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English

PRE-INVESTMENT ASSISTANCE FOR PETROCHEMICAL INDUSTRY,

SI/AFG/77/801 .

AFGHANISTAN .

Terminal report .

Prepared for the Government of Afghanistan
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of Kennedy Nahas, Sr., petrochemical market analyst

United Nations Industrial Development Organization
Vienna

id.78-6902

Explanatory notes

Referenoe to dollars ($) are to United States dollars.

The monetary unit in Afghanistan is the Afghani (Af). During the period covered by the report, the value of the Afghani in relation to the United States dollar was $1 = Af 39.

Use of hyphen between dates (e.g., 1960-1965) indicates the full period involved, including the beginning and end years.

A full stop (.) is used to indicate decimals.

A comma (,) is used to distinguish thousands and millions

In tables, a blank indicates that the item is not applicable.

The following technical abbreviations are used:

GWh gigawatt hour

psig pound per square inch gauge

In chapter III, the year according to the Afghan calendar is given in parenthesis after the year according to the Gregorian calender.

ABSTRACT

The Special Industrial Services project "Pre-investment assistance for petrochemical industry" (SI/AFG/77/801) was requested by the Government of Afghanistan and approved by the United Nations Industrial Development Organization (UNIDO) on 27 June 1977. It was carried out by a petrochemical market analyst from January to August 1978.

The original objective of the project, to assess the market for petrochemical end-products, was altered in view of the country's more pressing need to find an alternative to expensive imports of fuel used to generate power. The expert's main task became to study the possibilities of exploiting the abundant resources of natural gas for the purpose of power generation. He eventually issued a report entitled "A plan for the thermal generation of power using natural gas in co-ordination with the construction of a transmission system to encircle all of Afghanistan". A second report, "A plastics market survey", included a recommendation for the establishment of an integrated chemical and petrochemical complex. In the present report the expert has assessed the raw materials requirements for such a complex and given estimates of the country's natural gas needs until 1990.

With regard to thermal power generation using natural gas, the expert has recommended:

(a) That a comparison be made of the costs of thermal and hydro power generation;

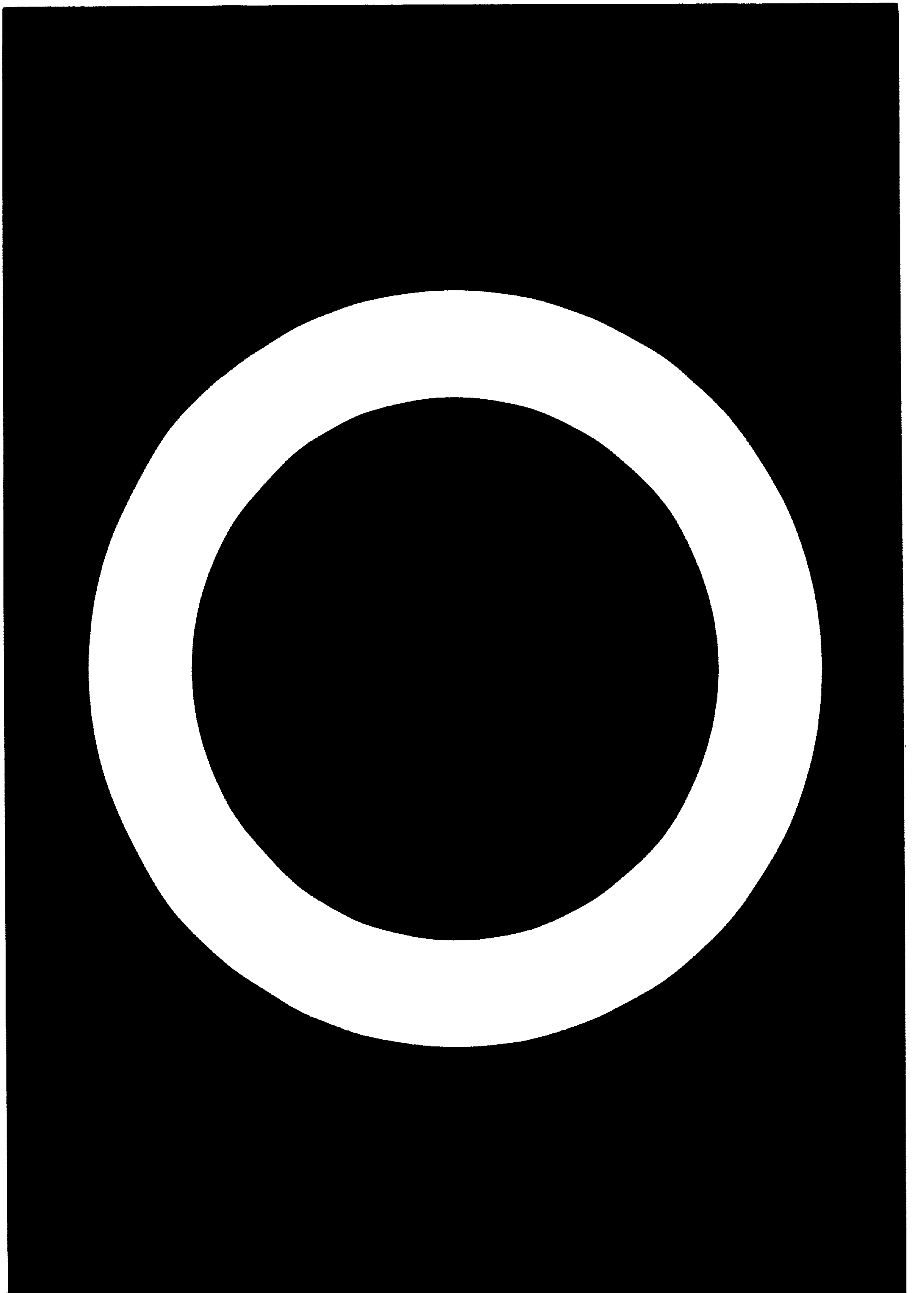
(b) That an assessment be made of the potential of natural gas reserves to meet all probable requirements from now until 2000;

