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Natural Gas Options for Bangladesh

বাংলাদেশের প্রাকৃতিক গ্যাসের সম্ভাব্য ব্যবহার

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About the Centre

Created in 1999, the Centre for Policy Research is a nonprofit research and educational institution, linked to IUBAT – International University of Business Agriculture and Technology.

Its goals are to identify current and emerging economic and social issues facing Bangladesh; to analyse options for public and private sector responses; to recommend, where appropriate, particular policy options; and to communicate the conclusions of its research in an accessible and nonpartisan form, in both English and Bengali.

Simon Fraser University in Burnaby (Vancouver), Canada, has entered into a memorandum of understanding with IUBAT. By this agreement, SFU will encourage participation by its faculty and students in projects of the centre.

While the centre takes care to assure the quality of published research, the conclusions of individual studies lie with the authors. Conclusions do not necessarily represent the opinion of IUBAT, SFU or the members of the centre's management committee.

About the Authors

Mark Jaccard is currently Director of the Energy Research Group at Simon Fraser University. He has worked on energy regulation and conservation policies within Canada and internationally. He has also served as Chairman of the British Columbia Utilities Commission, which is responsible for regulating the gas and electric utilities of this Canadian province.

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John Richards is a professor of public policy at Simon Fraser University. He is also a fellow-in-residence at the C.D. Howe Institute, a major Canadian policy institute. Professor Richards has a longstanding relationship with IUBAT as a visiting faculty member.

About the Cover

The front cover shows detail from a traditional Nakshi Kantha design.

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Table of Contents

Foreword

IUBAT IS THE FIRST NON-GOVERNMENT UNIVERSITY IN BANGLADESH. Over its first decade, IUBAT has grown in stature and has become a valuable source of intellectual activity in our country. Launching the Centre for Policy Research is another step forward. I hope that, in the years to come, the centre will serve both IUBAT and our country as a forum for serious, nonpartisan research into the economic and social issues facing Bangladesh.

I want to thank Mr. Muhammad Sirajuddin, Mr. Abdur Raquib and Dr. F.R. Al-Siddique for agreeing to join me as members of the centre's management committee. I also thank professor John Richards from Simon Fraser University, in Vancouver, Canada, who serves as advisor to the centre. Simon Fraser University has entered into a memorandum of understanding with IUBAT whereby this Canadian university will encourage its faculty and students to contribute to the work of the centre.

Deciding about development of our natural gas endowment – and, more generally, deciding how to manage the country's energy sector – is of utmost importance. Accordingly, the management committee of the Centre for Policy Research decided that the first publication should deal with this matter. The centre chose as authors three respected individuals who have experience, both in Bangladesh and abroad, with resource policy.

I have considerable pleasure in recommending to readers this thoughtful assessment of options for the Bangladesh natural gas sector. In addition to considering natural gas policy, the authors also address the problem of designing a modern regulatory framework that can respond to the needs of both the public sector and of private firms operating in the energy sector.

Dr. M. Alimullah Miyan
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Executive Summary

Bangladesh is not well endowed with most sources of energy. It has negligible resources of coal and oil, little hydropower potential, and nuclear power is beyond its financial capacity. Of traditional energy, it has a few forest areas for wood production. Its dominant agricultural sector does produce substantial biomass waste, but this is already largely dedicated to heating and drying applications in agriculture. The very low state of energy development is indicated perhaps most clearly by comparing per capita electricity consumption with other countries. Bangladesh consumes about 100 kwh per capita per year, which is not only much lower than the level in developed countries (at 10,000 to 15,000 kwh per capita) but also lower than in developing countries such as China (about 1,000 kwh per capita in 2000). Indeed, only about 15 per cent of the Bangladeshi population has access to electricity. Of those who do, mainly in the cities, electricity service is frequently interrupted (so-called "load shedding") during a typical day.

Clearly, Bangladesh must increase its use of commercial energy if energy is not to constrain economic development. The challenge is how best to do this. Fortunately, there is one bright prospect. In recent years, substantial natural gas has been found in the eastern half of Bangladesh. Present reserves are enough for 17 years of domestic consumption, even if it grows at the high rate of 10 per cent per year. Admittedly, future growth rates may be higher. According to Petrobangla, use of natural gas grew by 13.4% between 1996/97 and 1997/98.

Gas discoveries have been largely the result of an influx of foreign exploration capital from international oil companies. More gas is likely to be found if the exploration continues, but estimates of the ultimate extent of the resource vary considerably. The dilemma for Bangladesh is to decide how best to use its natural gas resource endowment as a contributor to economic and social development.

In this paper we present three contrasting views on how Bangladesh might use its natural gas endowment.

1. BANGLADESH MIGHT FOCUS ON exporting the natural gas. This would provide public revenues that could be directed to its many development needs (education, public health, communications, etc.). It would also provide early enough returns for international oil companies to ensure their continued exploration activity, which also has economic spin-offs. The negative side of this strategy is the concern that export revenues will never be sufficient to compensate Bangladesh for the forgone benefits from domestic use of the resource. There is also a concern that the resource is quite limited, that significant new discoveries will not occur. Finally, there is a concern that export earnings will be lost to the oil companies or corrupt officials.

2. BANGLADESH MIGHT FOCUS ON direct consumption of the natural gas for the many possible end-uses of domestic industry, agriculture and households. This would involve natural gas-fired electricity generation, but also end-use applications like fertilizer and chemical production by industry, cooking applications by households and intense use of compressed natural gas in all types of transportation vehicles. This strategy would focus on all the potential benefits of intense domestic exploitation of this indigenous resource. There is a concern, however, that concentrating on domestic uses of natural gas may result in inefficient developments that ultimately hamper economic development.

3. BANGLADESH MIGHT CONCENTRATE natural gas use primarily on electrification of the country. Thus, natural gas end-uses would be downplayed and extensions of the gas grid would only occur where they served the needs of optimal electricity generation. This strategy is based on the assessment that Bangladesh needs to prioritize the many demands on scarce investment resources. While the widespread domestic use of natural gas is desirable when viewed in isolation, the best use for the country's scarce energy investment resources may be to serve the needs of electrification.

For Bangladesh to manage effectively its natural gas sector, we suggest that some key institutional and market reforms need to occur. In general, these reforms involve increasing the role of private capital in determining investments, allowing most energy prices to result from supply and demand in competitive markets free from political interference; providing independent regulation of the common carrier segments of the industry; and establishing comprehensive processes by which government sets objectives, determines priorities, and carries out coordinating and regulatory functions for the entire energy sector. The Bangladesh government is already pursuing these reforms, but they need to be in place quickly.

These institutional and market reforms will help Bangladesh to decide if it favours one or a combination of the three strategies outlined above, or perhaps some other strategy. Our preliminary review leads us to make the following, qualified, recommendation: a focus on electrification will enable the natural gas endowment to make the greatest contribution to the country's eco-

nomic development. Our reasoning is simply that increased access by end-users to reliable electricity is more important than increased access by end-users to gas. The unmet demand for electricity is so acute that almost all available gas might – in the short and medium term – be devoted to electrical production, and that the country's scarce energy investment funds would be best used if concentrated in the electricity sector. Moreover, we believe that this strategy can be most effective by directing public subsidy to investment in the electric grid. This implies allocating virtually no subsidy to end-uses of natural gas, the commodity price of natural gas, the natural gas grid, or the commodity price of electricity. At the same time, we propose a five year moratorium on gas exports, thereby allowing time for the development of a surplus test for exports and a greater understanding of the resource potential.

FOLLOWING IS A LIST OF OUR RECOMmendations, organized in two sections. The first deal with government and market institutional reforms. The second expand on our – admittedly tentative – conclusion to use the natural gas endowment to accelerate electrification of the country.

Section 1

Continue and accelerate institutional reforms to foster private investment and to improve the transparency, efficiency and consistency of government corporations, ministries and agencies.

Recommendation 1

Continue to use competitive bidding for Production Sharing Contracts as the means of attracting IOCs to natural gas exploration and development.

Recommendation 2

Set a five year moratorium on natural gas exports and use this time to develop a surplus test mechanism and domestic priorities for use of gas.

Recommendation 3

Corporatize and vertically de-integrate state-owned natural gas and electricity providers.

Recommendation 4

Make the natural gas and electricity delivery networks into common carriers with predictable, independently set tariffs, allowing natural gas producers and independent power producers to negotiate directly with customers.

