quality oil shale is deposited in national property. US government is negative for release the land because of environmental destruction. Thus enterpriser can not industrialize according to the big risk and US government negative. At present, 8 enterpriser groups have plan of the project, and they endeavor to get indemnity for risk from US government.[27)]

In USA, spent oil shale back to shaft is not considered at present, spent oil shale will be disposed to open space, so water spray and afforestation must be necessary to prevent ash flying. In Estonia, USSR, powdered oil shale is burnt directly at electric power station, and air pollution of dust and SO_x is big problem.[9)] Environment assessment regulation is becoming severe year by year,

so when oil shale project is realized, countermeasure of environmental assessment should be unavoidable, thus production cost of shale oil should be going up according to conctruction of environmental assessment unit.

Required process water for dry distillation on the ground is 3~4 bbl/bbl synthetic crude and for dry distillation underground is 1~2 bbl/bbl synthetic crude. Above mantioned water must be secured. And another big problem is that pollution of drainage when water is sprayed on disposed spend shale oil.

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ATTACHMENT: Mr. M. Enomoto's information

In the present time, petroleum is one of the most important raw materials in producing fuels and petro-chemical products. The world petroleum reserves are, however, reported to expire in the near future. Then, the next available fossil resources will be coal, oil sand and oil shale. Although we do not have a large reserve of oil shale in Japan, there is a large amount of oil shale throughout the world. As Japan is obligated to assist the technical developments in utilizing fossil resources owned by developing countries, we, Petroleum Processing Division, are carrying out the study on oil shales from overseas.

An experimental retorting unit was constructed, in which oil shales from fifferent sources can be pyrolized varying retorting conditions such as temperature and the atmosphere of carrier gas. The product, crude oil, is analysed to clearify the relationships between the oil properties and retorting conditions. Based on the data, we aim at developing a new efficient retort.

The main themes in upgrading shale oil are denitrogenation, desulfurization and lightening of shale oils without the deposition of carbon.

Presently, we are carrying out experiments using oil shale from Thailand and Colorado, USA.

Oil shale retorting system

The batch retorting system (capacity 10 kg/one charge) was constructed to obtain such amount of oil shale that various kinds of analyses are possible for the evaluation of the shale oil. The retorting chamber, 60 cm (width) x 60 (depth) x 5 (height), heated with electric furnace to the max. of 800°C, can rotate within the degrees of 180° to facilitate the charging and discharging of oil shale.

Various kinds of gases, such as mitrogen, air and hydrogen, are introduced into the chamber to study the effect of a carrier gas on the oil properties.

Some of the data concerning the properties of shale oil obtained, using the above-mentioned retort in the presence of nitrogen as a carries gas, are given in the following:

Sources of oil shale	Colorado	Thailand
Shale oil properties		
Oil recovery (wt%)	10.7	20.1
Sp. gr. (50.0°C)	0.867	0.832
Pour point (°C)	25	37.5
Viscosity (cSt)	5.3	4.7
Sulfur content (wt%)	0.79	0.76
Nitrogen content (wt%)	1.66	0.97
Distillation (wt%)		
lower than 200°C	10.8	11.0
200° - 300°	21.2	16.7
300° - 400°	26.9	28.9
400° - 500°	33.4	34.5
residual oil	5.7	7.9
loss	2.0	1.0
Spent shale residual carbon wt%	12.4	12.1
By-product gas composition vol%		
H_2	22.6	30.8
CO	7.9	8.5
CO_2	32.8	15.9
H_2S	1.3	1.0
CH_4	18.3	26.3
$C_2 - C_5$	17.1	17.5

June 16, 1979

Request Technical Assistance for New Project

Project Title Additional Refinery Capacity for Thailand

Requesting agency National Energy Administration (NEA)
Ministry of Sciences Technology and Energy.

Proposed Sources of Assistance:

JAPAN;

1. Background

Petroleum products constituted 82 percent of the entire energy consumption in 1978 in Thailand. Total national consumption for petroleum products in 1978 was approximately 11,526 x 10^3Kl. The structure of petroleum consumption can be classified in percent of volume on total petroleum products consumption in 1978, is as follows :

diesel oil	34.02
fuel oil	34.43
motor gasoline	20.03
kerosene	2.30
JP-1, JP-4	6.83
LPG	2.39

At present, there are three local petroleum refineries with the combined nominal capacity of 165,000 barrels per stream day or 8,643 x 10^3Kl per year, actual crude oil thruput is 182,000 barrels per stream day or 9,750 x 10^3Kl per year in 1978. These refineries are private enterprises and produced about 78 percent of the country's need in petroleum products in 1978. In 1978, Thailand spent 795 million US dollars for crude oil and 245 million US dollars for the imported petroleum products. The entire amount accounted for 20 percent of the total import value. About 58 percent in value of the imported petroleum products was diesel oil. Before the energy crisis in 1974, the annual growth rate for petroleum products in Thailand was 16 percent. The demand for petroleum products is increasing at the growth rate of approximately 12 percent and would reach 16,863 x 10^3Kl per year or 322,000 barrels per stream day in 1980.

