ROLE OF PAKISTAN'S NATURAL GAS INDUSTRY TOWARDS SELF RELIANCE IN THE ENERGY ECONOMY

A. SAMAD

Project Manager
Sui Northern Gas Pipe Lines Limited
LAHORE

ABOUT THE AUTHOR

Mr. A. SAMAD passed B.Sc. degree in 1953 and his B.E. (Mechanical) from University of Peshawar in 1959. He obtained his M. Sc. (Petroleum Engineering) from University of Alberta, Canada in 1962. He worked with British American Oil Company, Edmonton, Alberta in 1962/63 as Petroleum Reservoir Engineer. Mr. Samad joined Sui Northern Gas Pipelines Limited in 1964 and is at presently designated as Projects Manager.

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INTRODUCTION

Since last winter's oil crisis there has been a lurking fear of the difficulties which may accompany the shortage of energy throughout the world. In the United States and some European countries the situation was more difficult but this difficult situation was suddenly transformed into a critical one when the Arab states decided to cut off the oil flow to these countries because of their support of Israel, and as a result the Americans and the Europeans had their first personal bitter shivering experience of the hardships brought by the energy crisis. Besides the inconveniences of the cold weather the world in general is now scared of the possibility of high inflation, unemployment and worst economic recession after a long economic boom. Production has been cut back of steel, chemicals, fertilizers, auto-industry, tyres, plastics and the petroleum based polyester fibres.

We in Pakistan although not self sufficient in oil have been fortunate in not feeling the pinch of oil squeeze due to continued oil supplies from our Arab brethren and due to production from our indigenous natural gas resources. But the energy crisis has started showing its adverse effects on our economy which has been growing on the basis of a $ 3 a barrel oil price and has now shot up to $ 10 a barrel and may even go up higher. This only means that most of our resources will be eaten up by import of oil at higher prices. The prices of imported materials, plant, machinery and spare parts which are vital for our economy will be pushed even higher and are bound to offset our development plans. On the other hand the increased cost of bunker oil is expected to have disastrous effects on the shipping lines which carry our export materials. As a result, our vital export business which has shown great promise in the last year will almost certainly be seriously sapped.

There appears to be a definite co-relation between the population of a country, its Gross National Product and the growth of energy

demand. In Pakistan, like most of the developing countries, the growth rate of energy demand is going to outstrip growth rate of gross national product, which will be determined by the product of our industries.

The growth of the industrial economy in Pakistan will mean an ever increasing demand for energy and will require great expansion of the Nation's financial, physical and human resources to meet this demand.

At present Pakistan gets 45 percent of its total industrial and commercial energy requirements from imported oil which used to cost Pakistan approximately Rs. 50 crores per year foreign exchange before the recent price hike. With the price increase the imported oil costs have risen to approximately Rs. 350 crores, which is about one third of Pakisran's total export earnings. Thus the import of oil will upset our foreign trade balance and nullify most of our efforts to earn maximum foreign exchange required for the development plans. How are we going to prevent this from happening ? One possible way could be to compete more vigorously in the export market of the world. But this can cause lot of hardships to our people and complications for our economy. But a better method to prevent upsetting of foreign trade balance will be to make a determined effort to search systematically for economically exploitable indigenous resources and to increase their utilisation.

Energy Policy of Pakistan

The development of a nation, its industries and peoples, and satisfaction of their wants depends upon the availability of energy. Therefore, the energy policy of Pakistan should have as its ultimate objective the creation of a just and prosperous society through control and effective utilization of all water and other natural resorces for the benefit of people. Since living conditions and life of people are based on the foundation of energy in all its forms and manifestations, high quality, reliable and low cost supply of energy is a precondition for a developed economy and a higher standard of living. Therefore, special attention should be paid at present to studies of energy resources and national compilation of fuel and energy balance for Pakistan.

Although an energy supply and demand survey is now being carried out by the Government with the help of United Nations, it is felt that means and possibilities of increasing the role of indigenous fuel resources in the energy economy of Pakistan requires immediate setting up by the Government, of a centralised energy statistical programme which should aim at collecting and compiling of all the statistics required for this purpose. This centralised agency staffed by highly trained Pakistani engineers, geologists and economists should encourage the establishment of common national statistical objectives, and development of statistics oriented towards basic economic principles. This system should be able to prevent conflicting demands from various sections of industry concerned with production and transportation of energy. This agency should provide complete commodity analysis of each energy form and interrelate these analysis to produce aggregations of energy consumption for manufacturing and other utilizing industries. These statistics can then provide all the data required to draw up an energy balance sheet for the country, which in turn should make forecasting analysis possible. In other words this centralised statistical programme should give all the information required by the Government to balance energy availability with energy needs in consideration of the inter-relationship with the various forms of energy, from the producer to the ultimate consumer.

Based on this statistical data of energy supply and demand inter-related projects may be planned for exploration of indigenous energy resources, the establishment of energy processing facilities and ancillary services for the transport, distribution and marketing of energy.

Planners should consider all forms of fuel and energy for which there is a potential economic use within the country. Besides coal, oil. natural gas, hydro power and nuclear power which are the known sources of energy in Pakistan, other conventional sources of energy such as fuel wood, animal wastes and non-conventional solar energy should also be considered.

We have to concentrate on exploration, development and extraction of energy resources, developing new technologies suitable for our local conditions, promoting efficiency, minimizing waste and thus wisely using our local resources. However because of limited finances

and forces available at present, the ultimate objectives will have to be met in successive stages.

As we are attempting to develop an industrial base it is important to assess our dependence on non-indigenous supplies, in terms of both balance of payments and the international political scene. It is in our national interest to keep production and consumption in line with our resources and to keep waste and losses at a minimum. We should be able to exercise some foresight and avoid errors of waste which may prove to be too expensive and disastrous for our next generation. While all efforts should be directed towards searching for and exploiting of indigenous sources of oil and gas and development of other sources of energy, we must take a step towards conservation by avoiding wastage of energy.

Pakistan's Principal Source Of Energy—Natural Gas

Nineteen years ago, contribution of natural gas towards energy requirement of Pakistan was almost nil while today it is Pakistan's only major source of indigenous fuel which supplies approximately one-third of the country's total energy demands. In increasing its share of the energy market from zero to 35% in the last 19 years, the actual average sales of natural gas has expanded from 10 million cubic feet per day in 1955 to 378 million cubic feet per day in December 1973. The average daily production of raw gas from Sui field in December 1973 was approximately 408 million cubic feet, The length of transmission lines has grown from 347 miles in 1955 to 1496 miles in 1973 *i. e.* an increase of 330%. Perhaps these few statistics convey in some small way the dynamic growth the Pakistan gas industry has enjoyed. This expansion has come about because gas is a convenient product ; as consumed, gas is easily controlled and is extremely clean. No overhead wires are required to transmit this energy neither it is delivered in noisy bowsers, but it is delivered by quiet under ground pipelines. The sensational expansion of natural gas industry in Pakistan has been due to the advantages of natural gas over other energy forms.

Exploitation and Development of Natural Gas.

Besides having adequate gas reserves and a potential market three things are very important for making a dynamic expanding gas industry and these relate to the economic aspect of the industry. Firstly, the explorers and producers of gas will not have any incentive to develop the

known fields and potential regions unless they get reasonably encouraging price for their well head gas production. Secondly a reliable pipeline and compression system must be available for economical transmission and distribution of gas and lastly gas must be delivered to the consumer at an attractive price.

Following paragraphs of my paper are directed towards the area of the availability of gas reserves, the position of transmission and distribution system, and the potential market for natural gas in Pakistan,

Natural Gas Fields.

Natural gas has been discovered in nine gas fields at Sui, Uch, Zin, Mari, Kandhkot, Mazarani, Khairpur, Sari and Hundi, with proven recoverable gas reserves of 16.741 million million feet and, which in terms of Sui quality raw gas is equal to 13.121 million million cubic feet, Fig. 1 shows the location of these fields and Appendix 1 gives the composition of gas for each of these fields, their original proven recoverable gas reserves, and recoverable reserves in terms of Sui quality gas after BTU adjustments. In addition to above dry gas fields oil fields at Dhulian, Meyal and Tut are also producing associated gas. Original recoverable reserves at Dhulian are estimated at 0,150 million million cubic feet. It is worthwhile to have a look at these gas fields with more detail.

Sui Gas Field.

