THE FEASIBILITY STUDY REPORT ON THE LUBRICATING OIL REFINERY PROJECT IN THE KINGDOM OF THAILAND

(SUMMARY)

DECEMBER, 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

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GLOSSARY

Base oil	means "lube base oil" in this document which is a raw material and major component of lubricating oil.
Base oil plant	this term is used interchangeably with "lube base oil palnt" or "lubricating oil refinery" which produces base oil.
Consultant, the	Ad hoc team formed to undertake the feasibility study on the Project under the name of JICA, or parent organizations of such team's members.
Lube oil	a final product of base oil blended with various kinds of additives for different purposes. Short form of "lubricating oil".
Plant, the	the base oil plant specifically planned by NEA and for which the Consultant is studying from technical, financial and other aspects.
Project, the	Overall project including planning, design, construction, operation, etc. related to the plant.
S/W	"Scope of Work" which is a written scope of feasibility study on the lubricating oil refining project contained in the agreement between NEA and JICA.

ABBREVIATIONS AND SYMBOLS

<u>Unit and Conversion</u>

mm	Millimeter
cm	Centimeter
m	Meter
km	Kilometer
in	Inch (1 in = 2.54cm)
ft	Foot (pl. feet)(1 ft = 0.305m)
cm^2	Square centimeter
m^2	Square meter
ha	Hectare (1 ha = 10,000m^2 = 2.471acres)
ft^2	Square foot (1 ft^2 = 0.0929m^2)
Rai	(1 Rai = 1,600m^2)

m^3	Cubic meter
Nm^3	Normal cubic meter
MMm^3	Million cubic meters
ft^3, cu ft, cft	Cubic foot (1 ft^3 = $0.0283m^3$)
SCF	Standard cubic foot
MMSCF	Million standard cubic feet
l	Liter
kl	Kiloliter
gal	Gallon (1 British gallon = 4.546litters, 1 U.S. gallon = 3.785litters)
bbl	Barrel (1 barrel = 42 U.S. gallons)
g	Gram
kg	Kilogram
t, T, ton, Ton	Metric ton
lb(s)	Pound (1 lb = 0.454kg)
LMT	Liquid metric ton (50% aques solution of caustic soda)
sec	Second
min	Minute
h, hr, Hr	Hour
d, D	Day
m, M	Month
y, Y	Year
°C	Degree centigrade
°F	Degree fahrenheit
cal	Calorie
Kcal, K cal	Kilo calorie
BTU, Btu	British thermal unit (1 BTU = 0.252 K cal)
MMBTU, MMBtu	Million British thermal units
LHV	Low heating value
HHV	High heating value
A	Ampere
V	Volt
W	Watt
kW	Kilowatt
mW	Megawatt

kVA	Kilo-volt ampere
mVA	Mega-volt ampere
kWH, kWh	Kilowatt-hour
mWG, mWh	Megawatt-hour
HP	Hoursepower
%	Percent
ppm	Parts per million
g/Nm^3	Gram per normal cubic meter
pH, PH	Hydrogen ion concentration
kg/cm^2	Kilogram per square centimeter
lb/in^2	pounds per square inch
mmAq	mm aqua (= water)
t/d, ton/day, T/D	Tons per day
t/y, ton/year, MTA, MT/Y, T/Y	Tons per year
MMSCFD, MMscfd	Million standard cubic feet per day
BPCD	Barrels per calendar day
BPSD	Barrels per stream day
TPCD	Tons per calendar day
TPSD	Tons per stream day
MD	Man days
F/Ton, F/T	Freight tons
SCF/Bbl	Standard cubic feet per barrel

Technical Terms

HDPE	High density polyethylene
LDPE	Low density polyethylene
PP	Polypropylene
PVC	Polyvinyl chloride
VCM	Vinyl chloride monomer
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
NG	Natural gas
BFW	Boiler Feed Water
BS	Bright Stock
CTW	Cooling Tower Water

DAO	Deasphalted Oil
EFO	Equivalent of Fuel Oil
E.P.C.	Engineering, Procurement and Construction
Flash Point (COC)	Flash Point (Cleveland Open Cup)
H/C	Hydrocracking
H/F	Hydrofinishing
LVGO	Light Vacuum Gas Oil
MEK	Methyl-Ethyl-Ketone
MM	Millions or Man-Months
NMP	N-Methyl-2-Pyrrolidone
PDA	Propane Deasphalting
S. Wax	Slack Wax
T/C	Thermalcracking
V/B	Visbreaking
VGO	Vacuum Gas Oil
VI	Viscosity Index
VR	Vacuum Residue
WWT	Waste Water Treating
60 N	60 Neutral Base Oil
150 N	150 Neutral Base Oil
300 N	300 Neutral Base Oil
500 N	500 Neutral Base Oil
150 BS	150 Bright Stock Base Oil
140 P	140 Paraffin
150 P	150 Paraffin

