SULTANATE OF OMAN

THE REPORT
OF
THE FEASIBILITY STUDY
ON
THE REFINERY CONSTRUCTION PLAN

OCTOBER 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

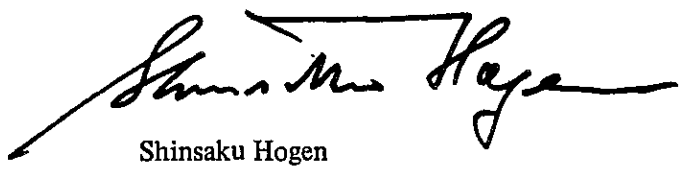
At the request of the Government of the Sultanate of Oman, the Government of Japan has decided to undertake a feasibility study on a refinery construction project planned in Oman, and has commissioned the Japan International Cooperation Agency to conduct the study.

The Agency organized a study team headed by Mr. Mizuho Kitamura, and dispatched the team to Oman for twenty-five days from 2nd March to 26th March 1979. The team made an extensive survey to collect necessary data and information for the study, with good assistance from the Omani Governmental authorities concerned. After returning to Japan, the team made detailed analyses of these data and information, ranging from market study to site selection, refinery planning and evaluation of the project. The results of the analyses are incorporated into the study report.

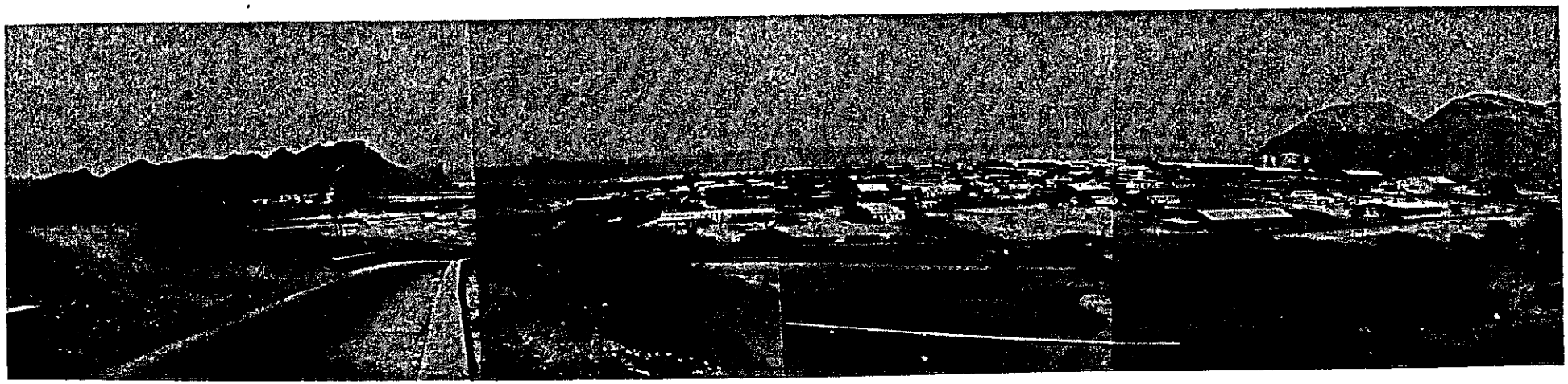
It is our sincere hope that this report will be useful and informative to the refinery project of Oman and will prove contributive to the enhancement of the close relationship between Oman and Japan.

Lastly, we would like to express our sincere gratitude to the Omani officials for their courtesies extended to our study team and for their cooperation given us in expediting this study. Our particular appreciation is directed to the Omani counterpart team members.

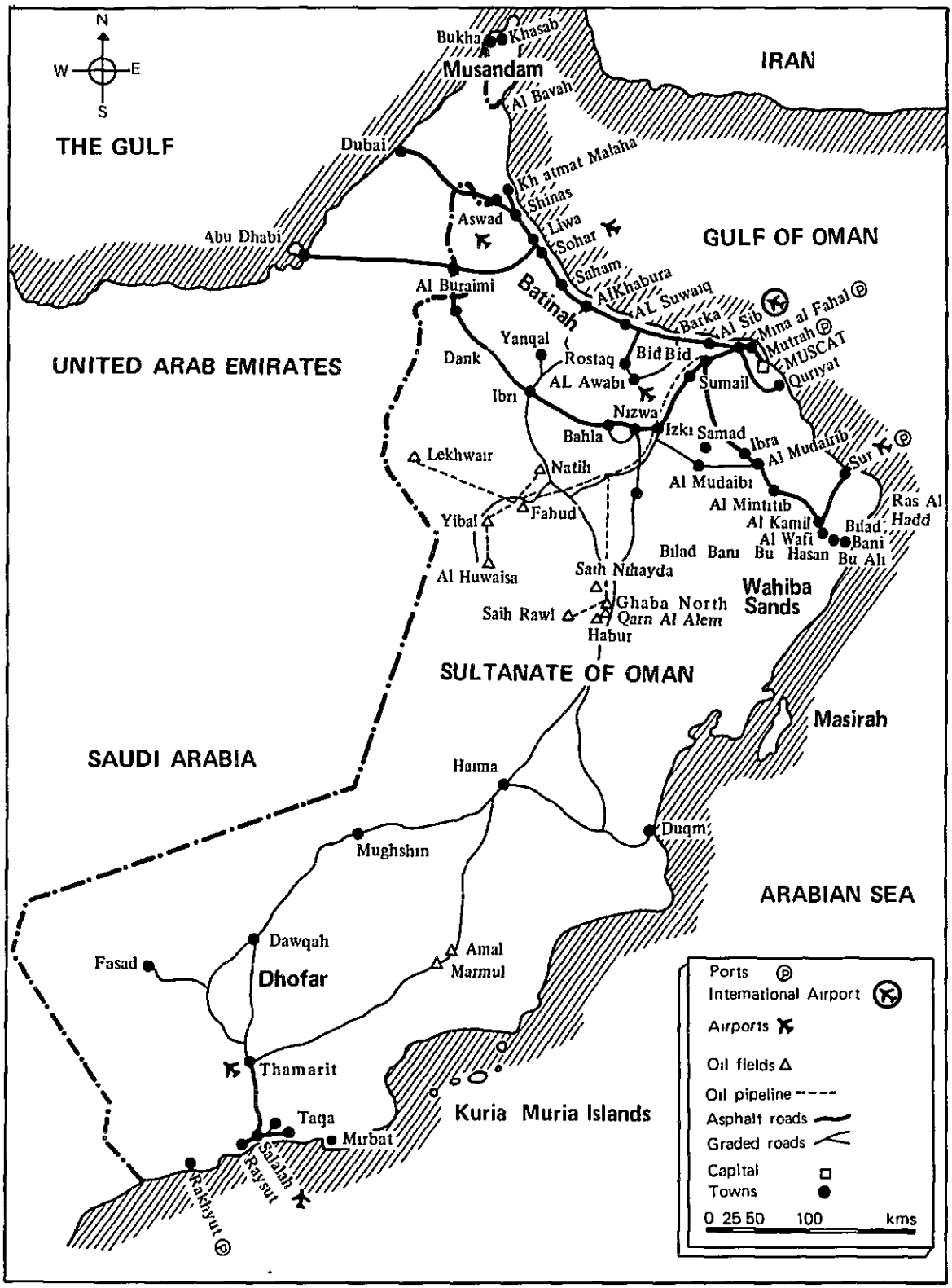
October 1979



Shinsaku Hogen
President
JAPAN INTERNATIONAL COOPERATION AGENCY



CANDIDATE SITES – MINA AL FAHAL



SOURCE: Middle East Economic Digest

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UNIT

°API	gravity of petroleum defined by American Petroleum Institute
Baisa	1,000 Baisas = 1.0 R.O.
BBL (or B)	barrel
BPCD (or bpcd)	barrel per calendar day (1 year = 365 days)
BPSD (or bpsd)	barrel per stream day (330 days a year)
BTU	British Thermal Unit
¢/USG	cent per US gallon
°C	degree centigade
CST	centistokes
$/bbl	US dollar per barrel
DWT	dead weight ton
°F	degree fahrenheit
G-Pb/l	lead by gram per litter of gasoline
Hr.	hour
Kg	kilogram
KWH	kilowatte hour
L	litter
M	thousand
m	meter
m^2	square meter
m^3	cubic meter
MM	million
MW	megawatte
%	percent
% wt.	weight percent
% vol.	volume percent
ppm	parts per million
R.O.	Rial Omani (1R.O. = 2.89234 US$)
RON	Research Octane Number
scf	standard cubic feet
scfd	standard cubic feet per day
Sp. Gr.	specific gravity
TPCD	tons per calendar day
t	metric ton
US$	US dollar
y	year

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INTRODUCTION

1. Background and Course of the Study

The Government of the Sultanate of Oman requested the Japanese Government in December 1978 to render technical assistance in performing a feasibility study on an oil refinery construction plan in the country.

Prior to this request, a "Preliminary Feasibility Study for the Industrial Development in the Sultanate of Oman" was carried out in 1978 by Japan International Cooperation Agency (JICA) as the first undertaking of Oman-Japan technical cooperation. The study proposed a number of industries as the strategic sectors for the industrial development. The aforementioned request by the Omani Government was understood that the Government placed the first priority on the petroleuim refining among those industries proposed.

In response to the request, JICA organized a study team, composed of Mr Kazuho Kitamura, the team leader, and six other experts, for the purposes of examining the feasibility of the refinery construction in Oman, and of studying various problems concerning the refinery construction. The study team visited the Sultanate as well as Saudi Arabia, where there is the Japanese Embassy to Oman, from 2nd to 26th March 1979.

Oman is an oil producing country with production of about 300,000 barrels per day of crude oil, but is wholly dependent on import for the domestic supply of petroleum products since presently there is no oil refinery in the country. The imported oil products have come mostly from the countries on the Arabian Gulf.

In the past decade, demand for petroleum products in Oman has increased enormously along with the rapid modernization of the country, and now the petroleum products have become indispensable material to run the economy of Oman. Incidentally, since the latter half of 1978, import of petroleum products to Oman has been threatened by the political unstableness in one of the Gulf coast countries. Presntly, it is one of the most important policy tasks for the Omani Government to assure stable supplies of petroleum products. The aforementioned request of the Omani Government for the technical assistance in the field of refinery construction seems to be made in such a context.

The field study team, keeping the above-mentioned situation in mind, collected relevant information and materials in Oman. After coming back to Japan, the team analyzed the collected materials and an intensive study has led the team to a conclusion that construction of a petroleum refinery in Oman around 1983 will be feasible. The team also made a comprehensive examination on the ways and measures for the realization of the refinery project.

The "Draft Final Report" of the study which described the result of the study was sent to the Omani Government toward the end of July 1979. And one month later, in August, JICA

again sent a team of three experts led by the same leader as before to explain the study results and discuss with the Omani Government.

The outcome of the study is this "Final Report".

2. Purpose of the Study.

The study had the following two main purposes:

(1) To establish a plan of a petroleum refinery in Oman to fulfil the future domestic demand for petroleum products by examining such varied aspects as raw material, future market situation, location problems, etc., and also to study whether the plan is justifiable from financial and national economic viewpoints.

(2) At the same time, to provide the Omani Government with economic and technical information which may be useful for the Government in the couse of implementation of the refinery project.

3. Organization of the Team

The study team was composed as below:

(1) Field Study

Mr. Mizuho Kitamura, The Team Leader
Mr. Tan Hashida
Mr. Toshio Kurokawa
Mr. Akio Iwaki
Mr. Masahiro Nakamura
Mr. Kojiro Kobayashi
Mr. Masaru Shishiwa

(2) Presentation of the Report

Mr. Mizuho Kitamura
Mr. Akio Iwaki
Mr. Ryosuke Hashimoto

4. Field Study

The Field Study Team entered Oman on March 5, 1979 after spending a few days at the Japanese Embassy to Oman in Jeddah, Saudi Arabia to explain the purposes and methods of the study. One of the secretaries of the Embassy accompanied the Team.

The Team started its work in Oman by visiting Ministry of Foreign Affairs, Ministry of Commerce and Industry, as well as Ministry of Agriculture, Fishery, Petroleum & Minerals to explain the intention, purposes and methods of the study and to get the Ministries' approval on them.

Then the Team, assisted by counterparts from the Ministry of Commerce & Industry, paid visits to government agencies, public organizations, private enterprises, etc., in order to collect various information and materials. Also, the team undertook on-the-spot surveys at two candidate locations for the planned refinery indicated by the Government to make physical observations.

The outline of and major observations from the field survey were described in the "Field Survey Report" which was presented to the Omani government before the Team left the country, and was reproduced as an Annex to this Final Report.

The itinerary of the Field Survey is summarized as follows:

SURVEY ITINERARY

DATE	TIME	PLACE OF VISIT, PERSONS INTERVIEWED
Mar. 6 (Tue.)	10:00	Ministry of Commerce & Industry
		– Dr. Faisal (Director of Project Studies)
		– Mr. D. K. Saxina (Adviser, UNDP)
		– Mr. Inayat Malik (Adviser)
		– Mr. Latif Juma Adam
		– Mr. Sulaiman Salih Sulaiman
	12:00	Ministry of Foreign Affairs
		– Mr. Mohamaed Hassan Ali (Chief, Economic Affairs)
		– Mr. Essa Hassan Ali (Third Office)
Mar. 7 (Wed.)	09:00	Development Council
		– H. E. Dr. Sherif Lotfy (Vice-President)
		– Mr. Ahmed Abdul Rahman (Director General, Planning & Follow-up)
	10:30	Ministry of Agriculture, Fisheries, Petroleum & Minerals
		– H. E. Hassan Al Muraza (Undersecretary)
		– Mr. Ali Al Batashi (Director of Finance)
		– Mr. Abdul Qader Y. Al Saad (Expert of the Ministry)
		– Mr. Ken Bodine (Adviser)
	11:30	Chamber of Commerce
		– Mrs. Naemat Khboury (Director of Public Relations)
		– Mr. Ahmed Suleiman (Assistant Director)
	13:00	– Ministry of Commerce & Industry
		– Mr. Malek Adawi (Director of Petroleum Products)
	14:00	Observation of Candidate Sites
Mar. 8 (Thur.)	11:00	Survey Agency, Ministry of Defence
		– Mr. W. W. Spearey
	11:00	BP Arabian Agencies Ltd.
		– Mr. Sandison (Area Manager)
		– Mr. W. R. Adams (Operations, Superintendent)
	15:30	Observation of Candidate Sites
Mar. 10 (Sat.)	10:00	Shell Market (Middle East) Ltd.
		– Mr. H. E. Evens (Manager – Present)
		– Mr. G. Choyce (Manager – Next)

DATE	TIME	PLACE OF VISIT, PERSONS INTERVIEWED
Mar. 10 (Sat.)	11:30	Dept. of Water Resources, Ministry of Agriculture, Fisheries, Petroleum & Minerals – Mr. P. M. Horn – Mr. D. G. Read
	12:00	Ministry of Agriculture, Fisheries, Petroleum and Minerals – H. E. Salim Shaban (Undersecretary) – Mr. Ali Al Batashi (Director of Finance)
	12:30	Port Service Corporation Ltd. – Mr. Collier
Mar. 11 (Sun.)	10:00	Seeb International Airport – Mr. T. C. Hoopes
	13:00	Water Department, Ministry of Water & Electricity – Mr. Hussain M. Awabh (Director General of Water)
	13:00	Ministry of Commerce & Industry – Mr. Malek Adawi (Director of Petroleum Products)
	14:30	Oman Shapoorji Construction Co. – Mr. Rao – Mr. Moolgaokar
Mar. 12 (Mon.)	08:00	Observation of Access Roads to Candidate Sites.
	09:30	Central Laboratory, Ministry of Commerce & Industry – Mr. Arnold. E. A. McLeod (Adviser)
	09:30	Ministry of Commerce & Industry – Mr. Malek Adawi (Director of Petroleum Products)
	10:00	Ministry of Civil Aviation, Road and Port – Mr. Abdulla Al Qutbi – Mr. Tariq Al Manthery
	15:30	Sogex International Ltd. – Mr. Abuzeid (Administration Manager)
Mar. 13 (Tue.)	08:30	Ministry of Commerce & Industry – Mr. Malek Adawi (Director of Petroleum Products)
	09:00	Ministry of Agriculture, Fisheries, Petroleum & Minerals – Mr. Ali Al Batashi (Director of Finance) – Mr. Ken Bodine (Adviser)

DATE	TIME	PLACE OF VISIT, PERSONS INTERVIEWED
Mar. 13 (Tue.)	09:40	Statistic Section of Customs Department, Royal Oman Police
		– Mr. Gamini De Alwis
	10:00	Ministry of Commerce & Industry
		– Mr. Ali. M. Mirza (Director of Company Affairs)
	10:50	Development Council
		– Mr. A. Abdul Rahman (Director General, Planning & Follow-up)
	13:00	Ministry of Finance
		– Mr. Suleiman Muhanna Al-Adawi (Director, Department of Income)
	13:00	Observation of Access Roads to Candidate Sites
	15:30	Sogex International Ltd.
		– Mr. Kiswani (Director of Operation)
		– Mr. Mukerjiee (Chemist)
		– Mr. Chalchal (Desalination Engineer)
		– Mr. Hassan (Mechanical Engineer)
Mar. 14 (Wed.)	11:00	Statistics Department, Development Council
		– Mr. H. K. El-Harthy
	13:00	Dhofar Office, Ministry of Commerce & Industry
		– Mr. A. N. Al Ghasani (Director)
		– Mr. Tahir Abdulla
Mar. 15 (Thur.)	09:00	Raysut Port Authorities
		– Mr. M. A. Triroosh (Deputy Manager)
		– Mr. M. K. Najeem (Operations Officer)
	10:00	Shell Raysut Oil Depots
		– Mr. S. U. Ahmed (Operations Supervisor)
	11:00	Department of Road, Ministry of Aviation, Roads and Ports
		– Mr. Salim Al Gasany (Director General of Road)
	11:00	Port Service Corp.
		– Captain J. F. Moniz (Harbour Master)
	13:00	Observation of Candidate Sites
Mar. 16 (Fri.)	09:00	Observation of Candidate Sites

DATE	TIME	PLACE OF VISIT, PERSONS INTERVIEWED
Mar. 17 (Sat.)	09:00	Department of Electricity, Ministry of Electricity & Water – Mr. Saif Salim Al-Mahri (Undersecretary) – Mr. Ahmed Ghunaim (Technical Advisor)
	09:50	Royal Oman Police – Mr. Al Suleman
	11:00	Oman Telecommunication – H. E. Noor Mohammed (General Manager, Executive Manager)
	11:00	Sogex International Ltd. – Mr. Shooth (General Manager) – Mr. Kiswani (Director of Operation) – Mr. K. H. Shublack
Mar. 18 (Sun.)	09:30	Ministry of Commerce & Industry – Mr. Malek Adawi (Director of Petroleum Products)
	12:00	Oman Development Bank – Mr. Mohamed Bechir Ben Othman (General Manager)
	15:50	Three Engineers – Mr. M. Nakamura, Mr. M. Shishiwa & Mr. K. Kobayashi left for Tokyo, Japan.
Mar. 19 (Mon.)	09:45	Seeb Airport – Mr. M. R. Ba-Omak (Director General)
	12:00	Department of Road, Ministry of Aviation, Roads and Ports – Mr. Albarad
	13:00	Central Bank of Oman – Mr. Hamood Sangour Hasim (Vice President) – Miss. Fauziya H. Al-Kindy (Assistant Manager, Research Department)
Mar. 20 (Tue.)	09:00	Ministry of Commerce & Industry – Mr. Malek Adawi (Director of Petroleum Products)
	10:15	Royal Oman Police – Mr. Hamed Suleiman
	13:00	Ministry of Social Affairs and Labour – Mr. Ahmed Nasser Al Rhabi (Deputy Director)

DATE	TIME	PLACE OF VISIT, PERSONS INTERVIEWED
Mar. 20 (Tue.)	13:30	Ministry of Land Affairs
		– Mr. Kamal Ismail (Director of Town Planning)
	15:30	Taylor Woodrow-Towell Co.
		– Mr. John Irving
		– Mr. Andrew P. Leslie
Mar. 21 (Wed.)	09:00	Development Council
		– H. E. Dr. Sherif Lotfy (Vice-President)
	10:00	Mothercat Ltd.
		– Mr. S. A. Rahhal (Acting Area Manager)
	11:30	Ministry of Finance
		– H. E. Mohammad Moosa (Undersecretary)
	11:30	Oman National Transport Company
		– Mr. Graham Fletcher (General Manager)
	12:20	BP Arabian Agencies Ltd.
		– Mr. W. R. Adams (Operations, Superintendent)
Mar. 22 (Thur.)	09:30	Ministry of Commerce and Industry
		– Mr. Malek Adawi (Director of Petroleum Products)
	10:00	BP Arabian Agencies Ltd.
		– Mr. Adams (Operations, Superintendent)
	10:00	Ministry of Electricity & Water
		– Mr. Mohammed S. Lotofy (Project Engineer)
	11:00	Ministry of Agriculture, Fisheries, Petroleum & Minerals, Water Resources Department
		– Mr. Read
	11:30	Ministry of Commerce & Industry
		– Mr. Malek Adawi (Director of Petroleum Products)
Mar. 24 (Sat.)	10:00	Mothercat Ltd.
		– Mr. S. A. Rahhal (Acting Area Manager)
	10:30	Taylor Woodrow – Towell Co.
		– Mr. John Irving
		– Mr. Andrew P. Leslie
	12:00	Kassara Transport Co. (NALCO)
		– Mr. R. R. Gnant (General Manager)

DATE	TIME	PLACE OF VISIT, PERSONS INTERVIEWED
Mar. 24 (Sat.)	01:30	Ministry of Commerce & Industry – H. E. Mohammed Zubair (Minister) – Mr. B. Al-Lamki (Director General, Dept. of Industry) – Mr. Malek Adawi (Director of Petroleum Products) – Dr. Faisal (Director of Project Studies) – Mr. D. K. Saxina (Adviser, UNDP)
Mar. 25 (Sun.)	09:00	Ministry of Commerce & Industry – Mr. Malek Adawi (Director of Petroleum Products) – Dr. Faisal (Director of Project Studies) – Mr. D. K. Saxina (Adviser, UNDP) – Mr. Latif Juma Adam – Mr. Suleiman Salih Suleiman – Mr. Ali Al Dhahab
	10:30	Ministry of Foreign Affairs – Mr. Essa Hassan Ali (Third Office)
	11:00	Ministry of Agriculture, Fisheries, Petroleum & Minerals – H. E. Salim Shaban (Undersecretary) – Mr. Ali Al Batashi (Director of Finance)

SUMMARY AND CONCLUSION

OUTLINE OF THE RECOMMENDED PROJECT

Project:	Petroleum Refinery	
Crude Throughput Capacity:	40,000 barreles per stream day (BPSD)	
Location:	Mina al Fahal area	
Probable Start-up:	Early 1983	
Processing Scheme:	as indicated in Fig. 1.	
Main Processing Units:	Crude atmospheric distillation	40,000 BPSD
	LPG and naphtha hydrodesulfurization	8,910 BPSD
	Naphtha catalytic reforming	6,000 BPSD
	Kerosene sweetening	4,680 BPSD
	Gas recovery	1,030 BPSD
Feedstock:	Oman Crude	40,000 BPSD

Product:	Production (BPSD)	Estimated 1985 Demand (BPSD)
LPG	230*	380
Premium Motor Gasoline	5,450	5,510
Regular Motor Gasoline	2,210	2,160
Kerosene/Jet A-1	4,680	4,060
Gas Oil	8,600	8,730
Marine Bunker Fuel	9,945	9,945
Heavy Fuel Oil	7,855**	–
Bitumen	– ***	15 (TPSD)
Lubricating Oil	– ***	333

Note: * Supply of 150 BPSD of LPG is expected from the Rusayl LPG plant

** To be exported

*** Demands for the two products are too small to justify commercial production

Utilities Requirements:	Electricity	3,410 KW
	Fuel	1,590 x 10^6 Kcal/Day
	Fresh Water (Net)	670 Ton/Day
	Sea Water	30,100 Ton/Day

Personnel:	Managers	29 persons
	Foremen	29 persons
	Skilled	122 persons
	Semi-skilled and Unskilled	33 persons
	Total	213 persons
Construction Cost:	Processing Units	10.04 MM R.O.
	Utility Facilities	1.82 MM R.O.
	Tankege & Oil Handling	7.25 MM R.O.
	Other Offsite Facilities	2.97 MM R.O.
	Site Preparation	0.17 MM R.O.
	Products Pipelines	0.08 MM R.O.
	Total	22.33 MM R.O.

Pay-Out Time: 9.05 years

Internal Rate of Return on Total Capital: 8.52%

Construction Period: 30 months plus 3 months for test-run

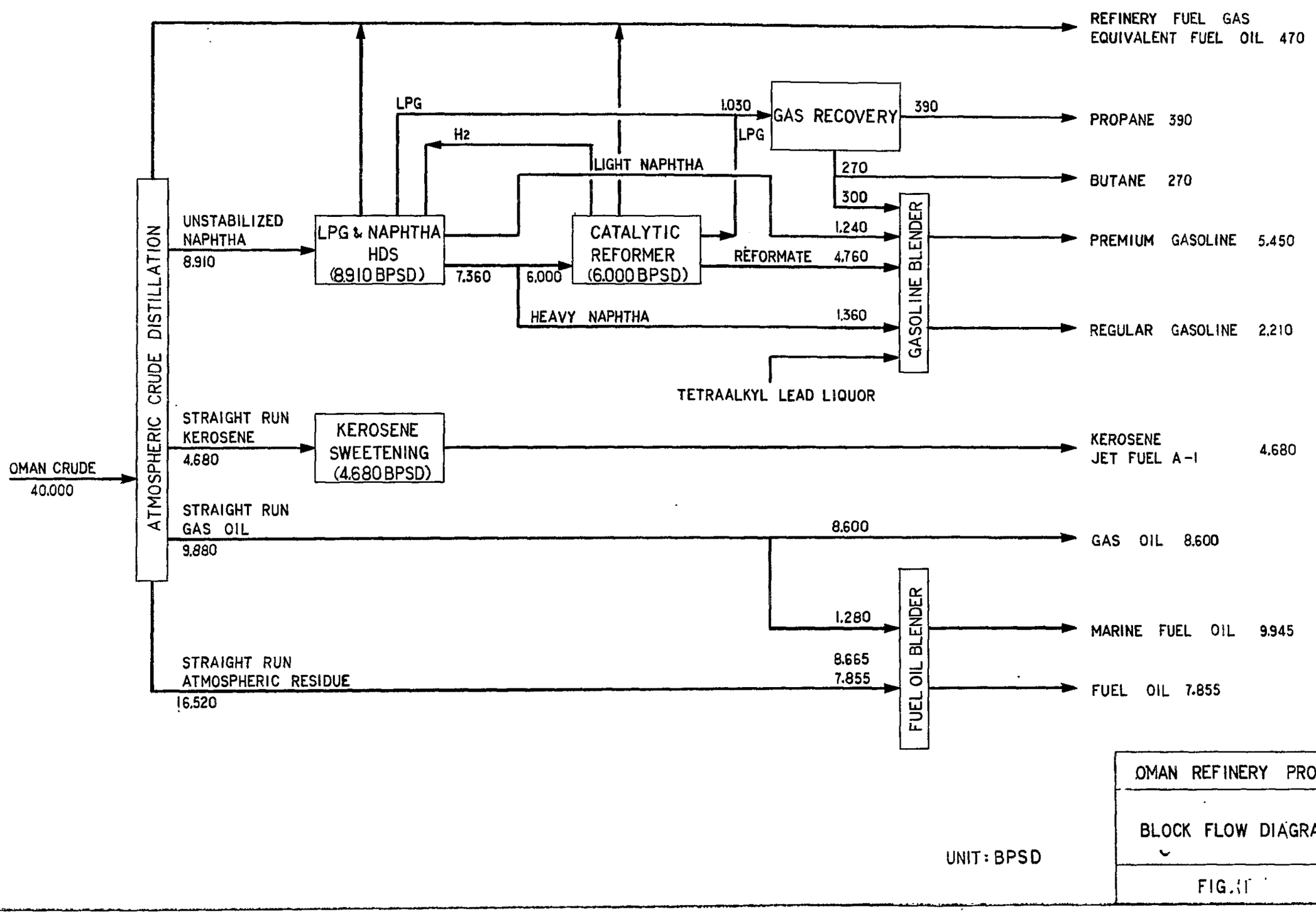
CHAPTER 1 ECONOMY AND PETROLEUM IN OMAN

Oman's economy, which experienced a phenomenal high rate of growth in the first half of the 1970's, is now passing a sort of adjustment period. And, after 1980, the nation's economy is expected to resume a moderate, but steady, course of development.