Biggest producer by far is the Sui field discovered by Pakistan Petroleum Limited in 1952. The original Sui gas reserves are estimated to be 8.62 million million cubic feet with a gross heating value of 933 BTU per cubic feet and methane content of 88.52 percent. 18 wells have been drilled in this field while well No. 19 was spudded in early February 1974. By end of December 1973 a total of approximately 1.0 million million cubic feet of gas was produced from this field or approximately 11.6 percent of the total gas in place has been produced since 1955. This total gas sold is equivalent in heating value to 23.8 million tons of furnace oil.

Mari Gas Field.

Pakistan's second natural gas field to go into production and the second largest after Sui is at Marri near Dharki in Sind. This field was

discovered by Standard Vacuum Oil Company (renamed as Esso Eastern Inc.) in 1957. Recoverable gas reserves of Marri field are currently estimated at 3.942 million million cubic feet having a Gross Heating Value of 723 BTU/cu ft. which is equivalent to 2. 99 million million cubic feet of Sui quality gas. Gas production from Marri field was commenced in 1967, and due to high concentration of nitrogen (19. 5%) is mainly used as feed stock in Esso's urea fertilizer plant at Dharki. Till the end of December 1973 approximately 48,500 million cubic feet of gas has been produced from this field.

ZIN AND UCH GAS FIELDS

Fields at Zin and Uch in Baluchstan located in the same general area as Sui were discovered by Pakistan Petroleum Limited in 1954 and 1955 respectively. Original recoverable reserve at Zin are estimated to be 0.10 million million cubic feet with a low calorific value of 484 BTU/cu. ft. and is equivalent to only 0.050 million million cubic feet of Sui quality gas. Recoverable reserves at Uch are estimated at 2.5 million million cubic feet. Uch gas reserves although quite sizeable have a low heating value of 308 BTU/cu. ft, and are equivalent to only 0.80 million million cubic feet of Sui quality gas. Due to their remoteness from the centers of consumption and their low gross heating value exploitation of Zin and Uch at this stage is not considered to be economically feasible.

Khairpur gas field

Gas reserves at Khairpur were also discovered by Pakistan Petroleum Limited in 1957. The original gas reserves of this field are estimated at 1.0 million million cubic feet. Khairpur gas has a very low component of methane and ethane (12.2%) and is very rich in carbon dioxide (70.6%) and therefore has an extremely low Gross Heating Value of 130.0 BTU/cu. ft. As such exploitation of Khairpur gas for using as a fuel or feed stock in fertilizer and other chemical industries is not considered economical. However, this gas can be beneficially used to produce carbon dioxide. It is estimated that approximately 100 tons per day of carbon dioxide can be produced from Khairpur gas fields, which is a very valuable raw material for variety of industrial uses.

Mazarani Gas Field

Mazarani field in Sind was discovered in 1958 by Pakistan Petroleum Ltd. and has recoverable gas reserves of 0.090 million million cubic

feet. Gross heating value of Mazarani gas is 976.0 BTU/cu. ft. which is the highest of all the natural gas fields in Pakistan. The reserves in terms of equivalent Sui quality gas are estimated at 0.094 million million cubic feet. Mazarani gas field is very conveniently located to supply gas for industries near Larkana area.

Kandhkot Gas Field

Pakistan Petroleum Ltd. also discovered a gas field at Kandhkot in Sind in 1959. The original recoverable reserves are estimated at 0.410 million million cubic feet wiih Gross Heating value of 842 BTU/cu. ft. which is equivalent to 0.370 million million cubic feet of Sui quality raw gas. Kandhkot is also very conveniently located to supply gas either to WAPDA's Thermal Power Station at Guddu, or to the proposed Fauji Foundation Fertilizer Plant at Machi Goth.

Sari and Hundi Gas Fields

Sari Singh Field situated about 45 miles north east of Karachi was discovered by Oil and Gas Development Corporation in 1967. Its original recoverable gas reserves are estimated at 0.029 million million cubic feet with a Gross Heating Value of 873 BTU/cu. ft. which in terms of Sui quality gas are equivalent to 0.027 million million cubic feet. A second gas field was discovered by OGDC in 1970 at Hundi in the neighbourhood of Sari Singh. Hundi field has an original recoverable gas reserve of 0.050 million million cubic feet with a Gross Heating vaiue of 828 BTU/cu. ft. which is equivalent to 0.040 million million cubic feet of Sui quality raw gas.

OGDC's Sari and Hundi fields are now being developed to supply approximately 14 million cubic feet of gas to Karachi.

Safed Koh Region Gas Fields.

Recently OGDC has discovered gas reserves in the Safed Koh Region i.e. at Rodho, near Taunsa, located in D.G. Khan District. However, it is too early to comment on the production prospects of this field where formation testing is now underway.

ASSOCIATED GAS

Dhulian

Besides the above dry natural gas fields associated gas is available in Attock Oil Company's Dhulian Gas Field which was discovered in

1935. Original recoverable reserves are estimated at 0.150 million million cubic feet with Gross Heating value of 1100 BTU/cu. ft. which is equivalent to 0.176 million million cubic feet of Sui quality raw gas. Dhulian gas is being supplied to Rawalpindi area since March 1957 and to Daudkhel since June 1972.

Tut

Tut oil field was discovered by OGDC in 1968 but the recoverable reserves estimated are not yet available. It is, however, estimated that approximately 2 to 3 million cubic feet gas per day will be produced for supplementing Dhulian gas supply to Daudkhel by early 1975.

Meyal

Meyal Oil field was discovered by Pakistan Oil Fields Ltd. In 1968. Estimates of recoverable associated gas reserves are not available. However, gas supply at a rate of 12 million cubic feet per day will be available from November/December 1974 which is expected to increase to 15 million cubic feet per day by 1975/76.

Development of Gas Fields

In view of above gas recoverable reserves from various fields a policy of development of these fields must be decided upon by the Government. The guiding principle of this policy should be the obtaining of maximum proceeds for the Pakistan economy by being self-reliant.

The rate at which the gas can be produced and sold determines the value of the gas reserves. The sale of gas, of course, must take into consideration the price at which it can be sold in competition with other fuels, including imported oil. According to the simple economic laws quantities and prices are interdependent, so that in this case there is a problem of optimization of quantities and production which keeps gas prices at a favourably competitive level in comparison with other fuels. The maximum present day value of the nett proceeds from the existing reserves can be determined by making a study in which allowance is made for production possibilities, production costs, transport costs and the influence of price variations on the quantities sold.

The basic consideration in such a study will have to be the consumer demand with regard to the period over which the gas supply can be maintained. Big fertilizer and cement plants as well as other industries, which install processes based on natural gas feed stock or build new

gas fired installations or convert existing equipment to natural gas, will require a firm assurance of regular gas supply for a period of at least 20 to 25 years from the gas distribution companies. In the case of power sector too, the choice of fuels for their machines is also partly determined by the period of supply, which must at least be equal to the depreciation period. In view of heavy investment made by the gas distribution and transmission companies they will ask for guaranteed gas deliveries for at least 30 to 40 years, especially as the Government rules allow 40 years period for depreciation of transmission pipelines.

In view of above, if natural gas is not to be regarded as a very temporary source of energy (as in the case of Sari/Hundi fields which will only supplement Sui gas supply to Karachi for 15 years period) it must be taken into account when exploiting the available reserves that the sales of gas must be capable of being continued for a period of at least 30 years. The most favourable production pattern in the development of gas field is determined by a number of economic and technical factors.

After the build up, depending entirely on the speed at which a market can be created, a certain production level can be maintained until about 80% of the existing reserve has been produced. A gradual decline in pressure, and consequently production, will then have to take place.

For a large gas reserve like Sui a production period of about 30 years can reasonably be regarded as economically justified from the production point of view. The decline in production after about 80% of the reserve has been produced implies that with reserves of 8.62 million million cubic feet at Sui, supply contracts can be concluded in which Sui gas quantities can be guaranteed until the time a cumulative figure of about 6.9 million million cubic feet has been sold. The rest of 1.72 million million cubic feet can be sold in those sectors of the energy market where it has most important application, which should be determined by the Government. However, for Sui gas field after reaching gas offtakes of 935 million cubic feet per day estimated to be attained in 1978/79, it will be necessary to maintain the supplies at that level for approximately 15 years till production starts declining. In other words if no other fields are exploited the gas supply expansion programme will have to be stopped after reaching a level of 935 million cubic feet per day from Sui gas field, and after 1994 drastic gas curtailment and disconnections will be required to maintain gas supplies at a sliding scale commensurate with declining production.

