Report No. 3873-BD

Bangladesh: Issues and Options in the Energy Sector

October 1982

Report of the Joint UNDP/World Bank Energy Sector Assessment Program

JOINT UNDP/WORLD BANK ENERGY SECTOR ASSESSMENT PROGRAM

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ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
BBL	Barrel
BES	Bangladesh Energy Study (1976)
BPC	Bangladesh Petroleum Corporation
BPDB	Bangladesh Power Development Board
CF	Cubic Feet (normally of gas)
CFD	Cubic Feet per Day
CHT	Chittagong Hill Tracts
CNG	Compressed Natural Gas
ERL	Eastern Refinery Ltd. (Chittagong)
GDP	Gross Domestic Product
GWH	Gigawatt hour (10^6 KWH)
IDA	International Development Association
KFAED	Kuwait Fund of Arab Economic Development
kg.o.e.	Kilogramme of oil equivalent
KVA	Kilovolt-ampere
KW	Kilowatt
KWH	Kilowatt-hour
LPG	Liquified Petroleum Gases
LT	Long Tonne
MCF	Thousand Cubic Feet
MMBTU	Million B.T.U.
MW	Megawatt
MWH	Megawatt-hour (10^3 KWh)
MT	Metric Tonne
PBS	Palli Bidyut Samities (Rural Electricity Co-operatives)
REB	Rural Electrification Board
TE	Traditional Energy
TOE	Tonne of Oil Equivalent
TPY	Tonnes Per Year
USAID	U.S. Agency for International Development
USF	Unclassified State Forests

This report is based on the findings of the Energy Assessment Mission undertaken during October 1981. The composition of the mission was: Trevor Byer (Mission Chief), F. Manibog (Economist), A. Ezzati (Energy Planner), M. Mitchell (Research Assistant), K. Wijetilleke (Refinery Engineer), D. Singh (Asian Development Bank), G. Schramm (Consultant), B. Shetty (Forestry Consultant), P. King (Gas Consultant) and M. Boddington (Energy Conservation Consultant). Secretarial assistance for this report was provided by Ms. Linda Walker-Adigwe and Ms. Josefina Regino-Suarez. The draft report was reviewed with the Government in September 1982 and revisions incorporated as appropriate.

Associated with this report are two other documents produced by the Energy Assessment Mission:

(i) "Bangladesh: Rural and Renewable Energy Issues and Options", World Bank Energy Department Note No. 5, April 1982; and

(ii) "Bangladesh: Donor Activities in the Energy Sector", Paper prepared for April 1982 Paris Meeting of the Bangladesh Aid Group, March 1982, Document BAN-82-5.

Currency Equivalents

Currency Unit	Taka (Tk)
100 Paisa	1 Taka
US$1	19 Taka - October 1981
US$1	22 Taka - July 1981

Conversion Factors

Fuels	Physical Units per TOE 1/
Liquid Fuels (Cubic metres)	
LPG	1.85
Gasoline	1.38
Jet Fuel	1.34
Kerosene	1.25
Diesel Oil	1.19
Fuel Oil	1.06
Ethanol	1.38
Coal (tonne)	1.5
Natural Gas (MCF)	43.57

1/ 1 toe = 41.0 x 106 BTU

Energy Conversion Factors

Hydro electricity	1 KwH	=	3,412 BTU
Natural gas	1 CF	=	941 BTU
Electricity (at end-use level)	1 KwH	=	3412 BTU
Motor gasoline	1 L.T.	=	1.124 TOE
Naphtha	1 L.T.	=	1.070 TOE
Kerosene	1 L.T.	=	1.086 TOE
Diesel Oil	1 L.T.	=	1.042 TOE
Fuel Oil	1 L.T.	=	0.987 TOE

Fiscal Year

July 1 - June 30

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BANGLADESH

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CHAPTER I

SUMMARY AND RECOMMENDATIONS

A. Overview

1.01 Bangladesh faces two energy crises, one involving commercial and the other traditional fuels (agricultural waste, firewood and cow dung). Although it has one of the world's lowest per capita energy consumption levels (100-130 kg. of oil equivalent, of which over two-thirds is traditional), its net oil imports of around 1.6 million tons in 1980-81 cost about US$460 million, using about 60% of its total foreign exchange earnings. At the same time, the country's forest reserves are being rapidly depleted and the availability of other traditional fuels is declining. Fuelwood prices have increased dramatically over the last 10 years. If present trends continue, a fuelwood crisis in many rural areas is likely in the near future.

1.02 The country has no known oil reserves, no economically exploitable coal, and limited hydropower potential. However, it has substantial economically recoverable natural gas reserves (about 10 trillion cubic feet) which at present consumption levels would last for several decades. The rapid and effective use of this major resource could be a crucial element in alleviating the country's current payments problems and enhancing its energy outlook.

1.03 Despite low levels of energy consumption Bangladesh uses its energy inefficiently. There are substantial losses in the conversion, transmission and distribution of power as well as frequent and costly power outages; the security of supply of natural gas is inadequate; production from the oil refinery does not match domestic demand, and there is considerable scope for improving industrial energy efficiency. Many of these deficiencies, and the difficulties in addressing them, stem from major institutional and policy shortcomings, including shortages of skilled managers and technicians in the country's energy agencies, inadequate energy price levels and related serious financial problems, and inadequately designed and maintained physical plant for the production, transformation, distribution and consumption of energy.

1.04 The potential is large for improving the country's energy situation through proper management and the development of programmes based primarily on the following principles:

(i) Expanded production, distribution and use of natural gas, particularly for power generation and industry, to meet growing energy demands and to substitute for more costly imported fuels;

(ii) Major improvements in domestic oil refining facilities;

(iii) More efficient use of energy through better control of conversion and distribution losses and industrial energy conservation;

(iv) Increases of energy prices to economic levels, particularly for electricity, petroleum fuels and gas; and

(v) Reforestation and improved development of fuelwood and charcoal production.

1.05 These courses of action, supported by and based on appropriate preparatory studies, technical assistance, capital investment (amounting to about US$2.05 billion over the next 5 years) and policy changes, would moderate growth of energy demand, lead to the use of less costly energy sources, improve the reliability of supply systems, alleviate the problem of traditional energy shortages and limit the growth in energy imports. Historic and tentatively projected commercial energy balances are summarized in Table 1.1. (Data on non-commercial energy are inadequate to allow their inclusion in the table). A detailed discussion of the underlying energy demand forecasts and their implications is given in Chapter 3, while supply projections are discussed in Chapter 4.

1.06 The major factors highlighted in this table are:

(a) Though commercial energy demand growth is expected to be about 8.8%/year between 1979/80 - 1984/85, this would be achieved with a negligible increase in net oil imports, which should increase at only 1.7%/year.

(b) Virtually all of the increase in commercial energy demand over this period would be met by increased domestic gas production growing at a rate of about 16.3%/year between 1979/80 - 1984/85.

(c) The level of commercial energy losses is estimated to show some improvement over the period in question, declining from 20% (561,000 toe) of commercial energy supply in 1979/80 to about 15% (720,000 toe) in 1984/85. This is in large part due to the expected improvement in power losses being instituted by BPDB.

(d) With net oil imports expected only to rise marginally to about 1.64 million toe in 1984/85 the estimated cost of these net imports would be about US$520 million (1981 $) compared to US$460 million (1981 $) in 1980/81.

1.07 In the longer term, Bangladesh should aim at using its gas reserves to spearhead its export earnings.

B. Major Issues and Options

1.08 The major issues and options facing Bangladesh's energy sector are:

Table 1.1

BANGLADESH: PAST AND FUTURE COMMERCIAL ENERGY BALANCES
(000 metric tons of oil equivalent)

Energy Demand/Supply	1979/80 000 toe	1979/80 %	1984/85 000 toe	1984/85 %	Annual Growth Rate %/year 1979/80 - 84/85
Domestic Energy Demand					
Residential/Commercial	546	24.7	686	20.4	4.7%
Industrial 1/ (energy & non-energy)	1061	48.1	1903	56.6	12.4%
Transport	451	20.4	539	16.0	3.6%
Agriculture	99	4.5	221	6.6	17.4%
Other	51	2.3	16	0.5	-20.7%
Total Final Demand	2208	100.0%	3365	100.0	8.8%
Domestic Energy Supply					
Production					
Natural Gas	1035		2205		16.3%
Hydro	50		67		6.0%
Net Energy Imports					
Petroleum (Crude plus products)	1505		1641		1.7%
Coal	177		177		0.0%
Less					
Conversion and Transmission Losses	561		723		5.2%
Total Energy Supply 2/	2206		3367		8.8%

1/ Both energy and non-energy uses of fuels in the industrial sector are aggregated. The major non-energy use being gas used as fertilizer feedstock.

2/ These figures do not exactily match to demand number due to rounding errors in conversions to oil equivalent.

(i) Management of Public Sector Energy Companies

1.09 Many of the major problems identified by the mission that need to be addressed urgently in the petroleum, gas and power sectors arise directly because of:

(a) A serious hemorrhage of skilled manpower through migration because of inadequate levels of remuneration for key skills;

(b) The need to up-date and up-grade the technical and management skills at both senior and middle management levels through the institution of training programmes.

1.10 The management of the public sector energy enterprises cannot be significantly improved unless government confronts these issues directly and undertakes measures to alleviate them. Specific recommendations for each of the sub-sectors and for national energy planning are given in the main body of this report.

(ii) Gas Development and Utilization

1.11 Natural gas supplies are substantial and gas is an ideal fuel in many applications. The goverment therefore should put a substantial effort into developing gas as the primary commercial energy source in the country.

(a) Oil/Gas Exploration and Development

1.12 Given Bangladesh's limited capability in mounting an exploration program on its own, it would need to make concerted efforts to secure the participation of foreign oil companies in this area. Further, so as to attenuate the existing energy imbalance between the eastern and western zones, exploratory effort, at least in terms of seismic work, needs to be stepped up in the western zone. Even a modest discovery of natural gas in the western zone could significantly ameliorate the existing situation. In addition, in the producing gas fields in the eastern zone, seismic work should be undertaken using modern methods and technologies.

(b) Gas Supply

1.13 Of immediate concern is the security of gas supply and the safety of its distribution. The Dacca gas distribution system is currently vulnerable, because it is relying on a single source of supply, a single transmission line and has no boosting or storage capability. In the event of failure of either the transmission line to Dacca, the city gate station or the gas field, supply to the city could be quickly lost. If gas supply is to continue its rapid rate of expansion the need for "back-up" is critical, including an alternative supply to the Dacca city gate station. Theoretical network analysis has shown that pressures in the distribution system in the centre of Dacca could be as low as 7.7 psi even with normal pressures at the city gate. It is of paramount importance that the following actions be undertaken as a matter of urgency:

(a) Investment in additional gas production wells to provide reserve "back-up" capacity to the gas system.

(b) A second gas supply and transmission system to Dacca needs to be put in place.

(c) Measures need to be taken to strengthen the Dacca gas distribution system (e.g., through cross connections and looping of the network) to improve the physical reliability of the system.

(c) Gas Utilization

1.14 Measures already underway include the construction of the East-West electricity interconnector which will provide gas-generated power to the West and will substantially reduce fuel costs in that area. In addition, the IDA-financed Bakhrabad-Chittagong pipeline will lead to the replacement of fuel and diesel oil in power generation and industrial uses in Chittagong and adjoining areas. Also, gas is now being used as a feedstock for the manufacture of urea which would ultimately result in the total substitution of imported nitrogen-based fertilizer by domestic production.

1.15 The most important constraints to increased gas utilization are first, the rate of capacity expansion of the gas distribution sector and the training of qualified staff who can handle this potentially dangerous fuel; second, the high cost of gas infrastructure; and third, the high cost of gas as a transport fuel and as a fuel for small isolated demand centres.

(d) Development Opportunities

1.16 There are some new and challenging ways to even out the peaks and troughs in the fluctuating gas demand profile. These include gas-driven stationary automobile engines for local power, gas-driven water pumps (for pumps close to major pipeline networks), air conditioning, and gas compressors for refrigerated stores and freeze centres. (These latter two are particularly suitable for interruptible gas loads). Country brick kilns are another example of good load growth customers provided the seasonal variations can be accomodated within the system, the correct tariff is charged to counter seasonal demand and the kilns are close to the pipeline network. It should be noted, however, that with the commissioning of the Ashuganj and Ghorasal power plant extensions fluctuations in gas demand would decrease relatively.

(e) Gas to the West

1.17 There are two alternatives to take gas to the West. One is the construction of a pipeline; the other is the supply of LPG to selected distribution centres. The first alternative requires very high capital investment and faces the problem of limited markets relative to economic pipeline sizes in the absence of an export contract with India, as well as exceedingly difficult technical problems in crossing the major river systems. The second is much more flexible, less capital-intensive, and can be tailored to marketing requirements. It can also be implemented more rapidly. Furthermore, LPG can possibly be distributed at reasonable cost to rural villages. Potentially the greatest risk facing an east-west pipeline is that low-cost gas be discovered in the west long before the pipeline investment was fully amortized. Secondly, the economics of such a pipeline to meet solely the west zone's gas needs has to take full account of the east-west electrical interconnector, since the transmission of large blocks of power to the west pre-empts one the most important gas markets in the west - namely, that of power generation.

(f) LPG Recovery from Natural Gas

1.18 The Titas and Bakhrabad fields might produce up to about 30,000 tons of LPG per year at gas production levels of about 500 MMCFD per day. This would require the construction of gas separation plants. LPG could be economically transported by river to strategic locations where bottling stations would be established. Use of LPG could be promoted to displace kerosene used for cooking in urban areas. LPG supply of about 30,000 tpy could displace about 8-10% of present kerosene demand, which is the estimate of present kerosene use for cooking amongst higher income households in urban and rural areas without access to gas. Other potential uses of LPG include substitution for gasoline in spark ignition engine vehicles, as well as substitution for diesel oil in irrigation pumps. In the case of the former, this would tend to exacerbate the already large gasoline/naphtha surpluses. In the case of the latter, spark ignition engined irrigation pumps would be required in place of such pumps based on compression ignition engines. A further potential use of LPG is as a substitute for kerosene as a lighting source in non-electrified households. Here pressurized LPG lamps would have to be introduced to replace the conventional kerosene wick or pressurized kerosene lamps. All of these options need to be evaluated to determine the end-use that maximizes the overall benefits to the country.

(g) Compressed Natural Gas (CNG)

1.19 A pilot study of compressed natural gas use in the transport sector is being financed by IDA. It appears that rail transport offers particularly attractive possibilities for the utilization of CNG. The volume of petroleum product consumption in the railways' diesel engines is currently 100,000 tons, of which two-thirds is fuel oil 1/ and the

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1/ The diesel engines have been modified to run on fuel oil as well as diesel; this reduces the life of the engine.

rest diesel. The replacement of fuel oil by CNG would require about 10 MMCFD of gas per day and would increase the life of the engines. 1/

(h) Other Potential Domestic Gas Uses

1.20 A further possibility might be the production of single cell protein (SCP) which would require large quantitites of gas converted first to methanol and subsequently manufactured into animal feedstocks. There would be a large home market and potential scope for export. Methanol also has potential as a cooking and transport fuel; however, further international research into its potential for these uses as well as for lighting has to be undertaken before the economic and technical feasibility of these options in Bangladesh can be proven.

(i) Gas Export

1.21 Even on the basis of the very preliminary investigations undertaken so far, the supply of gas is likely to remain well in excess of Bangladesh's expected internal needs for a substantial period of time. Export options include the following:

(a) export gas through a pipeline to India;

(b) export gas after liquefaction; and/or

(c) attract export-oriented industries which are energy intensive e.g., methanol production and/or use natural gas as a feedstock.

The first of these would require an East-West gas pipeline, and the solution of a number of political, financial and technical problems. The second option may also be viable but an LNG plant capable of liquefying 500 MMCFD of gas, including tankers, is likely to cost more than two billion dollars. In addition, considerable investment would be required to create a deep-sea terminal or make alternative arrangements, as Chittagong harbour is incapable at present of accepting LNG tankers. In any event, new gas reserves will have to be delineated before an LNG plant can be given serious consideration. For purposes of determining the resources which would need to be deployed for increasing the economy's absorptive capacity for gas and also for evaluating the various options available to the government in terms of gas export, including methanol production and gas liquefaction, a detailed study should be carried out.

1/ Though there would be a loss in available power when using CNG and diesel oil rather than fuel oil and diesel oil the weight penalty associated with CNG use should be least in this transport mode.

(iii) Refinery Improvements

1.22 The 1.5 million TPY refinery at Chittagong is unsuited to meet current and projected petroleum fuel requirements of the country as it has neither the processing flexibility to match the market demand profile nor the processing capacity. For example, BPC's production program for 1981 envisaged the purchase of 2.6 million tonnes of crude oil, of which 1.3 million were to be processed by the Chittagong Refinery and the balance by the Shell Eastern Refinery, Singapore. This large crude oil throughput from both refinery operations would give a surplus of 780,000 tons of fuel oil and 230,000 tons of naphtha which would have to be disposed of on the world market at relatively low prices.

1.23 With the expansion of the natural gas substitution program the major petroleum product that will be replaced is fuel oil. This will increase the surplus of fuel oil from the refinery and increase the pressure for modifications of the refinery to permit conversion of fuel oil to needed middle distillates. To deal with these problems, the following refinery program appears promising:

Immediate Savings

(a) Spiking. By spiking the imported crude oil with deficit products up to the technical limitations of the Chittagong refinery, immediate savings of about US$5-7 million per year could be realized.

(b) Blending. To reduce the export of surplus naphtha and increase the production of middle distillates, some blending of heavy naphtha with middle distillates is feasible. This would require construction of a naphtha splitter to obtain the heavy naphtha component for such blending. The estimated annual saving would be about US$2.0 million for an investment of about US$4.0 million.

(c) LPG Recovery. At present LPG is recovered only from the crude unit of the refinery due to plant limitations and shortage of storage facilities. Thus, of the 15,000 tons/year of LPG which are available, only 4,000 tons are being recovered. The unrecovered LPG is used as refinery fuel or flared. About 75% of the LPG from the refinery is presently marketed in the Chittagong area and the remaining 25% is distributed throughout the country. Consumer demand for LPG is limited at present only by availability. It has been estimated that for tobacco-curing alone an additional 15,000 tons of LPG would be required. An investment of about US$11 million to recover this additional LPG and add storage facilities would offer an attractive rate of return.

Medium Term Option

Debottlenecking. Debottlenecking the refinery to increase the capacity to 45,000 barrels per stream day and increasing the quantity of spikes could yield savings of more than US$10 million per year. The estimated additional investment is about US$20.0 million at 1981 prices.

Longer Term Options

Cracking. Of various possible long term options examined by the mission, the one that would likely provide the greatest operating flexibility would eliminate net fuel oil output completely while giving the lowest import costs. This option (costing about US$140 million in 1981 prices) includes a hydrocracker complex with a hydrodesulphurizer and a deasphalter. A detailed study needs to be undertaken of this option as well as for the debottlenecking of the refinery as a matter of high priority. However, it needs to be stressed that decisions about secondary refining (cracking) investments are fraught with uncertainty at present due to the current state of the oil market and the fact that these investments are only economic if the differential between fuel oil and distillate prices remains sufficiently wide.

(iv) Energy Efficiency, Losses and Conservation

(a) Power Outages and Losses

1.24 The frequency of power outages in the BPDP systems is very high. In 1979/80 the probability that any one of the west side distribution feeders would be inoperative at any given time was in excess of 14%. A random sample over six months of a feeder in the Dacca Region showed a total outage time of 14%. In a sample month of its first operational year REB experienced power cuts at its sub-stations on 10 out of 30 days. One reason for the high level of outages has been the absence of firm capacity in the east and west zones.

1.25 Outage costs consist of six components:

(1) the costs to the utility of non-supply (loss of net revenue);

(2) the cost to the utility of outage repair;

(3) the net costs to power consumers from loss of productive output;

(4) the additional costs to production from the installation of stand-by or captive power plant equipment (these costs, however, reduce the costs listed under (3));

(5) the disincentive effect to prospective industries or other economic activities to establish themselves in areas of uncertain power supplies; and

(6) damage to equipment amongst power consumers.

1.26 Net losses to industrial activities due to outages in 1980/81 may have amounted to some US$30 million.1/ BDPB and the Government are trying to reduce these losses by a program to build special feeder lines to important industrial plants (e.g. 65 jute and 13 textile mills) and by authorizing the installation of captive or stand-by generating equipment in others. Captive plant capacity at present amounts to approximately 30% of total operative BPDB capacity.

1.27 The BPDB system is also subject to substantial energy losses that have fluctuated between 36 and 40% of total generation in recent years.2/ In spite of contractual commitments to reduce these, the various measures adopted have apparently been unsuccessful so far (or new sources of losses have nullified ongoing reduction measures). These losses contribute substantially to the dismal financial performance of BPDB. The actual costs of such losses are even higher than the measured discrepancy between production and recorded sales, because such losses occur mainly during peakload hours, thereby contributing significantly to overload and outages.

1.28 Losses are mainly caused by four factors: first, excessive distribution line losses from faulty or overloaded equipment; second, faulty or non-functioning meters; third, errors or fraudulent practices in meter readings and accounting; and, fourth, theft through meter tampering and illegal connections. Given the technical characteristics of the BPDB systems, it has been estimated that total losses (including auxiliaries) should be no higher that 23%. The remaining 13-17%, then, could be subject to appropriate remedial actions. A major problem is that BPDB lacks adequate metering capability to monitor the energy dispatch through its various distribution feeders. For example, in the Western Zone, it was found that out of 46 sub-stations only four had functioning meters. This means that in many cases the location of losses cannot be identified.

1.29 Outright theft is generally concentrated in major urban areas (mainly Dacca). These customer groups, however, contribute only about 10% to recorded sales, which means that the actual consumption rates in these areas may be more than 100% higher than recorded sales. These conditions are likely to worsen as a result of the projected rapid urban growth.

1/ Estimates of the mission.

2/ these losses include station auxiliary use.

1.30 Specific measures are to be undertaken by BPDB to reduce system losses 1/ to around 18% by 1985 and to 16% by 1990. This plan of action includes the separation of technical and financial losses and proposals to reduce each category; it also sets out annual targets against which BPDB's performance can be monitored. The commencement of these loss reduction measures is a condition of credit effectiveness for the recently negotiated Ashuganj power project.2/

(b) Gas Losses

1.31 Apparent consumption of gas for domestic use is substantially higher, perhaps by four times,3/ than cooking needs and the number of connections would indicate. A "loss" of about 6% of Titas gas sales is implied, with an economic value of about US$1 million annually, a significant amount since Titas's pre-tax profits in 1979/80 were only US$2.0 million. The causes of this are not clear, and could include inadequate identification of total system losses, faulty meters, theft, or inadequate statistics. Efforts should be made to identify the causes of these losses, and corrective action taken.

(c) Industrial Energy Conservation and Fuel Substitution

1.32 Preliminary audits of selected energy intensive industries (paper, steel, bricks, cement, textiles and ceramics) indicate considerable scope for energy savings through improved housekeeping (potentially 10% of total energy consumption or about 26,000 tons of fuel oil annually), fuel oil substitution by natural gas (up to about 260,000 tpy of fuel oil) and possibly further savings by process change or modification in certain industries, e.g. steel. The mission surveyed three categories of energy intensive facilities:

Category I - Those facilities in and around Chittagong currently using fuel oil but which will have gas available by 1983.

Category II - Those facilities in and around Dacca and Sylhet currently using gas, and

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1/ As a percent of net generation.

2/ Ashuganj Thermal Power Project - IDA Staff Appraisal Report 3719c-BD (May 1982).

3/ Since most domestic consumers are un-metered the reported domestic demand is essentially a system residual, which presumably includes all losses. According to 1979/80 data domestic demand amounted to some 60 CFD per household which is at least 4 times higher than what one would expect for meeting cooking needs.

Category III - Those facilities such as the newsprint mill in Khulna (west zone) where gas is not expected to be available over the next several years.

1.33 Total fuel oil savings resulting from substitution of fuel oil with gas in the Category I facilities would be 101,000 tonnes/year (about 38% of total industrial fuel oil demand in 1979/80). The net value of these savings would be about US$14.1 million/year after accounting for the value of the gas replacement fuel. Investments amounting to some US$3.34 million would be required to retrofit these facilities and would have a pay-out period of only some 3 months. Clearly, top priority needs to be assigned to undertaking these investments to substitute fuel oil by gas. In the case of the Category II facilities surveyed improved housekeeping measures would result in natural gas savings varying from 22% of gas consumed at the Meghna textile mill, to 10% at the Luxmi Narraynn textile mill, and to 1% at the Sylhet cement factory. The total gas savings from such measures would amount to only some 16.8 million CF/year, resulting in cost savings of only about $24,000/year and requiring an investment of some US$56,000. Thus while conservation measures in these types of facilities appear less attractive than those in Category I or III, they still promise a rate of return on investment which is substantially higher than the cost of capital.

1.34 The case for housekeeping investments is strongest for the Category III facilities - those for which the prospects for gas substitution are low over the next several years. At the Khulna newsprint mill, for example, about 11% of current fuel oil demand (49,000 tonnes/year) can be saved by improved energy management, yielding a saving of about US$1 million/year for an investment of $230,000.

(v) Energy Pricing

(a) Electricity

1.35 Bangladesh Power Development Board (BPDB). Historically, the revenues of the Bangladesh Power Development Board have been insufficient to cover the cost of operations. This is basically the result of insufficient tariff adjustments to reflect changes in the underlying cost structure, particularly the costs of fuel. In 1978/79 net losses of Tk 293.6 million amounted to some 45% of total revenues of Tk 649.8 million; in 1979/80 net losses (before Tk 130 million government subsidies) increased to Tk 376.1 million, or 42% of total revenues of Tk 895.3 million. These accounting deficits understate actual losses since depreciation is charged at the low rate of 3.2% of book value (31 years life) and interest charges are based on subsidized terms for concessional loans and a nominal rate of 5% for government-financed portions of the investment program. Some long-term relief with respect to rising fuel costs is in sight (fuel accounts for 69% of total expenses and petroleum for 58%), with the hoped-for completion in 1982/83 of 200 MW of new, gas-fired and hydropower plants and the completion of the East-West interconnector, which will reduce the share of oil-fueled western generation by gas-hydro generation in the east. The existing tariff, introduced in July 1982, though lower than that based on long-run marginal costs, will go some way towards improving the financial situation of BPDB despite the contraints of high system losses. This tariff, however, will not realize a net internal cash generation sufficient to finance a reasonable percentage of BPDB's investment programme. As a result of this GOB and BPDB have agreed with external financing agencies to institute appropriate increases in real terms in the BPDB tariff to ensure realization of net internal cash generation sufficient to finance at least 20% of BPDB's capital expenditure in FY83, 25% in FY84 and 40% in FY87. The mission welcomes this agreement. However, the agreed increases in BPDB tariffs may be inadequate to achieve these objectives if electricity sales turn out to be lower than expected.

1.36 Rural Electrification Board (REB). Tariffs of the REB system are set on an individual PBS basis. The general principle underlying the tariff structures of each independent PBS is that they should be self-financing after a grace period of five years. This requires temporary subsidies by the Government to the REB system. These are estimatd to amount to an average of TK 0.381/kWh during the first year of a new PBS operation, falling to TK 0.106/kWh by the fifth year and to zero thereafter. This assumes that average charges will rise from TK 1.00/kWh from now to TK 1.778/kWh then. However, the recently negotiated bulk tariff from BPDB to REB of TK 0.78/kWh does not cover the economic costs of supply. These, at the 33 KV entry point, were estimated to amount to TK 1.61/kWh in domestic terms and TK 1.2/kWh in border prices. In other words, the REB system initially will obtain its bulk energy at less than half of the economic costs of supply. GOB has however recently agreed with IDA that a study will be carried out, by December 1984, of the bulk and retail tariffs of all supply authorities in the power sector, they will be based on long-run marginal costs and that new tariffs will be implemented by July 1, 1985, for BPDB and PBS's based on the recommendation of the study. It was also agreed that until this new tariff is implemented, the average price per Kwh sold by PBS's shall not be less than the average price per Kwh sold by BPDB. The mission considers it important that the above time schedules be adhered to so that the many new REB customers do not develop a vested interest in continued public subsidies.

(b) Petroleum Products

1.37 The Bangladesh Petroleum Corporation (BPC) endeavours to price petroleum products so that total financial costs of supply are recovered from sales. This is not always the case as needed price adjustments are often delayed. Furthermore, depreciation allowances and insurance coverage for the refinery are presently based on historic costs; they should be based on a replacement cost basis instead. The mission commends the Government on the recent measures to increase petroleum prices. This has removed the economic subsidies on diesel oil and kerosene which existed to June 1982. There is also the need to establish an automatic trigger mechanism to pass along to consumers any additional increases in costs of imported crude oil and petroleum products, as well as changes in the costs of the refinery operations.

1.38 The increase in LPG supplies from the refinery and natural gas separation will add to the inter-fuel pricing problem, because gasoline retail prices are more than 4 times higher than those of LPG on a volume basis. This differential could attract considerable conversions from gasoline to LPG use in spark-ignition engines. With these levels of financial incentives legal enforcement of a possible prohibition of LPG use in vehicles will be difficult, as experience elsewhere has shown. At present the low level of market penetration of LPG is largely due to non-availability. This product should be priced at its full opportunity cost which implies a price increase at the ex-refinery level of over 200%.

(c) Natural Gas

1.39 The issue of what is the long run opportunity cost of natural gas in Bangladesh is the first issue to be addressed. The country has very large gas reserves relative to domestic demand for at least the next couple of decades. This implies that the high-value uses of gas as a fuel oil substitute can easily be accomodated and, unless massive quantities of gas can be exported (a prospect that can, at best, only be considered very modest over the next several years), the opportunity cost of gas will fall to its long-run supply cost. For such a depletable resource, this supply cost includes both production costs and "user costs", which represents the foregone future value of the gas due to depletion. Given the major uncertainties involved in large-scale gas exports, either overland to India or as LNG to other countries, the mission considers that the opportunity cost of gas in Bangladesh is represented by its long-run marginal supply cost including a depletion allowance. Although the latter cannot be calculated precisely in the absence of a full macroeconomic model, the mission calculated a range of estimates to indicate the order of magnitude (see para. 5.04-5.06). When these estimates are added to the long-run marginal supply cost to bulk consumers in the eastern zone of Bangladesh, the range of the total economic costs of gas shown below was obtained.

