ECONOMICS OF PETRO-CHEMICAL INDUSTRIES IN IRAN

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Shiraz Fertilizer Plant

The idea of transferring natural gas through the pipeline to Shiraz was put forward some time ago. After a meticulous investigation the National Iranian Oil Company decided that the Gachsaran gas resources, 240 KM's away, were by far the most suitable choice, with a gas pipeline of not smaller than 10″ diameter. It was estimated that the total cost for pipeline and distribution systems would be approximately $ 7 million, which on the basis of a 5 percent interest during 10 years will add another $ 1.5 million per annum to the cost. This expense would not pay itself off as there were no major gas consumers in Shiraz at that time, unless they could substitute the gas for liquid fuel, the consumption of which was 54 Mm^3. in those days (1955). Because of the difference of the heat value a greater amount of gas was necessary. But even this did not seem to be economical so they decided to establish a plant using natural gas as its main raw material. A fertilizer plant with a capacity of 240 tons a day was decided upon; the Ministry of Mines and Industry succeeded in obtaining the approval of the N.I.O.C., and a contract was signed by the said Ministry and the N.I.O.C. for the execution of the plan.

The construction and plant cost. In 1957, three French companies signed a contract with the Iranian government for the erection of the fertilizer plant in Shiraz which would have a daily output of 240 tons. An itemized cost of the plant is as follows:

Plant cost, insurance and freight	$ 23,710,000
Building and foundations	7,485,000
Pipeline from Gachsaran to Marvedasht	4,107,000
Hydrogen and sulfurate plant at Gachsaran	790,700
total	$ 36,092,700

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As the site is approximately 60 km away from Shiraz, and off the main road, it was decided to build houses for the employees and labourers close to the plant. The total cost of employees' housing (60 employees and 440 labourers), was almost $ 3 million, which together with the other costs gives a total of $ 39,092,700.

The plant is producing 120 tons of ammonium nitrate and the same amount of urea per day, as illustrated in Chart 1.

Fertilizer Consumption in Iran. The consumption of synthetic fertilizer in Iran began after the Second World War; but the total consumption of urea and ammonium nitrate at the time when the establishment of the Shiraz plant was contemplated, i.e. in 1957, was only 2,500 tons (see Figure 1). The total consumption of all kinds of fertilizers was 15,000 tons. In July 1963, when the plant was officially inaugurated, it was obvious that the factory could not sell even this low production, because:

1. The production began in July, so it was too late to introduce the fertilizer to the farmers who had already obtained their requirements from the importers.

2. There was a surplus of imported fertilizer from various sources, such as Germany, Austria, and the Netherlands; which, despite the new tariff restrictions, was still cheap enough for the consumers.

Moreover, the distributers of foreign produced fertilizers were controlling the market and were more efficient at meeting the demand.

3. The C & F price of foreign urea and ammonium was $ 82 and $ 53 respectively, whereas the Shiraz plant could only manufacture these at $ 330 and $ 580 (see Figure 2). This meant that the fertilizer plant in Shiraz could only sell at cost price, which was several times higher than the market price.

4. In the winter of the same year (1963), some of the pipelines in the plant were frozen and the factory was practically closed down for sometime. (More about this later on.)

5. The plant was certain to make a loss, because as mentioned before, the total consumption of the country, according to authorities, was only

22,000 tons. As this is only 1/4 of the plant's production capacity, it would not be economical for a plant to market only 1/4 of the yearly output. It is evident from Figure 2 that even in 1965 the cost price of ammonium nitrate is \$ 125 and of urea \$ 270. The imported goods were sold at Rls. 5 or Rls. 7 per Kg., of which 20 to 25 percent was profit, whereas Iranian fertilizer is sold at Rls. 10 per Kg. without any profit. Therefore, as production exceeded consumption, it was decided to export the surplus up to the time when supply and demand became equal (1969). But the export target could not be reached because of our higher price which is not competitive with foreign-made goods. The reason is self-explanatory: the nearest port from which the fertilizer could be exported is Bushire which is 293 km from Shiraz. The road is rough, narrow, and with sharp curves and deep valleys. For the next 3 or 4 years we need to export at least 40,000 tons per year. The transportation could only be made with trucks, and if each truckload is 10 tons, 12 trucks are needed a day. Based on Rls. 2.5 per ton per km. transportation charges, we have to pay Rls. 29,300,000 extra, $(40{,}000 \times 293 \times 2.5 = 29{,}300{,}000)$.