Financial and Economic Terms

DCF	Discounted cash flow
IRR, IRROI	Internal rate of return on investment
EIRR, EIRROI	Economic internal rate of return on investment
FIRR, FIRROI	Financial internal rate of return on investment
IRROE	Internal rate of return on equity
GDP	Gross domestic product
GDPR	Real gross domestic product
GNP	Gross national product
C&F	Cost and freight
CIF	Cost, insurance and freight

FOB	Free on board
EMP	Energy Master Plan

<u>Exchange Rete</u>

Baht	Thailand Baht (1 U.S. dollar = 23 Baht)
\$, U.S.\$,	U.S. dollar
yen	Japanese yen (1 U.S. dollar = 230 yen)

<u>Organization and Company</u>

NEA	National Energy Administration
GOT	The Government of Thailand
PTT	Petroleum Authority of Thailand
BOI	Office of the Board of Investment
NESDB	Office of the National Economic and Social Development Board
DTEC	Department of Technical and Economic Cooperation
MOI	Ministry of Industry
EGAT	Electricity Generating Authority of Thailand
PEA	Provincial Electricity Authority
NEB	National Environmental Board of Thailand
PAT	Port Authority of Thailand
MOR	Military Oil Refinery in Bangchak (= Bangchak Refinery)
TORC	Thai Oil Refinery
ESSO	Esso Refinery
JICA	Japan International Cooperation Agency
JETRO	Japan External Trade Organization
FDA	The U.S. Food and Drug Administration
OPEC	Organization of Petroleum Exporting Countries

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SUMMARY AND RECOMMENDATION

CHAPTER 1 SUMMARY

1-1 Project Background

Although Thailand consumed 170,000 kl of lube oil in 1981, it does not have a base oil plant to produce lube oil. Meanwhile, demand for fuel oil, feedstock of base oil, is expected to decline, and fuel oil will become even oversupplied due to production and utilization of natural gas in Gulf of Siam.

Under such circumstances, the Government of Thailand asked the Government of Japan to conduct the feasibility study of building a base oil plant for solving the fuel oil surplus problem as well as reducing foreign exchange reserves spent for importing lube oil and base oil. In response to the above request, the Japanese Government has decided to conduct a feasibility study on lubricating oil project and JICA (Japan International Cooperation Agency) has taken up the study.

1-2 Survey Schedule

Prior to the field survey, a questionnaire was distributed through NEA among blenders, who import base oils, blend them and add additives to produce lube oil for marketing, as well as lube oil consumers, representing industrial fields. The answers were collected while the survey team was in Thailand.

Following the recovery of the responses to the foregoing questionnaire, discussion meetings were held with NEA, upon which import statistics on lubricating oils in Thailand were analyzed, and the growth of the Thai economy and the demand for petroleum products forecast during the field survey. Also, a study of the prevalent state and future plans of petroleum refineries was made by analyzing NEA's available data and by visiting PTT, Bangchak Refinery and TORC Refinery.

After the field survey, based on the data and information collected throughout the field survey, demand analysis and forecast on lube oil and base oil in Thailand, price analysis and forecast on crude oil, petroleum products and based oil, decision of kind of crude oil to be used, selection of the most suitable process, estimation of the project investment cost and financial and economic analysis and evaluation of the project were made. While, three trainees from NEA were invited to Japan for technical training from July 5 thorough August 14, 1984, and a sinior officer of NEA was invited to discuss on the draft final report.

From September 17 to 21, 1984, the presentation meeting on the draft final report was held with attendants from NEA, PTT and MOR. In said meeting, NEA confirmed to study team that the draft final report covers all the scope of work satisfactorily, and further, NEA desires that, in order to realize the base oil project in Thailand, further study on consequence by base oil project to the petroleum refinery and energy balance in Thailand is to be scrutinized. NEA expressed to the study team their intention to ask another technical assistance to Japanese Government (JICA) for such extentional study.

1-3 Contents of Survey

1-3-1 Growth of the Thai economy and the supply and demand balance of petroleum products

To forecast the demands for petroleum products and lubricating oils (base oils) in Thailand, it is necessary first of all to forecast the future economic growth and industrial development in Thailand.

In Thailand, NESDB forecasts the growth rates of real term GDP and each industry by the use of a macroeconomic model, and NEA forecasts the demands for energy and petroleum products by the use of an Energy Master Plan Model (EMP) which is linked with the NESDB's macroeconomic model.

During our stay in Thailand this time, the demand for petroleum products was forecast by the use of EMP as Case 1 under the following assumptions.