Table 1.2

ECONOMIC SUPPLY COST PLUS DEPLETION FOR NATURAL GAS FOR REPRESENTATIVE REPLACEMENT FUELS (1981 PRICES) LEVELLIZED COSTS (1981-2000) (DISCOUNT RATES 6% AND 12%)

	Total Costs Per MCF			
Replacement Fuels 1/	Discount Rate 6%		Discount Rate 12%	
	Taka	US $	Taka	US $
Fuel Oil at $194/ton	36.88	1.94	21.42	1.13
Coal at $71/ton	24.53	1.29	17.05	0.90
Natural Gas at $1.50/MCF	12.56	0.66	12.49	0.66

1/ Replacement Fuels and their costs in the year 2000.

1.40 Of the three possible fuels (fuel oil, coal and gas) which could replace existing low-cost gas in the eastern zone at the point in time that depletion of current proven and probable gas reserves becomes binding (about 2000), the most likely, from a technical standpoint, is newly discovered gas for which development and production costs would be about 3 times higher, in real terms, ($1.50/MCF) than presently proven and probable reserves. The imported coal scenario is much less credible and the fuel oil scenario the least possible. On this basis the range of the total economic cost of gas to bulk consumers in the eastern zone is estimated to be between US$0.66/MCF and US$0.90/MCF assuming a 12% discount rate. The floor of this range is represented by new gas as the replacement fuel; the upper limit by imported coal.

1.41 Gas tariffs in July 1982 to the major bulk users (power and fertilizer) were about 75% of the lower level of this range. This suggests that these tariffs be increased. Clearly the minimum level of this tariff should be the "floor" of the range (US$0.66/MCF - 0.90/MCF). However, whether the tariff to bulk consumers should be increased above the "floor" and if so, by how much, depends on the issue of general resource mobilization. Gas represents the country's major natural resource and government needs to collect a larger share of the rent for development of other sectors, as well as ensure that the resource is not being sold below its economic cost to any consumers.

1.42 In the case of domestic and commercial consumers the joint cost of service to these consumers was estimated, for the year 1979/80, by the mission to be about TK 45.89/MCF (US$3.11/MCF) compared with average revenues from these groups of Tk 14.66/MCF (US$0.99/MCF). This implies that commercial and domestic consumers taken together received subsidies amounting to about US$2.12/MCF in 1979/80, or around US$7.4 million in total. This is to be compared with Titas Gas Co.'s pre-tax 1979/80 profits of US$2 million. Arguments of distributional equity that are normally used to justify such subsidies to these consumer groups appear unjustified when it is recognized that these benefits accrue to less than 0.8% of all households in the country. Clearly a series of significant upward adjustments in the tariffs for domestic and commercial consumers are called for. Since these tariffs have to be raised about 200% in real terms merely to cover costs they would have to be instituted over a period of time. It should be noted that raising domestic and commercial tariffs by about $2/MCF to cover their supply costs would mean that residential gas would still be about half the price of kerosene.

(iv) Renewable Energy Resources

(a) Fuelwood

1.43 Fuelwood resources, both in Government forests and private woodlots, are being overexploited to meet the increasing demand. If the present trend continues there is every likelihood of a fuelwood crisis in many of the rural areas in the near future. Fuelwood prices increased in the period 1971-1978 by an average annual rate of about 40% as compared to an inflation rate of about 18% annually. The need for taking up a massive tree-planting program in the rural areas is urgent. The success of such a program can be assured only if it is implemented with the active involvement of the local people. The ADB is currently financing a Community Forestry Project along these lines. Further such projects should be considered, including tree-planting on private lands, strip plantations along roads, canal banks and railway lines, and fuelwood plantations involving the replacement of existing damaged forests with fast-growing fuelwood species.

1.44 Also, 2.4 million acres of unclassified forests in the Chittagong Hills tracts have been seriously denuded by shifting cultivation, reducing the cycle of cultivation drastically due to soil erosion and leading to a diminishing return from the land. The consequent rapid siltation of the Kaptai reservoir will seriously affect the generating capacity of the Kaptai hydro-electric project. Rivers arising from this catchment area are also heavily silted up and floods have become a regular feature in recent times. A project for large-scale afforestation and for settling tribal groups on permanent land in this watershed could be initiated, resulting in improvement in the economic condition of the tribal people, substantial increases in wood production, establishment of forest-based industries, and creation of employment opportunities, in addition to soil and moisture conservation and general environmental improvements.

1.45 A note of caution however needs to be raised about projects in the Chittagong Hill Tracts which are populated by several ethnic minorities. Extreme care would have to be exercised to ensure that any projects in this area are not executed to the detriment of the tribal people. This is a critical issue.

(b) Other Renewables

1.46 The Government is committed to the development of renewable energy resources; it has recently established a Rural and Renewable Energy Section (RRES) in its Planning Commission and included survey, R&D and extension components in its Second Five-Year Plan. These encouraging actions should be vigorously pursued, but there is an urgent need to clarify the terms of reference of RRES, strengthen it through more qualified staff and greater financial support, and review its priorities. The ranking of renewable energy activities needs to be based on: (a) those urgent needs of the rural sector which can be realistically met by delivery systems of near-term applicability in the Bangladesh context; (b) the degree to which project components can be determined and their net contribution appraised; and (c) the limitations of current planning and implementation capabilities. Given these criteria the mission considers that the GOB should concentrate its efforts on large-scale dissemination of improved cooking stoves, community tree-planting schemes either in homestead or marginal land, charcoal conversion of logging wastes in the Kassalong Forest area, solar drying of grains, fish, fruits and vegetables and possibly biomass fuels. Biodigesters should be of lower priority and probably limited to animal feedlots.

1.47 Apart from a rural energy survey included as a component of the proposed technical assistance for energy to be financed by ADB and UNDP, and the USAID planned energy survey work to start in 1982, other areas of project activity for possible donor financing include a technical assistance program for the strengthening of the RRES for popularization of improved woodstoves (chulas) and for field testing demonstration of solar dryers, solar water heaters and solar pumps.

(vii) Energy Investment Programme

1.48 The government's proposed 5 year (FY80-85) energy sector investment programme envisages expenditure of about US$2.05 billion. The mission has the following observations on this proposed programme.

(a) Gas transmission and distribution investment of some US$180 million accounts for about 47% of total hydrocarbon investment. This may have to be increased if the urgently needed steps to enhance the security of supply of the Dacca gas distribution system are to be undertaken as well as the development of a second gas supply and transmission system to Dacca.

(b) The allocation for the rural electrification programme (about US$230 million) represent about 23% of power sector investment. Given the significant scaling down of the programme in its early years investment in this area would be lower than envisaged. This could allow investment in distribution to be increased, which is a high priority, given the urgent need to reduce system losses.

(c) Investment in petroleum product production and distribution of about US$47 million (12% of hydrocarbon investment) appears low given the need to invest in recovery and storage of LPG from the refinery (around US$11 million) and in a naphtha splitter (about US$4 million).

(d) Over US$50 million is allocated for atomic energy which is inordinately high given that this electrical energy source cannot compete with gas-based power in Bangladesh. This over-funding of atomic energy is further highlighted when compared to allocations for gas field development (about US$60 million) and petroleum product production and distribution (about US$47 million).

(viii) Energy Planning

1.49 There is a need for a medium-term energy investment plan for the period 1984-1988 to be prepared similar to the medium-term foodgrain production plan. The first step towards formulating such a plan would be a "stocktaking" of ongoing and proposed studies and projects and identificaion of other investment possibilities as components of such a plan. This medium-term investment plan would complement the longer-term comprehensive energy plan being financed by ADB and UNDP.

C. Major Recommendations

1.50 The major recommendations relating to the foregoing issues and options are as follows:

Gas Development and Utilization

(i) Take measures to attract foreign oil companies back to oil exploration (para. 4.86);

(ii) Initiate a program of extensive seismic work in the western zone where a fairly dense regional grid is required to identify promising structures (para. 4.86);

(iii) Undertake seismic work, using modern technologies and equipment, in the producing gas fields and the peripheral areas in the eastern zone (para. 4.86);

(iv) Maximize utilization of gas in power generation, industrial and commercial uses;

(v) Pursue further study of gas export alternatives (paras. 4.48, 4.58 and 4.67);

(vi) Consider an East-West gas pipeline only in the context of pursuing the possibility of gas exports to India (para. 4.48).

Refinery Improvements

(i) Urgently consider spiking of imported crude oil (para. 4.74);

(ii) Construct a naphtha splitter for blending the heavy naphtha component with middle distillates (para. 4.75).

(iii) Carry out detailed cost and engineering studies for debottlenecking (para. 4.79);

(iv) Carry out studies to determine the least-cost option for longer term modification/expansion (para. 4.82);

(v) Institute a training program (para. 4.78);

(vi) Carry out a complete review of operations (para. 4.78);

(vii) Finalize study and install facilities for increased LPG recovery and storage (para. 4.76).

Energy Efficiency and Conservation

(i) Carry out study and execute program to reduce power outages (para. 4.21);

(ii) Carry out program to reduce power losses, including improved metering, accounting and supervision and physical protection (para. 4.14);

(iii) Carry out detailed study to improve physical reliability of the Dacca gas transmission and distribution system (para. 4.41);

(iv) Carry out study to identify and correct causes of gas losses in domestic sector (para. 4.44).

(v) Direct gas marketing efforts to larger customers;

(vi) Institute manpower development program for power and gas sectors, including training, improved remuneration, and additional qualified staff;

(vii) Institute energy conservation program including detailed audits of major energy-using industries and power plants, preparation and execution of gas substitution projects and energy management training program (para. 3.61).

Energy Pricing

(i) Natural Gas. The gas pricing study which the Government agreed to do in the Bakhrabad credit should be undertaken urgently (para. 5.18 (a)). Major recommendations are made on increasing natural gas prices to all customer groups (para. 5.18 (b)-(c).

(ii) Electricity. The time schedules already agreed to by the Government for the bulk and retail tariff studies of the BPDB and PBS systems, as well as the implementation of the recommended tariffs need to be adhered to (para. 5.27).

(iii) Petroleum. Raising ex-refinery prices of diesel oil and kerosene by about 15-20% relative to September 1981 levels to remove subsidies. In the case of LPG increases in prices of about 200% at the ex-refinery level to reflect its full opportunity cost. Establishment of an automatic trigger mechanism to pass along to consumers any increases in crude oil and product import costs (para. 5.37).

<u>Renewable Energy Resources</u>

(i) Institute reforestation programmes and prepare projects (para. 4.98-4.99);

(ii) Study and carry out development of charcoal production (para. 4.100-4.101);

(iii) Obtain technical assistance for improvement of Renewable Energy Planning (para. 1.46), and preparation of projects on woodstove improvement (para. 4.103-4.104), and testing and demonstration of solar and biomass technologies (para. 4.107-4.113).

(iv) Development of hydro potential especially in the context of isolated local power systems.

1.51 Bangladesh has been successful in securing finance for the development of the energy sector, and especially for technical assistance, from several sources. However, the mission recommends that aid agencies pay more attention to priorities in the sector (as indicated in this report), to ensuring that there is no duplication of effort among them, and to ensuring that an adequate mechanism exists for the proper supervision of technical assistance projects (para 6.14).

CHAPTER II

ENERGY AND THE ECONOMY

A. Introduction

2.01 Total per capita energy consumption in Bangladesh is variously estimated to range between 100 to 130 kg. o.e. per year. It is one of the lowest in the world. Only 31 kg o.e. of this total is accounted for by commercial fuels 1/. The rest comes from traditional biomass resources. For all consuming sectors and the country as a whole, the problem of assuring a reasonable supply to support current activities and future developments is one of the most critical issues. It can be understood only against the background of geographic, resource-endowment and socio-economic factors which shape and constrain the economy.

2.02 Bangladesh covers some 55,600 sq. miles, or an area about half the size of Italy. Most of the country consists of the fertile delta of the Padma-Jamuna (Ganges-Brahmaputra) River system. The latter divides it into an eastern and western zone. Because of the huge width and the shifting, alluvia nature of the river beds, there are no bridges between the two zones. This strongly affects commercial fuel consumption patterns because the eastern zone is rich in low-cost natural gas while the west depends largely on high-cost imported petroleum products. Most of the country is very flat, and, therefore, subject to annual monsoon flooding. In bad years, as much as 40% of the total land area is under water for up to 6 months. On the other hand, during the dry periods, agricultural production depends on additional irrigation, mainly from pumps. This affects energy use. Heavy sedimentation hampers river transport, at least during the dry periods. Land transport by rail or road is difficult and time-consuming because of the many river crossings and the high costs of road bed construction. Much of the local transport is carried by human, bicycle rickshaw or bullock cart and over 80% of water-borne traffic moves in small sailboats rather than motor-driven craft.

2.03 With a population of some 90 million in 1981, and an average density of 1,620 persons per square mile, Bangladesh is the most densely populated country of the world, a situation exacerbated by the continuing high rate of population growth (2.7% per year). Over 90% of the population lives in rural areas and agriculture accounts for 80% of total employment. Land holdings are generally very small and the share of landless agricultural laborers is high. The country's Planning Commission estimates that 4/5 of the population cannot obtain minimum nutritional requirements and lives below the poverty line.

1/ Comparative rates of commercial consumption are 48 kg. o.e. for Burma, 151 kg. o.e. for India and 309 for all low-income countries.

2.04 Of the adult population, 76% is illiterate, and only 5% of the labor force has graduated from high school or advanced institutions of learning. There is a critical shortage of technically skilled persons and there are only about 30,000 scientists, engineers and technicians plus 100,000 skilled workers in the country. Out-migration rates to the Middle East are high. For the 1980 to 1985 period they are projected to be equivalent to around 40% of new graduates and trainees. This shortage of skilled manpower seriously affects the proper operation and maintenance of energy supply systems as well as other sectors of the economy. On the positive side, however, these high migration levels do result in significant foreign exchange remittances to the country.

B. The Economy

2.05 Bangladesh is one of the world's poorest countries with a per capita GDP in 1981 of only US$133 (in 1980 dollars) 1/. About 50% of its GDP is generated by agriculture, 30% by the service sector and only 14% by industry. Industry's share of total output has remained essentially stagnant since the mid-1970s. Between FY76 and FY81 total output increased at an average rate of 4.8%. However, it was subject to considerable swings, mainly as a result of year to year variations in agricultural output.

2.06 The country does not produce sufficient food to satisfy domestic consumption. Substantial imports in the form of grains and edible oils are needed year after year. Most of these imports are financed by concessional aid. A major focus of present development efforts is to make the country self-sufficient in foodgrain production by 1985. This, among others, requires substantial investments in irrigation pumps and fertilizer factories. This has implications for future requirements of natural gas, diesel fuels and electricity.

2.07 Exports (US$708 million in FY81) are dominated by jute and jute goods. In FY81 they accounted for 67% of total exports, followed by leather goods, with 8%, tea with 6% and fish and frogs legs with 6%. Of the remaining 14% of miscellaneous exports, about 1/2 were accounted for by the re-export of surplus naphtha and residual fuel oil. Overall, in 1981, exports accounted for only 28% of total imports. This ratio has steadily declined from some 53% in FY77. A major contributing factor was the drastic increase in the costs of crude oil and petroleum products, which more than doubled between FY79 to FY80 even though in quantitative terms they increased by only about 5%.

2.08 Imports are dominated by intermediate and consumer goods (31% in 1981), capital goods (23%), followed by petroleum and petroleum products (19%), grains and edible oils (14%) and cotton yarns and textiles (7%). Other important items are fertilizers and cement. In 1980, as a

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1/ Evaluated at the then prevailing rate of exchange. Since then the Taka has been devalued by over 25%.

consequence of poor harvests, food imports accounted for as much of 29% of total imports.

2.09 The share of petroleum imports relative to total exports has increased dramatically, from around 30% in the 1977 to 1979 period, to 54% in FY80 and 61% in FY81. For FY82 it is projected to rise to 69%. If the relatively modest coal imports of approximately US$18 million are added to petroleum imports, total energy imports amounted to a staggering 70% of the country's total exports in FY81.

2.10 This very high share is particularly serious because no help from outside donors is available to cover their costs. By contrast, much of the food, capital goods and significant portions of the intermediate goods imports are financed from concessional aid. Food aid disbursements between any two years are primarily a function of weather, crop failures and donor generosity in any given year and therefore may show significant variations. Between FY78 and FY81, for example, food aid disbursements paid for between 54 to 62% of total food imports and project aid amounted to between 84 and 99% of total capital goods imports. Overall, foreign aid covered as much as 61% of total import needs in FY78, but only 49% in FY81. This decline is as much a consequence of the reduction of foreign aid in real terms as it is a reflection of the sharp increase in the cost of energy imports. When one turns to non-food and non-project aid disbursements to meet import requirements other than food and capital goods, one finds that commodity aid covered 50.1% of such imports (excluding foodgrains, edible oils and capital goods) in FY78 but only 24.5% in FY81. The main reason being the large increase in petroleum prices in 1980 and the virtual stagnation in commodity aid disbursements in nominal terms (and their significant decline in real terms). Because prospects for increasing exports substantially are not very bright, given the dependence of the country's export sector on agriculturally-based products, reductions in energy imports must have high priority for the country's development strategy.

C. Energy-use Patterns

2.11 Energy consumption patterns in Bangladesh are characterized by a heavy dependence on traditional sources of energy. While exact data are not available, it is estimated that some 70-75% of total use is based on such sources. According to the 1976 Bangladesh Energy Survey, the most important ones are cow dung, (25%), rice husks, (24%), rice straw (18%), firewood or twigs (13%), and various others such as jute sticks, bagasse and miscellaneous organic wastes. In rural areas, energy use is almost entirely dependent on these traditional sources, with the exception of kerosene, which is widely used for lighting purposes. Traditional fuel sources are also important as fuels for commercial and small-scale industrial operations such as brick manufacturing plants. Bagasse is the major fuel used for steam production and power generation by the country's sugar mills.

2.12 The uses of commercial fuels, petroleum products (except kerosene), natural gas, coal and electricity are largely limited to the modern and urban sectors of the country. As can be seen from Table 2.1, in FY81 petroleum products accounted for the largest share with some 52%, followed by natural gas with 40%, coal with 6%, and hydro with 2%.

Table 2.1

COMMERCIAL ENERGY CONSUMPTION AND TRENDS
(in 10^3/toe) 3/

Source	75/76	78/79	79/80	80/81	Annual Average Rate of Growth 75/76-78/79 %	78/79-80/81 %
Coal 2/	223	177	177 1/	177 1/	-7.4	0.0 1/
Petroleum 2/ 6/	1,221	1,488	1,569	1,549 6/	6.8	2.0
Natural Gas 4/	677	821	1,085	1,180	6.6	19.9
Hydro 5/	40	48	49	49	6.3	1.0
Total	2,161	2,534	2,880	2,955	5.5	8.0

1/ Estimated.

2/ ADB Bangladesh Energy Country Report, September 1980.

3/ Jamuna Oil Company Performance Report 1979/80 and BPC for 80/81.
4/ Jamuna Oil Company Performance Report 79/80.

5/ ADB Country Report, September 1980; World Bank Rural Electrification Appraisal Report.

6/ Conversion Factors: 1 toe = 43.57 MCF of natural gas (1 scf = 941 BTU).
= 0.917 metric tons of petroleum products.
= 0.932 long tons of petroleum products.
= 1.5 tons of coal.
= 12,016 kWh of electricity.

Overall, the annual rates of commercial energy growth amounted to an average of 5.5% between FY76 and FY79 and 8% between FY79 and FY81. The much more rapid rate of growth in the last two years was entirely the result of the 20% p.a. increase in gas utilization.

2.13 The average energy growth/GDP growth ratio was 1.3 between FY76 and FY79 and 1.5 between FY79 and FY81. These ratios, however, overstate the actual relationship between economic growth and commercial energy consumption. This is so because much of total GDP is accounted for by the agriculture sector, while commercial energy use by the agriculture sector and the people employed in it is minimal. The major direct and derived agricultural commercial energy uses are kerosene and diesel fuels. If the share of agricultural use of these fuels is deducted from total commercial energy consumption and total agriculture output is deducted from GDP, the residuals allow a comparison of energy consumption in industrial and service sector activities. The resulting growth ratios are significantly lower than the non-adjusted ones, with 0.8 for the FY 1976 to 79 period and 1.2 for FY 1979 to 1981. These ratios are comparable to those of other developing countries.

2.14 Overall, the energy situation is critical for the country because of the dwindling supplies of traditional fuels in the face of growing demands, the huge burden of petroleum imports relative to the country's foreign exchange earnings and the additional need to finance highly capital-intensive natural gas projects that are designed to bring about further substitution of gas for oil.

CHAPTER III

ENERGY DEMAND

A. Current Demand Patterns

Introduction

3.01 Three important characteristics have shaped the growth of commercial energy demand in the past and will continue to shape it in the future. First, the War of Liberation in the early 1970's destroyed much of the industrial and energy supply infrastructure. Most of the efforts in the ensuing years were devoted to re-building these facilities. For this reason statistical series depicting energy consumption trends prior to 1975 are unrepresentative and do not reflect any orderly growth pattern of the economy. Second, much of the commercial energy consumption originates in the industrial sector where operating units are large in relation to the overall size of the supply system. As a result, the addition of a single new plant or facility (e.g. a fertilizer plant) can have a pronounced ratchet effect on energy consumption. Third, a significant proportion of potential commercial energy demands depends on the construction of supply facilities. For example, the extensions of gas distribution and electricity supply networks have major effects on consumption (e.g. rural electrification, natural gas supplies for the Chittagong Region, etc). Much of the growth in demand, therefore, is actually determined by supply. These factors must be kept in mind when past consumption data are evaluated and projections of future demands are made.

Electricity

3.02 Electricity demand has grown at annual average rates of over 13% between 1976 and 1980 and at a rate of slightly over 9% the following year. Consumption is dominated by the industrial sector which accounts for 59% of public utility sales and an estimated 70% of total electricity1/ consumption in 1981 (see Table 3.1). The next important user group is the commercial sector with 14%, followed by the domestic one with 12% and agriculture with 2%. An important characteristic of the public supply system is the very substantial loss rate, which is discussed in detail in Chapter IV.

3.03 The total number of connections served in 1980/81 was 568,309. This is minute compared to the country's population of 90 million. As a result, average annual per capita consumption was only 19.3 kWh in 1980/81. Only 1,596 out of a total number of 65,000 villages had been electrified by 1980, which means that only about 2% of the rural

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1/ Including captively generated electricity by industrial enterprises.

population had access to electricity. But even in those villages, towns and cities that have access the number of households connected is very small, ranging from a fraction of 1% to less than 20% in Greater Dacca. On the other hand, consumption per household is relatively high, with an average of 1,210 kWh/year in the Eastern Zone. This is because those few households that can afford electricity belong to the relatively affluent part of the population. By contrast, the household consumption levels of customers of the newly established rural electrification program amount to an average of only 262 kWh/year. This is likely to increase later since the rural electrification programme has only just started.

Table 3.1

ELECTRICITY CONSUMPTION BY SECTOR
(GWH)

Sector	1976	1981	Annual Growth Rate 1976-1981 %
Domestic	123.0	267.7	15.6%
Commercial	83.9	302.0	25.6%
Industrial	670.9	936.2	6.9%
Agricultural	19.5	33.8	11.6%
Other	25.9	53.5	15.6%
Total	893.2	1,594.6	12.3%
Captive Generation 1/	n.a.	614.0	
Overall Total	-	3,208.6	
Losses (Utility Only) 2/	507.7	1,067.2	

1/ Mission estimate: Based on 186 MW of existing capacity, 55% capacity utilization, 60% load factor.

2/ Includes station auxiliary use.

Source: BPDB

3.04 System load factors ranged from 55 to 58% between 1976 and 1981. These are high given the type of loads and the small size of the electric power systems. Two factors are likely to be responsible for these high utilization rates: first, the high share of industrial loads on total system demand, and, second, the frequent outages and power shortages that mainly affect peak load demands. A third factor reducing peak load demands is related to the refusal of BPDB in recent years to connect new customers to the system, particularly in the western zone. This was done because of the chronic power shortages of the system. As more reliable and efficient generating capacity comes on line in the future, it can be expected that system load factors will decline as a consequence.

Natural Gas

3.05 Initially the use of natural gas was confined to a fertilizer plant, which is supplied from the Sylhet field, and a cement plant supplied from another field at Chhatak. Subsequent to the discovery of the Titas gas field in 1962, transmission and distribution facilities were built to connect users in and around the Greater Dacca area. As Table 3.2 shows, gas utilization grew at compound rates of 11.8% between FY 1976 and 1980 compared to 8.7% between FY 1980 and 1981. These high rates of growth are a reflection of the low cost of natural gas relative to other commercial energy sources (all of which are imported), the rapid expansion of the gas supply and distribution system and the ongoing substitution of gas for other types of fuels. In 1980/81 some 38% was used by the power sector, 36% by the fertilizer industry, (both as a feedstock and a source of energy), 16% by other industries and 10% by the domestic/commercial sectors.

Table 3.2

NATURAL GAS CONSUMPTION BY SECTOR

Sector	1975/76 MMCF	%	1980/81 1/ MMCF	%	Annual Growth Rate 1975/76-1980/81 %
Fertilizer	15,252	54%	17,730	36%	3.1%
Power	8,722	31%	18,619	38%	16.4%
Industrial	3,367	12%	7,891	16%	18.6%
Commercial & Domestic	753	3%	4,711	10%	44.3%
Total	28,094	100.0	48,951	100.0	11.8%

1/ Preliminary.

Source: Petrobangla

3.06 The largest gas supply system is that of the Titas Gas Company which accounts for about 70% of total sales. Titas is the only system with an extensive utility-type distribution network. It had 115,248 registered connections in 1979/80 of which 97.4% were domestic. However, these accounted for only 7.9% of the system's gas consumption. Gas consumption is highly skewed, with a few large users accounting for most of it. Country-wide, two fertilizer factories accounted for 36%; four electric power plants for another 38%, while a single cement factory utilized another 3.5%. Of the rest, various industrial uses accounted for only 11% and miscellaneous commercial/domestic uses for 9% (1979/80 data).

Petroleum Products

3.07 Until now, petroleum products supplied the largest share of the commercial energy market, accounting for 52% of total consumption in 1980/81. Consumption is skewed towards middle distillates (kerosene, jet-fuel and diesel oil). A breakdown by product for selected years between 1975/76 and 1980/81 is shown in Table 3.3 below.

Table 3.3

PETROLEUM PRODUCTS CONSUMPTION (ACTUAL SALES)
1975/76 - 1980/81
(000 long tonnes)

Product	1975/76		1980/81		Annual Average Rate of Growth
	'000 toe	%	'000 toe	%	%
LPG	-	-	4	0.3	-
Gasoline	54	5%	57	3.9	1%
Naptha	9	1%	-	-	-
Kerosene	341	30%	448	30.4	5.6%
Jet-Fuel	24	2%	44	3.0	12.9%
Diesel	278	24%	448	30.4	10.0%
Fuel Oil	383	34%	414	28.1	1.6%
Jute Batching Oil	28	2%	36	2.5	5.2%
Others (non-energy)	20	2%	21	1.4	1%
Total	1137	100%	1472	100.0	5.3%

Sources: Jamuna Oil Company, Petrobangla.

Kerosene and diesel each accounted for 30.4% of total consumption in 1980/81 followed by fuel oil with 28.1%. Table 3.4 provides a sectoral breakdown of demand in 1979/80. As can be seen, the transport, household, industrial and power sectors were the major consumers of petroleum products accounting for 28%, 27%, 20% and 14% of demand respectively. The transport sector accounted for about one-half of diesel oil demand. The rest was consumed in the agriculture sector, mostly for irrigation pumps (21%) and in electric power generation (23%). The only petroleum product consumed in any significant quantity in households is kerosene, primarily for lighting in rural and urban areas. In the urban areas it is also used for cooking to some extent accounting for between 10-15% of total consumption. Very small amounts (less than 4000 tons in 1979/80) of LPG are being used, mainly in urban households for cooking purposes. Fuel oil demand by two industries, steel and paper, account for nearly 1/3 of industrial fuel oil demand. The rest is consumed in the power sector (21%) and by the railways (13%). Railways use fuel oil in diesel engines in the proportion of 2/3:1/3 fuel oil to diesel oil.

Table 3.4

DEMAND FOR ENERGY PETROLEUM PRODUCTS BY SECTOR, 1979/80
(in thousand long tons and %)

Sector	Motor Gasoline (MS, HOBC) LT	Kerosene LT	Jet A-1 LT	Diesel Oil (HSD) LT	Fuel Oil (HS) LT	Total LT	Total (%)
Agriculture	-	-	-	92	-	92	(7)
Electric Power	-	-	-	104	(96)	200	(14)
Households	-	384	-	-	-	384	(27)
Industry							
Steel	-	-	-	-	(45)	45	(3)
Paper	-	-	-	-	(112)	112	(8)
Other	-	-	-	8	(112)	120	(9)
Sub-Total				8	269	277	20
Transport							
Air	-	-	(44)	-	-	(44)	(3)
Rail	-	-	-	(31)	(59)	(90)	(6)
Road	(62)	-	-	(117)	-	(179)	(13)
Water	-	-	-	(78)	-	(78)	(6)
Sub-Total	62	-	44	226	59	391	28
Bunkers	-	-	-	(17)	(45)	(62)	(4)
Other	-	-	-	-	(2)	(2)	-
Total	62	384	44	477	471	1408	100

Source: Bangladesh Petroleum Corporation.

3.08 Between 1975/76 and 1979/80 demand for energy petroleum products increased at an average rate of 6.6%/year. The most rapid increase in demand has been for diesel oil (12.6%/year) and jet-fuel (16.4%/year), while demand growth for residual fuel oil, gasoline and kerosene has been much slower, averaging 5.3%/year 3.5%/year and 3%/year respectively. All products showed a sharp slow-down in growth between 1979/80 and 1980/81 except kerosene. The structure of demand for petroleum products has undergone some important shifts, particularly as a result of the increasing role of natural gas in the energy supply mix. Between 1975/76 and 1980/81 the share of middle distillates has increased from 57% to 64% while those of fuel oil and gasoline have declined.

3.09 The demand for kerosene, most of which is used for lighting in rural areas, appears to be sensitive to changes in both price and income in the agricultural sector. As the data in Table 3.5 appear to suggest, the rate of growth in kerosene consumption slows down significantly following years of declines in agricultural output. Overall, kerosene consumption has grown at about the same rate as population.