(c) That certain areas within the Ministry of Water and Power be strengthened. The need for better accounting procedures should be given particular attention;

(d) That a study be prepared of the possibility of establishing a circular grid of transmission lines around the country;

(e) That co-ordination between power production and distribution centres be improved.

With regard to the establishment of an integrated chemical and petrochemical complex, the expert has recommended, as initial steps, that requirements for a plant operating at 80 per cent of capacity be surveyed; that a study be prepared of the costs of setting up a turnkey complex; that a statement of projected earnings for five years be elaborated; and that a publicity brochure be put together in order to attract foreign sources of financing.



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INTRODUCTION

The project "Pre-investment assistance for petrochemical industry" (SI/AFG/77/801) was requested by the Government of Afghanistan and approved by the United Nations Industrial Development Organization (UNIDO) on 27 June 1977 under the Special Industrial Services programme. The assistance was intended to follow up work done by a petrochemical engineer under another UNIDO project, SM/AFG/75/004, from October to December 1975. The allocation of $78,200 included the service of two experts, a petrochemical market analyst and a petrochemical processing-plant design and costing engineer. The market analyst was to prepare the ground for the arrival of the second expert. His nine-month mission began on 31 January 1978.

Objectives of the project

The purpose of the project was to assess present and medium-term markets for petrochemical end-products, such as PVC, which can be economically produced on a small scale, sufficient to supply domestic requirements. This was to be done by collecting market data and analysing the market for expected demand for end-products that could be produced with indigenous raw materials.

During the expert's first month in the country, however, it became clear to him from conversations with government authorities and officials of the Afghan Petroleium Company (and its subsidiary Petroleum Institute) that project priorities should be reconsidered in view of the goals of the existing national plan. The country was spending a great deal to import diesel oil for generating power, and hydrogenerated power would soon be inadequate to meet demand. Moreover, the current and foreseeable demand for petrochemicals was small, and imports of plastics such as PVC, if they continued on the modest scale expected, would not be nearly as serious a drain on foreign exchange reserves as that caused by continuing imports of oil and oil products. The country's most pressing need was therefore to exploit its reserves of natural gas in order to generate power. Moreover, it would be necessary to ascertain the total oil reserves available to the country and subsequently to make prefeasibility studies for the erection of a refinery capable of meeting most of the domestic demand for gasoline, diesel oil, kerosene, fuel oil and asphalt. Finally, as a long-term endeavour, a small petrochemical complex could be established for the manufacture of PVC resins and polypropylene.