The Omani economy has been heavily dependent on petroleum. The government has been making efforts to diversify the economic and industrial structure and to widen the basis of the national economy. These efforts seem to bear fruits, though slowly, and it is expected that contribution of the petroleum sector in GDP, which presently is as high as over 60 percent, is to be reduced substantially in the coming decade.

As a result of an enormous effort of the government, such economic and social infrastructures as roads, ports, airports, telecommunication, and public utilities have been steadily developed during the past decade. This was a wise selection to avoid confusion which some of the neighboring countries have encountered as a result of a discrepancy between rapid industrialization and inadequate infrastructures.

In the coming decade, construction of infrastructures is expected to attain a state of saturation, so that investments in the production sectors will gradually take the place of major items of fixed capital formation. This means that Oman is to enter a period of diversified


REFINERY FUEL GAS
EQUIVALENT FUEL OIL 470
LPG
1.030
GAS RECOVERY
390
PROPANE 390
H2
LPG
LIGHT NAPHTHA
270
BUTANE 270
300
UNSTABILIZED
NAPHTHA
8.910
LPG & NAPHTHA
HDS
(8.910 BPSD)
CATALYTIC
REFORMER
(6.000 BPSD)
1.240
PREMIUM GASOLINE 5.450
REFORMATE 4.760
7.360
6.000
HEAVY NAPHTHA
1.360
GASOLINE BLENDER
REGULAR GASOLINE 2.210
TETRAALKYL LEAD LIQUOR
ATMOSPHERIC CRUDE DISTILLATION
STRAIGHT RUN
KEROSENE
4.680
KEROSENE
SWEETENING
(4.680 BPSD)
KEROSENE
JET FUEL A-1
4.680
OMAN CRUDE
40.000
STRAIGHT RUN
GAS OIL
9.880
8.600
GAS OIL 8.600
1.280
MARINE FUEL OIL 9.945
STRAIGHT RUN
ATMOSPHERIC RESIDUE
16.520
8.665
7.855
FUEL OIL BLENDER
FUEL OIL 7.855
UNIT: BPSD
OMAN REFINERY PROJECT
BLOCK FLOW DIAGRAM
FIG. 11

industrialization.

One of the characteristics of the Omani economy is that Oman is spending a considerable portion of the foreign exchange earned by crude exports to import refined petroleum products. The import of petroleum products accounted for nearly 9 percent of the crude export revenue in 1977. And the ratio is likely to increase in future since the demand for the products will certainly continue to increase whereas the production and exports of crude are declining.

Petroleum products have already become indispensable materials required to run the economy of Oman. And it is one of the most important policies today for the government to secure a stable supply of petroleum products.

Therefore, it is considered quite natural for an oil producing country like Oman to try to attain self-sufficiency in petroleum products by refining its own crude oil.

CHAPTER 2 PETROLEUM PRODUCTS MARKET IN OMAN

Present Supply of Petroleum Products

Presently, Oman is wholly dependent on imports for its supply of petroleum products. Imported products have been coming mostly from Arabian Gulf countries such as Bahrain and Iran. However, since the latter half of 1978, when Iranian refineries could not produce oil products at a normal rate, Oman has had to import a part of its oil requirements from as far away as Singapore.

The imported Petroleum products are marketed by two dealers – Shell and BP, both have their imported oil storage terminals at Mina al Fahal in the capital area. The Ministry of Commerce and Industry of the Omani Government owns a storage terminal at Raysut port, Dhofar. Operation of the facilities was commissioned to Shell.

Demand for Petroleum Products in 1978

The petroleum products now being imported to Oman include LPG, aviation gasoline, premium and regular motor gasolines, domestic kerosene, jet A-1, gas oil, fuel oil, marine bunker oil, bitumen and lubricating oil. Among them, marine bunker oil is supplied to the ships calling at Omani port; that is, it is not consumed within the country; so, too, is a part of jet A-1.

The 1978 demand for the all petroleum products above totaled about 8.1 million bbl annually or about 22 thousand bbl per day. The demand excluding marine bunker oil was about 3.89 million bbl or about 11 thousand bbl/day. This amount can be roughly regarded as the total domestic consumption of petroleum products. (The demands for fuel oil, bitumen and lubricating oil are so small that they can safely be neglected from the overall viewpoint.)

Demand Forecast for 1985

The demand for petroleum products excluding marine bunker oil, bitumen, and lubricating oil in 1985 is estimated to rise to 6.88 million bbl (18,900 bbl/day) from the 1978 figure of 3.89 million bbl (10,700 bbl/day). If demand for marine bunker fuel is added, the estimated 1985 demand is 10.17 million bbl (27,800 bbl/day) against 8.14 million bbl (22,300 bbl/day) in 1978.

Past and present trend of petroleum products demand as a whole is illustrated in Fig. 2.

Demand for each kind of petroleum products is estimated by utilizing the correlationship with most suitable parameters for each products; for example; number of registered vehicles for motor gasolines; mumber of take-off flights for jet A-1; electric power generation by Diesel power plants for gas oil; etc.

The results are summarized in Fig. 3 in contrast with demand in 1975 and 1978. Please note that scale for LPG, aviation gasoline and domestic kerosene is enlarged by ten times compared to the scale for other products since the demands for these three products are relatively small.

As clearly seen from the graph, demands for premium motor gasoline, jet A-1, and gas oil will increase rapidly in the future. The growth of demand for LPG will be also high though the demand is not so big compared to other products. In contrast, no rapid growth is expected for aviation gasoline, regular motor gasoline, and domestic kerosene. As to marine bunker oil, which presently shares about a half of the total petroleum products demand in Oman, the demand is anticipated to decrease substantially, reflecting the declining tendency of production and, accordingly, export of Omani crude oil.

The expected change from 1978 to 1985 in the ratio of the demand for each product is illustrated in Fig. 4. The ratios are indicated in percentages where total demand for distillate products (LPG, gasolines, jet/kerosene, and gas oil) is taken as 100 percent. Percent ratio of demand for marine banker fuel to total distillate demand is also indicated in the chart.

It is observed from this chart that, whereas the ratio of premium gasoline is to increase and the ratio of regular gasoline to decrease, there will be no substantial change in the ratio of total gasoline fraction.

This also apply to kerosene and gas oil fractions. And, it is worth to be noted that the ratios of these three distillate fractions approximately correspond to those contained in Oman crude oil, that is also indicated in the same chart.

Contrary to the above, ratio of demand for marine bunker oil to the demand of distillate products is estimated to undergo a substantial change. Whereas marine banker oil in 1978 has a larger demand than that for all distillate products, the ratio is to decrease to 48 percent of total distillate demand in 1985. Since the marine bunker oil is made largely of residue fraction, of which the content in Oman crude is 70 percent of distillate fractions, it will be

FIG. 2 PETROLEUM PRODUCTS DEMAND IN OMAN – PAST AND FUTURE

CURVE A EXCLUDING BITUMEN AND LUBRICATING OIL

CURVE B EXCLUDING MARINE BUNKER, BITUMEN AND LUBRICATING OIL

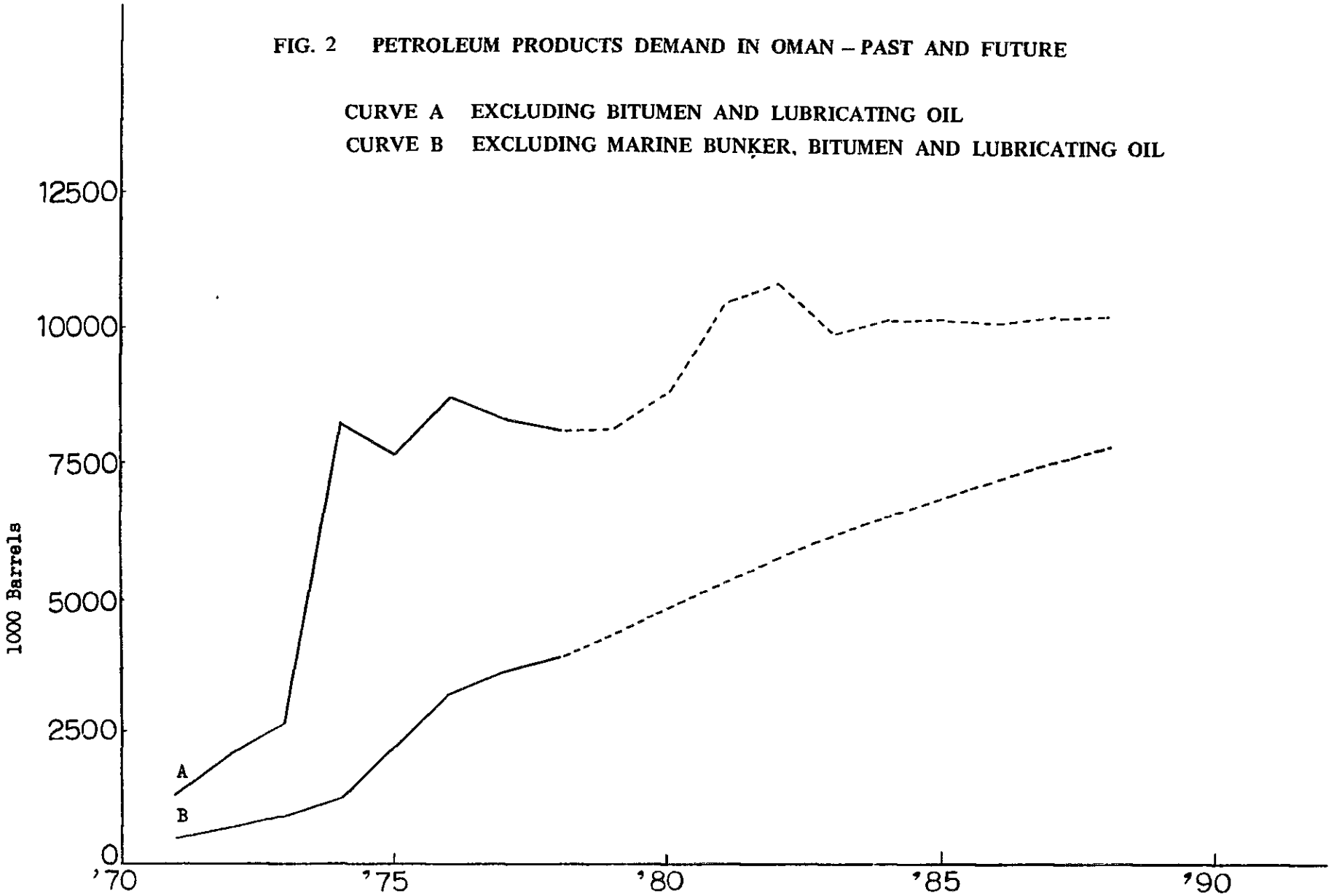


FIG. 3 DEMAND FOR PETROLEUM PRODUCTS – PAST RECORD AND 1985 ESTIMATION

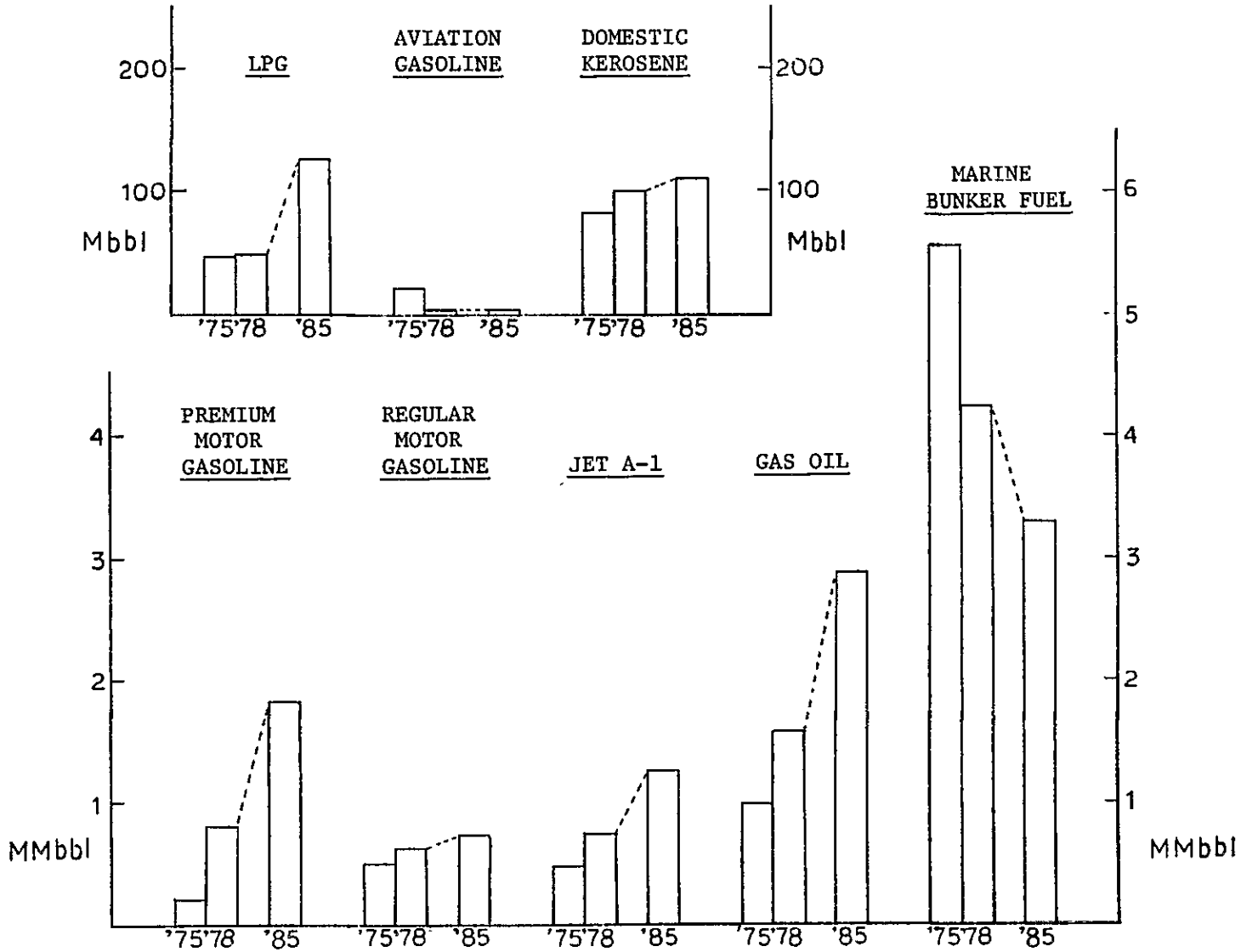
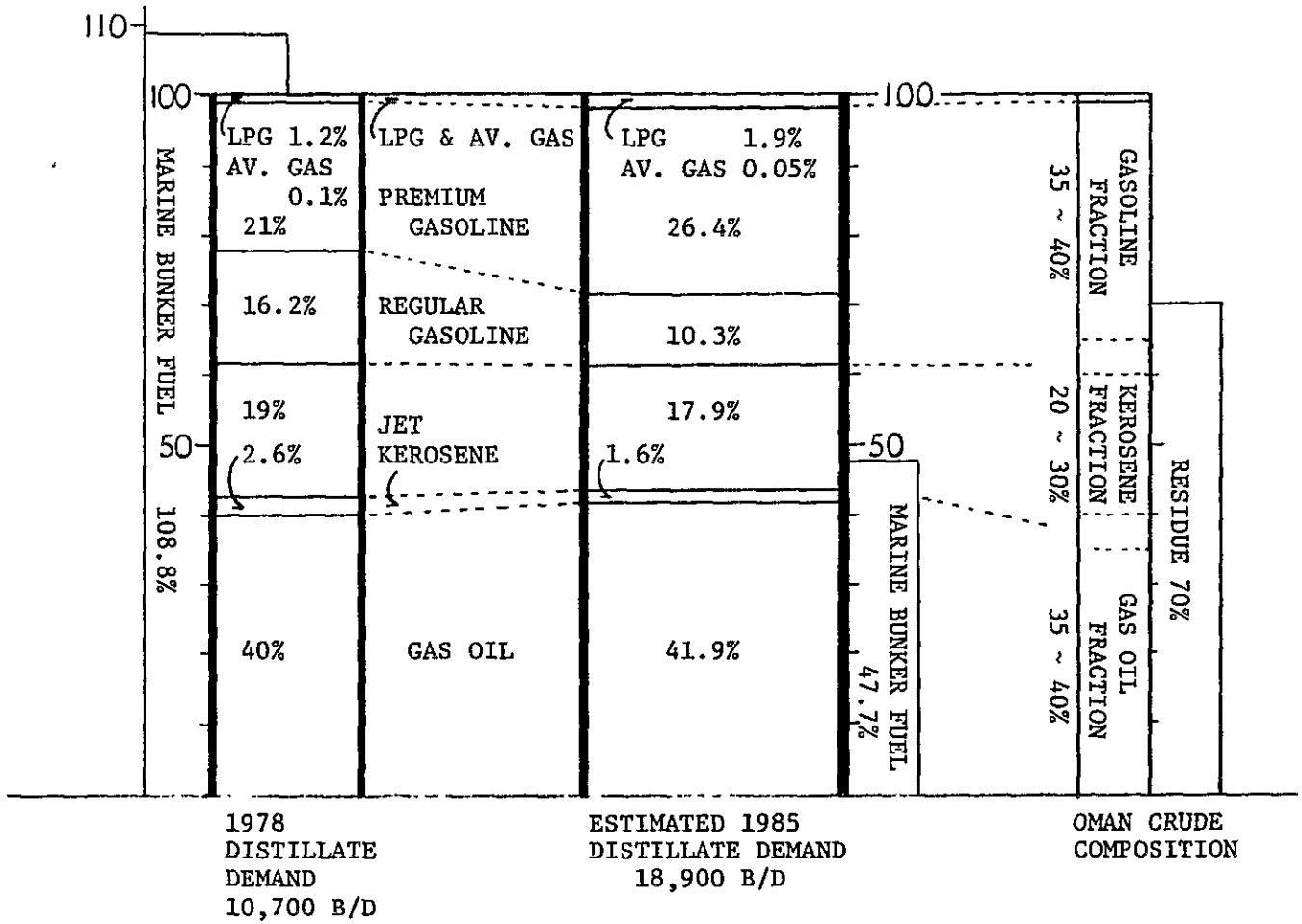


FIG. 4 DEMAND STRUCTURE FOR PETROLEUM PRODUCTS, 1978 & 1985 COMPARED TO THE COMPOSITION OF OMAN CRUDE



note 1: percent ratios are to total distillates.

2: width of colum is proportional to the demand in each year.

inevitable that residue fraction (heavy fuel oil) is to be produced in surplus as far as Oman crude is refined to meet the domestic demands of distillate products.

CHAPTER 3 AVAILABILITY OF CRUDE OIL

The 1979 crude oil production in Oman is estimated at 300 thousand bbl/day. Although the oil production from the existing oil fields has shown a tendency to decline in recent years, the total production in future is expected to increase to a peak in 1981 of 352 thousand bbl/day because of the development of new oil fields. Afterward, production is forecasted to decrease to a 1984 level of 322 thousand bbl/day, according to PDO, as indicated in Fig. 5.

From 1985 onward, no formal production forecast has been published. However, it is impossible to imagine that the refinery now being studied cannot get its crude requirements in the range of 20 to 40 thousand bbl/day from domestic sources.

In addition, the Ministry of Agriculture, Fisheries, Petroleum and Minerals suggested that when a oil refinery is set up in Oman, crude supply to the refinery would be given the highest priority. Therefore there is little concern for the supply of Omani crude oil to the planned refinery.

CHAPTER 4 PUBLIC UTILITIES

Utilities required by a refinery are electricity, water and fuel. All of the three are readily available from the respective public supply systems in the capital area, which have sufficient capacities compared with the amounts required by the refinery being planned.

As to electricity, the power station at Al Ghubra has an existing installed capacity of 125 MW, which is to be extended to 225 MW in 1979. Further extension to 300 MW is being planned. Electric power requirements of the refinery are estimated to be 3,500 KW.

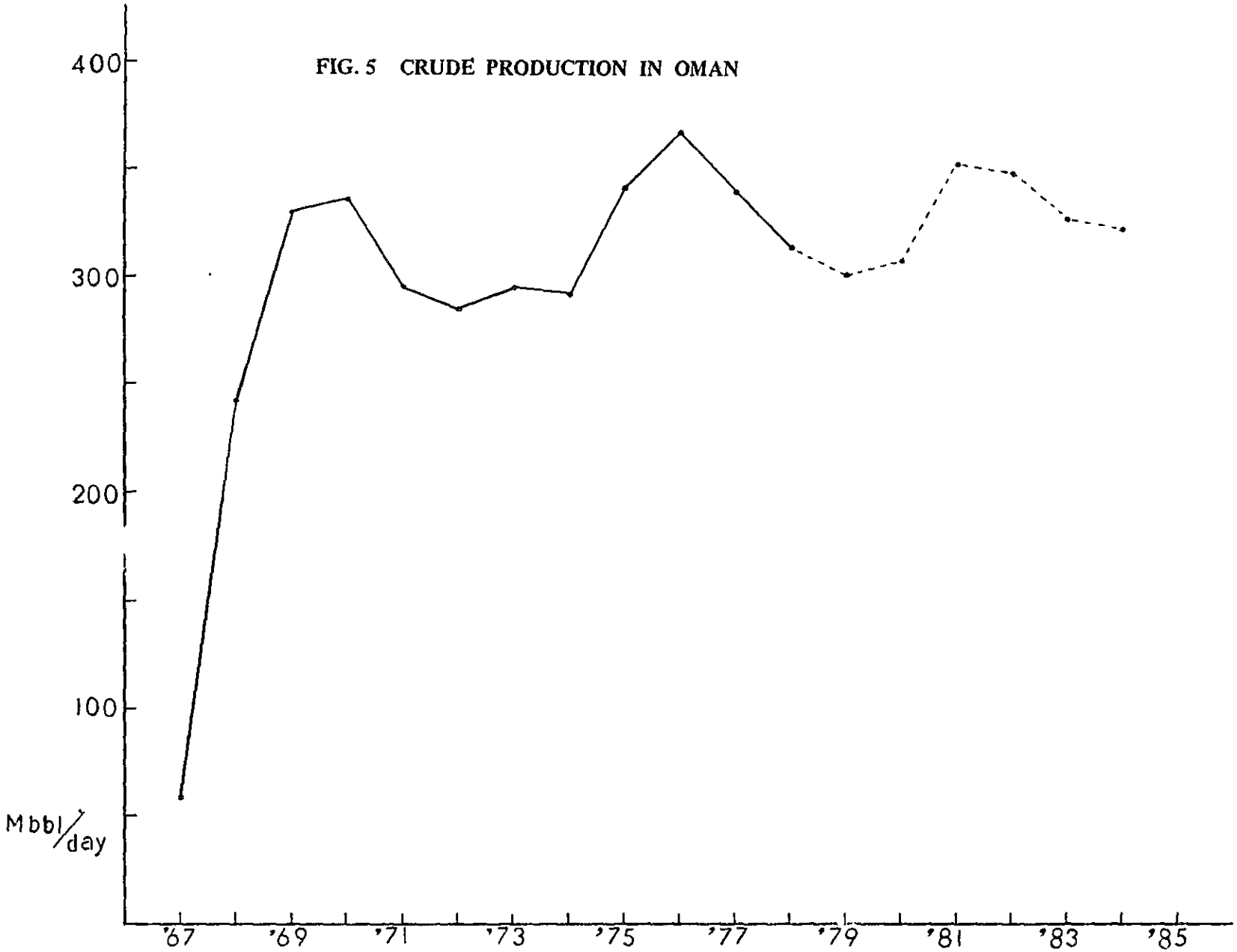
Present public water supply system in the capital area has a daily capacity of 15,700 tons from both the water wells and the Al Ghubra desalination plant. There is a plan for increasing the capacity of the Al Ghubra plant to 90,000 tons per day. Compared to the above, industrial water requirements of the refinery are not more than 2,600 tons per day.

The natural gas pipeline from the Yibal gas field to the Al Ghubra power station/desalination plant has a design capacity of 140 MM scfd, whereas the plant consumes only 20 MM scfd of gas. Even if the above mentioned expansion plan of the Al Ghubra plant is realized, the pipeline still have a reserve capacity to supply as little as 9 MM scfd of gas to the refinery being planned.

The cost of the above public utilities are found to be as follows.

Electricity: 20 Baisa/KwH

FIG. 5 CRUDE PRODUCTION IN OMAN



Water: 2 Baisa/imperial gallon

Natural gas: half the crude oil price for the same calorific value.

CHAPTER 5 REFINERY LOCATION

Two candidate locations were indicated by the Omani government, that is, Mina al Fahal area and Al Ghubra area. It was found on the field observation that the former area has two lots of land that are suitable as the site for a refinery. These are indicated in Fig. 6 and 7.

The Mina al Fahal area is advantageous in that (1) the area is situated near existing oil facilities, a part of which can be used for the construction and operation of the refinery; and (2) land transportation of refinery equipment and materials from Mina Quaboos port will enconter less trouble.

The Al Ghubra area is advantageous for its wide and flat land, good ground conditions, a short distance to the power generation/water desalination plant, and little existence of nearby facilities that may cause trouble. However, the following are remarkable disadvantages for the area, that is, (1) distance from the existing crude and products tanks at Mina al Fahal area causes high cost of laying products pipeline; and (2) long-distance go-and-return transport of raw materials and products will result in troublesome operation.

In conclusion, the Mina al Fahal area is found to be more suitable as a refinery site than the Al Ghubra area. Within the Mina al Fahal area, Site A with its better ground conditions is superior to Site B.

However, this does not mean that Site B in the Mina al Fahal area and the Al Ghubra area is totally unsuitable as a refinery site.

CHAPTER 6 OUTLINE OF A REFINERY TO BE CONSTRUCTED IN OMAN

6.1 Products

Products to be produced by the planned refinery are:

- LPG
- Premium Motor Gasoline
- Regular Motor Gasoline
- Jet A-1
- Domestic Kerosene
- Gas Oil
- Marine Bunker Fuel

Specifications of all the products conform to international standards.