In terms of dollars this would be almost \$ 390,000. Dividing this into 2, for urea and ammonium we get $390{,}000 \div 2 = 195{,}000$.

The cost price for urea was \$ 360 per ton. For 20,000 tons it would be \$ 1,200,000.

For handling charges and other expenses such as loading and unloading, we add Rls. 1, which is Rls. 20 million for each, which is equivalent to \$ 4,200,000.

Our F.O.B. price for urea is therefore 7,200,000 + 2,666,000 + 195,000 + 7,661,000 dollars, or \$ 383 a ton and \$ 233 for ammonium nitrate.

The most lucrative market for our fertilizer is India or Pakistan. If we add \$ 10 per ton for shipment, the C. & F. price of our products in India and Pakistan in urea and ammonium would be \$ 393 and \$ 243 respectively. This is almost 5 times more than that of our competitors and there is no doubt that we could not get into the market with these prices. Therefore, we should not have established this plant merely to protect the

1. \$ 1.00 = 76 rials

Chart 1

Operation Chart of Shiraz Fertilizer Plant

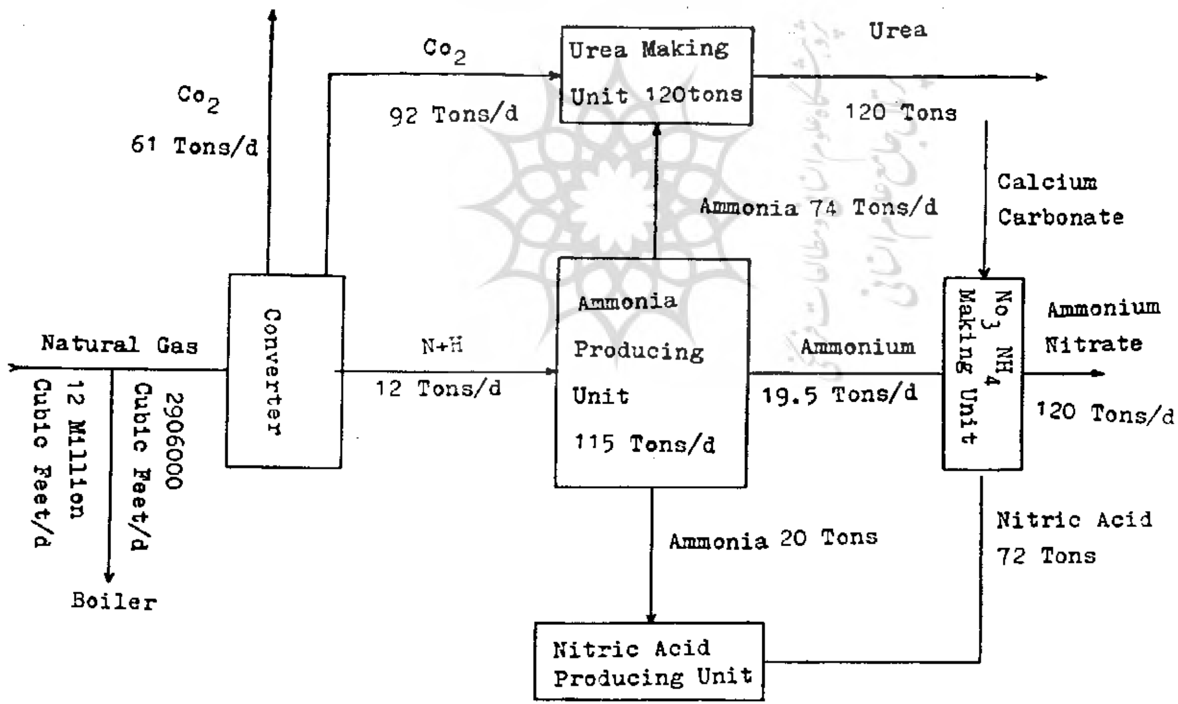


Figure 1

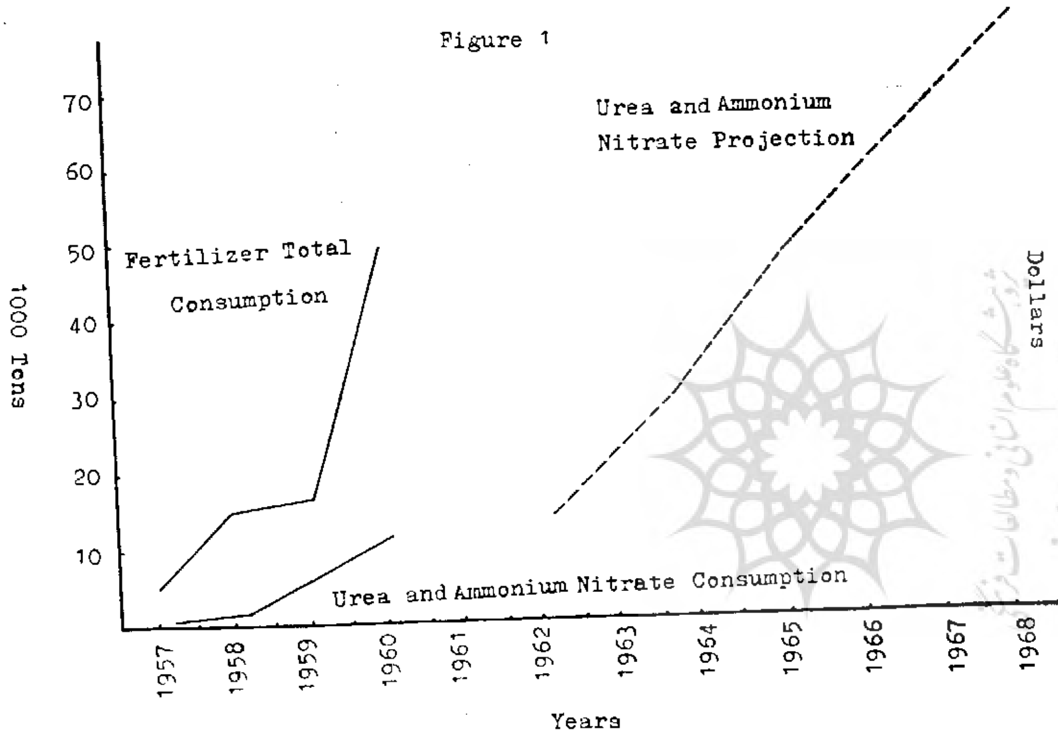
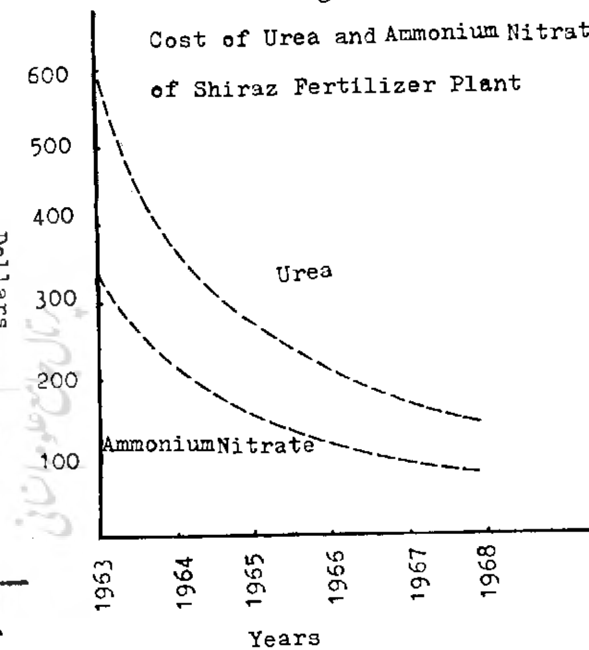


Figure 2

Cost of Urea and Ammonium Nitrate of Shiraz Fertilizer Plant



consumer from paying a higher price for imported goods or to gain foreign currency by the export of the surplus fertilizer.

In the light of the above it was clear that the transportation of the natural gas to Shiraz could not have paid off unless the fertilizer plant was erected, and that despite the fact of the minimum economical output of the plant, the demand for such a product was not more than 1/2 of the output the first year after it was commissioned. It was the intention to export at least 1/2 of the total output, but as it was pointed out our C. & F. prices were not compatible in international markets. We therefore conclude that the establishment of such a plant in Shiraz was not based on sound economic measures.

Price factors. Let us turn our attention once more to the factors influencing the fertilizer price and find out why this new industry cannot compete price-wise. In order to delve into the matter deeply we shall have to analyze the price components such as the depreciation of raw materials, wages and salaries, maintenance cost, insurance, interest and packing.

