(before tax) is estimated to be 64%, with 4 million tons of annual production capacity. Even if the capacity utilization declines by 20% (or 80% of capacity utilization in the 3rd year of operation and onwards), the IRR is expected to be 49%.

(2) Suggested supporting measures for the project implementation

1) Development of industrial standards for crushed stone aggregate

The crushed stone aggregate industry often encounters intensive competition based on the construction demand. In particular, the presence of many small companies leads to excessive competition, resulting in the production of low-grade aggregates. On the other hand, it is very important for the industry to maintain a certain quality level required for exports. The consistency in quality is one of the critical factors to effectively compete in export markets. The development of industrial standards covering at least the following three types of crushed stones is highly desirable:

1) Fine aggregate for concrete
2) Coarse aggregate for concrete
3) Crushed stone for road construction

2) Collection of market information

At present, there is little information on crushed stone aggregate demand available in surrounding countries.

3) Consideration of regulatory measures for environmental preservation

Since large-scale quarrying may lead to environmental degradation, regulatory measures should be established at the outset, and made known to the industry. A clearly defined regulatory framework is important for effective environmental preservation as well as for investment promotion.

4.2 Development of New Applications for Locally Available Resources

4.2.1 Gypsum board

4.2.1.1 Project description

Oman has abundant reserves of high-grade gypsum, which are currently used for cement production. The production of gypsum board is the major demand for gypsum besides cement production, in most of the countries in the world (for instance, 4,950,000 tons out of 9,160,000 tons of annual gypsum demand in Japan are used for gypsum board production). This project aims to produce gypsum boards locally.

In Oman and Middle Eastern countries, use of gypsum boards is increasing gradually at present for constructing industrial and high-rise commercial buildings using steel frames, but it is not so popular for housing construction. Gypsum boards have excellent fire resistance as well as high-temperature resistance as insulation materials are inserted between the board and the wall. It likewise improves fire resistance and safety of houses and other buildings, while saving electricity consumption for air-conditioning. All these features, however, have not been so significant in Oman where building owners are not conscious about their energy costs since it is borne by tenants, and where construction of buildings utilizes mostly steel bars.

Since the gypsum board production process includes the baking of natural gypsum ($CaSO_4$-$2H_2O$) into calcium sulfate ($CaSO_4$-$1/2H_2O$), which can be used for production of products applicable to a variety of applications, including plaster, craft works, medical materials, and cast, it is expected to be effective for developing the relevant industries, which would otherwise be hard in being established.

4.2.1.2 Market aspects

As discussed in the previous section, the commercial use of gypsum board in Oman has begun only recently. There are several contractors who use imported gypsum boards mainly for ceiling and interior partition wall finish but this has been largely limited to the construction of public buildings like hospitals, airport buildings, etc. where steel frame is used.

A contractor consumes an estimated 24,000m^2 of gypsum board annually, from which total demand is estimated at around 100,000m^2, assuming that the operation among contractors is placed on the average. Potential demand seems to stand at least 1 million m^2 annually[5] which will be able to support a small-scale factory operation.

However, the expected growth in this demand will be from minimal to none, because building owners in the Middle East including Oman have no incentive to adopt energy saving designs, and buildings do not use little interior materials limiting the use of *gypsum board as partition material.*

The largest demand for gypsum board in GCC is found in Abu Dhabi where a minimum floor number is set by law. For other GCC countries, demand forecasts would

[5] According to official statistics, the number of building permits, approximately 4,000 units (with all the types of buildings being converted to housing units) are constructed annually in the country. Assuming that each housing unit has a floor area of 400m^2 (20m x 20m) and is 10m high (5m x 2 levels), the area covered by ceilings and external walls in each unit totals 1,600m^2. If gypsum board is used for finishing all the houses, total potential demand amounts to 6.4 million m^2 per year

be similar to Oman.

Most of the gypsum boards are imported from Saudi Arabia. Countries outside the region that also supply include, United Kingdom and Thailand, but prices are relatively higher particularly for European sources (cif price of European sourced products is RO.1.2/m^2 while that in Saudi Arabia ranges from RO. 0.84 to RO. 1.075/m^2).

The National Gypsum Co. in Saudi Arabia has an estimated production capacity of 0.6 – 1 million m^2/year. On the other hand, the minimum required production capacity in Japan is 3 million m^2 per month.

4.2.1.3 Technical aspects

The general outline of the gypsum production process is as follows:

(1) Acceptance of raw material: Quality inspection of raw gypsum for acceptance.
(2) Drying: Blowing of hot air (around 100℃) to raw gypsum to remove moisture.
(3) Baking: Baking of dried raw gypsum at 170–180 ℃ for 3–4 hours and produce calcium sulfate.
(4) Crushing: Crushing calcium sulfate in a lump into fine particles.
(5) Mixing: Mixing water and other additives with the calcium sulfate powder.
(6) Forming: Shaping the mixture into a board having a specific thickness and affix paper on both sides.
(7) Hardening: Hardening of the gypsum board on a belt conveyor.
(8) Cutting: Hardening the board into pieces having specific dimensions.
(9) Drying: Removal of moisture remaining in the boards.
(10) Inspection and packaging: Checking dimensions and quality of the boards and package them for shipment.

Construction technology related to the gypsum board plant is mostly owned by manufacturers. A gypsum board maker who wins a contract to build a gypsum board plant procures necessary machinery and equipment from various suppliers, and assembles or install them. For this reason, it is very difficult to estimate the required plant cost without knowing individual equipment costs. Very rough estimates are somewhere between 6 billion and 10 billion yen for a 30 million m^2 plant.

4.2.1.4 Conclusion

There appears to be no prospects for production of gypsum board for a domestic market because of the lack of its application in building construction in the country.

However, the production for export has better possibilities targetting the markets in Southeast Asia and East Asian countries, due to cheaper container freight rates in supplying to these countries.

Since cost estimate for the gypsum board plant is very difficult, as mentioned above, it can be safely said at this moment that the total production cost will be lower than a typical cost of US$1.80/$m^2$ in Western Europe (compared to the market price of US$3.60/$m^2$) given the lower energy and labor costs in Oman. The container freight rate from Oman to Japan is US$900/40ft., and if related expenses of US$123 per container are added, the total transportation cost is US$0.62/$m^2$ (1,650m^2/container). The resultant unit price upon arrival in Japan is US$2.42/$m^2$, compared to the Japanese market price of US$2.5/$m^2$. Thus, if further saving can lower production cost, then local production of gypsum board will become feasible. A further detailed study is recommended in this direction.

4.2.2 Rock Wool

4.2.2.1 Project description

Rock wool is a mineral wool made by melting high-temperature resistant minerals mainly consisting of limestone and silica in a cupola or an electric furnace at 1,500–1,600℃. It is used as a heat/sound insulating material for both buildings and industrial plants, and its use for the former dominates in markets in industrialized countries.

In Oman, the use of rock wool started in building construction, side by side with the increased use of gypsum board. Also, its potential use extends to industrial facilities and equipment that require heat insulation, such as oil refineries and petrochemical plants.

Oman has sizable reserves of rocks suitable for rock wool making, and the project proposes production of rock wool for local consumption and the export market using these available rock resources.

4.2.2.2 Market aspects

As in the case of gypsum board, the use of rock wool for building construction started only recently in Oman. Several contractors appear to use rock wool as a construction material. One company consumes 1,000–1,500m^2/year of rock wool for walls and ceilings of industrial plants and office buildings, which is equivalent to 2.5 tons per year, and the total demand does not exceed 100 tons annually for construction purposes[6]. Its demand for industrial use was rather minimal even at the time new construction of industrial projects were carried out. Other Middle East countries utilize rock wool mainly for industrial purposes.

Potential domestic demand for construction materials is estimated at around 10,000 tons annually[7], if the use of rock wool is encouraged extensively for energy saving. However, this demand may be hampered with the increasing disconcern over the need to raise energy efficiency in buildings on the argument that energy costs are anyway paid by tenants. In addition, there is a degree of preference in the use of polystyrene as an insulating material due to its cheaper costs and easier handling by workers. Workers prefer the use of polystyrene because rock wool pricks during handling, requiring it to be conveniently packed in plastic bags in most countries for ease in handling.

Six rock wool plants are currently operating in the Middle East region showing signs of a rather competitive environment. There are three plants located in Pakistan while there is one each in Fujairah, Saudi Arabia and Jordan. The very substantial share of freight cost to a total rock wool value is placed at about 35 to 40 percent indicating that a viable market may be limited to the neighboring plant areas. In Fujairah alone, transportation costs is about DH 2,000 to DH3,000 per container while the cost of production is placed only at DH12,000 to DH15,000 per container.

Further, in industrialized countries, rock wool is mostly substituted by iron slag wool produced as a wastage of iron production, and this is already a highly competitive market to penetrate. Thus, the project should be complemented by stimulating domestic demand, rather than solely tapping export markets.

4.2.2.3 Technical aspects

(1) Raw material Availability

The most promising raw rock deposits are dolerite found in Rusayl. These deposits are of sufficiently high grade and can be mined and transported economically.

(2) Production technology and equipment

Major operations requiring capital investment are summarized as follows;

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6) The import of slag wool, rock wool and similar mineral wools (HS Code 68-06-1000) in the Sultanate was 666 tons in 1992 and 20 tons in 1991.

7) See demand projection method of gypsum board.

1) Acceptance of raw material: Accepting and storing raw rock.
2) Melting: Mixing the raw rock with coke heated and melt the mixture in a cupola at approximately 1,500℃.
3) Wool making: Spouting the melted mixture through a nozzle in a fabric form, by means of centrifugal force or jet stream.
4) Collection: Catching and collecting rock wool coming out of the wool making process in a collection chamber.

The proposed plant will not need the following processes which are usually incorporated in rock wool plants in industrialized countries, because rock wool in Oman is mostly used in its raw wool form:

1) Curing: Bonding wool filaments by using synthetic resin as a binder, and shaping them into rock wool.
2) Cutting: Cutting the formed rock wool into pieces having specified dimensions.
3) Packaging: Packaging rock wool products for transportation and use.

The minimum economic size of rock wool production is estimated at about 7,000 tons/year. A representative example is the rock wool plant in Fujairah in which the production capacity is 28,000 tons per year, consisting of four lines of 7,000 tons per year.

According to an estimate made in 1994 for a rockwool production project in a Southeastern country, the required investment cost for the plant with production capacity of 3,000 tons per year was 600 million yen, including 30,000 m^2 of land acquisition costs.

4.2.2.4 Conclusions

The rock wool production becomes a venturable activity only on the basis of its demand as an insulation material for building construction in Middle East countries where industrial accumulation remains to be low, and where demand for industrial use fluctuates yearly depending on the availability of plant construction projects. The capacity utilization rate varies significantly in the Fujairah plant for example, to a high 65% to 75% during peak seasons, to as low as 40% on lean years like what has been experienced in 1985 and 1986. Thus, given the current conditions, a rock wool project targetting domestic market and neighboring countries, will hardly be viable.

In the future perspective however, should a new regulation on standards be instituted, especially those pertaining to the use of building materials that are fire resistant and energy saving, the project's viability should be assessed again.

Nevertheless, it would be worthwhile to study more in detail the promotion of the project targetting export market particulary Southeastern countries. The markets are located favorably in view of container freight rates to the market from Oman, and their current supply sources are mainly West European countries. The expected major demand is from industrial use for such plants as oil refinery, petrochemicals, and power generation, etc., manufacturing factories of home appliances and electronics component parts, and high rising building; construction of these plants, factories and buildings are significantly growing due to upward trend of economy in the region in recent years.

4.2.3 Chrome ore for refractory bricks and indefinitely shaped refractories

4.2.3.1 Project description

Refractory bricks are non-metal substance which have resistance to high temperature of over 1,500℃, and are used in a variety of industrial furnaces, including blast furnaces, converters, electrical furnaces, cement rotary kilns, glass melting furnaces, as well as pottery kilns and solid waste incinerators. Indefinitely-shaped refractories are similar to refractory bricks in material and use, but are made from powder or paste form applied to surfaces of kilns and other similar structures forming a specific shape.

Raw materials for refractory bricks and indefinitely-shaped refractories include non-metal minerals such as alumina, chrome, and magnesia. Chrome refractories using chrome ore are classified as a neutral refractory with high temperature resistance, and a low level of reactivity with silica refractories and magnesia refractories. Also, when combined with magnesia clinker, chrome ore makes basic chrome-magnesite bricks which can overcome the limitations arising from the use of chrome bricks such as, burning, shrinkage and spalling.

Oman has reserves of chrome ore of over 2 million tons in total. However, deposits are not geographically concentrated, and the size is mostly limited to a few thousand tons. Globally, the existence of chrome resources dominates in South Africa and the former Soviet Union. South America produces more than 4 million tons annually. Since Oman lacks international competitiveness in chrome production due to a relatively small scale of production, it is currently exporting chrome ore suitable for steelmaking. Unsuitable ore is usually disposed.

The project is designed to use the currently disposed chrome ore as a raw material for refractory production. Meanwhile, many small deposits found throughout the country can be strip mined without special equipment. Chrome ore from these deposits is not suitable though for steelmaking, but can be used for refractory production. Generally, chrome ore in Oman has high alumina content and relatively low silica content, making it a very suitable refractory material.

Today, refractories are made from diverse materials with wide range of shapes and fitting according to purpose. This include bricks, tiles, powder and granular forms for coating. In many cases, refractory bricks or indefinitely-shaped refractories are custom-designed by contractors who themselves build or repair furnaces or kilns according to specific operating requirements and conditions. For this reason, export of final products is not very common, except in the case where local production is difficult.