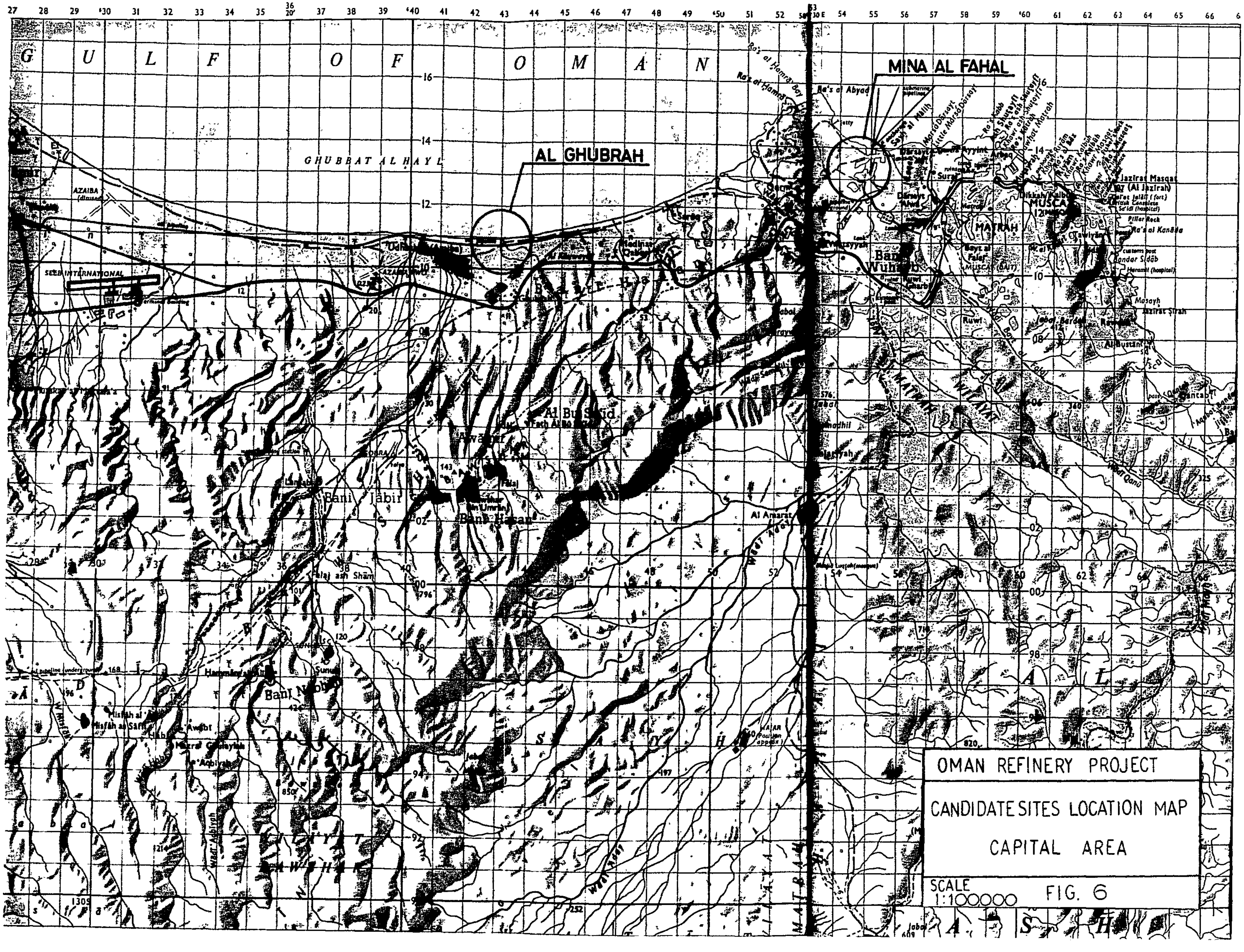
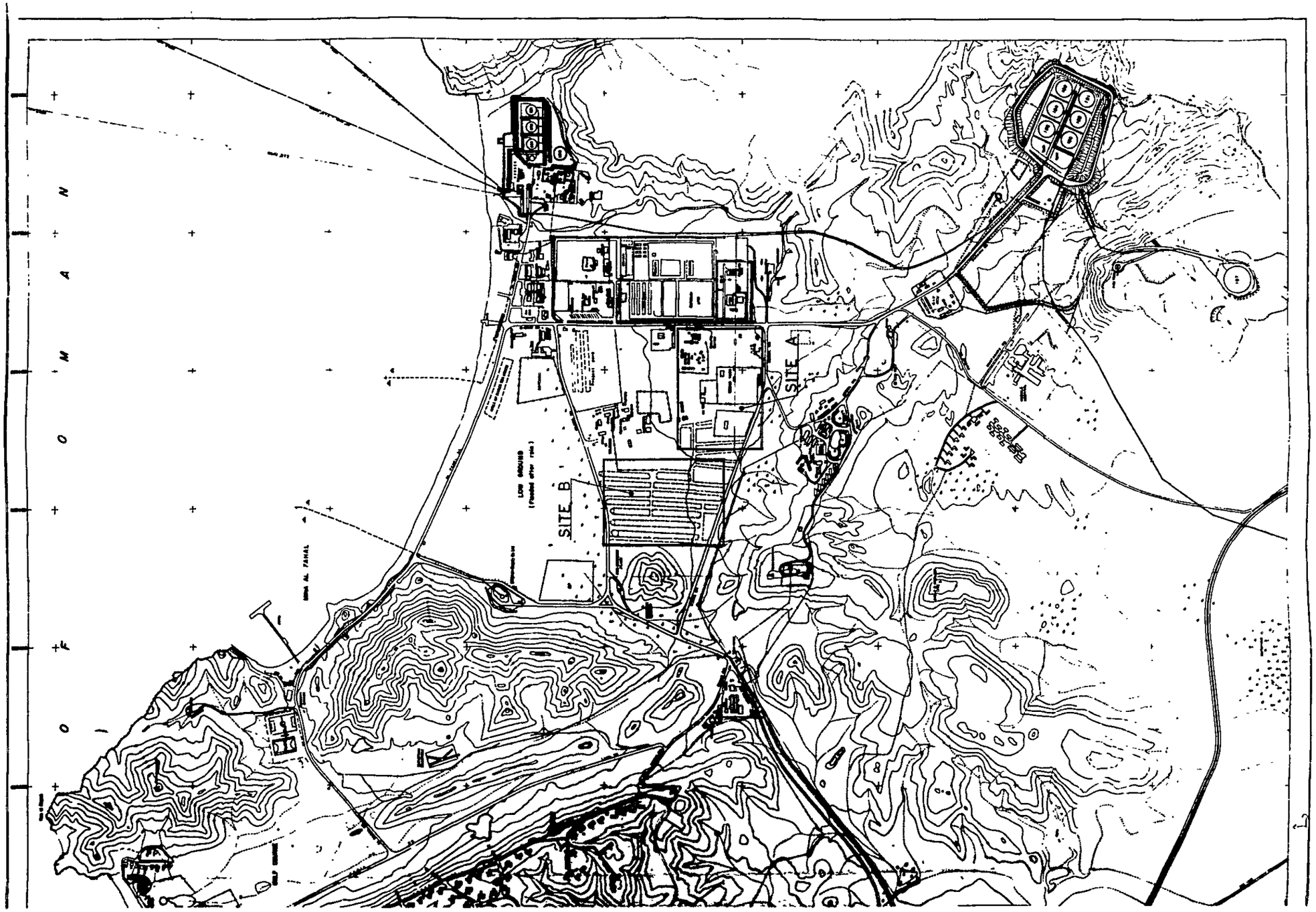

GULF OF OMAN
GHUBBAT AL HAYL
AL GHUBRAH
MINA AL FAHAL
SEEB INTERNATIONAL
AZAIBA
MUSCAT
MATRAH
Bani Jabir
Bani Hasan
Al Bu Said
Al Amarat
Bani Nabhan
OMAN REFINERY PROJECT
CANDIDATE SITES LOCATION MAP
CAPITAL AREA
SCALE
1:100000
FIG. 6

FIG. 7 CANDIDATE LOTS LOCATION MAP – MINA AL FAHAL



6.2 Crude

This planned refinery is to process Oman crude.

6.3 Refinery Configulation

Main Processing Units

The planned refinery is to be equipped with the following process units:

- Atmospheric distillation unit, which fractionates the crude oil into four main fractions, that is: LPG and naphtha, kerosene, gas oil, and residue.
- LPG and naphtha hydrodesulfurization unit, which remove sulfur compounds from the fraction and separate it into LPG and naphtha.
- Catalytic reforming unit, which improve the octane number of the naphtha.
- Kerosene sweetening unit, which yields jet A-1 and domestic kerosene of specified quality.
- Gas recovery unit, which separates LPG fraction into propane and butane and recover them in liquid form.

Crude Throughput Capacity

Two kinds of crude throughput capacities are selected for the refinery being studied: 40,000 BPSD and 20,000 BPSD. These capacities are those of crude distillation units of the refinery and capacities of the other prossessing units also change proportionally as shown below.

Atmospheric distillation	40,000 BPSD	20,000 BPSD
Hydrodesulfurization	8,910	4,460
Catalytic reforming	6,000	3,000
Kerosene sweetening	4,680	2,340
Gas recovery	1,030	520

The amounts of the products to be produced by the two types of refinery are as shown in Fig. 8.

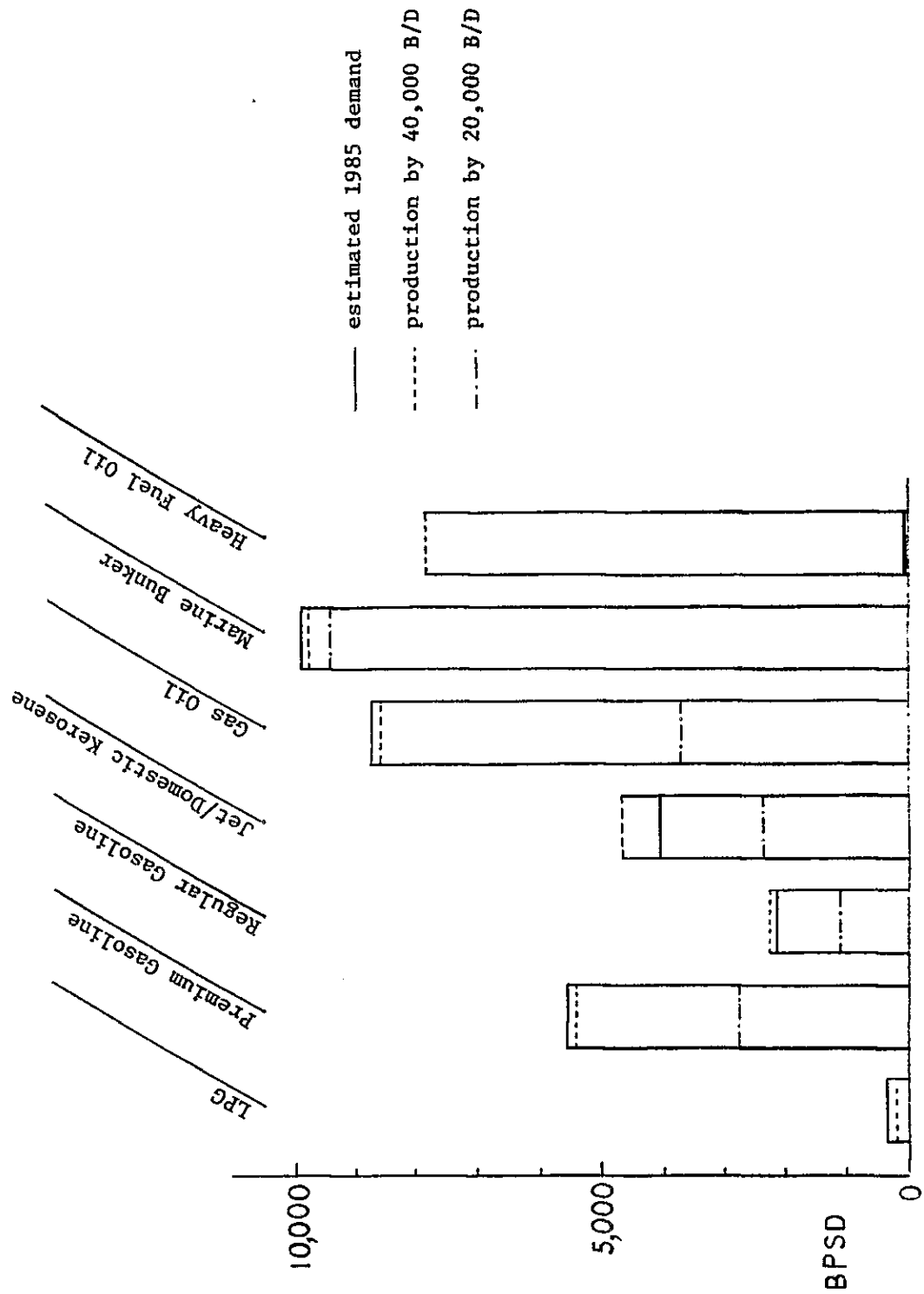
In the 40,000 BPSD case, estimated 1985 demands for all products are to be fulfilled almost completely, the problem is that 7,855 BPSD of heavy fuel oil, for which no domestic demand is expected, is to be produced in surplus. This heavy fuel oil will have to be exported.

In the 20,000 BPSD case, no surplus fuel oil is to be produced. However, estimated 1985 demands for other products are to be fulfilled only partly. Consequently, Oman will have to be still dependent on imports for these petroleum products.

Utilities

As stated in Chapter 4, the refinery being studied will be able to get its utility requirements from public supply systems. However, there is another possibility that the refinery is to make its own supply of electricity and water requirements by installing its own power genera-

FIG. 8 ESTIMATED DEMAND VS. PRODUCTION BY 40,000 BPSD AND 20,000 BPSD REFINERY



tion/desalination plant. Final choice will have to be made based on the total economy of the refinery.

Therefore, two alternative cases are examined for each of the crude throughput capacities. That is, utility purchase case (P) and utility self-supply case (S).

Consequently, now four cases of refinery are to undergo further examination:

- 40,000 BPSD/Utility Purchase (40/P)
- 40,000 BPSD/Utility Self-Supply (40/S)
- 20,000 BPSD/Utility Purchase (20/P)
- 20,000 BPSD/Utility Self-Supply (20/S)

Oil Storage and Oil Handling

The refinery is to be supplied with crude oil from the existing crude tankage of P.D.O. whose capacity is more than enough for the refinery.

Therefore, only service tanks are required by the refinery to store crude oil corresponding to three days' throughput, namely;

- in the 40,000 BPSD cases, two 10,000 KL tanks
- in the 20,000 BPSD cases, two 5,000 KL tanks

For final and intermediate products, tankage plan is based on the following preconditions:

- Total product storage capacity is to correspond to the production of 30 days, which is a period for a shut-down maintanance.
- Existing product tanks owned by Shell and BP at Mina al Fahal are to be utilized by the refinery as far as possible.
- Marine transportation to the Salalah products terminal is to be considered. Also export of surplus heavy fuel oil (in 40,000 BPSD cases) as well as storage for products to be imported (in 20,000 BPSD cases) are to be taken into consideration.

As the result, a tank installation plan is worked out as shown in the table on the next page and the tank system is as illustrated in Fig. 9.

Product Transfer

As described above, the existing product tanks at Mina al Fahal terminal are to be converted to the use of the refinery. Therefore, the products will have to be transferred to these tanks from the refinery.

For the purpose, products pipelines are to be laid as below:

To Shell Terminal: One pipeline for marine bunker fuel and heavy fuel oil, and one pipeline for gasoline, jet/kerosene, ans gas oil

To BP terminal: One pipeline for gasoline, jet/kerosene, and gas oil

	40,000 BPSD	20,000 BPSD
Crude	10,000KL x 2	5,000KL x 2
Final Products		
Gasoline	7,500 x 2 3,000 x 2	5,000 x 2 2,000 x 2
Kerosene/Jet A-1	8,000 x 2	4,000 x 2
Gas Oil	10,000 x 2 4,000 x 1	10,000 x 2
Marine Bunker/Fuel Oil	20,000 x 2	5,000 x 2
Propane	500 x 2	500 x 2
Butane	600 x 2	500 x 2
Intermediates		
Light Naphtha	700 x 2	400 x 2
Reformate	3,000 x 2	1,500 x 2
Heavy Naphtha	800 x 2	400 x 2
Reduced Crude	5,000 x 2	5,000 x 2
Slops		
Light Slop	3,000 x 1	1,300 x 1
Heavy Slop	3,000 x 1	1,300 x 1

Land Area and Plot Plan

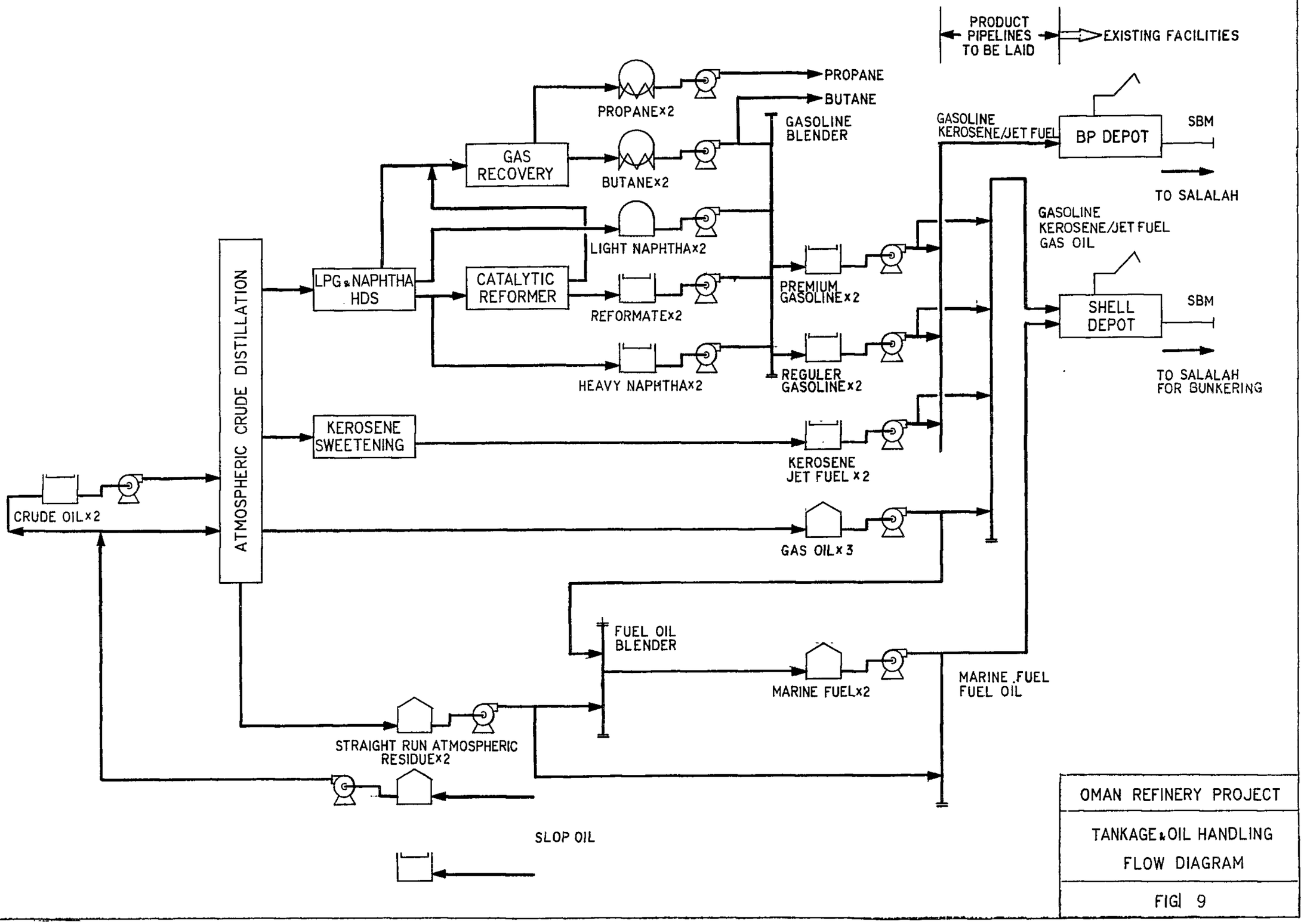
Land area required by each case of the refinery is as follows:

40/P	40/S	20/P	20/S
130,000 m^2	135,000 m^2	92,000 m^2	94,000 m^2

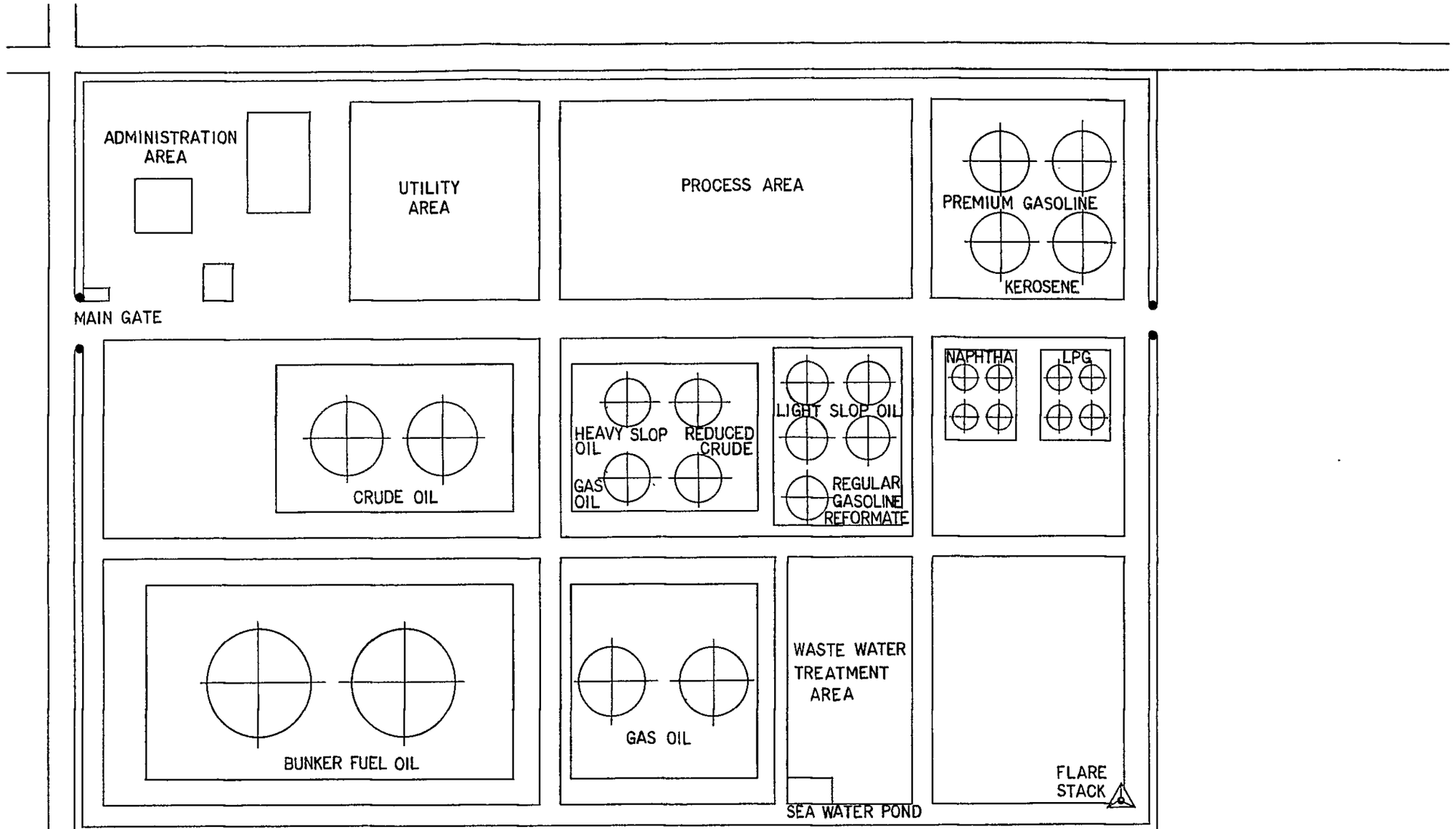
An example of the plot plan of the refinery is shown in Fig. 10.

6.4 Refinery Organization and Manning Plans.

Personnel required by the refinery is 213 persons for the utility self-supply cases and 200 persons for the utility purchase cases, irrespective of refining capacity.



OMAN REFINERY PROJECT
TANKAGE & OIL HANDLING FLOW DIAGRAM
FIG. 9



SCALE
0 50 100m

OMAN REFINERY PROJECT

GENERAL PLOT PLAN

FIG.1 10

A breakdown of the personnel requirements is as shown in the following table.

Position \ Case	40,000 & 20,000 BPSD	
	Self-Supply	Purchase
Refinery Manager	1	1
Assistant Refinery Manager	1	1
Secretary	2	2
Production Dept.	92	80
Technical Service Dept.	23	23
Maintenance Dept.	39	38
General Affairs Dept.	55	55
Total	213	200

The organizational structure of the refinery is as shown in Fig. 11:

CHAPTER 7 ECONOMIC EVALUATION

7.1 Cost Estimation

Fixed Capital

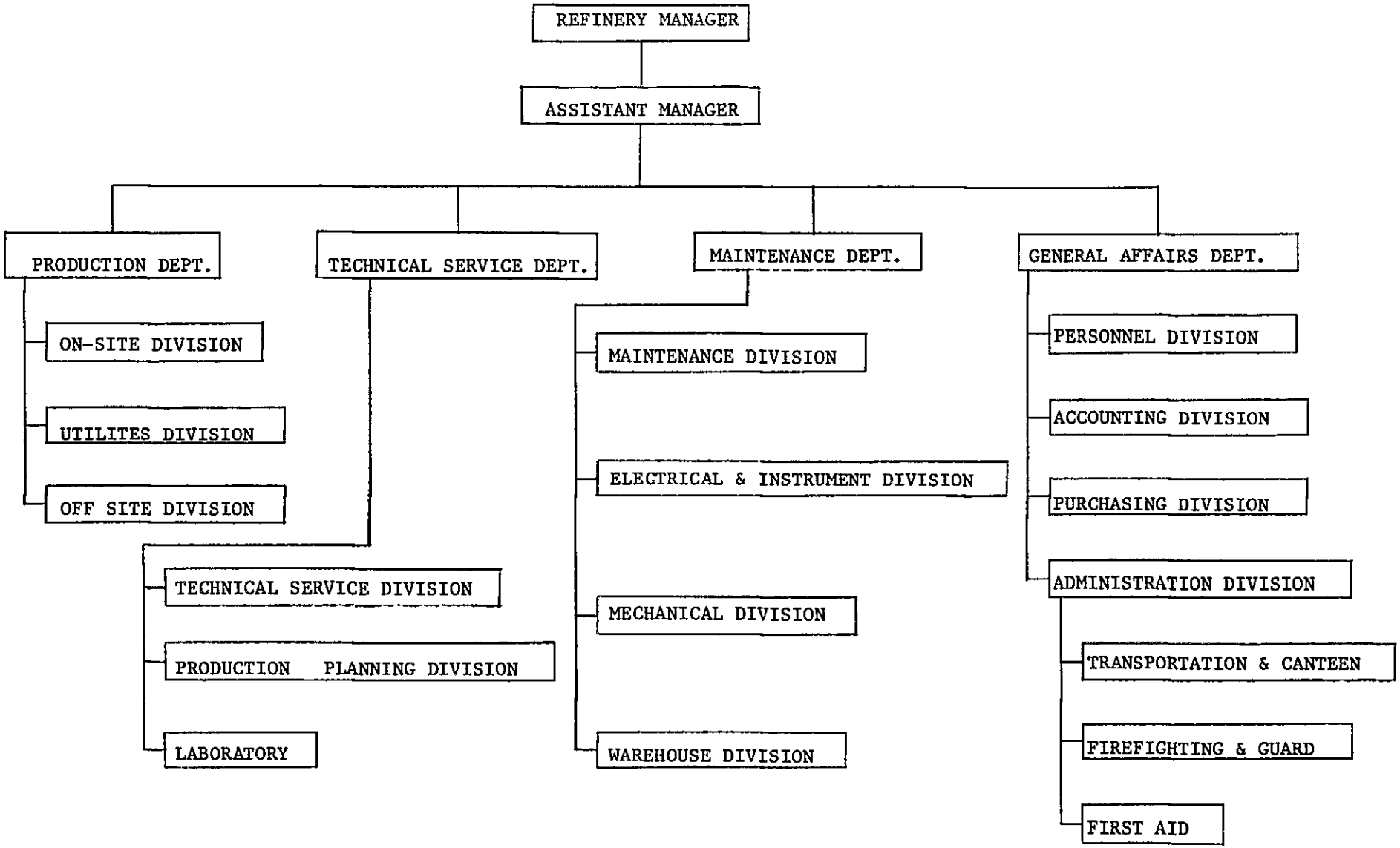
Total fixed capital requirements of the four cases of the refinery being studied are as below. "Other Fixed Capital" includes: Preoperating expenses sush as training fee for employees, administration cost, and start-up expenses; Paid-up royalty; Initial charges of catalyst and chemicals; and Interest paid during construction.