I. Raw materials: i.e., natural gas. In order to find out how much a cubic meter of natural gas is going to cost us at the plant we shall have to determine the production and consumption of the natural gas:

According to the contract signed between the N.I.O.C. and the former Ministry of Mines and Industry, the natural gas should not exceed the cost price which must be evaluated on the following yearly expenses.

Depreciation on a 20 year basis	Rls. 57,507,000
Maintenance on 5 percent charges	31,930,000
Equipment charges at the gas field	767,800
Total	Rls. 90,204,800

Natural gas consumption in the Shiraz area would have to be limited for the following purposes:

1. Cement plant with daily demand of 2,373,167 cubic feet.

2. Sugar plants at Guvar and Marvedasht with total of 4,900m³/h. These two plants work only 5 months in the year.

3. Nemazi Hospital and water supply system 200 m³/h.

4. Dairy and Textile plant, 1,400^{3}m/h.

5. Shiraz fertilizer plant, 12,000m^{3}/h.

6. Shiraz power house not determined yet.

Therefore, the total demand, with the exception of items 4 and 6, is 159 mm^{3} per year. Allowing 10 percent for the holidays and emergency shut-downs, the total consumption is 144 mm^{3} a year.

The cost price. The international price of the natural gas at the oil field is 1.62 cents per 1,000 cubic feet; but taking into account the desulfurating equipment and a pipeline of 240 km's we shall have to modify the price for 1,000CF as follows:

1. Natural gas at oil fields (Gachsaran)	1.62 cents
2. Desulfurating and drying expenses	7.0
3. Carrying through the pipelines	5.5
4. Depreciation	4.5
Total	18.62

The Shiraz fertilizer plant will use 12mCF a day, so the price of the raw material would be $\frac{12\text{mCF} \times 18.62}{1{,}000 \times 100} = 2234.2$ dollars. Converting to rials, this would be equivalent to Rls. 167,565. The other raw materials such as lime-stone and talc powder would cost us Rls. 64,800 a day.

II. The catalysts and motor oil, chloric acid, caustic soda, ammonium sulfate and other usable materials would cost Rls. 35,000 a day.

III. The depreciation charges on machinery and building at 6 per cent is \$ 12,420 per day or Rls. 921,500.

IV. Salaries and wages:

a. Foreign engineers and skilled labor		Rls. 190,870.
b. Employees		34,570
c. Wages		123,683
V. Maintenance and overheads	\$ 4,480	or Rls. 336,000
VI. Interest on capital	\$ 559	or Rls. 41,925
VII. Paper bags and packing		75,000

VIII. Insurance	77,052

The total daily cost would be:

1. Natural gas	Rls. 167,565
2. Lime-stone	64,800
3. Usable materials	35,000
4. Depreciation	931,500
5. Wages:	123,683
Foreign and skilled labor	190,857
Employees	34,570
6. Maintenance	336,000
7. Interest	41,925
8. Packing	75,000
9. Insurance	77,025
Total	Rls. 2,077,943

As the demand is only 1/2 of the output of the plant, our daily loss is at least one million rials. Considering the above it is clear that the Shiraz fertilizer plant is not, economically speaking, a sound enterprise.

Technical shortcomings. on execution of this project the designers and foreign advisors committed unforgivable errors in calculation which are briefly outlined below:

1. In establishing a plant, not only must the economic factors such as the proximity of the market, the low cost of raw materials and the transportation facilities, be considered; but also the other influencing agents such as the wind velocity, maximum snow and rain-fall and elevation soil testing. The creators of this plan did not carry out tests to find the minimum temperature of the area, with the result that in the winter of 1964 when the temperature dropped a few degrees lower than usual, all the exposed pipelines were frozen, and the plant had to be shut down for sometime for repairs. The consequent loss amounted to many million rials.

2. As the plant was commissioned by the French, all the pipes were

delivered on the Cg's system (i.e. in millimeters). This was against the tradition of the N.I.O.C. and private enterprise, who used to order the pipes in inches. Naturally when some of the plant tubes were frozen and had to be replaced, it was very difficult and almost impossible to obtain the replacements in Iran; so there was no alternative but to order the pipes from France, which took a long time to arrive.

This non-standardization is seen in all the components and equipment. The high tension transformers for instance provide another example; in case of damage or breakdown they have to be purchased directly from France as no other country produces them in series. It is obvious that by so doing we are bound to pay whatever price is asked.