Table 3.5

RATES OF CHANGE OF AGRICULTURAL OUTPUT AND KEROSENE CONSUMPTION (%)

	FY 77	FY 78	FY 79	FY 80	FY 81
Agriculture Output	-3.0	10.1	-0.4	0.5	8.1
Kerosene Consumption	5.6	-1.9	4.8	3.8	-1.8 1/

1/ Excludes price induced kerosene use by other sectors.

Coal

3.10 All coal used in Bangladesh is imported. Its use has steadily declined over the last decade, largely as the result of the elimination of coal-fired steam locomotives by the railways and the partial conversion of industrial uses to gas. Consumption by the railway fell from 120,000 tons in 1969/70 to 32,000 tons by 1979/80. In recent years total consumption ranged between 230,000 to 250,000 tons. The major steam coal supplies come from India at about US$40/ton (1980). Some supplies of higher quality coal come from China in the form of steam coal at c.i.f. costs of US$54/ton and lump coal (mainly for metallurgical purposes) at US$69/ton.

3.11 The major user in recent years has been the brick manufacturing industry. Brick manufacturing is a vital industry and is widely spread throughout the country, with bricks providing the basic building material for buildings, foundations and road ballast in the absence of gravel deposits. Between 1975/76 and 1978/79 the industry used between 155,000 and 192,000 tons per year. No clear trend is observable. This is probably the result of year to year changes in the granting of import licenses, which are strictly rationed. The main fuel alternatives for the industry are firewood, fuel oil or natural gas if the plant is close to the pipeline system. Both firewood and fuel oil are considerably more expensive than imported coal (see para. 3.20), but natural gas is considerably less.

Traditional Energy (TE) Consumption

Per Capita Use of Traditional Energy

3.12 There are at least 10 studies available from which sharply conflicting figures on rural energy use can be derived. What follows is mainly based on the more recent and rigorous of these surveys, namely those of Islam (1980 a and b), Briscoe (1979), Douglas (1981a and b), Aliff (1981) and Tyers (1978). The first nationwide estimate of TE consumption was the (BES) Bangladesh Energy Study (1976), with the results shown in Table 3.6 below.

Table 3.6

CONSUMPTION OF TRADITIONAL ENERGY SOURCES (1973/74)

Fuel Type	Amount Used (106 mt)	Total Energy 1/ (1012 kcal)	% of Total Traditional Energy
Cow Dung 2/	6.1	17.0	25
Rice Husks	4.1	12.2	24
Rice Straw	3.0	9.1	18
Small Prunings, Twigs and Leaves	1.5	4.7	9
Jute Sticks	1.0	3.0	6
Bagasse	1.5	2.8	5
Bulk Fuelwood	0.5	1.6	4
Other Wastes	1.5	4.6	9
Totals	19.2	55.0	100

1/ Conversion factors are based on Douglas (1981) and account for energy expended in driving off excess moisture in the combustion process. They are lower than those used by BES.

2/ Dry weight.

Source: "Bangladesh Energy Study" (1976) prepared by Montreal Engineering Co. Ltd. et. al.

On the basis of a 77.8 million population in 1973/74, average per capita TE use amounted to 0.71 million kcal or 0.07 TOE. This level of consumption is very low compared to per capita TE use in Burma and Nepal (0.18 TOE)1/ and in India (0.23 TOE)2/. The major reason for this low estimate appears to be that the BES based its consumption data on aerial photographs and estimates of available fuelwood volumes. In reality, however, a large proportion of biomass fuels is utilized in the form of twigs and leaves.

3.13 Other more recent studies use a physical consumption-survey, rather than a supply-potential, basis. The striking fact is that the results of these studies vary widely, ranging from a low of 70 kg o.e. per capita per year to as much as 170 kg. o.e. This is a reflection of the many uncertainties that necessarily surround consumption estimates of the wide variety of biomass materials that are utilized throughout the various annual growing cycles.

3.14 Future surveys need to be designed so as to produce directly comparable results. In particular, more attention needs to be given to the actual utilization of "tree fuels," which reportedly serve as a "stopgap" fuel when crop residues are unavailable. However the objective of such surveys should be the identification and preparation of projects rather than simply a further compilation of baseline consumption data.

Traditional Energy Use in Dacca

3.15 Although the country's urban population accounts for only 9% of the total, it is growing at a rapid rate of about 10% per year. A survey 3/ in five major zones and one fringe area of Dacca is the only study on urban traditional and commercial energy consumption available so far. Unfortunately, the study's results appear to be based on a sample biased towards higher-income households, because it claims that 70% of the households had gas connections, whereas only about 17% of the total number of households in Dacca actually are supplied with gas.

3.16 The study reports a high per capita per year use of kerosene of 20 kg. o.e. by low-income and urban fringe households in areas in which gas connections were scarce. This high consumption is probably the result of the relatively lower price of kerosene vis-a-vis commercial fuelwood (see also para. 5.14). In the Dacca area, it is reported that use of tree-based fuels per capita per year amounts to 5 kg. o.e. This is low, and compares with around 110 kg.o.e. in rural areas. Use of agricultural residues and charcoal is negligible. However, in the urban

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1/ 1979 FAO Yearbook.

2/ The Indian Forester, Vol. 102 (10) 1976.

3/ "Industrial Forestry Sector of Bangladesh," by J.J.Douglas et. al. (1981), UNDP/FAO/GOB Project BBGD/78/010, Field Document No. 3.

fringe area, per capita per year use of these fuels is reported to be 50Kg o.e., or nearly half of rural rates.

Traditional Energy Utilization Patterns

3.17 The only attempt so far to account for TE flows into various uses was made by Tyers (1978)1/. His data indicate that around 90% of rural energy comes from TE sources, of which about 60% are from crop residues. The largest domestic end-use consumer is cooking, which accounts for around 95% of total household energy consumption. As a proportion of total energy consumption, cooking accounts for 70%. Almost 60% of cooking needs are met by crop residues and 30% by cowdung. A major end-use is rice parboiling: paddy rice is soaked, heated, then dried and milled; the flavor, nutritional value and milling characteristics of the hardened and gelatinized kernels are improved in the process. Crop residues are estimated to meet 90% of rice parboiling requirements.

Competition From Industrial Uses of Biomass

3.18 In order to assess fully the magnitude of supply constraints, account must be taken of industrial needs for biomass as fuel and raw material. Consumption of wood and bamboo falls into four categories: (1) domestic and industrial fuel, of which the former has already been discussed; (2) material for buildings and a wide variety of tools and equipment used in rural areas; (3) processed forest products (newsprint, matches, etc.) and (4) sawn timber. Almost all the wood and bamboo used for household construction, community structures, implements and transport equipment comes from homestead complexes.

3.19 The bulk of wood supplies also comes from homestead complexes (sometimes loosely referred to as "village forests"). Industries such as tobacco-curing, lime manufacture, conversion of date palm juice to molasses, sericulture, and lac, catechu and sitalpati production depend entirely on homestead sources. The brick and match manufacturing and boat building industries depend on homestead areas for up to 90% of their wood supplies. Only the pulp and paper and tea chest veneer industries draw 70% and 90% of their wood supplies from public forests. The pulp and paper industry also utilizes reeds, jute cuttings, bagasse and wheat straw. Annex I provides a summary of the major industrial wood usages.

3.20 In general, all the industries studied are experiencing an increasing scarcity of wood for use as a fuel or raw material. Current production in the match, tea chest veneer, and pulp and paper industries is far below capacity due mainly to raw material shortages.

1/ "Optional Resource Allocation in Transitional Agriculture: Case Studies in Bangladesh" by R. Tyers (1978).

3.21 The shortages are apparent from the high costs of firewood: For example, brick manufacturing plants in and around Dacca face the following comparative 1980 fuel costs for producing 1,000 bricks: TK 420 for wood-fired kilns; TK 331 for combined wood and coal-fired kilns; and TK 300 for gas-fired kilns. Because the demand for fuelwood from homestead sources is continually increasing it is not clear how projected future requirements can be met.

Draft Power Shortages

3.22 A major problem confronting the agricultural sector is the growing shortage and poor quality of draft animals. It is caused by the severe scarcity and inferior quality of feed and fodder for buffalos and cattle. Larger, stronger animals generally require more feed which is already in very short supply partly due to increasing diversion of agricultural residues to domestic cooking fuels. These animals subsist primarily on straw from paddy, wheat and pulses, and from meager grass in and around homesteads. Given the impossibility of opening new grazing land, actions to alleviate the draft power shortage need to focus on three issues which are of relevance to the energy sector1/. These are:

(i) Reductions in household consumption of residues through the use of more efficient cooking stoves;

(ii) A shift to woodfuels. However, this possibility is limited due to the wood supply constraints discussed earlier;

(iii) The planting of alternative sources of fodder from multipurpose tree species (e.g. "ipil - ipil2/, tropical grasses etc. on field bunds and strips of marginal land).

(iv) Diffusion of improved equipment to improve the efficiency of draft animal use.

Energy Consumption in Agriculture

3.23 The major consumer of commercial energy in the agricultural sector is irrigation pumping. Mechanical farm implements are insignificant users by comparison. There were only 3,454 tractors and 1,738 power tillers in operation in the country in the late 1970s.3/

1/ A more detailed discussion is presented in the report produced by the Assessment Mission - "Bangladesh: Rural and Renewable Energy Issues and Options", World Bank Energy Department, Paper No. 5, p. 15 (April 1982). See also Annex of Bangladesh Country Economic Report (1981) Vol. III.

2/ Leucaena leucocephala.

3/ Bangladesh Bureau of Statistics. Agricultural Census 1977.

On the other hand, there were a total of 40,000 low lift pumps, 48,000 shallow tube wells (STW) and 14,000 deep tube well pumps (DTW) in operation in 1980/81. Overall targets for 1984/85 are 170,000 pumps of all types, of which some 70,000 are to be electrified, while the balance will be mainly diesel-powered.

3.24 Irrigation pumping is highly seasonal. The main season occurs in the period between February and May, although occasional dry spells in other months may lead to heavy usage as well. Overall, the load factors of irrigation pumps are low. Surveys undertaken for BPDB show an average of 1,680 operating hours for DTWs pumps and 1,200 for STW and LLP pumps, or annual load factors of 19% and 14% respectively1/. One of the consequences of the planned strong expansion of irrigation pumping, and the simultaneous electrification program of irrigation pumps, will be the lowering of systems load factors for the BPDB system as a whole.

3.25 Another important factor in assessing the energy demands for the irrigation sector is that these demands fluctuate substantially from year to year as a consequence of water conditions (i.e., rainfall patterns). This can be seen from the record of electricity consumption by the agriculture sector in recent years in Table 3.7.

Table 3.7

AGRICULTURAL ELECTRICITY CONSUMPTION 1976-1981
(GWH)

1976	1977	1978	1979	1980	1981
19.5	33.2	14.2	55.2	34.8	33.8

These substantial fluctuations on a year to year basis have occurred in spite of a steady increase in the number of electric irrigation pumps in operation. Increased agricultural irrigation pumping loads, therefore, will result in more volatile and fluctuating demands for diesel fuels as well as electricity.

B. Future Energy Demand

3.26 Demand forecasts for Bangladesh are subject to even greater uncertainties than elsewhere. This is because:

1/ BPDB Power Market Survey - Eastern Region, Volume I, June 1981, page 138.

(i) Existing supply and consumption data for traditional fuels are uncertain and subject to wide margins of error.

(ii) Commercial energy use is concentrated in a few small sectors of the economy that themselves are subject to substantial and frequently unexpected changes; a few industrial and power plants account for the bulk of natural gas, fuel oil and electricity consumption; breakdowns by these plants are common and projected expansion plans are often subject to long delays.

(iii) A significant percentage of projected future energy demands depend on the expansion of energy supply networks (i.e., rural electrification, natural gas distribution networks, LPG extraction and distribution), but the projected completion dates of these projects are often uncertain.

(iv) Existing demand forecasts for the various commercial fuels are mostly based on projections originally developed for the Second Five-Year Plan; the goals of the latter, however, are not realizable, which invalidates substantial segments of projected additions to energy demand (see also paras. 3.30 to 3.51).

3.27 Because of these many difficulties, the mission has limited its demand forecasts to the year 1985. This provides an adequate basis for immediate planning purposes. It was felt that inadequate information is available at this time to extrapolate this forecast further into the future since much of the potential energy demand in the second half of the 1980s will depend on presently ongoing and planned investment activities and their proper execution, on the level and composition of foreign aid to Bangladesh, and on outside events such as changes in world oil prices, or the production and relative price of jute goods, the country's most important export commodity.

3.28 However, while demand forecasts are subject to wide margins of uncertainty, it is precisely because of these uncertainties that major efforts must be made to improve and regularly update existing forecasts.

Recommendation

3.29 The mission, therefore, recommends that a special energy demand forecasting unit be created as part of the Energy Cell of the Planning Commission. Revisions of forecasts, preferably made every year, should be distributed to government agencies and the energy producing companies and discussed with them.

Electricity Demand Forecasts

Introduction

3.30 Electricity demand forecasts are available from the Bangladesh Power Development Board (BPDB) covering the 1981 to 1990 period. These incorporate the separately prepared demand forecasts for the Rural Electrification Program. (REB purchases all of its power requirements from BPDB. However, they exclude the production of the various captive power generating facilities that are operated independently of the BPDB network. The mission developed a scenario of power sales and generation up to FY84/85. Given the many uncertainties surrounding the development of the country's economy and its power-consuming sector, it was considered inappropriate for the mission to attempt to develop a demand scenario beyond FY84/85. Barring unforeseen major new developments the presently planned expansion program of BPDB appears sound until the mid-1980s based largely on projected peak demand requirements. Since the present system is capacity constrained, at present an important issue in the power sector's development program is the need to bring new plant on-stream to meet forecast peak demand. In 1980 peak demand in the western and eastern zones was 124 MW and 348 MW respectively. The BPDB forecasts this to increase, on the interconnected system, to 936 MW by 1985 and 1823 MW by 1990.

3.31 The mission reviewed the various consultants reports and information available about the expansion plans of the power consuming sectors in assessing the BPDB demand and energy forecasts. Some of the points highlighted by this analysis are:

(a) Rural Electrification Forecast

The BPDB forecast relied on the original REB expansion plans as input data. These plans have been modified, however, at least for the early years. The total number of country-wide REB connections by June 1985 is now projected, by the REB, to be only about 124,000, or less than 5% of the originally projected number. However, the original projections were included in the BPDB forecast. This difference is important because in the domestic and commercial sectors almost all growth in demand in recent years has resulted from network expansion rather than increased consumption by already existing customers. The annual rate of increase of the latter was less than 2% in recent years. As a result, the mission's estimate of REB sales in 1985 is lower than that in the BPDB forecast--84.6 GWH compared to 216 GWH.

(b) Industrial Sector Power Demand

The BPDB forecast for power demand in the industrial sector incorporated the industrial expansion programme of the draft second Five-Year Development Plan. These goals have now been recognized as being somewhat optimistic, with the result that the mission's forecast for industrial sector power demand in 1985 is 1744 GWH compared to 2225 GWH in the BPDB forecast. This difference essentially arising from the exclusion of those new industrial plants which are now known to have been postponed.

(c) System Losses

The BPDB system loss reductin program agreed with IDA as part of the Ashuganj power project credit.is targeted to reduce total losses, including statin own use to 32% in 1981, 27% in 1983 and 23% by 1985. There is a significant risk that the stated goals may not be met if implementation of the various loss reduction programs is not as efficient as originally envisaged. As a result there may be some time lag in achieving the stated objectives.

(d) Load Factor

In the mission's view, by 1985 the load factor of the interconnected system will be around 51%, or somewhat lower than the 55% projected by the BPDB forecast. In part, this reflects the expectation that capacity shortages will be eliminated by that time so that the existing peak load demand restrictions can be removed. This is estimated to increase peak loads by almost 5%. Further, the composition of the load is projected to change somewhat, with high-load factor industry demand falling to some 60% compared to the 64% forecast by the BPDB. This reduced relative share of industrial power use will lower the overall systems load factor because of the much lower factors of other user categories.

(e) Table 3.8 compares the mission's lower energy consumption scenario for 1985 with the BPDB projection. Energy consumption is projected to be about 16% lower. However, the projected peak demand of the interconnected system is only 5% lower than that of the BPDB forecast. This is of critical importance for present system expansion plans, which remain sound on technical grounds since the projected difference of 5% in 1985 peak demands is well within the usual ranges of forecasting uncertainties.

Table 3.8

1981 and Projected 1984/85 BPDB Energy
Consumption, Generation & Peak Demand

Consumption 1/	Actual 1981	Mission Scenario 1984/85	BPDB Forecast 1984/85
Domestic	292.1	384	425
Commercial	329.3	517	450
Industry	1021.8	1744	2225
Agriculture	38.0	41	116
REB	-	85	216
Others	58.3	142	39
TOTAL	1739.5	2913	3471
Generation (GWH)	2661.8	3936	4508
Load Factor (Interconnected System)%	-	51%	55%
Peak Demand (MW)	-	889	936

1/ Includes energy consumed but not billed.

3.32 The 3936 GWH of gross generation in the mission's FY 84/85 scenario is expected to be generated by the following primary fuels:

(a) 800 GWH from hydro;

(b) 160 GWH from diesel oil of which 84% arises from west zone units;

(c) 457 GWH from fuel oil coming primarily from the two steam units at khulna, and

(d) 2519 GWH from natural gas fuelled steam and gas turbine units in the east zone.

This implies that oil fired generation would still represent as much as 16% of total generation due essentially to the two Khulna steam units being operated at a 30% plant factor. The reason for operating these units is apparently to provide adequate system reliability in the event of failure of the east-west interconnector and a 30% plant factor is the lowest operating rate at which they can be continuously maintained and operated. However, the costs of operating the system in this manner will be high (see para. 4.27-4.32) since it increases oil imports and reduces the use of gas in east zone generation units by about 4,900 MMCF per year.

3.33 The most recent REB connection forecast was used by the mission for projecting REB systems loads and energy requirements for up to 1984/85 and the year 1990. Annual residential demands per connection were projected to be 360 kWh instead of 480 kWh as assumed in other studies, given the observed average residential consumption of only 23 kWh per month in the Dacca I PBS. These low rates of residential use are consistent with those found by sample surveys of rural residential consumers connected to the BPDB system. All other sector forecasts are based on REB, AID or IDA projections. The resulting forecast of the REB system is shown in Table 3.9. In arriving at this forecast the calendar year connection projections were converted to fiscal year (ending 30 June) connections by assuming that the number of connections completed by the end of the preceeding calendar year represented an approximation of the total number of 12 month consumers for the fiscal year. As can be seen 1984/85 total energy sales are projected to amount to some 85 GWh, compared to 216 GWh, as projected in the BPDB forecast (see Table 3.8). The represents a reduction of over 60% in projected REB energy sales in that year.

3.34 The projected maximum load for the end of 1984/85 is 55 MW compared to some 204 MW that was included in the global demand forecast of BPDB. Given the BPDB's overall 84/85 projected demands of 936 MW, this revision in projected REB demands alone reduces maximum BPDB system demands by about 16%.

Table 3.9

RURAL ELECTRICIFICATION PROGRAM
MISSION ENERGY FORECAST (MWh)

Consumer Category	82/83	83/84	84/85	89/90
Residential	3,058	14,842	36,121	420,274
Commercial	836	4,056	9,873	114,875
Deep Tubewells	943	4,432	10,883	130,600
Shallow Tubewells	243	1,250	3,014	34,080
Low-lift Pumps	442	2,258	5,455	63,590
Small Industry	1,099	5,992	15,654	232,700
Medium Industry	210	1,554	3,570	7,938
Total	6,831	34,384	84,570	1,004,057
Load Forecast Coincidental Peak Demand (KW) 1/	7,270	25,940	55,330	499,700
Original REB Forecast (KW)	77,449	126,631	204,198	617,980

1/ Industrial load factors were assumed to be 66% and agricultural, domestic and commercial ones combined 37%.

Natural Gas Demand Projections

3.35 Demand projections were prepared by the mission for major consumer groups and separately for the new Bakhrabad system. These projections are summarized in Table 3.10. Overall, the rate of growth of consumption will continue to be rapid, with an average annual rate of growth of over 18% until 1984/85. Fertilizers and power will maintain their dominant position, accounting together for about 71% of total consumption.

Table 3.10

PROJECTED NATURAL GAS DEMAND BY MAJOR CONSUMER GROUP
SUMMARY
MMCF

Category	1980/81 1/	Percentage Share	1984/85	Percentage Share	Annual Average Growth Rate, % 1980/81-1984/85
Power	18,619	38.0	28,458	29.6	11.2%
Fertilizer	17,730	36.2	40,170	41.8	22.7%
Industry	7,891	16.1	20,506	21.4	27.0%
Commerce	1,282	2.6	1,888	1.9	10.2%
Households	3,429	7.0	5,020	5.2	10.0%
Totals	48,951	100.0	96,042	100.0	18.4%

1/ From Table 3.2.

Source: Mission forecast.

(a) Power Sector Demand for Gas

3.36 1984/85 projections for the power sector were based on the projected power demands and generating plant utilization for the BPDB (see Annex II). The projections do not take account of gas consumption in captive power plants. These were included in the respective forecasts for the fertilizer and industrial sectors. The estimated generation of each plant was based on efficiency ratings, subject to minimum operating requirements for all plants. Total gas consumption for the power sector is projected to amount to some 28,500 MMCF in 1984/85. This is somewhat less than the 34,000 MMCF demand implied by the BPDB electricity generation forecast.

3.37 If the two Khulna oil-fired units were shut down and replaced, through the east-west electric interconnector, by gas-fired east zone generation, this would increase the power sector's gas demand in 1984/85 by some 4,900 MMCF, or by about 17% above the mission's projected consumptions (see paras. 4.27-4.32).

(b) Fertilizer Industry Demand for Gas

3.38 With the addition of the Ashuganj 1/ and the Chittagong urea factories now under construction, the fertilizer industry will become the largest single gas consumer in the country. Projections for the two operating and two projected plants have been shown in Annex I.A. A fifth, barge-mounted, export oriented plant may be established in Chittagong by 1986 or 1987, depending on the success of ongoing negotiations with foreign sponsors. The consumption estimates for the long-established Fenchuganj Plant and for Ghorasal were based on past, optimum production rates. For Ashuganj and Chittagong the projected rates were used.

3.39 The estimated consumption rates have been based on the assumption of full capacity utilization of all existing and projected plants. Although in the past such high and continuous production rates have rarely been maintained due to equipment breakdowns and other factors, with the implementation of the rehabilitation project and availability of improved training facilities, the achievable production levels of existing plants are expected to improve. The addition of the Ashuganj and Chittagong plants will add substantially to domestic urea supplies 2/. However, unless additional capacity is planned, the projected rate of gas consumption by the fertilizer industry is likely to represent upper limits up to 1990/91 that may not be fully reached in a given year and by all plants simultaneously.

3.40 It must be noted that some of the gas consumption in these plants is for power production. All three operating plants own their own power generating equipment and produce most of their power requirements in-house. BPDB power supplies are used by them only for stand-by purposes.

(c) Industrial, Commercial and Domestic Sectors Demand for Gas

3.41 Demands of these three sectors have grown rapidly in the past, at rates of about 18% for industrial, 30% for commercial and as much as 48% for domestic uses. However, the overall demand in 1980/81 amounted to only 26% of total gas consumption. The rapid expansion rates of the past were the result of the extensive distribution line investments by the Titas Gas Company System in the Greater Dacca Area and the development of the cement and pulp and paper complexes at Chhathak and Habiganj, which use gas as fuels. Growth in the demand by the latter two industrial complexes (which accounted for about a quarter of total industrial consumption in the country in 1980/81) has levelled-off in recent years. The ADB-financed distribution network expansion project of

1/ The Ashuganj plant has been commissioned and is now operating.

2/ The country is projected to have small surpluses of urea for about three years but by 1989 Bangladesh will once again be a net importer.

the Titas System has now been completed. Hence, in both of these systems a slow-down in further expansion can be expected, unless additional major distribution network projects will be financed 1/.

3.42 The major stimulant for further growth will come from the completion of the Bakhrabad system, which will make it possible to convert most of the fuel-oil using industries in and around Chittagong to natural gas.

3.43 Industrial, commercial and domestic growth rates for the other gas supply systems have been estimated at 7% for industry and 10% for the commercial and domestic sectors respectively. These rates are somewhat lower than those projected by the Titas Gas Company for its own supply area. These ranged between 11% and 12% per year for the 1982 to 1990 period. Factors that are expected to bring about these lower rates of growth are the relative maturity of the systems - a substantial number of the larger, potential industrial customers have already been connected, so that new connections would tend to result in lower off-take on average, while the growth in the demand of existing customers will depend on their respective rates of increase of output only.

Petroleum Products

3.44 Forecasts are available from the Bangladesh Petroleum Corporation (BPC) and the Planning Commission. For 1984/85, they differ by some 20%. BPC's projection reflects a continuation of past trends with an annual average growth rate of 6.5% compared to a rate of 6.6% between 1975/76 and 1979/80. The Planning Commission projected a marginal decline in absolute quantities between 1980/81 and 1984/85, largely because of its projection of large-scale substitution by gas in the power and industrial sectors.

3.45 The mission tried to take account of the various sectoral developments that are likely to affect petroleum demand in the future and prepared its own forecast for 1984/85 which is summarized in Table 3.11. It projects an average annual increase in total petroleum product demand of some 2.3%. Sharp changes in some of the demand components are projected as a result of displacements by natural gas.

1/ Negotiations are underway with the ADB for such projects in the Dacca Region as well as for the Bakhrabad project in the Chittagong region.

Table 3.11

PETROLEUM PRODUCT DEMAND FORECAST
(1980/81 and 1984/85)
(thousand long tons)

Fuel	1980/81	1984/85	Average Annual Rate of Growth, %	Percentage Share 1984/85
DIESEL OIL				
Agriculture	60	209	36.6	13.1
Electric Power	152	49	-24.7	3.1
Industry	8	12	10.7	0.8
Transport	207	294	9.2	18.5
Rail	(38)	(60)	12.1	3.8
Road	(117)	(141)	4.8	8.9
Water	(52)	(94)	16.0	5.9
Bunkers	21	29	8.4	1.8
Sub-Total	448	593	7.3	37.2
FUEL OIL				
Electric Power	63	139	21.9 1/	8.7
Industry	218	89	-20.1	5.6
Paper	(99)	(51)	-15.3	3.2
Steel	(40)	(-)	-	-
Rail Transport	48	50	1.0	3.1
Bitumen	29	89	32.4	5.6
Bunkers	53	66	5.6	4.1
Others	3	5	13.6	0.3
Sub-Total	414	438	1.4	27.5
JET FUEL	44	50	3.3	3.1
JUTE BATCHING OIL	33	35	1.5	2.2
MOTOR GASOLINE	57	80	8.8	5.0
KEROSENE	448	397	-3.0	24.9
TOTAL	1,452	1,593	2.3	100.0

1/ This high rate is misleading because of the low base in 1980/81 which resulted from the breakdown of the 60 MW steam plant in Khulna. If the 79/80 consumption of 96,000 tons is used as base, the annual rate of growth would be 7.8%.

Source: Petrobangla.

3.46 Demand for diesel fuel is projected to grow at an annual average rate of 7.3%, spurred on by a 37% growth rate in agricultural use, mainly for irrigation pumping, an 11% growth rate in industrial demand and a composite 9% growth rate in the transport sector. These high rates of growth are partially offset by a sharp decline in diesel use by the electric power sector, mainly as a result of the replacement of the Khulna barge-mounted powerplant by gas-supplied electricity from the east and fuel-oil-based power from the new Khulna thermal units.

3.47 Overall the demand for fuel oil will grow slowly, at an annual rate of 1.4%. However, demands by the power sector are projected to grow significantly inspite of the expected massive substitution by gas-fired energy following the completion of the East-West Electric Interconnector. The projected increase is the result of the commissioning of the new 110 MW Khulna thermal unit in 1984. Industrial fuel oil demand is projected to fall sharply following the completion of the Bakhrabad gas pipeline to Chittagong. Bitumen production will rise substantially as a result of the new bitumen plant installed at the Chittagong refinery. A significant percentage of its output will be exported.

3.48 Kerosene consumption is projected to decline relative to 1980/81 but rise slowly compared to consumption in 1979/80. The 1980/81 kerosene consumption was artificially high because of price-induced substitution for diesel fuels. Expansion of kerosene for household use, which traditionally grows at the rate of population increase, will be affected by the rural electrification program which will lead to a 1984/85 substitution of about 11,000 tons, thereby reducing demand marginally.

3.49 The remaining petroleum products account for only about 11% of total consumption. They will grow at modest rates except for gasoline whose demand is projected to increase at 9% p.a. although its total market share will still be only about 5% in 1984/85.

3.50 LPG is presently produced at a rate of 4000 tons/year in the Chittagong refinery. The output is marketed for domestic, commercial and small industrial use in and around Chittagong. With suitable investments refinery output could be increased to 15,000 tons per year (see para. 4.75). The potential market for such additional LPG as a substitute for kerosene and firewood (e.g. in tobacco curing) is large but marketing issues need to be addressed.

Coal

3.51 Coal consumption is assumed to remain basically unchanged over the next few years. The main users of steam coal will be brick manufacturing plants, although small quantities of higher grade coal (e.g. metallurgical coal) will also be needed. Given the lower costs of coal relative to fuel oil or domestic firewood the Government's policy of restricting imports should be reviewed. Other potential future users may be the country's western pulp and paper mills without access to natural gas.

Traditional Fuels

3.52 No attempt has been made to project the demand for traditional fuels given the uncertainties surrounding the existing consumption data. It is clear, however, that these fuels will remain the only major potential sources for domestic and small-scale commercial uses in rural Bangladesh. No viable commercial alternative is in sight given the low income levels of the population. Hence, the basic demand is likely to grow at the rate of rural population increase, subject to the success of policies that will foster a more efficient fuel use (e.g. improved cooking stoves).

Industrial Energy Conservation

3.53 The mission undertook a number of rapid energy audits. Plants surveyed were in the paper, steel, fertilizer (TSP), brick, cement, textile and ceramics industries. The paper and steel industries alone consume about 62% of the fuel oil used by the industrial sector.

