The Economics of Alternative Uses of Non-Associated Natural Gas in The Arabian Gulf

by

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This paper analyses the options available to the Arabian Gulf countries for utilizing non-associated natural gas. The purpose of this analysis is to focus on certain policy issues and point to the need for a strategy for the utilization of non-associated natural gas reserves of the region. In the 1950's and early 1960's, associated natural gas did not receive appropriate attention. The natural gas produced with oil used to be flared. There were no sufficient efforts to maintain it underground or to carry out the necessary investments for utilizing the gas produced. However, since early 1960's the Oil Producing Countries have been utilizing the associated natural gas available in providing power stations and water desalination plants with the required fuel. Also, some countries started to make use of natural gas in certain industries, particularly cement, chemical fertilizers and oil refineries.

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With the realization of worldwide energy shortage since early 1970's, oil companies have been sharing the Producing Countries' interest to utilize natural gas. This is attributable to the growing concern of the industrial countries about future energy supplies. This concern motivated the oil companies to liquefy the natural gas of the producing countries for export.

Thus, the increasing interest by the governments of oil producing countries on one hand, and of the oil companies backed by the consuming countries on the other, led to the establishment of various gas-based projects. These projects together with those under construction will absorb most, if not all, of the associated natural gas presently being produced in the Arabian Gulf Countries. Therefore, the new gas-based projects have to be realized from non-associated natural gas reserves. This development merits a detailed consideration and this paper will discuss the subject under the following broad heads:

1. Natural gas reserves;
2. Alternative choices for utilizing non-associated natural gas;
3. Comparison of net financial revenues: an LNG Complex Vs a Petrochemical Complex;
4. Comparison of economic impact: an LNG Complex Vs a Petrochemical Complex;
5. Economic viability and Social desirability of the Petrochemical Strategy.

1. Natural Gas Reserves:

The table below gives the oil and natural gas reserves in the Arabian Gulf Countries :

Table - 1

Proven Crude Oil and Natural Gas Reserves in the Arabian Gulf Countries as of January 1, 1980

Country	Crude Oil Reserves (billion barrels)	Percent	Natural Gas Reserves (trillion SCF)	Percent	Natural Gas Reserves by their equivalent of Crude Oil (billion barrels)
U.A.E	29.40	9.74	20.50	8.25	3.54
Bahrain	1.24*	0.08	9.00	3.63	1.55
Iraq	31.00	10.27	27.50	11.08	4.74
Kuwait	65.40	21.67	31.00	12.49	5.34
Oman	2.40	0.81	2.00	0.81	0.34
Qatar	3.60	1.19	60.00	24.17	10.34
Saudi Arabia	162.50	54.17	93.23	37.56	16.07
Neutral Zone	6.26	2.07	5.00	2.01	0.86
Total	301.80	100.00	248.23	100.00	42.78
Total for OPEC Countries	435.57	69.29	995.93	24.92	171.71
World Total	641.62	47.04	2573.24	9.65	443.66

Source: Oil & Gas Journal, No.77, Dec. 31, 1979.

* Inclusive of one billion barrels from the oil reserves of Abu Sa'afa Oil Field.

Table 1 shows that proven natural gas reserves in the countries of the region are estimated to be 248 trillion cubic feet, i.e. about 9.5% of total world reserves or about 28.5% of the OPEC member states' reserves. These natural gas reserves are equivalent to 13.5% of crude oil reserves, i.e. 42.8 billion barrels of oil. The reserves in most countries of the region, except Qatar and Bahrain, still represent the associated natural gas reserves. No serious exploration efforts have so far been made for non-associated natural gas which could possibly raise the estimates of gas reserves for the region considerably.

In Qatar and Bahrain, where explorations were made for non-associated natural gas, substantial quantities have been discovered which have greater significance than their crude oil reserves. Qatar, alone, has about one-fourth of natural gas reserves of the Arabian Gulf Countries.

2. Alternative choices for utilizing non-associated Natural Gas:

Production of non-associated natural gas is characterized by its independence from crude oil. This makes the task of decision-makers easy and allows them to make their decision independently from oil production policy and related considerations. If the policy for utilizing associated natural gas is based on minimisation of wastage by flaring it, and therefore, any value or benefit that can be obtained is better than flaring, the policy for utilizing non-associated natural gas should be based on different premises.

Options for utilizing non-associated natural gas can be viewed both in a time perspective and in a functional perspective. In a time perspective, it will be possible to choose one of the two alternatives: either to produce it as early as possible, or to tarry its production. Choice of either of the alternatives must be based on possible financial, economic and social returns to be derived out of the timing of the commencement of non-associated natural gas production, compared to tarrying its production until such time as the country becomes capable to absorb and prepared to make use of the potential benefits from exploitation of such important national resources. However, a political analysis based on wider national considerations should also guide such an option.

In a functional perspective, it is possible to primarily compare two strategies; first: liquefaction of gas for export to world markets; second: use of gas as a source of energy and feed-stock for local industries. However, it may be argued that these are not two mutually exclusive alternatives and that gas can be made use of both for liquefaction and export and for local industries. But this view may be objected to, because of the limited capacity (constructionwise and operationwise) of any of the countries to implement more than one or few industrial complexes at a time. This limitation, practically makes any commitment to construct LNG Complex a postponment of other alternative opportunities. In addition, allocation of large quantities of gas to liquefaction poses a threat to supply of energy to local industries and electricity and water desalination facilities in the long run. In this light, therefore, to combine the two strategies does not appear a practical or sound policy specially if a country started with an LNG Complex with investment of more than $ 4 billion.

3. COMPARISON OF FINANCIAL RETURNS FOR BOTH LNG COMPLEX AND PETROCHEMICAL COMPLEX

To determine the net financial return for a country, as the owner of natural gas, a comparison will be made between the expected financial return for two alternative complexes. Table 2 will show the financial return from LNG Complex and Table 3 will show the financial return from Petrochemical Complex.