Due to short production history of Marri gas field reserve estimates cannot be confirmed. Furthermore, it is anticipated by the owners of Marri gas field that only 60 percent of the reserves are recoverable at a maximum deliverability rate of 328 MMCFD over a period of approximately 20 years, before the production decline starts.

Taking into account total recoverable reserves of Sui raw gas quality of 12. 317 million million cu. ft. from the gas fields at Sui, Mari, Mazarani, Kandhkot, Sari Singh, Hundi and associated gas at Dhulian (recoverable gas reserves at Meyal and Tut not being known have been ignored), sales contracts can be assured till a total quantity of 9. 85 million million cubic feet of Sui raw quality gas has been produced.

Total natural gas consumed uptil 31 December 1973 and the projected loads for existing areas, firm projects and possible projects which may materialise on Sui Gas Transmission, Sui Northern and Marri gas systems from January 1974 to December 1991 is estimated to be 9. 45 million million cubic feet of equivalent Sui quality (raw) gas.

It means that after 1991 a gradual decline of production will be required and Goverment will have to decide the industries which being of premium importance should receive gas in preference to other industrial and commercial consumers.

Taking the above considerations into account it becomes obvious that although the energy situation viz-a-viz availability of gas reserves is quite happy today it will become critical by 1990 and therefore detail studies have to be made by the Government, as soon as possible to arrive at the most appropriate development policy for the existing fields and for new gas explorations. A policy is also required to be made for conservation of energy by the end of 1980 so that the industries using natural gas as feed stock do not get affected,

Gas Transmission

Having examined the situation of gas reserves and their possible development policy, it is appropriate to have a brief look at the gas pipeline transmission systems that carry gas from the source to the consumer's premises.

Beginning with the construction of a pipeline from Sui to Karachi during 1954/55, these years have seen considerable and concerted activity and endeavour in the field of both transmission and distribution develop-

ment of natural gas. This will be apparent from the fact that since 1954, the gas industry in West Pakistan has constructed 1496 miles of high pressure main pipelines and looplines varying from 4 inches to 24 inches. In this total length of pipeline 13.77 percent is the length of looplines. Proportion of various sizes of pipeline lengths in the total length of 1496 miles of high pressure gas pipelines is as under :—

16″ dia.	=	48.49%
10″ dia.	=	19.45%
18″ dia.	=	11.36%
8″ dia.	=	7.62%
12″ dia.	=	7.09%
6″ dia.	=	4.86%
4″ dia.	=	1.07%
24″ dia.	=	0.06%

In addition to the pipelines a total compression of 42,600 horse-power has been installed on the gas transmission systems transporting Sui gas to Southern and Northern gas systems. Approximately 79 percent of this compression is installed on the Sui Northern system.

Gathering Lines and Purification Plant at Sui

In 1953 Pakistan Petroleum Ltd. installed field gathering system at Sui. At the same time a natural gas purification plant of 74 million cubic feet per day capacity was constructed at Sui by the Pakistan Petroleum Ltd. to remove the harmful constituents found in the raw gas, such as carbon dioxide, hydrogen sulphide and water so as to make it suitable for industrial, commercial and domestic uses and harmless for the transporting pipelines.

Sui Gas Transmission Company, which was formed in 1954 for the purpose of construction and operating of a transmission pipeline from Sui to Karachi, also took over operations of the Sui purification plant.

The capacity of the purification plant was increased to 200 million cubic feet per day by adding two banks in 1960 and modifying the existing plant to handle 50 million cubic feet per day through each of the 4 banks. Bank No. 5 was added in 1964 and Bank 6 and 7 in 1971. The present purification capacity at Sui is 475 million cubic feet per day, out of which a capacity of 255 MMCFD is dedicated to Sui Northern's operations and 220 MMCFD for Sui Gas Transmission Company's operations.

Two new banks of 100 MMCFD capacity each are to be installed under Sui Northern's Project 4 and one new bank of 100 MMCFD by Sui Gas Transmission Company by mid 1977. This will raise Sui Purification Plant capacity to 775 MMCFD.

Southern Transmission System

The 16" diameter 347 miles of pipeline from Sui to Karachi was constructed in 1954, with a free flow capacity of 70 million cubic feet per day under normal conditions. In 1964 this capacity was increased to 90 million cubic feet per day by raising the inlet pressure at Sui from 1070 psig to 1130 psig. With the increase in gas demands the capacity of this system was further increased to 140 MMCFD by the addition of two compressor stations, each of 4500 installed HP commissioned in 1966 and 1968.

Based on the projected gas demands in Karachi, Hyderabad, Nawabshah, Sukkur and other towns south of Sui, upto year 1987 Government has approved construction of 305 miles of an 18" pipeline, between Sui and Karachi along the Indus right bank route passing through Shikarpur, Larkana, Dadu and Sehwan, This project will be carried out in two phases. In the first phase 45 miles of pipeline from Sari/Hundi gas fields to Karachi will be constructed which is expected to be completed by end of April 1975. In the second phase remaining portion of 260 miles of pipeline between Sui and Sari/Hundi fields will be constructed. Government has provided the foreign exchange portion for import of pipe and other material for the first phase of construction while for the second phase foreign exchange cost is being arranged through an Asian Development Bank loan.

The completion of first phase of pipeline from Sari/Hundi fields to Karachi will provide a capacity addition of 14 million cubic feet per day. Completion of second phase from Sui to Sari/Hundi will make additional 112 million cubic feet per day available for southern system. Thus total capacity of Sui Gas Transmission Company's existing pipelines and new Indus Right Bank pipeline will be 266 MMCFD. With economical compression on the Indus right bank pipeline in future additional capacity of 114 million cubic feet per day can be provided.

Northern Transmission System

To meet the requirements of gas firing of boilers of WAPDA's 265 MW capacity thermal power plant and the feed stocks for PIDC's fertilizer

factory at Multan a 217 miles of 16" pipeline was laid from Sui to Multan. Work on the construction of this pipeline was started in 1956 and completed by 1958. In the absence of Guddu Barrage over river Indus an 82 miles of 10" pipeline link was laid between Rohri and Bhong on the left bank of Indus.

In 1963 Sui Northern Gas Pipelines system was incepted and took over operations of Sui-Multan pipeline and a small 6" gas distribution system supplying gas from the Dhulian oil field to a few consumers in Rawalpindi and Wah. In late 1963 Sui Northern started planning for the extension of Sui system from Multan northwards to Lyallpur, Lahore, Gharibwal, Khewra and Dandot and connecting Sui gas system with Dhulian gas system at Galli Jagir and for establishing and developing complete distribution systems at all these places.

During December 1963 one mile long 24" diameter pipeline was installed at the newly completed Guddu Barrage crossing and the 82 miles of 10" link line from Rohri to Bhong on left side of Indus was uplifted.

In June 1964 construction of 5880 feet long pipeline bridge crossing over river Sutlej near Panjnad Head Works was completed. This bridge comprises 6 feet diameter piers, 160 feet deep, carrying a self supporting structure of 3×12" diameter pipeline.

In December 1964 the construction of 129 miles of 16" Multan-Lyallpur pipeline was commenced and gas supply in Lyallpur was made available in June 1965. 98 miles of 12" line from Lyallpur to Haranpur, Khewra and Dandot was completed in February 1966, while gas supply to cement plant at Gharibwal was commissioned through an 8 mile long 8" dia. pipeline from Haranpur to Gharibwal. A 74 miles long 10" diameter pipeline was laid from Lyallpur to Shahdara which was further on extended to Kala Shah Kaku. This line was commissioned in June 1966 to supply gas to industrial, commercial and domestic consumers in Lahore, to WAPDA's gas turbine generating station at Shahdara and to the industrial complex at Kala Shah Kaku.

Simultaneously with laying of the above mentioned high pressure transmission pipelines Sui Northern's own construction group was formed as early as June 1964 which undertook the work of uplifting of 27 miles of Dhulian to Galli Jagir 6" pipeline and replacing it with a 10" diameter high pressure pipeline, thus increasing the flow capacity of Dhulian to Galli Jagir line, where it was connected to Sui gas system through a 67 miles of 10" diameter pipeline from Dandot to Galli Jagir, which was commissioned in October 1967, together with 28 miles of 10" pipeline from

Galli to Wah, which had replaced Attock Oil Company's old 6" pipeline. A 6 miles long 6" dia, pipeline was constructed between Wah and Hattar in July 1966 to supply gas to the cement plant at Hattar.