3.54 The objectives of the industrial energy audits were:

(a) To quantify the actual energy used by each industrial sub-sector and by individual factories;

(b) To identify priority areas for energy conservation efforts;

(c) To undertake a preliminary analysis of the magnitude of energy and foreign exchange savings that could be achieved through:

(i) Improved housekeeping;

(ii) minor retrofits;

(iii) major capital investments;

(iv) substitution of fuel oil by natural gas;

(d) to estimate the investment required, and

(e) to prepare detailed terms-of-reference for a national industrial energy conservation programme.

3.55 Annex IV summarizes the energy savings that could be achieved in the plants surveyed through improved housekeeping and minor retrofits (H); fuel substitution with natural gas (S) and major capital investment (C). There were three categories of facilities surveyed from the standpoint of current and potential opportunities for inter-fuel substitution of fuel oil for gas. These categories are:

(i) Those facilities in and around the Chittagong region currently using fuel oil that will have gas available by 1983.

(ii) Those facilities in and around Dacca and Sylhet currently using gas, and

(iii) Those facilities, such the newsprint plant in Khulna (west zone), where gas is not expected to be available for the time being.

3.56 The total fuel oil savings due to improved housekeeping in the facilities surveyed amounts to about 10% of the 156,700 tonnes/year of fuel oil consumed, worth around US$3.4 million. These savings could be achieved with an investment of about US$1.1 million yielding a pay out period of about 4 months. However, it must be noted that all of the facilities surveyed and using fuel oil, except the Khulna newsprint will have gas available to them by 1983. Hence the potential savings would be short-lived.

3.57 Total fuel oil savings resulting from substitution of fuel oil for gas in the Category I facilities would be 101,000 tonnes/year (about 38% of total industrial fuel oil demand in 1979/80). The net value of these savings would be about US$14.1 million/year after accounting for the value of the gas replacement fuel. Investments amounting to some US$3.34 million would be required to retrofit these facilities. The pay out period would be only some 3 months. Clearly in the case of these Category I facilities, top priority should be assigned to undertaking the US$3.34 million of investments to substitute fuel oil by gas as it becomes available. The housekeeping investments appear unattractive since the gas would be available within about 18 months.

3.58 In the case of the Category II facilities surveyed (those currently using gas as the major fuel) improved housekeeping measures would result in natural gas savings varying from 22% of gas consumed at the Meghna textile maill, to 10% at the Luxmi Narraynn textile mill, and to 1% at the Sylhet cement factory. The total gas savings from such measures would amount to some 16.8 million CF/year, resulting in cost savings of only about US$24,000/year and requiring an investment of some US$56,000 not counting the costs of technical advisory services. Clearly conservation measures in these types of facilities appear relatively unattractive.

3.59 The case for housekeeping investments is strongest for the Category III facilities - those for which the prospects for gas substitution are low over the next several years. At the Khulna newsprint mills, for example, about 11% of current fuel oil demand (49,000 tonnes/year) can be saved by improved housekeeping yielding a saving of about US$1 million/year for an investment of US$230,000.

3.60 In the course of executing the survey several issues became apparent that explained the current lack of energy conservation measures. These issues include the following:

(i) Almost all the industries are desperately short of middle management engineers and technicians.

(ii) Many of the industries do not have the basic instrumentation for carrying out measurements of energy consumption and levels of energy use efficiencies.

(iii) There exists a chronic shortage of spare parts due to shortages of foreign exchange or poor communications with outside institutions. The case of a textile mill stands out, whose standby generator has been out of order since 1962 while the mill experiences heavy financial losses due to frequent power failures.

(iv) Process temperature control equipment is in short supply in many of the plants.

(v) Most factories that use steam let the condensate run to waste rather than returning it to the boiler feed system. Considerable energy savings would be achieved by hot water recovery.

(vi) In many of the industries, installations were nearing the end of their useful life and inefficiency was compounded by worn-out and oversized equipment.

Recommendations

3.61 On the basis of these findings the mission recommends the following:

(i) Top priority should be assigned to substituting fuel oil with natural gas in those industries with access to the Chittagong pipeline and other gas distribution systems.

(ii) A detailed energy audit of selected energy intensive industries, including power plants, should be undertaken in the west zone or in other parts of the country where gas is unavailable.

(iii) A comprehensive training programme in energy management should be instituted at both senior management and technical staff levels for the industries included in the audit programme.

(iv) A special programme should be launched to improve the safety standards in facilities and power plants using natural gas-fired boilers.

(v) A special energy demand forecasting unit should be created as part of the Energy Cell of the Planning Commission. Revisions of forecasts, perferably made annually, should be distributed to government agencies and the energy producing companies, reviewed with these entities and discrepancies reconciled.

CHAPTER IV

ENERGY SOURCES AND SUPPLY

4.01 The principal domestic energy resources are large deposits of natural gas, all located east of the Jamuna River, a small hydro potential in the south-eastern part of the country, crop residues, dung, wood, twigs and leaves from limited public forest lands located in the south and south-eastern sectors and from homesteads. In addition, there are some potential, but high-cost, peat and coal resources. All petroleum and coal requirements must be met by imports. Electricity is generated by hydro, gas-fired and oil-fired plants and is distributed by two separate distribution networks in the eastern and western part of the country. In addition, industry-owned power plants account for about 25% of total installed capacity. Gas distribution facilities are limited to a few large users and a more extensive utility network in the greater Dacca Region. About two-thirds of needed petroleum products are refined at Chittagong, the rest are imported directly.

A. Power Sector

Hydro

4.02 In spite of the very larger river systems, the country's hydro resources are rather modest, because of the flat terrain. At present 80 MW of capacity are operating at Kaptai in the southeastern zone of the country. Plans call for the commissioning of another 50 MW unit in 1982, and two additional 50 MW units by 1987, for a total of 230 MW, all at the same site. Further economically justifiable conventional sites appear to be small, given the production costs of alternative generating facilities based on natural gas, but for isolated local power systems, some development of these sites may be justified.

4.03 At the policy-making level, the two main government institutions involved in the power sector are: The Planning Commission, which coordinates the development of the power sector with those of other sectors of the economy and sanctions all investments of more than TK 5,000,000 (US$260,000), and the Ministry of Energy, which supervises the sector and to which all power generating and distributing institutions are accountable.

4.04 Electric power generation, transmission and distribution is the responsibility of the Bangladesh Power Development Board (BPDB). BPDP is a statutory government corporation that was formed in 1972, shortly after the war of liberation. Until 1977, BPDB was the only agency responsible for electric utility services in the country. In that year the government formed the Rural Electrification Board (REB) which has responsibility for the distribution of electricity in rural areas. Individual co-operatives (PBS's) supervised by REB purchase their electricity from BPDB. Almost all consumers are directly supplied by

BPDP except those in the newly established REB networks, of which the first was energized in 1980. Ultimately, REB will be responsible for supervision and control of all rural electricity distribution throughout the country.

4.05 Bangladesh is divided into two zones--east and west--by the Ganges/Brahmaputra River System. The enormous size and shifting course of these rivers has prevented the construction of road, rail or electrical power transmission facilities between the two zones. BPDB, therefore, operates two independent power supply systems, one in the eastern and one in the western half of the country. However, the two separate power systems will be interconnected into a nation-wide grid after the completion of the 230 KV, 500 MW capacity East-West interconnector which is currently under construction. Completion is expected by the end of 1982. The attached map shows the location of major power stations, substations and transmission lines.

Existing Electricity Supply

4.06 The separate power systems in the East and West zones cover all four of the country's administrative divisions. In 1980/81, BPDP's available capacity totaled 663 MW, 426 MW (64%) in the eastern and 237 MW in the western zone (Annex II). In addition BPDP owns and operates some 3.5 megawatts of capacity in isolated and standby plants in the east zone and 2 megawatts in the west zone (actual capability rating). Captive power plants account for another 186 MW of operating capacity. The most important of these supply fertilizer, jute, urea, pulp and paper, cement and sugar factories. In addition, several hundred small generating sets are owned by various enterprises for standby purposes. Most of the operators of captive generating equipment are also connected to the BPDP grid. However, the larger ones produce their own requirements and draw on public supplies only in the case of emergency.

4.07 The major reasons for this high share of captive and stand-by power plants are the unreliability, insufficient capacity and high outage rate of the public supply network. However, some of the captive plants are used as a source of both power and steam (e.g. sugar mills and pulp amd paper plants), and, for this reason, would remain in operation even if the public system improves. In addition, fertilizer plants and the cement plant at Chhatak would maintain their low-cost gas-fired power plants. Together, some 151 MW are likely to continue operation even after the BPDP system improves.

4.08 All power plants in the eastern half of the country are fired by natural gas or are hydro installations. In the western zone, on the other hand, the only fuels available are imported petroleum products, either fuel oil or diesel fuels. No gas is available in the west. Therefore, the average financial costs of fuel per kilowatt hour generated in the western zone is nearly TK 1.7/kWh (US¢9/kWh) while it is only about TK 0.10/kWh (US¢0.5) in the eastern zone. In 1980/81 the average cost of fuel per kilowatt hour of total generation was TK 0.511 (US¢2.7) while the actual costs of thermal generation alone was TK 0.668

(US¢3.5). These average fuel costs per kWh are expected to decrease after the completion of the east-west interconnector to TK 0.42/kWh (US¢1.22) in 1982/83 and to TK 0.37/kWh (US¢1.95) in 1983/84. Further significant reductions would be possible if the two Khulna fuel oil fired units (west zone) were not operated (see paras. 4.27-4.32).

Major Issues in the Existing Power System

4.09 There are four major issues facing the power sector at present, these are: (i) system losses (paras. 4.10-4.14); (ii) power outages (paras.4.15-4.21); (iii) the BPDB's financial performance (see Para. 5.23); and (iv) the continued operation of oil-fired capacity after interconnection of the east and west systems (paras. 4.27-4.32).

Power System Losses

4.10 The BPDB system is subject to substantial energy losses that have fluctuated between 36%-40% of total generation in recent years. Indeed in 1979/80 and 1980/81 these losses increased to the present level of 40% whereas earlier they were about 36%. Inspite of contractual commitments to reduce them, the various measures adopted have not apparently been successful so far (or new sources of losses have nullified ongoing reduction measures). These losses contribute substantially to the dismal financial performance of the BPDB. Losses can be caused by four factors: first, excessive distribution line losses from faulty or overloaded equipment; second, faulty or non-functioning meters; third, errors or fraudulent practices in meter readings and accounting; and, fourth, theft through meter tampering and illegal connections.

4.11 Given the technical characteristics of the BPDB systems, it has been estimated that total losses should be no higher than about 18%.1/ The remaining 22%, then, could be subject to appropriate remedial actions. One major problem is that BPDB lacks adequate metering capability to monitor the energy dispatch through its various distribution feeders. For example, in the Western Zone, it was found that out of 46 sub-stations only four had functioning meters. This means that the location of losses cannot be identified. The actual costs of such losses are even higher than the measured discrepancy between production and recorded sales because such losses occur mainly during peakload hours, thereby contributing significantly to overloads and outages.

4.12 Outright theft is generally concentrated in major urban areas (mainly Dacca) and, within these areas, in sections with low-income

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1/ Including station uses. The BPDB programme of loss reduction measures has as targets the achievement of 23% losses by 1985 and 20% by 1990.

commercial and domestic activities. These customer groups, however, contribute only about 17% to recorded sales. These conditions are likely to worsen as a result of the projected rapid urban growth. Physical theft prevention measures introduced under similar conditions in other countries (e.g. tamper proof wiring and protected meters) have had very high payoffs.

4.13 At present, an ADB-sponsored, syndicated loan to BPDB is designed to improve and rehabilitate generating and transmission facilities.1/ This project contains special provisions for the study and evaluation of loss reduction measures, but does not contribute anything to the improvement of distribution facilities.

4.14 Under the recently negotiated Ashuganj power project 2/ the BPDB is to implement a series of measures to reduce system losses. The objective being to lower these losses (including power station consumption) to 23% and 20% by 1985 and 1990 respectively. This programme includes the separation of technical and financial losses with proposals to reduce each category. The commencement of loss reduction measures is a condition of credit effectiveness. Major efforts need to be made to achieve these targets. This is re-enforced by the fact that losses increased between 1979 to 1980 from 37% to 40% with the result that the loss reduction programme is starting with losses at a higher level than envisaged at the time the orginal targets were set. There is therefore a high risk that the agreed targets may not be met if implementation is not as efficient as originally envisaged.

System Operating Conditions and Power Outages

4.15 One of the major problems of the existing BPDB system is its generally poor generating conditions leading to frequent power outages. For example, in 1980/81, of a total installed capacity of 813.2 MW only 707.4 MW were available. Most of the existing plants have actual capabilities well below their nameplate ratings, because of poor physical conditions and lack of maintenance, although some are now being rehabilitated. Maximum demand in 1980/81 was 544 MW. Theoretically, this would imply a comfortable capacity to reserve margin. However, frequent equipment failures, particularly in the western zone, where overall capacity is inadequate, have resulted in frequent load shedding, peak load restrictions and low and fluctuating voltage levels and frequencies.

4.16 Another reason for the unreliability of supplies is the inadequacy of BPDB's distribution facilities, especially in major urban

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1/ ADB, Power System Rehabilitation and Expansion Project, August 1981.

2/ Ashuganj Thermal Power Project, IDA Staff Appraisal Report, No. 3719c-BD (May 1982).

areas, where lines are too long and overloaded. There is a great need for additional sub-station capacity. To improve the situation, the distribution networks in major urban areas are being partially rehabilitated and extended with assistance from external donors: - IDA/OPEC (Greater Khulna Power Distribution Project) and Asian Development Bank and the United Kingdom (Greater Dacca Power Distribution Project).

4.17 The frequency of power outages in the BPDB system is very high. A detailed study of a west-side 11 KV, 6 line distribution feeder shows, for example, that in 1979/80 the probability that any one of the lines would be inoperative at any given time was in excess of 14%. A random sample of a feeder in the Dacca Region showed a total outage time of 14% over a six-month period in 1980. REB reports that in a sample month of its first operational year power cuts at its sub-stations occurred on 10 out of 30 days.

4.18 Outage costs consist of six components:

(1) the costs to the utility of non-supply (loss of net revenue);

(2) the costs to the utility of outage repair;

(3) the net costs to power users and consumers from loss of productive output and raw materials;

(4) the additional costs to production from the installation of stand-by or captive power plant equipment (these costs, however, reduce the costs listed under (3)); and

(5) the disincentive effect to prospective industries or other economic activities to establish themselves in areas of uncertain power supplies.

(6) the damage to equipment amongst power consumers.

4.19 Claims by power users of the costs of outages are very high. They are generally based on average gross output values per unit of time and, therefore, represent an upper limit of possible costs. Nevertheless, studies undertaken outside of Bangladesh show that net losses to industrial production may range between US$3-5/kWh not supplied, compared to a cost of electric energy of less than US$0.10/kWh. Given the observed frequency of power outages, it is not unreasonable to assume that net losses to industrial activities in 1980/81 have amounted to some US$30 million.

4.20 BPDB and the Government are trying to reduce these losses by a program to build special feeder lines to important industrial plants (e.g., 52 jute and 13 textile mills) and by authorizing the installation of captive or standby generating equipment to others.

4.21 Recommendation. Studies should be undertaken on a plant by plant basis to identify the net economic costs of outages and the best remedy to reduce them to an economically efficient minimum, by taking into account both the reduction of net losses to the user and the costs of the added facilities to the power company.

The Rural Electrification Program

Background

4.22 REB's task is to undertake an ambitious program of rural electrification, following the principle of comprehensive area coverage through locally administered cooperatives (Palli Bidyut Samities, or PBS). Aided by substantial financing from USAID, REB so far has created thirteen cooperatives, of which eight have been partially energized so far, serving 6,571 customers as of May 1981.

4.23 The primary objectives of the program are stated as follows:

(i) To replace costly energy sources such as kerosene for lighting, and diesel fuel for irrigation pumping and village industries, by electricity generated mainly from domestic natural gas, and

(ii) To create additional productive opportunities in rural areas through increased irrigation and the establishment of new small industries.

4.24 Financing for the first two stages has been arranged or is under negotiation. Foreign funds are being supplied by USAID and KFAED. Total foreign exchange costs are estimated at US$190 million. Local costs, accounting for about 50% of foreign exchange costs, are to be covered through grants by GOB to REB. Construction began in 1978. However, in the spring of 1981 USAID estimated that completion of its first phase would be delayed by approximately 20 months.

REB's Initial Operating Results

4.25 The Dacca I PBS was the first PBS to start operation in June 1980, while four other PBS's have been energized during 1981. The available data indicate that though it is very early in the programme to arrive at firm conclusions, most activities have gone satisfactorily except for the average rate of completing the consumers' connections (262 connections per month per PBS) if compared to the average number of PBS's members (49,200). Billing and collection of revenue have been satisfactory for this early stage of operation -- 95% of consumers are billed on time and 83% of bill payments were received in due time. However, in the Dacca I PBS there was a disproportionally high share of disconnections, due to non-payment of bills, for irrigations pumps -- 49 out of a total of 99, or some 48%. Disconnections arising for the same reason were also high for industrial use and street lighting (12% each). The rate of residential disconnections was however very low (about 2.5%).

4.26 These trends need to be closely followed as more data become available since one of the major objectives of the rural electrification programme is the stimulation of increased production, employment and income generation.

West Side Fuel Oil vs. East Side Gas-Fired Generation

4.27 Present system expansion plans include the final rehabilitation of the existing 60 MW oil-fired steam powered unit at Khulna in the west zone, as well as the completion of a new 110 MW oil-fired steam unit at the same location. These units are expected to be kept in operation even after completion of the East-West interconnector, albeit at a reduced plant factors of 30% for two reasons. First, this is the lowest operating rate at which they can be continuously maintained and operated. Second, to provide adequate system reliability in the event of failure of the East-West inter-connector.

4.28 This will be costly relative to their potential total displacement by gas-fired plants in the eastern zone. Their total annual fuel oil requirements are estimated at about US$21 million (at US$150/ton, the lowest 1981 f.o.b. Chittagong export price). If this fuel oil could be replaced by gas at an economic cost even as high as US$1/MCF, the net savings would amount to US$16 million/year (after allowing for 10% line losses).

4.29 The 500 MW capacity of the 230 KV interconnector should be sufficient at least until 1988/89 to supply the full load even at peak time of the western zone. It also appears that sufficient capacity will be available in the eastern zone to supply these requirements. Evaluated at a discount rate of 12%, the potential net savings from not operating these two oil-fired steam units for a five-year period starting in 1983 would amount to US$58 million (as of 1983, but expressed in 1980 dollars).

4.30 Offsetting these potential gains would be the increased risk of complete power outages from a failure of the 230 KV transmission interconnector. This risk might be high because of the incidence of tornados. However, it could be partially offset by maintaining the presently existing 56 MW barge-mounted gas turbine plant in Khulna, instead of having it towed to the east zone for use as a gas-fired peaking plant.

4.31 An evaluation of this issue appears warranted in view of the sizeable savings that can be achieved through not operating these two oil-fired Khulna power units in the mode envisaged. In addition, savings in reduced oil imports would be very large (about 139,000 tons/year). Given the 1979/80 operating results of the Bangladesh Power Development Board, for example, they would have been sufficient to cover some two-thirds of the Board's deficit on an annual basis. Appropriately shadow-priced for foreign exchange, they would cover all of it.

4.32 Recommendation. Studies should be undertaken within the framework of the ADB-financed Power System Master Plan to test the technical and economic consequences of de-activating the two Khulna units and to relegate them to emergency stand-by status instead.

B. Natural Gas Sector

Background

4.33 Under the Petroleum Act of 1974, Petrobangla was established as the state company entrusted with all tasks relating to exploration and production of oil, import of oil, refining and marketing of petroleum products, and exploration, production, transmission and distribution of natural gas. As of 1977 the functions of crude oil import, refining and marketing of petroleum products were given to a newly established state company, Bangladesh Petroleum Corporation (BPC). Petrobangla is a holding company with direct operational and managerial tasks performed by a series of companies under its supervision and control. On-shore exploration is handled by Toila Shandhani, a subsidiary company. Gas production at the Titas and Habiganj gas fields is performed by Bangladesh Gas Field Company Ltd, (BGFCL). Bangladesh Petroleum Limited (BPL) owns and operates the Sylhet and Chhatak gas fields. For transmission, distribution and marketing of natural gas there are 3 other subsidiary companies - the Titas Gas Transmission and Distribution Company and the Bakhrabad Gas System Ltd. The latter company is to operate the Bakhrabad gas fields as well as the associated transmission and distribution systems. The attached map shows the location of the major gas fields and transmission systems.

Gas Reserves

4.34 Bangladesh is well endowed with natural gas and so far eleven gas fields onshore and one gas field offshore have been discovered. All discoveries are confined to the East Zone. There have been a few gas shows in the West Zone, but data secured so far are inconclusive. No systematic attempt has been made so far to quantify all of the reservoirs or even delineate the fields. The number of wells drilled in relation to discoveries has been limited. However, on the basis of available data, estimates of proven, possible and probable reserves have been made by Petrobangla. To arrive at an estimate of total reserves, probabilities of 1.0 were used for proven reserves, 0.5 for probable reserves and 0.25 for possible reserves. On this basis gas in place is estimated at about 12.3-13.4 trillion cubic feet, of which 75% should be recoverable through normal production methods. The current gas reserves are given in Annex III.A.

Existing Gas Transmission and Distribution Systems

4.35 At present only the Titas field is being exploited in any significant measure; a 14" pipeline, 55 miles long, transports gas to Dacca via Ashuganj and Ghorasal. There are four other lines, each of which connects a main consumer to a particular field, (See Map and Annex

III.B). As production facilities in Titas are presently limited, Petrobangla proposes to supply the new Ashuganj fertilizer factory with additional gas from the Habiganj gas field and for this purpose a 12" pipeline is currently under construction. A further project under construction will link Chittagong with the Bakhrabad gas field through a 24" high pressure pipeline. In addition to these transmission pipelines, there are gas distribution networks in Dacca and eight other towns.

Technical Problems

4.36 Titas Gas Company is the only major gas utility in Bangladesh that serves a large number of domestic and industrial consumers as well as major users such as power and fertilizer plants. Its system depends on one 55 mile long, 14" transmission pipeline from the Titas field. This pipeline was originally designed to operate at 1000 p.s.i. and a line flow capacity of 175 MMCF. However, it is understood that due to gas field difficulties neither throughput nor pressure have achieved design rating. This pipeline was subjected to severe damage during the 1971 war of liberation and the repair work that was carried out would not meet current international standards for such transmission pipelines. It is further understood that the pipeline has not been internally inspected (i.e. pigged). Therefore its internal conditions are of unknown quality.

4.37 The mission considers that the Dacca gas distribution system is currently vulnerable, because it is relying on a single source of supply, a single transmission line and has no storage or boosting capability. In the event of a failure of either the transmission line, the city gate station or the gas field, supply to the city could be quickly lost. Should this occur, Titas Gas Co. would be faced with a massive problem: first, to render the distribution system and appliances safe, then to undertake repairs and subsequently to bring the network on stream again. This would be a major task. It is doubtful that the company has sufficient qualified staff available to undertake it within a realistic timescale. This mission also doubts that enough plant and equipment resources are on hand to promptly rectify a major failure of the system. Even minor losses of supply in other parts of the world have taken several days to restore.

4.38 Titas Gas Company has obtained from British Gas a network analysis computer program for the whole of its Dacca system. This program will enable the distribution engineers to pinpoint pressure deficiencies and indicate where urgent strengthening works are needed. The need for various cross connections has already been identified and much of the required work has been completed. Nevertheless, the program indicates quite clearly that the distribution network is almost saturated and that there are points within this network where negative pressures could occur.

4.39 During a visit to the city gate station by the mission, inlet pressures were 40% below design pressures which means that pressure may not be sustained at minimum levels in the rest of the distribution network. This was confirmed at Mirpur Station on the transmission line where outlet pressure was only 47 psi. The British Gas computer analysis has shown that pressures in the distribution system in the centre of Dacca could be as low as 7.7 psi even with normal pressures at the city gate. Total loss of pressure would lead to loss of supply and possible loss of life because of the danger of air penetration into the pipe network and possible explosions that could occur throughout the system right up to the city gate station because of the lack of slam-shut valves in the system. In the event of a total rupture in the transmission line, this would necessitate the use of specialized equipment and highly skilled welders to repair the break. If such a break were to occur during the wet season this could mean that the line would be out of operation until the floods subside. The economic losses resulting from such a supply interruption would be massive, since the Titas system is currently meeting almost 30% of the country's commercial energy requirements.

4.40 Recommendations. On the basis of the mission's findings it is recommended that:

(a) The rapid expansion of the Dacca distribution network be slowed down until a detailed study of the transmission and distribution system has been undertaken. The objective of this study would be to identify measures and investments required to improve the physical realiability of the system. The study should be commissioned urgently.

(b) There should be a second source of gas supply to Dacca,coming possibly from the Kaliganj field near Dacca if its reserves can be proven and appraised in the near future. Use of this field as a second source appears attractive since a second city gate station could be established at Joydepur and the need for a major river crossing avoided. Another alternative supply source would be from the Bakhrabad field. However, this would require a major river-crossing. These options should be analyzed and their costs determined.

(c) A further option that needs to be addressed is the construction of storage facilities in the vicinity of the existing city gate station. This could be used for peak load shaving and as an alternative supply in the event of a minor loss in the transmission line. However, this would not improve the reliability of supplies to the power station and fertilizer plant at Ghorasal and Narshingadi. An often-used alternative, the installation of pressure-boosting compressors, cannot be recommended since the internal condition of the pipeline system is not known at this time. It would first require extensive cleaning and testing.

Apparent Systems Losses

4.41 The Titas system had 115,248 registered connections in 1979/80 of which 97.4% were domestic ones. Of the various consumer categories all are metered except most of the domestic consumers who are billed at a flat monthly rate which is based on the number of gas cookers reported to be in use per connection. Since domestic connections are un-metered the reported domestic demand is essentially a system residual, which presumably includes all losses. According to the 1979/80 level of reported domestic consumption, the average daily household consumption would have amounted to about 60 CF (about 60,000 BTU) or roughly 4 times what approximate calculations indicate it should be for meeting cooking requirements.

4.42 There may be various explanations for this apparent overuse. First, there is no incentive to turn-off a gas burner because of the flat monthly charge. This could lead to massive waste 1/. Secondly, the reported consumption may in fact hide substantial losses of the distribution system or of conservatively callibrated meters. A third explanation could be fraudulent non-reporting of billing. Whatever the reason, the quantities of gas involved are large enough to call for investigations to ascertain the nature of these losses and undertake measures to rectify the situation, if needed. The economic value of this amount of gas is about US$1.1 million/year, compared to Titas Gas Company's pre-tax 1979/80 profits of US$2 million.

4.43 Recommendations: Investigations should be carried out to establish the causes of these seemingly excessive domestic consumption rates. Remedial actions should be taken, if indicated.

East-West Natural Gas Pipeline

4.44 The west of Bangladesh has to rely on imported oil to meet most of its commercial energy requirements. This has resulted in very high costs of power generation and industrial operations relative to the East where low cost gas is available. However, with the completion of the East-West electrical interconnector in early 1983 the western region will begin to benefit from low-cost gas-generated power in the east.

4.45 A project of high interest to the Government is the construction of an east-west natural gas pipeline. This pipeline would extend over 350 miles from the eastern gas fields at Titas, Kailashtila and Habiganj to Khulna and Jessore in the southwest while another branch would extend to the northwest region around Ishurdi. The pipeline would have to cross 12 major rivers including the Jamuna river, which would involve a very difficult crossing. The technical difficulties of this are considerable,

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1/ It is reported that many domestic consumers leave their gas burners on virtually 24 hours/day.

and estimates of the cost are therefore fraught with uncertainty. Current opinion places costs for a pipeline of 300 MMCFD capacity at around US$600 million. As much as five years may be needed to complete it, because of the interruption of field work in the wet season.

4.46 Potential demand for gas in the west of Bangladesh is very low. At present, the only significant users would be the fuel-oil fired power units in Khulna and the few industrial plants in that region using fuel oil. The most important industrial demand is the newsprint mill at Khulna which consumed some 49,000 tons of fuel oil in 1980/81. With the completion of the East-West electrical interconnector in 1983 the fuel oil demand from the existing power units and the new 110 MW power unit at Khulna will amount to some 139,000 tons/year with these plants operating at a load factor of 30%. This indicates that by 1983 fuel oil demand in the west that could be substituted for by gas would amount to around 188,000 tons/year. This substitution would only require about 22 MMCFD of gas 1/. Even if the potential demand for gas in the west zone in the late 1980's were as high as 100 MMCFD (or 4 1/2 times higher than in 1983) the fixed costs of the pipeline transmitting this volume of gas would be about $2.41/MCF 2/. With the "floor" economic cost of gas being at about US$0.66/MCF, the economic benefit of displacing fuel oil (about US$160/ton November 1981 price in Singapore) would only amount to around US$1/MCF of gas. Clearly this could not be justified economically.

4.47 At current oil prices the east-west pipeline may only be justified if Bangladesh were to be able to negotiate a major overland gas export contract with India in excess of 250-300 MMCFD. This would reduce the delivery costs of gas to around US$0.9-1.30/MCF and would offer a reasonable margin to negotiate an attractive long-term supply contract with India. However, it also would require a commitment of some 2.5 trillion CF of gas, or about 25% of the country's current reserves, to serve such a contract. It should however be stated that the technical difficulties in crossing the rivers and attendant uncertain costs related to such a pipeline make such an option of uncertain economic merit.

4.48 Recommendations: The mission considers that unless an agreement in principle can be reached between Bangladesh and India for the export and purchase of at least 250-300 MMCFD of gas, this project should be assigned low priority. Such an agreement would, of course, have to be subject to detailed studies of the technical and economic feasibility of such a pipeline. Without such substantial overland exports, it would be difficult to economically justify the pipeline, even if oil prices were to double in real terms during the 1980's, a prospect that is unlikely.

1/ With a gas pipeline in place it would probably be higher because it would no longer be necessary to restrict the two Khulna power plants to a minimum, 30% load factor operation.

2/ Assuming capital recovery based on 12% interest rate for 15 years.

Potentially the greatest risk facing an east-west gas pipeline is that low-cost gas would be discovered in the west zone long before the pipeline investment was fully amortized. A second note is that if such a pipeline were commissioned within the next few years, effect of the East-West Electrical Inter-connector on such an investment would have to be taken into account.