Table - 2

FINANCIAL RETURN FROM THE USE OF NATURAL GAS IN A LIQUEFIED NATURAL GAS COMPLEX

1.	Natural Gas Requirement	1,000 million SCF/Day
2.	Total Product Capacity *	7.684 million MT/Year
3.	Average estimated sale price	US$ 290.77 per MT
4.	Average Production Cost**	US$ 198.95 per MT
5.	Gross Government Potential Revenue	US$ 1.77 per 1000 SCF
6.	Net Government Potential Revenue ***	US$ 1.27 per 1000 MT

* Product package consists of LNG: 5.510 million MT/Year, Raw NGL : 660,000 MT/Year, natural gasoline 1.44 million MT/Year and Sulphur 74,000 MT/Year.

** Including 15% Return on Investment, but excluding any price for gas at plantfence.

*** After deducting 50 US Cents for production cost and transportation of the gas to the fence of the plant.

Source: Appendix A

Table - 3

FINANCIAL RETURN FROM THE USE OF NATURAL GAS IN PETROCHEMICAL COMPLEX

	Fuel Methanol	Chemical Methanol	Ammonia	Ethylene	Gas Liquids	Total/Weighted Average
Natural Gas Requirement (in MMSCF/day)	160	80	193	57	110	600
Total Capacity (in '000 MT/Year)	1,320	660	1,600	280	799.5	4,659.50
Average Sales Price (US $/MT)-FOB	225	240	190	575	298	249.00
Production Cost (US$/MT) *	103	135	105	339	188	136.97
Gross Government Potential Revenue	3.29	2.60	2.19	3.63	2.50	2.73
Net Government Potential Revenue	2.73	2.10	1.69	3.13	2.00	2.23

ncluding 15% ROI, but excluding any price for natural gas at plantfence.

fter deducting 50 US Cents for production cost and transportation of natural gas.

ce: Appendices B, C, D, E and F.

From Tables 2 and 3 a comparison can be made between the potential government financial realizations from both LNG complex and Petrochemical complex. The following table shows the comparson:

Table - 4

COMPARISON OF NET GOVERNMENT POTENTIAL FINANCIAL RETURNS FROM BOTH LNG COMPLEX AND PETROCHEMICAL COMPLEX

		LNG COMPLEX	PETROCHEMICAL COMPLEX
1.	Natural Gas requirement (MM SCF per day)	1,000	600
2.	Average Product Price	290.77	249.00
3.	Average Production Cost	198.95	136.97
4.	Total Revenue realized (US$ per 1000 SCF)	1.77	2.73
5.	Net revenue realized (US$ per 1000 SCF)	1.27	2.23

From the above comparison, the potential government realization per 1000 SCF by utilizing natural gas for liquefaction is US Cents 127 as against US Cents 223 in a basic Petrochemical complex as outlined above. This result shows the relative financial realizations from LNG Complex and Petrochemical Complex. Therefore, the advantage is obvious in the case of Petrochemical Complex.

4. COMPARISON OF THE ECONOMICS OF BOTH LNG COMPLEX AND PETROCHEMICAL COMPLEX

In addition to comparing net Government financial realizations of the two alternatives, we shall also attempt here a comparison of other economic parameters that should guide the project choice. These parameters include return on investment, value-added from the projects and risks in addition to economic and technological impact which the projects may cause to generate in the economy of a producing country. Table - 5 gives these economic indicators for the Petrochemical Complex and Table - 6 gives the comparison of the economics of the Petrochemical Complex with the economics of the LNG Complex.

TABLE - 5

MAIN ECONOMIC PARAMETERS:

PETROCHEMICAL COMPLEX

(APRIL 1981)

Chemical Methanol	Methanol	Ammonia	NGL	Ethy-lene	Propy-lene	Urea	Formal-dehyde	Urea Formal-dehyde	LDPE	Poly-Propy-lene	Total/ Weighted Average
80.0	160.0	193.0	110	57	-	-	-	-	-	-	600
660	1320	1600	799.5	280	90	640	90	150	140	85	5854.50
260	484	482	430	240	25.5	180	23	63	245	132	2564.50
158	399	304	244	161	41	160	38	90	147	102	1844.00
61	124	124	102	68	29	112	26	47	126	69	888.00
97	275	180	142	93	12	48	12	43	21	33	956.00
37.31	56.82	37.34	33.02	38.75	47.06	26.67	52.17	68.25	8.57	25.0	37.28
143.6	353.2	268.0	208.0	146.8	17.2	82.3	16.6	54.0	62.4	58.6	1410.70

B - L

TABLE - 6

MAIN ECONOMIC PARAMETERS: COMPARISON OF THE ECONOMICS OF LNG AND PETROCHEMICAL COMPLEX (APRIL 1981)

		LNG	PETROCHEMICAL COMPLEX
1.	Gas Requirement Million SCF per day	1000	600
2.	Capacity- 000 MT per year	7684.00	5854.50
3.	Total fixed Investment - Million US $	4390.00	2564.50
4.	Gross Revenue - Million US $	2234.00	1844.00
5.	Production Cost per year - Million US $ (Excluding ROI but including gas cost of US Cents 50 per 1000 SCF)	1035.00	888.00
6.	Net Profit - Million US $	1199.00	956.00
7.	Value added - Million US $	1893.50	1410.70
8.	Net Revenue per 1000 SCF gas input - US $	6.77	9.31
9.	Net Profit per 1000 SCF gas input - US $	3.63	4.83
10.	Value added per 1000 SCF gas input - US $	5.74	7.12
11.	Return on Investment - (%)	27.31	37.26

Source: Table 5 and Appendix A

Table - 6 shows that the Petrochemical Complex in comparison with the LNG Complex would require lower fixed investment in addition to being less gas-intensive. Whereas, value-added per unit throughput of gas and the return on investment are both considerably higher in the case of the Petrochemical Complex. Return on investment for the Petrochemical Complex is 37% as against 27% for the LNG Complex. Value added per 1000 SCF OF gas throughput in the Petrochemical Complex is US $ 7.12 as against US $ 5.74 for the LNG Complex.

The magnitude of initial investment need in the case of the LNG Complex is US $ 4.4 billion whereas it is only US $ 2.6 billion for the Petrochemical Complex. This huge investment outlay for the LNG Complex involves commercial, technological and political risks that far excced those related to the Petrochemical industries. What is more, those risks are to be borne by small countries with only limited influence on international political and economic events. The commercial risks relative to the LNG Complex arise because the product-mix is heavily skewed towards LNG which accounts for about 77% of the total products while others account only for 23%. The liquefied natural gas, it should be understood, is a very specialised commodity. The consumers of this commodity are mainly in Japan and the USA where there are facilities for receipt, storage and onward use of LNG.

