Natural gas and the fertilizer industry

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The initiative for exploiting the commercial potential of natural gas as feedstock and fuel by planning NGFF for producing urea fertilizer in the mid-1950s was based on a single gas field in what is now Bangladesh. The use of natural gas as a fuel in Chhatak Cement Factory in 1960 replaced imported coal and thus began the era of cleaner fuel for industries in Bangladesh. The commissioning of NGFF in 1961 for producing urea, a proven source of nitrogen nutrient especially for rice, marked the beginning of the green revolution in Bangladesh. The consumption of natural gas during the past decade up to 2001 shows that the power sector consumes approximately 45 %, fertilizer sector 35 % and the other sectors 20 %. There are now 53 production wells capable of producing more than 36.8 million standard cubic metres (Mm^3) per day of gas from 12 gas fields.

In 1972, there were only two ammonia-urea complexes having a combined installed capacity of 446,000 tonnes (t) of urea per year. Today the country has seven ammonia-urea complexes (six in the public sector and one in the private sector) with a total installed capacity of 2,895,700 t of urea and 1,886,700 t of ammonia per year. All seven complexes are of the grass-roots type.

In the various complexes consumption of natural gas used as feedstock per unit production of ammonia or equivalent quantity of urea is not significantly different irrespective of the age of the plant or technology used, but the consumption of natural gas as fuel burned in the primary reformer (PRF), auxiliary boilers (utility boilers) and captive power plants is influenced by the way process heat and waste heat from PRF and power plants are recovered, utilized and integrated in the plant energy requirement system. In the larger plants the steam system is integrated by considering convenience of generation and utilization as motive power, heating medium as well as process feed. Since natural gas in Bangladesh is rich in methane, the ammonia plant has to be oversized by a few per cent to produce the required carbon dioxide for the rated urea production. This leads to additional natural gas consumption per unit urea production and obviously this is a penalty in a competitive market. Modifications and revamping of the complexes have been carried out from time to time. Most process modifications have required sizable capital investment. When these complexes were designed and equipment procured, today's concepts of energy efficiency were in their formative stages. More efficient motors, pumps, turbines, compressors, boilers, furnaces, etc. could have been procured, but the issues of provenness and reliability were of paramount importance as against savings from being more energy-efficient.

The performance of these complexes is discussed in the context of utilization of stream days, capacity utilization and consumption of natural gas (both for process and fuel) per t of urea produced. The economic performance is not discussed, because the sale price of urea and depreciation to be charged are fixed by the government for the six plants owned by BCIC, while KAFCO either exports its urea produced or sells it to BCIC at world market price. The sale price of urea fixed by the Government is today about US$ 40 below the price offered by KAFCO.

NGFF remained the lone major consumer of natural gas up to 1967, consuming about 87 % of the annual gas production. In 1968, other sectors such as power, domestic and commercial started to use gas as fuel. With the commissioning of UFFL in 1970 the share of gas used by the fertilizer sector further rose. With the commissioning of a new urea complex there has been a clearly identifiable rise in the gas demand, indicating the low annual demand growth in Bangladesh. It is only from 1984 that the power sector's natural gas consumption exceeded that of the fertilizer sector. Today the connected gas load of the seven urea complexes is 7.85 Mm^3/day and the annual consumption with all plants operating is about 2.55 Gm^3. The natural gas industry through its association with the fertilizer sector has been able to standardize the gas intake stations for bulk consumers, metering stations and maintenance/operation of gas transmission system.

Even though the power sector has a connected gas load of about 18.4 Mm^3/day, all energy demand projections consider the fertilizer load an equally important category, and this is the reason why the fertilizer industry is considered to be a separate sector. The demand for natural gas by the

fertilizer sector in the next two decades will, however, not increase significantly. Even if the country needs to produce an additional 1 million t of urea, the gas requirement would be an additional 1.42 Mm^3 if plants such as NGFF, UFFL and PUFF are shut down. The fertilizer sector based on natural gas has provided the necessary life support for the development and growth of the gas industry since the first discovery of natural gas in the country. Urea fertilizer together with natural gas based electricity is today recognized as the cornerstone of the country's food security and political stability.

1. Introduction

Exploration for oil and gas in the areas that today constitute Bangladesh was initiated for finding oil in 1908 with the first exploratory well drilled at Sitakundu (Figure 1) [BGSL, 1999]. The first discovery of natural gas was made in 1955 at Haripur (Sylhet Gas Field) and this was followed by the discovery of the Chhatak Gas Field in 1959. Since then the exploration of oil and gas resources has led to the discovery of 22 gas fields and one oil field (Figure 1) [TGTDCL, 1999; BGSL, 1999].