3. The equipment is spaced so close together that maintenance and repair would be extremely difficult.

4. The designers have omitted some of the vital suction pumps believing that they have economized in overall expenditure. The difficulties encountered by this omission is more than the money saved by not ordering them.

5. There is no conveyer belt for the products to be taken to the trucks; therefore, some of the paper bags are broken in handling and a lot of man-power is wasted in loading.

6. The warehouses, (only 2 in number), are too small to accommodate all the output. Therefore the bags are piled and stacked on top of each other in spite of the prevailing rules which result in the bursting of the bags and subsequent deterioration of the fertilizer.

7. The equipment is erected in such a way that expansion seems to be out of the question, or at least extremely difficult.

8. The construction materials used are not of a very high quality, and the price difference of this material and that of a better quality is so small that practically no money is saved by such measures.

9. No workshop or mobilized service station is envisaged, and it is not known why this important item has escaped the designer's minds.

10. The apparent saving gained in eliminating some of the equipment

will limit the efficiency of the plant.

11. The site chosen for the erection of the plant was not firm, and therefore an elaborate job was done to reinforce it by a concrete foundation which cost the factory a lot of money. Only a few hundred meters away the soil is strong enough to withstand the extra weight and pressure of the equipment.

12. In selecting the site of the plant the designers who projected it have neglected the following well-known rules of market research:

First, the plant is far away from the raw materials. The natural gas is transported from the oil field some 240km's away.

Second, it is far away from centers of consumption. In the case of fertilizer, Khorasan, Gorgan, Mazandaran and Azarbaidjan, (north and north east of Iran), are the main markets.

Shiraz or Fars province could not be a favourable market for synthetic fertilizer because it is a mountainous region with little rainfall and no main river. Besides, some of its population are nomads with very little interest in farming.

Third, it is far away from any skilled man-power. Most of the engineers and skilled laborers are sent from Tehran. Their salaries and wages are therefore, higher than the normal pay. Besides that, a 3 million dollar housing project especially designed for their accommodation was needed.

Fourth, the plant is located in a vicinity which is almost cut off from the rail-roads, and there is no communication to the main towns of Iran except by the Shiraz-Isfahan asphalt road. The nearest railway station is also 500 km away.

There is no navigable river or port to the sea. The distribution of the fertilizer across the country is exclusively carried out by trucks. The result is a higher price for the consumers.

Our Proposed and Counter Project: An Ammonia Plant on the Persian Gulf

Is it possible to find a relatively lucrative project which could easily replace the present petro-chemical fertilizer plant in Shiraz? Certainly we could invest in a manner by which both the consumer and producer would profit economically.

The following, for instance, is one of the many projects which, if carried along in a meticulous and careful way, would be preferable to the Shiraz fertilizer plant.

We have no doubt that to increase our agricultural output we should use domestic or imported fertilizers. But mere necessity for one commodity can not justify the implementation of a manufacturing plant unless a reliable market is at hand.

The farmers are the main consumers of fertilizers, but they would not be at a price almost double that of the imported product.

In the private sector an adequate market with a relatively large potential increase in demand is sufficient to encourage the investment. Unfortunately our country with its scattered population and low incomes could not have justified the erection of the plant, because the residents of the towns with their higher incomes do not use fertilizers (except on a small scale in their home and gardens), and the main consumers are the farmers whose incomes are too small for high cost fertilizers. In order to increase the purchasing power of these people the national income and per capita earning should be increased and this is only possible with advanced productive capability and exporting.

For the export of our fertilizer products we should look for a market with the following characteristics:

1. The market must have an extensive total arable land with a large population.

2. The would-be market must be located in a country void of oil fields and/or natural gas.

3. The market must be thousands of kilometres away from the main petro-chemical producing countries, enabling us to compete efficiently with their products.

Where is there such a favourable market? Europe, with more than 244 petro-chemical complexes and a great industrial potential, is hardly the one. Africa, with its large reserves of natural gas in the Sahara, and its proximity to Europe is not a tantalizing market either. The competition from Japan will certainly make itself felt in the far Eastern Islands. Latin American markets are easily accessible to the U.S. industries.

East of Suez and west of Singapore is a large area with more than 600 million people; 450 million of which are living in India and 95 million in Pakistan. Fertilizer consumption has been rising at a rapid rate. In 1961-62 it was close to 300,000 tons in terms of nitrogen ($4\frac{1}{2}$ times that of the Shiraz fertilizer plant's output). The country's planning authorities have estimated that at least a seven-fold increase of nitrogen fertilizer will be required by 1970-71, and have planned for an output of two and one-quarter million tons. (30 times that of Shiraz).