Due to rapid increase of gas offtakes in the newly connected areas it was foreseen that it would soon not be possible to transmit gas without gas compression. In order to obtain the maximum throughput from a given pipeline system at minimum total cost it is necessary to re-compress the gas at intervals to maintain the highest level of pressure in the mainline. Sui Northern increased the free flow capacity of 90 million cubic feet per day ex-Sui fields to 172 million cubic feet per day (12 MMCFD coming from Dhulian) by installing 4 gas turbine driven centrifugal compressor stations totalling 13,200 HP on Sui-Multan sector during 1967-68.

The need for further increase of pipline flow capacity was felt to meet the gas requirements of Dawood Hercules Fertilizer and that of general industry upto 1971. As a result of an evaluation of economic merits of looping the pipeline versus construction of compressor stations, for increase of capacity from 172 million cubic feet per day to 207 million cubic feet per day, 93 miles of 18" partial loopline between Sui and Multan was installed, together with installation of 9900 HP compression. Under the programme, called Sui Northern's Project 2 a new compressor station with 3300 HP was installed at Lyallpur and 6600 HP was added at the 4 existing compressor stations. This capacity increase was achieved in 1971.

Under the third project of Sui Northern Gas Pipelines Limited pipelines have been extended to Peshawar, Nowshera, Mardan, Takhtbai, Charsadda, Daudkhel and Gujranwala. The gas demands in these new areas and the normal industrial growth necessitated an expansion in system capacity from 207 to 277 MMCFD, which was achieved by addition of 10600 HP compression and installing of 76 miles of 18" looplines between Sui-Multan and 30 miles of 16" loop between Multan-Lyllpur. This project was completed in July 1973.

A 38 miles of 16" diameter pipeline from Sui to Guddu was laid by Sui Northern in 1973 to supply raw gas for WAPDA's thermal power station at Guddu.

Pipeline projects of Northern system

In order to supply 26 million cubic feet of gas per day to meet a

part of the gas requirements of WAPDA's new 200 MW gas turbine station at Lyallpur, Sui Northern is now implementing its project designated as Project 3A. Under this project Sui Northern's system capacity is to increase from 277 MMCFD to 297 MMCFD by constructing a 10" dia 14 miles new pipeline between Meyal and Dhulian fields and 51 mile of loopline between Sui and Lyallpur. This also involves shifting of 4 compressor units from Sui to other existing compressor stations. The pipeline between Meyal and Dhulian was completed in March 1973 and the compressor units from Sui have been shifted. Construction of looplines was started in July 1974 and completion is expected by January 1975. Foreign exchange requirements for this project have been provided by the Government,

In addition to the above mentioned project Sui Northern is also planning to further expand its system capacity by 118 MMCFD so as to meet increased gas demand of WAPDA for additional power generation, for the new fertilzer plant at Multan, Dawood Hercules fertilizer plant expansion, new fertilizer plant near Nowshera, a new sugar mill at Peshawar, expansion of cement plants at Dandot and Hattar and normal growth in industrial, commercial and domestic consumption till 1978. This proposed expansion of 118 MMCFD in system capacity envisages construction of 181 miles of pipelines including 116 miles of looplines and 65 miles of new pipelines to extend gas supplies to the towns of Sialkot, Wazirabad, Sheikhupura and Sargodha. In addition to this, incremental compression facility of 27200 horse power will be installed.

As the purification capacity at Sui will not be adequate to meet Sui Northern's gas demands for this expansion programme, 2 additional purification banks of 100 MMCFD capacity each will be installed at Sui,

According to the proposed schedule the expansion of the transmission system capacity from 297 MMCFD to 415 MMCFD will be achieved by June 1977.

This project known as Sui Northern's Project 4 will be implemented in two phases. The first phase called Project 4A will involve construction of 28 miles of 18 inch diameter loopline between Sui and Multan and one purification bank of 100 MMCFD capacity at Kashmore. The remaining Project 4 work will be executed in the second phase which will be known as Project 4B.

Possible Future Projects

As the demand for natural gas in the Punjab and NWFP increases there will be a need for additional transmission capacity. The Planning and Development Department, Government of Punjab has recently completed a survey of gas demands for industrial units in the Punjab and NWFP, which will remain unconnected after completion of Sui Northern's Project 4 expansion programme. Keeping in view tremendous demand of gas in various cities and towns in Punjab and NWFP a new pipeline on west bank of Indus, bringing gas to Multan via Dera Ghazi Khan, Kot Addu, Muzaffargargh from possible new fields in the Safed Koh region *i.e.* Rodho, Dhodak, Zindapir and Sakhi Sarwar in D. G, Khan District is a near possibility. If a sizeable gas reserve is discovered then gas pipelines can also be extended to Khanewal, Chichawatni and Sahiwal on one side and D. I. Khan, Mianwali, Hangu and Kohat on the other.

Before undertaking a huge expansion programme of the above mentioned magnitude the availabilities of gas reserves and the deliverability rates of various fields will have to be kept in mind.

Although the question of pipeline optimisation and compressor design is not within the scope of this paper, it is relevant to indicate at this point that the design of a transmission system is affected by a number of factors, the most important of which is not only the size of the load, but also its rate of growth, load factor and location. These parameters are by no means constant so that investigations need to be carried out as the system develops and the modification to the solution can be introduced in the light of new data. When making decisions, a solution should be chosen which gives the widest possible tolerance to variations in design parameters without making it invalid. Criteria which are most important in this respect are demand, its rate of increase and ultimate development, and of course rate of return on capital. It is therefore suggested that any future expansion programme envisaging construction of a pipeline on west bank of river Indus bringing gas to Northern areas must be based on a firm demand keeping in view the rate of increase and ultimate development. The economics of a new pipeline on west bank of Indus will have to be weighed against those of expansion of existing system by further economic looping and addition of compression. Furthermore, the question of gas supply extension to new

areas should be viewed in a larger perspective of the total energy demands and availability and production capability of gas reserves and other energy supply sources such as furnace oil and LPG from the refineries in Pakistan.

Gas Distribution and Utilization

The first ever distribution network in Pakistan was constructed in Karachi, Hyderabad and Rohri by Sui Gas Transmission Company in 1954/55. Subsequent to commissioning of Sui-Karachi transmission pipeline the distribution network in Karachi was handed over to Karachi Gas Company, and in Hyderabad and Rohri to Indus Gas Company.

Karachi Gas Company

Upto end of December 1973 Karachi Gas Company has laid a total of 764,5 miles of distribution pipelines varying from 3/4"" to 20" diameter, serving 73,007 consumers in Karachi. Out of this total number 69, 123 were domestic, 2136 commercial and 629 industrial consumers. The average daily sales of Karachi Gas Company in December 1973 stood at 94. 4 MMCFD. Category wise power stations are Karachi Gas Company's largest consumers consuming approx. 40% of the KGC's total sales, next in order of consumption are the textile mills which consume approx. 17% followed by cement industry which takes care of about 10%, the balance of 33% of total sales goes to the host of other industries like chemicals and pharmacuetical, iron and steel, glass and ceremics, oil and soap and many others, and commerical and domestic consumers.

Indus Gas Company

Indus Gas Company was formed in 1955 by WPIDC to operate distribution network in Hyderabad, and Rohri mainly to supply gas to the cement plants at these two locations. As the demand for gas increased, Indus Gas Company extended their operations to the towns of Sukkur, Khairpur, Nawabshah, Shikarpur, Kotri, Tando Adam, Shahdadpur and Dhabeji. The total length of distribution pipeline networks in all the above mentioned towns at the end of December 1973 was 404 miles. The total network in nine towns fed gas to 17200 consumers at the end of December 1973, of which 15,844 were domestic, 1215 commercial and 141 industrial. Average daily gas sales during December 1973 amounted to 53.7 million cubic feet. Major consumers of Indus Gas Company are

Power and Cement plants which consume approx. 47% and 36% of total gas offtakes respectively. Balance 17% is consumed by other small industries, commercial and domestic consumers.

LPG/Air Mix Supply

In 1973 Indus Gas Company was commissioned by the Government of Baluchistan to supply Liquified Petroleum Gas (LPG)/Air mix in Quetta town for commercial and domestic consumers. Under this scheme LPG will be transported in special tankers to Quetta where it will be mixed with air in a gas plant making its Gross Heating Value equivalent to Sui quality gas. This LPG/Air mix will then be distributed to the consumers through distribution pipelines. Indus Gas Company had laid about 4 miles of 6" and 4" feeder mains in Quetta at the end of December 1973. The system is to be commissioned before the end of 1974.