	1982 - 1986	1987 - 2001
Real GDP growth rate (%/year)	6.0	6.5
Crude oil real price increase rate (%/year)	-5.0	2.5
Natural gas production	650 MMSCFD	Free

By without estimation of the natural gas production for 1987 and thereafter, the natural gas production for 1996 was computed to be 1,000 MMSCFD. Because of many uncer tainties with respect to the reserves and production rates of natural gas, computation was also made on the assumption that production of 650 MMSCFD will continue in and after 1987.

Incidentally, NESDB lowered its assumed annual growth rate of real GDP to 5.5% for the 1982-1986 period in this July. Since the average annual growth rates achieved in all of the past five year plans even including the one in which the second oil shock took place, were 6.2% or more without exception and, what is more, Thailand is about to take a big leap forward industrially, too, a forecast growth rate of 6% is not considered too high, but for this study, the demand for base oils was computed also for the case in which the economic growth rate has decelerated to 5% a year.

The prevalent state and future plans of refineries as the supply side of petroleum products were investigated. Thailand has such major refineries as MOR, TORC and Esso, whose combined crude throughput capacity today is 168,000 bbl. a day. As this capacity is insufficient to meet the domestic demand in Thailand, Esso is carrying out debottlenecking, while TORC is scheduling to install a hydrocracking facility as its first stage expansion program in order to cope with surplus fuel oils and the shortage of middle distillates, and an additional topper as the second stage expansion program. When these programs are realized, the capacity will reach 248,000 bbl. in 1991 by which the demand and supply of each petroleum product will approximately balance. But by 1996, petroleum products, with the exception of fuel oils, will become short again.

The following shows the projected supply and demand of fuel oils.

(Unit: BPCD)

	1987	1991	1996	1996 (N.G. Production 1,000 MMSCFD Case)
Demand	45,710	53,750	45,760	121,430
Supply	55,050	54,100	54,100	54,100
Balance	9,340	350	8,340	(-)67,330

According to this table, supply of fuel oils will over run demand if TORC's first and second stage expansion programs are implemented and 1,000 MMSCFD of natural gas is produced.

If, however, only 650 MMSCFD of natural gas can be produced, the demand for fuel oils in 1996 will be increased to 121,430 BPCD and a shortage of 67,330 BPCD will result.

The supply and demand balance for fuel oils will change depending on the forecast demand for fuel oils, producible volume of natural gas, and construction plans of refineries, particularly by the installation of fuel oil cracking facilities. However, even with the production of natural gas of 650 MMSCFD only, the ratio of the demand for fuel oils to total demand for petroleum products is slightly less than 30%, so that if Thailand attempts to become self sufficient in petroleum products, it would have to export surplus fuel oils if there is no additional upgrading facility.

1-3-2 Current demand for base oils in Thailand

The market study of lube oils in Thailand has been conducted on a basis of the following three method--import statistics, surveys by lube blenders and surveys of lube oil consumers.

(Unit: kl)

Method of survey	Demand in equivalent base oil (1983)
Import statistics	174,520
Lube blenders	164,964
Consumers	147,080

Since import statistics involve problems of inventories and statisticaly errors, and the survey of consumers is hard to seize the usage for others than vehicle and industry entire picture, we have decided to adopt the figures provided by lube blenders as the total demand for base oil in 1983.

However, the answers provided by lube blenders have also another problems for distribute the consumption to the each uses, and therefore we have decided to replace their figures for vehicles and industry with those obtained in the consumer survey.

	In base oil equivalent (kl/y)
Vehicles	121,367
Industry	25,713
Others[1)]	17,884
Total	164,964

1) Including Military use

1-3-3 Future Demand Forecast of Base Oil in Thailand

The future demand forecast has been attempted with the lube oil demand in 1983 as a base. Considering the construction period of the base oil plant and its operating conditions (refer to Part IV Chapter 1), we have forecasted the demand quantity in 1993.

In forecasting the future demand, we conducted the macro forecast method based on the survey of consumption by uses in 1983 as well as the micro forecast method based on the consumer research.

As macro-forecast, with regard to vehicles, the increase in gasoline, diesel oil and LPG for transportation uses calculated for EMP model run has been used as a base for obtaining lube oil for vehicles in 1993. With regard to industry, the increase in value added of industrial sector calculated by NESDB has been used. Also with regard to other demands, an estimated GDP growth rate calculated by NESDB has been used as a base.

The micro forecast has been obtained by gaining quantities in each sector (Number of vehicles, production amount of industry and others) in 1993 through each figures or each growth rate, and by multiplying them in principle by lube oil consumption unit in 1983.

The result of macro and micro forecast is as follows:

(Unit: kl)

	Macro-economic Forecast	After Adjustment[1]	Micro Forecast
Vehicles	225,136	160,811	168,230
Industry	52,156	52,156	44,070
Others	33,103	33,103	33,103
Total	310,395	246,070	245,403

Note: 1) In the macro forecast, the lube oil consumption in 1993 is estimated at 310,395 kl. However, this forecast does not pay attention to the lengthened oil change period for vehicles and the reduction of oil to be replenished. Therefore, the lube oil demand will be reduced as the improvement measures are taken. After adjusting such discrepancies, the lube oil consumption forecast will be 246,070 kl.