Manufacturing processes involved in the production of refractory bricks and indefinitely-shaped refractories consist of crushing raw minerals into specific grain sizes, mixing of minerals in a desired proportion depending on the performance requirements of each furnace, and forming the mixture into bricks and other shapes. In Oman, industries requiring refractory structures are growing in number and size, including copper smelting, cement production, thermal power generation, oil refining and petrochemical production. Refractories used by these industrial plants wear-out over the years requiring replacement on a periodical basis (for instance, refractories for cement kilns are replaced once a year), so that a constant demand can be expected. Another favorable factor worth mentioning is the presence of deposits of other refractory materials, including quartz sand and dolomite. Given all these conditions, a practical strategy in developing the refractory industry with a small domestic market like Oman is to start from the production of refractory materials and target large export markets, rather than aiming highly-customized final products in terms of material mix and design.

Once refractory materials are locally produced, existing brick works can be mobilized to produce refractory bricks and indefinitely-shaped refractories demanded by local industries. This may be the first step of establishing the refractory industry capable of meeting domestic demand.

4.2.3.2 Market aspects

As a general tendency, durability of refractories has increased significantly with the advancement of production technologies by user industries, and the demand for improved quality required of refractory products. This has resulted in steady declines of refractory requirements per product unit. At the same time, the production of indefinitely shaped refractories have been increasing, accounting for over 40% of total refractory production.

Japan exports refractory bricks and indefinitely shaped refractories mainly to Southeast Asia, at around 100,000 tons and 60,000 tons per year, respectively (including refractories made of materials other than chromite). Note that Japan imports minimal amount of refractories, while refractory materials are imported in large quantities.

Japan considers shifting domestic production of refractory outside and importing from there. This action will be taken to meet the request of its major customer, the steel industry. China has been considered as a site where production base can be shifted.

Theoretically, based on cement production and refractory demand in the country, and demand for refractories in industrialized countries, the demand in Oman is estimated at 800 tons and expected to grow by 2,000 tons in the future.

However, in actual practice, users in Oman are small in size and exchanges of bricks in their furnaces are seldom done. Even in case of exchanging bricks, they contract the maintenance job outside the company which procures goods from foreign sources. In this sense, the demand will not meet the production size.

4.2.3.3 Technical aspects

The refractory production process consists of: 1) crushing, 2) mixing, 3) forming, 4) drying, 5) baking, and 6) inspection, packaging, and shipping. The project is primarily comrised of two processes, these being; 1) crushing, and 2) inspection, packaging, and shipping.

4.2.3.4 Conclusions

It is difficult to expect enough demand size for production, this project seems to be unfeasible.

4.2.4 Natural gas based industries

4.2.4.1 Project description

Oil and natural gas are vital but limited resources in Oman, thus, development of industries utilizing these resources must be carefully examined, if the goal is to attain higher value-added, efficiency in use and other economic effects consequential to industrial development.

At present, an overwhelming part of crude oil produced in Oman is exported, except for some portions being refined to petroleum products at the existing refinery for domestic consumption. The current exports of crude oil will continue despite the absence of increases in domestic consumption because there are no plans of building a new refinery, or expand the existing refinery in the coming few years.

The current domestic sales of natural gas is approximately 70,000 MMSCF per annum. This gas is supplied to power plants and other industrial consumers for fueling purposes through the existing gas supply system called the Government Gas System (GGS) or the GGS gas, as it is called.

There is a petrochemical project which is being studied by the Ministry of Industry and Commerce. It involves the set-up of a petrochemical complex which will produce ethylene and its derivatives from ethane, propane and butane, and all these can be extracted from the GGS gas. The final products to be produced in the complex will be polyethylene and polypropylene which are typical plastic resins being widely consumed in the world. Because the domestic demand for these products are small, this project will be mainly geared for exports.

Aside from this petrochemical project, there are two gas-based projects that are still under study by the Ministry of Petroleum and Minerals, both entailing the use of natural gas that in turn will be produced in large volume with the development of the large non-associated gas reserves discovered in the interior regions. These projects are enumerated below:

1) LNG project which will produce a large quantity of LNG for exports. This project shall consist of setting-up a giant LNG complex and the construction of a trunk gas pipeline system from gas fields to the LNG plant site.

2) Project for manufacturing ammonia/urea fertilizer and/or chemical methanol by using a part of natural gas supplied for the LNG project.

It is a common practice for a large volume of natural gas to be exported in the form of

LNG under a long-term contract with committed importers. Therefore, the development of new gas reserves will depend on the implementation of the LNG project which will process a substantial amount of gas produced from the new gas fields that will be developed. Hence, the LNG project will be pursued as a main component of the new gas reserve development cognizant of the government's policy outlook for the energy sector which is beyond the scope of this study.

The manufacturing of ammonia/urea fertilizer and chemical methanol is a typical part of the hydrocarbon chemical industry for which natural gas, particularly methane being the main component of the gas, is used as feedstock. Since Oman has little demand for urea fertilizer and chemical methanol, ammonia/urea and methanol projects must be developed for exports.

The ammonia/urea fertilizer and methanol projects, as well as the petrochemical project are among the significant programs that will boost the basic chemical industry. This industry which utilizes natural gas resource in Oman will possibly bring about substantial growth of industrial output and non-oil exports. In this respect, the feasibility of developing these industries may be assessed with a preliminary review of export markets and cost competitiveness of producing in Oman.

However, since feasibility studies on these specific projects are conducted by relevant authorities, the assessment in this study will comprise of examining the basic framework and direction to consider the development of these industries in Oman.

4.2.4.2 Market aspects

(1) World Market

Since the domestic demand for petrochemical products, particularly polyethylene and polypropylene as well as urea and methanol are very small, their production should be mainly geared for exports.

Overview of the international supply and demand trends on petrochemical products as well as urea and chemical methanol are presented in Chapter 6. This overview indicates export possibilities of those products from Oman as follows:

(1) Polyethylene and polypropylene

The world consumption of polyethylene combining LDPE (low density polyethylene, LLDPE (linear low density polyethylene) and HDPE (high density polyethylene) amounts to 31.1 million tons in 1992, in which about 10 million tons or 32% are met by imports. EEC is the largest importer with 4.8 million tons, followed by Asia importing 2.3 million tons.

The world consumption of polypropylene amounts to 13.6 million tons in 1992, in which 4.2 million tons or 31% are met by imports. Similar to polyethylene, EEC is the largest importer with 2.1 million tons followed by Asia importing 1.3 million tons.

It is forecasted that the world consumption of these products will increase to 38.6 million tons for polyethylene, and 17.2 million tons for polypropylene in 1997 and further to 46.9 million tons and 21.2 million tons, respectively by 2002. Likewise, import requirements for these products will increase accordingly.

This large size of import requirements for polyethylene and polypropylene will provide export opportunities for Oman. However, it is likely that an over supply condition will result, as production capacities rise, inducing keen competition among exporters in the international markets.

In view of this future outlook, possible exports of petrochemical products from Oman would depend largely on how Oman can produce those products at competitive costs, enabling it to sustain competitive pressures offered by other exporters in the international markets.

(2) Urea fertilizer

The Indian Subcontinent, especially India is a large consumer of nitrogen fertilizer, particularly urea. Demand forecasts in this region will reach 12.5 million tons, with a 2 million ton supply shortage. India accounts for more than two-thirds of the regional demand, requiring remaining importation of nearly 2 million tons to be served. If Oman can produce urea at internationally competitive costs, there is a great possibility for Oman to export it to India.

(3) Chemical methanol

The world consumption of chemical methanol shows conspicuous growth boosted with the increasing production of MTBE in recent years. In 1992 the world consumption of methanol reached 20.9 million tons, in which 8.4 million tons or 40% are met by imports. Despite a continuing growth in demand, the international market remains to be experiencing a short supply, and it is likely that this tight supply condition will continue with further increases in demand. Methanol is an internationally traded commodity. As a market outlook, Oman may embark in the production of chemical methanol for exports, provided that it can be produce at internationally competitive costs.

4.2.4.3 Assessment of production costs

Assuming that ethylene derivatives represented by polyethylene (HDPE and LLDPE), urea fertilizer and chemical methanol are to be produced in Oman, competitiveness in terms of production costs must be assessed.

There are four main factors which substantially affect production costs. These are:

1) Production capacity of plants;
2) Capital costs for plants;
3) Costs for feedstock; and
4) Capacity utilization in operation.

Process technologies in manufacturing these products are consecutive-flow-type which are characterized in production economics as being sensitive to the "economies of scale". Innovation of modern process technologies has enlarged the production capacities of manufacturing plants in these industries. Nowadays, plants at international standards have at least attained the following capacities:

1) Ethylene plant: 300,000 tons/year (1,000 t.p.d.)
2) Ammonia/urea plant: 560,000 tons/year of urea (1,000 t.p.d. of ammonia and 1,700 t.p.d. of urea)
3) Methanol plant: 500,000 tons/year (1,500 t.p.d.)

Tables A4-6 to 10 show the production costs for ethylene, HDPE, LLDPE, urea fertilizer and chemical methanol which are estimated on the assumption that these are produced at plants of international standards. The given costs include 10% ROI (Return on Investment), and take the following assumptions:

1) Value of ethane to be fed for ethylene production: US$2.00/MMBTU
2) Value of natural gas to be fed for the production of ammonia/urea and methanol: US$1.50/MMBTU
3) Operation at 100% capacity utilization

Tables A4-11 to 14 show changes in the estimated costs affected by changes in value of ethane and natural gas, and also in capacity utilization rates, which are also illustrated with graphs in Figure A4-1 to 4.

Tables A4-15 and 16 and Figure A4-5 and 6 show the past trends of international prices of ethylene, HDPE, LLDPE, urea fertilizer and chemical methanol.

Cost competitiveness for the production of these products in Oman is assessed with reference to estimated production costs, and international price trends given above.

(1) Ethylene derivatives (HDPE and LLDPE)

The estimated production costs for HDPE and LLDPE, typical ethylene derivatives, are given in Table A4-12, at US$755.65 per ton for HDPE and US$708.11 for LLDPE including, 10% ROI and assuming the feed of ethane valued at US$2.00/MMBTU, and an operating capacity utilization rate of 90%.

The international prices of these products, as given in Table A4-15 and Figure A4-5, were maintained at stable prices in the range of US$948 and US$1,014 per ton for HDPE; and a range of US$882 and US$959 per ton for LLDPE up to 1987. These values fell to a range of US$660 and US$700 per ton for HDPE, and the range of US$610 and US$680 per ton for LLDPE in 1992 and 1993, after a rise to a level averaging over US$1,100 per ton for both in four years from 1988 to 1991.

The economic recession in the industrialized economies depressed demand growth, while supply capacity has increased either through plant expansion or operation of new ones in recent years. With this market condition, current international prices followed a downward trend.

It is predicted that the prices will rise to some extent in the coming few years with a fair increase in demand, as industrialized economies recover from the economic recession leading to further demand growth. On the other hand, however, it is foreseen that competition among exporters becomes more intense as export production increases.

Given the future outlook, Oman should seek a plant gate cost level, including ROI of US$750 per ton for HDPE and US$700 per ton for LLDPE. This level of production costs could be realized assuming ethane is supplied at US$2.00/MMBTU or lower, and if the plant is operated at a capacity utilization of not lower than 90% on the average. In order to realize this supply cost for ethane, natural gas to be fed for extracting ethane, propane and butane must be supplied at a price not higher than US$1.50/MMBTU since ethane extraction cost is estimated as US$0.4 to 0.5/MMBTU. Lean gas remaining after extraction which accounts for about 76% of gross volume of natural gas fed, can be supplied to GGS gas consumers at the current commercial gas prices.

(2) Urea fertilizer

The production cost estimate, as given in Table A4-13, indicates that with the price of natural gas assumed at US$ 1.50 MMBTU, and a capacity utilization rate of 90%, the yield is US$169 per ton of urea in bulk at a plant gate cost including 10% ROI.

The past trends of export prices (FOB) of bagged urea from the Middle East show sharp fall from US$160 per ton in 1991 to US$115 per ton in 1993. Although the prices tends to rise in 1994, it is foreseen that the future export price will not be higher than US$120 per ton of bagged urea, or US$110 per ton of bulk urea. Assuming this future outlook for export prices of urea is realized, it would seem difficult for Oman to produce urea for exports to international markets, even if the price of natural gas is supplied at an excessively low price.

However, the production at US$160 per ton of bulk urea for the Indian market would still be attractive because domestic production costs in India are still much higher, not to mention the substantially lower transportation costs because of its relative proximity to Oman. If natural gas is supplied at US$1.00/MMBTU, it would be possible to attain the production cost level earlier mentioned.

(3) Chemical methanol

The estimated production cost for chemical methanol, as given in Table 4-13, shows a level of US$124 per ton at a plant gate cost, including 10% ROI and assuming the supply of natural gas at US$1.50/MMBTU, and operating at 90% capacity utilization rate.

The import prices of chemical methanol in EEC range between US$105 to US$115 per ton at cif prices, during a four year period from 1989 to 1992. But in 1993 there was a sharp rise to cif US$150 per ton reflecting the tight supply prevailing in the global market. Since this tight supply condition is likely to continue in the coming few years, the current prices will remain for the time being. However, in order to sustain international competitiveness, the production cost should not be higher than US$110 per ton. This price range can be realized if natural gas is supplied at a price not higher than US$1.00/MMBTU.