Recommendation 5

Create an arms-length regulatory agency responsible for both natural gas and electricity.

Recommendation 6

Conduct integrated resource planning for the energy sector, including environmental and social objectives.

Section 2

Coordinate policies on commodity pricing, private investment, institutional design and infrastructure expansion so that the natural gas endowment directly contributes to the accelerated electrification of Bangladesh.

Recommendation 7

Do not provide capital subsidies to investments for special end-uses of natural gas like fertilizer plants, domestic cooking, CNG vehicles, etc.

Recommendation 8

Do not subsidize natural gas transmission and distribution extension.

Recommendation 9

Eliminate commodity subsidies for natural gas, electricity and all forms of energy except perhaps renewables.

Recommendation 10

Direct virtually all public energy sector investments and subsidies to expansion of electricity transmission and distribution.

Recommendation 11

Encourage direct sales by IPPs to any potential customer – including industrial firms, municipal utilities, PBSs and perhaps even households.

Recommendation 12

Continue to support the role of PBSs in rural electrification.

মূল বক্তব্য

বাংলাদেশ অধিকাংশ শক্তি উৎসসমূহ দ্বারা সমৃদ্ধ নয়। এখানে তেল ও কয়লার উৎস নগন্য, জল বিদ্যুতের সম্ভাবনা খুবই কম, আর পারমানবিক শক্তি উৎপাদন এ দেশের আর্থিক সঙ্গতির বাইরে। প্রচলিত শক্তি উৎস হিসাবে কাঠ উৎপাদনের জন্য বনভূমিও যৎসামান্য। এ দেশের প্রধান উৎপাদন ক্ষেত্র কৃষি খাতে প্রচুর পরিমাণ কৃষিবর্জ্য উৎপন্ন হয় সত্য কিন্তু এর অধিকাংশই কৃষি কাজে তাপসৃষ্টি ও কৃষিপণ্য শুকানোর কাজে ব্যবহৃত হয়। শক্তি উৎপাদন ক্ষেত্রে এ দেশের পশ্চাৎপদতা উপলব্ধি করার জন্য আমরা এ দেশের মাথাপিছু বিদ্যুৎ ব্যবহার এর সঙ্গে অন্য উন্নত বা উন্নয়নশীল দেশের মাথাপিছু বিদ্যুৎ ব্যবহারের পরিমাণ তুলনা করতে পারি। বাংলাদেশে মাথাপিছু বাৎসরিক বিদ্যুৎ ব্যবহারের পরিমাণ ১০০ কিঃ ওঃ ঘঃ যা

কেবল উন্নত দেশের তুলনায় (১০,০০০ - ১৫,০০০ কিঃ ওঃ ঘঃ) কম নয়, এমন কি উন্নয়নশীল দেশ চীনের (১০০০ কিঃ ওঃ ঘঃ ২০০০ সালে) তুলনায় যৎসামান্য। প্রকৃতপক্ষে বাংলাদেশে মাত্র ১৫% লোক বিদ্যুৎ সুবিধা ভোগ করে। যারা বিদ্যুৎ সুবিধা পাচ্ছেন তাদের অধিকাংশই শহরে বাস করছেন এবং সেখানে বিদ্যুৎ সরবরাহ প্রায় প্রতিদিনই লোড শেডিং এর নামে ঘন ঘন বিঘ্নিত হয়।

বাংলাদেশের অর্থনৈতিক উন্নয়নের অন্তরায় অপসারণের জন্য বাংলাদেশকে অবশ্যই বাণিজ্যিক শক্তির ব্যবহার বৃদ্ধি করতে হবে। প্রশ্ন হল কোন উপায়ে দক্ষতার সঙ্গে এটা করা যায়। সৌভাগ্যক্রমে এ ব্যাপারে একটি উজ্জ্বল সম্ভাবনা আছে। সম্প্রতিকালে বাংলাদেশের পূর্বাঞ্চলে প্রচুর পরিমাণে প্রাকৃতিক গ্যাস পাওয়া গিয়েছে। যদি দেশীয় ব্যবহারে বার্ষিক শতকরা ১০ ভাগ উচচ হারে বৃদ্ধি পায় তাহলেও এই গ্যাস আগামি ১৭ বৎসরের জন্য যথেষ্ট হবে। ধরা যায় যে এই গ্যাস ব্যবহারের বার্ষিক বৃদ্ধির হার আরও বেশী হবে। পেট্রোবাংলার হিসাব মতে ১৯৯৬-৯৭ হতে ১৯৯৭-৯৮ সালের মধ্যে প্রাকৃতিক গ্যাসের ব্যবহার ১৩.৪ শতাংশ বৃদ্ধি পেয়েছে।

আন্তর্জাতিক তেল কোম্পানীগুলির বিদেশে তেল অনুসন্ধানের জন্য মূলধন বিনিয়োগের তৎপরতা প্রাকৃতিক গ্যাস ক্ষেত্রগুলি আবিস্কারে সহায়তা করেছে। এই ধরণের অনুসন্ধান চলতে থাকলে আরও গ্যাস ক্ষেত্র আবিস্কৃত হবার সম্ভাবনা রয়েছে। তবে গ্যাস সম্পদ মজুদের চূড়ান্ত পরিমাণ নিয়ে মতভেদ রয়েছে। বাংলাদেশকে এখন

সিদ্ধান্ত নিতে হবে দেশের অর্থনৈতিক ও সামাজিক উন্নয়নের জন্য প্রাকৃতিক গ্যাস সম্পদের কোন ধরণের ব্যবহার সর্বোৎকৃষ্ট বলে বিবেচিত হতে পারে।

আমরা এই প্রতিবেদনে বাংলাদেশ কিভাবে প্রাকৃতিক গ্যাস সম্পদ ব্যবহার করতে পারে তার উপর তিনটি সম্ভাবনা নিয়ে পর্যালোচনা করেছি।

১। বাংলাদেশ প্রাকৃতিক গ্যাস বিদেশে রপ্তানী করতে পারে। এতে সরকারী রাজস্বখাতে অর্থাগমন হবে যা বিভিন্ন ধরণের উন্নয়নমূলক কাজে (যেমন শিক্ষা, জনস্বাস্থ্য, যোগাযোগ ব্যবস্থা) ব্যবহৃত হতে পারে। এতে আন্তর্জাতিক তেল কোম্পানীগুলির বিনিয়োগকৃত অর্থ দ্রুত ফেরত পাওয়া সম্ভব হবে যা ঐ সব তেল কোম্পানীর অনুসন্ধান কাজ অব্যাহত রাখা নিশ্চিত করবে এবং এর সঙ্গে অন্যান্য অর্থনৈতিক সুযোগ সৃষ্টি হবে।
এর নেতিবাচক দিক হল যে এই সম্পদের আভ্যন্তরীণ ব্যবহারের মাধ্যমে বাংলাদেশ যে উন্নতি লাভ করতে পারত, গ্যাস রপ্তানীকৃত অর্থ তা অর্জন করার জন্য যথেষ্ট হবে না, তাছাড়া উদ্বেগের যথেষ্ট কারণ রয়েছে যে পরিমাণের দিক থেকে গ্যাস সম্পদের সীমাবদ্ধতা থাকতে পারে বা নতুন গ্যাস ক্ষেত্র নাও পাওয়া যেতে পারে। পরিশেষে রপ্তানী আয় তেল কোম্পানীগুলি এবং অসৎ আমলাদের হাতে চলে যাওয়ার ভয়ও আছে।

২। অপর সম্ভাবনা হল বাংলাদেশের গৃহস্থালী, কৃষি, দেশীয় শিল্প ইত্যাদি বিভিন্ন ক্ষেত্রের প্রান্তিক ব্যবহারে এই প্রাকৃতিক গ্যাস সরাসরি ব্যবহার করা যেতে পারে। এতে প্রাকৃতিক গ্যাস জ্বালিয়ে বিদ্যুৎ উৎপাদন হতে পারে, আবার সার উৎপাদন, রাসায়নিক শিল্পে, গৃহস্থালী রান্নায় প্রাকৃতিক গ্যাস বা যোগাযোগ ব্যবস্থা সম্প্রসারণে গাড়ীর জ্বালানি হিসাবে ঘনিভূত প্রাকৃতিক গ্যাসের ব্যবহার হতে পারে। মোটকথা দেশীয় এই সম্পদকে দেশের সম্ভাব্য সব ধরণের কাজে ব্যবহার করার উপর গুরুত্ব দেয়া হবে। তবে ভাবনার বিষয় হল যে প্রাকৃতিক গ্যাসকে কেবলমাত্র আভ্যন্তরীণ ব্যবহারের মধ্যে সীমাবদ্ধ রাখার ফলে দেশের উন্নয়ন কর্মকান্ড অকার্যকর হয়ে পড়তে পারে যা শেষ পর্যন্ত দেশের অর্থনৈতিক উন্নয়নে প্রতিবন্ধকতা সৃষ্টি করতে পারে।