UNIDO decided that formal revision of the project data sheet was unnecessary, since the change in emphasis could be reflected in the expert's work plan. Nonetheless, the arrival of the design and costing engineer for the petrochemical processing plant was postponed to give the expert time to prepare reports that took into account his new perspective on the situation. The post of the design and costing engineer was later cancelled at the request of the Government.

Work accomplished during the project

With the expert's help, a letter was prepared and sent to five international engineering companies soliciting proposals for the construction of a pipeline from Sheberghan gas field to Kabul. Responses were received from firms in Italy and in the United Kingdom of Great Britain and Northern Ireland. At the end of April there was a change in government, and the new Government concluded a contract with the Union of Soviet Socialist Republics on erecting a refinery.

The expert worked with the Ministry of Water and Power on the uses of natural gas in the thermal generation of power and in May issued the final version of a report entitled "A plan for the thermal generation of power using natural gas in co-ordination with the construction of a transmission system to encircle all of Afghanistan". The expert's second report, "A plastics market survey", was issued in July and included a recommendation for the establishment of an integrated chemical and petrochemical complex. The expert gathered preliminary data on the complex during the rest of his assignment.[1] He also reviewed, on government request, two prefeasibility studies, one on caustic soda and the other on the manufacture of woven polypropylene bags to be used to hold urea fertilizer, and evaluated a proposed integrated process for the manufacture of urea.

Finally, the expert was asked to assess (a) the raw materials requirements for an integrated chemical complex and (b) the country's natural gas requirements until 1990. His reports on these topics, which involved elaboration of his previous work, are contained in the present document.

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[1] Since then, the Government has decided to set up the complex with bilateral aid from the Soviet Union.

I. POWER GENERATION

At present, most of the power in Afghanistan is hydrogenerated or generated with imported oil. About 90 per cent of the total hydrogeneration of power takes place in five provinces located in the north-east, where many of the natural water resources are: Kabul, Parwan, Nangarhar, Ghazni and Pektia. These provinces account for 40 per cent of the population.

The hydrogenerating stations are within a 200-km radius of Kabul. Because of the concentration of power generation within this radius, industrial growth has also been confined to this area.

Problems in power generation are caused by:

(a) An inadequate supply of water owing to drought and insufficient snow melt, resulting in interruptions in the operation of the hydro stations;

(b) The uncertainty of diesel-oil imports in the winter, when transport is hazardous and sometimes impossible;

(c) The expense of power generation using diesel oil. All of the diesel generating stations operate only from 6 p.m. to 11 p.m.

By 1983 the total energy demand is expected to increase more than three-fold from 486.31 GWh (the 1976 figure) to 1,645.59 GWh. In the same period, foreign exchange expenditures on imported oil and derivative oil products will increase by a factor of 2.6, from $87.7 million to $226 million. To reduce expenditures on oil, indigenous natural resources need to be developed.

Afghanistan has a large natural gas resource, which is used partly in the thermal generation of power and partly at an ammonia-urea fertilizer plant. The balance is exported. In addition there are limited proven reserves of oil and some mineral deposits. Exploitation of the natural gas and oil would decrease foreign exchange expenditures, and the development of the iron and copper mines could result in earnings of foreign exchange.

Thermal power generation using natural gas

The only thermal generating station is located in the Mazar-Balkh area in the north. It is supplied with natural gas by a pipeline from the gas fields in the Sheberghan area. The line also supplies natural gas to the ammonia-urea fertilizer plant. The Ministry of Water and Power buys power from this station for distribution in the northern areas.

The proven gas fields are located approximately 657 km north-west of Kabul. The three possibilities for using the natural gas as a source of energy are:

(a) To construct a pipeline from the gas fields to Kabul, with spurs to be located along the route;

(b) To liquefy the gas at the fields and transport it cryogenically by truck to tank farms;

(c) To use the natural gas to generate power, which would be transmitted to consumers by power lines.