The potential of natural gas as industrial fuel and feedstock for chemical plants was envisaged as soon as the first discovery of gas had been made. Its use as a fuel, drawn from the Chhatak Gas Field, in the Chhatak Cement Factory in 1960 marked its first commercial exploitation. It was fed to the first ammonia-urea grassroots complex, Natural Gas Fertilizer Factory (NGFF) at Fenchugonj, in 1961 as feedstock and fuel, drawn from the Sylhet Gas Field. Since then over the years the consumption of natural gas has been increasing and it has contributed to national development tremendously.

The use of natural gas as a fuel in Chhatak Cement Factory in 1960, replacing imported coal, began the era of cleaner fuel for industries in Bangladesh. In a very modest way it was a step forward towards self-reliance and import substitution. The commissioning of NGFF for producing urea, a proven source of nitrogen nutrient especially for rice, marked the beginning of the green revolution in Bangladesh. Even when the population was 75 million, Bangladesh was deficient in rice production. Today the country has achieved self-sufficiency in rice production for its 130 million people. The urea-based nitrogen nutrient required for agriculture is produced locally by the country's seven ammonia-urea complexes having a total urea production capacity of 2.9 million tonnes (Mt) per year. Self-sufficiency in rice production has given the country peace and social stability, though the fulfilment of the other entitlements of every citizen is yet to be assured.

The initiative for exploiting the commercial potential of natural gas as feedstock and fuel by planning NGFF for producing urea fertilizer was taken immediately after the discovery of the Sylhet Gas Field. The planning for the complex was based on a single gas field and the envisaged reserve (recoverable proven and probable) to production (annual gas quantity required by NGFF) ratio was about 42. The total investment for NGFF in those days was in excess of US$ 50 million and this was recognised as a prestigious industrialization landmark. The complex is still in operation today with capacity utilization in excess of 85 %.

Natural gas is considered an important indigenous hydrocarbon resource in Bangladesh. It is now the major fuel for power generation. It is the feedstock and fuel for production of urea fertilizer and ammonia. It is the fuel for many industries and commercial establishments. It is an important cooking fuel in the metropolitan areas such as Dhaka, Chittagong, Sylhet, Comilla, Mymenshing, and Tangail, replacing older fuels such as wood and kerosene. Of late it has been in use in cars, buses and three-wheelers as compressed natural gas (CNG), replacing motor spirit and diesel. Of the total electricity generation in the country, 90 % is natural gas-fuelled. Against the installed capacity of 4713 MW as of January 2003, 16 gas-fired plants account for 3989 MW. The consumption pattern of natural gas during the past decade up to 2001 shows that the power sector consumes approximately 45 %, fertilizer sector 35 % and the other sectors consume 20 % (industrial 8-10 %, domestic 8-10 %, commercial 1.5 % and seasonal 0.1-0.2 %) [TGTDCL, 1999; Quader and Gomes, 2002].

There are now 53 production wells capable of producing more than 36.8 million standard cubic metres (Mm^3) of gas from 12 gas fields. According to Petrobangla, the remaining recoverable reserves of the 22 gas fields in June 2000 were estimated to be 328 billion m^3 (Gm^3). The remaining recoverable reserves of 12 gas fields now producing were 207 Gm^3 while those of 10 non-producing fields are 121 Gm^3. Opinions are divided regarding the reserves of these fields. Today's production rate is approximately 31.1 Mm^3.

2. Development of urea fertilizer industry in Bangladesh [BCIC, 2001]

A major commitment of the development plans of Bangladesh since its independence in 1971 has been to attain self-sufficiency in food grain production by increasing yield per unit available cultivable land, by increasing the application of fertilizers and use of irrigation, introducing high-yielding seeds and expanding agricultural credit in rural areas. Since the beginning of the new millennium, the country has achieved self-sufficiency in food grain production, especially rice. However, the present level of application of nitrogenous fertilizer, which is derived mostly from urea, is below the dosage recommended and the application of fertilizers is not balanced with respect to phosphorus, potassium and other plant micro-nutrients.