Such being the case, the base oil demand for 1993 is estimated at 250,000 kl, as the base.

The forecast of base oil demand in 1993 for the case of lower economic growth by 1% per each year is 235,000 kl instead of 250,000 kl.

1-3-4 Kind and Specification of Base Oil

Shown on the left side of Table 1 is the base oil imported by lube blenders as classified by types. Since it will be highly uneconomical to work out the production plan according to what was reported, it has been decided to make 600N, 650N and 700N by mixing 500N and 150BS at the blender and or base oil plant.

The specifications of base oils qualities set for this study are summarized in Table 2. In setting up the above specifications, the following sources are taken into consideration:

a. Answer of base oil importers in Thailand on the questionnaire
b. Actual records of Japanese base oil exporter
c. Typical specifications which are acceptable in the world-wide market

As for VI (Viscosity Index), it can be said that base oils having higher than 95 VI are coming commonly into the international market while low grade base oils having 85 VI are being put on a part of market.

As for sulfur content, it is a fact that sulfur content in base oils governs essential qualities of base oils, and that most of base oil are being imported to Thailand with the specification of low sulfur content.

1-3-5 Prices of Crude Oil, Base Oil and Other Petroleum Product

As for crude oil prices, those assumed conditions for Case 1 stated in par. 1-3-1 were adopted because they were considered reasonable, being similar to and in line with predictions made by other companies and also to secure consistency with EMP Case 1.

Both th base oil prices and the prices of other petroleum products are closely correlated with the crude oil prices, so that their future prices were forecast by the respective linear regression equations derived from their past correlations.

With regard to base oil prices, CIF Bangkok price was obtained from Thai import statistics, FOB Singapore price from Singapore export statistics, the base oil price (FOB) in Singapore from Platt's Oilgram Price Report, and CIF Bangkok price from blenders' questionnaire.

As bases, forecasts made by Platt's Oilgram and the responses made by blenders were utilized.

The prices of petroleum products produced as by-products from the base oil plant were estimated on the basis of their respective viscosity indexes, octane value and/or by comparing with diesel oil.

For petroleum products commonly dealt in the market, the comparative study of the following three price trends has been made as a base for forecasting the future petroleum product price -- The petroleum product price on FOB terms Singapore, one of main exporting countries to Thailand and which is accepted as an international price trend, Thai import price on CIF terms, and Thai ex-refinery prices. As a result of above study, ex-refinery price was caused to be used for the study.

1-3-6 Selection of Crude Oil

As for the type of crude oil to be used in the base oil plant now being studied, Arabian Light was adopted as a base for the following reasons.

1) Arabian Light, Basrah Light, Daquing and Qatar Marine are suitable for producing higher VI base oils matched to the Thai market.

   The required volume of each crude oil to produce 100,000 kl of base oil, and the base oil yield on each crude are as tabulated below:

Crude Oil	Crude Oil Volume (bbl)	Base Oil Yield on Crude Oil (Vol. %)
Arabian Light	17,200	10.0
Basrah Light	17,200	10.0
Daquing	17,200	10.0
Qatar Narine	17,600	9.8
Kuwait	19,900	8.7
Murban	21,200	8.1
Iranian Heavy	31,300	5.5
Sumatran Light	32,200	5.4
Phet	64,400	2.7

2) In view of its large reserves, Arabian Light will be a stable source of supply in future, too.

3) For the demand pattern of each petroleum product in Thailand with high ratios of middle distillates and low ratios of heavy fuels, light crude is suitable.

4) At one time, Arabian Light was priced too high compared to Arabian Heavy, but the price disparity on a spot basis is decreasing on account of the increase in heavy oil up-grading facilities, this will probably lead to a reduction in price differential in terms of posted official price, eventually.

1-3-7 Forecast of Worldwide Supply and Demand for Lubricating Oils

The increase in demand for lubricating oils in response to future economic growth of the world and the accompanying increasing in demand for energy was forecast.

Also, future supply volumes were estimated on the basis of existing base oil plants and new plants currently being planned throughout the world.

The worldwide supply and demand balance according to the foregoing calculations is as shown below. The current excessive supply will be liquidated by 1990 with demand approximately matching supply. By geographic region, the supply capacity of the developing countries, led by the Middle East countries, will increase while the supply capacity in the advanced countries will remain stagnant or decline.

(Unit: million bbl/yr)

	1980	1985	1990
Supply	193.7	213.4	220.8
Demand	175.6	195.7	221.1
Balance	18.1	17.7	-0.3

1-3-8 Selection of the Production Process

The manufacture of lube base oils consist of a series of separation or subtractive processes which remove undesirable components from the feedstock leaving a lube base oil that meets performance requirements.