৩। বাংলাদেশ তার প্রাকৃতিক গ্যাস সম্পদকে প্রধানত বিদ্যুতায়নের জন্য ব্যবহার করতে পারে। এতে গ্যাসের প্রান্তিক ব্যবহার হ্রাস পাবে এবং যেখানে বিদ্যুৎ উৎপাদনের অনুকূল চাহিদা রয়েছে কেবল সেখানে গ্যাস গ্রীড সম্প্রসারণ করা হবে। বাংলাদেশের বহুবিধ চাহিদার প্রেক্ষিতে দেশের দুষ্প্রাপ্য বিনিয়োগযোগ্য সম্পদের ব্যবহারে অগ্রাধিকার নির্ধারণ করার প্রয়োজনীয়তার উপর ভিত্তি করে এই কর্মপন্থার প্রস্তাব করা হল। বিচ্ছিন্নভাবে বিবেচনা করলে দেশীয় প্রয়োজনে প্রাকৃতিক গ্যাসের ব্যাপক ব্যবহার বাঞ্জনীয় কিন্দ সামগ্রিক বিবেচনায় দেশের দুর্লভ এই শক্তি উৎসকে বিদ্যুতায়নের প্রয়োজনে বিনিয়োগ করাই শ্রেয়।

বাংলাদেশের প্রাকৃতিক গ্যাস খাতের দক্ষ পরিচালনার জন্য কিছু মৌলিক প্রাতিষ্ঠানিক ও বাজার সংস্কারের প্রয়োজন রয়েছে। সাধারণভাবে এর মধ্যে রয়েছে অধিকতর হারে বেসরকারী মূলধন বিনিয়োগ, বেসরকারী খাতের প্রাধান্য বৃদ্ধি যাতে রাজনৈতিক প্রভাব মুক্ত হয়ে প্রতিযোগিতামূলক বাজারে সরবরাহ ও চাহিদার ভিত্তিতে অধিকাংশ শক্তিপণ্যের মূল্য নির্ধারণ, এই শিল্পের সাধারণ পরিবহণ অংশের (common carrier segments) স্বতন্ত্র নীতিমালার ব্যবস্থা এবং এমন একটি সমন্বিত প্রক্রিয়া গ্রহণ করা যাদ্বারা সরকার সমগ্র শক্তি খাতের নিয়ন্ত্রণ, সমন্বয়, অগ্রাধিকার নির্ধারণ এবং উহার উদ্দেশ্য নির্ধারণে সমন্বিত কার্যক্রম গ্রহণ করতে পারে। বাংলাদেশ সরকার ইতিমধ্যেই এই সমস্ত সংস্কার কাজে হাত দিয়েছেন কিন্ত দ্রুততার সঙ্গে এই সব সংস্কার সম্পন্ন করা প্রয়োজন।

বাংলাদেশ উপরে উল্লেখিত কোন একটি বা সবকটি পদ্ধতি অথবা সম্ভবত অন্যকোন পদ্ধতি অনুসরণ করবে সে সম্পর্কে সিদ্ধান্ত নিতে এ সব প্রাতিষ্ঠানিক ও বিপনন সংস্কার সাহায্য করবে। প্রাথমিক পর্যালোচনা থেকে আমাদের সতর্ক সুপারিশ হল দেশের বিদ্যুতায়নে এই প্রাকৃতিক গ্যাস সম্পদের ব্যবহার দেশের অর্থনৈতিক উন্নয়নে সর্বাপেক্ষা ব্যাপক

অব্যাহত রাখা নিশ্চিত করবে এবং এর সঙ্গে অন্যান্য অর্থনৈতিক সুযোগ সৃষ্টি হবে।

এর নেতিবাচক দিক হল যে এই সম্পদের আভ্যন্তরীণ ব্যবহারের মাধ্যমে বাংলাদেশ যে উন্নতি লাভ করতে পারত, গ্যাস রপ্তানীকৃত অর্থ তা অর্জন করার জন্য যথেষ্ট হবে না, তাছাড়া উদ্বেগের যথেষ্ট কারণ রয়েছে যে পরিমাণের দিক থেকে গ্যাস সম্পদের সীমাবদ্ধতা থাকতে পারে বা নতুন গ্যাস ক্ষেত্র নাও পাওয়া যেতে পারে। পরিশেষে রপ্তানী আয় তেল কোম্পানীগুলি এবং অসৎ আমলাদের হাতে চলে যাওয়ার ভয়ও আছে।

২। অপর সম্ভাবনা হল বাংলাদেশের গৃহস্থালী, কৃষি, দেশীয় শিল্প ইত্যাদি বিভিন্ন ক্ষেত্রের প্রান্তিক ব্যবহারে এই প্রাকৃতিক গ্যাস সরাসরি ব্যবহার করা যেতে পারে। এতে প্রাকৃতিক গ্যাস জ্বালিয়ে বিদ্যুৎ উৎপাদন হতে পারে, আবার সার উৎপাদন, রাসায়নিক শিল্পে, গৃহস্থালী রান্নায় প্রাকৃতিক গ্যাস বা যোগাযোগ ব্যবস্থা সম্প্রসারণে গাড়ীর জ্বালানি হিসাবে ঘনিভূত প্রাকৃতিক গ্যাসের ব্যবহার হতে পারে। মোটকথা দেশীয় এই সম্পদকে দেশের সম্ভাব্য সব ধরণের কাজে ব্যবহার করার উপর গুরুত্ব দেয়া হবে। তবে ভাবনার বিষয় হল যে প্রাকৃতিক গ্যাসকে কেবলমাত্র আভ্যন্তরীণ ব্যবহারের মধ্যে সীমাবদ্ধ রাখার ফলে দেশের উন্নয়ন কর্মকান্ড অকার্যকর হয়ে পড়তে পারে যা শেষ পর্যন্ত দেশের অর্থনৈতিক উন্নয়নে প্রতিবন্ধকতা সৃষ্টি করতে পারে।

৩। বাংলাদেশ তার প্রাকৃতিক গ্যাস সম্পদকে প্রধানত বিদ্যুতায়নের জন্য ব্যবহার করতে পারে। এতে গ্যাসের প্রান্তিক ব্যবহার হ্রাস পাবে এবং যেখানে বিদ্যুৎ উৎপাদনের অনুকূল চাহিদা রয়েছে কেবল সেখানে গ্যাস গ্রীড সম্প্রসারণ করা হবে। বাংলাদেশের বহুবিধ চাহিদার প্রেক্ষিতে দেশের দুস্প্রাপ্য বিনিয়োগযোগ্য সম্পদের ব্যবহারে অগ্রাধিকার নির্ধারণ করার প্রয়োজনীয়তার উপর ভিত্তি করে এই কর্মপন্থার প্রস্তাব করা হল। বিচ্ছিন্নভাবে বিবেচনা করলে দেশীয় প্রয়োজনে প্রাকৃতিক গ্যাসের ব্যাপক ব্যবহার বাঞ্জনীয় কিন্দ সামগ্রিক বিবেচনায় দেশের দুর্লভ এই শক্তি উৎসকে বিদ্যুতায়নের প্রয়োজনে বিনিয়োগ করাই শ্রেয়।