(unit: MM R.O.)

Refinery Case	40/S	40/P	20/S	20/P
Plant Construction Cost	24.36	22.33	16.07	14.65
Other Fixed Capital	2.73	2.65	2.13	2.06
Total Fixed Capital	27.09	24.98	18.20	16.71

Note: codes for cases of the refinery are as below:
40/S: 40,000 BPSD, Utilities self-supply
40/P: 40,000 BPSD, Utilities purchase
20/S: 20,000 BPSD, Utilities self-supply
20/P: 20,000 BPSD, Utilities purchase

FIG. 11 ORGANIZATION CHART



Working Capital

Initial working capital for each refinery case including: Operating cash, Raw material and Products inventories, and the difference between Receivable and Payable accounts is as follows:

(unit: MM R.O.)

	40/S	40/P	20/S	20/P
Initial Working Capital	3.47	3.50	1.81	1.84

Production Costs

Production costs include: Direct production costs such as raw material, labor, and utilities, maintenance, operating supplies, and catalyst and chemicals; Depreciation; General expences; Interest; etc. Presuppositions for calculating major cost items are as follows:

- Crude oil cost is set at 5.186 R.O. per bbl except for "1978 price" based calculation, where the crude cost of 4.494 R.O. per bbl was used.
- Labor cost is calculated on the basis of personnel planning described in Chapter 6. Total annual payroll for each refinery case is as below:

	40,000 BPSD and 20,000 BPSD	
	Self-Supply	Purchase
Total Personnel	213	200
Total Annual Payroll (in 10^3 R.O.)	940	895

- Unit costs of utilities purchased from respective public supply systems are set as below:

Electricity	0.02 R.O./KwH
Industrial Water	0.44 R.O./Ton
Natural gas	0.484 R.O./MMBTU

- Maintenance cost is set at 4 percent of the construction cost annually.
- Depreciation of fixed capital as defined before is to be made by the following method: Straight-line, 10 years starting from the first year of commercial operation, with salvage value of 10 percent.
- No income tax is imposed, nor any dividend is taken into account in this financial analysis.

7.2 Financial Analysis

Financial analysis is carried out by use of a computer to develop financial statements including:

- Income statement

- Funds outlook
- Cash flow analysis table
- Balance sheet

Premises

- The refinery is scheduled to start commercial operation in January 1983. Fifteen years is taken as the project period for the analysis, namely, from January 1983 to December 1997.
- The operating rates of the refinery in the first and second years of commercial operation (1983 and 1984) are set at 85 and 95 percent, respectively, of the design capacity. From 1985 onward the refinery is supposed to run at its full capacity throughout the project period.
- 40 percent of refinery construction cost is to be covered by owned capital. The rest of the fixed capital is to be covered by long-term loans.

  The conditions of the loan are:

  Interest rate: 7.5% annually

  Repayment: Evenly divided over 8 years from the second year of commercial operation (1984)
- Short-term loan is to be borrowed to cover the deficit in cash requirement after the operation start-up. The conditions are:

  Interest rate: 11.0% annually

  Repayment: At a later time when fund becomes surplus, the surplus is earmarked to repay the principal of the short-term loan.
- The prices of the products for domestic and export market are set as below.

	Product Price (R.O./bbl)	
	Domestic	Export
LPG	3.549 (3.540)	– –
Premium Motor Gasoline	8.357 (7.334)	7.741 (6.845)
Regular Motor Gasoline	7.611 (6.665)	6.891 (6.099)
Kerosene and Jet A-1	7.655 (6.752)	7.005 (6.245)
Gas Oil	6.908 (6.100)	6.426 (5.652)
Marine Bunker Fuel	– –	4.213 (4.054)
Heavy Fuel Oil	– –	3.856 (3.868)

Note: figures in parenthes are used only in "1978 basis" analysis.

Results

Results of the financial analysis for the year 1985 are as tabulated below.

(unit: MM R.O.)

	40/S	40/P	20/S	20/P
Sales Revenue	76.0	76.0	38.1	38.1
Production Cost				
Raw Material	68.5	68.5	34.2	34.2
Other Direct Cost	2.7	2.9	2.1	2.2
Indirect Cost	4.8	4.5	3.6	3.5
(Total Production Cost)	76.1	75.9	40.0	39.8
Net Income	–0.1	0.1	–1.9	–1.7
Cash Flow	3.7	3.6	1.0	1.0
Cumulative Short-Term Loan	2.5	2.3	6.0	5.6
Pay-Out Time (year)	9.56	9.05	not recoverable	
IRR on Total Capital (%)	7.89	8.52	–3.23	–2.52

Comparison of the Four Cases

– 40,000 BPSD cases are superior in financial aspect. Net income of the 40,000 BPSD cases, though they are negative or slightly positive in 1985, are to turn into positive value from 1986 onward. In contrast, net income of the 20,000 BPSD cases hold negative throughout the project period, and the principal of the short-term loans continue to accumulate.

Investments in the 40,000 BPSD cases are to be paid out within 10 years, whereas those in the 20,000 BPSD cases are not recoverable. IRR of around 8 percent is expected for the 40,000 BPSD cases, but they are negative for the 20,000 BPSD cases.

– Comparison of the utility self-supply and utility purchase case for the 40,000 BPSD refinery indicates the following.

From financial aspects, the utility purchase case is superior to the self-supply case, since the net income value of the former is higher, though slightly, than that of the latter, and also the utility purchase case has better pay-out time and IRR value than those in the utility self-supply case.

Sensitivity Analysis

– Profitability of the refinery project is not very sensitive to the variation in refinery construction cost. IRR value of the 40,000 BPSD/utility purchase case holds positive even if the

construction cost should increase by as much as 30 percent. In contrast, the IRR value of 20,000 BPSD/utility purchase case is expected to become positive only when the construction cost is saved by more than 20 percent.

- Changes in the cost of crude oil have serious effects on the profitability of the refinery. If the crude cost is raised, and the prices of the products fail to be raised keeping the pace with the crude cost, there is a fear that the project run into deficit. If the prices of the products are raised by the same rate as the rise in crude cost, the refinery will enjoy a higher IRR value.
- Changes in production costs other than crude oil cost do not seem to affect seriously the profitability of the refinery.
- Even if the operating ratio of the refinery in the first year of commercial operation is reduced to as low as 30 percent from the presupposed ratio of 85 percent (because of delay in construction, for example), profitability in terms of IRR value is not seriously affected.

7.3 National Economic Evaluation

Economic Internal Rate of Return (EIRR)

EIRR is calculated by defining the cost and benefit of the refinery project as follows:

- The cost is set as the value obtained by subtracting the incidentally required investment in product storage tanks from a sum of the total capital investment and the total production cost of the refinery.

  The rationale is: theoretically, there is no requirement to install product storage tanks as long as the refinery keeps continuous supply of petroleum products. Therefore, the investment in the storage tank becomes necessary from a national security viewpoint, so that it may be regarded as a sort of minimum security cost.
- The benefit is set as the total sales revenue.

The result of calculation is as below:

	40/P	40/S	20/P	20/S
EIRR (%)	9.9	9.0	minus	minus

Sensitivities of the above EIRR values to various parameters are almost similar to those of IRR values as described before.

National Economic Profitability (NEP)

NEP as defined by the equation:

$$NEP = \frac{\text{average annual benefit} - \text{average annual production cost}}{\text{total investment cost}}$$

is calculated for the four refinery cases as follows:

	40/P	40/S	20/P	20/S
NEP (%)	12.0	11.4	–4.2	–4.4

Foreign Exchange Effect

The refinery project will affect the foreign trade balance of Oman in the following ways:

- Foreign exchange outflow – import of plants, payments for imported catalysts and chemicals, wages paid to expatriate workers, interests on long-term loans.
- Export-Import balance – derived from decrease in crude export revenue and decrease in products import payment.

The results of the calculation of accumulated foreign exchange balance of the refinery project are as below:

(unit: MM R.O.)

	40/P	40/S	20/P	20/S
Outflow	–40.0	–42.6	–29.6	–32.2
Ex.-Im. Balance	113.1	113.1	58.9	58.9
Surplus	73.1	70.5	29.3	26.7

Other Benefits

- Not so much increase of employment opportunities is expected. The direct employees of the refinery count around 200 persons, most of which are engineers and skilled workers.
- As to the new development of the refinery-related or -supporting industries, not so much is expected, too. Since various types of contractors are either already in existence in Oman, or some, which require sophisticated skills, may have to be introduced from overseas.

  Though various types of repair shops are needed near the refinery for the smooth operation of the latter, it is not necessary for Oman for the time being to manufacture high quality machines and their parts. Employment to be created in the peripheral industries is estimated at around 100.
- The largest effect is the enhanced national security of Oman; that is, the country can get out of her dependence on imports of petroleum products, which has already become indispensable materials for the country.

7.4 All Over Evaluation

- As the results of the foregoing analyses, the 40,000 BPSD/utility purchase case seems to be most recommendable among the four cases examined. Its IRR value of 8.5 percent seems to be rather low for a commercial project that should seek profit, the IRR level could be fully acceptable in such kind of governmental project as this refinery which has

as its aim economic security and other national economic benefits.

– There are a number of important premises for the conclusion above:

(1) The surplus heavy fuel oil produced should be fully exported. Should the export revenue of the heavy fuel oil be reduced by 25 percent due to reduction in the export price and/or the export volume, the economy of the 40,000 BPSD refinery would certainly be inferior to that of a 20,000 BPSD refinery which produces no surplus product. However, the inherent noneconomy of the 20,000 BPSD refinery is never to be changed.

(2) Price systems of the utlities should be kept unchanged. If the cost of electricity, for example, is raised substantially, the 40/S case, despite additional construction cost for utility facilities, may be more preferable to the 40/P case.

(3) Prices of products should be raised keeping their pace with the possible future increase of crude oil prices. Otherwise, the profitability of the refinery would be badly damaged as indicated by the result of the sensitivity analysis. Accordingly, if the Omani government intends to hold the low-price policy for the petroleum products some subsidizing measures will have to be introduced.

– The benefits to be expected by the realization of a refinery would be enumerated as below:

(1) A basis for stable self-supply in petroleum products will be formed and thus contribute to the security of the Omani national economy. Also, such unproductive investments as the storage terminal for imported products are to be saved.

(2) Contribution will be made to improving the foreign exchange balance of the country.

CHAPTER 8 PROBLEMS IN PROJECT IMPLEMENTATION

Project Implementation Steps

Estimated period required for the design and construction of the refinery is 33 months including the test-run and adjustment. If the commercial operation of the refinery is to be scheduled to start in January 1983, basic design of the refinery will have to be started in April 1980.

Prior to the start of the basic design, the following steps would be required.

(1) Decision making on the construction of a refinery and establishment of an executing body.

(2) Selection of a consultant to assist the executing body in the implementation of the project.

(3) Establishment of a contract policy and tender specification.

(4) Selection of, and contract with, a contractor.

Construction Work

- Construction period from the start of basic design to mechanical completion would be 30 months. It will take another 3 months for test-run and adjustment. Thus, the refinery is to go into commercial operation in the 34th month, as shown in Fig. 12.
- Total number of workers for the construction work in the site is estimated at about 277,000 man-days. A maximum of 800 men should be mobilized a day during the peak period.
- 30- to 125 ton crane trucks seem to be readily available in Oman. However, 300- to 350 ton cranes would be desirable for installation of the main towers of the refinery and other heavy machinery and equipment.
- There are a number of obstructions for the land transportation of equipment and materials from Mina Quaboos port to the candidate sites. Direct unloading on the site would call for close consideration.
- Temporary works, especially those for electricity and water supply to the construction site would require timely preparations.

Personnel Training

Technical personnel are expected to participate the operation of the refinery from the start of the test-run. For that purpose, they are to undertake a certain period of vocational training.

Trainees are those technical persons who are to belong to Production, Technical Service, and Maintenance Departments, and are divided into two groups. One is a group of those who are going to managerial staff members, and the other is a group of operators, testers and technicians.

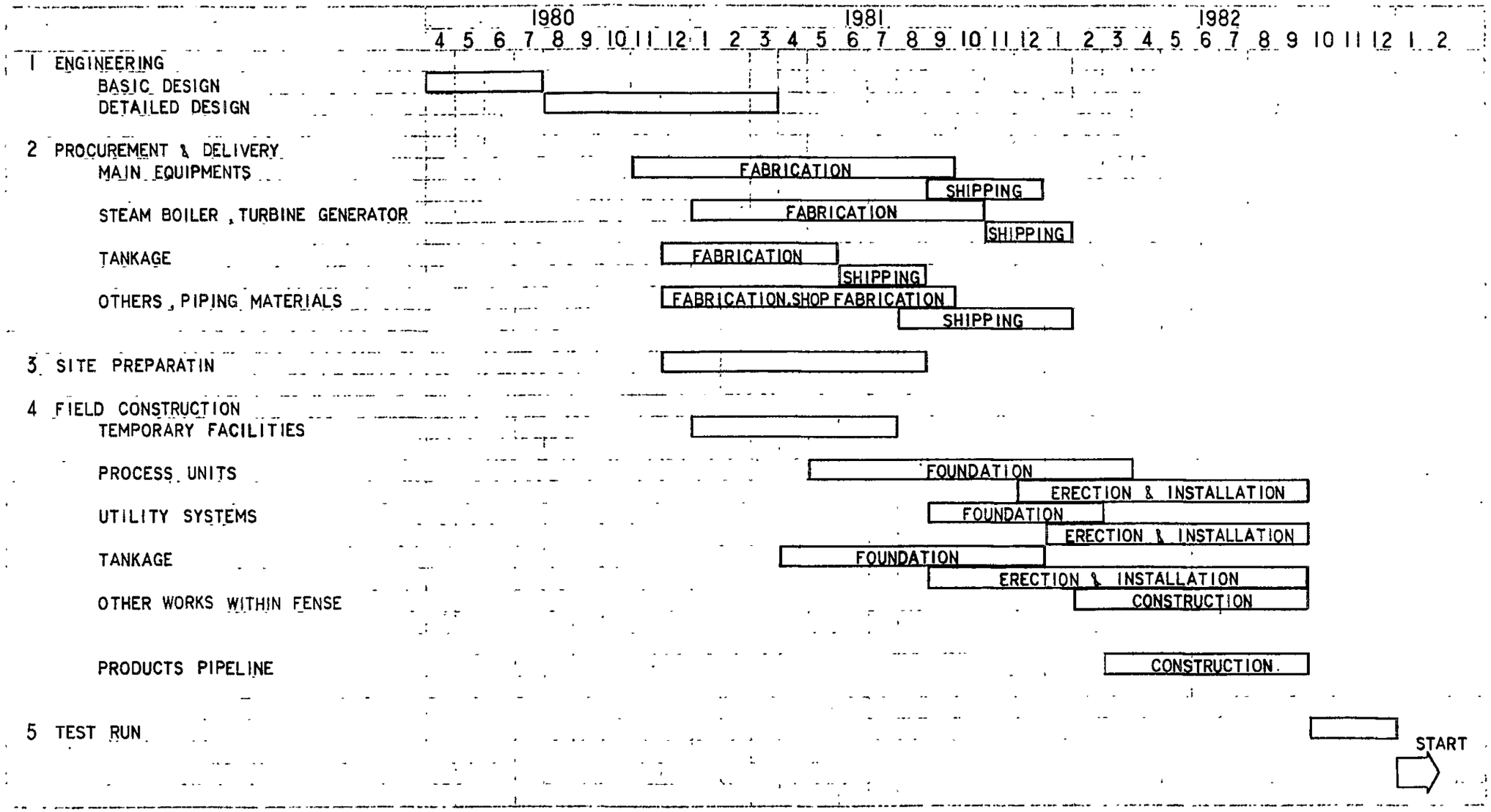
Number of persons in the two groups is as below:

	40,000 BPSD and 20,000 BPSD	
	Utility Purchase	Utility Self-Supply
Manager Class	36	36
Operator Class	88	101
Total	124	137

Training of the managerial group lasts for 10 months. During the initial 6 months, they learn managerial disciplines and techniques through participation in the daily work of an overseas refinery. Then they attend at the construction site to get a practical knowledge about the refinery in which they are to work. This on-the-site training lasts for 4 months. When the test-run starts, they are requested to instruct the operator class trainees and prepare for the start of commercial operation.

On the other hand, the operator group is to be trained for 3 months prior to the start of the test-run. In the first place they are given basic knowledge of the refinery through classroom lectures. During the next one month, which corresponds to the final stage of the construction work of the refinery, they are desirably allowed to experience at the construction site the installation of the equipment they are to handle for the purpose of obtaining practical knowledge.

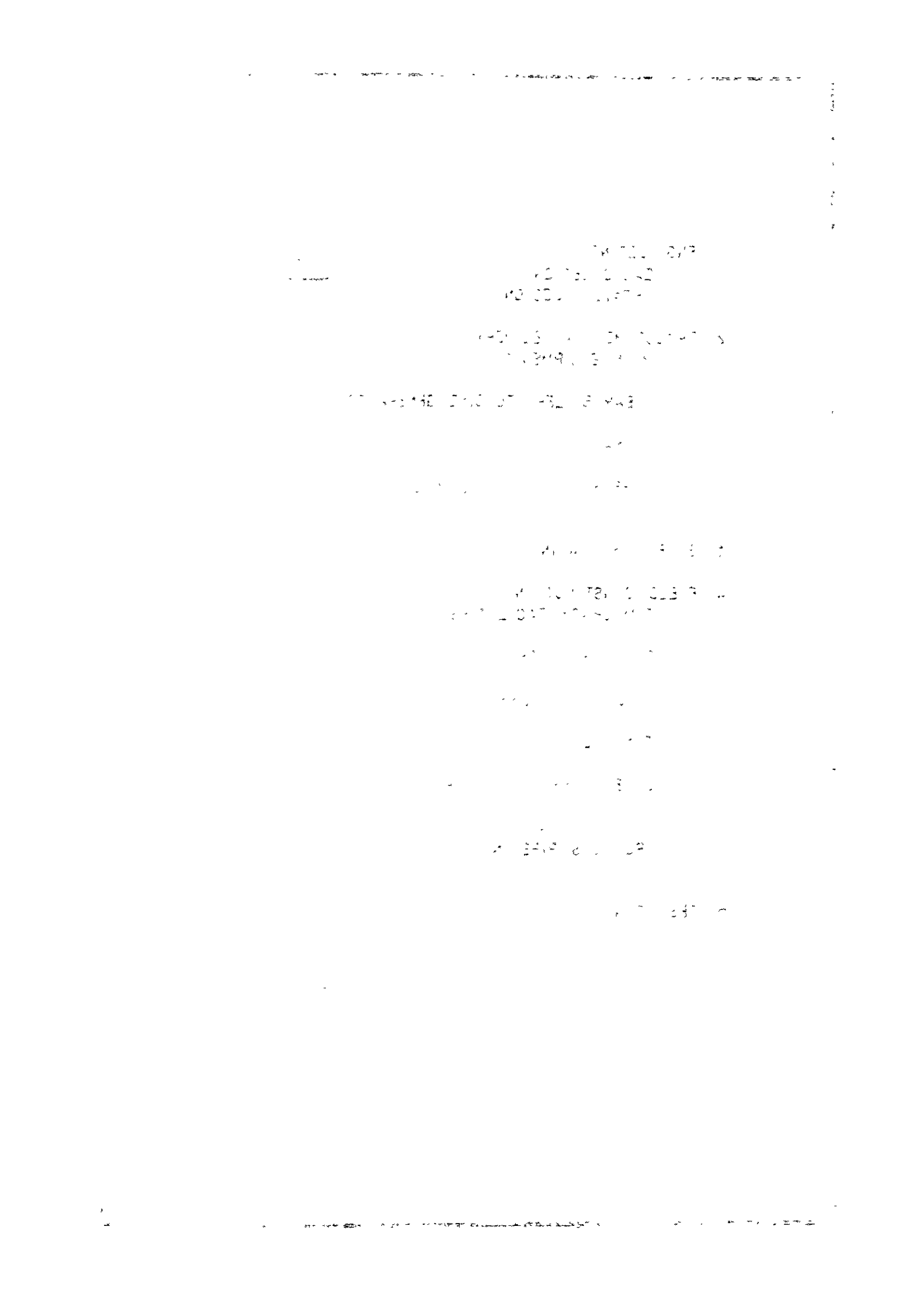
The overall training schedule is shown in Fig. 13.

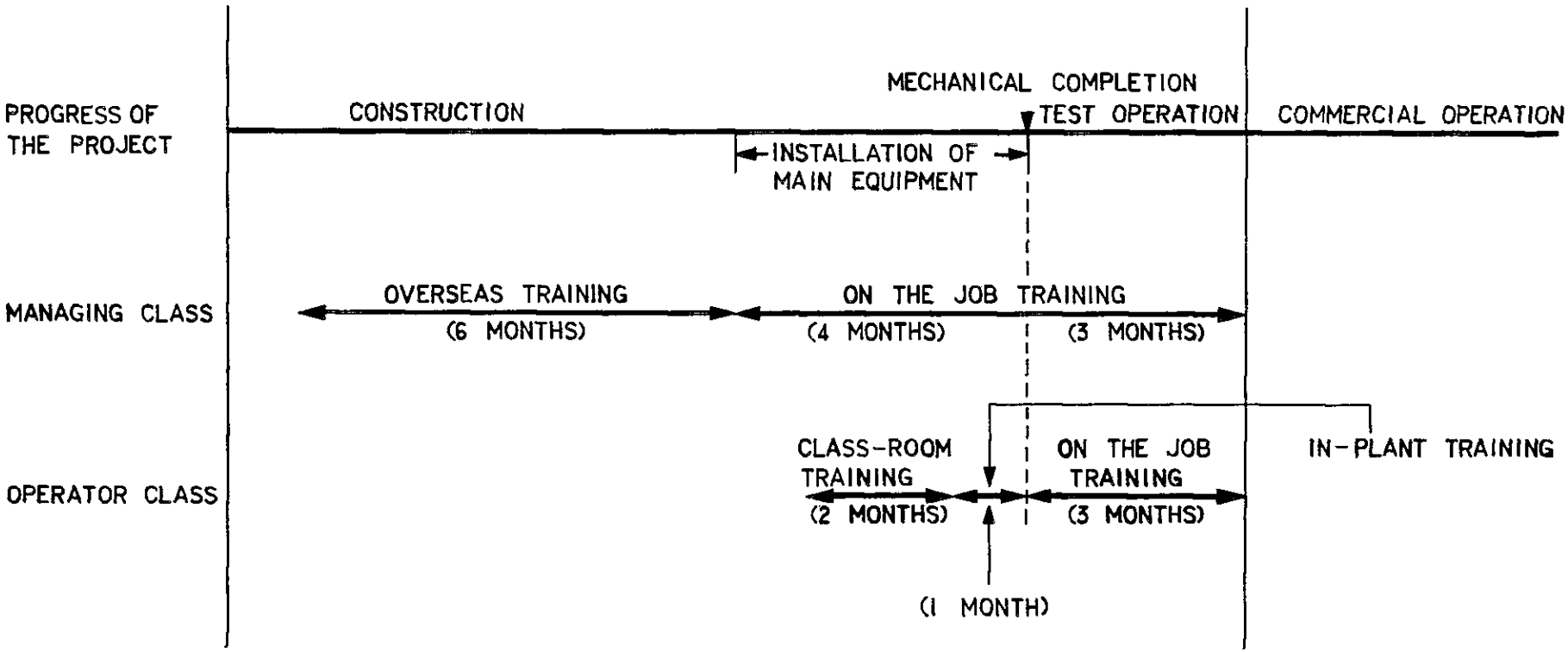


OMAN REFINERY PROJECT

PLANT CONSTRUCTION SCHEDULE

FIG. 12





OMAN REFINERY PROJECT

TRAINING SCHEDULE

FIG. 13

CHAPTER 1 ECONOMY AND PETROLEUM IN OMAN

1.1 GROWTH AND FEATURES OF OMANI ECONOMY

Since 1967 when crude oil production started in Oman, the Omani economy experienced the following three stages:

(1) 1967–1970: Start of petroleum development and economic growth.

(2) 1970–1975: Period of rapid economic growth caused by an opendoor policy and increased oil production with higher oil prices.

(3) 1970–present: Period of steady economic growth and shift to industrial diversification.

These situations can be clearly seen from Table 1-1. Although the latest real growth rate of GDP is unknown, it is likely that Oman has undergone zero or minus overall economic growth, because of the slowdown in the growth of major industries including petroleum and the imported inflation.

Table I-1 Oman's Economic Growth

	GDP at Market Price (MM R.O.)	Nominal Growth Rate (%)	Real Growth Rate
1968	78.7	103	100
1969	100.0	27	
1970	106.8	7	
1971	125.1	17	4–6
1972	140.8	12	
1973	169.4	20	
1974	568.5	238	40
1975	724.2	28	20
1976	827.0	14	N.A.
1977	880.1	6	N.A.

(Source) IBRD, Development Council

As shown in Table 1-2, the Omani economy is characterized by the large contribution made by the petroleum sector which in 1977 occupied 60.8 percent of GDP. Among other industrial sectors, agriculture and fisheries occupied 2.7 percent; and manufacturing 0.9 percent. Therefore, the petroleum sector can be considered to constritute a major part of industrial activities of Oman. Dependence of the Omani economy on petroleum can be understood well by the fact that crude oil export accounts for more than 97 percent of the total trade income and more than

Table I-2 Gross Domestic Product by Industrial Origin

(Unit: Current Prices in MM R.O.)