In the expert's opinion, thermal generation of power from the natural gas at Sheberghan and Mazar-i-Sharif would be the cheapest and most practicable method. (See his report "A plan for the thermal generation of power using natural gas".) The alternatives to the use of natural gas, considering only fossil sources of fuel, are crude oil, diesel oil, coal, wood and waste materials of various kinds, all of which would cost more per kilowatt hour generated than natural gas. Central to the expert's proposal for generating power from natural gas are:

(a) The creation of a circular grid of power transmission lines connecting all rural, urban and industrial sectors of the country;

(b) The connection of the transmission system with existing lines and power generating stations, thereby ensuring a constant supply of electricity.

Shortages of power would thus be overcome in areas where new projects for sugar, cement and textiles are planned.

The total estimated cost per kilowatt hour would be (in Af):

Generation of power	0.5207
Transmission system	0.4223
Total	0.9430

Cost of power generation using various fuels

The chemical composition of natural gas usually determines its fuel value. The natural gas of Afghanistan is rich in methane but poor in ethane, propane and butane; its density is 0.720 kg/m^3 under standard conditions. Natural gas containing ethane, propane and butane has an average fuel value of 39.07 MJ/kg (9,334 kcal/kg) compared with 33.28 MJ/kg (7,950 kcal/kg) for Afghan natural gas. The table below compares the fuel value and cost of natural gas, crude oil and diesel oil used for generating power.

Table 1. Comparison of fuel values and price between Afghan natural gas, crude oil and diesel oil used to generate power

	Type of fuel		
Feature	Afghan natural gas	Crude oil	Diesel oil
Theoretical fuel value	6.656 kWh/m^3	10.478 kWh/l	10.755 kWh/l
Actual fuel value	2.222 kWh/m^3	2.000 kWh/l	3.226 kWh/l
Performance (%)	33	19	30
Fuel price	0.820 Af/m^3	4.50 Af/l	8.00 Af/l
Fuel value per Afghani	2.710 kWh	0.444 kWh	0.403 kWh

Note: The actual fuel value of natural gas at the thermal station at Mazar-i-Sharif was supplied by the Electricity Department, Ministry of Water and Power. The source of the other energy data was Energy Tables (Stone and Webster International Consultants, New York).

As no data on hydro systems had been received from the Ministry of Water and Power at the time this report was written, it has not been possible to compare the annual operating costs of thermal and hydrogenerating power plants.

Recommendations

The expert made the following recommendations:

1. The operating costs per kilowatt hour of thermal generation and hydrogeneration of power should be compared with a view to demonstrating that the thermal generation of power using natural gas is cheaper than hydrogeneration. This will require developing cost accounting records for hydrogeneration of power, which are not available now (see recommendation 3 (c), below).

2. The requirements for natural gas and adequacy of reserves from now until 2000 should be assessed in terms of:

   Export demand

   Thermal generation of power

   An expansion of the ammonia-urea facilities

   The proposed integrated chemical complex

   Possible exploitation of the Hajikak iron ore deposits

Energy demand for copper ore concentration (and smelting) if the ore is not exported as 40-50 per cent concentrate

Household and industrial use

3. There are areas within the Ministry of Water and Power that should be strengthened. This can be accomplished through bilateral aid agreements, grants-in-aid or assistance from international agencies. The areas are:

(a) Management, which will be increasingly burdened as the country becomes more industrialized;

(b) Long-term planning;

(c) Accounting procedures, which require upgrading, especially in the maintenance of records on the electrical energy generated at all generating stations and the average operating costs at the hydro station. Such records are needed so that the cost of subsidizing the sale of electrical energy to the public and private sectors can be determined. Moreover, they would facilitate future decisions on purchasing power from a neighbouring country by allowing a comparison of the cost of imported power and that of domestic production.

4. An in-depth study should be made of the possibility of extending and connecting transmission lines so that they would form a circular grid around the country at a future date. Such a transmission system would be able to supply power, light and heat to all areas of the country at all times.

5. There should be better co-ordination between the centres producing and distributing power in order to avoid power losses and black-out.