Indus Gas Company is also working on a similar scheme for supply of LPG/Air mix in Larkana where approximately 12 miles of feeder mains had been laid at the end of December 1973.

Sui Gas Supply for Baluchistan

The Baluchistan Development Authority is planning to lay a 35 miles long pipeline for supply of gas to the proposed industrial infrastructure at Temple Dera, a place located between Sibi and Jacobabad, Similarly another pipeline from Karachi will take gas to Uthal industrial estate in Lasbela District of Baluchistan.

Gas Distribution in Areas North of Sui

Simultaneously with the commissioning of 16" diameter transmission pipeline from Sui to Multan, construction of a gas distribution network in Multan was completed by Sui Gas Transmission Company for supply of gas to WAPDA's thermal power plant, and to WPIDC's fertilizer plant. This transmission and distribution system was then transferred to Indus Gas Company. A small distribution network was installed by IGC in Rahimyar Khan and connections provided to a few consumers in Zahirpir.

With the inception of Sui Northern Gas Pipelines Ltd. in 1963 the ownership and operation of both the Sui-Multan transmission pipeline and the distribution networks in Multan and Rahimyar Khan were handed over by Indus Gas Company to Sui Northern.

Together with the completion of construction of transmission lines to Lyallpur, Lahore, Gharibwal, Khewra, Dandot and Rawalpindi in 1965/66 distribution networks in these towns were also completed. During 1972 distribution networks were also laid in Peshawar, Nowshera Mardan, Takhtbai, Charsadda, Daudkhel and Gujranwala.

The entire area of Sui Northern's operations, extending from Sui to Peshawar, is divided into five distribution areas of Multan, Lyallpur, Lahore, Rawalpindi and Peshawar.

Sui Northern's total length of distribution mains and services as at end of December 1973 stood at 1331 miles. Total number of consumers served on Sui Northern system at the end of December 1973 were 83,243 while total number of customers were 58, 241 out of which 52, 540 were domestic, 4479 commerical, 1207 general industries, 3 fertilizer plants, 5 cement plants and 7 power plants.

The average daily sales of Sui Northern system was 229.5 million cubic feet per day (inclusive of 20 MMCFD from Dhulian) in December 1973, when power stations, being Sui Northern's largest consumers, took 29.32% of total sales ; fertilizer plants, the next largest consumers, consumed 25% of total sales and cement plants ranked third with 10% of total sales. Other industries such as textile, oil and soap, glass and other miscellaneous industries accounted for 30% of the total sales, while commercial sales were 1.62% of total sales and domestic sales 2.30%.

Utilisation Potential

Approximately 35 percent of the total energy consumption in Pakistan is supplied by the indigenous natural gas which is roughly equivalent to Rs. 280 crores per year worth of imported oil based on the present price of $ 9 per barrel.

Natural gas industry's performance during July to December 1973, with regard to the percent of total sales for southern and northern gas systems for various categories is given below,

	Sui Gas		**Marri Gas**
	Southern System	*Northern System*	
WAPDA Power Stations	17. 1%	30. 9%	—
Electrical Utility Companies	24. 5%	2. 2%	—

Cement	19. 8%	11. 3%	—
Fertilizer	—	25. 6%	100%
Other Industries	31. 4%	27. 0%	—
Domestic and Commercial	7. 2%	3. 0%	—

Power Generation

It is evident from the above figures that power generation claims the largest consumption of natural gas in Pakistan. The growth of the thermal power generation industry was accelerated by the discovery of natural gas in 1952. Total gas consumption for power generation in October 1955, when Karachi Electric Gas Corporation's first boiler was fired, was only 5 million cubic feet per day. In December 1965, power generation facilities in West Pakistan consumed natural gas at an average rate of 95 million cubic feet per day, while in December 1973 this figure increased to 133.2 million cubic feet per day. With the commissioning of the two units, each of 110 MW generation capacity, of the thermal power station at Guddu near Kashmore, which is based on consumption of raw Sui gas, and of 200 MW new gas turbine station in Lyallpur the share of natural gas towards power generation will further increase. Natural gas is playing a very vital role in providing cheap power for industrial development and hence economic uplift of Pakistan.

Fertilizer Industry

Today chemical fertilizers are being used for increasing the yields of main food and cash crops. Natural gas is the most important feed stock and fuel source for the fertilizer industry. Ammonia is the basic material used as a base for nitrogenous fertilizers. Ammonia when reacted with nitric acid produces ammonium nitrate. While urea is produced by the reaction of carbon dioxide and ammonia, and ammonium phosphate is produced by the reaction between ammonia and phosphoric acid. Thus ammonia is the basic chemical for manufacture of fertilizers. The capital outlay and the production costs of ammonia plants based on natural gas are the lowest.

The first fertilizer factory using approx, 9 MMCFD of natural gas as feed stock was established by WPIDC in Multan in 1959. Esso installed a fertilizer plant at Dharki based on Marri gas. In 1970/71 a big fertilizer plant was constructed by Dawood Hercules Ltd, near Lahore which consumes 35 to 40 MMCFD of gas. Gas pipeline was extended to Daudkhel in 1972 to feed WPIDC's fertilizer plant located there.

During December 1973 consumption of natural gas for manufacture of fertilizer in Multan, Dawood Hercules, Daudkhel and Esso's fertilizer plants averaged 85 million cubic feet per day comprising 57 million cubic feet of Sui gas and 28 million cubic feet of Marri gas.

Construction of a new fertilizer plant at Multan has been approved by the Government which is expected to commence production by December 1976 and will consume 38 to 40 MMCFD of gas. In addition to above, two big fertilizer plants, one at Mirpur Mathelo and the second at Machi Goth, based on Marri gas source are now being planned.

Cement Industry

The discovery of natural gas in Pakistan stimulated the growth of cement industry in Pakistan. The first cement kilns to be fired by natural gas in Pakistan were Zeal Pak Cement Factory's kiln in Hyderabad and A.C.C.'s kiln in Rohri. Total gas consumption of both the plants in December 1955 averaged 3.5 million cubic feet per day.

Today the cement industry is the third largest consumer of natural gas in Pakistan which consumed at an average rate of 50.1 million cubic feet per day during December 1973.

With the increasing internal consumption of cement and the possibility of its export to Middle East countries, natural gas is destined to play its role effectively in the production of cement in increasing quantities over the years ahead.

General Industries.

Among the other industries textile and cotton ginning, chemicals and pharmaceuticals, glass and ceramics, iron and steel, oil and soap, sugar and paper etc. have been adequately served by natural gas in the past. Although individual consumption of most of these industries is not large, yet collectively, they generate a sizeable gas load.

In December 1973 the average daily consumption of other industries in Pakistan amounted to 115.0 million cubic feet per day.

Commercial and Domestic

The first commercial and domestic supply was given in Karachi, followed by Hyderabad in 1955. The percentage of total gas consumption for both commercial and domestic consumers forms a very small part of total Sui gas sales. In December 1973 average daily commercial and domestic consumption in Pakistan amounted to 19.8 million cubic feet per day.

Effects of Gas Prices

Although domestic consumption forms only approx. 2.0 percent of the total gas sales the number of consumers in this category is the largest. The total number of connections provided to the new domestic consumers by Karachi Gas Company and Sui Northern Gas Pipelines Ltd. is in the order of 12000 each per year, while Indus Gas Company give 300 connections to consumers every year. People are progressively becoming more aware of the advantages of gas over other fuels such as firewood, charcoal, kerosene and LPG. Furthermore, due to the recent energy crisis not only the prices of fuels other than natural gas have sharply increased, they have also become scarce. As such, demand for gas supplies for domestic uses is increasing at a fast rate.

In our country, over the years the prices of all the other fuels except natural gas has gone up. In other parts of the world prices of gas have also been rising along with the price of other fuels, but in Pakistan price of gas for domestic supply is the same as in 1968 and, therefore, is the cheapest fuel. Just to quote an example price of kerosene is 162% higher and that of firewood 235% higher than the price of gas on the basis of quantities for equivalent heating values.