The Bakhrabad Gas Development Project

4.49 Development is underway of an integrated gas production, transmission and distribution project that will bring natural gas from the Bakhrabad field northeast of Dacca to the Chittagong Region (see map). Its total costs are projected at US$164 million. It consists of the drilling of five wells, the installation of the necessary separation facilities, a 24", 110 mile long pipeline to a city gate station outside Chittagong and a 55 mile major distribution network in and around Chittagong. Completion is expected in 1983. The Asian Development Bank is currently negotiating a loan for the installation of additional gas storage, distribution and metering facilities to supply additional industries and households in the city of Chittagong and several smaller towns along the route of the pipeline.

4.50 The project will have a major impact on petroleum product consumption and energy costs in its supply area. Gas consumption is projected to be about 21,000 MMCF (512,000 TOE's) in 1985, 38,000 MMCF (927,000 TOE's) in 1990 and 74,000 (1,804,000 TOE's) MMCF in the year 2000. The 1985 consumption alone is equivalent to about 28% of the country's total projected petroleum consumption in that year. The project will sharply reduce the energy costs of several major industrial plants including a steel mill, and a major pulp mill whose present fuel oil costs account for almost 50% of its total operating costs. The supply of gas will also help to increase the net yield of petroleum products from the refinery by substituting gas for the fuel oil and LPG now used as refinery fuel.

LPG from Natural Gas

4.51 The various gas fields in Bangladesh contain small fractions of butane, propane and ethane. These could be recovered through separation plants and the butane and propane fractions sold as bottled LPG gas. Depending on actual gas production rates, LPG production at the Titas and Bakhrabad fields alone could reach some 31,000 tons annually. This would require the installation of two separate extraction plants. A third could be installed at the northeastern gas fields of Chhatak, Sylhet and Kailashtila.

4.52 Both the Titas and Bakhrabad-based plants would be located close to navigable rivers which would reduce shipping costs to other parts of the country, particularly to the gas-deficient western zone.

4.53 Based on cost estimates of LPG extraction plants presently under construction in Egypt and Thailand, extraction costs may range between

$65/ton to US$120/ton 1/. To this would have to be added the economic costs of gas which have been estimated elsewhere (see para. 5.07) at to be at least US$30/ton. Total LPG costs, fob plant, exclusive of cylinder costs, would range between US$95 to US$150/ton, compared to an end 1981 FOB price in Singapore of some US$270/ton. This, clearly indicates that LPG extraction is an attractive option.

4.54 LPG should find a ready market as a household fuel and in the commercial as well as industrial sectors (e.g. tobacco curing). It can also be used as a substitute for kerosene in lighting. LPG-fuelled incandescent lamps provide a luminous power and efficiency about equal to those of pressurized kerosene incandescent lamps. The fuel consumption is about the same as for kerosene wick lamps; however, in terms of the amount of light provided, wick lamps are far inferior. Both kerosene and LPG pressurized incandescent lamps are more expensive than simple kerosene wick lamps. Other possible uses of LPG which need to be evaluated, are as a gasoline substitute in cars, as a diesel oil substitute in irrigation pumps if such pumps are replaced by spark ignition pumps and for cooking (see para. 1.18).

Recommendations

4.55 Studies should be commissioned without delay that would evaluate the technical and economic feasibility of installing LPG extraction plants at the major producing gas fields in Bangladesh. The study should include a market analysis as well as an evaluation of the needed distribution facilities, including domestic manufacturing plants for pressure cylinders and valves. In addition an analysis of the end-uses of LPG that maximize economic benefits to the country should be undertaken.

Liquified Natural Gas (LNG)

4.56 The liquifaction and exportation of natural gas has long been considered a potential source of major foreign exchange earnings in Bangladesh. For several years a British consortium held a letter of intent to develop such a project. However this preliminary agreement has been terminated.

4.57 LNG marketing involves four major problems: The first is that it requires the commitment of 3.5 trillion CF of gas to serve such a plant or almost one-third of the country's estimated gas reserves. Second, the capital costs are very high, exceeding US$2.5 billion for a

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1/ Based on projected capital costs, 20 year life, 12% interest plus 20% of capital costs for operating and maintenance expenses. The Thai costs are likely too high for Bangladesh's conditions because costs include expensive carbon dioxide separating, as well as elaborate storage and export shipping facilities.

500 MMCFD plant. Third, there are presently no deep-sea port facilities available that could accommodate LNG tankers. Fourth, the location of Bangladesh relative to potential markets in Japan, Korea, North America or Europe is much less favourable than those of other potential suppliers with large, under utilized gas resources (e.g. Northern Australia, Indonesia, Malaysia, Thailand for Pacific markets and the Middle East and North Africa for European markets). The world market for LNG is already highly competitive and will become more so in the future given the huge unutilized gas resources available. Potential netbacks for Bangladesh, therefore, could be quite modest, once the additional harbor development costs and higher shipping costs are taken into account.

Recommendation

4.58 The mission considers the prospects for signing a favorable LNG contract are low. While the Government should continue its efforts to find potential buyers, no significant domestic resources should be used for any specific development unless firm letters of intent have been signed with long-term buyers who are prepared to cover all development costs.

Compressed Natural Gas (CNG)

4.59 CNG may become a useful and cost effective substitute for high-priced petroleum products particularly in the transport sector. A CNG utilization pilot study has been financed by IDA and is underway. So far, most efforts at utilizing CNG have been concentrated in the road transport field for either cars or light trucks up to about 7 tons. The somewhat reduced power output of engines operated on CNG militates against its use in heavy trucks. Furthermore, the latter are almost all diesel-powered which would require the installation and maintenance of a dual-fuel system.

4.60 The major disadvantages of a CNG road vehicle system are the weight penalty of the high-pressure cylinders, the shortened range of the vehicle and the resulting need for closely spaced costly compressor-refilling stations. However, preliminary estimates seem to indicate that overall cost savings of about 15% of total transportation costs per mile could be achieved compared to gasoline or diesel-powered vehicles.

4.61 It appears that rail transport could offer particularly attractive possibilities for the utilization of CNG. The volume of petroleum product consumption in this sector is currently 100,000 tons of which two thirds are fuel oil and the rest diesel. The replacement of the fuel oil would require about 10 MMCFD of gas per day. The use of CNG for rail transport appears attractive because the weight penalty of the heavy pressure cylinders is insignificant for this transport mode. In addition, few filling stations would be required. In this situation CNG and diesel oil would be the dual fuels in ratios to be optimized. One factor that needs to be assessed is the sustainable degree of power loss that can be tolerated in trains using this dual fuel mixture.

Recommendation

4.62 The mission recommends that the terms of reference of the IDA pilot study be expanded to include a technical and economic feasibility study of the systematic introduction of CNG as a dual fuel along with diesel oil fuel for railway transport.

Methanol

4.63 Methanol can be produced from methane gas. It is widely used as a chemical feedstock throughout the world. However, it can also be used as a vehicle fuel, replacing gasoline. It is less suited as a replacement for kerosene in lighting applications because of its near invisible flame. Another problem related to its use is toxicity when ingested.

4.64 The substitution of methanol for gasoline still has several technical problems associated with it and therefore cannot be considered attractive in Bangladesh at the present time. Alternative uses could be exports, the gradual development of a methanol-based chemical industry, or the conversion of methanol to single-cell protein as a supplemental animal feed.

4.65 Heavy dependence on exports may be unattractive given the rapid expansion of methanol production capacity in other gas-rich regions of the world (e.g. the Middle East, Canada, Trinidad-Tobago, etc.). For the coming decade a significant world-market oversupply is predicted unless substantial quantites are diverted to use as vehicle fuels which appears unlikely at present.

4.66 Single-cell protein production appears to be attractive given the chronic animal feed shortages in Bangladesh. However, the technical problems are difficult and the economic feasibility of such a plant in the context of the country's poverty-stricken agricultural sector is unknown.

Recommendation

4.67 The feasibility of methanol production for export should be further investigated. However, investments in such a plant should not be made unless an foreign partner could be found who would guarantee long-term marketing at attractive net-back prices for the gas. The single-cell protein option should be discussed with the developers of the underlying technology. If it appears feasible and attractive, technical and economic feasibility studies should be undertaken to test the potential for marketing the output both in Bangladesh and in neighboring countries.

C. The Oil Sector

Background

4.68 The Bangladesh Petroleum Corporation (BPC) was established by the Government in 1977 and charged with the responsibility of importing, exporting, refining and marketing crude oil and petroleum products. BPC does not distribute or market these products directly, but discharges these functions through various subsidiaries. The distribution and marketing of petroleum products is the responsibility of three marketing companies. The major share of the market (40%) is held by Burmah Eastern, a successor of the Burmah Oil Company. The latter still retains 49% of the equity capital. The other major marketing unit is the Jamuna Oil Company which is the successor to the Pakistan National Oil Company. It is fully owned by BPC and markets about 32% of the petroleum products. Meghna Petroleum Company (successor to ESSO) controls 27% of the market share. In addition, BPC owns two other marketing subsidiaries, the Eastern Lubricating Plant Limited and the Standard Asiatic Company. These are currently engaged in blending and marketing lubricants and special products. There is a refinery at Chittagong of 34,000 bbls/stream day capacity (1.5 million tons/year) which was established by Burmah Oil Company in 1963 and is now owned by BPC which operates it through its subsidary, Eastern Refinery Ltd. (ERL).

Existing Petroleum Product Supply

4.69 Bangladesh's entire domestic demand for crude oil and petroleum products is met through imports. Petroleum products currently are obtained from four different sources: (a) domestic refining of imported crude oil in the ERL refinery; (b) processing of purchased Bangladesh crude oil in a Singapore refinery under contractual arrangement; and (c) purchases of petroleum products from spot markets and through barter trade with the USSR. The design capacity of the Chittagong refinery is based on Iranian light crude oil and a recently built asphalt plant. It has no secondary processing facilities to convert residual fuel oil to distillate products, but has only atmospheric distillation, catalytic reforming and hydrodesulfurization units. An LPG recovery and bottling plant with an initial capacity of 4,000 tons/year was recently established to recover butane and propane which were formerly used as refinery fuels.

4.70 Table 4.1 shows the refinery's production program in 1981 and compares it to demand, indicating the surpluses and deficit of specific products that resulted from the imbalance between market demand and the refinery's yield pattern.

Table 4.1

ERL'S 1980/81 PRODUCTION VERSUS PRODUCT DEMAND
000's Metric tonnes

Product	Production	Demand	Surplus (+) Deficit (-)
LPG	4,000	4,000	-
Gasoline/Naphtha	155,000	55,000	+100,000
Middle Distillates	515,000	960,900	-445,900
Fuel Oil/Bitumen	567,000	468,000	+ 99,000
Other	1,000	1,000	-
	1,242,000	1,488,900	-246,900
Refinery Fuel/Gas	58,000		
Total	1,300,000		

It can be seen that a surplus of about 100,000 tonnes of gasoline/naptha and 99,000 tonnes of fuel oil had to be exported and about 446,000 tonnes of kerosene and diesel oil imported. The deficit products are presently supplemented by:

(a) Processing ERL-procured crude oil in the Shell Eastern Refinery in Singapore for a fee, importing the kerosene and diesel oil produced and selling the surplus naphtha and fuel oil in the Singapore market; and

(b) Importing, through barter arrangements, marginal quantities of diesel oil from the USSR.

4.71 A preliminary analysis of these offshore processing arrangements highlights the following issues:

(a) The current mode of supplementing deficit products by processing in the Shell Refinery will be economical if the relative fuel oil to crude oil price ratio is at or above 80%. A decline of this ratio reduces the cost advantages. At current prices, it results in a substantial loss compared to purchases in the spot market.

(b) The current ERL operation produces surplus naphtha and fuel oil which have to be exported at depressed prices.

(c) ERL has no fuel oil conversion facilities. Its production profile does not match market demand.

(d) Domestic natural gas is expected to further displace fuel oil following the completion of the Bakhrabad-Chittagong pipeline and the East-West electricity interconnector. Unless fuel oil conversion facilities are added to the ERL refinery, the level of surplus fuel oil to be exported will increase for a given crude throughput. As domestic demand grows, the need to import deficit middle distillates will grow as well.

4.72 There are certain improvements which can be implemented over the next 12-24 months to meet the country's oil imports at lower cost. Others, termed medium-term improvements, could be implemented within 24-36 months.

Immediate Improvements in Refinery Operations

A. Spiking Refinery Feedstock

4.73 Instead of processing 1.3 million metric tons of crude oil as in 1980/81 the refinery can be operated with about 1.1 million metric tons of whole crude oil spiked with 90,000 tons of diesel oil. This would eliminate the fuel oil surplus and reduce the naphtha surplus to about 73,000 metric tons from 100,000 metric tons. Preliminary analysis (Annex V) indicates that this would result in total savings of about US$7 million annually. These savings can be achieved with no additional investment and are based on a surplus fuel oil export price f.o.b. Chittagong of US$190/MT1/. If it were to be $160 MT (the Singapore price) 2/ then the annual savings would increase to about US$10 million.

B. Blending of Surplus Naphtha With Diesel Oil

4.74 ERL has proposed the separation of a heavy naphtha fraction for blending with diesel oil. This would allow the absorption of about 40,000 metric tons of naphtha in the diesel oil cut, and result in an estimated annual savings of US$2.0 million, since less naphtha would have to be exported and less diesel oil imported. An investment of about US$4 million would be required for the naphtha splitter.

C. Enhanced Recovery of LPG

4.75 Presently the refinery is recovering about 4,000 metric tons of LPG per annum. It is estimated that another 11,000 metric tons can be

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1/ In mid-1981.

2/ In January 1982.

recovered. For a total investment of US$11 million, annual foreign exchange savings of about US$3 million could be obtained.

D. Safety and Reliability of Operations

4.76 The refinery appears to be poorly maintained. There is evidence of corrosion in much of the equipment. Several major columns and towers do not appear to have received anti-rust treatment for several years. The safety practices appear lax and require improvement. The refinery's technical management appears to have inadequacies both in number and depth of skills. Several of the higher management and technical staff seem not to have received training within the recent past to update their skills. An immediate effort to strengthen management systems and institute satisfactory safety, preventive maintenance and operations practices and training programs for key personnel appears to be urgently required to bring about and ensure safe and efficient operation of the refinery.

Recommendations for Short-Term Improvements

4.77 It is recommended that:

(a) Better housekeeping, safety and preventive maintenance practices be instituted at the refinery.

(b) The refinery be insured at its replacement value and not, as at present, at its book value.

(c) A training programme be implemented to update the technical and managerial skills of the refinery staff at senior and middle management levels.

(d) Spiking of crude oil with refined products, to the extent possible with the existing facilities, be instituted. This requires no process modifications. Some technical assistance and guidance may be needed, however, to ensure a step-wise increase in spiking up to the operational limits of the refinery.

(e) A decision be made about the construction of a naphtha splitter as soon as a review of the design work as well as the economics of this option is completed. The construction of the naphtha splitter would take about 12 months.

(f) The further recovery of LPG from the crude oil be considered without delay. The construction of the LPG facilities, for which the design has already been done, can be completed in 15 months.

Medium Term Options - Debottlenecking

4.78 Medium term improvements refer to modifications that would take from two to three years to implement. The refinery as designed has a capacity of 1.5 million metric tons. Given the uncertainties associated with off-shore processing and the extent to which the economics of this operation is affected by the relative movement of fuel oil and crude oil prices, spiking of crude oils beyond the levels permissible with existing facilities needs to be evaluated as a possible medium term option as well as a required intermediate step for a longer term solution. Debottlenecking (i.e. expansion) of the refinery is based on the assumption that the facilities should be able to process 2 million metric tons of crude oil per annum and be able to accept about 40 percent spikes in the period after 1986. The modifications required for such an operation would consist of a prefractionator (a process unit similar to a crude unit), and debottlenecking of the crude unit and associated equipment such as the crude heater and overhead condenser. This would entail capital requirements of about $20 million.

Long-Term Options-Cracking

4.79 Simultaneous with the study of refinery debottlenecking, a detailed evaluation of refinery modification options should be commissioned to determine the extent of potential net benefits that could be realized. ERL appears to require fuel oil conversion facilities. In order to make a proper assessment of the appropriateness of such facilities, three conversion options should be studied:

(a) Visbreaking of residual fuel oil.

(b) Hydrocracking.

(c) Black oil conversion (BOC).

Fluid catalytic cracking should not be considered as it would yield a relatively high proportion of gasoline which is already a surplus product and will likely remain so for a long time. In addition this process would also yield fairly high proportions of LPG which should become increasingly available from natural gas extraction facilities.

4.80 Preliminary evaluation indicates that the options of either mothballing the refinery and importing all products after processing in an offshore refinery or the installation of a visbreaker or a BOC unit with a thermal cracker are unattractive. The option that appears to offer maximum advantage is the installation of a hydrocracker. These findings, of course, are only preliminary and can serve only as a guide to further studies.

Recommendations for Long-Term Actions:

4.81 A detailed study should be commissioned to determine the best strategy to modify the refinery1/ to meet the expected petroleum needs, taking into consideration the further expansion of natural gas supplies and potential gas derived petroleum product substitutes (i.e. LPG and CNG).

Oil and Gas Exploration Appraisal and Development

4.82 Bangladesh has 10 established gas fields in the east, largely undeveloped, associated with anticlinal structures which are readily identifiable. In the west there is a completely unknown potential which requires a detailed and extensive exploration before it can be evaluated. Most of the offshore Bay of Bengal is similar to the Bengal trough of the western onshore. To date, nine offshore exploratory wells have been drilled with one gas discovery. The most promising offshore areas in the northwestern portion of the Bay of Bengal, and just east of the one discovery, has not yet been drilled. Fifteen dry wildcats and 12 gas discoveries have been made to date in the eastern gas trend.

4.83 Petrobangla's exploration strategy is influenced by: (a) the desire to find oil; (b) pressure to explore the whole country; and (c) serious financial constraints. The company is willing to enter into contracts with foreign companies for exploration and development but this does not form an integral part of its exploration strategy. One contract has been signed with Shell for a large area east of Chittagong. Interest has been shown by five other companies which are in various stages of discussion. An important part of Petrobangla's ongoing work is the multi-well exploration program consisting of seismic and drilling in the northwest and north-central part of the country, financed by a loan from the Federal Republic of Germany. Petrobangla currently has one land gravity party and five land seismic crews operating. Four of the seismic crews are owned and operated by them (one digital and three analog crews) and one is on contract from PRAKLA (W. Germany), a digital crew working on the Multi-Well project. However, coverage is quite slow as each crew averages only about 40 km/month during the six-month dry season. Seismic effort is somewhat diffuse and being used to locate drilling prospects. Two crews, including the digital crew, are located in the western region where a fairly dense regional grid will be required to identify promising leads in an area where only subtle traps are likely and very little prior data are usable. This effort is inadequate to support proposed exploration drilling in this large areas of interest. The other two crews are located in the eastern region where they have a better chance of finding drillable prospects. However, little or no seismic effort is planned for detailing past field discoveries or adjacent prospects. In fact, some of the most important gas discoveries do not have any modern

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1/ Through debottlenecking followed by secondary refining investment.

seismic coverage. These would include Titas, Bakhrabad, Habiganj, Kailashtilla and Rashidpur. Others, such as Beani Bazar and Feni, have only minimum modern seismic coverage.

4.84 In addition to the Multi-Well program, Petrobangla has three exploratory wells approved for drilling at this time. One of these is at Sitakund, north of Chittagong, where several wells drilled in 1910-14 encountered gas shows. Another is at Kamta just to the northeast of Dacca, a low relief feature, west of the Bakhrabad structural axis. The third is at Patharia in the northeast adjacent to the Indian border in which four previous wells were drilled between 1933 and 1953, three of which had oil and gas shows. At the same time little or no appraisal drilling is planned in the area of established discoveries.

Recommendations

4.85 The mission is of the view that:

(a) Bangladesh would need to improve and refine its exploration strategy. Lack of skills and technology in this area, coupled with a severe financial constraint, make it inadvisable for Bangladesh to undertake exploration on its own. Further, given the perception of its limited hydrocarbon potential, GOB would need to make a much greater effort to secure participation of foreign oil companies for undertaking exploration.

(b) In the absence of any commercial energy resource in the western zone, Bangladesh would be required to import oil for meeting its energy requirements. This is inspite of the substantial surplus of natural gas in the eastern zone. In order to attenuate the existing energy imbalance, it may be necessary to make greater exploratory effort, at least in terms of seismic work, in the western zone. Even a modest discovery of natural gas could significanly ameliorate the existing situation.

(c) Given the fact that seismic control even in the producing gas fields of the eastern zone is inadequate, it would be advisable to undertake seismic work in these fields and the peripheral areas. Besides assisting in better well location, it could help identify new structures.

D. Solid Fuels Sector

Coal

4.86 Substantial coal deposits, estimated to amount to at least 700 million tons, exist near Tamalganj in the northwestern part of the country. However, the deposits are located at depths ranging between 2,300 to 3,000 feet and underneath water-bearing, alluvial strata. This raises difficult and costly production problems that so far have prevented any development. Most recent studies of the likely development and production costs indicate that coal from this deposit could not compete with imported steam coal from India for the foreseeable future.

Traditional Energy Resources

Forest Resources

4.87 Bangladesh is poorly endowed with forests. Legally constituted government forests cover only 1.3 million hectares or 9% of the total land area. In addition, there are about 1 million hectares of Unclassified State Forests (USF) in the district of Chittagong Hill Tracts (CHT), which, although designated as forests, are largely denuded of tree growth due to shifting cultivation. State forests thus total 2.3 million hectares. Forest distribution is uneven, being concentrated in the southern and eastern regions; over 90% of the forested area is concentrated in 3 districts.

4.88 The legally constituted government forests can be broadly classified into four major groups:

(a) tidal forests;

(b) hill forests;

(c) plain land forest and

(d) plantations.

4.89 The tidal forests consist mainly of mangrove species that are being utilized for timber, pulp wood and firewood production. It is feared that removal rates have exceeded the sustainable yield limit. In the hill forests, populated mainly by Malayan-type species, severe encroachment by shifting cultivation in several places has exacerbated the already degraded forest conditions created by previous heavy logging. In the Rankhiang reserve forest alone, it is estimated that 55% of the total volume of growing stock has been lost through illicit removals and large-scale encroachments; degradation due to the same causes is occurring in the plain land forest, that consist largely of Sal species. Present output from plantations is negligible. As of June 1979, a total of about 26,000 hectares of plantations has been raised in coastal areas, primarily to stabilize newly accreted land and put it under productive vegetative cover.

Unclassified State Forests(USF)

4.90 The USF cover around 971,000 hectares. Shifting cultivation by local tribes has caused almost total denudation of the forests. The previous 10-year cultivation cycle is now reduced to 2 years or even less due to soil erosion and diminishing returns from the land. The resulting rapid siltation of the Kaptai reservoir will seriously affect the generating capacity of the Kaptai hydroelectric project. Floods have also occurred more frequently in recent years due to the heavy siltation of the rivers in this catchment area.

4.91 It has been estimated that around 729,000 hectares out of the total area of 971,000 hectares are suitable for forestry. So far, 40,500 hectares have been transferred to the Forest Department. In the area transferred, the Forest Department has initiated two schemes for the 1980-85 period, namely: (1) Phase I Afforestation in the USF - 20,200 hectares; and (2) Phase II Development of Pulpwood Plantations in the USF - 13,800 hectares. Although the production from these planations will be primarily timber and pulpwood, anywhere from 15-40% of the total yield is expected to be fuelwood. Transfer to the Forest Department of the remaining 688,500 hectares considered suitable for reforestry in the USF would widen the scope for increasing reforestation and potential future fuelwood availability. However, it remains to be seen whether these reforestation efforts will be successful, and whether the growing trees can be protected against encroachment and illicit filling.

4.92 A note of caution however needs to be raised about projects in the Chittagong Hill Tracts which are populated by several ethnic minorities. Extreme care would have to be exercised to ensure that any projects in this area are not executed to the detriment of the tribal people. This is a critical issue.

Village Homesteads

4.93 The ADB estimates the total area covered by homestead trees to be 270,000 hectares. There are no "village forests" as such; what is available are homestead fruit tree areas (45% mango and 20% jackfruit approximately) which serve as the wood source. These homestead "forests" provide around 40% of sawn timber, 80% of bamboo production and 80% of fuelwood in the country. Homestead complexes are the main source of tree fuel in rural areas. On most parts of the deltaic plain, villages consist of houses built on raised earth mounds as protection against flooding. The mounds usually contain a multi-storeyed vegetation of shrubs, bamboos, palms and other trees.

Fuelwood

4.94 The recorded fuelwood removals from government forests is .37 million tons (or 468,000 m) with two-thirds of the total coming from the tidal forests, the balance from the Chittagong Hill Forests. They account for only 6% of total fuelwood consumption while 94% (6.2 million tons or 7.9 million m3) comes from village homestead complexes. However, the government data covering government forests only cover permitted fellings. Because of serious incursion problems, illicit removals most likely exceed recorded forest production levels, but no data are available.

Agricultural Residues

4.95 Agricultural residues and cow dung account for 62% and 25% of TE use respectively. Apart from cow dung, major household fuel sources are rice straw and jute sticks. Total production of rice straw in 1973/74 was estimated at 30 million tons. Output of jute sticks amounted to some

2 million tons in the same year. Projections indicate declining per capita availability of the major agricultural residues. The straw yield of rice HYVs 1/ (0.5 metric tons/hectare) is lower than that of traditional varieties (0.6 - 0.8 metric tons/hectare). Thus, the output of rice straw is not likely to keep pace with population growth as a progressive shift to HYVs occurs. While the output of rice hulls should increase, they will be required in rice par-boiling and for fodder. The output of jute sticks will remain stagnant or decline because no sustained increases in raw jute production is expected.

Animal Dung

4.96 Total livestock population is currently estimated at 20.5 million cattle and 0.5 million buffalo. They produce an estimated annual total of about 75 million tons of dung which is equivalent to around 20 million tons of dry dung. About 10 million tons (50%) are used as fertilizer. The percentage of cow dung collected and used as cooking fuel is estimated to be 35% (7 million tons) of all dung available. The heating value is equivalent to around 0.6 million tons of kerosene, worth about US$225 million. Dung availability will depend critically on livestock population growth. Because of a lack of fodder, the medium-term outlook is close to stagnation, hence per capita availability of dung is likely to decline.

Future Traditional Fuel Supply

4.97 The critical traditional energy supply situation in Bangladesh requires the promotion of projects to increase overall fuelwood production, to increase the recovery of forestry wastes and to improve end-use efficiencies. The mission recommends that the following biomass projects be evaluated in detail and implemented if they turn out to be suitable and cost efficient.

A. Community Forestry Project (Phase II)

4.98 The project would extend community forestry activities to the 14 districts not covered by the first ADB Community Forestry Project. It would include planting in homestead backyard lots, along field bunds and roads, railways and canal banks, and the conversion of depleted and degraded forests to plantations of fast-growing species for fuelwood. If about 8,000 villages where fuelwood scarcity is particularly acute were to be selected the total number of households covered would be approximately 400,000. Some 200 Community Forestry Growth Centers (CFGC) would be needed, each with a nursery and training facilities. With some 3,500 miles of strip plantations and fuelwood planatations covering some 6,000 hectares the estimated annual fuelwood production would be about 0.3 million tons. Costs for such a project would be about US$30

1/ High yielding varieties.

million. Initiation of this project should await preliminary results of the ADB financed Phase I project, however, in order to make use of the lessons that will be learned.

B. Development of Pulpwood/Fuelwood Planations in the Unclassied States Forests (USF)

4.99 Two projects which may be worthwhile considering in the future are, first to raise plantations on 14,000 hectares and to settle 840 families of shifting cultivators on permanent land. The annual wood yield is estimated at 340,000 m3 (.25 million tons) of which 15% (.04 million tons) would be fuelwood. The cost of this project is estimated at US$5.3 million. The second envisages afforestation of 210,200 hectares and the permanent settlement and rehabilitation of 1,500 families of shifting cultivators. The estimated annual yield is 0.1 million tons of which the fuelwood yield would be .04 million tons. The total costs are estimated at US$7 million.

C. Portable Charcoal Kilns in the Chittagong Hill Tracts (CHT)

4.100 Around 70% of the 162,000-hectare Kassalong reserve forest is earmarked for clear felling and tree planting with more valuable species. Around 10 tons per acre of the felled produce are left at site and burnt due to the inaccessibility of the region. Much of this waste can be salvaged through on-site charcoal conversion. A suitable portable kiln prototype is already being fabricated. Around 100 kilns, each with a capacity of 425 m3 (stacked) per year, would be required to convert the unutilized wood to charcoal. Estimated charcoal production would be 10,000 tons per year. Project costs are estimated at US$0.4 million.

D. Charcoal Production in the Sunderbans

4.101 A study on the feasibility of undertaking charcoal production in the tidal Sunderbans forests is proposed. Potential benefits are the reduction of wastage of felled material, the introduction of charcoal as a substitute fuel in households and small industries (e.g., brick making) and the reduction of transport costs. The Sunderbans are flooded during high tide (presenting problems for wood drying), are subject to violent cyclones, and form the habitat of endangered species. Therefore, the kilns would have to be mounted on movable barges. The estimated cost of the study is US$120,000. Wildlife preservation in the Sunderbans is now a declared Government objective. This region represents a very fragile eco-system and extreme care would have to exercised in formulating such a project proposal to ensure that such concerns are fully taken into account.

Incremental Fuelwood Production

4.102 Table 4.2 presents the anticipated additional fuelwood production from ongoing and proposed projects. If the proposed projects are implemented within the next 2 years, the indicated incremental wood supplies would be available about 1990.

Table 4.2

ESTIMATED ADDITIONAL FUELWOOD PRODUCTION FROM ONGOING AND PROPOSED PROJECTS

Project	Additional Annual Production of Fuelwood (Million tons)
Mangrove Afforestation Project*	0.75
Hill Plantations*	0.05
Afforestation in the Unclassified State Forests (Phase I)	0.04
Development of Pulpwood Plantations in the Unclassed State Forests (Phase II)	0.04
Community Forestry Project (Phase I)*	0.14
Community Forestry Project (Phase II)	0.32
Total	1.34
Charcoal Production in Kassalong Reserve Forest	10,000 tons

*On-going projects.