Dependence on a few consumers in a limited number of countries for sale of the products makes the project a difficult undertaking entailing the risks of the exporter being irretrievably bound to certain large buyers. The buyers will have the upper hand throghout the project life with all the characteristic commercial evils of oligopsony markets.

Also, there are the technological risks and uncertainties related to this technology-intensive project of liquefaction. The technology of gas liquefaction and refrigerated transportation to distant market locations is a new one highly succeptible to innovations. There are also worldwide developments such as the use of Methonol as a fuel in the automotive sector which will open up vast avenues for gas-based Methanol industry. The infancy of LNG industry also places grave doubts about the accident - proof nature of the industry itself. This would be much less in petrochemical industries which, by and large, are better stabilized in their processes and safety techniques. These risks and hazards might lead to situations where industry planners tend to tarry the utilization of gas

The political risks that go with LNG projects emanate from the overly nature of reliance of the exporting countries on a few industrially and commercially strong consuming countries, such as the U.S. and its affiliates in the International Energy Agency. The policy-mix of these countries, on balance, is such that they are called upon to exert pressures on the exporting countries so that energy prices for the consuming countries are kept at the lowest possible levels and flow of sufficient energy supply is ensured with little consideration for the national interests of the exporting partners.

The strongest of arguments in favour of setting up of a Petrochemical complex in the countries of this region as opposed to the LNG Complex is that it helps diversify the national product in a manner that reliance on one single activity is discouraged and economically justifiable linkages are encouraged to come into being. Basic petrochemical industries such as Methanol, Ammonia, Ethylene and Natural Gas Liquids make available in an economy primary products on which a host of secondary and derived products could be based, thus creating economy-wide impulses and integrations. There is also ample flexibility for the industrial planning machinery to restrict industrial activities to a select few basic chemicals that could be exported initially while linking industries can be considered at later stages as the entire socio-economic system shows adequate preparedness to build more and more down stream units. This potential for building an essentially self-sustaining industrial base and diversifying the national product is not present in case the country chooses to accept the LNG path for utilising the gas resources.

Last, but not the least in importance, is the opportunity afforded by petrochemical industries to absorb new technologies and to adapt them to individual situations. The absorption of technology takes place both in the form of management art and commercial experience. Gas liquefaction, its technological sophistication notwithstanding, is limited to a single plant employing a specialimplementation of a petrochemical complex a host of technologies relevant to a variety of products focussed on a number of markets world-wide come to interact. This provides a very fertile training ground for local management talents to develop and gain experience. This transition from the age of mere oil exports to manufacture and marketing of petrochemicals is highly desirable for the countries of this region. This, however, is not to say that the road to the complete assimilation of new technologies and absorbing them into the socio-economic system is a smooth walk; but on the other hand, any positive steps to face those realities earlier will be welcome. Establishment of petrochemical industries enables us to take these steps faster.

5. Economic Viability and Social Desirability of the Petrochemical Strategy.

The financial and economic justifications for establishing petrochemical industries as opposed to the LNG Complex are very strong as evident in the foregoing analysis. The policy makers are then concerned with certain questions which centre round the petrochemical complex itself, its techno-economic viability and also its social desirability. These questions are:

(i) Are the estimated capital costs for the above industries real ?

(ii) Do the countries of the region enjoy a relative advantage in the production of those commodities ?

(iii) Do the expected world demand developments justify the establishment of these industries ?

(iv) Does the development process in the Arabian Gulf Countries need sophisticated industries such as these ?

(i) Reality of Average Estimated Capital Costs:

The following table shows average estimated capital investments as calculated in the attached Appendices for different petrochemical industries compared with the actual investments for a number of modern plants in other industrial locations.

Table - 7

Average Capital Investments per MT of Production Capacity

(in US $)

Product	Estimated Cost in Arabian Gulf	Cost outside Arabian Gulf	Arabian Gulf Cost as % of the other
Methanol	367	268 (1)	136
Ammonia	301	224 (2)	114
Ethylene	857	541 (2)	158
Propylene	284	268 (3)	106
Urea	281	209 (2)	134
Formaldehyde	256	252 (4)	102
LDPE	1750	855 (5)	205
Polypropylene	1553	1200 (5)	129
Urea Formaldehyde	160	112 (2)	143

(1) Methanol Plant employing MAUI gas, New Zealand.

(2) Gulf of Mexico (USA)

(3) Cost based on SRI, International estimations.

(4) Montedison, Italy.

(5) Japan

It can be noticed the estimated costs in this analysis exceed the recently realized project costs. However, the differences rest within acceptable limits due to locational disadvantages manifest in the infancy of industrial development, limited infrastructural developments, lack of construction manpower and skills and the like. It should be noted that the commission that goes to a local agent for procurement of plants and machinery is not included in these estimates. A reasonably efficient and professional execution is assumed and any departure from this can alter the situation to the detriment of cost efficiency. Such anomalies of course, can kill a number of viable investment possibilities and may be treated as a social cost caused by Government policy to distribute oil revenues.

(ii) Presence of Competitive Advantage:

On balance, the Arabian Gulf countries are at present endowed with competitive advantages in a number of industries based on petroleum raw materials. These advantages are primarily manifest in the production of basic petrochemicals and intermediaries. Even though initial fixed investments are higher, these disadvangates - often within acceptable limits - are more than off-set by the visible economies in fuel and feed costs. In a recent study conducted by SRI, International for Gulf Organisation for Industrial Consulting (GOIC), it was concluded that the region's cost for a number of petrochemical products is less than in other industrial locations. The following table shows some of the results of the study:

Table - 8

Comparison of Production Costs for some Petrochemical Products (1978)

Cost of Gulf of Mexico, USA : 100

Product	Gulf of Mexico, USA	West Germany	Japan	Al Shu'aiba, Kuwait
Ammonia	100	93	177	50
Urea	100	103	131	72
Ethylene	100	90	76	83
Polyethylene	100	101	106	104
Methanol	100	62	158	44

The Gulf region, as evident from Table - 8, enjoys an absolute advantage in the production of Ammonia, Methanol and relative advantage over West Germany for production of Ethylene. The relative disadvantage noticed in respect of other products can be overcome by better mobilisation of management and technical skills as also by improving industrial infrastructural facilities. This would eventually help a desirable localization of newly established world petrochemical industries around the Gulf region.