4.2.4.4 Considerations required for project development

As discussed in the previous sections, there are possibilities for Oman to develop 1) an olefin petrochemical complex to produce ethylene derivatives, particularly polyethylene for exports based on ethane, propane and butane extracted from the GGS gas, and also 2) an ammonia/urea fertilizer complex to produce urea fertilizer for export to India, and 3) a chemical methanol plant to produce chemical methanol for exports by using a part of natural gas which will be supplied for LNG when LNG project is set up along with the development of new non-associated gas reserves. Enumerated below are considerations required for the development of these projects.

(1) Pricing policy for natural gas to be supplied

1) Gas price for the olefin petrochemical complex

The estimated production costs clearly indicate that natural gas supplied to the proposed olefin petrochemical complex needs to be at a lower level than the current domestic price. More specifically, the proposed olefin petrochemical complex may be feasible if extraction of ethane, propane and butane components of the GGS gas is priced not higher than US$1.50/MMBTU for input to the extraction unit, especially during the initial five years. It is lower by about US$0.58/MMBTU or about 28% compared to the current price of GGS gas priced at US$2.08 per 1,000 SCF (equivalent to 1 MMBTU). As the volume of ethane, propane and butane to be used for an annual production of 300,000 tons of ethylene amounts to approximately 16.84 trillion BTU which accounts for about 24% of gross gas volume, the reduction of gas price for the petrochemical complex by US$0.58/MMBTU may result in reducing the annual revenue of GGS gas by about US$9.8 million or about 7% of total GGS gas revenue. On the other hand, however, a 300,000 t.p.a olefin petrochemical complex is expected to generate about US$150 million of value-added including, a 10% return on investment as well as about US$200 million of foreign exchange earnings annually. Hence it will contribute to substantial increases in the sectoral value-added in the manufacturing industry sector and non-oil exports.

2) Gas price for ammonia/urea and methanol projects

The estimated production costs for ammonia/urea and methanol projects imply a possibility for Oman to develop an ammonia/urea project for exports to India and also a chemical methanol project, if natural gas could be supplied at US$1.00/MMBTU.

Assuming the production scale of urea and chemical methanol at 560,000 tons/annum and 500,000 tons/annum respectively, an annual requirement for natural gas is estimated as 11.37 billion SCF for the ammonia/urea project and 17.5 billion SCF for the methanol project, totaling 28.87 billion SCF. As this volume of natural gas is not available from the existing gas sources, these projects can be developed only when the new gas reserves are developed for the LNG project.

The LNG project, assuming the production at 6 million tons per year, will require approximately 288 billion SCF of natural gas per annum. The gas requirement for ammonia/urea and methanol projects, as shown above, is about one-tenth of that for LNG. If a new gas supply system is set up for the LNG project, the gas can be supplied to the ammonia/urea and methanol projects at a low price since almost all of the capital costs for gas transmission can be recovered, as gas is supplied for the LNG project. The ammonia/urea and methanol projects are expected to generate value-added including 10% return on investment at US$69 million for urea, and US$58 million for methanol, and foreign exchange earnings of US$80 million for urea and US$45 million for methanol annually. Hence these projects will also contribute to increases in the industrial value-added and non-oil exports.

(2) Securing the export market

Petrochemicals, urea and methanol are international commodities for exports. Although there is an implication that Oman can produce these products for exports at competitive costs if the natural gas is supplied at a concessively set price. However, the international market prices for these products are subject to fluctuation.

For instance, the price of urea varies greatly to reflect various factors, especially weather conditions in major food production areas. Price fluctuation is also amplified by the fact that international trade of urea is mostly done through competitive tender by suppliers. Unsold products have to be disposed on the spot market at discount. In other words, the success in the international market depends upon whether the exporting country can secure long-term contracts, which would assure stable exports in terms of quantity and price. For many importing countries, stable supply in terms of delivery, quantity, and price is also important for food production.

India, as reviewed earlier, stands as a sizable potential market for Oman, which in turn can offer various locational advantages assuring stable supply. First of all, Oman is situated outside the Gulf and is thus not directly affected by the smoldering regional conflict that is a matter of concern for the world community. Also, the country offers a shorter distance of transportation to India, compared to other GCCs. Therefore, the establishment of a long-term relationship with India seems to be a major strategic option for Oman to secure export markets for its products.

In case of petrochemicals and methanol, it is crucial to establish an international marketing network, although India will be a potential export market for Omani exports to some extent. Hence it would be of vital importance to develop these projects with involvement of foreign partners who have international marketing networks as well as technical capabilities for the management of petrochemical industries.

(3) Other requirements

These complexes need to be supported with various relevant infrastructure. In many countries including neighboring GCC countries, those projects have been developed with government's support for the development of relevant infrastructure. It would be required for the government to take such considerations for the development of these projects in Oman.

4.2.5 Production of copper materials

4.2.5.1 Project description

Copper is mostly used to produce electric wires and cables used for communication lines, motors, and electrical equipment (in Japan, this application accounts for 70% of total demand).

The next largest application is rolled copper (which accounts for 30% of total demand in Japan). Copper or copper alloy (including brass (copper/zinc alloy), bronze (copper/tin alloy), and nickel silver) is rolled and extruded to produce sheets, pipes, and bars. Rolled copper products are widely used for power distribution equipment, motors, radio/TV components and parts, lighting apparatuses, as well as components and parts for automotive engines and radiators, metal hardware, household goods, and construction materials and building hardware.

Other applications include copper castings and coins, which are very small in volume compared to the foregoing two.

Electric wires and cables, and rolled copper products are produced from semi-processed materials (intermediate products), such as unprocessed copper wires.

Oman smelts locally-produced copper ore; produces and exports 99.99% grade electrolytic copper. The smelting operation constitute a production capacity of 20,000 tons per year. However, Oman does not produce processing materials for the manufacture of copper products, so these have been imported.

The project is designed: 1) to produce processing materials for copper products production thereby creating value added in producing electrolytic copper, and; 2) to supply copper product industries with copper materials at low prices.

4.2.5.2 Market aspects

Table A4-17 shows recent trends in Oman's copper material imports, which have grown rapidly, particularly copper wires. Imports of copper wires for production of electric wires and cables amount to an estimated 1,200 tons, accounting for a major portion of the domestic demand.

The domestic demand is expected to expand in the near future especially with the production expansion of Oman Cable, from a present annual consumption of 250 to 300 tons, to as much as 2,000 tons for Oman Cable alone.

There are several cable manufacturers in GCC countries. Among them, Saudi Cable has a copper smelter while the remaining notable ones largely resort to importations of copper rods for their raw material.

Dubai imports approximately 16,000 tons of copper materials annually[8]. This may be attributed to a project of Emirates Cable in the production of wire. From this project alone, an annual requirement of 12,000 tons is needed.

However, there is a project that caters to the production of copper rods in Dubai, namely, Emirates Copper. Oman will supply this entirely. Dubai Cable may benefit from this project as it plans to purchase from Emirates Copper about 8,000 tons of copper rods for its total yearly requirement of 15,000 tons.

Given the continued development of power distribution and communication networks in the country, copper wire demand will grow rapidly in the future. As a result, the demand in Oman and neighboring countries will reach to an optimum that can economically justify local production of copper wire.

In the Middle East, electric wire is produced in Iran, Iraq, and Dubai (one company).

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[8] Between the import volume of copper wire in 1991 and 1992, there is a significant difference.

4.2.5.3 Technical aspects

The smallest shop producing copper wire in Japan has a production capacity of 3 tons/hour, which is translated to approximately 24,000 tons (per year assuming 24-hour operation for 330 days). On the other hand, the current copper smelting capacity in Oman is 20,000 tons per year which is less than Japan's capacity, indicating the rather limited size of plant operations that can be set up.

One serious obstacle though is the depletion of copper deposits currently mined resulting to its abandonment in the future.

4.2.5.4 Conclusions

Saudi Arabia is currently studying a copper smelting project in cooperation with India. The project is designed to smelt copper in Saudi Arabia where electricity cost is relatively low, and export smelted copper to India where electrolytic copper is costly due to a high electricity cost. If the project materializes, the copper smelting operation will be larger than that in Oman, and becomes the first to be started in the Middle East. Nevertheless, even without the realization of this project, an additional copper rod production seems to be not viable in the region mainly because of market saturation and depletion of the resource.

4.2.6 Pet food production

4.2.6.1 Project description

Fishery production in Oman is characterized by a high rate of loss after catch. Because fishery products are all exported, strict quality standards are applied to selection of suitable products.

The project attempts to re-use and process these wastes into products for exports.

4.2.6.2 Market aspects

Pet food, particularly those for dogs and cats which constitute a sizable market, is estimated to satisfy 60-80% of calorie requirements for these animals in the US and Europe. In Japan, the percentage is 32% for dogs and 40% for cats, which are expected to reach the levels in the US and Europe.

Pet food is roughly divided into wet type and dry type. In Japan, foreign pet food companies import both types of products from their parent companies (mainly the US). Domestic suppliers produce the dry type locally by themselves or by their subsidiaries and import the wet type. This reflects the fact that the dry type requires a relatively large production capacity to enjoy economy of scale, which is estimated at around 5 billion yen. While some supplier produce the wet type by domestic canners, most of them enter in a contract with foreign makers. In the Japanese market where price competition is fierce, cost reduction is critical for pet food makers who are actively pursuing opportunity for overseas production.

The Japanese pet food market and export/import data are summarized in Table A4–18. Of the market size of 500,000 tons annually, the wet type for cats which mainly uses fish amounts to approximately 90,000 tons, of which 70,000 tons are imported. Major pet food consuming countries are the US, Canada, Western Europe, and Japan. Recently, consumption grows rapidly in Hong Kong and Taiwan (Table A4–19).

Major exporting countries are major beef producers such as the US and Australia, and Thailand which produces fish–based products. Major importers are Japan and Canada. In particular, Japan is the largest importer of fish–based pet food, followed by the US and Australia.

4.2.6.3 Technical aspects

The most adequate fish as raw materials for pet food may be small size sardine due to its quantity, and ease in the mode of fish catch.

The largest fish catch in Oman is that of tuna and sardine. Tuna is caught and then, exported by foreign fishing boats; transported to the neighboring countries; or subject to canning. The tuna used for canning is priced lowest among them at US$ 1,000 to 1,200/ton.

The sardine is classified into small sized and large sized. The large sized sardine is exported as frozen, while the small sized is used as camel feed, fertilizer, or simply abandoned. The purchase price from fishermen is RO. 0.1/kg for the large sized sardine, while RO. 0.25/kg for the large sized for frozen.

4.2.6.4 Conclusion

Judging from the sales price, the small sized sardine is worth further studying as an export pet food. The dried small sized sardine is sold at RO. 3.3/kg in Japanese market, and export would be viable even if taking into account the cost for packaging and transportation.

However, 1) since the scale of fish catch is small in Oman, collection system of caught sardine to fulfill the volume required is necessary, 2) provision of trading functions to respond to small scale transaction with foreign buyers is necessary, and, 3) the technology acquisition of drying method without reducing the value sardine is necessary.

In the Japanese pet food market, a large number of makers have previously competed intensively for market share. Today, many of them including a few leading suppliers have withdrawn from the market, but fierce competition still continues, and price competition is expected in the years to come. At supermarkets and pet shops, makers are competing to secure a space for their products. In addition to pricing, product diversification and differentiation through the use of different materials, nutrients, seasoning, and packaging hold the key to the success in the market. Also, advertising is an important element of marketing effort. Thus, if Oman is to make a success in pet food export business, technical cooperation with foreign makers having established sales routes will be essential.

4.3 Promotion of Import Substitution

4.3.1 Glass bottles

4.3.1.1 Project description

Oman's imports of glass bottles have reached 18,000 tons annually[9], which is close to the level suitable for local production. In addition, results of a mineral resource survey indicate that Oman has deposits of quartz sand used as a primary material for glass production.

The project is designed to achieve two objectives: 1) to produce glass bottles that are otherwise imported in large quantities, by using locally available resources, and ; 2) to export to neighboring countries.

Local production of glass bottles may also serve to contribute to resource conservation and environmental protection. Pending the adoption of an appropriate disposal and proper collection system for recycling, the use of glass bottles, being a renewable resource is desirable, especially if local production is feasible.

4.3.1.2 Market aspects

There appears to be sufficient domestic demand for glass bottles, as carbonated drinks gain popularity. While exact demand estimates are not available, information obtained from the beverage industry placed it within the range of 120 to 130 million bottles annually, at the low end, to a high 200 million bottles.

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9) In 1992.

Possibilities for further demand growth are hinged on two factors. First, is the continued popularity of carbonated drinks in bottles than in cans, and second, the thrust among beverage companies to shift from canned drink production to bottled drinks. On the other hand, the mineral water market is far from utilizing glass bottles because of the existence of PET bottle plant operations. Notwithstanding this, Oman remains to have sufficient domestic demand to justify local production of glass bottles.

At present, all glass bottles used in beverage production are imported. Among the major country sources are Saudi Arabia and Turkey. Recently, imports from India have been increasing due to a very low price offered. Information has also been gathered regarding an ongoing construction of one glass bottle plant in the UAE. In the future, a very stiff competition is likely to be experienced with India, as earlier cited. India is able to produce at a very cheap FOB price of US$ 2.9 per case of 24 bottles compared to US import price between US$89 to 90 per case.