As the configuration of refining scheme for lube base oil production, the following two types are general and adopted by most of the worldwide manufacturers:

Conventional Scheme
Hydrotreating Scheme

The hydrotreating scheme has some definite advantages as a substitute or replacement for the conventional (solvent extraction) scheme when the available quality of crude is poor for lube base oil production and high quality base oils of which VI's are over 100 are required to be produced, since the hydrotreating processes are highly flexible and chemically produce lube base oil components from less desirable hydrocarbon types.

The conventional solvent extraction, on the other hand, is more cost effective than the hydrotreating for the manufacture of current viscosity index level base oils from suitable crudes normally used by most refineries, because advantage of hydrotreating scheme in high yield rate is offset by higher construction cost and higher operating costs.

Considering the surrounding bases of this project to be studied, Arabian Light Crude, which is one of the most suitable crude for lube oil production, is available to supply feedstock to lube plant, and the specified qualities of product base oils, viscosity index of which are not specially high (max. 100), are normal levels which can be attained by refining in the conventional scheme.

Thus, the conventional configuration of refining scheme can be consequently recommended as a study base from an evaluation described above.

1-3-9 Alternative Plans for the Project

The following were considered as alternatives available for the project.

1) A base oil plant must be build adjacent to a refinery for the convenience of receiving feedstock and utilizing by-products. As of now, there are three major refineries of MOR, TORC and Esso in Thailand, every one of which is suitable for building a base oil plant. Since TORC and Esso are almost in the same conditions, two cases, - one locating the plant in Bangchak and the other, in Sri Racha - were assumed.

2) To utilize the by-products from the base oil plant, the production of wax and asphalt may be considered.

Accordingly, the merits of adding production facilities for wax and asphalt were studied for the case of building the base oil plant in Bangchak.

As a consequence, it turned out that although merits might accrue from the production of asphalt, it was better not to undertake the production of wax if the rate of profit of the base oil plant was to be made higher.

Accordingly, it was decided that a study should be made case of adding an asphalt production facility to the base oil plant in Sri Racha.

3) Another problem is the form of operation, whether to establish a new company for producing base oil, or install a base oil plant as an expansion program of the refinery.

From the above, it was decided that a comparative study should be made of the following four alternative plans. The results of computation to explain the case with wax plant (Bangchak-AX) or without asphalt plant (Bangchak-AY) will be given with it.

a. Bangchak-A	New Company
b. Bangchak-B	Expansion
c. Sri Racha-A	New Company
d. Sri Racha-B	Expansion
e. Bangchak-AX	New Company, Wax Production
f. Bangchak-AY	New Company, No Aspahlt, Production

1-3-10 Conditions for Investment

The conditions for investment in the Base Case were assumed to be as same as an ordinary industrial investment project. Special conditions are applied in the supplementary case study and in the sensitivity analysis, as follows,

Case Study

1) Tax insentive case
   Tax priviledges by BOI such as exemption of duties on imported equipment, tax holidays, etc.

2) Different escalation factors
   All costs and prices were projected under different escalation factors.

Sensitivity Study

1) Different interest rate
   Different interest rates which are higher than ordinary long term loan and lower nearly as soft loan were applied for sensitivity test.

2) Flactuation in investment cost
   Effect of flactuation in the investment cost with certain range were studied.

1-3-11 Base Oil Plant Construction Schedule

In consideration of the period necessary to review the results of the current study, and to complete the formalities within the government and prepare the inquiries, the contract for the plant was assumed to be concluded as of January 1, 1988, and the plant to go into commercial production in January, 1991 after a three year period for construction and trial run.

1-3-12 Project Cost

Table 3 presents the estimated project cost for each alternative plan.

In the event a new company is to be established, the amount of investment would be somewhat higher than if an existing refinery were to construct a base oil plant, due to acquisition of land, construction of common facilities and so forth. (A: establishment of a new company, B: investment by an existing company)

Investment cost would naturally be higher if a wax plant were to be added (AX): and if an asphalt plant is not construction (AY), the amount of investment would be that much lower.

1-3-13 Financial Analysis (Table 4)

1) As a general conclusion, this project is financially feasible as the after tax return is 17.5% or more in current term and 12.2% or more in constant term in the every cases.

2) Locating the site at Bangchak is more advantageous than locating it at Sri Racha because the distances to the lubricating oil blending plants are much closer.

3) A higher profitability can be anticipated for this project if an existing refining company were to implement it as an additional investment rather than establish a new company.

4) Asphalt production will contribute to improve financial viability.

5) Wax production will not contribute to improve financial viability.