Sector	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Agriculture & Fisheries	14.3	15.1	16.1	16.6	16.8	17.0	16.7	17.4	20.2	21.4	24.0
Petroleum & Mining	12.0	50.7	69.4	71.6	73.9	76.4	94.5	389.0	486.8	530.4	534.8
Manufacturing	0.1	0.1	0.1	0.2	0.2	0.3	0.6	2.0	2.4	4.0	8.3
Construction	8.3	7.3	7.7	10.6	20.4	22.6	24.0	58.0	70.8	83.0	84.2
Transport & Communication	0.4	0.6	0.6	0.7	2.1	3.2	4.4	12.3	23.5	25.5	28.2
Electricity & Water	–	–	–	0.1	0.3	0.7	0.9	1.2	1.8	5.0	6.3
Commerce & Trade	1.0	1.3	1.9	1.6	2.8	3.8	8.3	27.2	38.5	50.3	65.5
Banking	0.1	0.2	0.3	0.6	0.7	0.8	0.9	3.5	9.8	11.2	13.3
Ownership of Housing	1.2	1.2	1.3	1.5	2.1	2.5	2.9	4.8	9.3	13.8	18.3
Public Administration & Defence	0.6	1.3	1.8	2.3	4.1	11.0	13.1	46.4	53.0	71.0	83.4
Service & Other Sectors	0.8	0.9	0.9	1.0	1.7	2.5	3.1	6.7	8.4	11.4	13.8
GDP at Market Prices	38.8	78.7	100.0	106.8	125.1	140.8	169.4	568.5	724.2	827.0	880.1
Indirect Taxes	–0.8	–1.0	–1.2	–1.1	–1.1	–1.6	–2.0	–2.8	–2.5	–4.5	–4.6
GDP at Factor Cost	38.0	77.0	98.8	105.7	124.0	139.2	167.4	565.7	721.7	822.5	875.5

(Source) IBRD, Development Council

Table I-3 Trade Balance

(Unit: MM R.O.)

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Export	13.1	55.2	74.6	78.7	82.3	83.6	114.9	419.1	489.2	551.2	559.4
(Oil)	(12.3)	(54.4)	(74.0)	(78.3)	(81.9)	(83.2)	(114.3)	(418.2)	(488.1)	(543.8)	(545.9)
(Non-Oil)	(0.9)	(0.8)	(0.6)	(0.4)	(0.4)	(0.4)	(0.6)	(0.4)	(1.1)	(1.4)	(1.5)
Import	8.7	11.6	11.9	21.0	40.2	61.6	85.8	211.7	348.4	383.8	392.9
Balance	4.4	43.6	62.7	57.7	42.1	22.0	29.1	207.4	140.8	167.4	166.5

(Source) IBRD, Central Bank of Oman

Table I-4 Government Revenue

(Unit: MM R.O.)

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Oil Receipt	1.9	25.5	38.6	44.4	47.6	49.6	61.3	291.5	373.1	454.7	482.2
Other Revenue	0.9	1.2	1.0	1.0	2.2	3.4	3.6	11.7	14.6	32.7	38.0
Grants	–	–	–	–	–	–	3.5	8.3	71.6	18.0	93.0
Total	2.8	26.7	39.6	45.4	50.1	53.1	68.4	311.5	459.3	505.4	613.2

(Source) IBRD, Central Bank of Oman

78 percent of the Government revenue. Table 1-3 and Table 1-4 give the trend of petroleum contribution to the trade balance and Government revenue, respectively.

However, under the present 5-year plan (1976–1980), the Government is trying to reduce such excessive dependence on the petroleum sector. As found in Table 1-5, these efforts are beginning to bear fruit, although expected reduction is still slight. Recently, there can be seen a trend of price rise for crude oil, and this will lead to a larger petroleum revenue and an increased GDP level of the petroleum sector. The high growth of other production sectors besides petroleum cannot be expected, so that the petroleum sector will keep its position as the most important sector, still holding the present level of contribution.

Table 1-5 Weight of Oil Sector in Omani Economy

(Unit: %)

	1974	1975	1976	1977
1. Ratio of Oil Sector in Production Sector* of GDP	95.2	95.6	95.4	94.3
2. Ratio of Oil Sector in Government Revenue**	96.1	96.2	93.3	92.7

* Agriculture, Fisheries, Mining, Oil & Manufacturing
** Excluding Grants

One of the features found in the trade pattern of Oman is "to export crude oil and, in return, to import oil products paying a considerable part of the foreign currency revenue from the crude export." As shown in Table 1-6, the imports of petroleum products including marine bunker oil accounted for 12 percent of total import and nearly 9 percent of the total crude oil export value in 1977, increasing at 20 percent annually during 1975–1977. Since nominal growth rate of GDP during this period was around 10 percent annually, the elasticity of petroleum products consumption (import) against GDP was approximately 2 during the same period. The Omani economy is passing through an adjusting period at this moment, but the consumption of oil products will keep an upward trend for the time being, occupying a major part of the total import value.

Table 1-6 Crude Oil Export and Petroleum Products Import

(Unit: MM R.O.)

	1975	1976	1977
A. Crude Oil Exports	488.1	543.8	545.9
B. Total Imports	348.4	383.8	392.9
C. Petroleum Products Imports	32.9	40.3	47.2
C/B (%)	9.4	10.5	12.0
C/A (%)	6.7	7.4	8.6

(Source) Ministry of Commerce and Industry

1.2 INDUSTRIAL DEVELOPMENT POLICIES

1.2.1 Present Situations in Industrial Development

The number of registered companies in the production sectors including agriculture & fisheries, petroleum, mining and manufacturing is as given in Table 1-7. Except for the petroleum sector, most of the companies are small, with their average capital of 60 thousand R.O.

Table 1-7 Number of Registered Companies in Production Sectors

(As of October, 1979)

	No. of Company	Total Capital (MM R.O.)
Fisheries	3	0.06
Oil	13	13.98
Metal and Stone	5	0.08
Industry	466	8.87
Sub-Total (Production Sectors)	487	22.99
Total (Whole Industries)	5,646	202.19

(Source) Directorate General of National Statistics

Table 1-8 gives those industries now in active business and those that are being planned. The planned projects having been strongly promoted to actual implementation include oil refining, steel rolling, cement, glass, copper smelting, and marble production.

When these industries become a reality and start business, Oman's basis for industrialization will be enhanced to some extent.

Table 1-8 Industrial Projects, Existing and Planned

Category	Existing Industires	Planned Projects
1. Import Substitution Based on Omani Resources	Dairy Products, LPG, Lime Bricks	Cigarettes, Table Salts, Petroleum Products, Cattle Feed, Ceramics, Prefabricated Concrete Units
2. Import Substitution Based on Imported Resources and Raw Materials	Bakery, Flour Mill, Furniture, Asbestos-Cement Pipes, PVC Pipes, Paints, Steel Structures, Aluminium Window Frames and Doors, Concrete Brocks, Soft Drinks, Automotive Repairing	Confectionary, Refined Sugar, Footwares, Matches, Retreading of Tyres, Re-rolling of Steel Billets, Nails and Screws, Batteries
3. Import Substitution Plus Export-Oriented Based on Omani Resources		Mineral Water, Vegetable Oil, Frozen Fish, Cement, Glass Products
4. Export-Oriented Based on Imported Resources and Raw Materials	Asbestos-Cement Pipes	
5. Export-Oriented Based on Omani Resources	Date Products	Canned Fish, Petrochemical Products, Nitrogenous Fertilizers, LNG, Marbles, Glass Fibre, Fire-Refined Copper Ingots

(Source) Ministry of Commerce and Industry
JICA Mission

The Oman Government's industrial development policies can be summarized as follows:

(1) Development of import-substituting industries to save foreign currency.
(2) Effective utilization of domestic natural resources in Oman.
(3) Satisfaction of domestic demands and attempt to export some products with international competitiveness.
(4) Achievement of balanced development of entire economy and industry.

Underlying these policies is a desire on the part of the Government to reduce the present dependence on petroleum. This principal policy can be clearly seen in the

Table 1-9 Government Expenditures under the 5-Year Plan (1976–1980)

(Unit: MM R.O.–1976 Prices)

Sector	1976	1977	1978	1979	1980	Total
Petroleum & Mining	23.3	40.0	51.0	28.0	12.0	154.3
Agriculture & Fisheries	2.6	5.9	8.5	11.5	12.5	41.0
Manufacturing	2.6	7.1	5.0	10.0	15.0	39.7
Trade and Tourism	8.7	3.2	–	–	–	11.9
Economic Infrastructure	175.2	166.6	88.6	63.8	44.5	538.7
Social Infrastructure	40.2	29.9	26.7	17.7	17.7	132.2
Financial Institutions	3.0	2.0	4.0	4.0	4.0	17.0
Total	255.6	254.7	183.8	135.0	105.7	934.8

(Source) The Five-Year Development Plan

Government expenditures under the present 5-year plan, as given in Table 1-9. The table indicates an obvious tendency that investment in economic infrastructures and petroleum sector will decline gradually, whereas production sectors will receive more and more importance.

1.2.2 Development of Economic Infrastructures

Table 1-10 gives the trend of economic infrastructures such as, for example, roads, airports, harbors, telecommunications, electricity, etc. These have been steadily developed since 1970, regardless of fluctuation in economic growth.

In other words, Oman started its economic development with emphasis on the construction of economic and social infrastructures. Oman is so prudent that she has avoided possible confusion which neighboring countries have encountered when they gave priority to an erroneous line of development plans.

As regards road construction, paved roads 1,447 km long and unpaved roads 10,509 km long were complete by 1977. There still remain a plan on the 780 km paved road between Nizwa and Thamarit and a plan for construction of feeder roads in the Southern part of Oman. Since, however, a basic network is now complete, the future efforts will put emphasis on the improvement of existing roads and the construction of local roads.

As regards ports, there will be no trouble in the import-export activitites for the time being, when the construction of Raysut harbor is complete. Then, for the next step, the improvement and construction of Sur harbor and Sohar harbor, both including

Table 1-10 Indicators of Economic Infrastructural Development

Item	Unit	1970	1971	1972	1973	1974	1975	1976	1977
1. Total Length of the Roads	1,000 km	1.83	2.20	3.26	3.92	4.53	6.20	9.77	11.96
2. Tonnage Loaded and Discharged at Ports	1,000 shipping tons	129	185	329	432	793	1,305	1,440	1,536
3. Aircrafts Movement	1,000	N.A.	N.A.	N.A.	12.3	20.1	30.1	35.4	39.1
4. Post Offices and Sub-Post Offices	number	2	10	12	17	20	27	37	42
5. Telephone Lines Installed	number	557	989	1,208	2,226	2,937	3,701	6,649	9,912
6. Electricity Generated	MM kwh	104.9	110.9	130.0	172.5	229.9	306.3	412.9	549.3
7. Water Supply	MM Gallons	14	85	187	330	546	359*	430*	1,442

* Salalah figures are not included.

(Source) Directorate General of National Statistics

fishing ports, are being planned. It is anticipated in the future that a supplementary port to Mutrah harbor may be constructed in the capital area.

In regard to airport development, there is no large project other than the improvement of terminals at Seeb Airport and the improvement of Salalah Airport to make it work as another international airport. If the scale of Omani land is considered, there is a possibility of increased domestic air transport using small aircrafts. In that case, the development of local airports will be examined.

Concerning telecommunications and mail services, a telephone network throughout the country needs urgent development.

Oman's electric power production has been continuously trending upward, as shown in Table 1-11. In the capital area, Al Ghubra power plant has been operating since 1976. The gas turbine generators attached to Al Ghubra power station went into operation in 1978. These developments enable the power station to meet the peak demand in the capital area for the time being, but additional power generating equipment will soon be required.

Table 1-11 Electric Power Generation, Installed Capacity

(Unit: Megawatts)

	1969	1970	1971	1972	1973	1974	1975	1976	1977
Public Utilities									
Capital Area	3.0	3.0	3.4	12.2	17.1	37.4	37.4	66.2	116.2
Sourthern Region	–	0.1	0.9	1.8	2.3	6.6	15.3	17.2	22.0
Rural Area	–	–	–	–	–	–	–	–	8.2
PDO	30.4	30.4	30.4	30.4	30.4	33.4	38.1	37.1	37.5

(Source) Directorate General of National Statistics

Meanwhile, an electrification plan is now under way for local areas. This plan makes use of Diesel power generation, and electrification has already been completed in more than 10 areas, with the electrification of 26 areas in all being planned under the 5-year plan.

Water supply in the capital area has some reserve capacity at present, owing to the supply from the Al Ghubra desalinating plant. It is estimated, however, that water will run short. In response to this forecast, the second-stage expansion project is now getting started, with the target date scheduled for 1983 or 1984. The expansion includes both the desalinated water and ground water.

1.3 FUTURE DEVELOPMENT OF OMANI ECONOMY AND INDUSTRY

The Omani economy, passing through the present adjustment period, is expected to keep growing at least up to around 1985, though any long-term quantitative forecast is not easy. However, the future growth of the Omani economy will be much slower, and steadier, compared with the past high growth period.

Fixed capital formation and government consumption will continue to occupy big shares in GDP. But investments in the production sectors will gradually take an increasing share in the amount of fixed capital formation in the 1980's, when construction of social infrastructures is expected to achieve a state of saturation.

A big increase in exports seems to be difficult, since a tendency to decline in crude oil production is forecasted.

In contrast, import will increase in line with investments into production sectors. Consequently, it is anticipated that the trade balance may even run into red in the 1990's.

Possible changes in the industrial structure of Oman is presumed on the bases of the past trend observed in Table 1-2, and of the industrial development policies discussed in the previous section. While the production sectors, manufacturing in particular, will grow substantially and also diversify during the coming decade, petroleum will still hold the position of the most important sector in Omani industry. Dependency on the petroleum sector seems to decline to as low as less than 50% only in the 1990's.

1.4 PRESENT SITUATIONS IN THE DEMAND-SUPPLY OF PETROLEUM PRODUCTS

Oman is a petroleum producing country which produces 300 thousand bbl/day. Because it has no refinery at present within the country, those petroleum products to be consumed domestically have all been imported, mostly from the countries bordering on Arabian Gulf, such as Bahrain and Iran. But the oil import pattern of Oman was forced to change from the latter half of 1978, when Iran got into political confusion and could not produce oil products at a normal refining rate. As a result, Oman had to import a part of its oil requirements from such country as Singapore.

The petroleum products now being imported to Oman include LPG, aviation gasoline, premium and regular motor gasolines, domestic kerosene, jet A-1, gas oil, fuel oil, marine bunker oil, bitumen, and lubricating oil. Among them, marine bunker oil is supplied to the ships calling at Omani port; that is, it is not consumed in the country. A part of jet A-1, too, is not domestically consumed, as it is supplied to the aircrafts outgoing to foreign countries.

The 1978 demand for a total of above petroleum products including marine bunker oil amounted to about 8.1 million bbl annually or about 22 thousand bbl/day. The demand excluding marine bunker oil stood at about 3.9 million bbl or about 11 thousand bbl/day. This amount

can be roughly regarded as the total domestic consumption, although in a strict sense, a part of jet A-1 must be further subtracted from this amount.

From 1971 to 1976, this consumption marked a big boost, up 45 percent a year. In current years, the consumption has been growing at a relatively mild rate of 10 percent annually. This is partly because fuel for the power plant in the capital area has been switched from gas oil to natural gas. Now that gas oil occupied a considerable part of the total demand, the consumption had to drop during 1976–1977.

Seeing the trend of each product, LPG had a 1978 demand of 130 bbl/day, with an average growth rate of 1.1 percent annually during the past two years; aviation gasoline the 1977 and 1978 demands of around 10 bbl/day each, with a growth rate levelling off; premium gasoline 2,230 bbl/day in 1978, up average 48 percent annually; regular gasoline 1,730 bbl/day, up 5.6 percent; jet A-1 2,030 bbl/day, up 31 percent; domestic kerosene 280 bbl/day, up 10.3 percent; and gas oil 4,270 bbl/day in 1978, up 4.4 percent over the previous year. Premium gasoline and jet A-1 marked especially high growth rates. In addition to the above fuel products, bitumen had a demand of 40 tons/day, and lubricating oil 210 bbl/day in 1978.

As regards marine bunker oil, the 1978 sales amounted to 11,620 bbl/day. This volume is almost equal to the total demand for other products, but the demand was trending downward at a rate of 10–15 percent annually for the past 2 years. This decline seems to be related to the export of Omani crude oil which recently has been declining to some extent.

The imported oil products are marketed by two dealers – Shell Market (Middle East), Ltd. and BP Arabian Agencies, Ltd. BP has a jet A-1 share of more than 70 percent. For other products, Shell Market occupies more than 70 percent.

Both dealers have their imported-oil storage terminals at Mina al Fahal in the capital area. Mina al Fahal is also the Omani crude export base. The Ministry of Commerce and Industry of the Omani Government has the storage facilities of imported oil products at Raysut port on Salalah, the central city in the Dhofar area in the southern part of Oman. Operation of these facilities was commissioned to Shell.

1.5 THE NEED FOR A REFINERY IN OMAN

So far, Oman continued its dependence on imports for all of the demands for petroleum products. This can be fully justified under the circumstances in which Omani people have consumed only less than 10 thousand bbl/day of oil products, which were readily available from those foreign refineries on the coast of Arabian Gulf having large capacities to export their products. However, as obvious from afore-mentioned rapid increase in the demands for petroleum products experienced in recent years, these products are already indispensable materials required to run the economy of Oman. It is the most important policy today for the Oman

Government to ensure the stable supplies of oil products. If the stable supply of oil happens to get disturbed, as its sign was observed in the latter half of 1978 through the crisis of a country facing Arabian Gulf, then Oman will go into a crucial phase in the light of security of its economy. As already stated, the import of oil products has turned out to be a large factor of the drain of Oman's foreign exchange reserve. From the trade-balance point of view, there is a fear that in the future, the import, together with decreasing crude export and rising demands for oil products, may cause a strong pressure on the healthy trade balance of Oman.

Therefore, it is considered quite natural for an oil producing country like Oman to try to attain at self-sufficiency of oil products, by refining the crude oil of its own.

On the other hand, it is no longer likely that the demand for oil products will grow at an explosive rate such as found in the past. But, even if the demand grows at a mild rate of around 10 percent annually, the 1985 demand for distillate products is estimated to reach a level of 20 thousand bbl/day. To meet this demand level, a refining capacity of 30 to 40 thousand bbl/day of Oman Crude would be required.

A refinery of such a scale is not so large, as compared with today's world standard, yet it may ensure necessary economic efficiency on a commercial basis. In fact, there are many refineries of this scale or even smaller scales through the world over.

Many countries follow the general trend of the world in constructing refineries within their countires, with a view to attaining at self-sufficiency of oil products, as soon as domestic demands for oil products reach a certain level, no matter how little their domestic oil production is.

In constructing a refinery within the country to refine the crude oil of its own for the purpose of self-sufficiency of oil products, Oman senses a strong request for the security of national economy, as stated above. It has also a sufficient reason from a trade balance point of view. After all, as long as a degree of economic efficiency can be anticipated from the refinery under this study, nothing can prevent Oman from bringing the plan into a reality.

CHPATER 2 PETROLEUM PRODUCTS MARKET IN OMAN

2.1 PAST TREND IN THE DEMAND FOR PETROLEUM PRODUCTS

The demands for petroleum products in Oman over the past 8 years (1971–1978) have trended as shown in Tables 2-1. Table 2-1(A) indicates annual demands; Table 2-1(B) the corresponding daily values calculated from (A), based on the 365 days-per-year basis.

The demand for petroleum products other than marine bunker oil was as small as 480 thousand bbl (1,300 bbl/day) in 1971. The term "demand for petroleum products other than marine bunker oil" approximately corresponds to the domestic oil consumption in Oman. Strictly, however, the volumes of jet A-1 supplied to the outgoing aircraft must also be subtracted from the figure. It reached 3.89 million bbl (10,700 bbl/day) in 1978, boosting to a level eight times as large as the 1971 figure during these 7 years. This demand increase corresponds to a yearly growth rate of about 34 percent on average. Recently, the rate of growth over the previous year was trending downward, making 13 percent in 1977 and 8 percent in 1978.

This remarkable decrease in the growth of demand for petroleum products since 1977 is, for one thing, due to the drop in the gas oil demand which has once occupied 40 percent of the domestic oil consumption. The gas oil demand was forced down because the electric power generation fuel has been switched from gas oil to crude oil and then natural gas for the power used in the capital area.

In early 1976, a power plant combined with a seawater desalination plant was constructed at Al Ghubra on the outskirts of Muscat. The plants went into operation successfully in 1977. The power plant thus began to supply most of the power required in the capital area, replacing the old Diesel power plant in Riyam.

Whereas the Riyam power plant used gas oil, the Al Ghubra power plant mainly used crude oil in 1977, but the fuel was switched in 1978 to natural gas when the natural gas pipeline was completed in that year from the gas field of inland Yibal to Al Ghubra.

For reference, the Al Ghubra power plant generated 339 x 10^6 KWH of electricity in 1978. If this power was generated by Diesel power plants, about 600 thousand bbl of gas oil would be consumed.

Major oil products used in Oman include premium and regular motor gasolines, jet A-1, gas oil, and marine bunker oil. Let us follow the trends of these products now.

The demands for motor gasolines showed an annual average growth rate of 33 percent for the past 8 years. This high growth rate was due to the construction of main highways throughout the country and subsequent increase in the number of automobiles. Although the growth rate is slightly lower than the annual average growth rate for all the oil products, the demand for gasolines is still high. The growth rate for gasolines keeps a level of more than 20 percent, even when the recent growth of the demand for all petroleum products stays around 10 percent.

The annual growth rate of demand for premium gasoline was as high as 71 percent during

Table 2-1 Petroleum Products Demand in Oman – Past

[A] Yearly Demand (Unit: 10^3 barrels)

	LPG	Aviation Gasoline	Premium Gasoline	Regular Gasoline	JET A-1*	Domestic Kerosene	Gas Oil	Sub-Total	Marine Bunker Oil	Total	Bitumen (10^3 Tons)	Lubricating Oil
1971	NA	NA	8	182	72	NA	222	484	806	1,290	NA	NA
1972	NA	2	24	237	100	NA	336	699	1,359	2,058	NA	NA
1973	NA	3	54	294	162	NA	387	900	1,629	2,529	NA	NA
1974	NA	9	95	394	217	NA	529	1,244	6,995	8,239	NA	NA
1975	NA	21	206	511	474	NA	981	2,193	5,504	7,697	NA	NA
1976	46	7	372	564	431	84	1,669	3,173	5,562	8,735	NA	62
1977	68	5	586	593	749	95	1,494	3,590	4,718	8,308	22	63
1978	47	4	813	630	742	101	1,557	3,894	4,242	8,136	16	78

[B] Daily Demand (Unit: Barrels per Calendar Day (BPCD))

	LPG	Aviation Gasoline	Premium Gasoline	Regular Gasoline	JET A-1*	Domestic Kerosene	Gas Oil	Sub-Total	Marine Bunker Oil	Total	Bitumen (TPCD)**	Lubricating Oil
1971	NA	NA	20	500	200	NA	610	1,330	2,210	3,540	NA	NA
1972	NA	10	70	650	270	NA	920	1,920	3,720	5,640	NA	NA
1973	NA	10	150	810	440	NA	1,060	2,470	4,460	6,930	NA	NA
1974	NA	20	260	1,080	590	NA	1,450	3,400	19,160	22,560	NA	NA
1975	NA	60	560	1,400	1,300	NA	2,690	6,010	15,080	21,090	NA	NA
1976	130	20	1,020	1,550	1,180	230	4,570	8,700	15,240	23,940	NA	170
1977	190	10	1,610	1,620	2,050	260	4,090	9,830	12,930	22,760	60	170
1978	130	10	2,230	1,730	2,030	280	4,270	10,680	11,620	22,300	40	210

Note: * Past consumption figures of JET A-1 include domestic kerosene consumption up to 1975.
** TPCD; Tons per Calendar Day

(Source) Ministry of Commerce & Industry, Statistical Year Book
Foreign Trade Statistics

the 1974–78 period, as compared with an annual growth rate of 13 percent for regular gasoline. The proportion of premium gasoline occupying in the total motor gasoline demand was only 4 percent in 1971. It steadily increased to 19 percent in 1974, 40 percent in 1976, and 56 percent in 1978, outrunning the demand for regular gasoline.

The demand for jet A-1 showed rapid growth since October 1972, when Seeb International Airport was opened within the capital area and the domestic airports, one by one, continued expansion and improvement of their facilities. The demand, which was only 72 thousand bbl in 1971, reached 742 thousand bbl in 1978, with a high average growth rate of 39.5 percent annually.

The demand for gas oil also marked an outstanding growth since Diesel power plants were continually constructed or expanded under the Governmental infrastructure development project. The demand, 222 thousand bbl in 1971, rose to 1,669 thousand bbl in 1976, marking quite a rapid growth rate of average 50 percent annually.

The drop in 1977 and 1978 is, as already stated above, attributable to the fuel switching from gas oil to crude oil, then to natural gas at power plants within the capital area.

The demand for marine bunker oil sharply rose from 1.63 million bbl in 1973 to 7 million bbl in 1974. From 1975 onward, its trend was almost proportional to the export of Omani crude oil.

2.2 FUTURE DEMANDS FOR PETROLEUM PRODUCTS

Future demands have been forecasted for those petroleum products having a great deal of demands in Oman, including LPG, aviation gasoline, premium and regular motor gasolines, domestic kerosene, jet A-1, gas oil, marine bunker oil (including other types of fuel oils), bitumen, and lubricating oil. Forecast figures have been derived from a forecast equation which was obtained by analyzing the correlation between the past demands for each of these products and various parameters. Table 2-2 gives the forecasted demand for all these oil products. As in Tables 2-1 (A) and (B), annual demands are given in (A) of Table 2-2; daily values in (B).

The past demand trend and future demand estimates are plotted against calendar years in Fig. 2-1 for the total petroleum products excluding bitumen and lubricating oil, as well as for the total petroleum products excluding bitumen, lubricating oil and marine bunker oil, i.e., the total distillate products.

The methods used in demand forecasting of all products will be described in details in the next section "Demand Forecast by Petroleum Product." It is sufficient here to briefly outline the results of forecast on major products.