Due to this price difference in various fuels an anomalous situation has come into being. Families living in the areas where gas supplies are available pay only Rs. 15.00 per month on gas whereas people of the similar income groups living in the parts of towns where gas has not been made available spend at least Rs. 40 on alternative fuels. Unfortunately it is in the poorer localities, where the income of resident's is low, that gas is not available and they have to use more expensive fuels. The distribution gas companies in Pakistan, therefore, must meet the growing demand in the poorer localities to fulfill their social obligations as public utility companies. The rate of domestic connection must be increased so as to cover the entire localities in all towns in a short span of time. But at the present gas tariff distribution companies cannot fulfill their obligations as they will incur more losses with each new domestic connection. The Government should, therefore, increase the domestic gas tariff to a level at which it will still be cheaper than other fuels, and shall be able to offset additional losses of the gas companies.

Another aspect of the low gas tariffs would be that the producers of gas will not get reasonable returns on their capital investment. This

factor may prove to be a great deterrant to increase exploration activity which is of prime importance at this juncture of our national economy. The well head gas price in Pakistan is the cheapest in the world and is only about one fifth of the well head price in the United States. It is suggested that Government should appoint a high level committee to look into the problem of gas prices so that the gas is made available to all classes of society and does not become a disincentive to the development of the gas resources,

Self Reliance in Pipeline Construction

After having a look at the availability of gas reserves, the position of transmission and distribution system, and the potential market for natural gas in Pakistan, it is worthwhile to investigate the ways in which Pakistani engineers in gas pipeline industry can contribute towards self reliance by control of investment costs and the future operation and maintenance expenses through proper design and construction.

The design features of a new major natural gas transmission system are the product of the skills, knowledge, experience and creative ability of the engineers assigned to the task. The character of the engineering work directly affects the cost and the quality of the pipeline. Pakistani engineers will have to be ingenous at design stage to control the economic factors involved in pipeline construction work.

The technique of high pressure natural gas pipeline design and construction, which has been projected in Pakistan by the vested interests as a highly technical job, and as a privilege of a small number of highly technical nations, has been taken as a challenge by the Pakistan engineers, which is a big step forward towards self reliance.

Pipeline Costs

The fixed overheads in a balance sheet relating to the operation of a gas pipeline are (*a*) depreciation of the pipeline, compressors stations and other anciliary facilities (*b*) interest on investment (*c*) taxes and insurance and (*d*) royalties. The magnitude of these fixed financial overheads is very high to the tune of 70 to 75%. It is, therefore, essential that every effort be made to reduce investments. Every rupee saved with efficient design and construction of a system contributes directly in reducing the cost of transportation of gas and helps meet the competition for energy supplied at the consumers premises.

The cost of building a high pressure gas pipeline is divided between the following four main heads :

1. Cost of pipe and other related material
2. Cost of laying the pipelines and anciliary facilities
3. Cost of engineering and administration overheads
4. Cost of land.

In Pakistan following are the average percentage values, expressed in terms of the total expenditures, of the above four items, if the pipline is constructed through international contractors (based on present prices of materials).

1. Pipe and other material 71%
2. Cost of laying the pipelines and other anciliary facilities 25%
3. Cost of engineering and administration overheads 3%
4. Cost of land 1%

It is, therefore, evident that high portion of the total investments in a pipeline project is required for material and the laying costs by the contractors.

1. Materials

The main materials required for pipelines are line pipe, valves and fittings, coat and wrap material, cathodic protection material and telecommunication equipment.

(a) Line Pipe

Major cost of material (approx. 85%) of a pipeline project is for the high pressure steel line pipe. Due to a number of reasons the cost of line pipe has increased beyond all reasonable proportions in the last one year. Line pipe of API 5LX Grade 46, which used to be available at a C & F (Karachi) price of U. S. $ 166.00 per ton in 1970 increased to U. S. $ 360.00 per ton in 1973 and to $ 840 per ton in 1974. Price for higher grade steel pipes will be still higher.

In the year 1974, a total of 28,000 miles of pipelines is being constructed in all the areas of the world. Therefore, almost all the pipe mills of the world are running at top capacity to meet this unsatiable demand of expanding pipeline industry. Pipe mills are heavily booked and placing of firm orders is becoming a near impossibility. This factor

is now threatening to delay start up of some of Pakistan's proposed pipeline projects. To overcome similar problem in other countries of the world where pipeline activity is proposed in the next few years, they are establishing their own pipe mills. Steel strip is imported from Japan or other steel producing countries and manufacture pipe in their own mills out of imported strip. F. O. B. Japanese port cost of steel strip is about 75% of the F. O. B. cost of ERW pipe of similar specifications. Approximately 7 to 8% savings in cost of freight can be accrued by import of steel strip instead of steel line pipe. The foreign exchange cost of local manufacture of line pipe from steel strip is estimated at 5% of the total cost of strip. Thus there will be an overall saving of 20% in foreign exchange cost of imported pipe if steel strip is imported and line pipe manufactured locally.

Indus Steel Pipes Ltd. at Kotri can manufacture line pipes ranging from 6" to 20" in diameter, and has a yearly manufacturing capacity of 18,000 tons of 18'' line pipe. Although this mill has not yet been approved by American Petroleum Institute for manufacture of API specification line pipes, it has got all the facilities for ultrasonic, radiographic, hydrostatic and other non-destructive tests of the pipe after manufacture. Outlook for pipeline construction for both gas and oil in Pakistan for the next decade is very bright. In view of substantial savings in foreign exchange costs by local manufacture of pipes from imported steel strip, Government should consider immediate expansion and modernisation of Indus Steel Pipes Ltd. and establishment of a second mill with larger capacity and modern techniques.

(*b*) **Coat and Wrap Material**

The C & F cost of coat and wrap material is about 7 to 8 percent of the C & F cost of line pipe. The coating and wrapping material used in the construction of high pressure transmission pipelines are (*i*) coaltar based or oil based enamel for coating purposes (*ii*) fibre-glass to be used as inner wrap and (*iii*) thermoglass for outer-wrap. Let us have a look at the possibilities of local manufacture of these items and exercising savings in foreign exchange costs.

(*i*) **Coatings :** Coaltar enamel, which is not locally available in Pakistan and is considered to be most suitable for pipeline coatings for prevention against corrosion is superior to Attock

Oil Company's indigenous oil base enamel in two characteristics. Firstly, the coaltar base enamel is less hygroscopic than the local oil base coating, secondly, the locally available oil base coating is more prone to sulphur reducing bacteria attack. Due to these two advantages life of a coaltar base enamel coating is double that of a coating of indigenous oil base enamel.

With the joint efforts of Sui Northern and Pakistan Council of Scientific and Industrial Research suitable modifications have been made in the locally available oil base enamel to improve its hygroscopic qualities and make it equivalent to imported coaltar base enamel. The water absorption rate of local oil base enamel has been improved from 1200 ppm to 200 ppm, water absorption rate of imported coaltar base enamel being 150 ppm, The second problem of bacteria attack on oil base enamel has also been solved by blending the enamel with an additive which creates a resistance to sulphur reducing bacteria. After carrying out various tests regarding suitablilty of this modified indigenous oil base enamel Sui Northern have decided to use this enamel for coating of all their future pipelines and thus save valuable foreign exchange required for import of coaltar enamel at a C & F cost, which is 9 to 10% of the line pipe cost. A very small portion of this foreign exchange cost will be needed for import of additives for improvement of qualities of local oil base enamel,

(*ii*) **Wrapping** : The inner wrap material used for coating and wrapping of pipe is a woven mat of glass fibre filaments bound together with urea formaldehyde or phenolic resin.

Besides wrapping of pipelines, fibre glass is also used in other industries for heat and electrical insulations and there is enough potential in this country for uses of fibre glass, which justifies local manufacture of glass fibre filaments from indigenous ingredients.

The outer wrap, known as thermoglass is 2.5 to 3 times the C & F cost of fibre glass, and is made just by impregnating the fibre glass with the coating enamel and filling it with gypsum powder.

Therefore, till the commencement of manufacture of fibre glass in this country, the pipeline industry can at least save valuable foreign exchange by manufacturing thermoglass by impregnating imported fibreglass with indigenous modified oil based enamel. This procedure is now being adopted by Sui Northern for their ongoing Project No. 3A.

(*iii*) **Cathodic Protection Materials** :- The material and equipment required for cathodic protection of pipelines are magnesium and high silicon iron anodes, transformer rectifiers, surge diverters and current control panels and bond boxes. All of these items, which used to be imported till a few years ago, are now being manufactured locally by Sui Northern's patronage. Only few items need to be imported for cathodic protection installations but these items do not cost more than 1% of the total cost of C.P. materials.