4.3.1.3 Technical aspects

The manufacturing process of glass bottles may be divided into the following steps:

(1) Mixing of raw materials: Glass is a mixture of silica acid (SiO_2) and sodium, calcium, and various metal oxides. Thus, the glass manufacturing process starts from preparing and mixing minerals and chemical products containing these constituents. A typical example of material mix for glass bottle is as follows:

Quartz sand	100
Sodium carbonate (soda ash)	20
Sodium sulfate (salt cake)	17
Limestone	28
Feldspar	15

Basic requirements for these raw materials include purity and grain size distribution, e.g., grain sizes of 0.5 – 2.0mm are desirable to account for more than 80% of quartz sand. In addition, cullet, i.e. cleaned and crushed used glass, also consist the mixture up to 70% of total. Such is also being imported.

(2) Melting: After mixing the above materials, the mixture is then placed in a furnace lined with refractories for heating and melting. The furnace is heated to 1,200℃ – 1,400℃, with the heat source usually being petroleum or gas.

(3) Forming: The molten mixture from the furnace are then poured into molds, and blown with air for final shaping. At present, the process is mostly done by automated equipment.

(4) Annealing: The shaped bottles are subjected to heat of 600℃ and then cooled down to room temperature for over 2 hours, in order to remove strain generated in the forming process.

(5) Inspection: Checking the produced bottles for shape, dimensions, weight, strength, and others. Again, the automatic tester is widely used.

4.3.1.4 Conclusions

The primary requirement for the project is the presence of enough demand to support local production. If the country can capture the domestic market and secure neighboring markets, there will be an opportunity to sustain local production on an economic scale.

The replacement of plastic bottles which are increasingly used as drink bottles in the country will create another potential market for glass bottles. However, the possibility for them to convert to glass bottle is very small since all the mineral water bottlers have their own PET bottle manufacturing plants.

4.3.2 Production of building hardware, electrical components and parts

4.3.2.1 Project description

The project proposes local production of building hardware, and general electrical components and parts for household and industrial uses, including small electrical equipment. The manufacturing process consists of plastic molding, metalworking, and assembly. In industrialized countries, these products are generally mass produced on separate, customized lines. In the countries which have small markets with diverse demand, general purpose processes such as casting, die casting, pressing, welding, and machining are combined to carry out flexible production.

The project aims at fostering microenterprises which have specialized in different processes, and have the ability to meet diverse demand by developing interdependent and cooperative production activities, instead of the current practice where a single company manufactures various products all by itself.

Since quality requirements for building hardware and electrical components vary greatly, the effort should start from those which do not require a high level of precision. Needless to say, mass production of low grade products is not the final objective of the project. Rather it aims to establish small-scale horizontal integration. It will give opportunity for microenterprises to improve their levels of technology in individual processes they specialize in. Then, they gradually move to high quality products. While an immediate target is set for import substitution, the long-term objective is to foster the industry which can be operated on a relatively small scale, and whose operations can easily be diversified into other products and components. Thus, the industry will become a seed for developing support industries such as machine elements.

4.3.2.2 Market aspects

At present, there is no company manufacturing small electrical equipment and components in the country. As for building hardware, non-standardized and highly customized products, such as fences, interior fixtures, and window frames, are produced locally, but general hardware which is suitable for standardization production is mostly imported because of scale of economy.

4.3.2.3 Conclusion

This type of project requires various kinds of working processes. In the case of Oman, there are no existing companies to be utilized for this purpose, requiring all processes to be newly established. The process necessary should be small enough to meet the requirement of small sized but diversified product processing. If the project is formulated to fulfill such requirements, a significant support from the government will be necessary for them to be independently operational. Thus, it is recommended to nurture this type of projects in the future after a certain level of industrial accumulation is attained.

In such case, support for cooperative production by micro enterprises will be advised.

Production of building hardware, and electrical components and parts involves a number of manufacturing processes. By organizing manufacturers who have different and complementary processes which can subcontract part of their work to each other, cooperative and flexible production activity becomes possible. This may take the form of an industrial park or a cooperative where certain products or components are produced through manufacturing processes run by different enterprises. In this arrangement, each enterprise is expected to satisfy certain levels of quality and specification, and the establishment of industrial standards will be effective in promoting the move.

However, such support by the government should be undertaken after the market and technological level is matured so that the industry will be able to sustain its growth by themselves with these initial support.

4.3.3 Metalworking corporation

4.3.3.1 Project description

1) Imports, storage, and marketing of steel and other basic materials

At present, large users (although quantity consumed is relatively small) import basic materials directly, and small users course it through importers. Collective imports through the corporation will contribute to significant cost reduction.

2) General processing services, including cutting, pressing, and heat treatment

To reduce the capital cost incurred by metalworking users which perform all the required metal working processes for imported materials, the corporation will instead undertake these basic metal working processes while providing subcontracting work on a per contract basis.

3) Testing services

To conduct standard tests for raw materials and products on a contract basis.

As generally seen in the GCCs, most of industrial development efforts face the following difficulties: 1) the lack of related industries and heavy reliance on foreign sources for supply of raw materials, components, parts, and services, and ; 2) the shortage of engineers and skilled workers which necessitate the hiring of foreign personnel.

General materials and standard parts (including those found in the export market) can be obtained in the local market, but prices are higher. However, those requiring special processing or treatment are either purchased at very high prices or are being replaced with standard products affecting the competitive value of these items .

The difficulty in hiring skilled workers poses a bottleneck to technology transfer and accumulation of technological resources. These factors make manufacturing projects in the GCCs unattractive for investment, unless special measures (such as protection of domestic industries) are taken.

The project aims to address these issues and improve cost competitiveness of the machinery and metalworking industry through cost reduction efforts. Also, the proposed project eliminates the need for manufacturing processes such as the preparation of basic materials, and; facilitatation of planning and implementation of other projects aimed at producing machinery and metalworking products. Finally, the above services will serve as an opportunity to train local engineers and skilled workers.

Many industrialized countries and newly industrializing countries have successfully achieved the industrialization process by nurturing basic industries, particularly the steel industry, under the government's initiative. However, Oman's small market size makes commercial steel production infeasible, so industrial development efforts on a much smaller scale is recommended.

4.3.3.2 Market aspects

Basically, the project will serve targeted users in the country. It is difficult to secure access to the UAE market since metalworking companies are reportedly operated in Dubai. Nevertheless, there may be processes that are not covered by these companies, which will provide as a potential market for the project.

4.3.3.3 Technical aspects

There are quite a number of workshop-type metalworking establishments in Oman, mostly small-scale or micro in size. The types of work they engage in include related activities as automotive parts repairing and small metalworking jobs that make use of general-purpose type of metalworking machines. Examples of these machines are lathes, boring mills, surface grinders, etc. These establishments are commonly found in a colony where workers are primarily foreign expatriates. Some of these workshops have the capacity to handle more complex jobs, whenever available.

The large manufacturers like PDO, ORC and OMCO own their machine shops but the remaining few only have the basic metal working machines at the minimum in their respective machine shops. This has concentrated the type of work done in these shops to regular maintenance jobs. Shutdown maintenance on the other hand, is contracted out on a turn-key basis. It is becoming a trend for large scale manufacturers to contract out metalworking jobs, even the regular maintenance. In most machine shops, workers are predominantly expatriates except in PDO which employs Omani workers that have gained significant years of working experience in the job. The workers' ages range between 45 to 50 years old. Recently, PDO has stopped recruiting workers for its machine shops as most of the jobs are contracted out.

There also exist metalworking contractors aside from the workshop-type metalworking establishments cited earlier. These contractors meanwhile, engage in jobs related to the oil and building construction sector. Since the demand for these sectors are also rather limited, contractors mainly do iron and steel fabrication with machining jobs being minor. Nevertheless, while most machining works can already be undertaken in Oman, the scope of work are rather focused due to constraints in demand. There are varying degrees in terms of quality between these contractors but it is reported that at least one performs at international standards.

Furthermore, stamping and iron casting factories do not exist in the country because of the absence of any demand.

4.3.3.4 Conclusions

(1) Project Viability

No amount of promotion to upgrade the metalworking sub-sector would be effective because of the limited demand both in Oman and in neighboring countries. This poses as a limiting factor for the public sector to develop the skills of Omani workers.

Likewise, owing to the meager demand, operation of iron and steel stockist business could be ideal but transporting iron and steel in bulk appears to be not cost-effective. In addition, there would be adverse competition on this type of operation with existing stockist based in Dubai. Because the role of iron and steel stockist to the development of metal-related industries could not be underestimated, its promotion must be linked to similar measures undertaken for the user industries.

Special attention must also be sought to improve the metalworking skills of Omani workers as this is a critical determinant of technological accumulation. Once achieved, this may pave the way for the self-creation of merging businesses that would be of great support to the metal-related industries.

Efforts must be focused in the Middle Eastern region because of its relatively weak metal working sector that has a potential to attract assembling industries like automotive parts and electrical product industries.

(2) Project Requirements for Implementation

Foreseeing the future development of metal-related industries, the government must institute other measures that will improve the operation of small/micro-sized metalworking workshops. These measures include: instituting a calibration system and disseminating its importance among users; establishing common facilities equipped with advanced machineries to be used by workshops, and adopting a system of time rental services with technological guidance for use, and lastly; instill the philosophy of quality control within the management engaged in metalworking business.

4.4 Promotion of Export Industries Capitalizing on Locational Advantages of Oman

4.4.1 Export-oriented food industry

4.4.1.1 Project description

This project is aimed at importing raw materials in bulk, which require only simple processing to produce end products, process or repack them into small package for distribution, and re-export . The main objectives of this type of projects are to induce foreign investment making most of the locational advantage resulting to, 1) cheaper freight rate of sea container to Southeast, and 2) favorable investment climate in Oman providing means to overcome difficulty of investments found in India , and contribute to the promotion of industrial accumulation in this country.

The required conditions for promoting this type of project include improvement of port facilities suitable for handling sea container in volume, and institutional improvement, including establishment of free zone, adequate for re-export business.

The following analyzes the projects of puffed cereal snack production and repacking of pharmaceutical products as examples for this type of projects.

(1) Puffed cereal snack food

1) Introduction

In the GCCs, many foreign workers, particularly those from Southwest Asian countries consume large amounts of processed food products that are mostly imported from India and neighboring countries. Thus, they form an appreciable market within the GCCs. In fact, the market area expands to the east coast of Africa where many Indian people are living.

On the other hand, the food processing industry in India faces a problem of outdated plants and equipment, and their products are not highly competitive in terms of quality and packaging. The lack of financial resources and high import duties on machinery and materials prevent them from modernizing their production facilities and improving product quality. Nevertheless, they still hold competitive edges in production technology and know-how, marketing knowledge (particularly consumer taste), and access to export markets.

The project is designed to foster the food industry in cooperation with experienced manufacturers or exporters in India. It will produce and supply a variety of processed food products primarily to Southwest Asian nationals in the east coast of Africa, Southwest Asia, and the GCCs.

Food products to be produced should be selected in consideration of the potential market size, potential Indian partners and their accessible market. As an example of potential project, the puffed cereal snack industry will be studied.

2) Market aspects

The product puffed cereal is a rather new product in India. The product or its variations have been in existence in the western countries and also in Japan. Kellogg's in the US is a renowned manufacturer of puffed cereals from wheat.

In India similar products are available in the market today. There are other similar "fun" snack foods available in market today, major ones among them corn flips and corn curls. As a product, puffed cereal as a "fun" snack could face competition from other products like roasted groundnut, potato chips, cashew, popcorn and so on, which also satisfy the same basic need as a ready-to-eat snack food. These products are largely processed and dispensed in the unorganized sector usually in low quality packaging or no packaging at all in unbranded form. Thus, these products are usually catering to the lower and the lower middle income class of the population.

If the product is marketed as a breakfast cereal, it would face competition from other breakfast cereals in the market today, mainly corn flakes. However, puffed cereal would be a premium product and will be catering largely to the upper income segment.

It is expected that about 75% of the output would be a marketed as a ready-to-eat snack food and 25% as a breakfast cereal, though the ratio varies depending on the market situation. To differentiate one product from the other, slight modifications in formulation and different brand names are suggested.

The market for puffed cereal would largely be in the urban areas. The promising segments for the snack food would be the upper middle class and upper income groups whereas that for the breakfast cereal would be the upper income group, and hotels.

Trade statistics are the most widely used source for general market study but do not provide information much needed for detailed analysis. Such information includes the accurate market size including the distribution stage, consumer taste trends, and consumer reactions to price and quality differentials, and can only be obtained through specially designed market research.

Note that instant noodles and cup noodles that are popular among Asian people are imported in large quantities from Singapore, Malaysia, and the Philippines. Also, a Japanese company plans to build a manufacturing plant in Saudi Arabia in order to supply instant noodle products to the Middle East market.

(2) Repacking of Pharmaceutical Products

1) Introduction

Foreign investment in pharmaceuticals is the most extensive of any segment of the chemicals industry due to the differentiation of markets and varying national regulations and standards for pharmaceutical products. It is estimated that foreign direct investment accounts for twice the value of pharmaceuticals products which enter into international trade. Most large pharmaceutical firms maintain production or assembly facilities wherever there are markets; multinational operations have helped pharmaceutical firms overcome obstacles to exports and recover high R&D costs.

The project aims to attract subsidiary operations of major pharmaceutical companies to Oman, which will serve as an international marketing strategy to establish production bases in the Middle East.

2) Market analysis

The world pharmaceuticals market is estimated at US$17.7 billion (as of 1988, according to OECD's estimate). Multinationals based in the US and Europe command a large share in the world market, while Japanese companies have started to make their way to overseas markets only recently. By country, the US is the largest producer (US$41.3 billion), followed by Japan (US$27.8 billion). Production in Western Europe amounts to US$46 billion.