The demand for the petroleum products excluding marine bunker oil, bitumen, and lubricating oil is estimated to rise from the 1978 figure of 3.89 million bbl (10,700 bbl/day) to 6.88 million bbl (18,900 bbl/day) in 1985. This increase corresponds to an average growth rate of 8.5 percent annually. A demand increase of yearly 10 percent or more will continue for a

Table 2-2 Petroleum Products Demand in Oman – Future

[A] Yearly Demand (Unit: 10^3 barrels)

	LPG	Aviation Gasoline	Premium Gasoline	Regular Gasoline	JET A-1	Domestic Kerosene	Gas Oil	Sub-Total	Marine Bunker Oil	Total	Bitumen (10^3 Tons)	Lubricating Oil
1979	55	5	1,017	656	845	110	1,662	4,350	3,823	8,173	26	83
1980	53	5	1,211	674	926	119	1,865	4,853	4,006	8,859	15	90
1981	69	5	1,380	687	1,006	117	2,069	5,333	5,159	10,492	15	95
1982	84	5	1,525	696	1,068	115	2,272	5,765	5,054	10,819	15	100
1983	99	5	1,643	704	1,129	113	2,475	6,168	3,746	9,914	15	104
1984	112	5	1,740	709	1,189	112	2,678	6,545	3,612	10,157	15	108
1985	126	5	1,818	713	1,230	111	2,881	6,884	3,282	10,166	5	110
1986	140	5	1,880	716	1,270	109	3,084	7,204	2,923	10,127	5	112
1987	154	5	1,928	718	1,311	108	3,287	7,511	2,719	10,230	5	114
1988	168	5	1,963	720	1,352	107	3,490	7,805	2,431	10,236	5	115

[B] Daily Demand (Unit: Barrels per Calendar Day (BPCD))

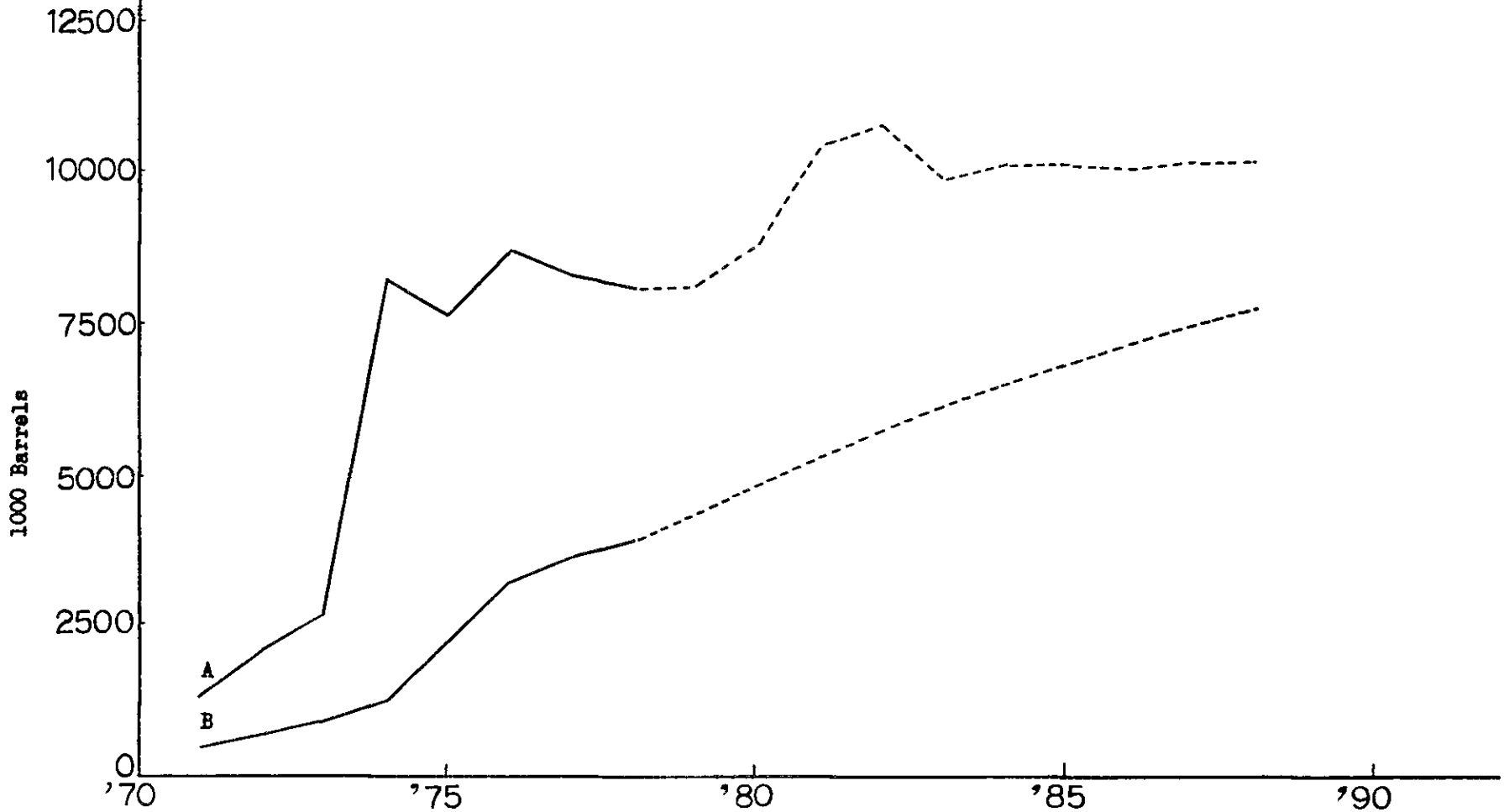
	LPG	Aviation Gasoline	Premium Gasoline	Regular Gasoline	JET A-1	Domestic Kerosene	Gas Oil	Sub-Total	Marine Bunker Oil	Total	Bitumen (TPCD)*	Lubricating Oil
1979	150	10	2,790	1,800	2,320	300	4,550	11,920	10,470	22,390	70	230
1980	150	10	3,320	1,850	2,540	330	5,110	13,310	10,980	24,290	40	250
1981	190	10	3,780	1,880	2,760	320	5,670	14,610	14,130	28,740	40	260
1982	230	10	4,180	1,910	2,930	320	6,220	15,800	13,850	29,650	40	270
1983	270	10	4,500	1,930	3,090	310	6,780	16,890	10,260	27,150	40	280
1984	310	10	4,770	1,940	3,260	310	7,340	17,940	9,900	27,840	40	300
1985	350	10	4,980	1,950	3,370	300	7,890	18,850	8,990	27,840	10	300
1986	380	10	5,150	1,960	3,480	300	8,450	19,730	8,010	27,740	10	310
1987	420	10	5,280	1,970	3,590	300	9,010	20,580	7,450	28,030	10	310
1988	460	10	5,380	1,970	3,700	290	9,560	21,370	6,660	28,030	10	320

Note: * TPCD; Tons per Caldendar Day

(Source) JICA Mission

FIG. 2-1 PETROLEUM PRODUCTS DEMAND IN OMAN – PAST AND FUTURE

CURVE A EXCLUDING BITUMEN AND LUBRICATING OIL
CURVE B EXCLUDING MARINE BUNKER, BITUMEN AND LUBRICATING OIL



couple of years, but later the demand growth will slow down, with an estimated growth rate for 1985 being 5 percent over the previous year.

The proportion of each product occupying in the total distillate demand for 1978 was as follows: 40% gas oil, 21% premium gasoline, 19% jet A-1, 16% regular gasoline, and several percent of other products. The corresponding estimates for 1985 are: 42% gas oil, 26% premium gasoline, 18% jet A-1, 10% regular gasoline, several percent of other products. Thus as long as the types of oil fractions are concerned, there will be no substantial change in the proportions of required distillates (excluding marine bunker oil).

Meanwhile, the marine bunker oil now occupies more than 50 percent of all the demands for petroleum products. Its demand will have a peak of about 5.1 million bbl in 1981 and 1982 when oil fields of Marmur and Amal in southern Oman go into commercial production and crude oil export is expected to increase. But the demand will gradually decrease in later years, mainly because of the decrease in crude oil export caused by the decrease in crude oil production and also by the domestic demand for crude coming with the construction of a refinery. It is thus estimated that the demand will be 3.28 million bbl in 1985, about 1 million bbl less than the 1978 demand.

Among the total distillate products excluding the three items of marine bunker oil, bitumen and lubricating oil, there are some products which will grow at rates higher than 8.5 percent, i.e., the annual average rate of growth estimated for 1978–85 for the total distillate products demand. These products include LPG, premium gasoline and gas oil, growing at 15, 12 and 9 percent, respectively.

On the other hand, little increase in demand is expected for such products as regular gasoline and domestic kerosene. These are estimated to have a growth rate of 2 percent or less on an annual average.

The marginal demand growth for regular gasoline is the other side of a fact that there is much growth for premium gasoline. On the whole, the total demand for motor gasolines will grow annually at an average of 8.4 percent, almost equal to the demand for total distillates which will grow at 8.5 percent.

Remarkable slowdown in the estimated demand for domestic kerosene is due to wide spread acceptance of LPG as a household fuel. It is estimated that more and more LPG will be used instead of kerosene.

LPG is now being imported from Dubai, a neighboring nation belonging to the United Arab Emirates, through onland shipment in 100-pound cylinders for marketing in Oman.

In the meantime, an LPG separating plant (with a capacity of 150–220 bbl/day) has already been constructed at the Yibal gas field in the inland part of Oman, as one of the natural gas processing facilities. This plant will go into operation as soon as Oman National Gas Company, Ltd. finishes construction of an LPG bottling plant in Rusayl on the outskirts of Muscat. According to the company plan, the plant will be completed in 1980. With this, the domestic distributing system is ready to start.

2.3 DEMAND FORECAST BY PETROLEUM PRODUCT

The previous section has outlined the overall results of demand forecast for the all petroleum products. This section will deal with particular method of forecasting each of individual products.

(1) LPG

According to the Ministry of Commerce and Industry of Oman, the past demand for LPG was 1,800 tons (55 bbl/day) in 1975, and 3,900 tons (120 bbl/day) in 1978. The Customs Department of the Royal Oman Police reported in its Foreign Trade Statistics that LPG was imported in amounts of 6,000 tons (190 bbl/day) in 1977 and 4,000 tons (130 bbl/day) in 1978.

Based on the above two types of data, the annual demands for 1976, 1977 and 1978 have been set at 46, 68 and 47 thousand bbl, respectively as the basis for demand forecast.

LPG, together with domestic kerosene, is mainly used for cooking in homes and restaurants. LPG and domestic kerosene serve the same purpose as the cooking fuel, but LPG is easier to handle. Korosene will be replaced by LPG in the cooking use, once the LPG distributing system is well developed and its price is acceptable to users.

Therefore, LPG demand is largely dependent upon the situations in which the LPG distributing system is being established in Oman, and so is the future demand for domestic kerosene.

In estimating the LPG demand, demands for both of LPG and domestic kerosene were converted to calorific values to obtain the total calorific demand. This total demand in terms of calorific demand for kitchen fuel. And this value was finally divided into the demands for LPG and domestic kerosene.

The following factors were used to calculate respective calorific values:

LPG:	0.9540×10^6 Kcal/bbl
Domestic kerosene:	1.3078×10^6 Kcal/bbl

It has been assumed that the demand for domestic kerosene would follow the past upward trend until 1980. It has also been assumed that the LPG demand is a value obtained by subtracting calorific kerosene demand from the total calorific demands for both LPG and domestic kerosene. From 1981 onward, the LPG bottling plant projected by Oman National Gas Company will go into normal operation. The domestic LPG distributing system will be gradually set up within Oman. As a result, LPG is expected to penetrate the domestic kerosene market established by 1980.

Two assumptions concerning this substitution are as follows:

- o LPG would occupy 50 percent of an increase in the total calorific demand for both of LPG and kerosene over previous year; and
- o LPG would replace 5 percent of the previous year's calorific demand for domestic kerosene.

Table 2-3 gives the past demands and the future estimated demands for both of LPG and domestic kerosene. Table 2-4 gives a procedure in which both demands have been converted to calorific values, in order to estimate the substitution of domestic kerosene by LPG. Fig. 2-2 shows a graphic illustration of both the achieved and estimated demands for LPG.

Table 2-3 LPG and Domestic Kerosene Demands – Past and Future

(Unit 10^3 barrels)

		LPG	Domestic Kerosene
Past	1976	46	84
	1977	68	95
	1978	47	101
	1979	55	110
	1980	53	119
	1981	69	117
Future	1982	84	115
	1983	99	113
	1984	112	112
	1985	126	111
	1986	140	109
	1987	154	108
	1988	168	107

(Source) Ministry of Commerce & Industry, Statistical Year Book
Foreign Trade Statistics
JICA Mission

Table 2-4 LPG and Domestic Kerosene Demands – Future Substitution of Kerosene by LPG

(Unit· 10^9 Kcal)

	LPG	Domestic Kerosene	Total	Domestic Kerosene in Trend	Substitution by LPG	Domestic Kerosene Estimated	LPG Estimated
1976	44	110	154				
1977	65	124	189				
1978	45	132	177				
1979			196	144	0	144	52
1980			207	156	0	156	51
1981			219	166	13	153	66
1982			231	178	27	151	80
1983			242	188	40	148	94
1984			254	200	53	147	107
1985			265	211	66	145	120
1986			277	222	79	143	134
1987			288	233	92	141	147
1988			300	245	105	140	160

(Source) JICA Mission

FIG. 2-2 LPG DEMAND – PAST AND FUTURE

(2) Aviation Gasoline

The past demand for aviation gasoline is as given in Table 2-5, according to the Statistical Year Book published by Development Council.

Table 2-5 Aviation Gasoline Demand – Past

(Unit: Barrels)

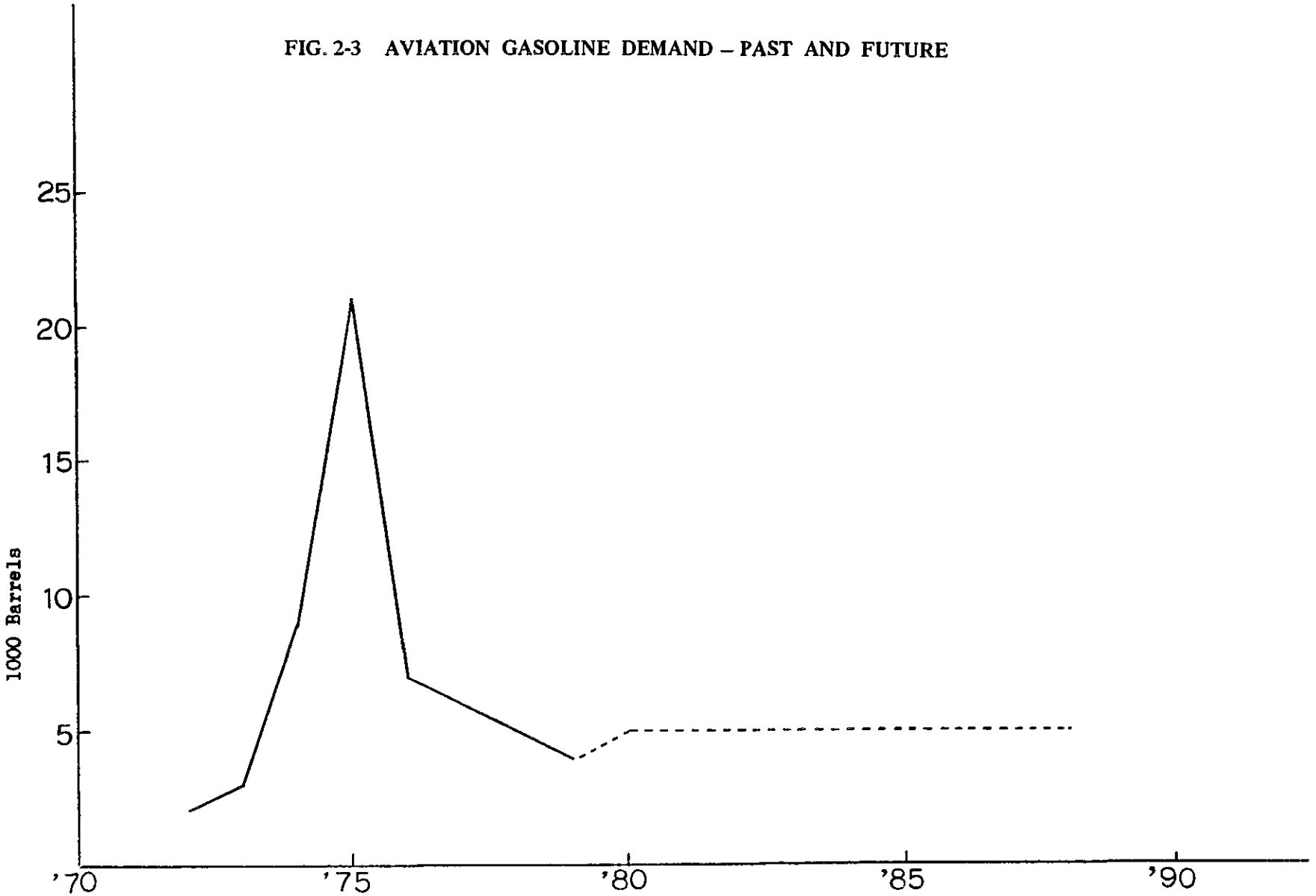
1972	2,100
1973	2,700
1974	9,300
1975	20,500
1976	7,300
1977	4,900
1978	4,100

(Source) Statistical Year Book

Aviation gasoline is mostly used by military airplanes, and its demand greatly depends on the military activities. The demand, which stood at 2,100 bbl in 1972, showed a sharp rise to a peak of 20.5 thousand bbl in 1975. With subsequent recovery to stable situations, the demand for aviation gasoline gradually dropped to a level of 4,100 bbl in 1978.

Future forecasting is quite difficult because this demand largely depends upon military activities. Thus, the 1977 and 1978 demands were averaged to give a value of 4,500 bbl. These years have been selected because the demand is found to have stabilized during this period. It has been assumed that the yearly demand for aviation gasoline in the future would be 5,000 bbl rounded to the fourth figure of the above value. Fig. 2-3 illustrates the future trend.

FIG. 2-3 AVIATION GASOLINE DEMAND – PAST AND FUTURE



(3) Motor Gasolines

There are two types of motor gasolines used in Oman – premium (RON 97) and regular (RON 90). According to the information released by the Ministry of Commerce and Industry of Oman, the past demand for these gasolines are as shown in the upper part of Table 2-6.

Table 2-6 Motor Gasoline Demand – Past and Future

(Unit: 10^3 barrels)

		Premium	Regular	Total
Past	1971	8	182	190
	1972	24	237	261
	1973	54	294	348
	1974	95	394	489
	1975	206	511	717
	1976	372	564	936
	1977	586	593	1,179
	1978	813	630	1,443
Future	1979	1,017	656	1,673
	1980	1,211	674	1,885
	1981	1,380	687	2,067
	1982	1,525	696	2,222
	1983	1,643	704	2,347
	1984	1,740	709	2,449
	1985	1,818	713	2,531
	1986	1,880	716	2,596
	1987	1,928	718	2,646
	1988	1,963	720	2,683

(Source) Ministry of Commerce & Industry
JICA Mission

The number of registered motor vehicles is likely to be a parameter used to predict the future demand for motor gasolines. The number of vehicles registered by the end of each year is given in the upper half of Table 2-7 which has been compiled from the Development Council statistics and the data released by the Registration Department of Royal Oman Police.

Table 2-7 Number of Registered Vehicles -- Past and Future

		Registered Number	Percent Increase from Previous Year
Past	1971	5,540	
	1972	9,731	75.6
	1973	13,607	39.8
	1974	20,652	51.8
	1975	31,468	52.4
	1976	44,173	40.4
	1977	58,041	31.4
	1978	71,401	23.0
Future	1979	84,110	17.8
	1980	95,550	13.6
	1981	105,390	10.3
	1982	113,720	7.9
	1983	120,540	6.0
	1984	126,080	4.6
	1985	130,500	3.5
	1986	134,020	2.7
	1987	136,700	2.0
	1988	138,750	1.5

(Source) Statistical Year Book, Royal Oman Police, JICA Mission

The number of registered vehicles and the motor gasoline demand have been found to have a very high first-degree correlation. Therefore, the demand has been forecasted by first getting future estimates of registered vehicles, and then calculating the demand, using a correlation equation between the motor gasoline demand and the number of registered vehicles.

The number of registered vehicles has been estimated by using exponential correlation of the past growth rates over previous year to time (calendar year). Results are given in the lower half of Table 2-7. These results have been used to obtain the demand forecasts of the total motor gasoline, which are given in the lower half of the column "Total" in Table 2-6.

As a next step, the total motor gasoline demand was divided into two categories of pre-

mium and regular gasolines. This was done by utilizing the correlationship between the premium/regular ratio in the past demand and the total motor gasoline demand. Thus, the ratio in the future demand was estimated, and the demand forecast of the total motor gasoline was divided into premium and regular in accordance with that ratio.

Table 2-8 gives the past trend in demand ratio of premium to regular gasoline, as well as the future trend in the demand ratio.

The results in which total demand has been divided into premium and regular are given in the column "Future" of Table 2-6. Fig. 2-4 is a graphic illustration showing the past and future trends in demands for total, premium and regular gasolines.

Table 2-8 Demand Ratio of Motor Gasolines, Premium to Regular – Past and Future

(Unit: %)

Past	Premium/Regular	Future	Premium/Regular
1971	4.4	1979	155.1
1972	10.1	1980	179.7
1973	18.4	1981	200.9
1974	24.1	1982	219.0
1975	40.3	1983	233.6
1976	66.0	1984	245.5
1977	98.8	1985	255.0
1978	129.1	1986	262.6
		1987	268.4
		1988	272.8

(Source) JICA Mission

(4) Domestic Kerosene

Demand forecasting for domestic kerosene has already been described in details in connection with the demand forecasting for LPG. As mentioned before, an LPG bottling plant is scheduled to be completed in 1980 at Rusayl on the outskirts of Muscat. With the start of operation, domestic kerosene will be replaced gradually by LPG. Thus the kerosene demand is expected to decline from a peak in 1980. The demands achieved in the past 3 years and estimated future demands are compiled in Table 2-9 and Fig. 2-5.

FIG. 2-4 MOTOR GASOLINE DEMAND – PAST AND FUTURE

A: PREMIUM MOTOR GASOLINE
B: REGULAR MOTOR GASOLINE
C: TOTAL

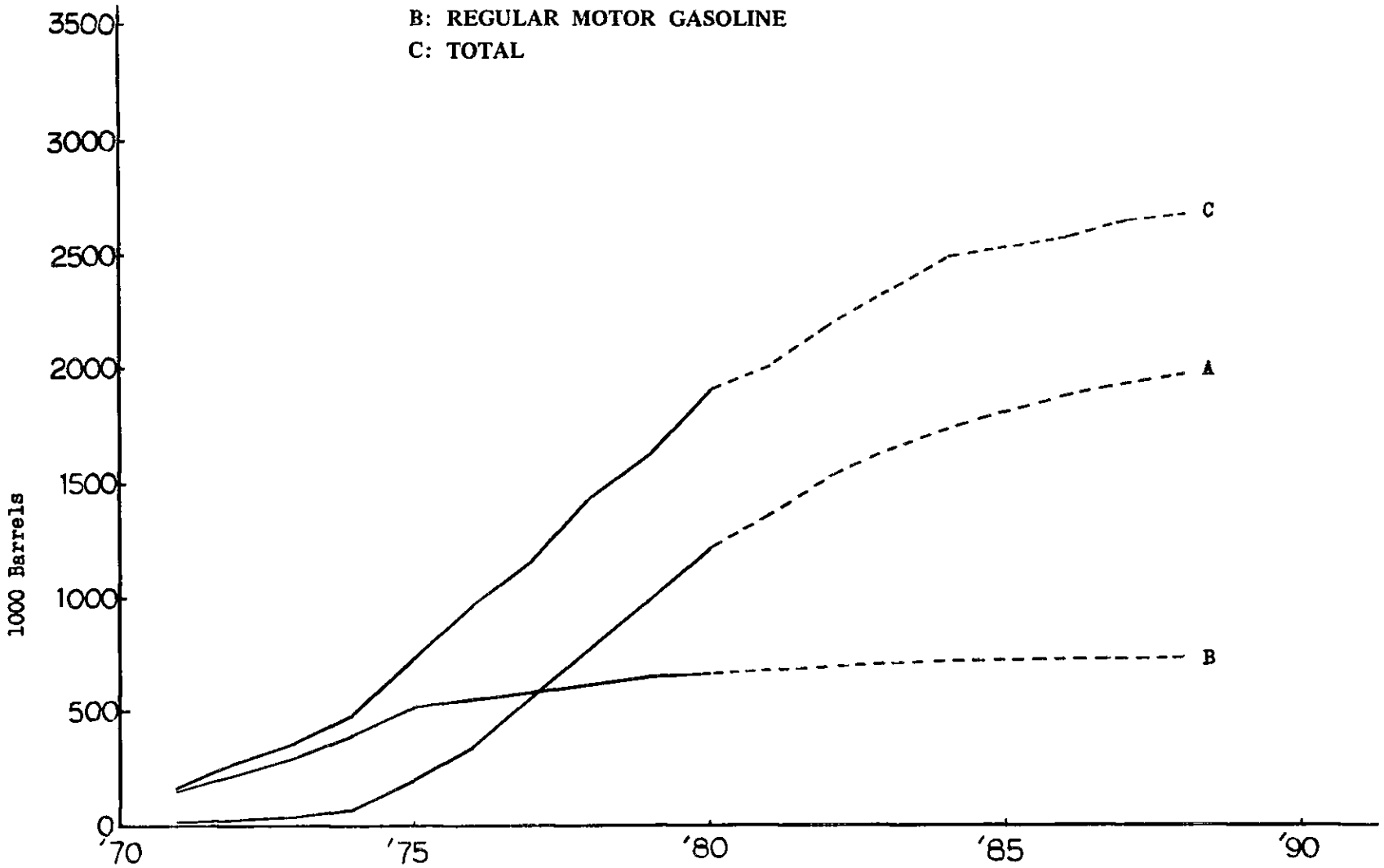


FIG. 2-5 DOMESTIC KEROSENE DEMAND – PAST AND FUTURE

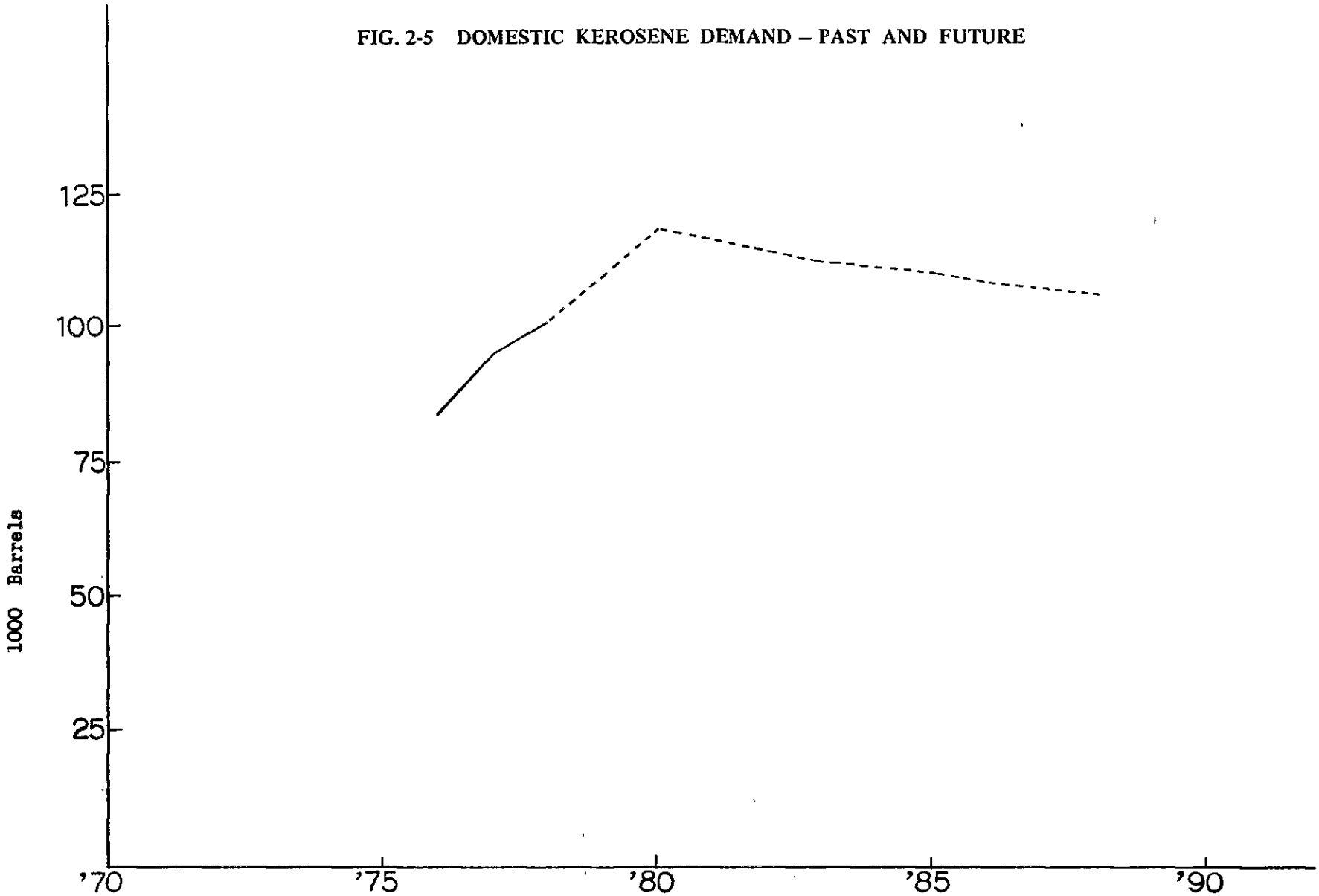


Table 2-9 Domestic Kerosene Demand – Past and Future

		Calolific Demand for Domestic Kerosene (10^9 Kcal)	Domestic Kerosene Demand (10^3 barrels)
Past	1976	110	84
	1977	124	95
	1978	132	101
Future	1979	144	110
	1980	156	119
	1981	153	117
	1982	151	115
	1983	148	113
	1984	147	112
	1985	145	111
	1986	143	109
	1987	141	108
	1988	140	107

(Source) JICA Mission

(5) Jet A-1

The Ministry of Commerce and Industry indicated that the past demand for jet A-1 was as given in Table 2-10. As for the period before 1975, there is no statistical data dealing with the demand for jet A-1 alone. Jet A-1 had been combined and dealt with domestic kerosene in one category.