In 1972, there were only two ammonia-urea complexes having a combined installed capacity of 446,000 tonnes (t) of urea per year and only 214,200 t of urea were

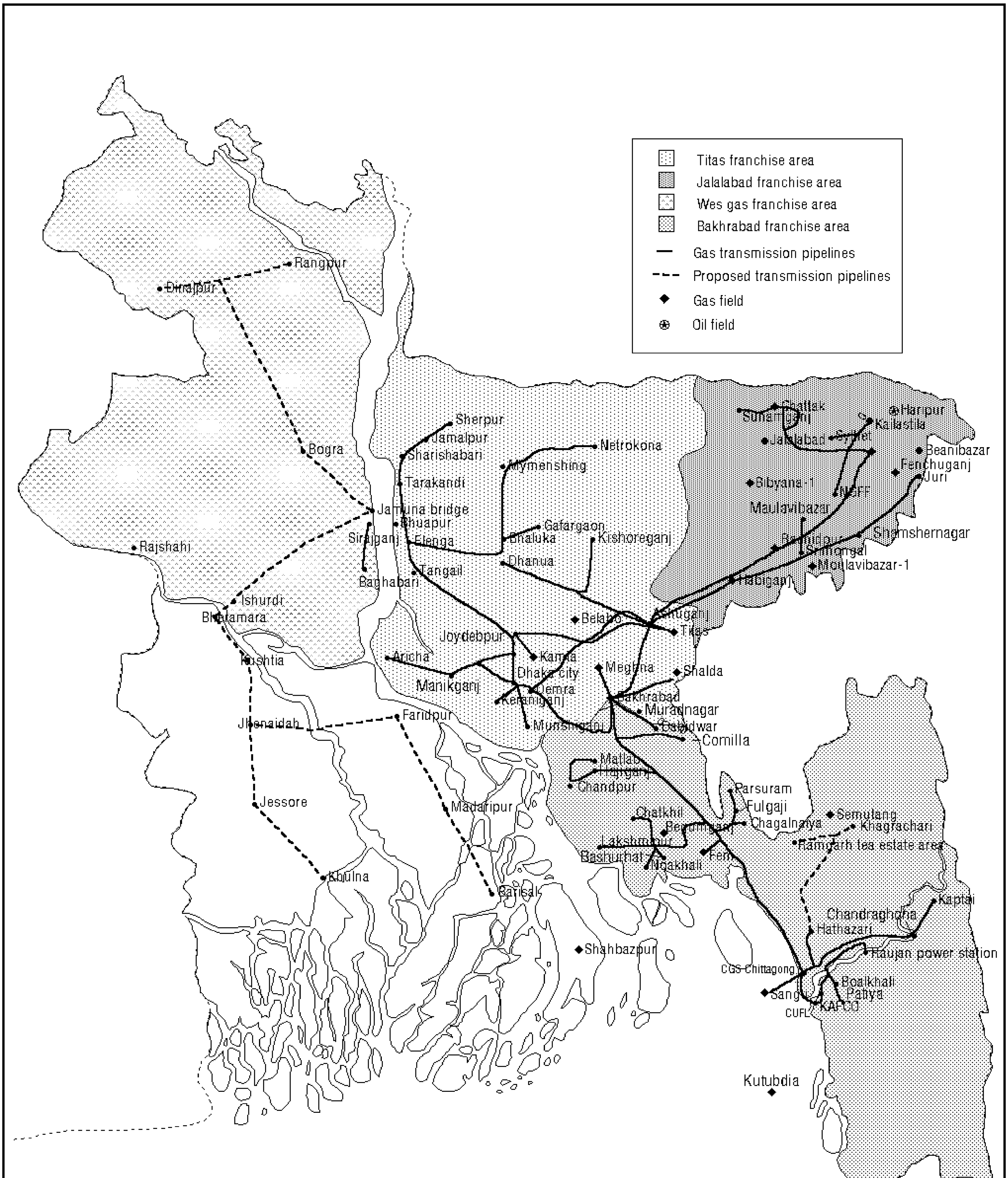

Figure 1. Gas transmission pipelines, gas fields and oil fields of Bangladesh

Table 1. Relevant information on seven ammonia-urea complexes

Complex	NGFF	UFFL	ZFCL	PUFF	CUFL	JFCL	KAFCO
Location	Fenchugonj	Ghorasal	Ashugonj	Polash	Rangadia	Tarakandi	Rangadia
Gas fields from where NG supplied[1]	Sylhet	Titas	Titas	Titas	Bakhrabad	Titas	Bakhrabad
Year of commissioning	1961	1970	1981	1986	1987	1991	1995
Plant capacity, t/year							
Urea	106,000	469,260[2]	528,000	95,000	561,000	561,000	575,425
Ammonia	66,000	272,250[2]	307,000	56,160	330,000	355,740	499,500
Type of urea produced	Prilled	Prilled	Prilled	Prilled	Prilled	Granulated	Granulated
Electric power	Captive	Captive	Captive	Captive	Captive	Captive	Captive
Ammonia process licensor	CCC (USA)	Toyo	Uhde	China	Kellog	Holder Topsoe	Holder Topsoe
Urea process licensor[3]	CCC (USA)	(TEC-MTC C-process) ACES	Stamicarbon	China	TEC-MTC D-Process	Snamprogetti	Stamicarbon
CO_2-removal[3] system for the reformed gases	CCC (USA)	(Vetrocoke) Benfield	Benfield	China	Benfield	Benfield	UOP
Type of compression							
1) ammonia synthesis	Reciprocating	Centrifugal	Reciprocating	Centrifugal	Centrifugal	Centrifugal	Centrifugal
2) urea synthesis	Reciprocating	Centrifugal	Reciprocating	Centrifugal	Centrifugal	Centrifugal	Centrifugal