The pharmaceutical sector in the industrialized countries tends to be more highly concentrated than overall chemical industry. World concentration levels are increasing in individual product markets with growing merger and acquisition activity among the large drug companies. The pharmaceuticals sector is comprised of a relatively small group of large multinational companies heavily involved in research and development and a few thousand smaller companies producing mostly generic and over-the-counter products.

Oman imports RO. 20 million (US$58 million) of pharmaceutical products (as of 1992). When combined with other GCCs, the region is expected to form a sizable market. (Note that there are a wide range of pharmaceutical products, and market study should be conducted for each type or field)

Efforts to establish the pharmaceuticals industry in the GCCs are not well known[10]. Saudi Arabia has established SPIMACO and looks for partners in industrialized countries.

4.4.1.2 Conclusion

(1) Snack food production

Feasibility of this type of projects is high with the estimated IRR being as high as 44%, though due consideration is necessary on the following points.

The variable costs of this project account for 87% of total direct manufacturing costs, indicating possibility of small size operation without being affected by a scale of economies. Packaging material cost accounts for around 75% of the variable costs, and therefore, whether the packaging materials are available at lower cost or not, it remains the key factor for viability of this project (if the packaging material cost is reduced by 20%, the IRR will increase to 63%).

The above analysis is based on the price for export to Southeast Asian markets. If the project assumes the export to Indian market, the price is necessary to be reduced. If the sales price is reduced by 20%, the IRR is estimated to decline to 17% Therefore, the project will be difficult to be materialized if the target market of India, making it more appropriate to target the Southeast Asian countries and Australia as its major export markets. Thus, the project is required to use quality packaging material.

The freight rate of sea container significantly influences sales prices, and eventually the viability of the project. The effect of change in labor costs and tax incentives will not be significant compared to the freight rate.

(2) Repacking of pharmaceutical products

Direct investment by foreign pharmaceutical makers is a prerequisite to the implementation of the project. To attract such investment, Oman has to conduct effective promotional activities and develop investment climate suitable for

[10] There is a joint project called Acdima (Arab Company for Drug Industries and Medical Appliances) among the Arab nations to establish pharmaceutical companies. Under this project, the Acdima is to establish J/V for pharmaceuticals production with the member countries, with the Acdima taking charge of marketing in other member countries. In 1986, Gulf Pharmaceutical Company was firstly established in UAE, but no detailed information is available after that.

pharmaceutical investment. The details will be studied on the specific local condition of Oman in the third field survey.

Pharmaceutical products are relatively free from local constraint because of high unit price per weight enough to cover transportation cost.

The pharmaceuticals industry possesses advanced levels of technology and quality control. Attraction of pharmaceutical plants and facilities to Oman, therefore, is a good starting point in establishing its position as a regional R&D and high-tech center in the field.

High quality standards are one of advantages Oman can offer to attract pharmaceutical companies. Another important factor which the pharmaceutical companies considers in siting their operation is the presence of a patent system acceptable to the international community, which demonstrates that the country protects their patent assets.

A detailed market study is required. Also, finding a good partner is important for the success of the project.

4.4.2 Upgrading of export-oriented apparel industry

4.4.2.1 Project description

The apparel industry is one of the major non-oil export industries developed in Oman, and thus sound growth of this industry is vital for the nation's economic growth.

In Oman there are 29 registered companies which are engaged in apparel manufacturing for exports, which comprise 24 companies specialized for ready-made garments and 5 companies for knitwear.

Ready-made garment manufacturers produce a variety of garments for exports using imported woven fabrics based on designs and patterns provided by foreign buyers. These are mostly low value-added products to be exported for low or middle-class consumer markets. The knitwear manufacturers make knitwear from imported knitted fabrics such as low-grade underwear or low-priced T-shirts for exports. All of these factories are comparatively small in production scale.

Apparel production is labor–intensive, and therefore labor costs in this industry account for a relatively large portion of production costs with the majority of the production costs accounted by material costs. Hence, cost competitiveness of apparel industry is relatively sensitive to labor costs. In Oman, cost structure of apparel industry broadly indicates 70/30 for material costs and processing costs including overhead. Labor costs still account for around 65% of the processing cost or 20% of total production costs.

The apparel industry in Oman incurs comparatively higher labor costs because of employing expatriate workers. The wages and associated expenses paid for these workers average around US$250 to US$300 per worker per month. It is double compared to the labor cost in Thailand and Malaysia and more than threefold compared to that in Southwest Asian countries, although real cost differentials should be smaller than the given figures because majority of expatriate workers employed in Oman are highly skilled and productive.

Venturing in the Omani apparel industry, on the other hand, poses several advantages, as fiscal incentives are provided by the government, low–cost finance; deregulated government procedures for import and export; and other business conditions. All these compensate to some extent, the disadvantages brought about by high labor costs. Nevertheless, the apparel industry faces difficulty in the export of apparels due to competitive pressures arising from exports of other countries with low labor costs. Given the existence of competition with exports from the countries with low labor costs, that low–value apparels exported by Oman are still significantly affected by differentials in labor costs.

In order for Omani apparel industry to sustain its operation, it is crucial to strengthen international competitiveness of the industry by upgrading productivity and quality with technology – intensive mechanized operation as well as diversifying products to include higher value–added items. With these objectives, the following two projects are sought for promotion:

(a) Common Service Project (CSP) for pattern grading, marking and cloth cutting for export garments
(b) High–grade knitwear manufacturing project for exports

(1) Common Service Project (CSP) for pattern grading, marking and cloth cutting for export garments

This project aims to set up a common service unit that will provide garment factories with computerized pattern grading and marking for diverse designs and; computerized cloth cutting.

Preproject will require the following equipment:

1) Computerized apparel pattern grading and marking machine (based on "CAD" system): 1 set
2) Computerized automatic cloth cutting machine (based on "CAM" system): 1 set

As these machines require relatively large investments, it is not feasible for individual apparel manufacturers to have these machines for own use. It is proposed to set up a common service unit through a joint investment by apparel manufacturers.

In strengthening export competitiveness and sustainability, as mentioned earlier, the Omani apparel manufacturers should undertake appropriate steps in upgrading product quality, as well as in diversifying products toward higher value-added items.

Toward this end, one essential step is to upgrade precision of pattern and cloth cutting. The Omani manufacturers carry out pattern grading, marking and cloth cutting by manual operation in a conventional manner. This way seems economical for making low-grade apparels in which buyers do not require high-standard of precision in term of uniformity in shapes and sizes. However, for upgrading quality especially in producing higher value-added items, the grading and marking of precision patterns and standardized cloth cutting are essential. The foregoing computerized machines can perform such precision work.

For making higher value-added apparels, it is necessary to develop more complicated patterns in a variety of sizes, and this work will increase because diversification toward higher value-added items require a shift to the production of a wide variety of products in each small-quantity lot. The computerized system can well satisfy this requirement. Another benefit from this system is to achieve optimum cutting to minimize cutting loss.

(2) High-grade knitwear manufacturing project

The existing knitwear manufacturers, as mentioned earlier, produce low-grade, low-price knitwear for exports by using imported knitted fabrics. In order to produce higher value-added knitwear, the knitwear manufacturers should likewise produce a variety of knitted fabrics so as to meet specifications of knitwear that will be finally produced.

Innovation has substantially advanced knitting technologies, and nowadays modern computerized knitting machines can produce a variety of high quality knitted fabrics in a mechanized system but in a relatively small production scale. There are two types of product lines as emmlrated below:

a) Manufacturing of high-value T-shirts and sports wear made from high quality single jersey or rib knitted fabrics that are produced through computer-control circular knitting machines.
b) Manufacturing of high-value cotton sweaters made from knitted fabrics in a variety of designs by using computer-control flat knitting machines.

In order to produce high-grade knitwear, it is also essential to set up a modern dying factory which can make a variety of high quality dying of yarns and clothes, because high value items require a variety of colored yarns and clothes to meet specifications of knitwear to be produced. The dying factory can be built for servicing several knitwear manufacturing factories which individually undertake knitting and stitching in making knitwear.

4.4.2.2 Market aspects

In 1992, the EC imported 49.4 billion ECUs (US$61.8 billion) of apparel and related products, far exceeding US importation of US$26.7 billion. Moreover, imports from other EC countries accounted for 55% of total. Major importers in other areas (1989 figures) are Turkey (US$2.1 billion), Morocco (US$900 million), Tunisia (US$800 million), India (US$1 billion), China (US$1.4 billion), Hong Kong (US$3 billion), and South Korea (US$1.4 billion). The major exporter in the Middle East is Israel (US$250 million).

By item, jersey, pullover, and trousers account for major portions, and grow in both volume and value. Men's shirts are gradually on the rise. On the other hand, imports of skirts and suits remain flat.

Major knitwear products cover a variety of types, including sports and leisure as well as fashionable wear, and underwear. Portugal and Greece have manufactured knitwear on a contract basis in the EC, but they are losing competitiveness partly because of the rise in labor cost, and because manufacturers in these countries have outdated machinery. The similar situation is observed in another major producer, Turkey. As a result, an increasing number of knitwear suppliers are shifting knitting contracts to other countries. This provides a major opportunity for Oman's knitwear industry to enter the EC market.

In view of these situations, the Omani apparel manufacturers have opportunities to enter into EC markets both for ready-made garments and knitwear if products are diversified towards higher value-added items, and if marketing activities are strengthened.

4.4.2.3 Conclusion

To promote the proposed projects, efforts for efficient use of machines are needed in the following areas:

(1) Employment and training of appropriate personnel to meet advanced technologies

The proposed projects involve modern computerized operation. Hence, it is important to employ and train engineers and operators who can efficiently carry out the operation of such modern machines.

Recruiting and education of designers and other professionals are also important, but will be promoted as a next step.

(2) Total quality control and process control

The increased complexity in the manufacturing process entails improvements in overall quality control and production management, in addition to control of product quality, which would contribute to the enhancement of productivity and the minimization of waste and loss. Particularly important are efforts of production managers and engineers to establish and maintain a production system capable of producing a variety of high quality products in small quantities.

(3) Procurement of raw materials

To import raw materials and accessories needed in producing high- grade products in a timely and economical manner, experienced staff workers will play a critical role. Also, financial resources are important to maintain a wide range of materials as inventory.

(4) Support by the government authorities and industrial association

It would be helpful if the government authorities and industrial association can provide support in the following areas:

1) Training of Omani engineers and operators to meet the foregoing requirement
2) Standardization of production control and quality control systems to meet demand for small lot orders with quick delivery
3) Collection of market information
4) Promotion of joint efforts or integration among apparel manufacturers

4.4.3 Export-oriented wood furniture industry

4.4.3.1 Project description

The furniture industry in Oman consists of small enterprises who manufacture custom-made furniture, and large furniture makers/interior contractors. The latter has the ability to produce high-grade furniture. The project is designed to promote the export furniture industry by providing assistance to major furniture makers in obtaining additional expertise, in making furniture competitive in export markets.

4.4.3.2 Market aspects

Furniture imports by Oman are very small on a value basis. Local furniture makers are already operating in the GCC market as interior contractors.

The value of furniture imports in the world exceeds US$14 billion annually. Major importers are the US and Western Europe. Japan's imports amount to US$460 million, which is not very large in the world market. However, the country's imports have grown rapidly at an annual 27% - 30% in recent years to reflect the increases in overseas production, and imports due to the rise in labor cost and the shortage of wood materials in Japan. In particular, high quality hardwood is difficult to obtain in the country, and a supplier of hardwood furniture is in a good position to sell them into the Japanese market.

4.4.3.3 Conclusion

Oman can procure hardwood materials from neighboring countries and Africa. If these materials can be processed by existing technologies and equipment to make high-grade furniture or its components, Japan is a prospective market for Oman's furniture makers.

At present, however, they procure wood materials from Southeast Asia. Obviously, the use of these materials does not give competitiveness to Oman companies.

Table A4-1 Export of Gypsum by Destination

Destination	Source:	Australia	Thailand	Morocco	Mexico		Toal
	Year:	1991/2	1992	1985	1992		
	Unit:	'000ton	'000ton(*1)	'000ton	'000ton(*2)	'000dollars	'000ton(*)
Total		160.7	5,845.2	140.4	5,183.1	13,920.0	11,329.4
USA		11.0			3,837.8	10,307.0	3,848.8
Japan		26.0	3,326.4	20.0	450.9	1,211.0	3,823.3
Taiwan			666.2				666.2
Malaysia			516.0				516.0
Etyopia					306.1	822.0	306.1
Indonesia			304.6				304.6
Korea Rep.			278.5				278.5
Colombia					162.7	437.0	162.7
Hong Kong			131.0				131.0
Ecuador					125.5	337.0	125.5
Singapore			122.3				122.3
New Zealand		97.2	20.5		0.0		117.7
Philippine			105.3				105.3
Kuwait			40.0				40.0
Sri Lanka			24.0				24.0
Others		26.5	310.5	120.4	300.1	806.0	757.5

Notes:(*1) Export to Japan was 14,544,201 tons according to the statistics of Thailand, while import of Japan from Thailand was 3,326,400tons. The figure for Japan was revised accordingly, whereas those for other countries are used as it is.

(*2) No data is available for the quantity. These figures are estimated on the basis of the imported quantity of gypsum to Japan from Mexico in 1992(450,916tons, or 1,291,556 Yen (US$ 10,188).