(*iv*) **Anciliary Equipment** :- Power generation and telecommunication facilities provided on all the existing repeater stations and section headquarter stations were imported. It is felt that large sums of foreign exchange can be saved if heavy engineering works in the country manufacture gas engines, diesel engines and alternators for use on pipeline installations. Similarly bulk of simple telecommunication system to operate on a pipeline can be manufactured locally. Multiplexing and radio relay equipment, teleprinters, telephone exchanges and telephone instruments can be manufactured by Telephone Industry of Pakistan (Haripur) or Carrier Telecommunication Industry (Islamabad). Telecommunication towers can easily be manufactured by any local heavy engineering work. Cost of materials required for a simple telecommunication set up are estimated at %6 of the C&F (Karachi) cost of line pipe. By obtaining most of the equipment made in Pakistan by TIP or CTI, not only the foreign element cost could be considerably reduced but local production would permit better utilization of the available resources of the country.

The only items which would not be economical to manufacture locally, due to their specialised nature and low market potential,

are high pressure regulators, relief valves, large size gas meters and other pipe fittings.

As discussed above, substantial savings of foreign exchange can be made by local manufacture of bulk of the material. The local manufacture will also provide employment opportunities to Pakistanis and develop local techniques and processes which can be exported to Middle East and North African countries.

2. Cost of Laying of Pipelines and Other Anciliary Facilities

As mentioned in a preceding paragraph, cost of materials and other anciliary materials is 71% and that of laying of pipeline is 25% of the total cost of a pipeline project (based on present high material costs). All international loans make it obligatory for clients to follow international competitive tendering for materials and for pipeline construction.

As all of Pakistan's pipeline projects in the past were financed by an international loan giving agency all of them were constructed by international contractors, who were awarded these contracts on the basis of international competitive tendering. Unfortunately, in the past 20 years of the life of gas pipeline industry in Pakistan no local pipeline construction company has been formed so as to be prequalified for quoting in the international tenders for construction of our pipelines. Thus a big portion of the foreign exchange loan proceeds coming from the foreign loan giving agencies is ploughed back into the economies of the member countries.

In the years ahead pipeline construction activity throughout the world is going to increase in a big way resulting in higher construction costs. Most of the proposed pipeline activity will be located in Canada, Western Europe, Australia, Algeria and Middle East countries. In Canada alone 1000 miles big inch pipeline will be under construction every year during this decade. Thus the international pipeline construction contractors would have enough work for them in these areas of activity. Contractors, generally, may be interested in acquiring contracts and moving their men and equipment to remote areas like Pakistan for a few hundred miles of pipeline only if they get relatively higher prices than those in the areas of major activity. Should we just dole out our precious foreign exchange to contractors coming from abroad to construct our pipelines because Pakistan does not have a pipeline construction company of its own ? Are

we not capable of constructing pipelines ourselves and saving exorbitent sums of money going out of our country by way of contractors costs ? The myth of sophistication of pipelining techniques, created by vested interests, stands shattered today as our engineers and workers are now busy laying pipelines in some of the mst difficult terrain, by any standards, at much lower costs than those quoted by the international contractors. Comparision of pipeline construction costs by international contractors and by a Pakistani Gas Company is given in Appendix 3 and is discussed in a following paragraph.

Local Construction of Pipelines

The need for departmental construction of pipelines was felt very early in the life of Sui Northern when in June 1964, it was decided to replace 6″ Dhulian to Galli Jagir line by a 10″ dia. pipeline. A construction group of all Pakistani staff was therefore formed to lay 26 miles of 10″ dia. 0.25″ w.t. API 5LX Grade 46 pipeline from Dhulian to Galli Jagir. This pioneer Construction Group did not have any construction equipment worth the name. The entire inventory of plant and equipment comprised following :

Welding machines	4
Pipe trailer with tractor	2
Dope Kettle	1
High pressure pump	1
Crane	1

This was purely a labour intensive project in which trenching, stringing, cleaning, priming, coating/wrapping and backfilling operations were manually carried out. This construction of 26 miles of 10″ dia. pipeline in rocky and hilly terrain was completed in 10 months i. e. at the rate of 2.6 miles per month and at a cost of Rs. 0.70 lakh per mile, (This cost includes land, construction, inspection, cathodic protection and engineering/administration overheads).

Total Accomplishments of Sui Northern's Construction Group

Ever since its formation this group has never looked back and is always on the move. In the last ten years this Construction Group has accomplished laying of 69. 1 miles of 10″ dia. ×0.25″ w. t. API 5LX46, 32 miles of 6″×0.219″, w.t. API 5LX 42 and API Standard Grade B, 16.75 miles of 4″ dia. ×0.219″ w. t. API standard grade B, 5 miles of 18″ dia. ×0.312″ w.t. API 5LX 52, 4 miles of 12″ dia. ×0.281″ w.t. API 5LX46 and

9.5 miles of 8″ dia. ×0.219″ w.t. API 5LX46 pipelines. In addition to above, this group acted as a subcontractor to one of Sui Northern's main contractors for coating and wrapping of 38 miles of 16″ dia. pipe, for Sui-Guddu line, in the yard, transporting to the site, and joint coating in the field.

On 31 March 1974 the Sui Northern's construction group completed laying of a 13.8 miles of 10″/8″ pipeline between Meyal and Dhulian oil fields in the Potwar area, This short length of pipeline had all the difficulties a pipeliner can ever imagine. The group fought the obstacles of water crossings, high country and tough sand stone. Just a few hundred feet after the line leaves the Meyal oil field gas station area the route meets several deep and wide ravines where the machines had a tough time negotiating the steep slopes. About 35 percent of the total trench excavated was in hard rock. Apart from the ravines, streams and hard rock a mile long of treacherous crossing at river Sil was involved where pipeline had to be buried at a depth of 10 feet below river bed. Huge dewatering and earth-moving work was involved. The construction group had some initial difficulties in procuring dewatering equipment but once the first well was lowered on 10th March 1974, the group worked round the clock and lowered entire 5000 feet of pipeline in a record time of 18 days. The entire cost of laying the Sil river crossing came to approximately 20% of the cost of a similar crossing on the same river two miles downstream which was carried out by an international contractor.

Another difficult task handled by the group, during February/March 1973, was laying of over 5 miles of 18″ diameter pipeline in exceptionally difficult terrain, north of Sui Northern's present pipeline crossing at river Sutlej near Panjnad. This section required laying of pipeline at depths ranging from 8 feet to 13 feet and installation of 667 river weights at an average spacing of 20 feet each weighing 1½ tons. The job was completed much ahead of schedule and at costs less than 20% of those indicated by an inter national firm. The coat and wrap jobs, undertaken by the group, was tested by current drainage surveys which indicated that the quality of work was by far the best when compared to jobs completed by the foreign contractors in Pakistan.

As the gas offtakes in 10″ Lyallpur-Lahore pipeline increased a bottle-neck situation was envisaged for winter of 1972/73. It was, therefore, decided with the permission of World Bank, that compressor station

CC-1 (Haranpur) should be shifted to a location BC-1 (Manawala), 38 miles downstream of Lyallpur on 10" Lyallpur-Lahore line. The construction group was made responsible for implementation of this work. The entire station pipe work including 20" headers, scrubbers etc. 2 Nos. 1100 BHP Solar Saturn Compressor Units, gas and diesel generators and all the control equipment was dismantled at CC-1, transported to BC-1 and reassembled. Civil works for compressors, generators and scrubber foundations and for industrial and staff residential quarters etc. were awarded to a local contractor, who started the work in August 1972. Foundations were ready in October 1972 and compressor units were installed in November 1972. Compressor station BC-1 was commissioned in the last week of December 1972, just in time to handle peak winter loads. It is interesting to note that the construction group's cost of dismantling of Haranpur compressor station, and construction of BC-1 excluding civil construction work, undertaken without the help of any consultants or technical advisers, was Rs. 10.73 lakh as compared to a foreign contractor's cost of Rs. 48.28 lakh for identical construction at Haranpur station.

Appendix 2 shows the details of all the pipelines constructed by the construction group, while Appendix 3 gives the comparison of pipeline construction costs by S. N's construction group and international contractors for various sizes of lines laid during the same period. This comparison shows that since 1965 the average cost of construction for sizes 10" dia, and below by Company's own construction group has been 33.8% of the contractors costs. For sizes larger than 10" cost has remained about 42%. This means that, all other factors remaining the same through local construction efforts a project can be completed at approx. 15% less cost. Furthermore, about 45 to 50 percent of contractors costs are to be paid in foreign exchange, while on construction through local resources, the only foreign cost involved is that of depreciation on the cost of imported plant and equipment, which remains between 8 to 10% of the foreign exchange cost of construction by contractors. Thus the foreign exchange savings in a project constructed locally is in the range of 80 to 85%.