Sources: BCIC, 2001; Quader, 1998.

Notes

1. When commissioned
2. Capacity after revamping (originally urea 340,000 t/year; ammonia 200,000 t/year)
3. Original process.

produced in the year 1972-73. Today, the country has seven ammonia-urea complexes (six in the public sector and one in the private sector as a joint venture between the Government of Bangladesh (GOB) and foreign companies) with a total installed capacity of 2,895,700 t of urea and 1,886,700 t of ammonia per year.

All seven complexes, being of the grassroots type, include a wide range of facilities, encompassing water treatment, power generation, steam generation, cooling tower, inert gas generation, material handling, etc. Each of these facilities in its own right can claim to be an independent engineering plant or operation of a speciality type. Building of these complexes as grassroots-type projects during the past four decades has provided the country with a wide range of process technologies, plant equipment and facilities considered to be "state-of-the-art". As a result, this sector has provided the country with an enviable "melting-pot" of engineering knowledge and technical experience. The seventh complex, KAFCO (Karnaphuli Fertilizer Company), is the latest and came on stream in 1994. Table 1 provides some relevant information on these complexes [BCIC, 2001; Quader, 1998].

Bangladesh Chemical Industries Corporation (BCIC), a state-owned corporation, operates the first six ammonia-urea complexes, namely, NGFF, UFFL (Urea Fertilizer Factory Ltd. at Ghorasal), ZFCL (Zia Fertilizer Co. Ltd. at Ashugonj), PUFF (Polash Urea Fertilizer Factory at Polash adjacent to UFFL), CUFL (Chittagong Urea Fertilizer Ltd. at Rangadia) and JFCL (Jamuna Fertilizer Co. Ltd. at Tarakandi), having a total annual production capacity of 2.32 Mt of urea. These complexes were built under a wide range of funding arrangements and contracting procedures with BCIC as the implementing agency. The engineering contractors along with the process licensors performed the basic and detailed engineering of the main ammonia and urea battery limit plants while the engineering contractors along with the package unit contractors completed the basic and detailed engineering of the utilities, auxiliaries and offsites. While implementing ZFCL and CUFL, separate companies were formed at the insistence of the donors in the hope of effective management of these projects. The projects were returned to BCIC after commissioning. The donors' prescriptions neither improved financial efficiency nor engineering management for these complexes.

In the case of ZFCL, the management consultant company first appointed by the donors had to be replaced by another company when its performance was found to be unsatisfactory. The EPC contractor did not perform guarantee tests of the complex. This led to litigation. In the case of CUFL some of the designs approved by the consultants were found to be unsound. For example, about 25 % of the tubes of air-swept evaporators were plugged during commissioning because these were oversized for the required service. This was done to enable the EPC contractor to meet the performance guarantee even though that part of the process was not proven at that time. Many such examples can be cited for CUFL. This arrangement actually prevented local participation in the design, engineering and inspection of these projects. Technology transfer took place instead to the foreign consultants as they were responsible for review and approval of engineering and

Table 2. Natural gas and energy related information on ammonia-urea complexes

Complex (year of commissioning)	Production capacity (t/day)		Design stream days	Connected gas load (Mm^3/day)	Design gas consumption ($10^3 m^3/t$ urea)	Captive power (MW)[1]	
	Ammonia	Urea				GTGs	STGs
NGFF (1961)	203	339	312	0.54	1.67	-	12(3)
UFFL (1970)	825	1422	330	1.27	1.00	16(1)	-
ZFCL (1981)	930	1600	330	1.42	0.79	-	13.5(2)
PUFF (1986)	180	305	312	0.48	1.41	8(2)	-
CUFL (1987)	1000	1700	330	1.42	0.78	-	12(2)
JFCL (1991)	1078	1700	330	1.22	0.69	-	8(2)
KAFCO (1994)	1500	1725	330	1.84	0.71	-	10(2)

Source: BCIC, 2001

Note

1. Capacity of each unit with number of units in parenthesis

related documents. There were also cost overruns associated with such donor interference.