বাংলাদেশের প্রাকৃতিক গ্যাস খাতের দক্ষ পরিচালনার জন্য কিছু মৌলিক প্রাতিস্ঠানিক ও বাজার সংস্কারের প্রয়োজন রয়েছে। সাধারণভাবে এর মধ্যে রয়েছে অধিকতর হারে বেসরকারী মূলধন বিনিয়োগ, বেসরকারী খাতের প্রাধান্য বৃদ্ধি যাতে রাজনৈতিক প্রভাব মুক্ত হয়ে প্রতিযোগিতামূলক বাজারে সরবরাহ ও চাহিদার ভিত্তিতে অধিকাংশ শক্তিপণ্যের মূল্য নির্ধারণ, এই শিল্পের সাধারণ পরিবহণ অংশের (common carrier segments) স্বতন্ত্র নীতিমালার ব্যবস্থা এবং এমন একটি সমন্বিত প্রক্রিয়া গ্রহণ করা যাদ্বারা সরকার সমগ্র শক্তি খাতের নিয়ন্ত্রণ, সমন্বয়, অগ্রাধিকার নির্ধারণ এবং উহার উদ্দেশ্য নির্ধারণে সমন্বিত কার্যক্রম গ্রহণ করতে পারে। বাংলাদেশ সরকার ইতিমধ্যেই এই সমস্ত সংস্কার কাজে হাত দিয়েছেন কিন্ত দ্রততার সঙ্গে এই সব সংস্কার সম্পন্ন করা প্রয়োজন।

বাংলাদেশ উপরে উল্লেখিত কোন একটি বা সবকটি পদ্ধতি অথবা সম্ভবত অন্যকোন পদ্ধতি অনুসরণ করবে সে সম্পর্কে সিদ্ধান্ত নিতে এ সব প্রাতিস্ঠানিক ও বিপনন সংস্কার সাহায্য করবে। প্রাথমিক পর্যালোচনা থেকে আমাদের সতর্ক সুপারিশ হল দেশের বিদ্যুতায়নে এই প্রাকৃতিক গ্যাস সম্পদের ব্যবহার দেশের অর্থনৈতিক উন্নয়নে সর্বাপেক্ষা ব্যাপক

সুপারিশ ৪

প্রাকৃতিক গ্যাস এবং বিদ্যুৎ সরবরাহ নেটওয়ার্ককে সাধারণ পরিবহণের (common carriers) আওতাধীন করা যেন পূর্বানুমিত, স্বতন্ত্রভাবে ধার্যকৃত মাসুল ব্যবস্থায় প্রাকৃতিক গ্যাস উৎপাদক এবং স্বতন্ত্র শক্তি উৎপাদকগণ (IPP) সরাসরিভাবে গ্রাহকদের সাথে দর কষাকষি করতে পারে।

সুপারিশ ৫

প্রাকৃতিক গ্যাস এবং বিদ্যুৎ নিয়ন্ত্রনের দায়িত্ব গ্রহণের জন্য ঘনিষ্ট নিয়ন্ত্রন ব্যবস্থায় একটি এজেন্সি সৃষ্টি করা।

সুপারিশ ৬

উচচ পর্যায়ে, সামাজিক এবং পরিবেশগত দিক বিবেচনায় রেখে শক্তি খাতের সমন্বিত পরিকল্পনা প্রণয়ন করা।

দ্বিতীয় খন্ড

প্রাকৃতিক গ্যাস সম্পদ যেন সরাসরি বাংলাদেশের বিদ্যুতায়নে অবদান রাখতে পারে সেজন্য পণ্য মূল্য নির্ধারণে, বেসরকারী বিনিয়োগ, প্রাতিস্ঠানিক রূপরেখা প্রণয়নে এবং এর সাংগঠনিক সম্প্রসারণের নীতিসমূহের মধ্যে ঐক্য ও সহযোগিতা রক্ষা করা।

সুপারিশ ৭

প্রাকৃতিক গ্যাসের প্রান্তিক ব্যবহারকারীগণ যেমন সার উৎপাদন কারখানা, গৃহস্থালি রান্না, ঘনিভূত গ্যাস চালিত যানবাহন প্রভৃতি খাতে বিনিয়োগের জন্য মূলধন ভর্তুকী না দেয়া।

সুপারিশ ৮

প্রাকৃতিক গ্যাস সঞ্চালন ও বিতরণ সম্প্রসারণে ভর্তুকী না দেয়া।

সুপারিশ ৯

সম্ভবত শুধুমাত্র নবায়নযোগ্য শক্তি ছাড়া প্রাকৃতিক গ্যাস, বিদ্যুৎ, এবং সব ধরণের শক্তির ক্ষেত্রে পণ্য ভর্তুকী বন্ধ করা ।

সুপারিশ ১০

সরকারী শক্তি খাতের সমস্ত বিনিয়োগ এবং ভর্তুকী বিদ্যুৎ পরিবহণ এবং বিতরণে নিয়োগ করা।

সুপারিশ ১১

স্বতন্ত্র বিদ্যুৎ উৎপাদনকারী (IPP) সমূহকে যে কোন সম্ভাব্য গ্রাহক যেমন শিল্প কারখানা, মিউনিসিপাল জন-উপযোগসমূহ, পল্লী বিদ্যুৎ সমিতি সমূহ এমন কি সম্ভবত গৃহস্থালি কাজের জন্য ও সরাসরি বিক্রয়ে উৎসাহিত করা।

সুপারিশ ১২

পল্লী বিদ্যুতায়নে পল্লী বিদ্যুৎ সমিতি সমূহের (PBSs) প্রতি সহযোগিতা অব্যাহত রাখা।

I Introduction

I.1

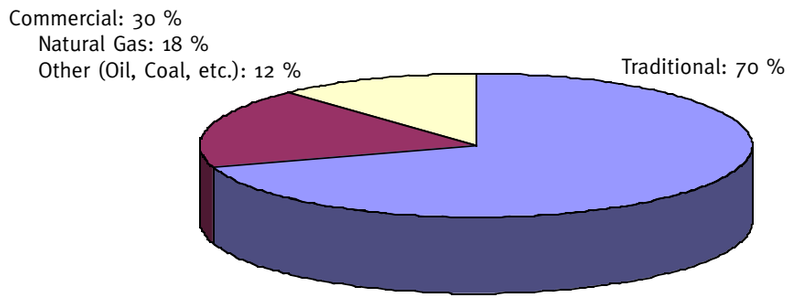
Overview of Energy in Bangladesh

Conventional, commercial sources[1] of energy include fossil fuels (coal, oil and natural gas) as well as hydropower and nuclear power. Bangladesh uses very little energy from these sources. Non-conventional, commercial sources of energy are generally thought of as new, commercial technologies based directly or indirectly on solar power. These include, for example, photovoltaic, windpower and biomass gasification. Traditional – as opposed to commercial – sources of energy include biomass (like wood and crop residues) and human and animal wastes. The direct thermal energy of the sun is also a traditional source of energy that is used extensively in non-industrial countries, drying and heating being the most common applications.

While the numbers are approximate, recent estimates for Bangladesh suggest that about seven tenths of needs are met by traditional energy sources and three tenths by commercial sources. The traditional energy comes primarily from agricultural residues (rice stalks and husks), scrub wood and animal dung. These are used mostly for cooking and in some cases agricultural processing (heating, drying).

Of the three tenths of Bangladesh energy derived from commercial sources, about 60 per cent of that is natural gas; the remainder oil and coal. Of the total natural gas use (about 1,000 mmcfd or 67 kgoe/capita[2]), more than one third is used as feedstock for fertilizer production and nearly one half for electricity generation. The rest is divided roughly equally between other industrial uses (like materials heating) and commercial/domestic uses (such as cooking). Of the petroleum products (almost all imported), most is used as gasoline and diesel by vehicles and a small amount as kerosene for domestic lighting and cooking. (Only four per cent of households use kerosene for cooking, though many households use it for lighting in rural areas, where four fifths of the population live.)

Figure 1: Energy Sources in Bangladesh, estimate 1997



ELECTRICITY IS A FORM OF ENERGY, NOT a source; it must be produced from some source. All electricity consumed in Bangladesh is produced within the country. In 1995, 93 per cent was produced from natural gas, virtually all the remainder from hydro power. A very small amount was generated by oil-using diesels. (Bangladesh will be producing one million tons of good quality coal from 2002, which will be able to meet various domestic demands as well as feed 300 to 350 MW of electricity generating capacity.) Bangladesh's per capita electricity consumption in 1996 was about 100 kwh / year, among the world's lowest. That year, India's per capita consumption was 3.6 times higher; China's consumption 7.1 times higher. Among the 10 South and East Asian countries included in Table 2, only Myanmar's per capita electrical consumption was lower.