6) Price increase of crude oil than forecasted herein will cause improvement in financial viability. Further, decrease in demand will cause lower capacity utilization, however, as proven in the case study of lower growth rate by one percent, its consequence to financial viability is not significant. (Table 5)

7) As it is seen in production cost analysis, share of variable cost is extremely high as eighty to ninety percent of total production cost. (Table 6)

Note: * The unit production cost hereabove are nominal figures and does not reflect actual production cost of the base oil only because the figures are calculated as unit cost of total production cost divided by production volume of only base oil.

8) In connection with the above 6) and 7), it will be critical for the project in case that balance of the prices among crude oil, raw material (long residue) and products (base oil, fuel oil, etc.) is suffered by reason such as change in supply-demand relation. (Some additional comment in this regard will be cited in the other part below here.)

9) Although it is anticipated that this project could be eligible for promoted industry and would be granted with privileges including various tax insentives by office of the Board of Investment of Thailand, this study has been made without such privileges. If such conditions are taken into assumptions for the study, further improvement in financial viability is expected.

10) Since cash position in the operating years are fairly good, initially calculated working capital is seemed excessive, therefore, practical adjustment to decrease in the initial working capital is possible.

11) No remarkable problem is identified in the figures of financial indicators including ratio analysis where fairly good profitability and financial stabilities are observed.

1-3-14 Economic Analysis (Table 7 and Table 8)

1) In general, this project will be economically justifiable, and it may largely contribute to the Thai national economy.

2) The alternatives of Bangchak-B and Sri Racha-B are most favorable cases in economical aspect while other cases show negative ENPV (Economic Net Present Value) when twelve percent (12%) of cutoff rate is applied.

3) Among other economic benefits, remarkable contribution to national economy is observed in foreign exchange saving effect where expected net saving will be approximately fifty percent of total foreign exchange outflow due to importation of base oil. Annual net foreign exchange saving during the operating years is estimated as approximately 70 million dollars (in real term) in average.

4) Other economic indirect benefits including creation of employment opportunity, creation of value added, contribution to regional development, industrial technology transfer, impacts on other industries are anticipated to be caused by this project.

1-3-15 Effective Fuel Oil Reduction in the Lube Plant

As stated before, the weight of raw material cost in the base oil production cost is quite high; and of the raw material, the amount that remains as base oil is about 21%, while the rest is utilized either as petroleum products or as feed material. In the case of Bangchak, of the 20,540 BPCD of raw material (long residue) input, 4,307 BPCD becomes base oil and 13,013 BPCD becomes fuel oil again. Thus, the reduced volume of fuel oil is 7,437 BPCD, the difference of 7,437 BPCD and 4,307 BPCD i.e. 3,130 BPCD is consumed as energy fuel in the process and converted to by-products. This is only natural since production of base oil is the process of removing inappropriate components from the raw material.

1-3-16 Factor Affecting Economics of the Project

1) Crude oil price

The price evaluation for crude oil, raw material (long residue), base oil and by-products are most crucial. (The viscosity of long residue is 275, which is almost identical to 280 of FO 2,500".) The price increase during 1984 and 2010 of crude oil, raw material (long residue) and base oil are as follows:

(Unit: US$/kl)

	Arab. Light FOB Ras Tanura	FO 2,500 Ex-Refinery	500N
1984	182.4	161.9	390.1
2010	1,292.2	1,097.2	2,428.9
Ratio	7.08443	6.777	6.226
Average increase ratio(%)	7.82	7.64	7.29

As for crude oil, it was assumed that the market price will remain the same between 1982 and 1986 (a 5% decline in constant price or real price) and rise by 2.5% a year in real price thereafter, with the assumed average inflation rate of 5.78% between 1984 and 2010.

As can be seen from this table, the price increase rate is assumed to be the highest for crude oil, secondly for fuel oil and the lowest for base oil. This is because the rate of rise in value added is assumed to be lower than the rate of rise in crude oil prices.

2) Base oil price

The base oil price adopted in the current study, however, is based on past price trend amidst excessive supply, so that its price relative to crude oil might possibly rise hereafter as the worldwide supply and demand is brought into equilibrium. As for fuel oil price, it might become bearish relative to the crude oil price on account of the progress made in oil substitution and surplus supply due to the rising ratio of heavier crude oils. Also, in Thailand, even if a hydrocracking plant is installed by TORC, the supply of fuel oil might become long if production of natural gas should reach 1,000 MMSCFD, for example. Accordingly, a drop in the relative price of fuel oil is also conceivable.

3) Price of long residue and intermediates

Should the above conditions materialize, the profitability of this project will improve further.

Furthermore, since 60% or more of long residue as raw material is resold as fuel oil, the relative prices of long residue and by-product fuel oil also have a large bearing on project economies. Their respective prices computed for 1983 are as follows:

	Long Residue	Fuel Oil A (Bangchak)	Fuel Oil B (Sri Racha)
Viscosity cSt @50 C	270	230	230
Specific Gravity	0.956	0.969	0.994
Price (Baht/kl)	3,691.6	3,609.8	3,635.8

Even though the viscosity of both Fuel Oil A and Fuel Oil B is lowered by means of vis-breaker or thermal cracking, the price for the same volume of Fuel Oil A is the same as that of Long Residue and somewhat lower for Fuel Oil B because of differences in specific gravity.