II. DEVELOPMENT OF THE PLASTICS INDUSTRY

The plastics industry in the private sector has made considerable progress in the last 10 years. Its future direction will depend on government policies and support. Eventually, local manufacture of PVC will be necessary, and this should take place within a small, integrated complex, since PVC can only be produced economically if caustic soda, soda ash and chlorine are produced at the same time. Such a complex will be needed by 1990.

Accordingly, the expert prepared a project for the establishment of an integrated chemical and petrochemical complex based on the following raw materials: natural gas; salt; sand, fluorites and feldspar; and sulphur. The complex would be located near a source of natural gas and would consist of six plants:

<u>Plant 1</u> For conversion of natural gas into acetylene, reaction with hydrogen chloride from plant 2 (caustic soda) to form vinyl chloride monomer, followed by emulsion polymerization to yield PVC

<u>Plant 2</u> For electrolysis of salt to produce caustic soda, soda ash and chlorine, using the diaphragm cell process

<u>Plant 3</u> For reaction of surplus acetylene with surplus chlorine (and hydrated lime) to produce the dry-cleaning solvent chemically known as perchloroethylene

<u>Plant 4</u> For reaction of caustic soda (and some salt) with palm oil and coconut oil, or their equivalents, and tallow to produce quality soaps and detergents

<u>Plant 5</u> For reaction of sands with fluorites and feldspars at a high temperature to produce plate glass (using the Fourcault process) and glass bottles

<u>Plant 6</u> A central power plant to supply steam, power and electricity, process and cooling water etc. for the entire complex.

The expert's detailed project outline is contained in his report "A plastics market survey".

Raw materials requirements for an integrated chemical complex

The raw materials required for the five processing plants would be as follows:[2]

Plant 1

Acetylene plant producing 7,300 t/a:

Natural gas	41,500,000 m^3
Oxygen	37,800 t
Electricity	11,550,000 kWh
Steam at 1.8 bar (25 psig)	35,000 t
Water for cooling	175,000 m^3

Vinyl chloride monomer plant producing 15,000 t/a:

Acetylene	6,600 t
Hydrogen chloride	9,900 t
Catalyst (mercuric chloride)	15 t

Polymerization plant producing 12,500 t/a PVC:

Emulsion polymerization of the vinyl chloride monomer into PVC

Plant 2

Producing 12,500 t/a caustic soda
5,000 t/a soda ash
15,488 t/a chlorine

Electrolysis plant:

Salt	26,250 t
Sodium carbonate (58%)	440 t
Sulphuric acid (relative density 1.84)	1,750 t
Steam	175,000 t
Electricity	48,125,000 kWh
Refrigeration	15,750 t

[2] The source used in calculating the requirements was Faith, Keyes and Clark, Industrial Chemicals (Chemical Process Technology).

Soda ash plant:

Caustic soda	5,000 t
Carbon dioxide	5,000 t

The carbon dioxide is bubbled at the cathode into a solution which reacts with sodium hydroxide (caustic soda) in the same diaphragm cell in which caustic soda is produced. Sodium bicarbonate is formed, precipitated, filtered, dried and calcined to form soda ash.

Plant 3

Producing 3,650 t/a of perchloroethylene:

Acetylene	700 t
Chlorine	5,500 t
Lime (hydrated)	1,650 t
Catalyst (antimony chloride)	small amount

Plant 4

Producing 12,000 t/a of toilet soap and detergents:

Tallow	584 t
Coconut oil	184 t
Palm oil	68 t
Sodium hydroxide (from plant 2)	151 t
Industrial salt	110 t
Perfume	11 t
Coloring material	small amount
Electric power	200,000 kWh
Industrial water	48,000 kWh
Fuel (diesel)	360 l

The above requirements are for the full boiled process, which produces high-grade soaps. In the process of manufacture, fats and oils and liquid caustic soda are fed into a pan and processed as follows:

Boiling

Salting out

Washing

Clear boiling

Settling

The neat soap thus produced (liquid soap) is cooled, then mixed, refined, extruded, cut, stamped and packaged.