(iii) World Demand Prospects for Petrochemical Products:

Petrochemical industry, no doubt, is a growth industry and new vistas are open to its development as time passes. Both market factors and technological factors are responsible for its rapid growth. Petrochemical products have been gaining replacement markets as substitutes for conventional products as well as development markets by generating new enduses for existing and newly developed products. Table - 9 below shows the possible demand in value for petrochemicals.

Table - 9

GROWTH OF WORLD CONSUMPTION VALUE OF PETROCHEMICAL PRODUCTS (IN US $ BILLION PER YEAR)

YEAR	CONSUMPTION VALUE
1970 A.D.	46
1974 A.D.	107
1980 A.D. (estimate)	200
1985 A.D. (expected)	351

Source: Abdulbaqir Al-Nouri - Petrochemical and Fertiliser Industry, The Third Conference on Background of Oil and Gas Industry, Kuwait, 1979.

Table - 10 below gives projected growth involving volumes demanded for selected future years:

Table - 10

(in thousand Metric Tons)

Product	1977	1982	1985	1987	1997
Methanol (Chemical)	7,720	10,117	12,023	13,294	17,697
Ammonia	35,150	58,681	66,584	73,408	91,760
Urea (N)	9,800	14,444	15,166	21,145	30,080
Ethylene	26,800	37,582	43,544	49,527	62,822
Propylene	18,200	-	36,638	-	-
Formaldehyde	3,885	4,578	-	-	-
LDPE	9,965	11,654	-	15,755	20,575
Polypropylene	3,500	-	6,974	-	-

Sources: (1) Chem Systems Study, 1978 for Gulf Organization for Industrial Consulting (GOIC),
(2) UNIDO, First Worldwide Study on the Petrochemical Industries, (1975 - 2000)

The demand pictures for the proposed petrochemical products loom very bright for the coming years as shown in the forecasts presented above. Taking into consideration the desirability of locating new petrochemical plants in the Gulf region, there is adequate scope for over seven Methanol plants of the size proposed herein. Scope also exists for 35 more Ammonia plants and 128 Ethylene plants. While this shows the horizon for a broad - spectrum planning, individual facilities would indeed require detailed project investigation.

(iv) Role of Petrochemical Industries in the Economic Development of Arabian Gulf Countries:

To talk about economic development of the region reminds one of one's distresses and makes one imagine serious economic problems of the future. This is because of the weak productive base of the region and overdependence on the export of crude petroleum. To table - 11 which shows the following feature of the GNP Structure in some countries of the region.

Table - 11

Contribution of Commodity Sectors to Gross National Products (1975)

(as percentages of GNP)

Country	Agriculture %	Extraction Industry %	Manufacturing Industry %	Total %
Iraq	8	64	7	81
Saudi Arabia	1	78	5	88
Kuwait	-	70	5	78
Qatar	-	82	1	85

Source: Industrial Development Centre for Arab States "The Existing Condition of Arab Industry and the Future Conception of Arabian Industrial Development upto 2000 AD" - Paper presented to the Seminar on the future trends of the Arabian Industrial Development upto 2000 AD, Baghdad, April, 1980.

The table shows up the present structural imbalance in the economies of these countries. Lion shares of the national income comes from mining and extraction. Manufacturing and agriculture represent insignificantly small percentages. It is,therefore, highly desirable to embark on investments which would augment the value-adding process in the economies of these countries. This not done, the large cash surplus flowing from the export of the minerals in the primary form will further create problems of imbalance and structural disequilibrium. Petrochemical/based industrial development carries sense as do also energy - intensive industries.

Summary and Conclusions:

The foregoing analysis attempted to look into the option open to the Arabian Gulf countries who are already or potentially will be gas producers and would like to build upon those hydrocarbon resources viable industrial structures. The choice of one from the options is a crucial task as it has longer term development implications. Financial and economic parameters strongly support the choice of the Petrochemical path in preference to the LNG path. To recapitulate, the owner net-revenue-realization for 1000 SCF of gas used in the Petrochemical Complex is expected to be US $ 2.23 whereas it is only US $ 1.27 in the LNG Complex.

Looked at from the view point of the revenue-earning-capacity of natural gas versus crude oil, it is not at all advisable to export the gas reserves for reasons of revenue; it will be much better to use crude oil as a revenue - earner and its present capacity to earn revenue is 5 times as high as that of natural gas. (Government revenue realization from LNG in terms of its barrell of oil equivalent is US $ 7 only compared to US $ 38 per barrell of Crude Oil). The revenue-earner argument which is sometimes advanced is not convincing either. None of the Arabian Gulf countries is in such dire need of financial resources to support their recurring budgets, to say the least.

If at all, then, natural gas is appealing to planners as a productive resource to be employed now, it should be its other economic effects when used as a feedstock for petrochemical industries. Better value - added, higher ROI and greater economic integration are strong points in favour of the Petrochemical Complex. Petroleum being a non-renewable resource, massive and random use of this wealth will only lead to the progressive impoverishment of the countries.

In addition to a number of forward linkages that the Petrochemical Complex affords, the technology transfer and absorption including management and commercial experience can hardly be overemphasised when the Petrochemical based industrial development takes place. This, of course, needs supporting policies which assure the involvement of the nationals of the country concerned in the running of industry.

While the LNG Complex will be in an unenviable position in terms of its market spread - usually a single or few markets - the Petrochemical markets, though competitive, are broad-based and evergrowing.

There is, however, one hard question which may stand in the way of deciding in favour of industrial development in general in the Arabian Gulf Countries. This stems from the need to make available technical skills and management talents for building up of these industries. Will not large scale immigration of labour from other labour-surplus countries involve certain long term social problems which are not always tolerated ? But, there is a way of tackling this issue, viz. minimising disguised and "luxurious" unemployment within these countries particularly in public administration. In these kinds of unemployment situations money is being expended on unproductive human resources. But a proper human resource development strategy can be integrated into the Petrochemical industrial planning thereby ensuring that local skills and talents are systematically activised and made productive. Properly planned and implemented, such an integration can result in the transformation of the presently negative marginal productivity of human resources in some cases to a positive one.