- Australia: 25201000 (Gypsum; anhydrite)
- Mexico: 25.20.10 (Yeso natural; anhidrita)
- Morocco: 25.20.10 (Gypse et Anhydrite)
- Thailand: 2520.100-105 (Gypsum)

Table A4-2 Supply and Demand Situation of Gypsum in Japan

(Unit: '000 ton)

	1980			1985			1990		
	Natural Gypsum	Chemical Gypsum	Total	Natural Gypsum	Chemical Gypsum	Total	Natural Gypsum	Chemical Gypsum	Total
Import	33 (1)	20 (2)	53	305	148	453	3,633	55	3,688
Production	0 (2)	6,105 (2)	6,105 (2)	0	5,888	5,888	0	5,466	5,466
Total	33	6,125	6,158	305	6,036	6,341	3,633	5,521	9,154
Consumption									
Cement production	0 (3)	2,638 (3)	2,705 (4)	22	2,551	2,347	824	2,094	2,860
Gypsum board/plaster			2,489 (4)			3,153			4,905
Others			719 (4)			552			658
Total			5,913			6,052			8,423

Sources: (1) Import Statistics, Ministry of Treasury
(2) Gypsum Industry Group
(3) Cement Statistical Yearbook
(4) MITI

Table A4-3 Export of Marble in Italy, 1992

	Marble		Total
	Crude	Dressed	
	2515.11	*2515.12*	
Australia	1.0		1.0
France		14.8	14.8
Greece			
Hong Kong			
Japan	34.5	12.7	47.2
Saudi Arabia	2.4		2.4
Spain	14.3	48.0	62.3
Switzld			
Tunisia	20.2		20.2
U King			
U.S.A.		8.9	8.9
Total	72.4	84.4	156.8

Source: Trade Statistics of Italy

Table A4-4 Import of Marble in Japan

(Unit: ton)

	1990	1992
Italy	92,044	88,371
Spain	17,453	15,281
Greece	7,925	6,728
Taiwan	7,833	6,808
Philippines	6,855	6,248
Others	20,921	17,352
Total	153,031	140,788

Note: Total of CCCN2515.11-010, 2515.12-010, 6802.91-011, 6802.91-019
Source: Japan Exports & Imports, Japan Tariff Asociation

Table A4-6 Estimated Production Cost at a New Plant

-Product: Ethylene-
(Assuming 100% Capacity Utilization)
-Production capacity: 300,000 tons/year
-Estimated plant cost: US$ 260 million

Cost Items	Consumption (per ton of product)	Unit Price (US$)	Production Cost		Remarks
			Annual Cost (US$'000)	Unit Cost (US$'000)	
I Variable Cost					
1.1 Feedstock (Ethane)	1,243 kg	0.09/kg	33,561	111.87	Net calorific value: 45.16 MMBTU/ton C2 Ethane cost: US$ 2.00/MMBTU
1.2 Byproduct credit			▲12,351	▲41.17	
- Fuel gas	4,052 x 10^3kcal	7.94/MMKcal	▲9,651	▲32.17	Valued at US$ 2.00/MMBTU
- Pyrolysis gasoline	78.5 kg	114.6/ton	▲2,700	▲9.00	
1.3 Utilities			11,940	39.80	
- Cooling water (make-up)	11.5 m^3	15.7/1,000m^3	54	0.18	5% of 229 m^3/ton
- Process water	1.9 m^3	210.0/1,000m^3	120	0.40	
- Electric power	18 kwh	34.0/1,000kwh	183	0.61	
- Inert gas (nitrogen)	5.9 Nm^3	17.0/1,000 Nm^3	30	0.10	
- Fuel gas	4,850x10^3kcal	7.94/MMkcal	11,553	38.51	US$ 2.00/MMBTU
1.4 Variable Cost-Total			33,150	110.50	
II Fixed Operating Cost					
2.1 Maintenance Cost			5,200	17.33	2% of US$ 260 mill.
2.2 Direct Labor Cost			2,700	9.00	@US$ 30,000/year x 90 persons
2.3 Fixed Operating Cost-Total			7,900	26.33	
III Direct Operating Cost (I+II)			41,050	136.83	
IV Overhead Cost					
4.1 Plant overhead & administrative exp.			4,050	13.50	150% of Direct Labor Cost
4.2 Depreciation			17,333	57.77	15 yrs straight line depreciation of US$ 260 mill.
4.3 Interest on Loans			7,280	24.27	Interest at 8% p.a. on 1/2 of 70% of US$ 260 mill.
4.4 Overhead Cost-Total			28,663	95.54	
V Total Production Cost (III+IV)			69,713	232.37	
VI ROI (10%)			26,000	86.67	10% of US$ 260 mill.
VII Plant Gate Cost with ROI			195,713	319.04	

Table A4-7 Estimated Production Cost at a New Plant

–Product: High Density Polyethylene–
(Assuming 100% Capacity Utilization)
–Production capacity: 100,000 tons/year
–Estimated plant cost: US$ 100 million

Cost Items	Consumption (per ton of product)	Unit Price (US$)	Production Cost Annual Cost (US$'000)	Production Cost Unit Cost (US$'000)	Remarks
I Variable Cost					
1.1 Raw materials			37,410	374.10	
- Ethylene	1,016 kg	319/ton	32,410	324.10	Cost for ethylene produced by using ethane valued at US$ 2.00/MMBTU
- Hydrogen	1.9 kg	*1)	–	–	
- Catalyst & Chemical		50/ton product	5,000	50.00	
1.2 Utilities			2,112	21.12	
- Steam	0.39 ton	*2)	–	–	
- Cooling water (make–up)	9.5 m^3	15.7/1,000m^3	15	0.15	5% of 190 m^3/ton
- Process water	0.3 m^3	210.0/1,000m^3	6	0.06	
- Electric power	600 kwh	34.0/1,000kwh	2,040	20.40	
- Inert gas	30 Nm^3	17.0/1,000 Nm^3	51	0.51	
1.3 Packaging		15/ton product	1,500	15.00	
1.4 Variable Cost–Total			41,022	410.22	
II Fixed Operating Cost					
2.1 Maintenance Cost			2,000	20.00	2% of US$ 100 mill.
2.2 Direct Labor Cost			3,000	30.00	@US$ 30,000/year x 100 persons
2.3 Fixed Operating Cost–Total			5,000	50.00	
III Direct Operating Cost (I+II)			46,022	460.22	
IV Overhead Cost					
4.1 Plant overhead & administrative exp.			4,500	45.00	150% of Direct Labor Cost
4.2 Depreciation			6,667	66.67	15 yrs straight line depreciation of US$ 100 mill.
4.3 Interest on Loans			2,800	28.00	Interest at 8% p.a. on 1/2 of 70% of US$ 100 mill.
4.4 Overhead Cost–Total			13,967	139.67	
V Total Production Cost (III+IV)			59,989	599.89	
VI ROI (10%)			10,000	100.00	10% of US$ 100 mill.
VII Plant Gate Cost with ROI			69,989	699.89	

Note: *1) Valued at vil assuming that hydrogen produced in the process of manufacturing ethylene is used.
*2) Valued at vil assuming that steam produced at the ethylene plant is used.

Table A4-8 Estimated Production Cost at a New Plant

–Product: Linear Low Density Polyethylene–
(Assuming 100% Capacity Utilization)
–Production capacity: 130,000 tons/year
–Estimated plant cost: US$ 110 million

Cost Items	Consumption (per ton of product)	Unit Price (US$)	Production Cost Annual Cost (US$'000)	Production Cost Unit Cost (US$'000)	Remarks
I Variable Cost					
1.1 Raw materials			47,590	366.07	
- Ethylene	943 kg	319/ton	39,107	300.82	Cost for ethylene produced by using ethane valued at US$ 2.00/MMBTU
- Butene–1	90 kg	725/ton	8,483	65.25	
- Hydrogen	0.5 kg	*	–	–	
1.2 Utilities			1,767	13.59	
- Cooling water (make–up)	2.6 m^3	15.7/1,000m^3	5	0.04	5% of 52 m^3/ton
- Electric power	381 kwh	34.0/1,000kwh	1,684	12.95	
- Inert gas	35 Nm^3	17.0/1,000 Nm^3	78	0.60	
1.3 Packaging		15/ton product	1,950	15.00	
1.4 Variable Cost–Total			51,307	394.66	
II Fixed Operating Cost					
2.1 Maintenance Cost			2,200	16.92	2% of US$ 110 mill.
2.2 Direct Labor Cost			4,200	32.31	@US$ 30,000/year x 140 persons
2.3 Fixed Operating Cost–Total			6,400	49.23	
III Direct Operating Cost (I+II)			57,707	443.89	
IV Overhead Cost					
4.1 Plant overhead & administrative exp.			6,300	48.46	150% of Direct Labor Cost
4.2 Depreciation			7,333	56.41	15 yrs straight line depreciation of US$ 110 mill.
4.3 Interest on Loans			3,080	23.69	Interest at 8% p.a. on 1/2 of 70% of US$ 100 mill.
4.4 Overhead Cost–Total			16,713	128.56	
V Total Production Cost (III+IV)			74,420	572.45	
VI ROI (15%)			11,000	84.62	10% of US$ 110 mill.
VII Plant Gate Cost with ROI			85,420	657.07	

Note: * Valued at vil assuming that hydrogen produced in the process of manufacturing ethylene is used.

Table A4-9 Estimated Production Cost at a New Plant

–Product: Urea (in bulk)–
–Production capacity: 560,000 tons/year
(Ammonia: 1,000 t/d, Urea: 1,700 t/d)
–Estimated project cost: US$ 250 million

Cost Items	Consumption (per ton of product)	Unit Price (US$)	Production Cost		Remarks
			Annual Cost (US$'000)	Unit Cost (US$'000)	
I Variable Cost					
1.1 Feedstock (NG)	20.30 MMBTU	1.50/MMBTU	17,052	30.45	- NG consumption for ammonia & fuel: 35 MMBTU/ton ammonia - Ammonia consumption for urea: 0.58 tons per ton of urea
1.2 Catalysts & Chemicals		1.16/ton urea	650	1.16	US$2.00/ton of ammonia x 0.58
1.3 Cooling water (make-up)	15.45 m^3	15.7/1,000m^3	134	0.24	- 5% of daily consumption: Ammonia: 320,000 m^3 Urea: 178,500 m^3 Utility: 27,000 m^3 Total: 525,500 m^3 - Daily production of urea: 1,700 tons
1.4 Boiler feed water	2.67 m^3	210.0/1,000m^3	314	0.56	4.6m^3/ton of ammonia x 0.58
1.5 Variable Cost–Total			18,150	32.41	
II Fixed Operating Cost					
2.1 Maintenance Cost			5,000	8.93	2% of US$ 250 mill.
2.2 Direct Labor Cost			6,000	10.71	@US$ 30,000/year x 200 persons
2.3 Fixed Operating Cost–Total			11,000	19.64	
III Direct Operating Cost (I+II)			29,150	52.05	
IV Overhead Cost					
4.1 Plant overhead & administrative exp.			9,000	16.07	150% of Direct Labor Cost
4.2 Depreciation			16,667	29.76	15 yrs straight line depreciation of US$ 250 mill.
4.3 Interest on Loans			7,000	12.50	Interest at 8% p.a. on 1/2 of 70% of US$ 250 mill.
4.4 Overhead Cost–Total			32,667	58.33	
V Total Production Cost (III+IV)			61,817	110.38	
VI ROI (10%)			25,000	44.64	10% of US$ 250 mill.
VII Plant Gate Cost with ROI			86,817	155.02	

Assuming a complex consisting of ammonia and urea plants designed for ammonia production in balance with urea production and also power and steam generation plants for self–balance of power and steam

Table A4-10 Estimated Production Cost at a New Plant

–Product: Chemical Methanol–
–Production capacity: 500,000 tons/year
(Methanol: 1,500 t/d)
–Estimated project cost: US$ 100 million

Cost Items	Consumption (per ton of product)	Unit Price (US$)	Production Cost		Remarks
			Annual Cost (US$'000)	Unit Cost (US$'000)	
I Variable Cost					
1.1 Feedstock (NG)	34 MMBTU	1.50/MMBTU	25,500	51.00	
1.2 Electric power	59 kwh	34.0/1,000 kwh	1,005	2.01	
1.3 Cooling water (make-up)	7.8 m^3	15.7/1,000m^3	60	0.12	5% of 156 m^3
1.4 Process water	4.8 m^3	210.0/1,000m^3	505	1.01	
1.5 Catalysts & Chemicals		5/ton product	2,500	5.00	
1.6 Variable Cost–Total			29,570	59.14	
II Fixed Operating Cost					
2.1 Maintenance Cost			2,000	4.00	2% of US$ 100 mill.
2.2 Direct Labor Cost			3,000	6.00	@US$ 30,000/year x 100 persons
2.3 Fixed Operating Cost–Total			5,000	10.00	
III Direct Operating Cost (I+II)			34,570	69.14	
IV Overhead Cost					
4.1 Plant overhead & administrative exp.			4,500	9.00	150% of Direct Labor Cost
4.2 Depreciation			6,667	13.33	15 yrs straight line depreciation of US$ 100 mill.
4.3 Interest on Loans			2,800	5.60	Interest at 8% p.a. on 1/2 of 70% of US$ 100 mill.
4.4 Overhead Cost–Total			13,967	27.93	
V Total Production Cost (III+IV)			48,537	97.07	
VI ROI (10%)			10,000	20.00	10% of US$ 100 mill.
VII Plant Gate Cost with ROI			58,537	117.07	

Table A4-11 Estimated Production Cost (New Plant) vs Changes in Capacity Utilization Rate (incl. 10% ROI)