Electricity consumption in Bangladesh in 1998 was allocated as follows: 45 per cent to the domestic (residential) sector, 36 per cent to households, 15 percent to the commercial / institutional sector, and four per cent to agriculture. Currently, the electricity system has very high losses, between 30 and 40 per cent of generation, due to general inefficiencies and theft (diversion of electricity to unauthorized uses plus unpaid bills). Among the 10 countries included in Table 2, only Myanmar experienced a higher estimated transmission and distribution loss. (See Table 2.)

[1] A glossary of energy terms is provided on page 59.

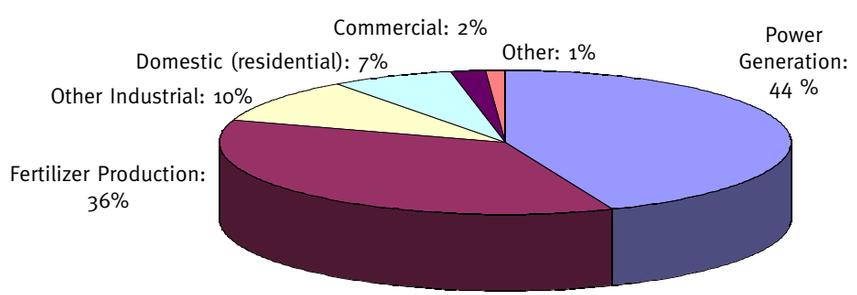
[2] A list of frequently used abbreviations is provided on page 61.

Table 1: Commercial Energy Use, Selected South and East Asia Countries

	Per capita consumption		Average annual per capita rate of growth, 1980 to 1996
	1980	1996	
	(kg o e*)		%
Bangladesh	172	197	0.9
China	604	902	2.6
India	352	476	1.9
Indonesia	402	672	3.5
Malaysia	809	1950	6.0
Myanmar	279	294	0.3
Pakistan	308	446	2.3
Singapore	2653	7835	8.1
Sri Lanka	305	371	0.7
Thailand	487	1333	7.3
* kilograms of oil equivalent			

Source: World Bank (2000)

Figure 2: Uses of Natural Gas, 1994



Source: World Bank (1999b)

Table 2: Electrical Consumption, Selected South and East Asia Countries

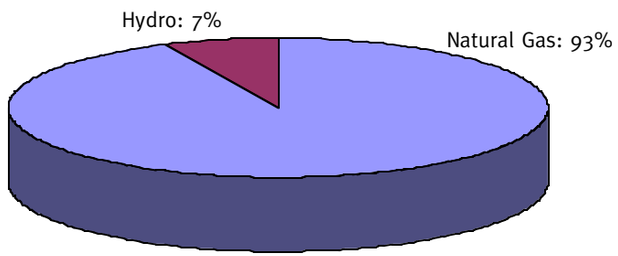
	Per capita consumption			Transmission and distribution losses	
	(kwh*)		(Bangladesh=1.0)	(% of output)	
	1980	1996	1996	1980	1996
Bangladesh	16	97	1.0	35	30
China	253	687	7.1	8	7
India	130	347	3.6	18	18
Indonesia	44	296	3.1	19	12
Malaysia	630	2078	21.4	9	11
Myanmar	31	58	0.6	22	36
Pakistan	125	333	3.4	29	23
Singapore	2412	7196	74.2	5	4
Sri Lanka	96	203	2.1	15	17
Thailand	279	1289	13.3	10	9
* kilowatt hours					

Source: World Bank (2000)

The first conclusion to appreciate is that, overall, the Bangladeshi economy has extremely low levels of commercial energy consumption. (Recall Table 1.) Many economic development thinkers believe that a low availability of commercial energy is a crucial bottleneck to a country's economic development. However, analysts recognize that the linkage between growth in commercial energy use and economic development is complex:

- Developing countries must concern themselves with the effect of energy use on the balance of payments. If commercial energy must be imported, this may be in lieu of alternative, valuable imports.
- Developing countries, like wealthy countries, are becoming more conscious of the serious negative effects on economic development of environmental damage. The increasing use of commercial, fossil fuels is generally associated with worsening air quality in urban and even rural areas. Some forms of traditional energy may be more environmentally benign. However, this depends on use levels, as continued reliance on wood has led to dramatic deforestation throughout the developing world.

Figure 3: Sources of Electricity, 1995

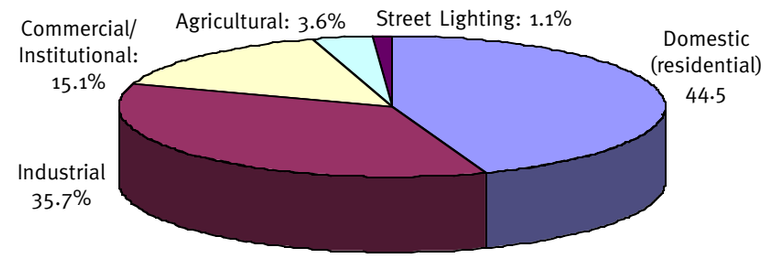


Source: Islam (1998)

While there is debate among development analysts about the net benefits from increasing use of conventional, commercial forms of energy, there is general agreement on the positive benefit of making electricity widely available throughout any developing country. Electricity is necessary for many aspects of economic development, including the most basic functions of industry, agriculture, commerce, administration, communications and households. And, if we look into the future, making electricity available is a requirement for a country to develop information technologies, whose role may help developing countries to find a different, less material-intensive path to development than that followed by presently industrialized countries.

Bangladesh is not well endowed with conventional energy sources. It has negligible oil and coal and, being essentially a delta, the country has limited hydropower potential. There are no uranium deposits, and safe nuclear power is too expensive in countries both rich and poor. Even new, non-conventional energy sources are limited. Bangladesh receives a lot of solar radiation, but photovoltaic electrical generation is expensive. While tidal power may one day be an option, albeit an expensive one, attempts to control tidal flows in Bangladesh's delta environment could adversely affect flooding patterns, navigation and soil fertility. Even biomass resources are limited; there is little land that can be allocated to wood production and the major biomass byproduct of agriculture, rice husks and straw, is almost entirely dedicated to rice drying.

Figure 4: Uses of Electricity, 1998



Source: Government of Bangladesh (1999)

I.2

The Virtues of Natural Gas

In the total Bangladeshi energy picture, the country's natural gas endowment stands out as a bright spot. Exploration by Bangladesh's public energy company, Petrobangla, and more recently by international oil and gas companies (IOCs) have established the existence of a significant energy source. In recent years, several trillion cubic feet (TCF) have been added to the confirmed 10.5 TCF known as of 1996. Because there has been comparatively little exploration to date, estimates of the total extractable natural gas resource in Bangladesh are uncertain and range widely. An estimate of 20 TCF is gaining acceptance among experts, but some argue that experiences in comparable basins elsewhere in the world suggest that the ultimate recoverable resource could be as high as 50 TCF or even 100 TCF.

At the current rate of natural gas use in Bangladesh (1000 mmcfd), today's estimated proven reserves would last 45 years. Even if the present rate of use increases at 10 per cent per year, these reserves would last about 17 years. A reserve-production (R/P) ratio of 17 is higher than that for most industrial countries heavily dependent on natural gas, examples being Norway, Canada, U.S., and U.K. (Here only the R/P ratio of gas is being considered for comparison. Relative to Bangladesh, these industrial countries have more diverse indigenous energy sources such as coal, oil, nuclear etc. The U.S. still uses coal to produce more than half its electricity.)

Natural gas is a flexible energy source. This has led to its becoming the favoured energy source in developed countries. It can be used for all types of industrial energy applications (boilers, direct heat, mechani-

cal drive), for domestic heating and cooking, in internal combustion engines of vehicles as compressed natural gas (CNG), and for electricity generation. (Natural gas could also be used economically as the carrier gas for hydrogen.)

Natural gas is a relatively clean energy source. Its combustion leads to much lower levels of greenhouse gas emissions and local air pollutants (which cause smog) than does the combustion of oil and – especially – coal. As a consequence, the use of natural gas has increased dramatically during the last decade in North America and Europe. Concern with levels of local air pollutants is increasing everywhere in the world.

Bangladeshis look upon their endowment of natural gas as a critical component of their economic development strategy. Bangladeshis frequently express fear, however, that the country may make serious mistakes in managing this endowment. This fear is not unfounded; there are examples around the world where countries have squandered valuable natural resources and realized only a small fraction of potential benefits.