Plant 5

Plant rated capacity 10,000 t/a of glass, based on 907 kg of cleaned sand:

Sand	907 kg
Limestone	23 kg
Calcium and magnesium oxides (dolomites)	218 kg
Soda ash (from plant 2)	308 kg
Feldspars:	
Potassium oxide Aluminium oxide Silicon oxide	68 kg

Two sources of fuel are in use at major glass plants: natural gas and, where it is not costly, electricity. Coal is seldom used. To produce plate glass, the Fourcault process is suggested. For glass bottles, an automatic process is recommended. Information on a small glass manufacturing plant for plate glass and bottles may be obtained from:

The Japan Consulting Institute
Hibiya Park Building
1-1, Yuraku-cho
Chiyoda-ku
Tokyo

Recommendations

In the initial stages of establishing a chemical complex, considerable forward planning will be required:

1. The requirements for establishing rated plant capacities operative at 80 per cent should be surveyed.

2. A prefeasibility study should be undertaken to determine the estimated total cost of a turnkey complex and to itemize the total requirements for domestic currency and foreign exchange.

3. An earnings statement should be elaborated, projected forward for at least five years, delineating net earnings, after all expenses, and the return on the total assets employed (which will include working capital).

4. A brochure should be prepared for use in seeking foreign sources of financing. It should refer to all of the basic elements of the complex and include a well organized financial section.

III. NATURAL GAS REQUIREMENTS UNTIL 1990 (1369)

In summary, the country's annual requirements of natural gas at intervals from 1975 (1354) until 1990 (1369) are (in millions of cubic metres):

1975 (1354)	192
1982 (1361)	1,013
1990 (1369)	1,285

These estimates may be exceeded, depending on the efficiency of plant operations and general maintenance. No provision has been made for the natural gas that will be required in the development of the Hajikak iron ore deposits. Natural gas is a preferred reducing agent. The coking qualities of Afghan coal should be rechecked, since the coal varies in quality from mine to mine. Furthermore, no provision has been made for Ainak copper ore. Power will be required if sintering is to be used to obtain a concentration of ore exceeding 40-50 per cent.

Table 2 gives the breakdown of natural gas requirements in 1975 (1354) and of the estimated requirements in 1982 (1361) and 1990 (1369), based on projected production in the particular area of use. The following explanatory remarks apply to the table.

Ammonia-urea fertilizer

According to the seven-year plan (p.127), 63 kt of fertilizer were to be produced in 1975 (1354) and 105 kt in 1982 (1361). Reference was also made in the plan to the need for a new fertilizer plant with a rated capacity of 300,000 t/a. By 1990 (1369), however, there may be shortfall in urea, and so the projected required capacity has been raised to 350,000 t/a. Approximately 810 m^3 of natural gas is needed to produce 1 t of liquid ammonia.[2/]

[2/] The other amounts of raw materials needed to produce 1 ton of liquid ammonia are:

Catalysts, small amounts	150 g
Caustic soda	250 g
Monoethanolamine	150 kg
Gas for compressors	7,095 kWh
Electricity	120 kWh
Water	25 m^3

Thermal power generation

According to the seven-year plan (p.172), the capacity of thermal power plants should be 42.7 MW in 1975 (1354) and 332 MW in 1982 (1361). Reference was also made in the plan to the need to reduce the effect of drought and insufficient snow-melt by supplementing hydrogeneration of power by thermal generation using natural gas and coal. An increase in capacity of 16,000 kW over the 332,000 kW shown in the plan for 1982 (1361) is projected by the end of 1990 (1369). The fuel value of natural gas per cubic metre at Mazar station, 2,222 kWh, was used in projecting the gas requirements for thermal generation. Annual operating hours of 6,048 were calculated (70 per cent of 360 days x 24 hours).