Due to the fact that the existing refineries are deficit to meet demand. Thailand is in urgent need of additional refinery capacity. If construction of expansion of existing refinery and/or new refinery is commenced soon, the construction might be completed in 1983 at the earliest. If so, additional capacity needed might be about 200,000 barrels per stream day in 1983. Therefore, installation work of expansion and/or new refinery should be commenced in urgent.

2. Details of the Project

2.1 Program goal

- To set up the optimum plan for increasing the refinery capacity in Thailand over a period of 5-15 years ahead

- To provide the computer program (s) used in the study

- Training the counterparts (NEA's staff) to have the capabilities to revise or updating the plan and computer programs.

2.2 Project objective

The project objective is to give recommendation to NEA and provide training facilities to its staff concerning the optimum plan and schedule to increase the refinery capacity in Thailand. The Study will identify locations, processes, crudes, products pattern and the comparative cash flow of each alternative in order to achieve the most benefit to Thailand within a period of 5-15 years.

2.3 Conditions expected at completion of project

If the study is completed, the Government will use the result of this study as guide line or setting up oil refinery policy in the future.

2.4 Recommended sources of information and data

2.4.1 Basic data and information supplied by NEA.

2.4.1.1 Statistical data of consumption, production, import and export of petroleum in Thailand and others.

2.4.1.2 Historical demand, origin and type of crude oil.

2.4.1.3 The capacity of existing petroleum refinery industries and yield pattern.

2.4.1.4 The past pattern of demand and supply of petroleum products, listing individual products.

2.4.1.5 The past pattern of import and export of petroleum products, listing individual products.

2.4.1.6 The consumption pattern of petroleum by economic sectors for the previous 5 years.

2.4.1.7 Specification of petroleum products required by the laws and analysis of petroleum products in the market..

2.4.1.8 Studies of petroleum product demand forecast made by NEA up to A.D. 2000.

2.4.1.9 Natural gas sales schedule and heating value, LPG production schedule from natural gas and C_{5+} production schedule from natural gas treament unit, not including condensate from gas well platform.

2.4.1.10 Thailand energy consumption.

2.4.1.11 Country economic development plan.

2.4.1.12 Other information and data.

a. import CIF price of each crude oil.

b. demurrage of crude oil tanker.

c. crude oil import business.

d. exrefinery price of each petroleum product.

e. import CIF price of each petroleum product.

f. export FOB price of each petroleum product.

g. petroleum product import and export business.

h. royalty or rental fee of refinery.

i. existing crude oil unloading facilities.

j. crude tanker size and unloading time at present

k. tanker and barge size of water shipping of each petroleum product at present.

l. petroleum products terminal location and capacity at present.

m. distribution business.

n. industrial water, drinking water, electricity and labor cost.

o. financial condition in Thailand.

p. depreciation.

q. import duty for petroleum products, construction materials and equipments in Thailand.

r. refund for export petroleum products in Thailand.

s. tax, fee and reserve for company.

registration fee.
municipal immovable property tax.
corporate income tax.
legal reserve.
medical compensation fund.
reserve for retirement allowance.
personal income tax.

t. insurance.

construction all risk insurance
election all risk insurance.
fire insurance (all risk cover).
public reliability insurance.

2.4.2 Basic data and information supplied by the consultant.

2.4.2.1 Statistical data of consumption, production, import and export of petroleum in the Southeast Asia region, especially, the present and future refinery capacity in this region should be supplied by the consultant.

2.4.2.2 Market survey of petroleum product in Southeast Asia region should be carried and report should be supplied by the consultant.

2.5 Duration of the project : Starting as

from : as soon as possible

to : 18 months later

2.6 Project site : Thailand

2.7 Project work plan

The following scope of work must be included in the feasibility study, but not limited to what herein described.

2.7.1 Scope and format of the feasibility report.

The feasibility report would be comprehensive in scope, giving due regards to all aspects of the most up-to-date concepts for determining the feasibility of this project.

2.7.2 Technical studies for 1st stage.

2.7.2.1 Review the petroleum product demand forecast and Thailand energy consumption made by NEA.

2.7.2.2 Determine the best means of expanding refining capacity from the current level.

2.7.2.2.1 By increasing the capacity of the existing oil refineries where possible.

2.7.2.2.2 By building a completely new refinery related with existing refineries.

2.7.2.3 Determine the maximum profit refining capacity.

2.7.2.3.1 Recommend the suitable types of crude oil charged.

2.7.2.3.2 Recommend the maximum profit refining scheme including the size of process units and auxiliaries.

2.7.2.3.3 Recommend the import and export petroleum products.

2.7.2.3.4 Recommend the most economical crude oil tanker size.

2.7.2.3.5 Recommend the most reasonable crude oil reserve.

2.7.2.3.6 Recommend the plant site.

2.7.3 Economic studies for 1st stage.

2.7.3.1 Initial investment including unloading and loading facility of grass roots refinery on breakdown.

2.7.3.2 Utilities consumption including chemicals, catalysts and own fuel on breakdown.