KAFCO was built as a joint venture between GOB and foreign companies, and it is being managed as a private limited company. GOB is the sovereign guarantor for the portion of investment made by the foreign companies and is responsible for assuring supply of natural gas at a special price. During the shortage of natural gas in 1996-97 BCIC suspended gas supply to CUFL so as to supply gas to KAFCO in accordance with the agreement. On the one hand, this caused large financial losses to CUFL because of loss of production and deterioration of plant equipment kept idle; on the other, the country had to buy urea from KAFCO at the world market price in accordance with the agreement, causing undue pressure on the balance of payments. During this shortage of gas, gas was also diverted to power plants by suspending production at PUFF and reducing production at UFFL and JFCL. Thus, these units, like CUFL, also suffered financial losses.

3. Energy utilization features of ammonia-urea complexes

Ammonia-urea complexes use natural gas as feedstock and fuel. For all the complexes consumption of natural gas used as feedstock per unit production of ammonia or equivalent quantity of urea is not significantly different, irrespective of the age of the plant or technology used, but the consumption of natural gas as fuel burned in the primary reformer (PRF), auxiliary boilers (utility boilers) and captive power plants is influenced by the way process heat and waste heat from the PRF and power plants are recovered, utilized and integrated in the plant energy requirement system. While NGFF and PUFF use electric drives for their pumps, compressors, fans and blowers, etc., the other five complexes have maximized the use of process heat and waste heat as far as is practical. Process heat is used to generate steam, preheating boiler feedwater and process streams where needed, while waste heat from the PRF is used to generate steam, preheat air, etc. Whenever steam is generated, whether by auxiliary boilers, waste heat boilers, or power boilers, the generating pressure and temperature is the same and at the highest possible level as far as is practical in order to drive the turbines for compressors, generators, pumps, fans, blowers, etc., in convenient steps of steam pressure, and to use in the process as feed and heating media. In some plants auxiliary boilers generate steam at intermediate pressure levels to facilitate start-up of the ammonia plant, and there are in some cases dedicated auxiliary boilers for urea plants generating steam at intermediate pressures depending on the separation processes used in the urea technology. In newer plants, steam is generated at pressures of about 100 kg/cm^2 plus. Wherever possible, a hydraulic turbine is employed to use the fluid head. Dual drives have also been employed on the understanding that the electric drive would be used during start-up and then switched to steam drive under normal operation. Table 2 provides information on connected natural gas load, consumption of natural gas as designed and other relevant data for the seven ammonia-urea complexes [BCIC, 2001].

In the larger plants the steam system is integrated by considering convenience of generation and utilization as motive power, heating media as well as process feed [BCIC, 2001; Kluwer, 1998]. Table 2 shows how the consumption of natural gas has been decreasing over the years because of integrating recovery of process and waste heat through steam generation for subsequent use as motive power and other purposes, except at PUFF, which is a small plant still using reciprocating compression and does not use process heat efficiently, while the oldest plant NGFF is based on electric drive and does not have process heat recovery sequences as found in new plants.

Natural gas in Bangladesh is sweet (H_2S (mercaptan) less than 7 ppm) and rich in methane, in excess of 96 % by volume. Because of very low H_2S content, the gas preparation before reforming is rather simple and in most cases only a ZnO-guard is employed. The feedstock gas being rich in methane, the ammonia plant has to be oversized by a few per cent to produce the required carbon dioxide for the rated urea production. This means that these complexes produce some ammonia in excess of what is required to produce urea. This leads to additional natural gas consumption per unit urea production and obviously this is a penalty in a competitive market. KAFCO has excess additional ammonia capacity to sell ammonia as a separate product at the rate of 500 t/day. NGFF has a 10,000 t/year ammonium sulphate plant built in 1968 for using the excess ammonia production capacity. The ammonium sulphate is used in the tea gardens of Bangladesh. Other complexes have additional ammonia production capacities in the range 40-80 t/day, depending upon the original design philosophy.

Modifications and revamping of the complexes have been carried out from time to time with assistance from the process licensor, engineering contractor and equipment vendors. Changes include use of new catalysts, process modifications, process heat recovery exchangers, waste heat boilers, new absorbing media, etc. [BCIC, 2001]. Most process modifications required sizeable capital investment.