1-3-17 Impact of Integration of Lube Plant to the Existing Refinery

If a base oil plant is constructed in annex to the petroleum refinery, the following influence will be caused to said refinery.

1) It is caused to be necessary to purchase and feed certain kind of crude oil which is adequate to produce base oil.

2) Pattern of refinery output is changed, in particular the residue from topping unit, as described in 1-3-16, will be decreased with respect to the proportions consumed for base oil production and consumed in the base oil plant as energy fuel.

3) Profitability will be improved as a while due to additional production of base oil creating high added-value.

In the course of base oil production, various intermediates are produced, and they are fed to the annexed refinery to produce petro-products. In this regards, it is necessary to study the details of refinery units thereby total pattern of refinery outputs could be assumed. Further, in order to evaluate ultimate financial contribution to total refinery complex, financial standing and projections of the refinery complex without base oil plant are definitely required.

In order to quantitatively clarify that how the base oil plant will influence to the annexed refinery and to suppliability of petro-products to Thai market, another study will be required.

CHAPTER 2 RECOMMENDATION

2-1 As the results of financial and economic evaluation of the base oil production plant indicate, the project may be claimed as justifiable from the financial and economic viewpoint and also from the viewpoint of contribution to the foreign currency balance.

2-2 As for the question of who should take up the project, the profitability is considered to be the highest if Bangchak were to take up the project as one of its expansion programs after rehabilitation is realized. At present, the blending companies, some of which relate to the major oil companies, buy their base oils from their overseas affiliates as well as from unrelated companies. It is of interest to all parties in forming up the company.

2-3 Although the benefits accruing from investment incentives were not taken into acount in figuring out the eonomics the financial position of the project plant can allow for competitive price. However, it is necessary, by all means, to avoid the adverse impact of dumping base oil from low price base oil by overseas supply sources.

2-4 In carrying out base oil production, it should be kept in mind that there will be necessity having to import suitable crude oils (Arabian Light was selected as a base this time) if the project is to be financially justifiable.

2-5 Refineries in Thailand have either modification or additional facility installation projects going on at present, which have been taken into consideration for this study, the establishment of lube oil plant will therefore not cause adverse effects to the refineries' current programs. It is advisable, however, that integration of the lube oil project into the refineries' programs at the early stage would be more advantageous.

Table 1 BASE OIL PATTERN CALCULATED FROM ANSWER FOR QUESTIONNAIRE TO LUBE BLENDER

Imported Base Oil		Base Oil to be manufactured(Kl)				
Kind	Quantity (kl)	60N	150N	300N	500N	150BS
60N	12,637	12,637				
150N	6,980		6,980			
300N	7,960			7,960		
500N	5,540				5,540	
600N	35,923				31,073	4,850
650N	43,404				34,723	8,681
700N	2,615				1,988	627
150BS	17,279					17,279
Tatal	132,338	12,637	6,980	7,960	73,324	31,437
(Vol%)	100.0	9.6	5.3	6.0	55.4	23.7

Table 2 PRODUCT SPECIFICATION OF BASE OILS

Properties \ Grades		60N	150N	300N	500N	150BS
Viscosity @40°C, cst		8.5-11.5	-	-	-	-
@100°C,cst		-	4.5-5.5	7.0-8.0	10.0-12.0	29.5-34.5
Pour Point, °C	Max.	-10	-10	-10	-10	-10
Viscosity Index	Min.	95	100	95	95	95
Sulfur Content, wt%	Max.	0.3	0.3	0.3	0.3	0.5
Colour (ASTM)	Max.	0.5	0.5	2.0	2.5	4.5
Total Acid Value, mg KOH/g	Max.	0.1	0.1	0.1	0.1	0.1
Flash Point, °C	Min.	130	190	210	230	240
Carbon Residue, wt%	Max.	-	-	-	0.3	0.8

Table 3 TOTAL PROJECT COST (SUMMARY)

(Unit: '000 US$)

		Bangchak-A	Bangchak-B	Sri Racha-A	Sri Racha-B	Bangchak-AX	Bangchak-AY
1.	Land Acquisition and Site Preparation	9,900	6,648	4,625	3,939	11,314	9,900
2.	Plant Construction Cost	266,505	233,565	267,058	227,780	301,896	265,314
3.	Pre-operational Expenses	18,895	18,299	18,977	18,349	19,570	18,852
4.	Interest During Construction	29,431	25,450	28,499	24,519	32,962	29,503
5.	Initial Working Capital	24,614	22,898	23,670	21,933	25,597	24,522
	Total	349,345	306,860	342,829	296,520	391,339	348,091