Not surprisingly, discussions have intensified as to the best way that Bangladesh should develop its natural gas resource. Here is a summary of the various dimensions to this discussion:

- **Speed of development.** Some argue that the natural gas resource should be developed slowly, the expectation being that natural gas will grow in value (domestically and internationally) over time. Others argue that the value of the resource may not grow, and that as a poor country Bangladesh needs to develop its natural gas resources quickly to meet urgent financial and energy supply needs.
- **Role of international oil companies.** Some argue that Bangladesh needs to attract foreign, equity capital to develop its natural gas resources. Others argue that foreign capital should come only in the form of loans, in order that ownership and profits remain with domestic (public and private) firms.
- **Ownership of the system for extracting, distributing and using gas.** Some want extraction and delivery systems to be privately owned in competitive, but regulated, markets. This, they argue, will ensure greater efficiency and ultimately a greater public benefit from the resource. Others argue that public ownership can better satisfy the needs of Bangladesh.
- **Natural gas exports.** Natural gas exports will provide revenue to the government for other programs, like education, health and infrastructure, and sustain incentives for IOCs to continue exploration and development. On the other hand, Bangladesh could lose from a natural gas export policy both in the short-term, because of misuse of revenues, and in the long-term, because of early exhaustion of a resource that may provide its greatest benefits in domestic use.
- **Natural gas pricing.** Some want domestic natural gas prices for all consumers to be set at prices that could be commanded in export markets (or at least at prices high enough to recover all costs of supply). They argue this will ensure that domestic users only use natural gas when they value it as much or more than would foreign users. Because, others argue, energy is such an important bottleneck to future economic development, there will be greater long-term benefits by maximizing the number of present consumers. They conclude that natural gas prices and extensions of the natural gas grid should be subsidized

In this paper, we review these and other dimensions of natural gas use in Bangladesh. While we do not present a definite policy program, we suggest some directions. This is based on our knowledge of Bangladesh and other natural gas markets throughout the world. Of course, the policy for Bangladesh must arise from the interplay of interests and concerns among the people of Bangladesh. Hopefully, this document can contribute to informing that interplay.

The document is organized into five sections. The first section is this introduction. The second provides a brief overview of the Bangladesh natural gas industry. The third outlines the major options for developing the natural gas industry. The fourth section steps back to look more broadly at the Bangladesh energy system as a whole, and at the relationship and potential contribution of this system to Bangladesh's economic and social development goals. The fifth and final section uses this analysis to sketch out a particular natural gas strategy that may offer the best prospects for attaining these broader goals from the energy system.

In brief, the underlying thesis of this paper is that a particular resource like natural gas can not – indeed should not – be examined in isolation either from the rest of the energy system or from the goals of Bangladesh society.

II Overview of the Bangladesh Natural Gas Industry

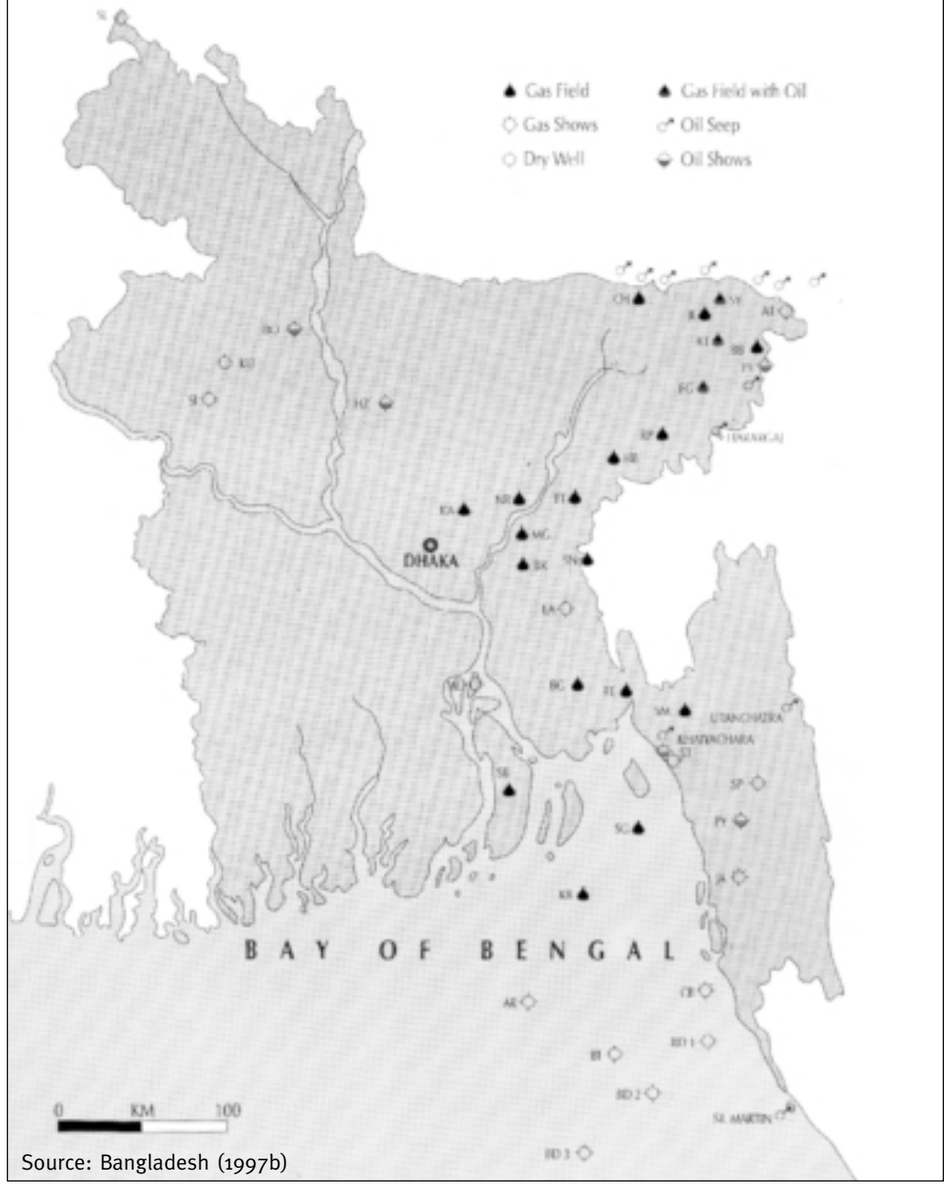
II.1

The Resource: Natural Gas Exploration and Supplies

Lying at the oceanic confluence of three major rivers, most of Bangladesh forms a delta, one of the largest in the world. The ongoing pressure of the Indian subcontinent tectonic plate against the Asian landmass has created over the millennia a north-south sedimentary foldbelt running the length of the eastern half of the country. This is a prime area for hydrocarbon resources.

Hydrocarbon exploration activity has been ongoing since the early days of the 20th century. In the first phase of exploration during the final decades of British rule (1910 to 1933), six exploration wells were drilled by foreign companies with no success. Exploration stopped until after the Second World War. In the second phase of exploration during the period of Pakistani rule (1951 to 1971), IOCs and Pakistani publicly owned corporations together drilled 22 exploratory wells and discovered eight gas fields. With the exception of one well, all exploration was onshore. All exploration was conducted under either joint ventures between the state exploration company and IOCs or by the state exploration company alone. In the third phase following liberation from Pakistan (1971 to January 2000), Petrobangla was formed (in 1974) and mandated to negotiate production sharing contracts (PSCs) with IOCs. Under the PSCs (with the exploration program of Petrobangla in parentheses) 20 (+ 16) wells, including nine offshore, have been drilled, leading to the discovery of five (+ 9) gas fields and (1) oil field. Thus, the

Figure 5: Gas and Oil Fields of Bangladesh



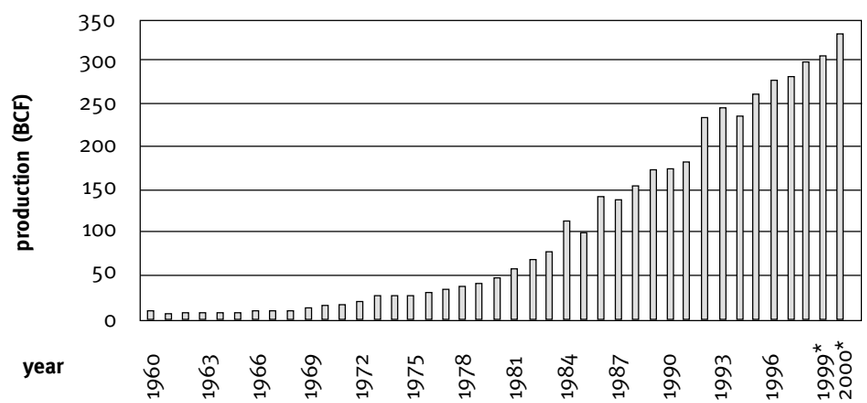
Source: Bangladesh (1997b)

total history of exploration activities in Bangladesh has led to the drilling of 64 wells and the discovery of 22 gas fields, including two offshore and (1) oil field. All fields are in the eastern half of the country; two are offshore. The gas contains 90 to 98 per cent methane and is sulphur free. The depth of the wells ranges from 900 to 3150 metres. Though only 64 exploration wells have been drilled in Bangladesh – a country with an area of about 207,000 sq.km. including off-shore – development could be considered to be at the medium maturity stage of exploration, because only about one quarter of Bangladesh has most of the potential gas deposits. Most exploration wells are located in this small area. (See the gas field map in Figure 5.)