When these complexes were designed and equipment procured, today's concepts of energy efficiency were in their formative stages. More efficient motors, pumps, turbines, compressors, boilers, furnaces, etc., could have been procured, but the issues of provenness and reliability were of paramount importance as against savings from greater energy efficiency. Additional fixed capital investment needed was also an important consideration. Moreover, the process licensors and engineering contractors would not have given the performance guarantees of the plants if plant equipment was not proven, and the clients would naturally be reluctant to accept equipment without a proven performance record. The problem is compounded by the fact that many of the furnaces, reactors, turbines, compressors and pumps are proprietary equipment and the issue of performance guarantee makes incorporation of efficiency of equipment alone untenable. The pivotal issue – who takes the risk and who covers the risk – remains the unanswered question in incorporating advanced efficient equipment in large plants.

4. Performance of the fertilizer complexes [BCIC, 2001; Quader and Gomes, 2002]

The performance of these complexes is discussed in the context of utilization of stream days, capacity utilization and consumption of natural gas (both for process and fuel) per t of urea produced. The economic performance is not discussed, because the sale price of urea and depreciation to be charged are fixed by the government for the six plants owned by BCIC, while KAFCO either exports its urea produced or sells it to BCIC at the world market price. BCIC sells all urea (produced by its plants and procured from KAFCO or imported) to dealers at the price fixed by the government. The sale price of urea fixed by the government is today about US$ 40 below the price at which it is offered by KAFCO.

4.1. Utilization of stream days [BCIC, 2001]

The number of design stream days per year for the urea complexes ranges from 312 to 333. Utilization of stream days has been in the range 270-310 for most years, but in some years stream days utilization has exceeded the design days. Immediately after overhauling, the utilization of stream days remains close to the design days for a couple of years, after which it starts to go down. However, whenever the plants are operating, the daily production achieves the name-plate capacity and sometimes even exceeds it by a few per cent. Reduced number of on-stream days is due to equipment failures, leaks, instrument malfunction and loss of power. In this respect older and newer plants, or smaller and larger plants show no marked difference.

4.2. Capacity utilization [BCIC, 2001]

A recent technical audit of BCIC's six urea complexes reports that they can sustain production of urea at a plant load in the range 0.96-0.98 with the current level of technical supervision and maintenance. For the past two years KAFCO has been operating close to, or a few per cent above, the design capacity. PUFF, even though it uses older production processes, has a capacity utilization of 100+ %. Even the 40-year-old NGFF plant still produces more than 85,000 t of urea per year against the name-plate capacity of 106,000 t. Overall capacity utilization in most years has been close to 90 %.

4.3. Consumption of natural gas (both for process and fuel) per t of urea [BCIC, 2001]

The consumption of natural gas (both for process and fuel) per t of urea produced in a year is a measure of both process and plant efficiency. The consumption of natural gas is stated in the performance guarantee of the plant on per unit product basis. During the normal operation of the plant, on a given day the plant usually consumes natural gas at a rate close to the design value. When the total natural gas consumption is considered on annual basis, natural gas used in start-ups, shutdowns, plant upsets, etc., is all accounted for, while no product is produced. Even when the urea plant suffers upsets or failures, the ammonia plant remains operational and delivers ammonia to the storage tank and vents the carbon dioxide because a complete shutdown of a complex would mean a 4-5 days start-up time. If long periods of operation between shutdowns cannot be sustained, the natural gas consumption per unit of urea or ammonia will exceed the design values.

Table 3 shows the natural gas consumption per t of urea for different complexes under BCIC during the decade ending 2000 [BCIC, 2001]. The major reasons for a significant increase in natural gas consumption on a yearly basis are:

- extra natural gas consumption for repeated shutdowns and start-ups;
- lower plant load of ammonia plant, requiring more steam from auxiliary boiler;
- lower efficiency of turbines, compressors, pumps, fans, etc., when operating at reduced load; and
- change of natural gas composition (decrease in C_{2+} against the design values) for CUFL.

The lower end of the range in % excess natural gas

Figure 2. Growth of fertilizer sector. The units shown on the y-axis are million standard cubic feet of gas per day (MMSCFD). 35.315 MMSCF = 1 m^3

consumed over the design value in Table 3 represents the natural gas consumption for most of the years mentioned. The highest values for each complex are for the year when stream days are fewest and the plant suffers an abnormal number of shutdowns and upsets.

5. The urea fertilizer industry and its impact on the natural gas industry

The planning of NGFF immediately after the discovery of the Sylhet Gas Field in 1955 laid down the foundation of the natural gas industry in the country. NGFF remained the lone major consumer of natural gas up to 1967, consuming about 87 % of the annual gas production. In 1968, other sectors such as power, domestic and commercial started to use gas as fuel. With the commissioning of UFFL in 1970 the share of gas used by the fertilizer sector again rose. It must be noted that with the commissioning of a new urea complex, there has been a clearly identifiable rise in the gas demand, indicating the low annual demand growth in Bangladesh. It is only from 1984 that the power sector's natural gas consumption exceeded that of the fertilizer sector.