Improved Chulas 1/

4.103 Improved chulas could reduce fuel requirements by 25 to 50%. Four standard models are currently being developed. These should be systematically introduced in villages and regions in which traditional fuel resources are in short supply. The chulas could be built by housewives and would require a maximum cash outlay of TK10.

Recommendation

4.104 A pilot project covering some 500 villages and about 5,000 households should be organized in a first phase to serve as a demonstration project for the dissemination of improved chulas. Ultimately the project should cover around 1,500 villages. Project cost have been estimated to be about US$450,000.

1/ Chulas are mud-stoves.

Non-Conventional Energy Resources

Mini-Hydro Potential

4.105 Topographical and hydrological conditions in Bangladesh do not favour small-scale hydro development. The topography is generally flat, with isolated hilly and mountainous areas located only in the Chittagong and CHT (Chittagong Hill Tract) Districts and, to a much lesser extent, in the Sylhet District. A recent study reports that mini-hydro projects in the 25-200 kW range may be feasible at around 15 sites in the country. Such installations could yield some benefits by serving electricity needs of nearby isolated rural areas.

4.106 The mission recommends that reconnaissance of other streams with apparent generating potential be undertaken. The potential for using vertical axis river turbines which are activated by the velocity of the water flow should also be studied.

Solar Energy Potential

4.107 The solar energy potential is discontinuous because of the extensive monsoon periods. No systematic data have been collected of available sunshine throughout the year. It appears that the most feasible solar applications may be crop and fish drying. Attempts to introduce solar cookers have failed due to the radical changes in cooking habits required.

Recommendations

4.108 To evaluate the potential of solar applications, the mission recommends that four studies are to be undertaken:

(a) a market demand survey for dried fish, fruits and vegetables;

(b) a feasibility study of large-scale fish-drying in the coastal areas and small-scale drying elsewhere;

(c) an evaluation 1/ of harvest grain losses due to inadequate drying; and

(d) an evaluation of the relative economics of small versus large-scale dryers.

1/ This is already going on under IDA's foodgrain storage project.

Solar Water Heating and Air Pre-Heating

4.109 It is estimated that the use of solar pre-heated water for cooking rice cooked with wood as a fuel would save about 0.4 million tons of fuelwood annually. Greater benefits in terms of increased fodder supplies could be realized if solar pre-heated water were to be used to substitute for rice hulls in parboiling paddy. Solar water heaters could be easily fabricated using locally available materials. The mission recommends that field testing of such water heaters be undertaken.

Wind Energy

4.110 Sailboats carry about 80% of all inland water cargoes in Bangladesh. Other potential applications of windpower could be windmills for water pumping in locations with reasonable reliable wind conditions. These are most likely to be found near coastal locations.

Biogas

4.111 Considerable research and demonstration have been undertaken on the use of bio-digesters based on animal dung. While there may be some potential for biogas utilization, the emphasis on family-size digesters does not seem justified given the high cost, the highly skewed ownership of livestock and land and maintenance requirements. A family-size biodigester costs anywhere from TK 8,000 (US$400) for the fixed dome type, to TK 14,000 (US$700) for the floating gasholder type, representing a significant investment which very few rural households can afford.

Recommendations

4.112 The mission recommends that efforts be re-directed towards larger biodigesters for small - or medium-scale enterprises and livestock farms, where the technology may be more economically viable.

Tentative Ranking of Technologies

4.113 The mission considers that some priority ranking of renewable energy activities is necessary because of the potential for duplication and dilution of efforts. The highest priority should be given to technologies that deal with biomass utilization and solar thermal applications.

Priority 1 (applicable in the near term)

- Tree-planting for fuel and fodder

- Improved cooking stoves

- Charcoal conversion of forest residues

- Solar drying of foodstuffs

Priority 2 (more R & D and field-testing required to be applicable)

- Biodigesters for larger livestock farms and rural enterprises

- Solar water heating (low temperature)

Priority 3 (economic and technical feasibility in the Bangladesh context still uncertain; applicability in the long term yet to be proven)

- Solar pumping for irrigation

- Mini- and micro-hydro power generation

- Solar distillation

- Solar salt production

- Photovoltaic generation for small power needs

- Windpumps

- Industrial process heat

Low Priority (presently seem to have low or no applicability in Bangladesh)

- Family-sized biodigesters

- Solar cookers

- Alcohol production

- Passive solar design for climate control

- Solar refrigeration and cooling

- Wind generators

Human Labor in Transportation

4.114 An important characteristic of the Bangladesh transportation systems is the prevalence of human labor both for moving freight and people by conveyances such as pushcarts and pedicabs. It is estimated that more than 200,000 of the latter operate in the Dacca region alone, against only about 900 taxis, 34,000 motorcycles and less than 58,000 motor vehicles in the country as a whole (1979 data). While efforts were made occasionally in the past to restrict pedicabs in major cities the resulting dislocation of labor would be so massive that the policies are not to be recommended for quite some time to come.

CHAPTER V

ENERGY COST AND PRICING ISSUES

5.01 In Bangladesh the prices of petroleum products, natural gas, electricity and coal are controlled by the Government. Prices of fuelwood, charcoal and other indigenous energy resources, on the other hand, are determined by the market.

Economic Value of Natural Gas

5.02 The issue of what is the long run opportunity cost of natural gas in Bangladesh is the first matter to be addressed. The economic value of natural gas is the opportunity cost to the country of the consumption of the marginal unit of gas. In order to determine this value one must assess the marginal use of gas which, in turn, requires a comparison of the potential production levels with potential demands. As noted earlier, Bangladesh has large gas reserves relative to domestic demand for the next couple of decades. This implies that the high value uses of gas as a fuel oil substitute can easily be accommodated and, unless large quantities of gas can be exported, the opportunity cost of gas will fall to its long-run supply cost. For a depletable resource, this supply cost includes both production costs and the so-called "user cost", which represents the foregone future value of the gas due to depletion. Given the major uncertainties involved in large-scale gas export, either overland to India or as LNG to other countries, the mission considers that the opportunity cost of gas in Bangladesh is represented by its long run marginal supply cost including an allowance for depletion. Although the latter is impossible to calculate precisely in the absense of a full macroeconomic model, a range of estimates is provided below to indicate the order of magnitude.

Marginal Gas Production and Supply Costs

5.03 The costs of the Bakhrabad Gas Development project were used as an estimate of the approximate marginal production and transmission costs of natural gas to bulk users in the Eastern half of the country. They amount to some TK8.24/MCF (US$0.53/MCF 1/) in 1980 prices evaluated at a 12% discount rate whilst at a 6% discount rate these costs are TK4.40/MCF (US$0.28/MCF). Adding a 17% inflator to escalate to 1981 prices these costs become TK9.64/MCF (US$0.51/MCF 2/) at a 12% discount rate and TK5.15/MCF (US$0.27/MCF 2/) at a 6% discount rate. These estimates can be taken as broadly representative of the long-run marginal costs of developing, producing and transmitting natural gas to major bulk consumers in the Eastern Zone of Bangladesh. The data on which this estimate is based are summarized in Table 5.1 below.

1/ Exchange rate in 1980 was TK15.50 = US$1.00.

2/ Exchange rate in 1981 was TK19.00 = US$1.00.

Table 5.1

DATA BASE FOR THE ESTIMATE OF LONG-RUN MARGINAL SUPPLY
COSTS OF NATURAL GAS IN EASTERN BANGLADESH
(Economic Analysis)
Million (1980) Takas and MMCF
(Bakhrabad Project Data)

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989
Costs	32.78	895.73	1,239.03	190.94	33.0	33.0	33.0	33.0	33.0
Gas Sales	-	-	-	11,942	20,957	32,634	33,784	34,445	34,988
Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Costs	33.0	33.0	104.03	439.54	33.0	33.0	33.0	33.0	33.0
Gas Sales	38,169	41,158	46,594	53,714	56,408	63,274	64,850	66,851	68,854
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**04-11**	**2012**	**2013**	**2014-20**
Costs	33.0	33.0	33.0	104.03	439.54	33.0	104.03	439.54	33.0
Gas Sales	71,327	74,212	-	-	-	74,212	-	-	74,212

Discount rate: 12%
Total economic costs (present value) TK2,077.23x10^6.
Total gas sales: (present value) 252,026.43x10^6CF.
Average costs of gas = TK8.24 (US$0.53)/MCF.

Source: World Bank, Staff Appraisal Report No. 2956-BD, Bangladesh, Bakhrabad Gas Development Project.

The Economic Costs of Depletion

5.04 Natural gas is a depletable resource. Therefore, one of the cost elements of gas utilization is represented by the future net difference between its own marginal long-run costs of supply and the costs of its next future substitute. This depletion allowance must be increased with time at the appropriate rate of interest, so that at the time of exhaustion (or complete commitment) it is equal to the net cost differential between the long-run marginal production cost of the gas and its substitute. These increases are in addition to any inflationary price adjustments that may be required. Since gas supply contracts entail long-term commitments the availability of non-committed gas stops long before actual resource exhaustion. In making estimates of possible depletion allowances, in this analysis it has been assumed that no new gas commitments could be entered into as soon as the committed annual reserve/production ratio falls to 15/1. At this point in time depletion is binding and substitutes must be utilized to meet incremental demand. Given the presently proven and probable gas reserves in Bangladesh of 10 trillion cubic feet (which are considered conservative) and optimistically projected consumption rates 1/, the time when the 15/1 reserve to production ratio is reached would be about the year 2000.

5.05 The range of depletion allowances to be added to the marginal supply costs vary as shown in Table 5.2 below according to the type and estimated future costs of the substitute fuel, as well as, of course, the discount rate chosen. 2/

1/ About 22% annual rate of growth in gas production from 1981-87 and 10%/year thereafter to the year 2000.

2/ The discount rate of close to 12% is considered as appropriate in Bangladesh. Calculations using a 6% discount rate were used purely to demonstrate the sensitivity of the economic costs to its value.

Table 5.2

CURRENT DEPLETION COST ALLOWANCE PER MCF OF NATURAL GAS FOR ALTERNATIVE REPLACEMENT FUELS IN 1981 AND LEVELLIZED BETWEEN 1981-2000 -- RATES OF INTEREST 6% AND 12% (In 1981 Prices)1/

Replacement Fuel	Depletion Allowance In 1981 per MCF				Levellized Constant Depletion Allowance per MCF for 1981-2000			
	6%		12%		6%		12%	
	Taka	US$	Taka	US$	Taka	US$	Taka	US$
Fuel Oil at US$194/ton	18.62	0.98	4.56	0.24	31.73	1.67	11.78	0.62
Coal at US$71/ton	11.40	0.60	2.85	0.15	19.38	1.02	7.41	0.39
Natural gas at US$1.50/MCF	4.37	0.23	1.14	0.06	7.41	0.39	2.85	0.15

1/ Exchange rate TK19.00 = US$1.00.

There are three possible fuels which could replace existing low cost natural gas in the eastern zone at the point in time that depletion of existing proven and probable gas reserves becomes binding -- i.e. the year 2000. The first of these is fuel oil whose price (in 1981 $) in 2000 is assumed to be US$194/ton (i.e. no real increase in fuel oil prices over the next 19 years) or US$4.57/MCF equivalent. The second fuel would be Australian steam coal whose 1981 c.i.f. Chittagong price of about US$58/ton is assumed to increase at 1%/year in real terms up to 2000. This implies a price for imported steam coal in Bangladesh in 2000 of US$71/ton (in 1981$) or US$ 2.82/MCF equivalent. The third substitute fuel is more natural gas from newly discovered and developed fields, however, with development and production costs about three times higher in real terms than presently proven reserves. Such "high" cost gas it is assumed to cost about US$1.50/MCF (1981 $) in 2000.

5.06 The eastern zone of Bangladesh is a highly prospective gas region. Further exploration is expected to add significantly to already existing gas reserves. As such the most likely substitute fuel around 2000 would be newly discovered gas. The ranges of the depletion allowance for each of the three substitute fuels assuming discount rates of 6% and 12% are shown in Table 5.2. The depletion allowance for the year 1981 is indicated as well as the levellized constant allowance between 1981-2000. At one extreme (that of fuel oil replacement) the levellized depletion allowance is US$1.67/MCF and US$0.62/MCF at 6% and 12% discount rates respectively. At the other extreme (that of "high" cost newly discovered gas) the levellized depletion allowance is

US$0.39/MCF and US$0.15/MCF at 6% and 12% discount rates. As stated above "high" cost gas as the replacement fuel in the year 2000 is considered to be the most credible scenario in Bangladesh, with imported coal being much less probable and imported fuel oil the least possible.

Total Economic Costs of Gas

5.07 The total economic cost of gas to bulk consumers consists of the sum of the marginal production and bulk transmission costs and the depletion allowance. The extreme ranges of these costs are shown in Table 5.3 at discount rates of 6% and 12%, the former being close to the consumption rate of interest and the latter to the opportunity cost of capital 1/. What is worth noting is that in the case of "high" cost gas as the replacement fuel the levellized total economic cost is about TK12.56/MCF (US$0.66/MCF) at discount rates of 6% and 12%. At the other extreme -- fuel oil as the replacement fuel -- the levellized total economic cost is TK36.88/MCF (US$1.94/MCF) at a 6% discount rate and TK21.42/MCF (US$1.13/MCF) at a 12% discount rate. Based on these preliminary estimates it is the mission's view that the economic cost of gas to bulk consumers in eastern Bangladesh is within the range Tk 17.05/MCF ($0.90/MCF) to Tk 12.49/MCF ($0.66/MCF). The floor of 66US¢/MCF represents "high" cost gas as the replacement fuel and the ceiling of US$0.90/MCF arises with imported coal being the replacement fuel.

Table 5.3

ECONOMIC SUPPLY COSTS PLUS DEPLETION ALLOWANCE FOR NATURAL GAS FOR REPRESENTATIVE REPLACEMENT FUELS -- LEVELLIZED COSTS 1981-2000 -- IN 1981 PRICES
(Interest Rates 6% and 12%)

	Total Costs Per MCF			
	6%		12%	
Replacement Fuels	Taka	US$	Taka	US$
Fuel Oil at US$194/ton	36.88	1.94	21.42	1.13
Coal at US$71/ton	24.53	1.29	17.05	0.90
Natural gas at US$1.50/MCF	12.56	0.66	12.49	0.66

1/ In Annex VI.A the economic supply cost plus depletion allowance for gas for the three replacement fuels at five year intervals between 1981-2000 is shown assuming a 6% discount rate.

Natural Gas Tariffs

5.08 The most recent tariffs introduced in July 1982, are shown in Table 5.4. The lowest rates of TK10.50/MCF (US$0.48) are charged to the power and fertilizer sectors, which together account for more than 73% of total gas sales of the Titas Gas Company. Titas is the only gas transmission and distributing company with significant numbers of industrial, commercial and domestic customers. Industrial and commercial tariffs are 31 TK/MCF. Metered customers have to pay a monthly meter rental charge in addition to the charges per unit of gas consumed. These rental charges, which have recently been substantially increased, range between TK73 (US$3.8) to TK307 (US$16) for commercial and from TK423 (US$22) to TK2,941 (US$155) for industrial customers. Most domestic customers are un-metered and are charged a flat monthly rate that is calculated on the basis of the number of gas burners owned. These flat rates are TK35 (US$1.59) for a single burner, and TK65 (US$2.95) for a double burner respectively. A few domestic consumers are however metered paying a rate of 27TK/MCF. Domestic users also have to pay a one-time connection fee of TK1,000 (US$53), which can be paid in ten equal monthly installations of TK100 each.

Table 5.4

NATURAL GAS TARIFFS (Titas Gas Co.)
July 1982 (Price per MCF except as noted)

Sectpr	End-User TK	Price per MCF 1/ US$
Electric Power	10.50	0.48
Fertilizer	10.50	0.48
Industrial	31.00	1.41
Commercial	31.00	1.41
Domestic (Metered)	27.00	1.23
Domestic (Unmetered):		
Single burner (per month)	35.00 2/	1.59 2/
Double burner (per month)	65.00 2/	2.95 2/

Note: Exchange Rate: TK22 = US$1.00

1/ Excludes meter rental charges and includes excise duties.

2/ These are flat monthly rates irrespective of consumption level.

5.09 Gas tariffs have been raised several times in recent years. However, when these increases in Taka prices are converted at the prevailing rates of exchange, the weighted average prices show a declining trend, from TK5.14/MCF (US$0.65/MCF) in 1974 to TK10.38/MCF (US$0.55/MCF) in 1981. These prices are far below those of competing commercial energy resources (Para. 5.13-5.15). In fact, the gas tariff to electric power and fertilizer users (TK10.50/MCF) is about 75% of the "floor" price indicating an economic subsidy to such consumers which account for about 74% of Titas Gas Co.'s sales. In addition, the combined class of domestic and commercial gas consumers are being heavily subsidized because Titas Gas Co.'s joint costs of supply to such consumers is considerably higher (see para. 5.10 below) than the revenues received from them.

Analysis of Domestic/Commercial Gas Tariffs and Supply Costs on the Titas System

5.10 In 1979/80 domestic and commercial customers accounted for some 99.6% of all connections, but only 11.2% of total gas sales and 18.9% of total revenues. On the other hand, a major percentage of the total operating expenses of the company must be attributed to these customer groups. The joint cost of service to domestic and commercial users was estimated (see Annex VI) for the year 1979/80 at about 45.89TK/MCF 1/ (US$3.11/MCF) compared with average revenues from these groups of TK14.66/MCF (US$0.99/MCF). This implies that commercial and domestic consumers taken together received large financial subsidies amounting to some TK31.23/MCF 1/ (US$2.12/MCF) in 1979/80, which amounts to a subsidy of nearly US$7.4 million in that year. Clearly very urgent steps are required to rectify this state of affairs for the following reasons:

(a) Arguments of distributional equity that are usually used to justify such subsidies to these consumer groups are irrelevant when judged against the yardstick that these benefits accrue to less than 0.8% of all households in the country.

(b) The financial performance of Titas Gas Company requires urgent improvement.

(c) Even if the tariffs charged to these customers were raised to a level to fully recover costs the price of gas would still be significantly below those of competing commercial fuels such as LPG and kerosene (See para. 5.13-5.17).

1/ At the then exchange rate of TK14.75 = US$1.00 and tariffs then in existence.

Titas Gas Company's Financial Performance

5.11 Owing to the low prices charged, the gas production and distribution companies show only a modest profit. In 1979/80 Titas Gas Co.'s pre-tax accounting profits were TK29.7 million, equal to about 11% of sales revenues, or 18% return on equity capital. This Company accounts for 70% of total gas sales in the country. However, these results are based on historic depreciation rates and on nominal rates of interest. For example, total interest and financial charges of TK28.363 million (US$1.92 million) 1/, compare with an outstanding debt of TK373.8 million (US$25.3 million) plus TK182.6 million (US$12.4 million) of current liabilities. This represents a payment of only 5.1% on outstanding debt. Clearly, the opportunity cost of capital in Bangladesh is much higher than that. If the costs of outstanding debt were to be evaluated at 12% p.a., for example, interest charges alone would amount to TK66.8 million; those for depreciation at a rate of 5% p.a. would be TK28.7 million, resulting in a total annual charge of TK95.5 million (US$5.8 million) 2/. These charges would exceed the nominal before-tax operating profit of TK52.1 million (US$3.5 million) by more than 60%. The picture would be even more dismal if assets were revaluated in terms of current replacement costs rather than at historic costs.

5.12 Apart from addressing cost saving measures such as reducing apparent system losses (Para. 4.42-4.44), improvement of this Company's financial performance will require further tariff adjustments, particularly for domestic and commercial consumers. In order to keep increases in gas tariffs in their proper perspective it is important to compare the costs of alternative fuels with that of gas.

A Comparison of Natural Gas Prices and Those of Alternative Fuels

5.13 The domestic costs of petroleum fuels are far higher than those of natural gas. The costs of gas to the power and fertilizer sectors, on a BTU-equivalent basis, amount to only 7.5% of those of heavy fuel oil, while for industry gas prices amount to 22% of those of fuel oil, see Table 5.5 below.

5.14 Compared to kerosene as an alternative fuel, gas prices in the commercial sector amount to 15%, and in the domestic sector to only 13%.

5.15 An important alternative fuel to industries without access to gas such as brick manufacturing is imported coal. Coal is sufficiently less costly than fuel oil, and it is competitive or lower-priced than firewood in urban markets (see Table 5.6 below). However, coal imports

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1/ Converted at the 1979/80 rate of exchange of US$1 = TK14.75.

2/ These calculations disregard the effects of inflation, which in 1979/80 was 17.3%.

are subject to import restrictions. A re-evaluation of this policy may be in order to encourage the use of coal as a replacement for higher-cost imported fuel oil for industries without access to gas.

Commercial and Household Fuels

5.16 The most important commercial and household fuels are fuelwood, kerosene, LPG and natural gas. On a net heat-rate basis, natural gas is by far the lowest-priced fuel (Table 5.6). For domestic users, LPG costs would be about four times 1/ higher; kerosene prices as much as 11 times higher and fuelwood costs 15 times higher in Dacca and 7 times higher in Comilla. To commercial users LPG costs almost 4 times more, kerosene 9 times more and fuelwood 12 times more in Dacca and 6 times more in Comilla.

5.17 Given these very large price differentials between natural gas and alternative fuels, it is evident that increases in gas tariffs to domestic and commercial users are still required to remove the large subsidies to these user groups. This would still allow gas to be much cheaper 2/ than alternative household fuels. This question is of added importance in the light of the substantial financial subsidies in the current tariff for supply to domestic and commercial gas users (para. 5.10).

1/ Despite the fact that LPG prices are currently subsidized in that at the retail level they are about 65% of the import parity prices (See Para. 5.31).

2/ For example, increasing domestic gas tariffs by as much as 200% would still result in gas being about 1/4 and 1/2 of kerosene and LPG end-use costs respectively.

TABLE 5.5

COMPARISON OF NATURAL GAS, COAL, AUTOMOTIVE DIESEL, KEROSENE AND HEAVY FUEL OIL PRICES AS OF JULY 1982
prices per million BTU

Consuming Sector	Natural Gas		Coal 3/		Diesel & Kerosene 2/		Heavy Fuel Oil		Natural Gas Price as a % of the price of the most likely subsititute (coal)
	Taka	US$	Taka	US$	Taka	US$	Taka	US$	
Electric Power	10.50	0.48	-	-	-	-	140	6.36	7.5
Fertilizers	10.50	0.48	-	-	-	-	140	6.36	7.5
Industry	31.00	1.41	69	3.15	-	-	140	6.36	22 (44.8)
Commercial 1/	31.00	1.41	69	3.15	204	9.27	-	-	15 (44.8)
Domestic 1/	27.00	1.23	-	-	204	9.27	-	-	13.3

Exchange rate: US$1.00 = TK22.

1/ Metered gas price.

2/ Based on prices ex depot, Chittagong.

3/ Indian steam coal, delivered (US$60/ton).

Table 5.6

END-USE COSTS OF ALTERNATIVE
COMMERCIAL AND HOUSEHOLD FUELS a/
(prices per million Btu)

Fuel	Raw Fuel Costs TK	Raw Fuel Costs US$	Efficiency %	Average Appliance Net Fuel Costs b/ TK	US$	% of gas costs
Natural Gas						
Domestic	27	1.23	45	60	2.73	100
Commercial	31	1.41	45	69	3.14	100
LPG c/	106	5.58	45	236	12.42	393 (domestic) 342 (commercial)
Kerosene d/	204	9.27	30	680	30.91	1133 (domestic) 986 (commercial)
Fuelwood						
Dacca	105	5.53	12	875	46.05	1458 (domestic) 1268 (commercial)
Comilla	53	2.79	12	442	23.26	737 (domestic) 641 (commercial)

Exchange rate US$1.00 = TK22

a/ As of July 1982 except for LPG price which is September 1981.

b/ Adjusted by average appliance efficiency.

c/ Retail price at Chittagong excluding bottle deposit of TK150 in September 1981 with an exchange rate then of TK19 = US$1.00.

d/ Ex-depot price Chittagong excludes local transport costs and retail margin.

Recommendations and Findings

5.18 Based on the above observations, the mission's findings and recommendations are:

(a) The major policy issue surrounding natural gas pricing in Bangladesh is not so much how one measures the opportunity cost of gas but that an appropriate pricing policy be instituted. In this context it is of paramount importance that the gas pricing study that the government agreed to do in the Bakhrabad credit be undertaken promptly. The appropriate pricing levels of different consumers is essentially a choice between the value of additional government revenues and the incentives that may be given to economic growth because of gas being priced below that of competing imported fuels.

(b) Preliminary estimates indicate that the levellized economic cost of gas to bulk consumers in the eastern zone of Bangladesh is within the range of TK 17.05/MCF (US$0.90/MCF) to TK 12.49/MCF(US$0.66/MCF). The July 1982 tariff revisions have basically still left prices to the power and fertilizer users at about 75% of the lower level of this range. Further adjustments upwards in real terms are required to enable tariffs to these bulk customers to reach the "floor" of the economic range of prices. In addition, domestic and commercial consumers of gas were receiving in 1979/80 a massive financial subsidy (in excess of US$2/MCF) in that the revenues received from these consumers, taken together, were about 1/3 of the joint cost of serving such customers. Clearly, a series of significant upward adjustments in the tariffs to domestic and commercial consumers is called for. Since these tariffs have to increase by about 200% in real terms merely to cover costs they would have to be instituted over a period of time. In the case of the power and fertilizer bulk consumers, though tariff increases are also required, here, however, the degree of increase above the floor of the range (US$0.66/MCF - US$0.90/MCF) depends on the issue of general resource mobilization. Gas represents the country's richest natural resource endowment and government needs not only to collect a larger share of the rent for development in other sectors but also to ensure that the resource is not being sold below its full economic cost to any class of consumer.

(c) The financial performance of Titas Gas Co. is unsatisfactory. Adjustments of tariffs along the lines outlined above, as well as measures dealing with apparent system losses (paras. 4.41-4.43) and the metering of all domestic customers are required to improve the situation. Depreciation and interest charges should be calculated at levels reflecting replacement costs for the former and market rates for the latter.

Electricity

BPDB Tariffs

5.19 Electricity tariffs charged by the BPDB were increased in September 1979 by 38%, in October 1980 by 47% and in July 1982 by a further 40% increase was instituted. The present rate structure is partly inverted, with very low charges to the domestic and irrigation pumping sectors for minimum quantities consumed. The current tariffs are shown in Table 5.7 below.

5.20 Historically, the costs of operations have been higher than revenues. This is basically the result of insufficient tariffs relative to costs, a highlevel of system losses and insufficient tariff adjustments in response to changes in underlying costs, particularly the costs of fuel. In FY 1979, fuel costs amounted to 67.8% of total sales. By FY 1981, this share had risen to 83%. In 1978/79 net losses of TK 293.6 million (US$19.06 million) amounted to some 45% of total revenues of TK 649.8 million (US$42.2 million). In 1979/80 net losses (before TK 130 million (US$8.44 million) of government subsidies) increased to TK 246 million, or 27% of total revenues of TK 895.3 million (US$58.14 million).

5.21 These accounting deficits understate actual economic losses since depreciation is charged at the low rate of 3.2% on book value (average 31 years life) and interest charges are based on the subsidized terms of conditional loan agreements, or a nominal rate of 5% for the government-financed portions of the investment program.

5.22 Another factor affecting costs is the level of domestic inflation and the declining value of the Taka relative to the US dollar 1/. These declines translate directly into increased costs of imported petroleum fuels, the major fuel expenses of BPDB at present. Some fuel cost relief is in sight, given the expected completion of the east-west interconnector, which will replace some of the petroleum-fueled base load power in the west by gas-fired generated power from the east. The expected decline in average fuel-costs between 1980/81 and 1983/84 is projected to be some 30%.

5.23 Based on the tariff existing up to June 1982, the average revenue per KWh sold in FY1982 will be TK 0.99 (US¢5.5) compared with TK 0.47 (US¢3.0) prior to September 1979. The tariff introduced in July 1982 although lower than that developed in a study 2/ based on long-run marginal costs will go some way towards improving the financial situation of BPDB despite the constraints of increased system losses and petroleum prices. The government and BPDB have agreed with outside financing agencies that tariffs need to be reviewed to ensure a realization of net internal cash generation sufficient to finance at least 20% of BPDB's capital expenditure in FY1983, 25% in FY1984 and 40% in FY1987. Added to the measures to reduce system losses (see paras. 4.10-4.14) substantial tariff increases are still required 3/ to achieve these objectives.

1/ The domestic inflation rate in 1979/80 was estimated at 17.3% and 8.1% in 1980/81. Average exchange rates were TK 15.4 per dollar in 1979/80; by the fall of 1980 they had declined to TK 19 per dollar. The external value of the Taka has continued to decline since then and is now about Tk 22 per US$.

2/ Tariff study by Coopers and Lybrand Assoc. Ltd. and financed by ODM.

3/ Tariff increases, in real terms, of about 40% in FY1983, 11% in FY1984 and 25% in FY1987 would be called for.

Table 5.7

BANGLADESH BPDB ELECTRICITY TARIFF STRUCTURE (JULY 1982)

Consumer Group	Minimum Monthly Charge per KW	UNIT RATES PER KWH: Up to 250 Units	UNIT RATES PER KWH: above 250 Units	UNIT RATES PER KWH: All units without time of day meter	All units with time of day meter: Peak	All units with time of day meter: Offpeak
LOW AND MEDIUM VOLTAGE						
(A) Domestic	—	(1)	(1)	— —	— —	— —
(B) Irrigation Pumping	Annual Charges:					
	TK 250 per H.P/year	50 paisa	100 paisa	—	—	—
	TK1000 (single phase)	—	—	—	—	—
	TK3000 (3 phase)	—	—	—	—	—
(C) Industry	TK 90 (single phase)			150 paisa	**400 paisa/KVAH**	**110 paisa/KWH**
	TK500 (triple phase)	—	—	—	—	—
(D) Ceremonial/ Temporary Purposes	TK 200 (single phase) TK1000 (triple phase)	—	—	TK 4.00	—	—
(E) Other Commercial	(3)	(2)	(2)	—	—	—
HIGH TENSION BULK						
(F) Consumers above 50 kw (excluding Jute Mills)	TK3500	—	—	155 paisa	**315 paisa per KVAH**	**90 paisa per KVAH**
(G) Jute Mills above 50 kw	TK3500	—	—	130 paisa	—	—
EXTRA HIGH VOLTAGE						
(H) 5 MVA or above (other than REB)	TK 65	—	—	135 paisa	**250 paisa per KVAH**	**80 paisa per KVAH**
(I) REB/PALLIBIDYUT SAMITY	TK 50	—	—	78 paisa	—	—

*100 Paisa = 1 Taka.