Table 4 FINANCIAL ANALYSIS

Case	Current Term		Constant Term	
	Before Tax (%)	After Tax (%)	Before Tax (%)	After Tax (%)
Bangchak-A (Base Case)	21.24	18.46	15.69	13.09
Bangchak-B	23.73	20.59	18.05	15.11
SRI RACHA-A	20.06	17.96	15.07	12.60
SRI RACHA-B	23.15	20.07	17.53	14.65
BANGCHAK-AX	20.21	17.59	14.70	12.26
BANGCHAK-AY	21.19	18.42	15.65	13.05

Table 5 SENSITIVITY ANALYSIS (BANGCHAK-A)

		Current (%)		Constant (%)	
		Before Tax	After Tax	Before Tax	After Tax
Base		21.24	18.46	15.69	13.09
Crude Oil	+20	24.26	20.94	18.57	15.46
	+10	22.79	19.74	17.18	14.32
	-10	19.57	17.05	14.10	11.75
	-20	17.76	15.48	12.38	10.25
Plant Cost	+20	18.47	16.11	13.05	10.84
	+10	19.77	17.23	14.29	11.91
	-10	22.92	19.84	17.30	14.41
	-20	24.89	21.44	19.18	15.95
Capacity Utilization Down		21.18	18.42	15.64	13.05

Table 6 PRODUCTION COST ANALYSIS (BASE CASE)

Cost Item	PRODUCTION COST					
	1991		2000		2010	
	Amount 1,000 US$	%	Amount 1,000 US$	%	Amount 1,000 US$	%
Variable Costs						
Long Residue	230,195	74.79	589,018	88.47	1,319,421	93.24
Utilities	10,040	3.26	23,073	3.47	45,387	3.21
Electricity	8,080	2.62	18,568	2.79	36,527	2.58
Hydrogen	1,960	0.64	4,504	0.68	8,860	0.63
Catalyst & Chemicals	413	0.14	877	0.13	1,581	0.11
Imported	385	0.13	812	0.12	1,455	0.10
Local	28	0.01	64	0.01	127	0.01
Other Chemicals	669	0.22	1,175	0.18	2,201	0.16
Imported	369	0.12	623	0.09	1,116	0.08
Local	300	0.10	552	0.09	1,085	0.08
Variable Cost Total	241,316	78.41	614,142	92.25	1,368,591	96.72
Fixed Costs						
Labor Cost + Payroll Burden	2,139	0.69	3,931	0.59	7,734	0.55
Administrative Overhead	855	0.28	1,573	0.24	3,094	0.22
Maintenance Cost	7,877	2.56	14,482	2.17	28,487	2.01
Operating Supplies	485	0.16	820	0.12	1,468	0.10
Tax & Insurance	2,854	0.93	2,854	0.43	2,854	0.20
Direct Fixed Cost Total	14,210	4.62	23,659	3.55	43,637	3.08
Cash Factory Cost	255,526	83.03	637,801	95.80	1,412,227	99.80
Depreciation	25,518	8.29	25,518	3.83	1,133	0.08
Amortization	9,665	3.14	-	-	-	-
Depreciation & Amortization	35,183	11.43	25,518	3.83	1,133	0.08
Total Factory Cost	290,709	94.46	663,319	99.63	1,413,360	99.88
Other Costs						
Sales Expenses	295	0.09	763	0.12	1,691	0.12
Operating Expenses	291,005	94.55	664,082	99.75	1,415,051	100.00
Interest on Long Term Debt	16,769	5.45	1,677	0.25	-	-
Total Production Cost	307,773	100.00	665,759	100.00	1,415,051	100.00
Unit Production Cost*	1.5389	-	2.6630	-	5.6602	-

Note: * The unit production cost hereabove are nominal figures and does not reflect actual production cost of base oil only because the fiures are obtained as unit cost of total production cost divided by production volume of only base oil.

Table 7 ECONOMIC ANALYSIS

Case	EIRROI (%)	
	Current	Constant
BANGCHAK-A	16.60	11.36
BANGCHAK-B	19.38	13.98
SRI RACHA-A	15.58	10.39
SRI RACHA-B	17.91	12.64
BANGCHAK-AX	15.36	10.18
BANGCHAK-AY	16.48	11.25

Table 8 ECONOMIC NET PRESENT VALUE

Case	ENPV (CONSTANT) ('000 US$) CUT-OFF RATE	
	10%	20%
BANGCHAK-A	19,152	-7,378
BANGCHAK-B	51,411	21,075
SRI RACHA-A	5,119	-17,676
SRI RACHA-B	32,147	6,428
BANGCHAK-AX	2,701	-22,974
BANGCHAK-AY	17,472	-8,595

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