Product	Cost Items		Production Cost per Ton (US$)		
			100% Capacity Util.	90% Capacity Util.	80% Capacity Util.
Ethylene	1	Feedstock (NG)	70.70	70.70	70.70
	2	Other variable costs	39.80	39.80	39.80
	3	Fixed costs	208.54	231.71	260.68
	4	Total costs	319.04	342.21	371.18
HDPE	1	Raw material (ethylene)	324.10	347.68	377.14
	2	Other variable costs	86.12	86.12	86.12
	3	Fixed costs	289.67	321.85	362.09
	4	Total costs	699.89	755.65	825.35
LLDPE	1	Raw material (ethylene)	300.82	322.70	350.04
	2	Other variable costs	93.84	93.84	93.84
	3	Fixed costs	262.41	291.57	328.01
	4	Total costs	657.07	708.11	771.89

Notes:

1 Production Capacity: Ethylene: 300,000 tons/year
HDPE: 100,000 tons/year
LLDPE: 130,000 tons/year

2 Ethane value for ethylene: US$ 2.00/MMBTU

3 Ethylene cost: 100% capacity utilization: US$ 319.0 per ton
90% capacity utilization: US$ 342.2 per ton
80% capacity utilization: US$ 371.2 per ton

Table A4-12 Estimated Production Cost (New Plant) vs Changes in Ethane Value and Capacity Utilization Rate (Incl. 10% ROI)

Ethane Value	Product	Production Cost per Ton (US$)		
		100% Capacity Util.	90% Capacity Util.	80% Capacity Util.
US$ 2.50/ MMBTU	Ethylene	347.04	370.21	399.18
	HDPE	728.34	784.10	853.80
	LLDPE	683.47	734.51	798.29
US$ 2.00/ MMBTU	Ethylene	319.04	342.21	371.18
	HDPE	699.89	755.65	825.35
	LLDPE	657.07	708.11	771.89
US$ 1.50/ MMBTU	Ethylene	291.04	314.21	343.18
	HDPE	671.44	727.20	796.90
	LLDPE	630.67	681.71	745.49
US$ 1.00/ MMBTU	Ethylene	263.04	286.21	315.18
	HDPE	642.99	698.75	768.45
	LLDPE	604.27	655.31	719.09
US$ 0.50/ MMBTU	Ethylene	235.04	258.21	287.18
	HDPE	614.54	670.30	740.00
	LLDPE	577.87	628.91	692.69

Notes:

1 Changes in production costs by changes in ethane cost at US$ 0.50/MMBTU

Ethylene cost: US$ 28.00/ton
HDPE cost: US$ 28.45/ton
LLDPE cost: US$ 26.40/ton

2 Production capacity

Ethylene: 300,000 tons/year
HDPE: 100,000 tons/year
LLDPE: 130,000 tons/year

3 Production costs for HDPE and LLDPE are estimated on the basis of the estimated ethylene costs given above.

Table 4-13 Estimated Production Cost (New Plant) vs Changes in Capacity Utilization Rate (incl. 10% ROI)

Product	Cost Items	Production Cost per Ton (US$) 100% Capacity Util.	90% Capacity Util.	80% Capacity Util.
Urea	1. Feedstock (NG)	30.45	30.45	30.45
	2. Other variable costs	1.96	1.96	1.96
	3. Fixed costs	122.61	136.23	153.26
	4. Total costs	155.02	168.64	185.67
Methanol	1. Feedstock (NG)	51.00	51.00	51.00
	2. Other variable costs	8.14	8.14	8.14
	3. Fixed costs	57.93	64.37	72.41
	4. Total costs	117.07	123.51	131.55

Notes:

1 Production Capacity: Urea: 560,000 t/y (Ammonia: 1,000 t/d, Urea: 1,700 t/d)
Methanol: 500,000 t/y (1,500 t/d)

2 Natural Gas Value: US$ 1.50/MMBTU

Table A4-14 Estimated Production Cost (New Plant) vs Changes in Natural Gas Value and Capacity Utilization Rate (Incl. 10% ROI)

Natural Gas Value	Product	Production Cost per Ton (US$)		
		100% Capacity Util.	90% Capacity Util.	80% Capacity Util.
US$ 2.50/MMBTU	Urea	175.32	188.94	205.97
	Methanol	151.07	157.51	165.55
US$ 2.00/MMBTU	Urea	165.17	178.79	195.82
	Methanol	134.07	140.51	148.55
US$ 1.50/MMBTU	Urea	155.02	168.64	185.67
	Methanol	117.07	123.51	131.55
US$ 1.00/MMBTU	Urea	144.87	158.49	175.52
	Methanol	100.07	106.51	114.55
US$ 0.50/MMBTU	Urea	134.72	148.34	165.37
	Methanol	83.07	89.51	97.55

Note: Changes in production costs by changes in natural gas value at US$ 0.50/MMBTU
Urea cost: US$ 10.15/ton
Methanol cost: US$ 17.00/ton

Table A4-15 International Prices of Ethylene, HDPE and LLDPE

(US$/ton)

	Ethylene						HDPE *4) US East Coast		LLDPE *5) US East Coast	
	EEC Materials *1) N.W. Europe (delivered)		Imported *2) N.W. Europe (cif)		US East Coast *3) (delivered)					
	Low	High	Low	High	Low	High	Low	High	Low	High
1983	551	567	n.a.	n.a.	520	531	1,064	1,069	838	877
1984	524	537	n.a.	n.a.	514	536	1,025	1,052	882	959
1985	456	494	351	375	485	507	948	1,014	882	959
1986	392	408	328	339	412	425	948	1,014	882	959
1987	405	414	415	435	362	373	948	1,014	882	959
1988	512	531	555	571	604	615	1,069	1,087	1,069	1,085
1989	596	620	537	554	668	679	1,153	1,153	1,153	1,179
1990	548	569	655	697	560	567	1,131	1,131	1,129	1,188
1991	463	475	320	333	516	518	1,036	1,190	1,058	1,213
1992	460	466	395	405	406	417	657	710	635	697
1993	398	402	273	286	470	472	661	705	617	683
1994#	394	394	n.a.	n.a.	463	463	661	705	617	683

Note: # Jan. – April

Source: *1), *2) *European Chemical News*

*3), *4), *5) Chemical Marketing Reporter

Table A4-16 International Prices of Urea and Chemical Methanol

(US$/ton)

	Urea *1) (Bagged) Mid-East (fob)		Methanol *2) (EEC materials) N.W. Europe (fob)		Methanol *3) (Imported) N.W. Europe (cif)	
	Low	High	Low	High	Low	High
1983	132	139	173	181	n.a.	n.a.
1984	174	182	161	166	n.a.	n.a.
1985	134	139	151	156	121	137
1986	85	85	100	105	86	89
1987	101	107	118	123	98	102
1988	137	142	182	186	165	171
1989	119	128	123	127	110	114
1990	138	143	136	139	115	118
1991	158	163	130	135	103	110
1992	145	150	114	118	102	108
1993	112	118	141	147	149	160
1994#	122	127	184	189	n.a.	n.a.

Note: # Jan. – April

Source: *1) Fertilizer Focus

*2), *3) European Chemical News

Table A4-17 Import of Copper Products in Oman and Dubai

Section	HS Code		Oman			Dubai	
			1992	1991	1990	1992	1991
15	74020000	Copper waste & scrap	140	292	133	607	669
	74081000	Wire of refined copper	1,068	818	328	5,136	1,486
	74072000	Bars, rods & profiles	138	73	19	4,397	4,885
	74090000	Copper plates, sheets & strip				338	214
	74110000	Copper tubes & pipes	138	113	31	4,649	1,443
	74120000	Tubes or pipe fitting	145	17	43	901	449
	Total		1,629	1,314	553	16,027	9,147

Note: Copper and articles of copper products imported more than 100tons/year in one of the above three years.

Table A4-18 Supply/Demand and Import of Pet Food in Japan

(Unit: '000 ton)

		1992						1991	1990
		Dry	Soft dry	Semi-moist	Wet	Others	Total		
Dog food	Production	144	16	9	5	2	176	155	135
	Import	53	0	0	65	1	119	81	65
	Total	198	16	9	69	3	295	237	200
Cat food	Production	55	0	0	19	0	74	71	49
	Import	25	0	0	67	0	92	81	63
	Total	80	0	0	86	0	166	152	112
Others	Production						24	22	20
	Import						0	0	0
	Total						24	22	20
Total	Production						274	248	204
	Import						211	162	128
	Total						485	410	332

Source: Ministry of Agriculture, Forestry and Fisheries, Japan

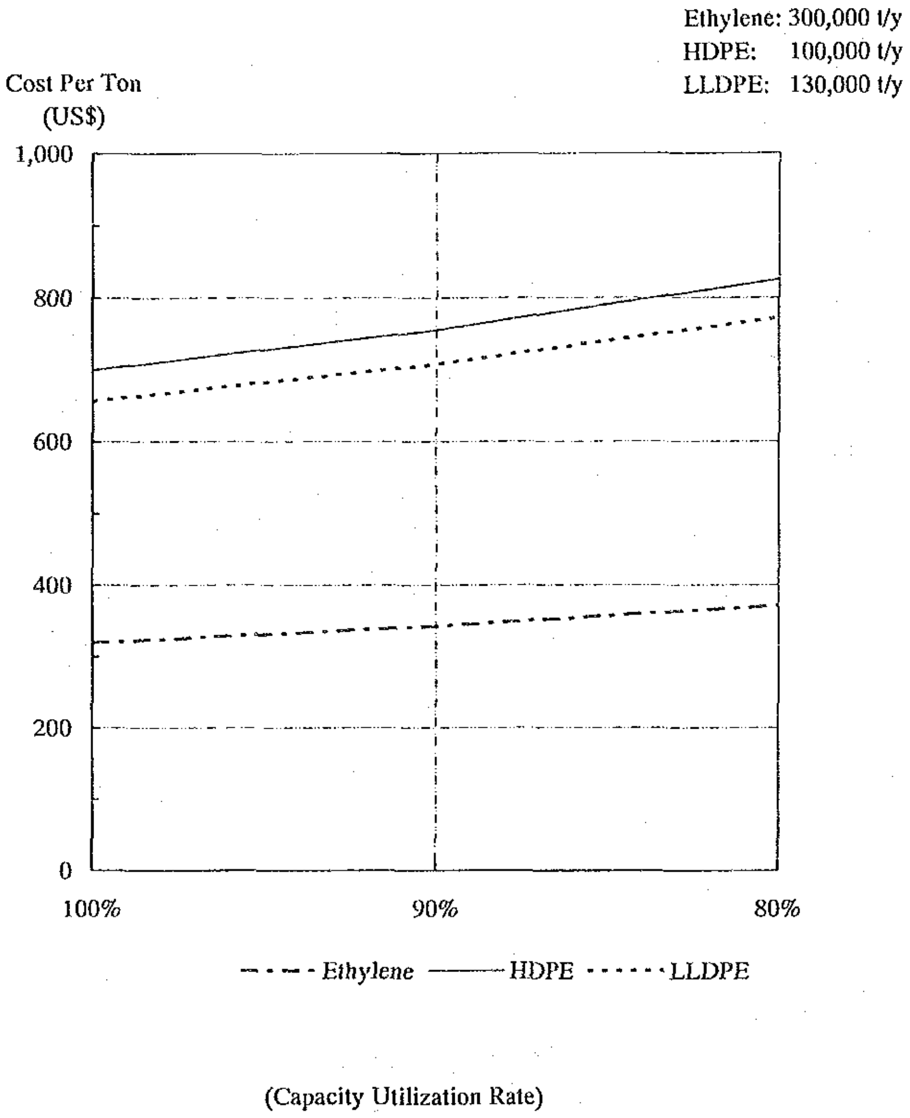
Table A4-19 Estimated Import and Export of Dog or Cat Food in Selected Countries

(Unit: '000ton)

Source / Destination	Total		Thailand		USA		Australia	
	1992	1991	1992	1991	1992	1991	1992	1991
Japan	238.6	208.1	65.1	58.3	95.3	82.1	56.7	110.0
Australia			28.3		1.8	0.0		0.7
New Zealand			2.6		0.0	0.0		22.2
USA	73.9		28.4		0.0	0.0		0.0
France			1.9		10.8	12.7		4.3
Sweden			2.9		11.2	0.0		4.5
U King			6.3		24.2	18.7		9.7
Canada			0.0		363.2	311.2		145.4
Taiwan			0.0		15.6	9.0		15.9
Others			0.0		119.6	0.0		57.0
Total			141.8		641.6	519.2		369.9

Note: Total including others

Figure A4-1 Estimated Production Cost (New Plant)
(incl. 10% ROI)



Ethane Value: US$ 2.00/MMBTU

Figure A4-2 Estimated Production Cost (New Plant)
(Incl. 10% ROI)