Integrated chemical complex

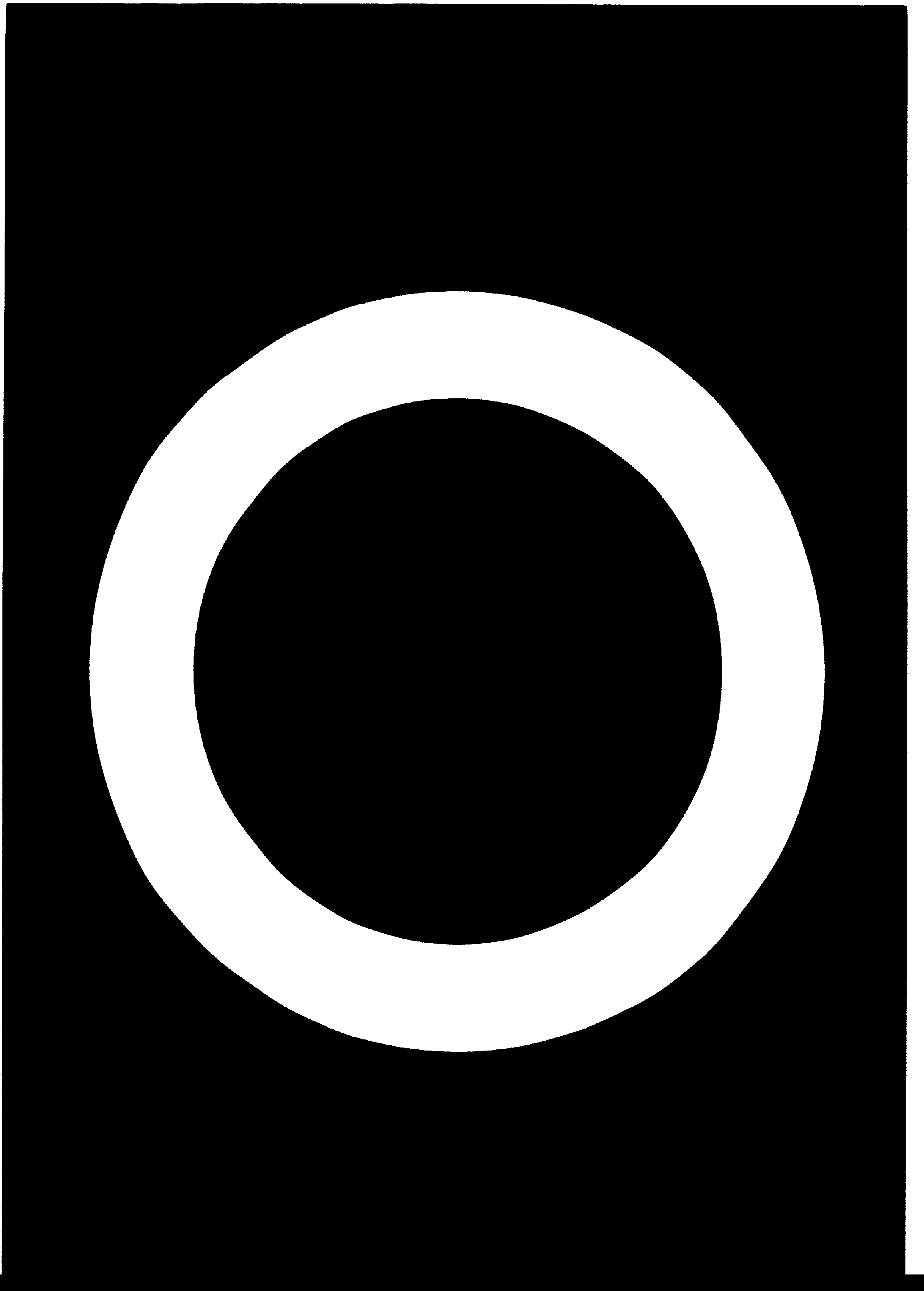
Although the power requirements for the proposed complex are shown separately for information purposes, they could probably be met by the expanded thermal generation facilities.

Other

This line covers other requirements mentioned in the seven-year plan. The requirement will have increased by 6 million cubic metres by 1990 (1369).

Table 2. Natural gas requirements for 1975 (1354), 1982 (1361) and 1990 (1369)

Area of use	1975 (1354)	1982 (1361)	1990 (1369)
Ammonia-urea fertilizer	51	85	283
Thermal power generation	117	904	945
Integrated chemical complex	-	-	27
Other	24	24	30
Total	192	1,013	1,285



Annex

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