Needless to state, a proper gas resource planning and merging of such a process to the whole fabric of economic development presume policies with vision and imagination. It would also involve short term sacrifices for long term and lasting gains. Without our planning process being premised in a positive will to develop, no matter how rich we are in the physical resource endowments, development will be a slave of our passions.

APPENDICES

A NOTE ON THE APPENDICES

Appendices A to L give the estimated economic indicators for the LNG and Petrochemical Projects based on the non-associated natural gas. The bases for these calculations are the result of the author's own personal investigations developed through contacts with existing plants and facilities and also contacts with various machinery suppliers and plant builders on turn-key basis. Some of the estimations had to be brought up-to-date and for this purpose a deflator of 1.1 has been adopted which fairly well represents the cost-escalating factor relevant to this region. Also, the locational disadvantage for the Gulf region has been built into the estimations. For this purpose the standards established by SRI, International have been largely used. As for current product prices the first quarter 1981 prices have been taken as the basis, except in cases where such prices represented abnormal situations following world political events. For estimations of operating costs, the actual experiences of currently operating plants are taken into consideration. Depreciation, debt-equity ratios, interest charges etc. are taken as per existing project evaluation methods.

APPENDIX - A

ESTIMATED PRODUCTION COST OF A PRODUCT PACKAGE BY LIQUEFACTION OF NATURAL GAS

Basis:

(i) Capacity	:	Liquefaction of around 1000 million SCF of natural gas per day.
(ii) Feedstock	:	Non-associated Natural Gas.
(iii) Investment	:	US$ 4390 million.
(iv) Working Capital	:	US$ 70 million.
(v) Loan Capital	:	The loan element of total capital has been assumed to be 50 percent of the fixed capital at 10 percent annual rate of interest.
(vi) Product Package	:	Est. Total Products 7,684,000 MTY LNG: 5,510,000 MTY Raw NGL: 660,000 MTY Natural Gasoline: 1,440,000 MTY Sulphur: 74,000 MTY
(vii) Product Prices	:	LNG: US$ 299.00 per MT (US$ 5.75 per 1000 SCF) Raw NGL: US$ 220.00 per MT Natural Gasoline: US$ 300.00 per MT Sulphur: US$ 130.00 per MT

ITEM	COST PER YEAR US$ MILLION	COST PER MT US$
A. Feedstock and Fuel	Not Considered	Not considered
B. Operating Cost (8% of fixed costs)	351.00	45.68
C. Depreciation (15 Years)	292.67	38.09
	643.67	83.77
D. Interest Charges		
(i) On term loan ½ of fixed cost at 10% p.a.	219.50	28.57
(ii) On Working Capital at 10% p.a.	7.00	0.91
	226.50	29.48
E. Return on Investment (15%)	658.50	85.70
F. Total Production Cost	1528.67	198.95

Estimated Revenue per year:

LNG (CIF)	:	US$	1647.50 Million
Raw NGL	:	US$	145.20 Million
Natural Gasoline	:	US$	432.00 Million
Sulphur	:	US$	9.60 Million
TOTAL	:	US$	2234.30 Million
Average Product Value per tonne		US$	290.77

Realization of Gas Value:

1.	Product Value per tonne	US$ 290.77
2.	Calculated Product cost per tonne	US$ 198.95
3.	Value Realized per tonne	US$ 91.82
4.	Realization of Gas Value per 1000 SCF (Gross)	US$ 1.77

BASIS FOR THE LNG INVESTMENT COST ESTIMATION.

(i)	Offshore gas production facilities	:	not taken into consideration
(ii)	Submarine pipelines for bringing gas to the production facility fence	:	not taken into consideration
(iii)	Onshore plant and facilities including fleet support facilities	:	U.S. $ 2,085 Million
(iv)	Onshore pipelines	:	U.S. $ 94 Million
(v)	Marine terminals	:	U.S. $ 201 Million
(vi)	LNG Carriers	:	U.S. $ 1,278 Million
			U.S. $ 3,658 Million
(vii)	Add 20% Physical contingencies	:	U.S. $ 732 Million
	Total	:	U.S. $ 4,390 Million

BASIS FOR THE LNG PRICE ASSUMPTION

(i) LNG price has been taken on the average CIF basis for the Japanese market.

(ii) The projects supplying to Japan are taken as:

- Brunei
- Indonesia
- UAE, and
- Alaska (USA).

(iii) Prices assumed for working out the average are prevailing prices as at the beginning of 1981. They are:

	US $ Per million Btu	US $ Per MT
Brunei	5.74	298.50
Indonesia	5.38	279.80
UAE	6.03	313.56
USA	5.86	304.72
Average	5.75	299.15

April, 1981

APPENDIX - B

ESTIMATED PRODUCTION COST FOR CHEMICAL METHANOL

Basis:

(i)	Capacity	:	1 Stream of 2000 MT x 330 days = 660,000 MT per year
(ii)	Feedstock	:	Methane (80 million SCF/day)
(iii)	Fixed Investment	:	US $ 260 million
(iv)	Working Capital	:	US $ 15 million
(v)	Loan Capital	:	The loan element of total capital investment has been assumed to be 50 percent at 10 percent annual rate of interest.
(vi)	Product Price	:	US $ 240.00 per MT

ITEM	COST PER YEAR US $ Million	COST PER TONNE US $
A. Direct Cost		
Feedstock + Fuel	Not Considered	Not Considered
Utilities	1.03	1.56
Labour	0.30	0.45
Other Materials	0.13	0.20
	1.46	2.21
B. Indirect Cost		
Maintenance + Spares	12.10	18.33
Overheads	0.35	0.53
Insurance + Contingencies	2.42	3.67
Depreciation (15 yrs)	17.33	26.26
	32.20	48.79
C. Interest Charges		
On term loan at 10 % of ½ FI	13.00	19.70
Overdraft 10 %	1.50	2.27
	14.50	21.97
D. Return on Investment 15 %	41.25	62.50
E. Total Production Cost	89.41	135.47