(1) Unit monthly rates: 0-50 KwH (TK0.50/KwH); 50-250 KWh (TK0.60/KwH); 250-400 KwH (TK0.70/KwH) and above 400 KwH (TK2.00/KwH).

(2) Unit monthly rate: 0- 100 KwH (TK1.40/KwH), above 100 KwH (TK2.50/KwH).

(3) Minimum charge dependent on load.

Given the projected reductions in average fuel costs resulting from the switch-over from oil-fired to gas-fired generation after completion of the east-west interconnector and the completion of more fuel efficient gas-fired generating plants, these tariff increases were projected to be adequate to satisfy the financial requirements set out above. However, BPDB's financial projections are based on 1984/85 energy sales forecast that are some 16% higher than those of the mission (para. 3.31). If the mission's scenario turns out to be closer to reality in 1984/85 then this will put added pressure on BPDB's financial performance.

5.24 An unusual feature of the present tariff structure is that no power factor correction charges are levied. While this simplifies billing procedures, it has the disadvantage that larger users have no financial incentive to install capacitors in order to reduce excess peak demands. This, in turn, needlessly increases system capacity requirements. It is interesting to note that by contrast, the REB system requires the installation of such power factor correction equipment by all users (at their own expense) whose power factor is less than 90%.

REB Tariffs

5.25 Tariffs for the REB system are set on an individual PBS basis. Annex VII shows the tariff structure of the Dacca I PBS, the first REB cooperative to be energized in 1980. The general principle underlying the tariff structures of each independent PBS is that they should be self-financing after a grace period of five years. This requires temporary subsidies by the Government to the REB system. These are estimated to amount to an average of TK 0.381/kWh during the first year of a new PBS operation, falling to TK 0.106/kWh by the fifth year and to zero thereafter. This assumes that average charges will rise from TK 1.00/kWh from now to TK 1.778/kWh then. However, the recently negotiated bulk tariff from BPDB to REB of TK 0.78/kWh does not cover the economic costs of supply. These, at the 33 KV entry point, were estimated to amount to TK 1.61/kWh in domestic terms and TK 1.2/kWh in border prices 1/. In other words, the REB system will obtain its bulk energy at less than half of the economic costs of supply. The need for the initial government subsidy is essentially two-fold: (a) the current bulk rate is higher than BPDB's retail to its domestic consumers which creates problems in areas where BPDB supply and PBS's supply are in the immediate neighborhood, and (b) the rate was based on a study in which the high system losses of BPDB (about 37%) were incorporated with no improvement assumed thereby increasing supply costs. These are legitimate factors and government agreed during recent negotiations 2/ that a study will be

1/ Tariff study by Cooper & Lybrand/Preece, Cardew & Rider; marginal cost calculations by USAID/NRECA and by World Bank staff.

2/ Negotiations with IDA for the Rural Electrification Project. Staff Appraisal Report 3728b - BD (May, 1982).

carried out , by December 1984, of the bulk and retail tariffs of all supply authorities in the power sector, which will be based on long-run marginal costs and that new tariffs will be implemented by July 1, 1985 for BPDB and PBS's based on the recommendation of the study. It was also agreed that until this new tariff is implemented, the average price per Kwh sold by PBS's shall not be less than the average price per Kwh sold by BPDB. It is important that the above time schedules be adhered to so that the many new REB customers do not develop a vested interest in continued public subsidies.

Long-run Marginal Cost

5.26 Recent consultants' studies and other estimates 1/ indicate that the long-run marginal costs (LRMC) of power supply in Bangladesh range between TK 1.00/kWh and TK 2.30/kWh in domestic terms, depending on supply voltage and consumption pattern. It is likely that the LRMC for domestic and agricultural consumers is between TK 1.80 and TK 2.30/kWh, while high-voltage industrial supply would have a significantly lower cost.

Recommendations and Findings

5.27 Based on the mission's analysis of BPDB's and REB's financial performance and their current tariffs relative to estimates of the long run marginal cost of power, the findings and recommendations are:

(a) Steps need to be urgently taken to strengthen the finances of BPDB since the massive financial losses of the recent past must be arrested. This requires urgent action to identify and then undertake measures to reduce the level of power losses (Para. 4.14). Secondly, BPDB's tariffs need to be reviewed continuously to bring revenues from sales more in line with costs. The projected increases slated for the period FY1983-FY1987 may be insufficient if the slower sales growth estimate by the mission is realized in the next few years.

(b) KVA demand charges have been introduced in the tariffs of individual PBS's thereby providing an incentive for the installation of capacitors by users whose power factor is less than 90%. This is a sound measure. On the BPDB system there is however no such KVA demand charge for larger users and the need for the introduction of such a charge should be assessed. What does exist on the BPDB system is a time of day tariff for larger users with significant penalties for on-peak consumption relative to off-peak demand.

1/ Tariff study by Cooper & Lybrand/Preece, Cardew & Rider; marginal cost calculations by USAID/NRECA and by World Bank Staff.

(c) It is important that the time schedule already agreed to by the government for the bulk and retail tariff studies of the BPDB and PBS systems, as well as the implementation of the recommended tariffs, be adhered to. This is especially important for the rapidly expanding PBS systems since it will be easier to deal with higher tariffs at the outset than to have to raise them substantially later.

Petroleum Product Prices

5.28 Petroleum product prices have been frequently adjusted to reflect changes in underlying costs. The Government levies some import duty and excise taxes ranging from 5% for kerosene to 11% for premium gasoline of the ex-refinery prices.

5.29 Table 5.8 shows a comparison, as of July 1982, of petroleum product prices in Chittagong at three levels. First, the ex-depot price which includes duties, taxes and markets margins; second the estimated c.i.f. prices for imports from Singapore (a measure of the border price), and third, the ex-refinery prices. Ex-depot prices vary among various locations in the country by small amounts to reflect transport costs. The price increases instituted by the Government in July 1982 are to be highly commended for they removed completely the implied economic subsidies in diesel oil and kerosene prices. Ex-depot prices of gasoline are over 100% above import parity whilst those of kerosene, diesel oil and fuel oil are around 10%, 15% and 30% respectively above import parity. At the ex-refinery level all of the major petroleum products, except LPG, are priced above import parity at present.

5.30 It should be noted however, that the structure of prices at the ex-refinery level is significantly distorted relative to import parity prices in that gasolines are over 100% above import parity, fuel oil about 20% above and kerosene about 3% above import parity. the present price structure should now permit ERL to recover its costs and obtain some return on investment. This is an improvement on the situation prevailing up to these latest price increases.

Table 5.8

PETROLEUM PRODUCT PRICES (JULY 1982)
EX-DEPOT PRICES CHITTAGONG, EX-REFINERY
PRICES CHITTAGONG AND IMPORT PARITY C.I.F. CHITTAGONG

Taka/imperial gallon (US$/barrel)

Product	Ex-Depot Price Chittagong Tk/IG (US$/bbl)	Import Parity 2/ c.i.f. Chittagong (US$/bbl)	Ex-Refinery Chittagong Price Tk/IG (US$/bbl)
Premium Gasoline	69.30 (110.16)	(46.29)	62.58 (99.47)
Regular Gasoline	63.80 (101.41)	(43.35)	57.55 (91.48)
Jet Fuel	42.02 (66.79)	(47.97)	40.17 (63.85)
Kerosene	32.81 (52.15)	(47.55)	30.71 (48.81)
Automotive Diesel Oil	32.81 (52.15)	(45.45)	30.00 (47.69)
Fuel Oil (High Sulphur)	24.54 (39.01)	(29.95)	22.71 (36.10)
LPG 1/	4800 1/ (252.6)	(436.9) 1/	2400 1/ (126.3)

Note: Exchange Rate July 1982 TK22 = US$1.00.

1/ LPG prices refer to September 1981 prices (exchange rate then TK19 = US$1.00) and are in Taka and US$ per metric tonne.

2/ F.O.B. Singapore prices plus freight to Chittagong taken at US$2.40/bbl for clean products and US$1.20/bbl for dirty products.

5.31 One issue concerns the the price of LPG ex-depot (US$5.42/MMBTU) in September 1981. At that time it was priced at the ex-depot level about 1/2 that of the import parity price - corrective action appears necessary. Currently LPG availability is very limited and this has restrained market penetration. For example, LPG prices were only 28% of premium gasoline prices on an equivalent energy basis. If this level of financial incentive is continued after LPG availability increases 1/ a

1/ Through increased LPG recovery from the refinery and extraction from natural gas.

significant amount of this fuel would be used to substitute for gasoline in spark-ignition engines, which after small modifications (costing about US$300) can burn LPG and gasoline as dual fuels. This would further exacerbate the gasoline/naphtha surplus in the country. LPG needs to be priced at its full opportunity cost, however even at that price level it would still be about 1/2 of gasoline retail prices on an equivalent energy basis. It should also be noted that premium gasoline prices are more than twice those of diesel oil at the ex-depot level, whereas the difference at the import parity level is a mere 3%. This massive differential could be retained provided that the stock of diesel fuelled private cars remains negligible. Such cars have a specific consumption efficiency that is about 35% higher than that of gasoline fuelled cars 1/ Given average annual mileages of not more than 10,000, only small differences in the economic values of premium gasoline and diesel oil, and differences in the capital costs of diesel and gasoline fuelled private cars of about US$800 net of taxes and duties, the economic benefit to the country of increased diesel-fuelled private cars is marginal relative to the massive financial return to a private motorist who buys a diesel car. Hence the import and use of diesel-fuelled private cars should be discouraged.

Financial Performance of BPC

5.32 The Bangladesh Petroleum Corporation (BPC) generally endeavors to price petroleum products in such a way that total financial costs of supply are recovered from sales. This is not always the case, however, because needed price adjustments are often delayed. For example, in FY 1979 BPC showed only a nominal profit rate of 1.9% on total sales, followed by net losses of 25.2% in FY 1980, which amounted to TK 1.34 billion. For the 1981 calendar year, the total projected loss was TK 1.03 billion (US$54 million). These most recent losses have been attributed to the following factors:

(1) Softening of world crude oil and product prices. BPC had a commitment to buy crude oil at relatively high prices and was forced to dispose of surplus products at depressed prices in the international market.

(2) BPC underpricing of middle distillates in the domestic market.

5.33 It should be noted that the financial performance of BPC is based on nominal accounting procedures. Furthermore, depreciation allowances and the insurance coverage for the refinery should be based on

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1/ For large horsepower engines the efficiency difference increases to 2:1.

a replacement cost basis, and interest applied should reflect actual opportunity costs in Bangladesh.

The ERL Operation

5.34 The ERL Refinery had an unprofitable operation in 1981, generating losses of about US$51 million in processing 1.3 million tons of crude oil. The unrecovered costs were about US$5.25 per barrel, reflecting a percentage cost recovery of about 86%. These losses would have been greater if the depreciation charges had been based on revalued assets.

The BPC Foreign Operation

5.35 The BPC foreign operations include the Singapore refining arrangement and petroleum products purchases from the spot market and from the USSR under barter arrangements. These foreign operations have been unprofitable and have generated losses of US$1.19 per barrel from the Singapore operation and US$10.43 per barrel from the spot purchases and barter arrangements.

The BPC Domestic Marketing Operation

5.36 The petroleum products are marketed domestically through three marketing companies: Jamuna, Meghna and Burmah. These marketing companies operate on a basis of cost recovery plus guaranteed profit. During 1981 they marketed 1.52 million tons of petroleum products at a total cost of US$1.16/bbl and a profit of US$0.13/bbl.

Observations and Recommendations

5.37 The mission commends the Government on the recent measures to increase petroleum prices. This has removed the economic subsidies on diesel oil and kerosene which existed up to June 1982. The mission however, recommends that the following addition measures be undertaken:

(i) LPG should be priced at its full opportunity value which implies an increase of about 70% over the September 1981 ex-depot price or about 200% at the ex-refinery level.

(ii) The establishment of an automatic trigger mechanism to pass along to consumers any additional increases in costs of imported crude oil and petroleum products, as well as changes in the costs of the refinery operations.

(iii) A revaluation of the refinery and other capital assets to ensure adequate accumulated depreciation (reserve) for future expansion, replacement investments, and insurance coverage and the application of market rather than subsidized rates of interest.

CHAPTER VI

ENERGY BALANCES, INVESTMENTS AND PROGRAMME PLANNING

Commercial Energy Supply/Demand Balances 1979/80 and 1984/85

6.01 Tables 6.1 and 6.2 show the 1979/80 and projected 1984/85 commercial energy supply/demand balances in detail. A more aggregated presentation was given in Table 1.1. The major features highlighted by these three balances are:

A. On the demand side:

(i) Though commercial energy demand growth is estimated to increase from 2.2 million toe in 1979/80 to some 3.37 million toe in 1984/85 implying a growth rate of about 8.8%/year this should be achieved with a very small increase in net oil imports from about 1.5 million TOE in 1979/80 to about 1.64 million TOE in 1984/85 - an average annual growth rate of some 1.7%.

(ii) The dominance of the industrial sector in commercial energy end-use demand would increase from 48% to 56% between 1979/80 and 1984/85, at which time it would account for about 1.9 million TOE. The only other sectoral demand share for commercial energy which will increase in this period is that of agriculture from 4% to 6% equivalent to 220,000 TOE in 1984/85. In contrast, the shares of both the transport and residential/commercial sectors in total commercial energy use will decline from 20% to 16% and 25% to 20% respectively. Though the share of the transport sector's demand for commercial energy will decline between 1979/80 and 1984/85, in absolute terms its demand will increase from 450,000 TOE to 539,000 TOE over this period. However, as a percentage of petroleum demand, transport's share will rise marginally from 33% in 1979/80 to 36% in 1984/85.

(iii) From the standpoint of specific fuels and energy sources the share of public electricity in meeting end-use commercial energy demand will marginally increase from 5.2% in 1979/80 to 7.2% by 1984/85. The most significant decline in specific fuel demand will be for fuel oil, the demand for which is expected to decrease from around 470,000 TOE in 1979/80 to about 370,000 TOE in 1984/85, a drop of about 21%. Fuel oil demand in 1984/85 could be reduced even further to almost 230,000 TOE if the fuel oil fired power units in Khulna are used only for stand-by and not as currently envisaged (See paras. 4.27-4.32).

Table 6.1

ENERGY SUPPLY/DEMAND BALANCE 1979/80

	Crude Oil (000's LT)	Petroleum Products (000's LT) LPG	Gaso-line	JP-1	Naptha	Kerosene	Diesel Oil	Fuel Oil	Total Petroleum Product	Natural Gas	Coal	Hydro	Electricity	Total Energy
	LT	LT	LT	LT	LT	LT	LT	LT (MMMCF)	000's TOE (LT 000s)	000's TOE (GWH)	000's TOE (GWH)	000's TOE	000's TOE	000's TOE
Primary Production	–	–	–	–	–	–	–	–	–	1033 (45)		50 (600)	–	1083
Imports	1,209	–	–	40	–	72	296	22	452	–	177 (266)	–	–	1838
Exports & Bunker	–	–	–	–	-70	–	-17	-64	-156	–	–	–	–	-156
Conversion and Losses	–	–	–	–	–	–	–	–	–	–	–	–	–	-561
Of Which:-														
Elec. Generation	–	–	–	–	–	–	-104	-96	-203	-365 (-15.9)	–	-50 (-600)	193 (2317)	-429
Refineries	-1,209	3	62	4	70	312	151	513	1154	–	–	–	–	- 55
Energy Sector Use & Losses	–	–	–	–	–	–	–	–	–	–	–	–	-77 (-932)	- 77
Total Final Demand/Supply		3	62	44	–	384	326	375	1247	668 (29.1)	177 (266)	–	115 (1385)	2207
Industry	–	–	–	–	–	–	8	269	274	330 (14.4)	137 (206)	–	73 (879)	814
Transportation	–	–	62	44	–	–	226	59	411	–	40 (60)	–	–	451
Agriculture	–	–	–	–	–	–	92	–	96	–	–	–	3 (35)	99
Commercial	–	1	–	–	–	–	–	–	1	23 (1)	–	–	16 (197)	40
Residential	–	2	–	–	–	384	–	–	419	62 (2.7)	–	–	19 (222)	500
Other Sectors	–	–	–	–	–	–	–	47	45	–			4 (52)	50
Non-energy uses	–	–	–	–	–	–	–	–	–	253 (11.0)	–	–	–	253

Table 6.2

ENERGY SUPPLY/DEMAND BALANCE 1984/85

	Crude Oil (000's LT)	Petroleum Products (000's LT) LPG	Gaso-line	JP-1	Naptha	Kerosene	Diesel Oil	Fuel Oil	Total Petroleum Product	Natural Gas	Coal	Hydro	Electricity	Total Energy TOE
	LT	LT	LT	LT	LT	LT	LT	LT	000's TOE	000's TOE (MMMCF)	000'S TOE (LT 000's)	000's TOE (GWH)	000's TOE (GWH)	000'S TOE
Primary Production	-	-	-	-	-	-	-	-	-	2205 (96.1)		67 (800)	-	2272
Imports	1,139	-	-	-	-	122	445	-	596	-	177 (266)	-	-	1912
Exports & Bunker	-	-	-	-	-	-	-29	-65	-94	-	-	-	-	-94
Conversion and Losses	-	-	-	-	-	-	-	-	-	-	-	-	-	-723
Of Which:-														
Elec. Generation	-	-	-	-	-	-	-49	-139	-188	-654 (-28.5)	-	-67 (-800)	328 (3936)	-581
Refineries	-1,139	13	80	50	-	275	187	437	1082	-	-	-	-	- 57
Energy Sector Use & Losses	-	-	-	-	-	-	-	-	-	-	-	-	-85 (-1023)	- 85
Total Final Demand/Supply		13	80	50	-	397	554	233	1395	1552 (67.6)	177 (266)	-	242 (2913)	3367
Industry	-	-	-	-	-	-	12	89	100	471 (20.5)	137 (206)	-	145 (1744)	853
Transportation	-	-	80	50	-	-	294	50	499	-	40 (60)	-	-	539
Agriculture	-	-	-	-	-	-	209	-	218	-	-	-	3 (41)	221
Commercial	-	3	-	-	-	-	-	-	3	44 (1.9)	-	-	43 (517)	90
Residential	-	10	-	-	-	397	-	-	442	115 (5)	-	-	39 (468)	596
Other Sectors	-	-	-	-	-	-	-	5	5	-	-	-	12 (142)	17
Non-energy uses	-	-	-	-	-	-	39	89	128	922 (40.2)	-	-	-	1050

B. <u>On the supply side:</u>

(i) By far, the most significant development during the period in question is the expected doubling in gas production from 1.04 million TOE in 1979/80 to 2.2 million toe by 1984/85, a growth rate of 16.3%/year. This implies that natural gas will supply the largest share of commercial energy, 54% in 1984/85, in contrast to 37% in 1979/80. Allied with this dramatic rise in the role of gas is the sharp decline in the share of oil in commercial energy supply. This will fall from being the major energy source in 1979/80 (54% of commercial energy supply, 1.5 million TOE) to 40% (1.64 million TOE) by 1984/85.

(ii) Within the power sector natural gas will increase its role in primary energy supply from 60% in 1979/80 to 72% (0.65 million TOE) in 1984/85, whilst that of diesel oil decreases from 110,000 TOE in 1979/80 to 52,000 TOE (6%) in 1984/85. Fuel oil, in constrast, will be about 15% to 17% (0.14 million TOE) in 1984/85. As mentioned above this use of fuel oil arises from the Khulna power units and this need should be re-examined (Para. 4.27-4.32).

(iii) What is particularly worth noting is that although commercial energy supply will increase by 7.9%/year from 2.8 to 4.1 million TOE between 1979/80 and 1984/85 the annual rate of increase of energy losses will only amount to 5.2%/year. Indeed total energy losses will rise from 560,000 TOE in 1979/80 (when they accounted for 20% of total supply) to only 720,000 TOE in 1984/85 at which time losses are estimated to be responsible for about 15% of commercial energy supply. This is primarily due to the expected improvement in power loss due to the BPDB loss reduction programme.

(iv) With net oil imports only expected to rise marginally to about 1.64 million TOE by 1984/85 the estimated cost of these imports is expected to be about US$520 million 1/ (US$1981) compared to US$460 million in 1980/81.

6.02 These broad trends highlight that the country's energy supply mix is moving in the right direction.

1/ Assuming constant oil prices in real terms from 1981 to 1985.

Energy Sector Investment Program

6.03 In 1980, the Government published its Draft Second Five-Year Plan (SEYP) FY81-85, which included an investment programme for the development of energy resources. The programme was designed to achieve the following objectives:

(a) ensure increased energy supply to facilitate rapid economic growth, especially in rural areas;

(b) reduce dependence of foreign energy sources by development of indigenous sources that are economically viable;

(c) improve the efficiency of energy use; and

(d) contribute to the improvement of the quality of life, especially in rural areas.

6.04 Implementation of these objectives requires a variety of investment undertakings in such areas as efficiency and conservation in commerical, industrial and household energy use, refinery operations, gas field development, power and gas transmission and distribution, and efficiency of both power and gas distribution and transmission to reduce system losses and waste. At the same time, these investments need to be quick-yeilding and must have high economic and financial payoffs in the short to medium term. As many of the needed investments will be indivisible and of a size exceeding Bangladesh's own capacity for self-financing, donor support will be crucial both in the form of direct financial assistance and of technical assistance aimed at providing the information and incentives for private foreign capital to be attracted into gas (and oil) exploration and development in Bangladesh. Where the size of individual projects exceeds the limits of individual donors' ability and/or willingness to finance, co-financing arrangements would be desirable in order to assure sufficient support and timely implementation of high-priority undertakings. Where co-financing is not required, it will nevertheless be of utmost importance that donors suitably cooperate not only with GOB, but also with each other in information sharing and in investment planning: this will help ensure cohesion within Bangladesh's overall energy sector development and prevent duplication of efforts and sub-optimal allocation and utilizaion of scarce financial, technical and managerial resources.

6.05 The most critical needs in the hydrocarbon sector include:

(a) increasing the economy's absorptive capacity for natural gas;

(b) appraising and developing the known gas reserves in a coherent, economically sound and rapid manner;

(c) continuing the search for gas and oil, particularly in the western zone;

(d) formulating and implementing rational and comprehensive pricing policies for the entire sector and strengthening the finances of the companies in this sector;

(e) streamlining and rationalizing the institutional and management structure of the sector;

(f) recovery of LPG and natural gas liquids from natural gas and the determination of the end-uses of LPG that maximize the economic benefits to the country;

(g) undertake modifications at the ERL refinery to match better the output mix of products to the demand, as well as to recover LPG from the refining process;

(h) to implement a programme to increase the level of efficient use of petroleum fuels as well as to take measures to reduce apparent gas system losses.

In the power sector, the most pressing problems to be addressed are:

(a) the serious deficiency of installed and available generating capacity;

(b) the inadequate maintenance of the existing generation and distribution system;

(c) the very high incidence and cost of system losses, outages and power theft;

(d) the inadequacy of present pricing policies and bill collection efforts and the need to improve the finances of BPDB and rural PBS's;

(e) the deficiency of demand projections and the resulting inappropriateness of investment decisions;

(f) the appropriateness of operating the two Khulna fuel-oil fired steam units after the east-west interconnector is commissioned.

6.06 The most important problems in the rural energy sector, which depends very heavily on non-commercial energy sources and on firewood, are relatively easy to identify but difficult to address. This difficulty, however, makes it essential that the information base required for decision-making be assembled as rapidly as possible and that development and investment decision be taken as soon as the improvement in the information base permits. The supply of traditional energy sources to rural households and cottage industries falls far short of demand, and this imbalance is increasing steadily. This worsening of the rural enegy situtation affects most severely the low-income groups who are neither self-sufficient in traditional fuels nor have the purchasing power to switch to costly commercial fuels. Development efforts must aim at improving the efficiency of traditional energy use, augmenting the supply of fuel from homestead and village woodlots, improving the output and marketing of fuels from public and commercially managed forests, and introducing economical renewable energy technology applications (e.g., biogas or solar energy).

6.07 Energy development, and oil and gas exploration and development in particular, has been designated a "core priority" in the Government's draft Second Five-Year Plan (SFYP), along with increased foodgrain production, primary education and family planning. These core priorities are to be reflected in the relative size of proposed investments during the Plan period (FY81-FY85) and to be protected as much as possible against shortfalls in available financial resources. The total allocation of financial resources to the energy sector proposed in the draft SFYP is US$ 2.05 billion, 1/ with a foreign exchange component of more than US$ 1 billion. 2/ This is equivalent to 15.3% of total public sector outlays planned for the SFYP period. Within the energy sector's allocation, power would account for 64%, hydrocarbons for 24%, forestry for 10%, and non-conventional energy (solar and wind), research, planning and training for 2%. Table 6.3 shows the distribution of proposed investments in the energy sector by major categories.

6.08 Of the roughly US$ 490 million in development outlays proposed for the oil and gas sector, 47% are earmarked for gas transmission and distribution and 16% for gas field development; compared with the proposed 25% share for survey and exploration activities, this reflects a reasonable ranking of relative priorities within the gas and oil sector.

6.09 The draft Plan provides for US$ 1.3 billion to be invested in the power sector. The dominant share is for the Bangladesh Power Development Board (BPDB), with about 73% of the subsectoral total, followed by the Rural Electrification Board (REB) with 22% and the Atomic Energy Commission (AEC) with about 5%. Planned outlays for power generation (excluding the proposed AEC investments in the Rooppur Nuclear Reactor) would account for 34% of the power sector total, transmission for 14%, and distribution (including the sizeable share for rural electrification) for 47%. Since the preparation of the draft plan however, the rural electrification investment programme has been reduced from Tk 4.38 billion to about Tk 3.0 billion.

6.10 The proposed forestry sector allocation of about US$ 210 million is dominated by afforestation and extraction programs for state forests

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1/ An exchange rate of Tk15 = US$1 was used in the preparation of the draft SFYP.

2/ No estimate of the foreign exchange component of planned investments in the forestry sector was provided in the draft SFYP.

(67%), while forest extension services and village forestry development (14%) and forestry research and training (12%) would receive far smaller financial allocations. Although the Plan proposes substantial increases in fuelwood extraction and distribution from state forests, present institutional and logistical constraints suggest that the actual effect of the proposed forestry development program will be primarily felt in increased lumber and bamboo supply for major industrial users located near the state forests rather than in improved fuel supply for the rural population.

The "Hard-Core" Energy Development Program

6.11 Since the publication of the draft SFYP in May 1980, it has become clear, however, that the financial resources (both domestic and foreign) available for development activities will be substantially lower than envisaged at the time the SFYP was drafted. Even the four declared "core priorities" will not escape scaling down their respective investment programs unless the present outlook for severe financial resource constraints can be altered. Accordingly, GOB is now revising the SFYP in line with lower resource availability estimates and on the basis of a renewed assessment of relative priorities both overall and within sectors. At the same time, the investment proposals incorporated into the Annual Development Program (ADP) for FY82 were revised downward, and the ADP planning process for FY83 has been based on these newly emerged considerations of planning in the face of resource constraints.

6.12 For the energy sector, GOB is preparing a "hard-core" development program for the SFYP period which will seek to complete as rapidly as possible those on-going projects which are already well advanced and concentrate additional resources on recognized high-priority undertakings with quick and high payoffs. This hard-core program is still under preparation, and cost estimates for the individual projects and programs being considered for inclusion are still being scrutinized and modified. Guided by the basic principles noted above, priority is to be accorded to projects for which foreign aid has already been secured, to projects with important linkages to others already completed or nearing completion, to projects with an immediate impact on reducing the energy import dependence, and to projects improving the energy supply to the western part of the country. Projects judged to be of lower priority are to be reduced in size or postponed. The mission concurs with these priorities.

6.13 Early indications about the on-going plan revision process suggest that the "hard-core" energy sector investment program will be based on the principles and comprise the elements outlined below:

(a) In power generation, two projects already well advanced (the Ashuganj and Ghorasal Thermal Power Station extensions) will be completed as quickly as possible, and two additional projects (a 100 MW gas turbine plant in the western zone, oil-fired, but convertible to gas, as well as the addition of two further 50 MW units of peak-load capacity at the Karnafuli Hydro-Power Station) will be undertaken. Although there are indications that the proposed 300 MW nuclear power plant at Rooppur, in Pabna district, may also be included in the "hard-core" program, this will depend primarily on the prospects for obtaining sufficient external financial and technical assistance. It is difficult to envisage this investment as an economic proposition compared to gas based power generation in the east zone followed by transmission to the west zone via the east-west interconnector. Indeed, the allocation in the draft SFYP (Table 6.3) for atomic energy (Tk 1 billion) is inordinately high when compared to that for hydrocarbon exploration (Tk 1.6 billion) and gas field development and transmission (Tk 1.2 billion). Accordingly, the mission considers that the level of investment in atomic energy in the draft SFYP should be reduced and accorded very low priority.

(b) In <u>power transmission</u>, GOB's immediate priorities for new project undertakings are likely to include the upgrading of substations in the existing national transmission grid, the construction of several new regional 132 kV transmission lines (e.g., Barisal-Patuakhali, Ishurdi-Saidpur, and Kaptai-Baraulia), and the construction of new transforming stations at Ishurdi and Tongi in the context of the East-West Electrical Interconnector system.

(c) Priorities in <u>urban power distribution</u> will be the further expansion and upgrading of the Greater Dacca and Greater Chittagong distribution systems, where most of the heavy system losses are incurred at present.

(d) <u>Rural electrification</u> in general is to continue to receive priority funding, given the pressing need to provide power to rural areas and the existing substantial aid commitments already secured. The scope and pace of further rural electrification program implementation, however, may have to be modified somewhat to correspond to actual resource availability and projected power supply increases.

(e) In <u>oil and gas exploration</u>, the resource constraint will not permit the implementation of Petrobangla's proposed 50-well drilling program 1/ and may in fact limit drilling to less than the 20 wells proposed in the draft SFYP. At the same time, GOB recognizes the importance of ensuring that

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1/ After publication of the draft SFYP, a more ambitious oil and gas exploration programme was proposed by Petrobangla, calling for the drilling of 50 exploration wells by 1985 instead of the 20 in the draft plan.

the exploration drilling program be continue without interruption, and donor support for this program will be crucial. Particular emphasis will have to be placed on seismic and other preliminary exploration activities in the western districts, with a view towards attracting private foreign risk capital into Bangladesh for subsequent drilling and development.