Future construction of pipelines

It is heartening to note that the Government has allowed both Sui Gas Transmission Company and Sui Northern Gas Pipelines to

undertake departmental construction of their current projects. 45 miles of 18" dia. pipline from Sari/Hundi field to Karachi, which is Phase 1 of Indus right bank project, is being constructed by S.G.T.C. and 51 miles of 18" and 16" dia. looplines between Sui and Lyallpur under Project 3A are being installed by Sui Northern's own construction group. Of this 33 miles of 16" dia. looplines between Multan and Lyallpur have already been completed and the construction of 18 miles of 18" loopline between Sui and Guddu is now well underway. 28 miles of 18" loop between Sui and Multan required for supply of 40 MMCFD of gas to new fertilizer plant at Multan under Sui Northern's Project 4A will also be constructed departmentally. Foreign exchange component for all the above projects is being provided by the Government.

Asian Development Bank has recently approved departmental construction of Phase II of Indus Right Bank Project by Sui Gas Transmission Company while efforts are being made to get IBRD's approval for departmental construction by Sui Northern of their Project 4B pipelines and other facilities involved.

We in pipeline industry feel proud of this achievement of undertaking our own pipeline construction work and thus endeavouring to keep the investment in pipelines to a minimum possible level, for providing cheap energy in the form of gas and conserving valuable foreign exchange for other vital projects.

Conclusions

1. The growth of industrial economy in Pakistan has resulted in growing gas demands, which require adequate gas reserves, transmission capacity and reasonable gas prices both for consumers and for the producers of gas fields.
2. For rational compilation of fuel and energy balance for Pakistan special studies are urgently required, which task should be entrusted to a centralised agency staffed by highly trained engineers, geologists and economists.
3. Although gas is available in sufficient quantities today it will become critical in 1990 and therefore appropriate development policy should be made by the Government for the existing resources and for conservation of energy by the end of 1980.
4. In order to be self reliant in energy economy in Pakistan it is essential that the work for exploration of oil and gas must

be accelerated. Both local and foreign capital must be attracted to discover new sources of energy and their proper development.

5. Development of gas transmission capacities have to be made in relationship with availability of gas reserves.
6. The present gas tariffs are such that the gas distribution companies are incurring heavy losses on sales to domestic consumers. If the domestic gas tariffs are increased to a level where gas losses due to additional connections to new domestic consumers are off-set, the gas companies will be able to step up their activities in relation to domestic connections in the lower income group localities where the gas is badly needed.
7. Enormous savings in foreign exchange costs can be realised by developing local manufacture of high pressure steel pipes out of imported steel strip, coat and wrap material, gas and diesel engines and telecommunication equipment.
8. It has been proved beyond doubt that construction of pipelines through departmental construction by gas companies can make sizeable savings in the cost of total project and also render better quality work. Government should encourage local pipeline construction efforts. In order to avoid duplication of efforts and to concentrate specialization a central agency for construction of oil/gas pipelines may be organized under the patronage of the Government. This agency can also bid for pipeline construction works in Middle Eastern countries.

Appenix-I

RESERVES OF NATURAL GAS IN WEST PAKISTAN

Gas fields	BTU Value	Recoverable Reserves	Original Recoverable reserves in terms of Sui quality raw Gas (trillion cft.)	COMPOSITION								
				Methane	Ethane	Propane	Butane higher	Nitrogen	Carbon di-oxide	Hydrogen	Hydrogen sulphide grains/100 cu. ft.	Mercaptan sulphide grains/100 cu. ft.
1	2	3	4	5	6	7	8	9	10	11	12	13
1. Sui	933.0	8.620	8.620	88 52	0.89	0.26	0.37	2.46	7.35	—	92.2	3.8
2. Zin	484.0	0.100	0.050	46.1	0.4	0.15	0.15	8.5	44.7	—	13.3	2.3
3. Uch	308.0	2.500	0.800	27.3	0.7	0.3	0.3	25.2	46.2	—	33.5	10.2
4. Khairpur	130.0	1 000	0.130	12.2	0.2	0.1	—	16.9	70.6	—	2.0	46.0
5. Marri	723.0	3.942	2.990	71.2	0.2	—	—	19.5	9.0	0.1	—	—
6. Mazarani	976.0	0.090	0.094	87.0	2.5	0.1	1.2	8.0	0.3	—	10.7	2.2
7. Kandhkot	842.0	0.410	0.370	79.2	1.1	0.2	0.4	16.6	2.5	—	30.8	1.2
8. Sari	873.0	0.029	0.027	80.87	2.11	0.92	0.26	14.14	1.71	—	28.0	—
9. Hundi	828.0	0.050	0.040	78.96	1.32	0.42	0.21	17.88	1.21	—	21.0	—
10. Dhulian (Associated Gas)	1100.0	0.150	0.176	—	—	—	—	—	—	—	—	—
TOTAL		16.891	13.297									

Note : 1 trillion cu. ft. = 10^{12} cu. ft. = 1 million million cu. ft.

Apendix-2

TRANSMISSION LINES CONSTRUCTED DEPARTMENTALLY BY SUI NORTHERN GAS PIPELINES

Sr. No.	Description	Length (Miles)	Pipe Dia. Nominal (inches)	Year of completion	Terrain
1.	DHULIAN-GALLI JAGIR	26	10	1965	Rocky-Hilly
2.	WAH-HATTAR	6	6	1966	Rocky-Hilly
2.	KALA SHAH KAKU-MURIDKE	5	10	1968	Partly water logged mainly agricultural plain
4.	KHURIANWALA-JARANWALA	14	4	1968	Agricultural flat land
5.	WAH-ISLAMABAD	26	6	1969	Rocky-Hilly
6.	TAXILA OFFTAKE	2.75	4	1969	Rocky-Hilly
7.	DAWOOD-HERCULES OFFTAKE	4	12	1969	Marshy, water logged area
8.	LYALLYUR LOOPLINE	3.5	8	1971	Agricultural
9.	MURIDKE-RAHWALI	30.3	10	1972	Partly water logged mainly agricultural plain
10.	SUTLEJ LOOPLINE	5	18	1973	Sandy, agricultral adjacent river
11.	MEYAL-DHULIAN	13.8	10/8	1973	Rocky and Hilly.

Appendix No. 3

COMPARISON OF PIPELINE CONSTRUCTION COSTS BY SUI NORTHERN'S CONSTRUCTION GROUP AND INTERNATIONAL CONTRACTORS

Sr. No.	Description	Pipe Dia Nominal (inches)	Year of Construction	Cost of Construction per mile (including supervision over-heads) Lakh/Rupee
	CONSTRUCTION BY COMPANY'S OWN GROUP			
1.	Dhulian-Galli Jagir	10	1965	0.70
2.	Wah-Hattar	6	1966	0.80
3.	Kala Shah Kaku-Muridke	10	1968	0.72
4.	Khurianwala-Jaranwala	4	1968	0.44
5.	Wah-Islamabad	6	1969	0.80
6.	Taxila Offtake	4	1969	0.50
7.	Dawood Hercules Offtake	12	1969	1.7
8.	Lyallpur Loopline	8	1971	1.03
9.	Muridke-Rahwali	10	1972	0.94
10.	Sutlej Loopline	18	1973	1.68
11.	Meyel-Dhulian	10/8	1973	1.17
	CONSTRUCTION BY AN INTERNATIONAL CONTRACTOR			
1.	Haranpur-Gharibwal	8	1965	2.10
2.	Lyallpur-Dandot	12	1965	1.80
3.	Lyallpur-Shahdara	10	1966	1.80
4.	Dandot-Galli Jagir	10	1967	2.80
5.	Galli Jagir-Wah	10	1967	2.80
6.	Lahore-Kala Shah Kaku	10	1968	1.70
7.	Sui-Multan Loopline	18	1970	3.30
8.	Sui-Multan Loopline	18	1972	4.00
9.	Nowshera-Peshawar	6	1972	1.60
10.	Nowshera-Charsadda-Takhtbai	6	1972	2.70
11.	Dhulian-Daudkhel	8	1972	3.10
12.	Wah-Nowshera	10	1972	4.00