Users of jet A-1 are those aircrafts taking off at Omani airports – mainly Seeb International Airport and Salalah Airport. Naturally, the demand for jet A-1 has correlated to the number of departing flights.

In fact, the jet A-1 demand was found to have a high first-degree correlation to the past number of take-off flights, according to the information released by the Directorate General of Civil Aviation of the Ministry of Civil Aviation, Roads and Ports. It was necessary, therefore, to predict future number of take-off flights and thereby to estimate the future demand for jet A-1, using an equation obtained from past correlation.

Table 2-11 and Fig. 2-6 show the past trend and the estimated future trend in the jet A-1 demand and the number of take-off flight.

Table 2-10 Jet A-1 Demand – Past

(Unit: 10^3 barrels)

	Jet A-1	Domestic Kerosene	Total
1971	N.A.	N.A.	72
1972	N.A.	N.A.	100
1973	N.A.	N.A.	162
1974	N.A.	N.A.	217
1975	N.A.	N.A.	474
1976	431	84	515
1977	749	95	844
1978	742	101	843

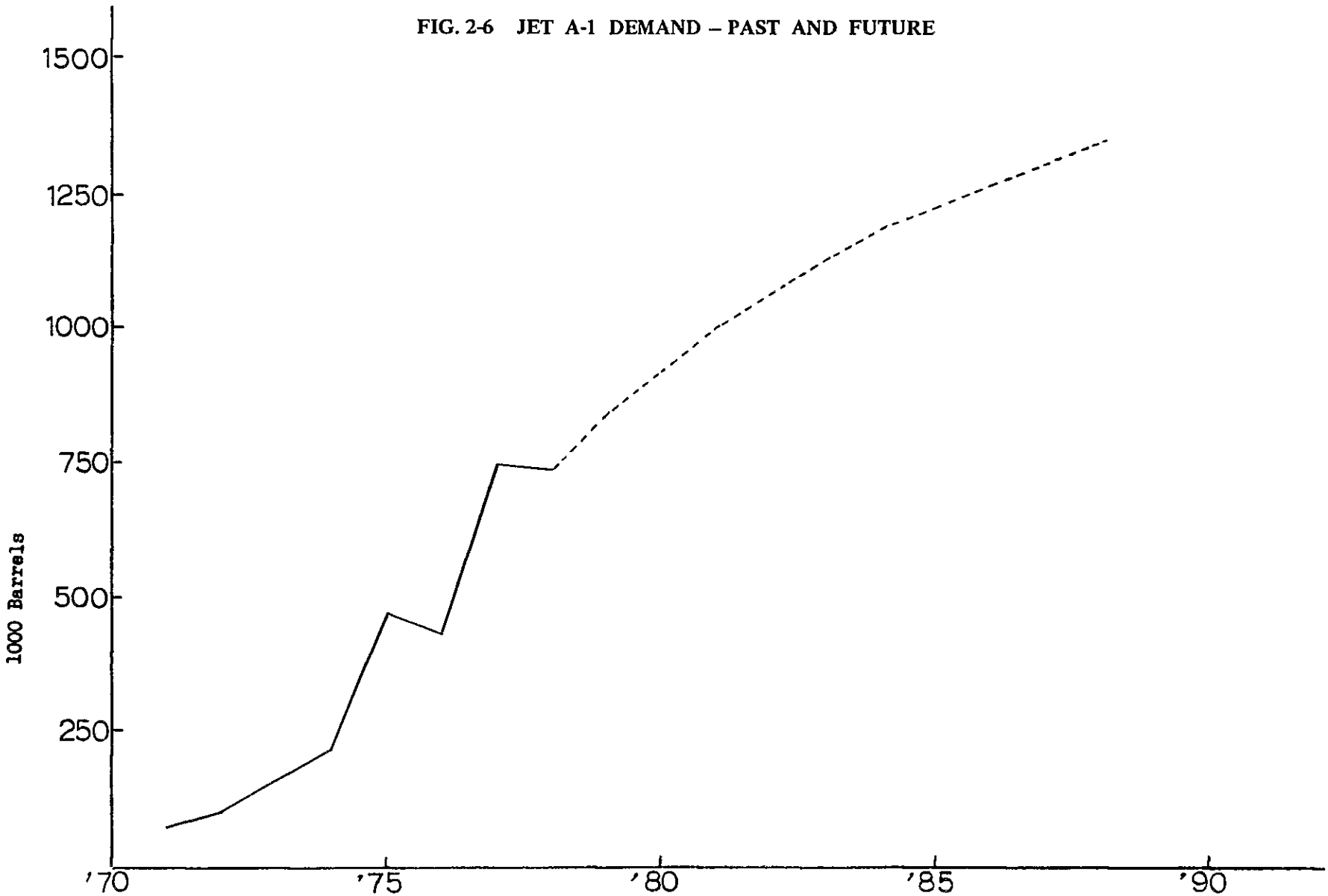
(Source) Ministry of Commerce & Industry

Table 2-11 Jet A-1 Demand and Civil Aircraft Take-off – Past and Future

		Jet A-1 Demand (10^3 barrels)	Civi Aircraft Take-off (Number)
Past	1975	420	7,503
	1976	431	7,694
	1977	749	12,958
	1978	742	13,660
Future	1979	845	15,120
	1980	926	16,580
	1981	1,006	18,040
	1982	1,068	19,135
	1983	1,129	20,230
	1984	1,189	21,325
	1985	1,230	22,055
	1986	1,270	22,785
	1987	1,311	23,515
	1988	1,352	24,245

(Source) Statistical Year Book
JICA Mission

FIG. 2-6 JET A-1 DEMAND – PAST AND FUTURE



(6) Gas Oil

According to the Ministry of Commerce and Industry, the past demands for gas oil are as given in Table 2-12.

Table 2-12 Gas Oil Demand – Past and Future

(Unit: 10^3 barrels)

Past		Future	
1971	222	1979	1,662
1972	336	1980	1,865
1973	387	1981	2,069
1974	529	1982	2,272
1975	981	1983	2,475
1976	1,669	1984	2,678
1977	1,494	1985	2,881
1978	1,557	1986	3,084
		1987	3,287
		1988	3,490

(Source) Ministry of Commerce & Industry
JICA Mission

Users requiring large volumes of gas oil are Diesel power plants operated under Governmental control. The gas oil consumption by Government-controlled power plants during 1971–1975 was estimated from power production by these power plants, as given in Table 2-13.

Table 2-13 Electricity Production and Estimated Gas Oil Demand by Governmental Diesel Power Stations – Past

	Electricity Production (10^6 KWH)	Estimated Gas Oil Demand (10^3 barrels)	Percent Ratio on Total Gas Oil Demand (%)
1971	38.6	68	31
1972	55.1	97	29
1973	82.0	145	38
1974	137.9	243	46
1975	216.4	382	39

Note: Gas oil requirement per million KHW (10^6 KWH) is supposed to be 1,762 barrels.

(Source) JICA Mission

The table shows that the gas oil demand by Government-controlled power plants occupied 37 percent on an average in the total gas oil demand during this period.

As already mentioned, a seawater desalinating plant was constructed in 1976 at Al Ghubra on the outskirts of Muscat. Al Ghubra power plant combined with this desalinating plant started since 1976 to supply the capital area with electricity, gradually taking over the role of Riyam Diesel power plant. By 1978, the Al Ghubra power plant supplied the capital area with 90 percent of power demand in this area. It started operation in 1976 with gas oil as the fuel, but it switched the fuel mostly to crude oil in 1977 and then to natural gas in 1978.

Future power demand in the capital area will be met by the supply from Al Ghubra power plant which is planning to expand the capacity by installing gas turbine generators. The power generation fuel is probably natural gas for the most part. On the other hand, the Diesel power plant at Riyam will be used only as a spare for emergency use.

Future demand for gas oil was estimated by using data on power generation at Government-controlled Diesel power plants as a parameter since statistics on power generation are well established.

Initially it was necessary to subtract the gas oil volume consumed by power production in the capital area from the total gas oil demand, so that the effect of fuel switching in the capital area since 1976 can be eliminated. The subtracted demand was then correlated to the power production at Government-controlled power plants located outside the capital area (including Diesel power plants at Mina al Fahal owned by PDO). It has been found

that there is a high first-degree correlation between power production level and gas oil demand.

Thus, the future power demand was forecasted for the areas other than the capital area, assuming that the demand for power is equal to the level of power generation. Estimated future demand for gas oil was then calculated using the above correlation equation.

It has been assumed that the gas oil demand by Al Ghubra and Riyam power plants for emergency use would amount to a level required to generate 5 percent of the total power demand in the capital area. This amount of gas oil was added to the above estimated future demand to obtain the nationwide demand for gas oil. Table 2-14 gives the past and future power production at all the Governmental power plants, at Riyam and Al Ghubra power plants in the capital area, and at those power plants outside the capital area.

The foregoing forecast is based on the correlation between the past gas oil demand and the power production which constitutes the largest part of the gas oil demand. The forecast does not take into account a gas oil demand to come in the future from such energy-consuming industry as to be established.

Among the industrialization projects planned for near future is a copper smelting project scheduled in the Sohar area. a northern part of Oman. This is an industry consuming a great deal of energy.

Gas oil is to be used under the project, because the smelting plant has to depend on Diesel power generation for its power requirement. This situation will not change unless a natural gas pipeline is extended from the Al Ghubra power plant to the northern Sohar area as an infrastructure for the industrial development of this area.

Economics of the project is the fundamental reason why natural gas is not used. If the construction cost of a natural gas pipeline between the capital area and Sohar is included in the copper project, the high cost of pipeline construction is considered to incur very bad economy for the project.

A report on the project estimates the power requirement at 115,500 megawatts-hour in a year. The gas oil demand required to produce this power is estimated at 204 thousand bbl a year. If the project is complete in 1983, with the plant put into operation in 1984, then this project requires 204 thousand bbl of gas oil annually from 1984 onward. This amount corresponds to about 8 percent of the 1984 gas oil demand of 2,678 thoudand bbl.

This gas oil demand from the copper smelting project was not added to the gas oil estimates now being studied. Those demand values calculated from power generation were used as the forecast data, accordingly. The results are given in Table 2-12, and Fig. 2-7.

No decision has yet been made as to the investment on the smelting project. On the other hand, one cannot simply deny the possibility that the Government may construct a gas pipeline as an infrastructure to develop the Sohar area.

Table 2-14 Electricity Production by Governmental Power Stations
– Past and Future

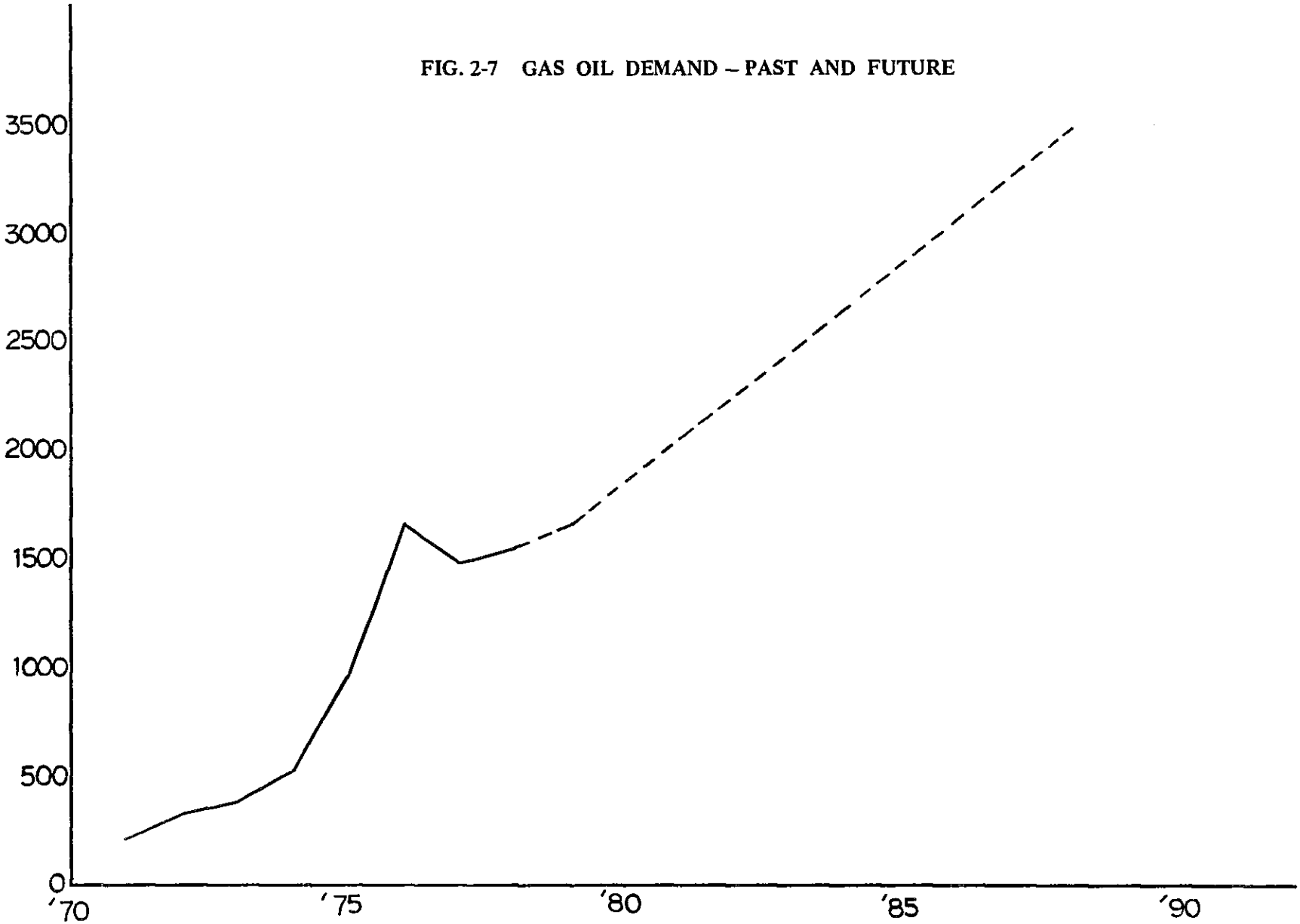
(Unit: 10^6 KWH)

		Total	Capital Area	Other Areas
Past	1971	38.6	12.0	26.6
	1972	55.1	22.0	32.9
	1973	82.0	38.9	43.1
	1974	137.9	72.6	65.3
	1975	216.4	121.9	94.5
	1976	348.8	214.2	134.6
	1977	511.0	329.3	181.7
	1978	585.6	376.8	208.6
Future	1979	621.2	398.4	222.8
	1980	704.3	453.9	250.4
	1981	787.6	509.5	278.1
	1982	870.7	565.0	305.7
	1983	953.9	620.5	333.4
	1984	1,037.0	676.0	361.0
	1985	1,120.2	731.6	388.6
	1986	1,203.5	787.2	416.3
	1987	1,286.6	842.7	443.9
	1988	1,369.7	898.2	471.5

(Source) Statistical YearBook
JICA Mission

If the copper smelting project goes on without pipeline, the gas oil demand estimated here would naturally need modification. On the contrary, if decision is made in favor of pipeline construction, existing Diesel power plant will eventually switch their fuel to less expensive natural gas. In that case, future gas oil demand should be modified downward.

FIG. 2-7 GAS OIL DEMAND – PAST AND FUTURE



(7) Fuel Oil

Statistics concerning fuel oil demand in Oman are found in the Foreign Trade Statistics compiled by Royal Oman Police. The past fuel oil imports are as given in Table 2-15, below, according to the Statistics.

Table 2-15 Heavy Fuel Oil Import – Past

	Import Volume (Tons)	Import Volume (barrels)
1977	22.5	150
1978	300.9	1,970

(Source) Royal Oman Police

It is mostly imported from the United Arab Emirates, a neighboring country of Oman, by way of land transportation. When judged from this import situation, the domestic demand for fuel oil is negligibly small as an imported petroleum product item. Future demand is also likely to be limited.

The reason for limited use of fuel oil is that there is no industry based on fuel oil as the energy source, among presently planned industrial projects of the energy-consuming type, such as cement plant, copper smelting plant and steel rolling plant. All these plants may be supposed to make effective use of natural gas as the energy source.

If the cement plant construction project now being planned depends its energy requirement, except electricity, on fuel oil rather than natural gas, there would be a fuel oil demand of about 600 thousand bbl annually (1,650 bbl/day).

It can be estimated from the foregoing situations that the future fuel oil demand, if any, is so small that it can be absorbed by the forecast demand of marine bunker oil. Actual statistics show that the 1978 demand for fuel oil stood at 1,970 bbl which accounted for less than 0.05 percent of the marine bunker oil demand of 4,240 thousand bbl. Thus, the fuel oil demand is not taken into account under this study.

(8) Marine Bunker Oil

The past demand for marine bunker oil released by the Ministry of Commerce and Industry is as given in Table 2-16.

The table shows that the demand rose sharply in 1974. In the fall of the previous year, the OPEC had taken a measure to ban the petroleum export from its member countries.

The member countries in compliance with the OPEC request decreased their supplies of marine bunker oil. A sudden increase in the demand for this item is probably because Oman could raise its position as a supplier of marine bunker oil under such circumstances. From 1975 onward, the supply of marine bunker oil from Oman has stayed on a stable level, and is roughly proportional to the exports of Omani crude oil every year. This indicates that Omani crude oil export is considered useful as a parameter to forecast the future demand for marine bunker oil. It has been found that there is a close correlation between the demand for marine bunker oil and the export of Omani crude oil from 1976 when the so-called oil embargo came to an end. Hence, the future demand for marine bunker oil was estimated by first predicting possible future exports of Omani crude oil and then using the estimated export levels in the correlation equation.

Table 2-16 Marine Bunker Oil Demand and Oman Crude Export – Past and Future

		Marine Bunker Demand (10^3 barrels)	Crude Export (10^6 barrels)
Past	1971	806	106.3
	1972	1,359	103.2
	1973	1,629	106.9
	1974	6,995	105.8
	1975	5,504	124.8
	1976	5,562	134.3
	1977	4,718	122.0
	1978	4,242	115.0
Future	1979	3,823	109.5
	1980	4,006	112.1
	1981	5,159	128.5
	1982	5,054	127.0
	1983	3,746	108.4
	1984	3,612	106.5
	1985	3,282	101.8
	1986	2,923	96.7
	1987	2,719	93.8
	1988	2,431	89.7

(Source) Ministry of Commerce & Industry
JICA Mission

With regard to the future exports of crude oil, reference was made as far as 1984 to a future crude oil production plan obtained from the Ministry of Agriculture, Fisheries, Petroleum and Minerals: As for the trend from 1985 onward, the crude oil production would hit a peak in 1981, and then would decline gradually. This pessimistic trend was extended as far as 1988 for the forecasting in this study.

It is premised here that a refinery with a crude oil processing capacity of 20 to 40 thousand bbl per day will go into operation in Oman in 1983. The possible future export of crude oil is an amount obtained by subtracting this 20 to 40 thousand bbl from daily crude oil production.

Table 2-16 gives both the past achievements and the future forecasts of the demand for marine bunker oil and the export of Omani crude oil. Fig. 2-8 is a graphic illustration showing the trend in the past and future demands for marine bunker oil.

(9) Bitumen

The past demand for bitumen was 22 thousand tons in 1977 and 16 thousand tons in 1978, according to the information offered by the Ministry of Commerce and Industry.

Bitumen is mainly used for road pavement, and this will not change in the future. Consequently, the future demand for bitumen largely depends on asphalted-road construction plans.

Information on the future plans for asphalted-road construction was obtained from Department of Road of the Ministry of Civil Aviation, Roads and Ports. According to the information, a major plan involves construction of a 780 km road connecting between Nizwa and Thamarit by the end of 1984. There are other minor plans involving construction of 80 km in total of roads. Thus the planned roads would have a total length of 860 km. It has been assumed that about 100 thousand tons of bitumen is required to construct the above asphalted-road 860 km long, based on the past bitumen demand and the length of constructed roads.

The Ministry of Commerce and Industry estimates that 26 thousand tons of bitumen will be required in 1979. From 1980 onward, the demand is estimated at about 15 thousand tons every year. This figure was obtained as follows: The 1979 demand estimated of 26 thousand tons is subtracted from a total of 100 thousand tons required by the end of 1984, to obtain 74 thousand tons. This figure was divided by 5 to give 15 thousand tons, assuming that there would be the same demand every year during the 1980–84 period.

As for the period from 1985 onward, the bitumen demand was estimated at 5 thousand tons annually, on an assumption that the demand would drop to a level 1/3 as small as the 1980–84 annual demand. This is because the planned construction of asphalted-roads would be almost complete by 1984. Table 2-17 gives the 1977 and 1978 demands for bitumen, the length of asphalted-roads to be constructed, and the estimated future demands for bitumen. Fig. 2-9 illustrates the trends in the past and future demands for bitumen.

FIG. 2-8 MARINE BUNKER OIL DEMAND – PAST AND FUTURE

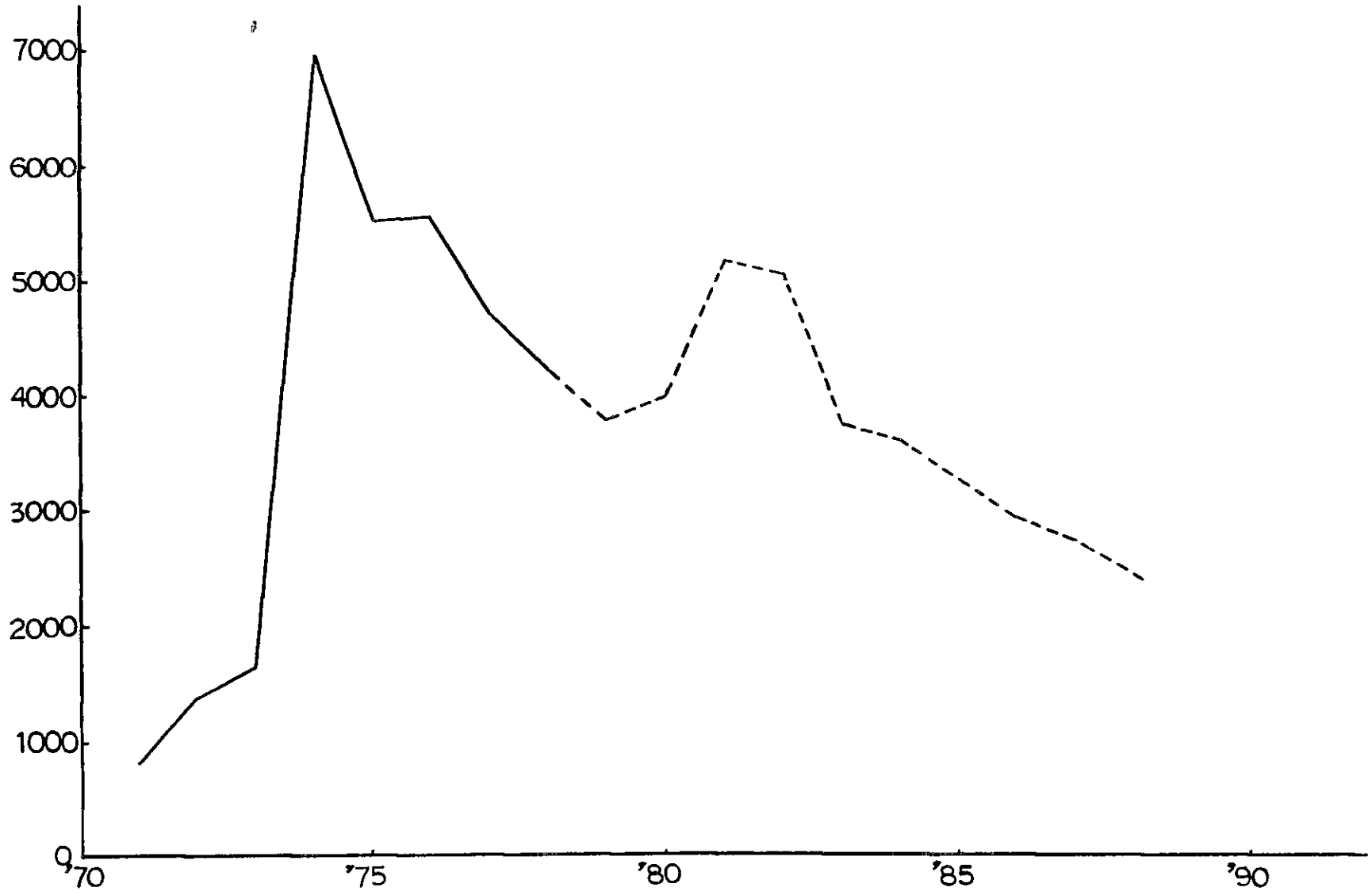


FIG. 2-9 BITUMEN DEMAND – PAST AND FUTURE

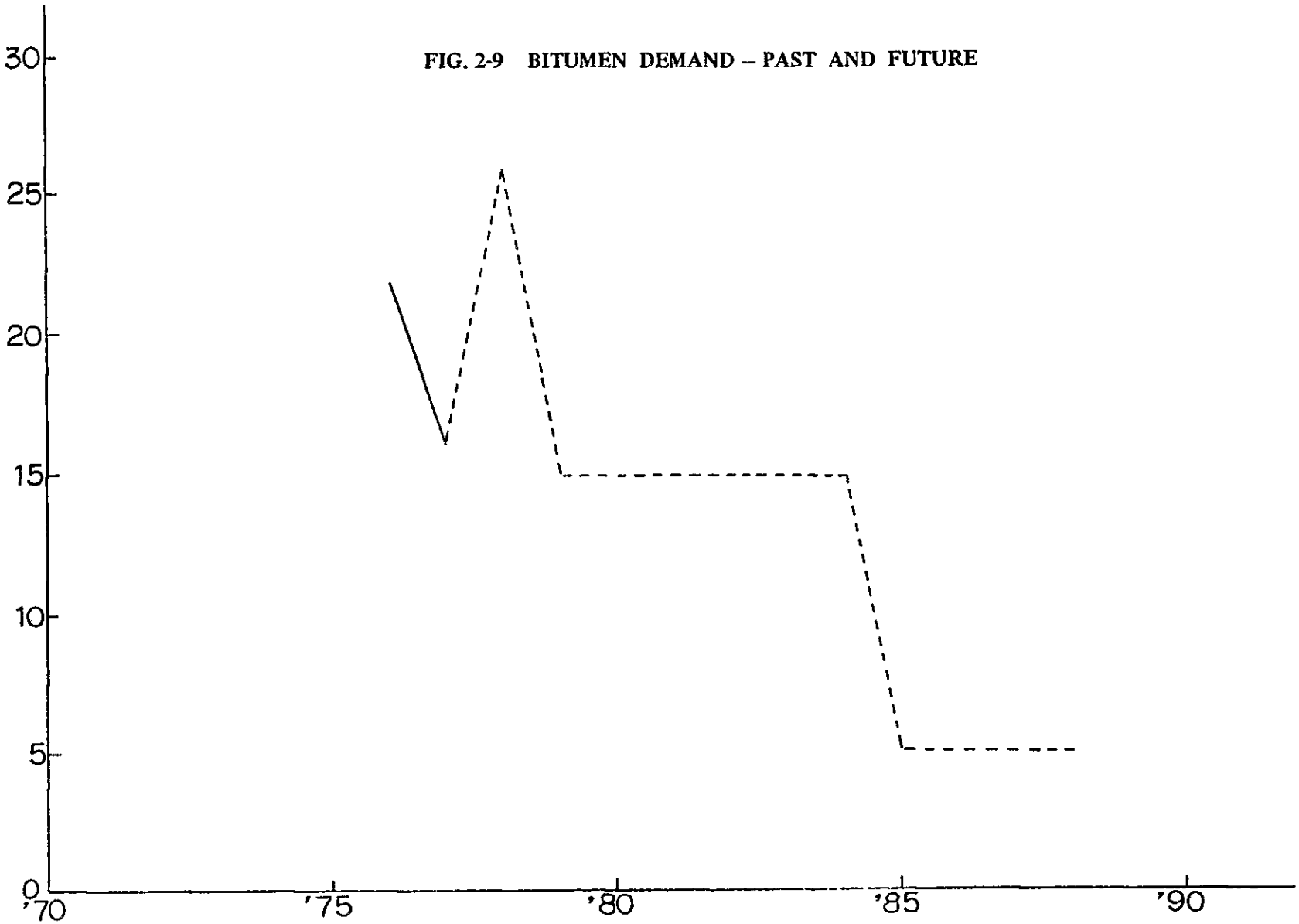


Table 2-17 Bitumen Demand and Asphalted-Road Construction – Past and Future

		Asphalt Demand (10^3 tons)	Completed Road Length (Kilometer)
Past	1977	22	175
	1978	16	153
Future	1979	26	860
	1980	15	
	1981	15	
	1982	15	
	1983	15	
	1984	15	
	1985	5	
	1986	5	
	1987	5	
	1988	5	