(f) Gas field development and gas utilization and distribution will be accorded higher relative priority than implied in the earlier Petrobangla proposals, given the urgency of obtaining greater immediate benefits from investments already made. Several donors (IDA and Japan at Bakhrabad, ADB at Titas and Chhatak, the Netherlands at Kailastila) are already financing field development drilling and recovery plants, and additional donor commitments are expected soon for further development at Titas. Nevertheless, Petrobangla will require substantial additional support to implement development plans at several other fields (e.g., Sitakund, Kamta, Rashidpur, Feni and Habiganj). Pipleline links from developed fields to the major gas consumption centers and between fields will need to be carefully evaluated in order to avoid unnecessary investments; this also requires very close coordination between GOB, Petrobangla and aid donors in the planning of gas field development and transmission pipeline construction.

(g) In gas utilization itself, the potential for recovery and utilization of natural gas liquids (NGL) and liquefied petroleum gas (both from oil refinery operations and from gas fields) is significant, but will require investments in recovery facilities, bottling plants and distribution systems as well as in the conversion of petroleum-fired equipment to LPG use. At the same time, plans for piping gas from the eastern to the western zone will need to be carefully reassessed and accorded lower priority in light of such considerations as the absence of a gas export contract with India, the limited size of the gas market in the West, and the possibility for meeting much of the future energy demand in the rural areas of the West through direct electricity distribution, through bottled LPG and/or by diverting petroleum products freed in the East to consumers in the West.

(h) In the petroleum processing sector, plans for refinery modifications to improve fuel efficiency, tailor the output mix more appropriately to the demand pattern in the economy, and recover more LPG from the refining process are under evaluation. The investment proposals emanating from these studies merit high priority for donor support.

(i) In forestry development, the priorities need to be balanced between energy and industrial raw material requirements. Present plans focus heavily on state forests afforestation and exploitation; this is not likely to lead to significant improvements in the supply of fuelwood to the majority of the rural population, but can be justified principally for its positive effect on the supply of raw materials to the construction, pulp, paper, newsprint and wood products industries. Improvements in firewood availability in rural areas will need to be pursued through well-planned community and homestead forest development programs, based on the experience gained with the on-going ADB-supported Community Forestry Project.

(j) Non-traditional energy development in Bangladesh still remains in the very initial stage of technology and design testing. Until technically feasible and economically sound schemes with real promise for application in an environment of extreme poverty and small farms and cottage industries have been identified and successfully tested in this environment, no large investment programs can be contemplated. Technical assistance for developing and testing appropriate technology for biomass wind, solar and hydro-power applications and for efficiency improvements in traditional energy use will be needed.

External Assistance to the Energy Sector

6.14 Bangladesh has been successful in securing finance for the development of the energy sector from several sources. A summary of the projects in the energy sector and their associated donors is given in a recently issued report 1/. However, the mission recommends that aid agencies pay more attention to priority areas (as spelled out in this report), to ensuring that there is no duplication of effort, and to producing an adequate mechanism for supervision of the technical assistance projects.

Energy Organization and Planning Issues

6.15 The responsibility for energy policies and programs in Bangladesh is dispersed over numerous agencies. Petrobangla is responsible for exploration, production and distribution of domestic oil and natural gas, and BPC is responsible for imports of crude oil, refining and marketing of petroleum products. Both of these companies are under the supervision of the Ministry of Energy and act as holding companies for smaller companies within each sector which function under

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1/ "Bangladesh: Donor Support for Energy Sector Development". Paper prepared for Paris meeting (April 1982) of Bangladesh Aid Group. IBRD Paper BAN-82-5.

their supervision and control. The Bangladesh Power Development Board is responsible for generation, transmission, and distribution of electric power, while rural electrification is the responsibility of the Rural Electrification Board.

6.16 At present, there is no institutional structure for coordinating the activities in the non-commercial fuels sector, and these activities appear to come under the responsibilities of a variety of government agencies, including the Ministries of Agriculture and of Local Government, Rural Development and Cooperatives.

6.17 Integrated energy policy making and planning processes have not yet been established. The draft SFYP document was prepared by merely collating the submissions of the various energy related agencies. The Government has taken positive steps towards central energy planning by establishing an Energy Planning Cell; however, more reorganization might be necessary and more effort would be required to enhance the Government's integrated energy planning capability.

6.18 The need for more integrated planning is evident, for example, in the enormous differences between petroleum product demand projections prepared by BPC and those prepared by the Planning Commission for the SFYP. BPC projected demand to increase at an average annual rate of 8.1% during the Plan period, whereas the corresponding figure reported in the draft Plan document itself is 1.7%. Demand projections are clearly crucial both for investment programming and balance of payments management.

6.19 Bangladesh needs a long-term energy plan with a horizon of 10-20 years within which five year energy plans could be better formulated. Towards this end a long-term energy plan is to be financed by the UNDP and ADB. The mission however feels that there is a need for a medium-term energy investment plan for the five year period 1984-1988 similar to the medium-term food grain production plan which was very useful to both the GOB and the donors. The first step towards formulating such a medium-term energy investment plan would be a stocktaking of ongoing and proposed studies and activities and identification of other investment possibilities as potential components of a medium-term plan. There may also be a need for study of institutional or policy issues to complement and support an investment program. The stocktaking exercise would pull together details of all ongoing and proposed activities (e.g., details of investments, terms of reference of studies, implementation schedules) and identify further studies which might be financed by IDA (technical assistance credit), UNDP or bilateral aid agencies. The ongoing and proposed studies need to be coordinated and their progress monitored; on their completion (possibly a year from now), it should be possible to put together fairly quickly a medium term energy investment plan. In the meantime the carrying out of a stocktaking exercise would in itself help to coordinate donor and government activities and begin to clarify, and focus attention on, priority investment areas and investment options.

ANNEX I.A

Projected Natural Gas Demand Forecasts for Fertilizers
(MMCF)

Plant	Gas System	80/81**	84/85	89/90
Fenchuganj	Sylhet	5,730	6,200	6,200
Ghorasal	Titas	12,000	12,000	12,000
Ashuganj	Titas	-	13,870	13,870
Chittagong	Bakhrabad	-	8,100	17,325
Chittagong- Barge-mounted**	Bakhrabad	-	-	17,000
Totals		17,730	40,170	66,395

* Under negotiation.

** Actual (preliminary).

Sources: Planning Commission, Petrobangla, World Bank Bakhrabad Appraisal Report.

BPDB

ELECTRICITY GENERATING CAPACITY (1980 - 1990)

Year Ending June 30	Installed Capacity Number and Rating of Units		Year of Commissioning	Fuel	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
					Available Capacity										
I. West Zone															
A. Existing (1980)	1x60	Steam	1973	Heavy Oil	40	60	60	60	60	60	60	60	60	60	60
Khpulna	1x12.75	Combustion Turbine	1976	Diesel Oil	-	10	10	10	10	10	10	10	10	10	10
	1x6.5	Combustion Turbine	1968	Diesel Oil	4	5	5	5	5	5	-	-	-	-	-
	4x4.15	Steam	1959-60	Diesel Oil	8	8	8	-	-	-	-	-	-	-	-
	1x10.5	Combustion Turbine	1980	Diesel Oil	10	10	10	10	10	10	10	10	10	10	10
	2x28	Combustion Turbine (Barge Mounted)	1980	Diesel Oil	56	56	56	56		Shifted to East Zone					
Sheramara	3x20	Combustion Turbine	1976-80	Diesel Oil	58	60	60	60	60	60	60	60	60	60	60
Saidpur	3x3.75	Diesel	1975-77	Heavy Oil/Diesel Oil	7	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
Thakurgaon	7x1.5	Diesel	1964	Heavy Oil	4	4	4	-	-	-	-	-	-	-	-
Other Small Diesel Units	13				13	13	-	-	-	-	-	-	-	-	-
Subtotal A	257				200	246.5	223.5	211.5	155.5	155.5	150.5	150.5	150.5	150.5	150.5
B. New	3x8.3	Diesel	1983	Fuel Oil				25	25	25	25	25	25	25	25
Barisal	1x2.5	Diesel					2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Khulna	1x110	Steam	1982	Fuel Oil				110	110	110	110	110	110	110	110
Not Yet Located	1x150	Steam	1989	Oil/Coal										150	150
Subtotal B	287.40				-	-	2.5	137.5	137.5	137.5	137.5	137.5	137.5	287.5	287.5
Total Available Capacity West Zone					200	246.5	226	293	293	288	288	288	438	328	438
II. East Zone															
A. Existing (1980)															
Kaptai	2x40	Hydro	1961-62		92	92	92	92	92	92	92	92	92	92	92
Ashugunj	2x64	Steam	1970-71	Natural Gas	100	100	120	120	120	120	120	120	120	120	120
Chorasal	2x55	Steam	1974-75	Natural Gas	110	110	110	110	110	110	110	110	110	110	110
Siddhirganj	3x10	Steam	1959-60	Natural Gas	24	24	24	24	24	24	24	24	24	24	24
	1x50	Steam	1971	Natural Gas	50	50	50	50	50	50	50	50	50	50	50
Shahjibazar	3x14.75	Combustion Turbine	1970-71	Natural Gas	50	50	50	50	50	50	50	50	50	50	50
	4x16	Combustion Turbine	1970-71												
Chittagong	2x6.5	Combustion Turbine	1968	Diesel Oil/Natural Gas		10	10	10	10	10	10	-	-	-	-
Subtotal A	519.25				426	236	476	476	476	476	476	396	396	396	396
B. New (Shifted from West zone)		Combustion Turbine	1980	Natural Gas	-	-	-	-	56	56	56	56	56	56	56
	2x28	Combustion Turbine	1980	Natural Gas	-	-	-	-	56	56	56	56	56	56	56
Kaptai	1x50	(Barge Mounted)	1982		-	-	-	-	50	50	50	50	50	50	50
	2x50	Hydro	1986-87		-	-	-	-	-	-	50	100	100	100	100
Chittagong	1x60	Steam	1983	Natural Gas	-	-	-	-	60	60	60	60	60	60	60
	1x150	Steam	1988	Natural Gas	-	-	-	-	-	-	-	-	150	150	150
Ashugunj Combined Cycle	2x30	Steam	1982-83	Natural Gas	-	-	60	90	90	90	90	90	90	90	90
	1x30	Combustion Turbine													
	2x150	Steam	1945-86	Natural Gas	-	-	-	-	-	150	300	300	300	300	300
	1x150	Steam	1990	Natural Gas	-	-	-	-	-	-	-	-	-	-	150
Chorasal	1x210	Steam	1985	Natural Gas	-	-	-	-	-	210	210	210	210	210	210
	1x210	Steam	1987	Natural Gas	-	-	-	-	-	-	-	210	210	210	210
Subtotal B	1,376				-	-	110	200	256	616	816	1,076	1,226	[illegible]	1,376
Total Available Capacity East Zone					426	436	586	676	732	1,092	1,292	1,472	1,622	1,622	1,772
Total Interconnected System:					-	-	-	1,025	1,025	1,385	1,580	1,760	1,910	2,060	[illegible]

ANNEX III.A

NATURAL GAS RESERVES AND CUMULATIVE PRODUCTION
(trillion C.F.)

Name of Field	No. of wells Drilled	Reserve Estimate	1979 Cumulative Production
Sylhet	6	0.29-0.43	0.078
Chhatak	1	0.04	0.017
Titas	4	2.25	0.167
Habiganj	2	1.28	0.038
Bakhrabad	2	2.78-3.70	under development
Rashidpur	1	1.06	-
Kailashtilla	1	0.6	-
Semutang	1	0.03	-
Kutubdia (offshore	1	1.0	-
Begumganj	2	1.0	-
Feni	1	1.0	-
Beanibazar	1	1.0	-
Totals	23	12.33-13.39	0.3

NATURAL GAS PIPELINES

Pipeline	Diameter Inches	Length Miles	Line Flow Capacity MMCFD	Existing Working Pressure psig
Titas-Dacca	14	60	175	1,000
Sylhet-Fenchuganj	8	33	25	650
Chhatak Cement Factory	4	12	9	650
Habiganj Shahjibazar Power Station	8	1.5	36	-
Nabiganj Ashuganj Fertilizer Factory (under construction)	12	35	120	-

SUMMARY OF ENERGY SAVING POTENTIAL IN THE INDUSTRIAL SECTOR
FOR THE FACILITIES SURVEYED

Housekeeping and Minor Retrofits (H); Fuel Oil Substitution with Gas (S);
Major Capital Investment (C)

Industry		Energy Saving Fuel Oil Savings tonnes/year	Natural Gas MMCF/year	Electricity MWH/year	Cost Saving US$ million per year (1)	Capital Cost US$ million	Pay-Back Period
I. Chittagong Steel Mills Ltd. *	(H)	4,600			1.0	0.16	2 months
	(S)	46,000			7.0	2.8	5 months
	(C)	28,000			5.8	64.0	11 years
II. Kernaphuli Paper Mills Ltd. *	(H)	5,900			1.13	0.61	6 months
	(S)	53,000			7.0	0.45	1 month
III. TSP Fertilizer Complex *	(H)			600	0.03	0.04	1 year
	(H)	75			0.02	0.01	6 months
	(S)	500			0.03	0.02	8 months
IV. Chittagong Brick & Clay Ltd.*	(H)	700			0.16	0.08	6 months
	(S)	1,700			0.10	0.07	9 months
V. Luxmi Narraynn Textile Industry + Decca	(H)		4.6		0.005	0.008	1.6 years
	(C)		18.0		0.019	0.085	4.5 years
VI. Meghma Textile Mills, + Decca	(H)		0.78		0.0009	0.003	3 years
VII. Cement Clinker, Sylhet +	(H)		11.0		0.015	0.035	2.3 years
VIII. Bangledash Insulator and Sanitary Ware, Decca +	(H)		0.37		0.003	0.01	3.8 years
IX. Newsprint Mills Ltd, Khulna	(H)	5,400			1.03	0.23	3 months
	(S)	49,000			7.4	0.3	1 month

(1) Fuel oil price taken as US$190/tonne and gas price according to the tariff for the facility in question.

* At these facilities fuel oil is being used but natural gas substitution will become possible on completion of the Bakhrebed - Chittagong gas pipeline in 1983.

+ At these facilities natural gas is presently used as the principle fuel.

IMPROVEMENTS IN REFINERY OPERATIONS

Spiking Refinery Feedstock

1. The ERL's production programme for the 1980/81 financial year anticipated the processing of 1.3 million tons of crude oil. The 1980/81 refining programme envisaged a surplus of naphtha and fuel oil amounting to about 100,000 tons of each product. However, running the refinery with about 1.1 million tons of whole crude spiked with about 100,000 tons of diesel oil would give no fuel oil surplus and reduce the nephtha surplus to about 73,000 tons. To estimate the potential savings, the planned production programme for ERL for 1980/81 is modified to yield a more desirable mixture of crude oils.

2. The actual 1980/81 crude oil mix was made up as follows:

Murban Crude	600,000	metric tons
Arabian Light	450,000	metric tons
Iranian Light	200,000	metric tons
Kuwait	125,000	metric tons
Total	1,375,000	

With the proposed spiking, the heavier Kuwait crude oil can be dropped and the expansive Murban crude oil reduced by 150,000 metric tons. This would result in the following crude oil composition and composit costs:

			(Million)
Murban	450,000 MT	@ US$279	= US$125.55
Arabian Light	450,000 MT	@ US$235	= US$105.75
Iranian Light	200,000 MT	@ US$261	= US$ 52.20
Total	1,100,000 MT		= US$283.50
Freight @ US$17.95/MT			= US$ 19.74
Cost c.i.f. Chittagong			= US$303.24

To estimate the potential savings from spiking crude, this next table compares the next cost of matching the same distillate products and fuel oil with the estimated net cost under the 1980/81 production program.

		Refinery Without Spiking US$ million	Refinery With Spiking US$ million
(a)	Exports		
	Naphtha @ US$275/MT	27.50 (100,000 MT)	21.20 (77,125 MT)
	Fuel Oil @ US$190/MT	18.81 (99,000 MT)	-
		46.31	21.20
(b)	Crude + Freight	361.10 (1,300,000 MT)	298.1 (1,073,000 MT)
	90,000 metric tons of Diesel Oil (Spikes) at $345/MT	-	31.05
	Processing Cost	4.90	4.90
		366.00	334.04
	Net Costs (a-b)	319.69	312.84
	Savings by Spiking		US$6.85 million

The estimated savings by spiking would be at US$7 million. If current fuel oil prices (about US$160-150/ton) are reflected in the export price, the savings will increase to US$10 million.

SERVICE COSTS TO DOMESTIC AND COMMERCIAL USERS ON THE TITAS GAS SYSTEM

1. Domestic and commercial customers accounted for 99.6% of all connections of the Titas System in 1979/80 but for only 11.2% of gas sales and 18.9% of total revenues (see Table VI.1). However, a major part of total operating expenses of the company must be attributed to these two customer groups. The following analysis breaks down the capital and operating costs according to customer groups and compares these costs with the corresponding revenue flows. These breakdowns are approximate only, because of the joint-cost characteristics of natural gas transmission and distribution systems. A basic assumption of analysis is that all transmission costs are attributable to large industrial, fertilizer and power uses. This favors the commercial/domestic sector by lowering their apparent costs.

Table VI.1

TITAS GAS COMPANY
Number of Customers by Group, Sales in MMCF, Revenue in $Tx10^6$
and Simple and Cumulative Percentage Shares
1979/80

Group	No.	% Simple	% CUM.	Consumption MMCF	% Simple	% CUM.	SALES $TKx10^6$	% Simple	% CUM.
Power	3	0.003	0.003	11,018	35.1	35.1	70.274	25.9	25.9
Fertilizer	1	0.001	0.004	11,975	73.2	73.2	75.860	28.0	53.9
Industry	451	0.4	0.4	4,923	88.9	88.9	73.913	27.2	81.1
Commercial	2,508	2.2	2.6	1,021	92.2	92.2	17.082	6.3	87.4
Domestic	112,285	97.4	100.0	2,472	100.0	100.0	34.140	12.6	100.0
Total	115,248	100.0	100.0	31,409	100.0	100.0	271.269	100.0	100.0

2. The operating expenses of Titas Gas Company were compared to those estimated for the Bakhrabad project, which amount to TK0.53/MCF, (US¢3.6), while those for Titas amount to TK2.3/MCF (US¢15.7). The difference of TK1.79/MCF (US¢12.1), or 77.2% of Titas' total operating costs, of 72.97 million TK in 1979/80, was assumed to be caused by its

commercial and domestic connections. Separate cost accounting would be appropriate if specific feeder lines would serve nothing but concentrated commercial loads while others would serve domestic ones only. Most often, however, commercial and domestic connections are intermingled, so that separate cost accounting for these two customer groups would be difficult. Results of this preliminary analysis have been summarized in Tables VI.2 and VI.3 below.

Table VI.2

Assumptions Underlying Determination of the Joint Cost of Supplying Domestic and Commercial Customers on the Titas System

1. 1979/80 Titas Gas Company total operating costs = TK72.97 million 1/

2. Operating costs related to commercial/domestic customers = 77.2% of TK72.97 million = TK56.33 million.

3. Total gas sales to these customers = 3,493 MMCF.

4. Unit operating costs of these customers = TK16.13.

5. Number of such customers = 102,116

6. Average connecting costs per customer = TK823 1/

7. Unit connecting cost for commercial/domestic users = TK24.06

1/ Data from Titas Gas Company.

Table VI.3

Revenues and Average Cost of Service to Domestic and Commercial Customers Jointly (Titas System) 1979/80
(per MCF)

Cost Category	Joint Commercial and Domestic Consumers TK	US¢*
Cost of gas	4.65	31.5
Cost of Meters	1.05	7.1
Connecting Costs	24.06	163.1
Operating Costs	16.13	109.4
Total Costs	45.89	311.1
Average Revenue	14.60	99.4
Loss	(31.23)	(211.7)

* Exchange rate during 1979/80 TK14.75 = US$1.00.

TABLE VI.A

Economic Supply Cost Plus Depletion Allowance for Natural Gas for Representative Replacement Fuels Five Year Intervals in 1981 Prices Interest Rate 6%

	Total Costs Per MCF									
Replacement Fuels/Year	1981		1985		1990		1995		2000	
	Taka	US$	Taka	US$	Taka	US$	Taka	US$	Taka	US$
Fuel Oil at $194/ton	23.77	1.25	28.66	1.51	36.61	1.93	47.25	2.49	61.49	3.24
Coal at $71/ton	16.55	0.87	19.54	1.03	24.41	1.28	30.92	1.63	39.64	2.09
Natural Gas at $1.50/MCF	9.52	0.50	10.67	0.56	12.53	0.66	15.03	0.79	18.37	0.97

ANNEX VII

POWER TARIFFS, REB SYSTEM
PBS I (1981)

Consumer Class	Demand Charge TK/KW/Month	Minimum KWH/Month	Minimum Charge TK	Energy Charges TK/KWH
Domestic, Schools, Public Buildings, Motors up to 5 HP, Lighting Temporary Service	-	15	15/month	0.75TK/KWH in excess of minimum.
Commercial, Industrial and other users, single or three-phase service	Up to 25 KW - no charge Above 25 KW - TK30	-		0-2500 KWH/month charge of TK0.90/KWH. Above 2500 KWH/month charge of TK0.60/KWH.
Irrigation Pumps Single or three phase			Single phase: TK 1000/year Three Phase: TK 3000/year	0.70TK/KWH

Source: REB

BANGLADESH ENERGY ASSESSMENT

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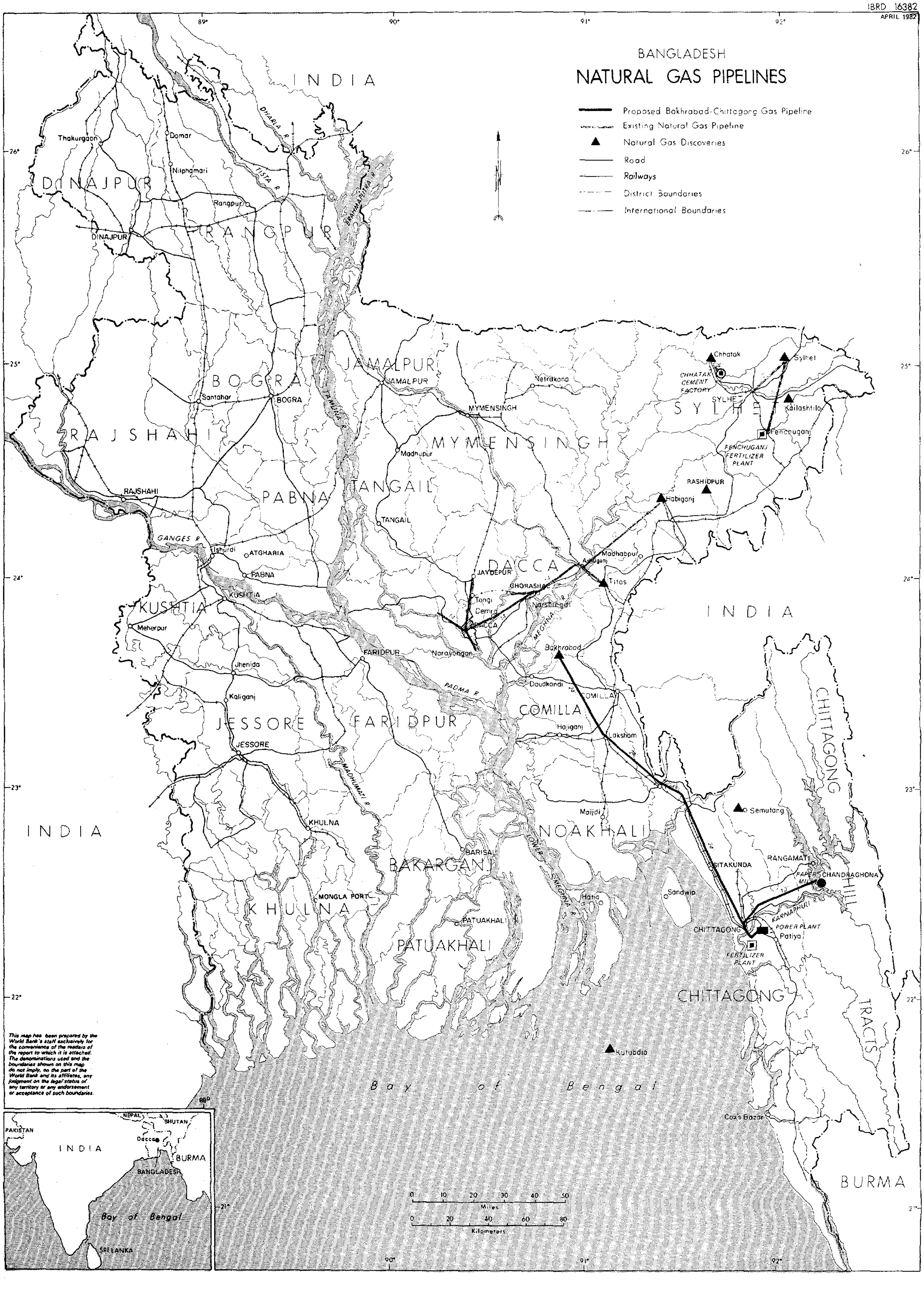

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Proposed Bakhrabad-Chittagong Gas Pipeline
Existing Natural Gas Pipeline
Natural Gas Discoveries
Road
Railways
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International Boundaries
INDIA
DINAJPUR
RANGPUR
BOGRA
RAJSHAHI
JAMALPUR
MYMENSINGH
SYLHET
PABNA
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JESSORE
FARIDPUR
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Titas
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CHITTAGONG
FERTILIZER PLANT
POWER PLANT
Patiya
PAPER MILL
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RANGAMATI
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Domar
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Rangpur
DINAJPUR
GANGES R.
PADMA R.
JAMUNA R.
BRAHMAPUTRA R.
TISTA R.
DHARLA R.
MEGHNA R.
LOWER MEGHNA
MADHUMATI R.
KARNAPHULI R.
Miles
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Kilometers
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PAKISTAN
NEPAL
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Dacca
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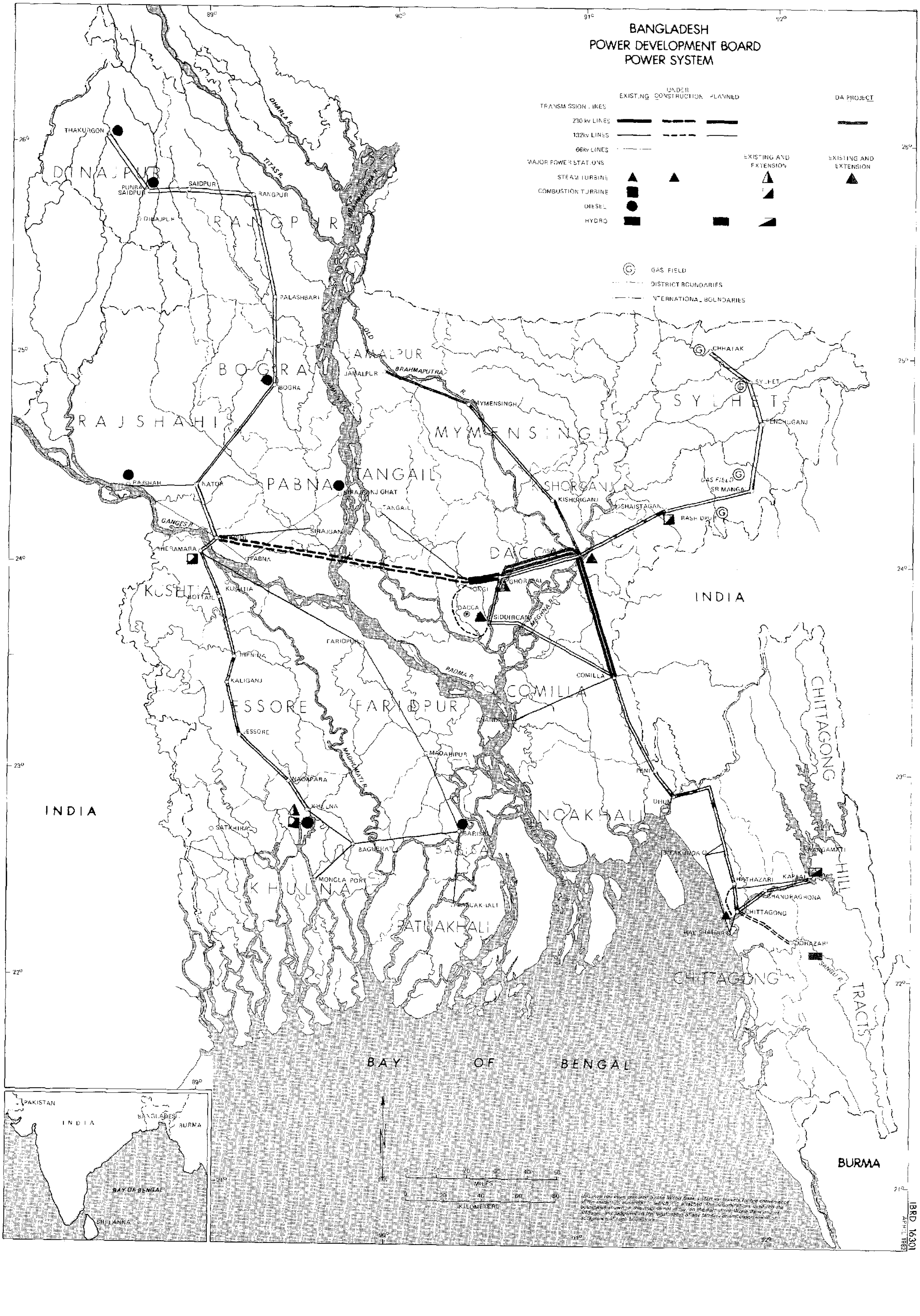

BANGLADESH
POWER DEVELOPMENT BOARD
POWER SYSTEM
EXISTING
UNDER CONSTRUCTION
PLANNED
IDA PROJECT
GAS FIELD
DISTRICT BOUNDARIES
INTERNATIONAL BOUNDARIES
INDIA
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BAY OF BENGAL
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