With rich oil fields and vast natural gas resources, rail communications, modernised harbours, inexpensive manpower and 50 years experience in oil products (know-how), we should consider ourselves more competent than any other Middle East producers to monopolize this market. We should have started this 15 years ago, or at least in 1961, when the construction of the Shiraz gas pipe-line began.

An inter-regional contract with India will avail us of a large market which could absorb almost all our fertilizer products. (Turkey, Pakistan, Afghanistan, Burma and Ceylon are disregarded in our calculations).

The proposed substitution project will operate as follows:

1. The natural gas pipe-line will be extended from Gachsaran to Ganaveh. (A town on the Persian Gulf 140 km away from the gas resources.) Thus the pipe-line cost would be half that of Shiraz; i.e. only $ 2 million. By completion of this pipe-line the capital cost depreciation and payment of interest would have been halved.

2. An ammonia manufacturing plant with a yearly output of 150,000 tons would be erected. The total cost of this plant is as follows:

Process units	$ 8.6 million
Offsite housing, pipeline and refrigeration	7.5 »
Warehouses	1.5 »
Dock or breakwater	3.0 »
Total	20.6 »

This cost is more favourable than the Shiraz plant's. 3 million dollars is allocated to docks and breakwaters which will have a tremendous effect on our future exports.

Manufacturing cost per metric ton of ammonia is $ 16.26

1. Gas (Feed and Fuel)	40 mm B.T.U.	$ 2
2. Catalyst and chemical		0.70
3. Insurance and taxes		3.08
4. Maintenance		2.03
5. Salaries and wages		4.0
6. Overheads and supervision		1.65
7. Cost working capital		0.80
	Total	16.26

Depreciation of processing units on a ten year basis, and 15 percent for construction and housing on a 20 year basis, would add another $ 24.40 to the above, which makes a total of $ 40.66.

To ship the ammonia in special tankers would add another $ 10 plus $ 5 for handling and storage at its destination. This would make the total C. & F India cost of Persian Gulf Ammonia $ 57.66.

An ammonia plant in Ganaveh would be preferable to the Shiraz fertilizer plant because:

A. Ammonia is the basic raw material for a variety of solid and liquid fertilizers as illustrated in Figure 1. Urea and ammonium nitrate are the two most important nitrogen fertilizers. One ton of synthetic ammonia applied will yield the equivalent of 12 acres of land. Thus it would be possible to solve the malnutrition of overcrowded India at a minimum expense. It is also more economical for India to import the ammonia and fertilize the cultivated area rather than depend on foreign exports of wheat and grain.

B. Transportation cost of liquid ammonia, by tankers, is less than solid fertilizer.

C. For India the import of natural gas is costlier and more complex, as it has first to be converted into liquid before its loading, which adds to the cost; therefore, ammonia has a more favourable market in that country.

One ton of anhydrous ammonia derived from oil in India will cost $ 119.59 (including taxes and capital interest), whereas Persian Gulf ammonia could be sold for $ 57.66 (more than 50 per cent cheaper).

3. We could have exported 150,000 tons of ammonia at $ 6.8 million a year, and as this project was less elaborate we could have completed the erection 3 years sooner; thus our earnings from the export of the above would have been more than $ 20 million.

4. The Zohreh river, a short distance from the gas field, is a suitable location for the erection of a power-house, as the natural gas could be used as fuel; and with 3 or 4 gas turbines with an output of 150 M.W., the power needed for the ammonia plant and the surrounding villages could be met in the most economical way. (A transmission line from the Dez dam would be extremely expensive.)

5. Inexpensive electricity would be delivered to the farmers for irrigation and domestic uses; thus the arable land would be increased, leading to an increase in income.

6. The natural gas could be used for desalination purposes in converting the sea-water to fresh water and so providing enough water for drinking and gardening purposes.

Other Related Industries

It is a well known fact that "industry begets industry". Once the first ammonia plant is successfully erected on the Persian Gulf, (in or around Ganaveh), a foundation will have been laid on which the other related industries could be built.

Abundant and inexpensive gas and electric power could make the establishment of numerous industries possible: brick kilns, tile, ceramic and cement plants are but a few examples. The synthetic ammonia is a key plant and the next step is to produce other fertilizers. The total output of the first ammonia plant will be exported and the erection of a second ammonia plant with the same output would be inevitable.