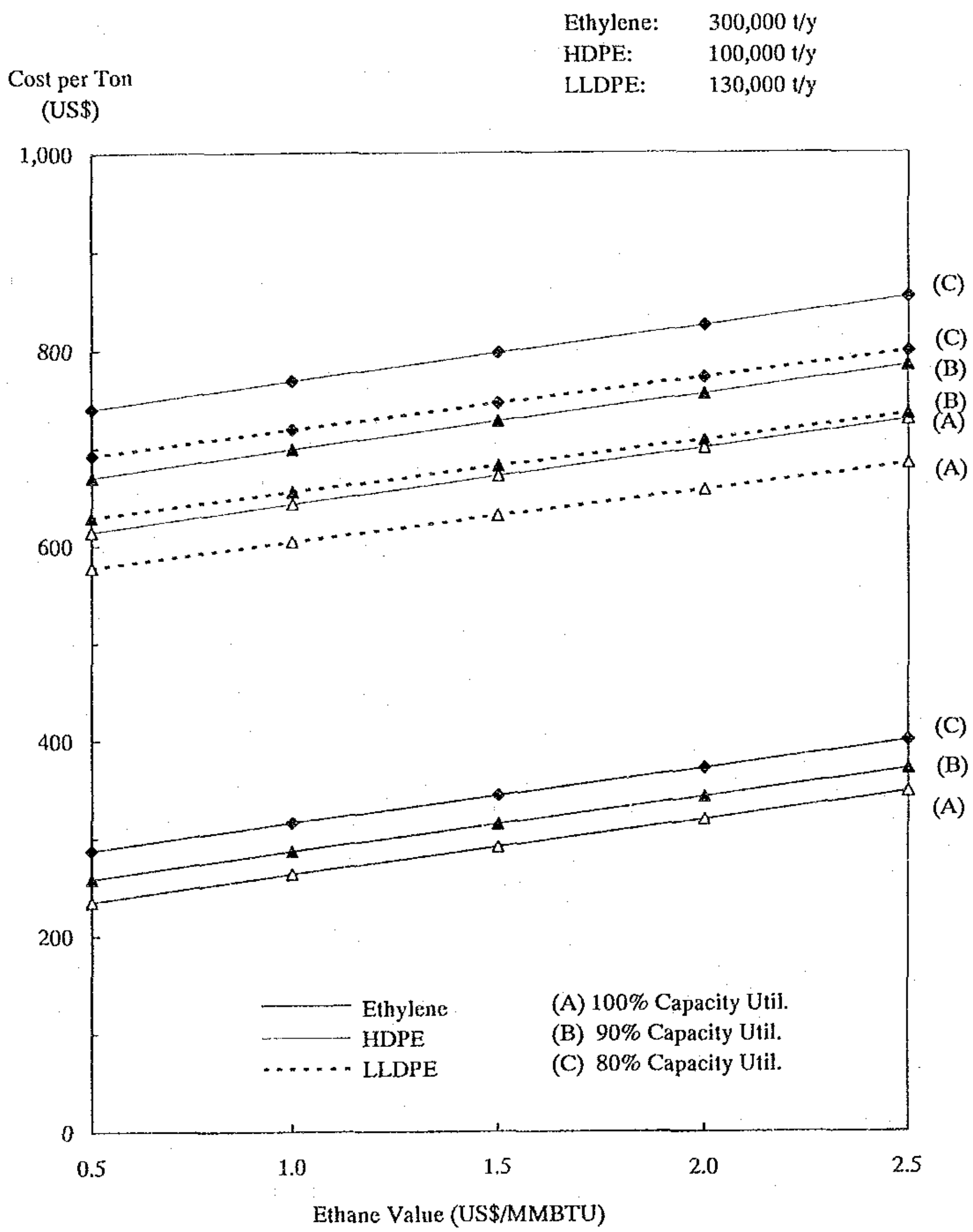


Figure A4-3 Estimated Production Cost (New Plant) (incl. 10% ROI)

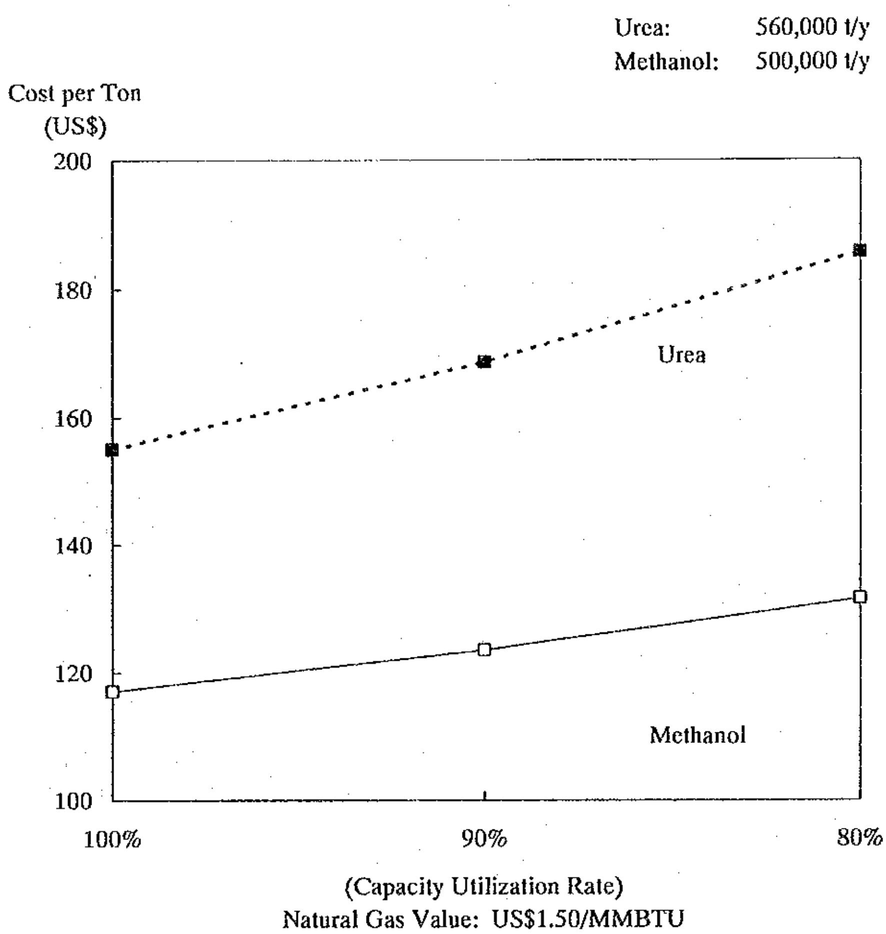


Figure A4-4 Estimated Production Cost (New Plant)
(incl. 10% ROI)

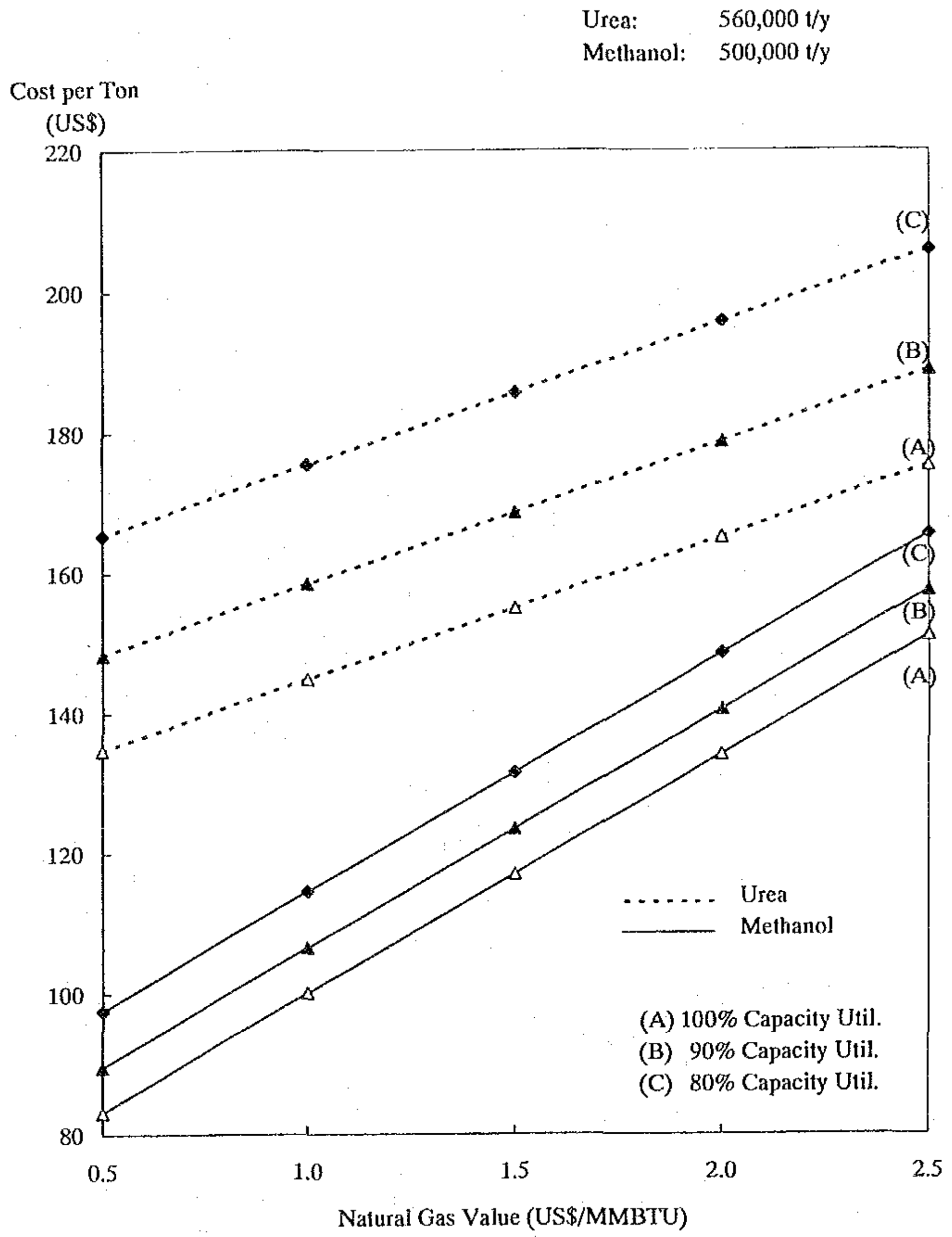


Figure A4-5 Prices of Ethylene, HDPE & LLDPE

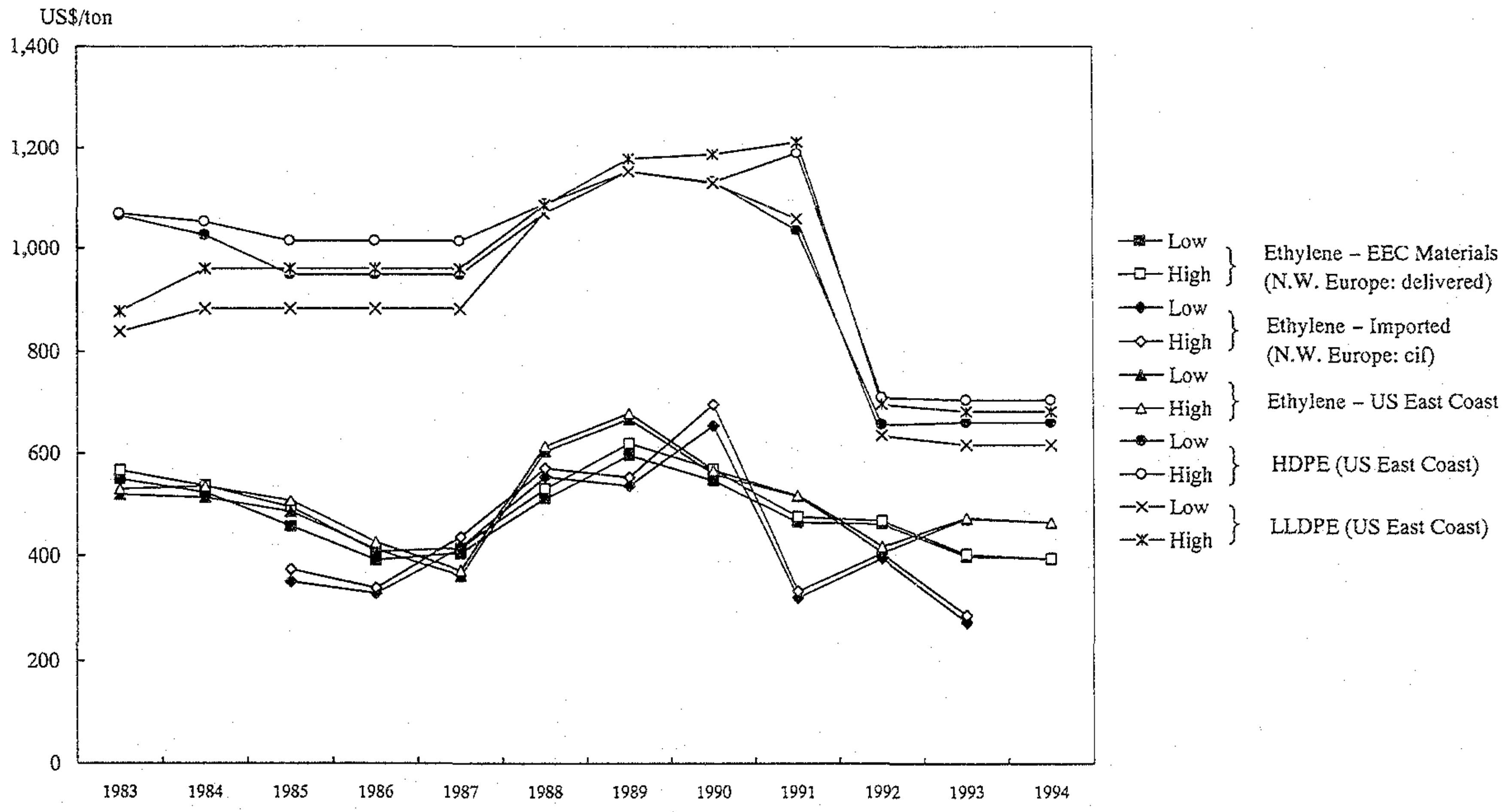


Figure A4-6 Methanol Price

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