Today the connected gas load of the seven urea complexes is 8.18 Mm^3/day and the annual consumption with all plants operating is about 2.55 Gm^3. Figure 2 and Table 4 show the growth of natural gas demand by the fertilizer sector while Figure 3 shows the sector-wise gas consumption from 1960 to 2000 [BCIC, 2001; TGTDCL, 1999; BBS, 1999].

Initially the gas sector developed its transmission system targeting fertilizer and power plants as anchor loads. This resulted in having a plant tied to a specific gas field. Considering even the present consumption of gas by the industrial and domestic sectors, this strategy was a well-thought-out and financially rewarding one. There were no system losses and the fertilizer sector has always been a good paymaster to the gas companies.

The natural gas industry through its association with the fertilizer sector has been able to standardize the gas intake stations for bulk consumers, metering stations and maintenance/operation of the gas transmission system. This, in the initial years, helped assure the other consumers that indigenous natural gas is a reliable source of hydrocarbon fuel.

Even though the power sector has a connected gas load of about 18.4 Mm^3/day, all energy demand projections consider the fertilizer load an equally important category, and for this reason the fertilizer industry is considered a separate sector. The demand for natural gas by the fertilizer sector in the next two decades will however not increase significantly, because by closing down the older plants such as NGFF and UFFL (aged over 30 years) 0.84 Mt of urea in place of the present 0.56 Mt can be produced if plants using JFCL or KAFCO type technologies are used [Quader and Gomes, 2002]. Even if the country needs to produce an additional 1 Mt of urea, the gas requirement would be an additional 1.42 Mm^3/day if plants such as NGFF, UFFL and PUFF are shut down. This