Realization of Gas Value

1.	Estimated Product Value per MT	US $ 240.00
2.	Calculated Production Cost per MT	US $ 135.47
3.	Value realized per MT.	US $ 104.53
4.	Realization of Gas Value per 1000 SCF	US $ 2.60

ESTIMATED PRODUCTION COST OF FUEL METHANOL

Basis:

(i)	Capacity	:	2 streams of 2000 MT x 330 days = 1,320,000 MT
(ii)	Feedstock	:	Natural Gas
(iii)	Fixed Investment	:	US $ 484 million
(iv)	Working Capital	:	US $ 27.5 million
(v)	Loan Capital	:	The loan element of total capital investment has been assumed to be 50 percent at 10 percent annual rate of return.
(vi)	Product Package Est.	:	Total Products 1,705,000 MT Fuel Methanol 1,320,000 MT Raw NGL 175,000 MT Natural Gasoline 210,000 MT
(vii)	Product Prices	:	Estimated Fuel Methanol, FOB - $ 225 per MT Raw NGL, FOB - $ 220 per MT Natural Gasoline, FOB - $ 300 per MT

ITEM	COST PER YEAR US $ Million	COST PER TONNE US $
A. Feedstock + Fuel	Not Considered	Not Considered
B. Operating Cost	38.72	22.71
C. Depreciation (15 yrs)	32.30	19.00
	71.02	41.71
D. Interest Charges		
(i) On term loan ½ of F.I. at 10%	24.20	14.20
(ii) Working Capital at 10% per year	2.75	1.60
	26.95	15.80
E. Return on Investment 15%	76.70	45.00
F. Total Production Cost	174.67	102.51

Revenue per year:		
	Fuel Methanol	US $ 297,000,000
	Raw NGL	US $ 38,500,000
	Natural Gasoline	US $ 63,000,000
	Total	US $ 398,500,000

Realization of Gas Value

1. Estimated Product Value per MT : US $ 234.00
2. Calculation Production Cost per MT : US $ 102.51
3. Value Realized per MT : US $ 131.49
4. Realization of Gas Value per 1000 SCF : US $ 3.29

APPENDIX - D

ESTIMATED PRODUCTION COST AND RETURN ON INVESTMENT FOR AMMONIA

Basis:

(i)	Capacity	:	5 streams of 1000 tonnes per day. 5000 x 320 stream days = 1,600,000 tonnes per year
(ii)	Feedstock	:	Methane (192·50 million SCF per day)
(iii)	Investment	:	US $ 482 million
(iv)	Working Capital	:	US $ 26 million
(v)	Loan Capital	:	The loan element of total capital investment has been assumed to be 50% at 10% annual rate of interest.
(vi)	Product Price	:	US $ 190 per MT FOB.

ITEM	COST PER YEAR MILLION US $	COST PER TONNE US $
A. Direct Cost		
Feedstock and Fuel	Not Considered	Not Considered
Utilities	3.05	1.91
Labour	0.63	0.39
Other Materials	1.10	0.69
	4.78	2.99
B. Indirect Cost		
Maintenance + Spares (5 % of F.I.)	24.25	15.16
Overheads	0.75	0.47
Insurance and Contingencies	3.20	2.00
Depreciation (15 Yrs)	32.13	20.09
	60.33	37.72
C. Financial Charges		
On term loan at 10% F.I.	24.25	15.16
Working Capital 10%	2.60	1.63
	26.85	16.79
D. Return on Investment 15%	76.20	47.60
E. Total Production Cost	168.16	105.10

Realization of Gas Volume

1	Estimated Product Value per MT	US $ 190.00
2.	Calculated Production Cost per MT	US $ 105.10
3.	Value Realized per MT over Cost	US $ 84.90
4.	Realization of Gas Value per 1000 SCF	US $ 2.19

APPENDIX - E

ESTIMATED PRODUCTION COST OF A PRODUCT PACKAGE BY FRACTIONATION OF STRIPPED NATURAL GAS

Basis:

(i)	Capacity	:	Fractionation of 110 Million SCF per day of stripped Natural Gas.
(ii)	Investment	:	Estimated US $ 430 million
(iii)	Working Capital	:	Estimated US $ 10 million
(iv)	Loan Capital	:	The loan element of total capital investment has been assumed to be 50 percent at 10 percent annual rate of interest.
(v)	Product Package	:	Total Product - 819,520 MT/Y
			Propane - 156,480 MT/Y
			Butane - 122,240 MT/Y
			Natural Gasoline - 520,800 MT/Y
			Sulphur - 20,000 MT/Y
(vi)	Product Prices Estimated	:	Propane US $ 310.00 per MT
			Butane US $ 300.00 per MT
			Natural Gasoline US $ 300.00 per MT
			Sulphur US $ 130 00 per MT

ITEM	COST PER YEAR MILLION US $	COST PER TONNE US $
A. Feedstock (110 MM SCF/Day) (35200 MM SCF per year)	Not Considered	Not Considered
B. Operating cost 8% of F.I.	34.40	43.03
C. Depreciation (15 yrs)	28.67	35.85
D. Interest Charges	21.60	27.02
E. ROI (15 %)	66.00	82.55
F. Total Production Cost	150.67	188.45

Estimated Revenue:

Propane	US $ 48.509 million
Butane	US $ 36.672 million
Natural Gasoline	US$156.240 million
Sulphur	US $ 2.600 million
	US $ 241.021 million

Average Product Value per tonne US $ 297.76

Realization of Gas Value

1. Estimated Product Value per Tonne US $ 297.76
2. Calculated Cost per Tonne US $ 188.45
3. Value Realized per Tonne over cost US $ 109.31

APPENDIX - F

ESTIMATED PRODUCTION COST OF ETHYLENE

Basis:

(i)	Capacity	:	280,000 MT per year
(ii)	Feedstock	:	Ethane Rich Gas - 57 million SCF/Day
(iii)	Investment	:	US $ 240 million
(iv)	Working Capital	:	US $ 14 million
(v)	Loan Capital	:	The loan element of total capital investment has been assumed to be 50 percent at 10 percent annual rate of interest.
(vi)	Product Price	:	US $ 575 per MT FOB - West Europe