Except for a few thousand tons, the output of the second plant would be used for the manufacturing of various nitrogen and other fertilizers. In order to accomplish this we need the following raw materials:

Natural gas	39 mmf*/d
Sulphur	126,300 tons
Phosphate rock (68 per cent B.P.L.)	482,600
Phosphate rock (77 per cent)	80,850

The second plant will yield:

Prilled nitrate	70,000
Amm. nitrate solution	70,000
Nitrogen solution	50,000
Urea	30,000
Ammonium sulphate	100,000
Mixture of 11-48-0	50,000
Mixture of 11-46-0	100,000
Triple super	200,000
Ammonia	19,000
Gypsum	548,000

The Shiraz fertilizer plant will yield 30,000 tons of urea in 1969. This is what we could have produced years ago by adopting the above solution. The increasing demand and popularity of urea lies in its high nitrogen content of 46 per cent which is extensively used in farming.

This product (urea)could be used to produce resin and adhesive. Inexpensive power, natural gas and access to the harbour are strong motives for other business activities.

According to informed circles, the country will consume some 40,000 tons of nitrate ammonium in 1969; the balance is, therefore, exportable.

The total output of our fertilizers (584,000 tons) at a price of $ 60 F.O B. will bring us an annual earning of more than $ 30 million.

In addition, we would have the income of the first ammonia plant, plus 89 thousand tons of fertilizer and 548 thousand tons of gypsum, which is ours at no cost.

Our total foreign currency income from the two plants would be $ 36.849 million; plus Rls. 54.8 million for gypsum, and Rls. 445 million from fertilizer sale in the domestic market, calculated only at Rls. 5 per kilo.

The capital investment necessary for the two plants would be as follows:

Investment in $ MM

1. Process units of first plant	$ 8.6
2. Offsite housing etc.	11.3
3. Process units of second plant	8.6
4. Fertilizer plant complete	20.0
5. Construction, erection and buildings	20.0
Total	68.5

This total is far less than the foreign currency accrued during the first year of production.

Another promising area of our natural gas utilization is in cement manufacturing. Although cement is not a petro-chemical industry, it is needed for construction, and large quantities are also used in the oil fields.

Furthermore, a cement operation might tie in with the fertilizer program, in that the by-product gypsum, from a phosphoric acid plant and limestone sludge, could be utilized. The raw materials, limestone, shale and clay, are all available in the Persian Gulf area.

A cement factory with an output of 280 thousand tons will require the following raw materials:

Limestone	310,500 tons
Shale	148,500
Clay	39,900
Sludge	7,200
Natural gas	54,000

The third potential for extending the petro-chemical industry is in the area of plastic monomers and electro-chemicals. An electro-chemical industry, especially aluminium and chlorine, would be interesting.

The raw materials needed for an electro-chemical industry are natural gas and sea-water. Decomposition of sea-water provides caustic soda, chlorine and hydrogen.

Chlorine and natural gas would provide the means of producing simple chloride monomer, either acetylene or ethylene. Methanol would be a by-product of acetylene rout which is traded world-wide in large volumes.

Methanol is used as a basis for the production of numerous resins. With 120,000 tons of sea-water and natural gas we should have the following products:

1. Methanol	75,000 tons
2. Vinyle chloride	75,000
3. Caustic soda	50,000
4. Vinyle acetate	25,000

Vinyle chloride is an intermediate in the manufacture of polyvenyle chloride (P.V.C.) plastics. Nylon and plastic bags for sugar, cement and fertilizer, plastic bottles, linoleum, and many other products could be obtained by P.V.C. and its by-products.

Conclusion

The above extensive project which was meant to replace the Shiraz fertilizer plant embraces all the advantages of sound economic engineering.

Iran would have become a petro-chemical centre in the Middle East, exporting its products to the vast south-east Asian market. Foreign currency earnings would be increased and a great many people would be employed. Agricultural activities would be augmented by abundant water, fertilizer and power. To handle the petro-chemical industries thousand of trucks would also be engaged. Embarkation facilities would enable the ships and boats to load directly at Ganaveh. The petro-chemical complex would find utilities: housing, roads, sewage, repair shops, port facilities, stores, restaurants, warehouses, schools, hospitals, movie-houses, etc.

Thus Ganaveh would become one of the major cities of Iran growing in population and business activities with its output going to the rest of the world.