Of the 20 discovered fields with assessed reserves, eight have probable and proven reserves in excess of one TCF, the others less. (Reserves of two fields are yet to be calculated.) Twelve of the fields are currently under exploitation, with 44 wells producing about 1000 mmcfd. Production has increased sharply since 1960, rising from just a few bcf/year in 1960 to about 25 bcf/year in 1975, 100 bcf/year in 1985 and over 250 bcf/year in 1995.

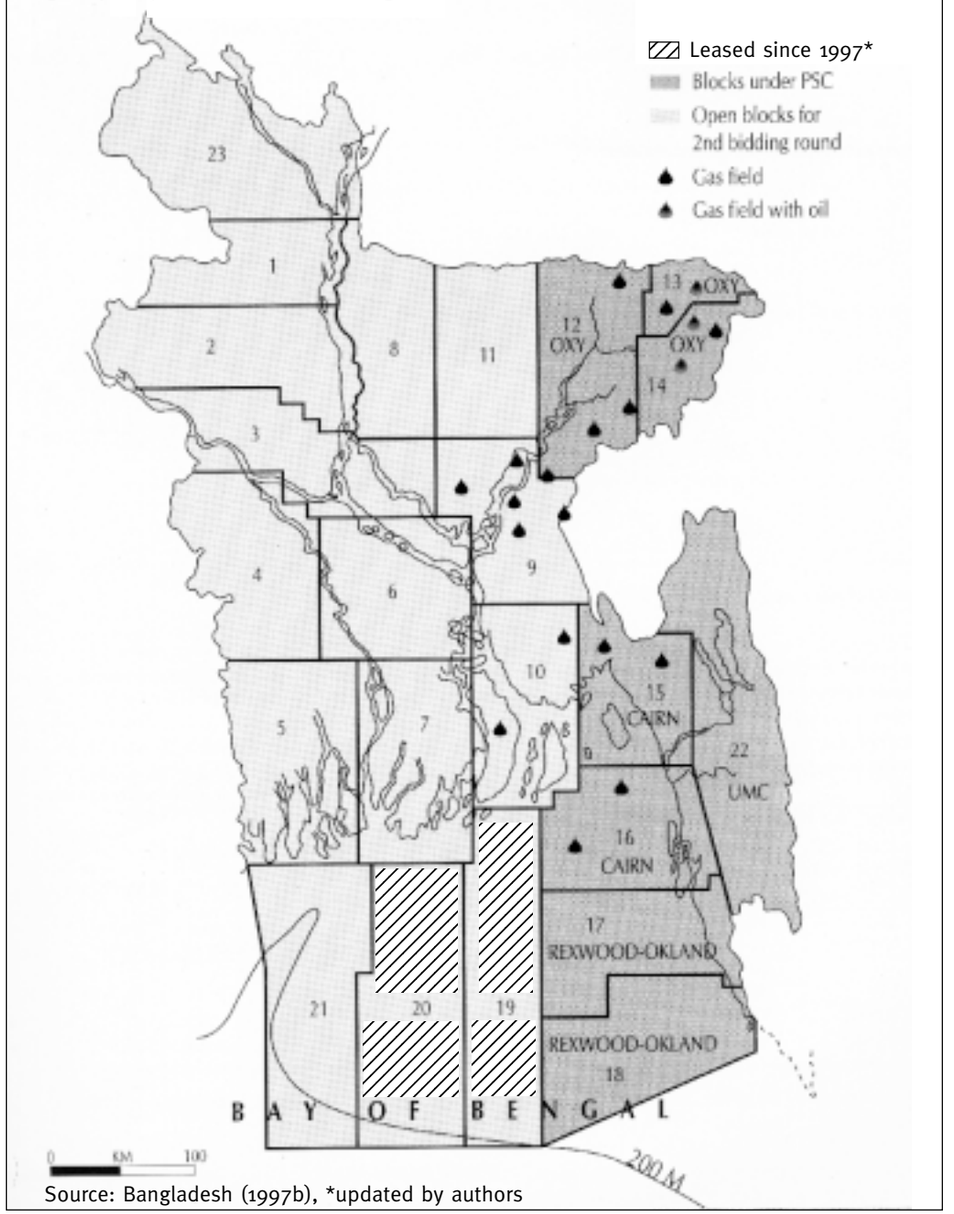
During the 1990s, participation by IOCs has occurred under a bidding process that leads to the signing of production sharing contracts (PSCs) with Petrobangla. For the bidding process, the country has been divided into 17 onshore and six offshore blocks of different sizes ranging from 1,650 to 13,500 square kilometres. Thus far, five onshore and five offshore blocks have been assigned under negotiated PSCs. These are the blocks in the easternmost part of the country. The government is now entertaining bids for the remaining onshore and offshore blocks.

Figure 6: Bangladesh Gas Production



*This is Petrobangla's estimate for the fiscal years July 1998 to June 1999 and July 1999 to June 2000.
Source: Data assembled by M.R. Khan

Figure 7: Exploration Blocks in Bangladesh



Source: Bangladesh (1997b), *updated by authors

Production Sharing Contracts

The Production Sharing Contracts (PSCs) are structured in the following way. An IOC makes an initial bid and, if successful, enters into negotiations with Petrobangla with respect to key elements of a PSC. The initial bid will propose critical features such as the maximum cost recovery by the IOC, the share of production between the IOC and Petrobangla, the price at which the IOC share of gas production would be sold to Petrobangla.

Under the PSCs, the IOC is like a contractor who gets paid for costs and risks from its share of the output from successful drilling. (Cost recovery is on a "block" basis. The IOC recovers the costs of its dry holes from the producing wells of that particular block). IOCs are responsible for all losses related to unsuccessful wells. In a successful field, the output will be shared. First, up to some maximum, the IOC receives a share of output to compensate it for the costs of exploration and production specific to that field. Costs are independently audited but, in any case, the shareholders of the IOC have an incentive to keep costs down; cost overruns directly reduce the returns to shareholders. The remaining output is shared, in tranches, between Petrobangla and the IOC based on the initial bid and subsequent negotiations. Petrobangla also has the right to purchase any or all of the IOC's share of production (i.e. the right of first refusal). This price, payable in U.S. dollars, is indexed at 75 per cent per unit energy content of the Singapore trading price for high sulfur fuel oil, although there may be negotiated discounts. This is also the price for estimating the share of production that will compensate the IOC for its costs. The PSCs also stipulate that the price for offshore gas will be 25 per cent higher than the price for onshore gas.

The PSCs are structured so that gas fields eventually revert to the Bangladesh government. Also, the area covered by a contract block reverts to the Bangladeshi government in the following sequence: 25 per cent of contract area at the end of the third contract year, 25 per cent at the end of the fifth contract year, and all remaining, non-producing areas at the end of the seventh contract year. Finally, IOCs are exempt from Bangladesh taxes.

There is great uncertainty about the ultimate magnitude of Bangladesh's natural gas resource. The ongoing exploration activities of IOCs, combined with the range of techniques that can be used to extrapolate from well data to total resource estimation, leads to a wide range of estimates. Some argue that it is imprudent to assume that any more natural gas will be found, and that current reserves represent the maximum potential of each field. Others argue that it is possible to use information from similar fields around the world to develop probabilistic estimates of the total size of the resource. Based on other fields in other countries at similar stages of exploration activity, estimates range from 30 TCF as high as 100 TCF.