ITEM	COST PER YEAR MILLION US $	COST PER TONNE US $
A. Direct Cost		
Feedstock + Fuel	Not Considered	Not Considered
Utilities	2.80	10.00
Labour	4.90	17.50
Other Materials	1.97	7.04
	9.67	34.54
B. Indirect Cost		
Maintenance + Spares	10.39	37.11
Overheads	5.88	21.00
Insurance etc.	3.66	13.07
Depreciation (15 yrs)	16.00	57.14
	35.93	128.32
C. Interest Charges		
On term loan (10 % on ½ F.I.)	12.00	42.86
10 % on Working Capital	1.40	5.00
	13.40	47.86
D. Return on Investment 15 %	36.00	128.57
E. Total Production Cost	95.00	339.29

Realization of Gas Value

1.	Estimated Product Cost per MT	US $ 575.00
2.	Calculated Cost of Production per MT	US $ 339.29
3.	Value realized per MT	US $ 235.71
4	Realization of Gas Value per 1000 SCF	US $ 3.63

APPENDIX - G

ESTIMATED PRODUCTION COST FOR UREA

Basis:

(i)	Capacity	:	2000 tonnes per day x 320 stream days 640,000 tonnes/year
(ii)	Feedstock	:	Ammonia - 384,000 tonnes/year Carbon dioxide - 493,000 tonnes/year
(iii)	Investment	:	US \$ 180 million
(iv)	Working Capital	:	US \$ 10 million
(v)	Loan Capital	:	The loan element of total capital investment has been assumed to be 50 percent at 10 percent annual rate of interest.
(vi)	Product Price	:	US \$ 250.00 per tonne FOB

ITEM	COST PER YEAR MILLION US \$	COST PER TONNE US \$
A. Direct Cost		
Feedstock	72.96	114.00
Utilities	1.24	1.94
Labour	0.56	0.88
Bags	3.52	5.50
	78.28	122.32
B. Indirect Cost		
Maintenance & Spares (5 % of F.I.)	9.00	14.06
Overheads	0.61	0.96
Insurance + Contingencies (1% of F.I.)	1.80	2.81
Depreciation (15 yrs)	12.00	18.75
	23.41	36.58
C Interest Charges		
On term loan (10 % on ½ F.I.)	9.00	14.06
10 % on working capital	1.00	1.57
	10.00	15.63
D. Total Production Cost	111.69	174.53
E. Total Product Value	160.00	250.00
F. Surplus (E - D)	48.31	75.47
G. Return on Investment .	$\frac{48.31}{180} \times 100 = 26.84\%$	

APPENDIX - II

ESTIMATED PRODUCTION COST FOR PROPYLENE

Basis:

(i)	Capacity	: 90,000 MT per year
(ii)	Feedstock	: Propane - 144,000 MT per year
(iii)	Estimated Investment	: US $ 25.5 million
(iv)	Working Capital	: US $ 5.0 million
(v)	Loan on Capital	: The loan element of the total capital investment has been taken to be 50 percent and interest charges at 10 percent per year
(vi)	Estimated Product Price	: US $ 450 per MT FOB West Europe

ITEM	COST PER YEAR MILLION US $	COST PER TONNE US $
A. Direct Cost		
Feedstock	23.04	256.00
Utilities	0.66	7.33
Labour	0.12	1.33
Other Materials	0.15	1.67
	23.97	266.33
B. Indirect Cost		
Maintenanace + Spares	1.28	14.22
Overheads	0.14	1.56
Insurance etc.	0.26	2.89
Depreciation (15 yrs)	1.70	18.89
	3.38	37.56
C. Interest Charges		
On Term Loan (10 % on 50 percent Investment)	1.28	14.23
Overdraft (10 % on US $ 5.0 million)	0.50	5.55
	1.78	19.78
D. Total Production Cost	29.13	323.67
E. Total Product Value	40.05	450.00
F. Surplus (E - D)	11.37	126.33
G. Return on Investment	$\frac{11.37}{25.5}$ x 100	= 44.59 %

April, 1981

APPENDIX - I

ESTIMATED PRODUCTION COST FOR FORMALDEHYDE

Basis:

(i)	Capacity	:	90,000 tonnes per year
(ii)	Feedstock	:	Methanol - 106,200 MTY
(iii)	Investment	:	US $ 23.0 Million
(iv)	Working Capital	:	US $ 6.0 Million
(v)	Loan Capital	:	The loan element of the total capital investment has been assumed to be 50 percent and interest charges at 10 percent per year.
(vi)	Product Prices	:	Formaldehyde (100 % grade) US $ 427.00 per MT The product to be sold is 37 % grade priced at US $ 158.00 per MT.

ITEM	COST PER YEAR MILLION US $	COST PER TONNE US $
A. Direct Cost		
Feedstock	20.18	224.22
Utilities	0.18	2.00
Labour	0.07	0.78
Other Materials	0.16	1.78
Packaging	0.90	10.00
	21.49	238.78
B. Indirect Cost		
Maintenance + Spares	1.15	12.78
Overheads	0.08	0.89
Insurance & Contingencies	0.23	2.56
Depreciation (15 yrs)	1.54	17.11
	3.00	33.33
C. Interest Charge		
On term loan (10 % on 50 % investment)	1.15	12.78
Overdraft 10 % on $ 6.00 million	0.60	6.66
	1.75	19.44
D. Total Production Cost	26.24	291.55
E. Total Product Value	38.43	427.00
F. Surplus (E - D)	12.19	135.45

G. Return on Investment $\frac{12.19}{23} \times 100 = 53.00\ \%$

APPENDIX - J

ESTIMATED PRODUCTION COST FOR UREA FORMALDEHYDE

Basis:

(i)	Capacity	:	150,000 tonnes per year
(ii)	Feedstock	:	Urea - 85,500 MTY Formaldehyde (37 %) - 69,000 MTY
(iii)	Investment	:	US $ 63.0 Million
(iv)	Working Capital	:	US $ 15.0 Million
(v)	Loan on Capital	:	The loan element of the total capital investment has been assumed to be 50 percent and interest charges at 10 percent per year.
(vi)	Product Price	:	US $ 600.00 per MT FOB Europe.