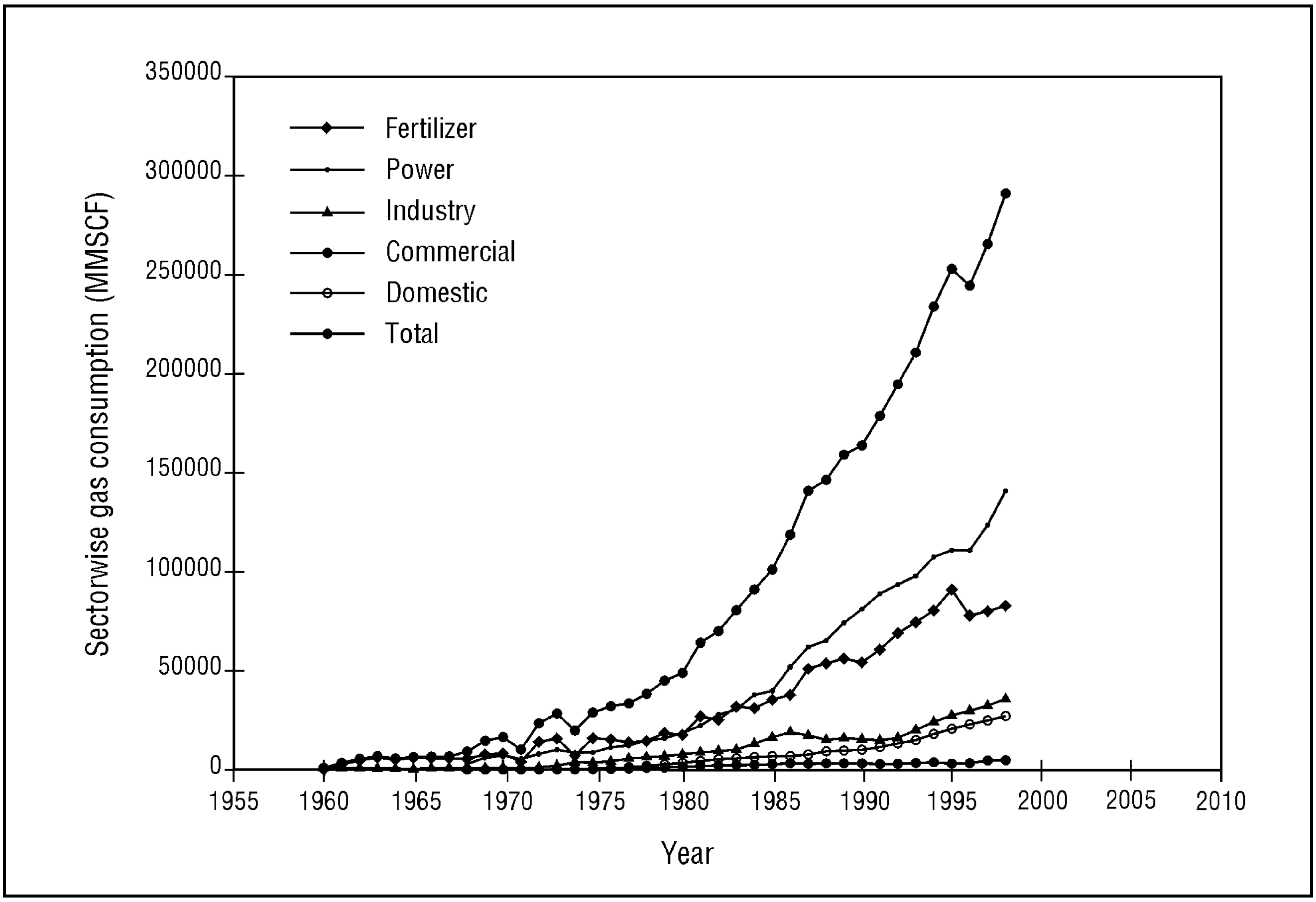

Figure 3. Sectorwise natural gas consumption

Table 3. Natural gas consumption per t of urea for different complexes under BCIC

Plant (capacity in t/yr urea), year of commissioning	**Consumption of NG as per design (10^3 m^3/t urea)**	**(Range of % excess NG consumed over the design value)**
NGFF (106,000) 1961	1.67	4.86 to 13.56 (during 1991-2000)
UFFL (340,000/ 469,260[1]) 1970	1.00	5.76 to 20.96 (during 1992-2000)
ZFCL (528,000) 1981	0.79	16.39 to 29.85 (during 1991-2000)
PUFF (95,000) 1986	1.41	-14.22 to 5.53 (during 1991-2000)
CUFL (561,000) 1987	0.78	10.69 to 21.60 (during 1991-2000)
JFCL (561,000) 1991	0.69	12.04 to 45.04 (during 1992-2000)

Sources: BCIC, 2001; Quader and Gomes, 2002

Note

1. After 1991 revamping.

means a connected gas load of 9.63 Mm^3/day. In any event, in the next decade or two, the fertilizer sector will remain important for the gas industry.

Today questions are often raised regarding the price of natural gas for urea production or the opportunity cost of natural gas. Before dealing with these questions, one

Table 4. Connected load of gas for fertilizer sector

Year	Plant	Load (Mm^3/day)	Cumulative load (Mm^3/day)
1961	NGFF	0.54	0.54
1970	UFFL	1.27	1.81
1981	ZFCL	1.42	3.23
1986	PUFF	0.48	3.71
1987	CUFL	1.42	5.13
1991	JFCL	1.22	6.34
1994	KAFCO	1.84	8.18

needs to return to the days when natural gas-based urea plants were planned. In those days natural gas was not a valued hydrocarbon as it is today. The tariff for natural gas for fertilizer or power in this country was comparable with that of crude oil on heating value basis when a barrel of crude oil (5.8 GJ) was \$ 2 to \$ 3 in the early seventies. The price of natural gas for the fertilizer industry, fixed by the government, had always been close to \$ 0.035/m^3 or \$ 0.95/GJ during the past fifteen years. Since the local currency has always been depreciating against the US dollar, it is clear that within a year of fixation of the gas tariff, the price of gas will become less on the dollar scale. From 1984 to today the exchange rate of the US dollar has gone from 25 to 59 taka (Tk), while the gas tariff for fertilizer over the same period has gone from Tk 0.459 to 2.05/m^3. The tariff in US dollars for natural gas for fertilizer in Indonesia is approximately equal to that in Bangladesh. If the tariff for natural gas had been \$ 0.071/m^3 in the year 2000, the production cost of bulk urea would have been increased by about 32 % for the larger plants; even then the cost of production of urea would have been below the world market price. For argument's sake, consider that Petrobangla refuses to sell gas at less than \$ 0.071/m^3 and the fertilizer plants have decided to shut down. One should now compute the opportunity cost of gas in the current context. The expected outcome certainly looks grave and grim for the country both economically and politically. The fertilizer sector based on natural gas has provided the necessary life support for the development and growth of the gas industry since the first discovery of natural gas in the country. Urea fertilizer together with natural gas-based electricity is today recognized as the cornerstone of the country's food security and political stability. ■

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With such a multi-disciplinary approach, *Energy for Sustainable Development* addresses itself to both specialist workers in energy and related fields, and decision-makers. It endeavours to maintain high academic standards without losing sight of the relevance of its content to the problems of developing countries and to practical programmes of action. It tries to provide a forum for the exchange of information, including practical experience.

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