(Source) Ministry of Commerce & Industry, Statistical Year Book
JICA Mission

(10) Lubricating Oil

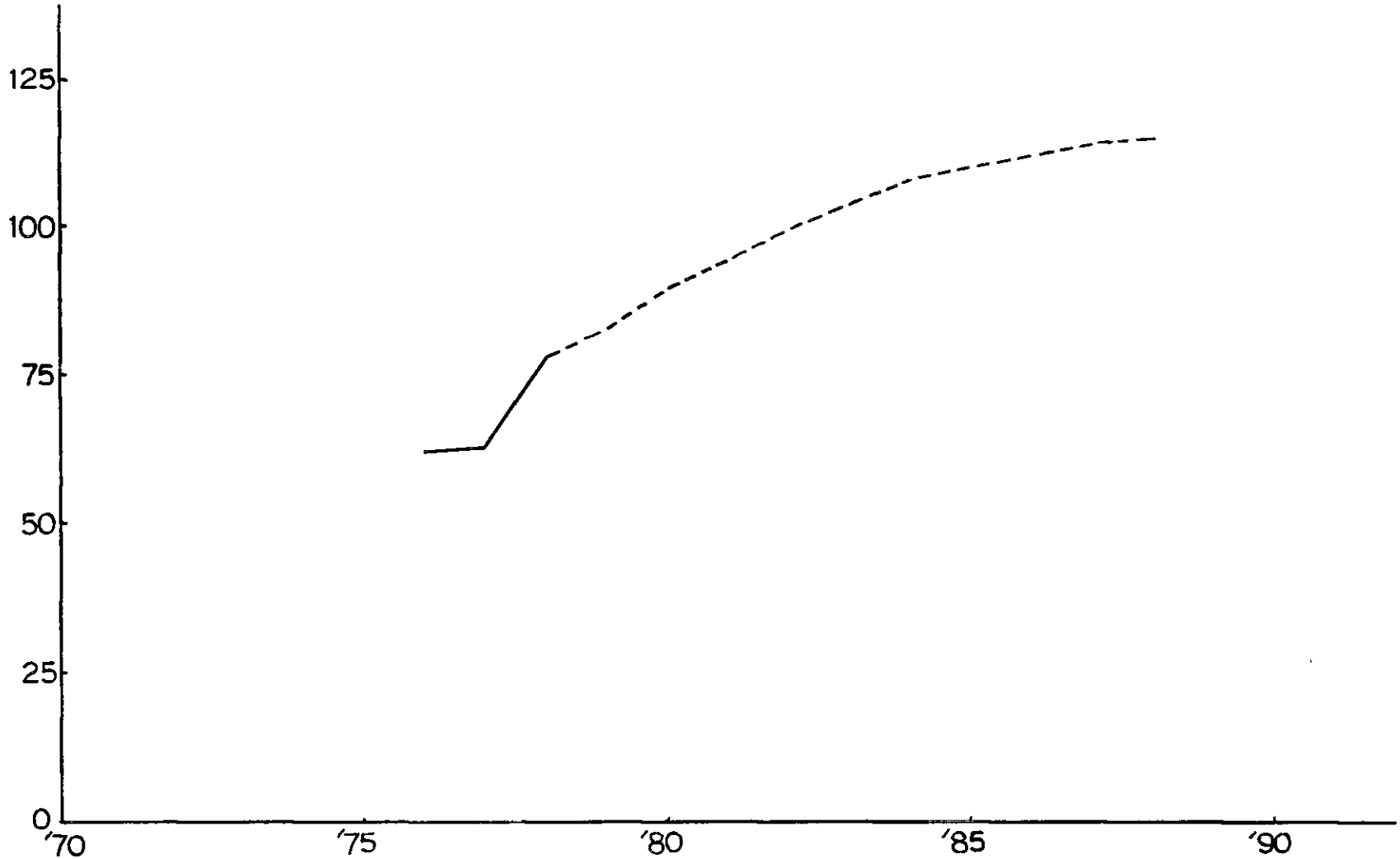
Lubricating oil finds its major use in motor vehicles. Its future demand was thus estimated by correlating the past demand with the number of registered vehicles. Table 2-18 gives both the achieved and the estimated future lubricating oil demands and number of registered vehicles. Fig. 2-10 is a graphic illustration showing past and future trends in the demands for lubricating oil.

Table 2-18 Lubricating Oil Demand and Number of Registered Vehicles – Past and Future

		Lubricating Oil Demand (10^3 barrels)	Registered Vehicles (10^3)
Past	1976	62	44 2
	1977	63	58 0
	1978	78	71.4
Future	1979	83	84 1
	1980	90	95.6
	1981	95	105.4
	1982	100	113.7
	1983	104	120.5
	1984	108	126.1
	1985	110	130.5
	1986	112	134.0
	1987	114	136.7
	1988	115	138.8

(Source) Ministry of Commerce & Industry, Statistical Year Book
Royal Oman Police
JICA Mission

FIG. 2-10 LUBRICATING OIL DEMAND – PAST AND FUTURE



2.4 REFINING INDUSTRIES IN NEIGHBORING COUNTRIES AND THEIR DEMAND-SUPPLY TRENDS OF PETROLEUM PRODUCTS

Outlines of refining industries in the neighboring countries of Oman and their situations in the demand and supply of petroleum products are shown in Table 2-19, which gives the capacities of existing and presently planned refineries, as well as the achieved and forecasted total demands for petroleum products, categorized country by country.

As obvious from the table, each of refinery-possessing countries (with exceptions of United Arab Emirates and Qatar) has a refining capacity of at least 100 thousand bbl/day. The total capacity of all existing refineries amounts to about 2.8 million bbl/day. In contrast, the petroleum product demand by these countries was a total of about 1.1 million bbl/day in 1978.

As for the refineries planned in the neighboring countries, the total capacity will reach a level of about 2.8 million bbl/day. About 60 percent of these refining capacities is to be constructed to export most of their production.

If it is assumed that all of these planned refineries go into operation by 1985 and that existing refineries hold the present capacities, then the neighboring countires, as a whole, would have a total refining capacity of about 5.6 million bbl/day in 1985. With an average operating rate of 80 percent for all the refineries, they have a total capacity of supplying about 4.5 million bbl/day of petroleum products.

Meanwhile, the demand for petroleum products by these same countries is estimated at about 2 million bbl/day for 1985. Therefore, a surplus of about 2.5 million bbl/day is expected. In other words, the neighboring countires of Oman will have large amounts of surplus petroleum products around 1985, and will surely to try to export them.

For reference, Table 2-20(A) gives a list of companies possessing existing refineries in the neighboring countires, together with refinery location, and capacities of major oil refining units. Table 2-20(B) gives a similar list for planned refineries, of which construction was already announced, and the anticipated date of completion.

Table 2-19 Refinery Capacity and Petroleum Products Demand in Neighboring Countries of Oman

(Unit: Barrels per Calender Day (BPCD))

Country	Existing Capacity	Planned Capacity	Total	Domestic Demand		
				1976	1978*1)	1985*1)
Abu Dhabi	15,000	121,000	136,000	12,400 (UAE Total)	18,200	37,600
Bahrain	250,000	–	250,000	NA	NA	NA
Iran	910,500	780,000	1,690,500	430,700	534,400	934,500
Iraq	178,500	300,000	478,500	100,000	107,600	161,900
Kuwait	712,000	–	712,000	30,000	37,700	68,600
Qatar	9,800	45,200	55,000	5,700	7,500	14,500
Saudi Arabia	615,000	1,370,000	1,985,000	160,300	400,000	800,000
Yemen (Democratic)	142,875		142,875	NA	NA	NA
Dubai	–	200,000	200,000	*2)	*2)	*2)
Ras Al Khaimah	–	NA	–	*2)	*2)	*2)
Total (Except Yemen)	2,833,675 (2,690,800)	2,816,200	5,649,875 (5,507,000)	739,100	1,105,400	2,017,100

Note: *1) Domestic consumptions in 1978 and 1985 are forecasted by JICA.
*2) Included in Abu Dhabi's figures as UAE total

Table 2-20(A) Existing Refineries in Neighboring Countries of Oman

(Unit: Barrels per Calender Day (BPCD))

Country	Company and Refinery Location	Crude Distillation	Vacuum Distillation	Catalytic Reforming	Caralitic Cracking	Thermal Cracking	Hydro-Processing
Abu Dhabi	Abu Dhabi National Oil Co.						
	Umm Al-Nar	15,000		2,800			HDT 5,300
Bahrain	Bahrain Petroleum Co., Ltd.						
	Awali	250,000	144,000	15,200	34,200	VB 19,000	HDT 15,200 HDS 71,000
Iran	National Iranian Oil Co.						
	Abadan	586,500	96,000	23,500	F 36,000		HDS 23,500
	Kermanshah	18,000		3,100			HDS 6,200
	Shiraz	40,000	18,400	6,215			DHC 9,280
	Tehran	200,000	80,000	27,500		VB 38,000	HDS 23,000 DHC 29,400
	Oil Service Co. of Iran						
	Masjid-i-Sulaiman	66,000					
	Total	910,500	194,400	60,315	36,000	38,000	91,380
Iraq	Oil Refineries Administration						
	Basra	70,000					
	Daura	71,000		5,000			HDT 13,000
	K3-Haditha	7,000					
	Khanaqiri	12,000					
	Mufthia	4,500					
	Qaiyarah, Mosul	2,000					
	Samawah	10,000					
	Iraq Company for Oil Operations						
	Kirkuk	2,000					
	Total	178,500		5,000			13,000

– continued –

Country	Company and Refinery Location	Crude Distillation	Vacuum Distillation	Catalytic Reforming	Catalitic Cracking	Thermal Cracking	Hydro-Processing
Kuwait	American Independent Oil Co., Ltd.						
	Mena Abdulla	132,000	112,000				HDS 32,000
	Arabian Oil Co., Ltd. (Japan)						
	Ras al Khafji	30,000					
	Getty Oil Co., Ltd.						
	Mina Sand	50,000					
	Kuwait National Petrolum Co., Ltd.						
	Shuaiba	200,000	100,000	16,000			HDT103,900 DHC 44,000 RHC 56,000
	Kuwait Oil Co., Ltd.						
	Mina al-Ahmadi	300,000		5,600			
	Total	712,000	212,000	21,600			235,900
Qatar	National Oil Distribution Co., Ltd.						
	Umm Said	9,800		1,285			HDT 3,500
Saudi Arabia	Arabian American Oil Co., Ltd.						
	Ras Tanura	500,000	100,000	36,000			HDS 22,500
	Jeddah Oil Refinery Co., Ltd.						
	Jeddah	95,000	18,000	2,900	F 9,500	VB 3,100	HDT 2,900 HDS 8,500
	Riyadh Oil Refinery						
	Riyadh	20,000	7,000	4,875			DHC 5,560 HDT 2,306
	Total	615,000	125,000	43,775	9,500	3,100	41,766
Yemen (Democratic)	Yemen Government						
	Little Aden	142,857		9,524			
Total		2,823,857	675,400	159,499	79,700	60,100	477,046

Note: Abbreviations F: Fluid catalytic cracking VB: Visbreaking DHC: Distillate hydrocracking
RHC: Residual hydrocracking HDT: Catalytic hydrotreating HDS: Catalytic hydrodesulfurization

(Source) Oil & Gas Journal

Table 2-20(B) Planned Refineries in Neighboring Countries of Oman

(Unit: Barrels per Calender Day (BPCD))

Country	Company and Refinery Location	Crude Distillation	Vacuum Distillation	Catalytic Reforming	Catalytic Cracking	Thermal Cracking	Hydro-Processing	Data of Completion
Abu Dhabi	Abu Dhabi National Oil Co.							
	Ruwais	120,000		14,000			HDT 30,000 HDS 56,000	1981
	Amerada Hess	1,000 under construction						
	Total	121,000		14,000			86,000	
Iran	National Iranian Oil Co.							
	Esfahan	200,000	96,800	29,600		VB 38,000	DHC 30,000 HDT 29,000	1978
	Tabriz	80,000	38,000	11,100		VB 16,500	DHC 18,000 HDT 11,100 HDS 13,300	1978
	Japan/Iran Joint venture							
	Bushehr	500,000						1983
	Total	780,000	134,800	40,700		54,500	101,400	
Dubai	National							
	Jebel Ali	200,000						1981
Iraq	National							
	Bai Hassan							
	First Phase	70,000						1981
	Second Phase	80,000						
	Baiji	150,000						
	Total	300,000						

– continued –

Country	Company and Refinery Location	Crude Distillation	Vacuum Distillation	Catalytic Reforming	Catalytic Cracking	Thermal Cracking	Hydro-Processing	Data of Completion
Qatar	Qatar National Oil Distribution Co.							
	Umm Said	45,200	6,000					
Saudi Arabia	Petromin							
	Riyad Refinery	100,000	37,300	30,000			HDT 21,000 HDS 14,500 HDC 27,500	1980
	Petromin							
	Yanbu	170,000		35,000			HDT 35,000	1983
	Yanbu	200,000					HDS 15,200	
	Petromin/Mobil Oil							
	Yanbu	250,000						
	Petromin/Shell							
	Jubail	250,000						1983
	Arabian American Oil Co.							
	Ras Tanura	200,000						
	Total	1,370,000						

Note: Abbreviations
- VB: Visbreaking
- DHC: Distillate hydrocracking
- HDT: Catalytic hydrotreating
- HDS: Catalytic hydrodesulfurization

(Source) JICA Mission

2.5 PRICES OF PETROLEUM PRODUCTS

The CIF prices of petroleum products in Oman are as given in Table 2-21, according to the information from the Ministry of Commerce and Industry.

Table 2-21 CIF Prices of Petroleum Products in Oman

Product	Unit	1978	January 1979	February 1979
LPG	Baisas/kilogram	88.18*1)	NA	99.20*1)
Aviation Gasoline	Baisas/liter	66.22*2)	NA	75.49*2)
Premium Motor Gasoline	"	46.13	50.64	52.56
Regular Motor Gasoline	"	41.92	46.31	47.87
Domestic Kerosene*3)	"	42.47	47.15	48.15
Jet A-1	"	42.47	47.15	48.15
Gas Oil	"	38.37	42.24	43.45
Marine Bunker Oil	"	25.50	26.50	26.50
Bitumen	Baisas/kilogram	78.07*4)	36.63*4)	NA

(Source) Ministry of Commerce & Industry

The asterisked (*) figures in the table may need some explanation, which will be described below in the numerical order.

1) The LPG prices are ex-factory, Dubai, for a 100-pound cylinder, calculated on a basis of 4.0 Oman Rial (R.O.) for 1978 and 4.5 R.O. for February 1979.
2) The 1978 price of aviation gasoline was calculated on a basis of 72.5 U.S. cents/U.S. gallon. The price for February 1979 was obtained by applying an increase of 14 percent over the previous year in the price of motor gasolines for February 1979.
3) With regard to domestic kerosene, dual purpose kerosene was imported for use as jet A-1, and a part of it was sold for home use. Hence, the domestic kerosene price is the same as that of jet A-1.
4) The 1978 price of bitumen was obtained from Foreign Trade Statistics published by the Royal Oman Police. The price for January 1979 was found in import statistics obtained from Customs Department of the Royal Oman Police.

The FOB prices of petroleum products at the petroleum export bases on the caostal areas of Arabian Gulf were extracted from Platt's Oilgram Price Report and compiled into Table 2-22. In this table, the prices of LPG, marine bunker oil and naphtha are FOB Bahrain (Caltex); those of other products are FOB Bandar Mah Shahr, Iran.

Table 2-22 FOB Prices of Petroleum Products in Arabian Gulf Area

Product	Unit	1978	January 1979	February 1979
LPG*1)	$/ton	118.8	119.1	119.1
Aviation Gasoline*2)	¢/USG	59.88	61.00	64.50
Premium Motor Gasoline	"	47.13	49.33	53.30
Regular Motor Gasoline	"	42.00	44.33	47.45
Domestic Kerosene*3)	""	43.00	43.49	48.23
Jet A-1	"	43.00	43.49	48.23
Gas Oil	"	38.92	40.49	44.25
Marine Bunker Oil*4)	$/bbl	11.19	11.03	11.15
Naphtha (Straight Run)	¢/USG	32.61	35.50	38.50

(Source) Platt's Oilgram

The above table, too, needs some explanation on the asterisked figures.

1) The LPG prices were calculated on the basis of refrigerated LPG for bulk users, in which propane and butane are mixed at a 50/50 ratio.
2) The type of aviation gasoline is Avgas Grade 100/130 which is imported to Oman.
3) The prices of domestic kerosene are same as Jet A-1 prices.
4) The prices of marine bunker oil were set at the same prices of fuel oil.

These prices of petroleum products were then converted into prices in Omani currency given in Table 2-23 for the same units as those shown in Table 2-21. The conversion from U.S. currency to Omani currency is based on the following rate:

R.O. 1.0 = U.S.$2.89234

Table 2-23 FOB Prices of Petroleum Products in Arabian Gulf Area in Omani Currency

	Unit	1978	January 1979	February 1979
LPG	Baisas/kilogram	41.08	NA	41.19
Aviation Gasoline	Baisas/liter	54.70	NA	58.92
Premium Motor Gasoline	"	43.05	45.06	48.69
Regular Motor Gasoline	"	38.36	40.49	43.34
Domestic Kerosene	"	39.28	39.73	44.06
Jet A-1	"	39.28	39.73	44.06
Gas Oil	"	35.55	36.99	40.42
Marine Bunker Oil	"	24.33	23.99	24.25
Naphtha	Baisas/kilogram	29.79	32.43	35.17

(Source) JICA Mission

The retail prices of petroleum products sold in Oman are as given in Table 2-24.

Table 2-24 Retail Prices of Petroleum Products in Oman

	Unit	March 1978	March 1979
Premium Motor Gasoline	Baisas/liter	60	62
Regular Motor Gasoline	"	56	57
Domestic Kerosene	"	50	53
Gas Oil	"	50	52

(Source) JICA Mission

CHAPTER 3 AVAILABILITY OF CRUDE OIL

3.1 CRUDE OIL PRODUCED IN OMAN

3.1.1 Prospect of Oil Production

The 1979 Omani crude oil production is estimated at 300 thousand bbl/day, down about 5 percent over 1978. Omani crude oil is produced at nine (9) oil fields in the middle and western parts of the country.

P.D.O. "Long Term Production Forecast (Base Case)" estimates that the production from existing oil fields will slightly decrease to a level of 291 thousand bbl/day in 1980, but that the total production will increase to 307 thousand bbl/day in the middle of 1980, when the newly developed Marmul and Birba oil fields in the south will be connected via new pipelines to existing crude oil pipelines, to put both oil fields into commercial operation scheduled for that year. Furthermore, when additional three (3) oil fields start production in 1981, the total production will reach 352 thousand bbl/day.

From 1982 onward, production will gradually decrease to a 1984 level of 322 thousand bbl/day, because the development of new oil fields is outrun by an exhausting tendency found in existing oil fields. (See Table 3-1)

With respect to oil production in years after 1985, no formal oil production forecast has been published. Even if it is assumed from a pessimistic point of view that oil production in existing oil fields will show a continuous decrease at about 7.1 percent on an annual average as anticipated in the above mentioned P.D.O. forecast, it would still take a decade until the production drops to a half the present level. Besides, oil exploration is now under way, and such an effort will certainly lead to the development of new oil fields during that decade. It is thus impossible to imagine that the day will come when the refinery now being studied cannot get its estimated crude oil requirement in the range of 20 to 40 thousand bbl/day.

There is another bright news. The Ministry of Petroleum has given a comment that when a refinery is constructed in Oman, the crude oil supply to the refinery would be given the highest priority. Under these circumstances, there is little concern for the supply of Omani crude oil to the planned refinery.

Table 3-1 Long Term Production Forecast of Oman Crude

(Unit: 1000 B/D)

Fields	1979	1980	1981	1982	1983	1984
Fahud	69	60	56	55	50	45
Natih	28	26	24	24	19	16
Yibal	80	84	85	85	85	85
Al Huwaisah	28	28	25	22	19	17
Lekhwair	24	27	24	21	19	17
Sub-Total	229	225	214	207	192	180
Saih Nihayda	35	31	27	22	16	10
Saih Rawl	21	20	16	14	12	9
Ghaba North	11	11	10	9	6	5
Qarn Alam/Habur	2	–	–	–	–	–
Sub-Total	69	62	53	45	34	24
NGL/LPG (Yibal, Fahud, Saih Rawl)	2	4	6	5	5	4
Total Oman (Producing Fields)	300	291	273	257	231	208
Marmul		14	50	37	30	28
Birba		2	6	7	8	8
Qaharir			10	8	7	6
Amal			3	10	9	8
Rahab				8	6	5
Sub-Total	–	16	69	70	60	55
South Oman (Firm)						
Amin South				1	1	1
Amal South East				2	1	1
Exploration Success No.1			10	18	14	11
Exploration Success No.2					10	18
Exploration Success No.3					10	18
Exploration Success No.4						10
Grand Total Oman	300	307	352	348	327	322

(Source) Ministry of Agriculture, Fisheries, Petroleum & Minerals.

3.1.2 Properties of Crude Oil

The Omani crude oil is gathered through pipelines from the aforementioned several oil fields, mixed and shipped as a single item of "Oman Crude". The latest information on its properties is given in Table 3-2. Among those crude oils produced on the coast of Arabian Gulf, Oman Crude can be regarded as a relatively light, low-sulfur crude oil of good quality.

Table 3-2 Characteristics of Oman Crude

(1) CRUDE OIL CHARACTERISTICS	
Specific Gravity, 15/4°C	0.847
API Gravity, 60°F	35.5
Kin. Viscosity at 50°F, cst	15.5
Kin. Viscosity at 100°F, cst	6.36
Sulfur, % wt	0.77
Pour Point, °C (°F)	−30 (−20)
Total Acid Number, mg. KOH/g	0.29
(2) LIGHT MYDROCARBONS (% wt. on crude oil)	
C_2 minus	0.01
C_3	0.13
iC_4	0.15
nC_4	0.41
iC_5	0.46
nC_5	0.67
Cyclo C_5	0.04
nC_6	0.86
Benzene	0.08
Other C_6	1.01

– continued –

(3) FRACTION DATA

Fractions °C	C5–65	65–100	100–150	150–200	200–250	250–300	300–350	>350
Yield on crude, % wt.	2.4	3.1	8.5	8.7	10.6	11.0	9.6	45.4
Yield on crude, % vol.	3.1	3.6	9.7	9.6	11.2	11.2	9.5	41.3
Position in crude oil, % wt.	0.7	3.1	6.2	14.7	23.4	34.0	45.0	54.6
Mid yield on crude oil, % wt.		4.7	10.5	19.1	28.7	39.5	49.8	
Specific gravity, 15/4°C	0.657	0.725	0.742	0.771	0.804	0.833	0.856	0.930
Kin. viscosity at 100°F, cst.					1.7	3.43	7.35	
Kin. viscosity at 210°F, cst.								27.4
Sulfur, wt. %		<0.01	0.02	0.06	0.16	0.36	0.62	1.44
Wax content, % wt.								7
Pour point, °C (°F)						–21(–5)	0(30)	12(55)
Research ON clear	70	55						
Paraffins/Naphthenes/Aromatics % wt.	91/5/4	59/25/16	67/21/12	56/30/14				
Aromatics, % vol.				11	15			
Smoke point, mm				31	26			
Freezing point, °C				<–60	–47			
Calc. cetane index						56	60.5	

(Source) General Information on the Crude Oil (Assay date June 1976)

It is expected in the future that the Oman Crude properties will change to some extent, because the proportions of component oils coming from respective oil fields will be varied. API gravity and sulfur content are estimated to get no substantial changes.

Because crude oil properties cannot be forecasted in such details as can be used for the planning of a refinery, it has been assumed in this study that the Oman Crude to be used at the planned refinery would have the same properties as those given in Table 3-2.

Oman Crude yields 35 – 45% gasoline fractions, 25 – 35% kerosene fraction, and 35 – 40% gas oil fraction, putting the total distillate fractions (a sum of gasoline, kerosene and gas oil fractions) as 100%. It is especially characterized in that this fractional composition roughly corresponds to the estimated demand structure of these fractions found in Omani market. This suggests that Oman Crude is a suitable crude oil to meet the domestic demands for oil products in Oman, as long as distillates are concerned.

On the other hand, Oman Crude contains about 41 percent of residue oil fraction. In Oman, most of the demand for residue oil is the demand as marine bunker fuel. It is estimated that the percentage of this demand in the total demand for oil products will reach the highest level of about 47 percent in 1982, and will drop to about 32 percent in 1985. Therefore, refining of Oman Crude to meet the domestic demands for distillates will inevitably pose a problem of surplus residue oil.

3.2 POSSIBILITY OF CRUDE OIL IMPORT

A possible alternative to the use of Oman Crude is to import some foreign crude oil lighter than Oman Crude. At first sight, this alternative looks reasonable, in order to get the right composition of products more fitting to the demand structure of Oman; i,e., to meet the domestic demand for distillates while avoiding excessive production of residue oil.

In fact, however, such a light crude oil is costly and difficult to get from those areas bordering Arabian Gulf. If high costs of transportation and storage are taken into consideration, refining of imported crude oil cannot be regarded as a wise means to attain at self-sufficiency of oil products in Oman.