ITEM	COST PER YEAR MILLION US $	COST PER TONNE US $
A. Direct Cost		
Feedstocks	32.28	215.20
Utilities	0.96	6.40
Labour	0.50	3.33
Other Materials	0.60	4.00
Packaging	2.00	13.33
	36.34	242.26
B. Indirect Cost		
Maintenance + Spares	1.40	9.33
Overheads	0.60	4.00
Insurance & Contingencies	0.24	1.60
Depreciation (15 yrs)	4.20	28.00
	6.44	42.93
C. Interest Charges		
On term loan (10 % on 50 % Investment)	3.15	21.00
Overdraft - 10 % on US $ 15.0 million)	1.50	10.00
	4.65	31.00
D. Total Production Cost	47.43	316.20
E. Total Product Value	90.00	600.00
F Surplus (E - D)	42.56	283.80
G Return on Investment	$\frac{42.56}{63}$ x 100 = 67.70 %	

April, 1981

ESTIMATED PRODUCTION COST FOR LDPE

Basis:

(i)	Capacity	: 140,000 MT per year
(ii)	Feedstock	: Ethylene - 144,200 MT per year
(iii)	Estimated Investment	: US $ 245 million
(iv)	Working Capital	: US $ 18.0 million
(v)	Loan on Capital	: The loan element of the total capital investment has been taken to be 50 percent and interest charges at 10 percent per year.
(vi)	Estimated Product Price	: US $ 1,050 per tonne FOB West Europe.

ITEM	COST PER YEAR MILLION US $	COST PER TONNE US $
A. Direct Costs		
Feedstock	79.31	566.50
Utilities	2.80	20.00
Labour	5.02	35.86
Packaging	2.54	18.14
	89.67	640.50
B. Indirect Costs		
Maintenance + Spares	3.60	25.71
Overheads	0.65	4.61
Insurance + Contingencies	1.80	12.86
Depreciation (15 yrs)	16.33	116.61
	22.38	159.85
C. Interest Charges		
On term loan (10 % on 50 % Investment)	12.25	87.50
Overdraft (10 % on US $ 18 million)	1.80	12.86
	14.05	100.36
D. Total Production Cost	126.10	900.71
E. Total Product Value	147.00	1,050.00
F. Surplus (E - D)	21.00	149.29
G. Return on Investment	8.57 %	

April, 1981

ESTIMATED PRODUCTION COST OF POLYPROPYLENE

Basis:

(i)	Capacity	: 85,000 MT per year
(ii)	Feedstock	: Propylene - 86,700 MTY
(iii)	Estimated Investment	: US $ 132 million
(iv)	Working Capital	: US $ 17.5 million
(v)	Loan on Capital	: The loan element of the total capital investment has been taken to be 50 percent and interest charges at 10 percent per year.
(vi)	Estimated Product Price	: US $ 1,200 MT FOB West Europe

ITEM	COST PER YEAR MILLION US $	COST PER TONNE US $
A. Direct Cost		
Feedstock	39.02	459 06
Utilities	1.98	23.29
Other Materials	0 90	10.59
Labour	0.32	3 76
Packaging	1.54	18.12
	43.76	514.82
B Indirect Cost		
Maintenance + Spares	6.60	77.65
Overheads	0.38	4 47
Insurance etc.	1.32	15.53
Depreciation - 15 yrs	8.80	103.53
	17.10	201 18
C. Interest Charges		
On term loan 10 % on 50 % Investment	6.60	77.65
Overdraft 10 % on US $ 17.5 million	1.75	20.59
	8 35	98.24
D Total Production Cost	69.21	814 24
E. Total Product Value	102.00	1,200.00
F Surplus (E - D)	32.79	385 76

G. Return on Investment $\frac{32.79}{132} \times 100 = 24.84\ \%$

References

1. 'First Worldwide Study on the Petrochemical Industry: 1978 - 2000', United Nations Industrial Development Organization, Vienna, Austria, 16th October, 1978.

2. 'Chemical Construction, Production and Distribution Cost - Methods of Cost Comparison of Chemical Plants in the Arab Gulf Versus Plants in the USA, West Germany and Japan'. SRI Report No. 7544 April 30, 1979.

3. 'Second Worldwide Study on the Fertiliser Industry: 1975 - 2000'. United Nations Industrial Development Organization, Vienna, Austria, 11th September, 1978.

4. 'Petrochemical Marketing Strategies Study', Prepared for Gulf Organization for Industrial Consulting, Chem Systems, May, 1979.

5. 'International Hydrocarbon Processing', Worldwide HPI Construction Box - Score, Section-2, June 1979.

6. 'Ammonia', Fertiliser Science and Technology Volume, edited by A.V. Slack and G. Russel James, Marcel Dekker Inc, New York. 1977.

7. 'European Chemical News', issues from January, 1979 to April, 1981.

8. 'Nitrogen'. 1979 issues, British Sulphur Corporation, London.

9. 'Fertiliser International', issues for 1979, British Sulphur Corporation, London.

10. 'SRI International, Chemical Economics Handbook', 1979.

11. 'Pipeline & Gas Journal', June, 1979, - LNG projects develop overseas, by Dean Hale.

12. 'Gastech', Houston, Texas, 13-16 November, 1979, Conference Papers.

13. 'Oil & Gas Journal', Dec. 18, 1978: LNG Baseload Projects - by T.G. Seay, P.J. Andersen and E.J. Daniels, Institute of Gas Technology, Chicago, USA.

14. 'Downsteam Operations in OPEC member countries - Prospects & Problems' - Background Information, OPEC, Vienna. October 9-11, 1979.

15. 'Project Economic Programme Reports', SRI International 1977.

16. 'OPEC Annual Report', 1978, Vienna, Austria.

17. 'LNG Market: World Survey' Jeffrey Segal, December, 1979.

18. 'Oil Revenues in the Gulf Emirates: Pattern of Allocation and impact on Economic Development', Bowker:Epping, 1978 - Dr. A. K. Al-Kuwari.

19. 'Fertiliser Manual', IFDC/UNIDO, International Fertiliser Development Center, December, 1979.

20. 'Nitrogen', issues 1978 January - 1981 April, British Sulphur Corporation, London.