The current official estimate (as of December 1999) is 23.1 TCF of proven and probable reserves. Total recoverable reserves, including cumulative past production of 2.9 TCF, are 13.7 TCF. Excluding past production, remaining recoverable reserves are 10.9 TCF. These estimates exclude the latest discovery (the Bibiyana field), which is under appraisal.

Uncertainty over the ultimate size of reserves creates, in turn, uncertainty as to the best natural gas development strategy.

II.2

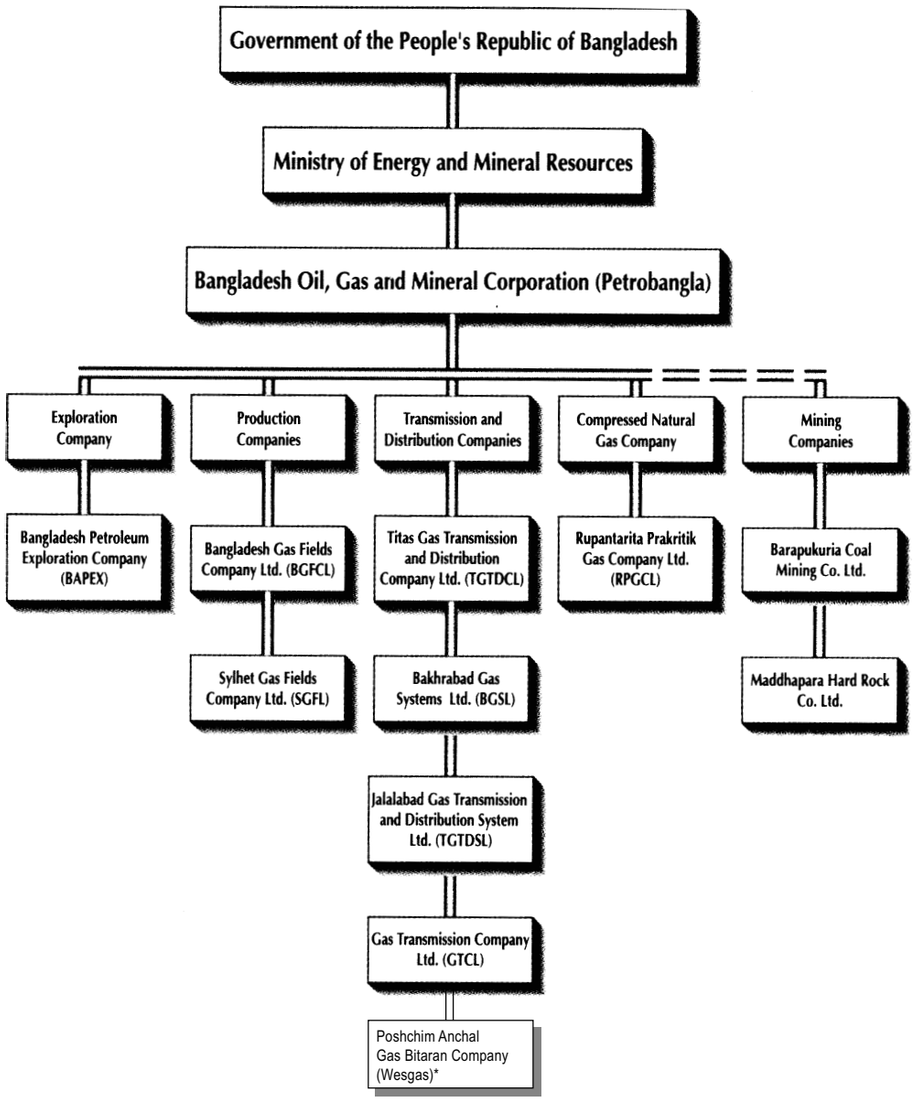
The Domestic Natural Gas Industry

Petrobangla (Bangladesh Oil, Gas and Mineral Corporation), a 100 per cent state-owned corporation, has the primary responsibility for the natural gas industry in Bangladesh. Petrobangla is under the direction of the Ministry of Energy and Mineral Resources; it comprises five groups of companies:

- an exploration company – Bangladesh Petroleum Exploration Company;
- production companies – Bangladesh Gas Fields Company, Sylhet Gas Fields Company;
- transmission and distribution companies – Titas Gas Transmission and Distribution Company, Bakhrabad Gas System, Jalalabad Gas Transmission and Distribution System, Western Zone Gas Supply Co. (Poschim Anchal Gas Bitaran Company, WESGAS, a new company for distribution of gas in the western part of Bangladesh);
- a compressed natural gas company – Rupantarita Prakritik Gas Company; and
- mining companies – Barapukuria Coal Mining Company, Maddhapara Hard Rock Company.

Just as the gas fields in Bangladesh are in the eastern part of the country, so too are the transmission and distribution pipelines. There is no natural gas supply to the western part of the country, although the recently

Figure 8: Petrobangla Organizational Chart



Source: Bangladesh (1997b) *updated by authors

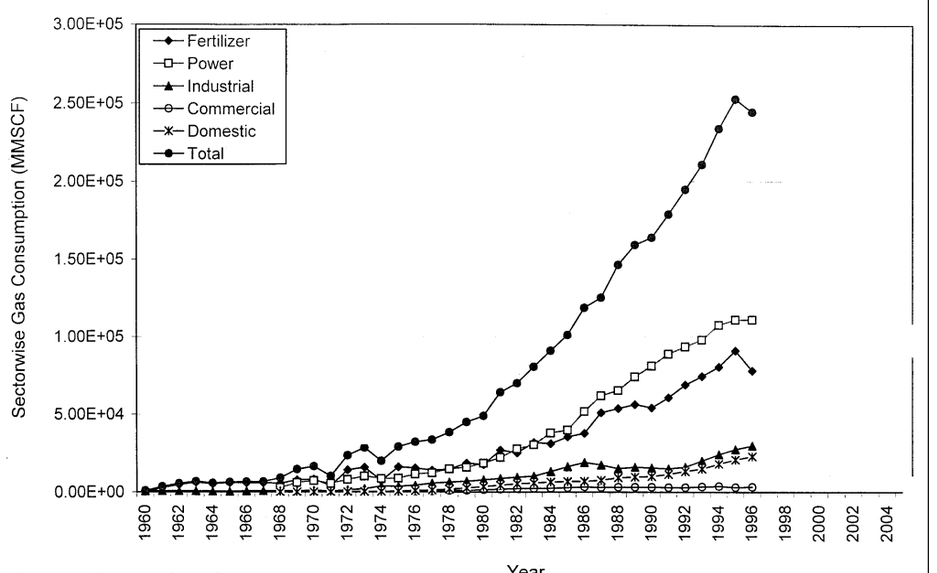
completed Bangabandhu bridge over the Jamuna River carries a pipeline that now opens the possibility of expansion to the west, and the Prime Minister has formally inaugurated the gas supply to the Western Zone. The present pipeline network includes 1,188 km. of transmission lines and 8,328 km. of distribution lines. Major cities in the eastern part of the country served by the gas network include Sherpur, Jamalpur, Sylhet, Tangail, Dhaka, Chandpur, Comilla, Noakhali and Chittagong. While Titas Gas, Bakhrabad Gas and Jalalabad Gas are focused on linking local gas fields to regional transmission and distribution, the recently created Gas Transmission Company is responsible for developing the national transmission grid.

II.3

Domestic Use of Natural Gas

Natural gas in Bangladesh is currently used for thermal power generation, as a feedstock in fertilizer production, as a thermal source for other industrial applications, and in commercial and household applications (primarily for cooking). (Refer back to Figure 2.) There are currently no imports or exports of natural gas, so the growth of domestic consumption tracks the growth of domestic production, a growth rate in the range of 10 per cent per year over the last

Figure 9: Natural Gas Consumption, by Sector



Source: Quader (1999)

couple of decades. The initial level of consumption was so low that even with this rapid rate of growth of demand, the total cumulative consumption of natural gas has been only three TCF. And, as noted above, the current rate of consumption, if held constant, would not exhaust current reserves for 45 years. If this rate continues to increase at 10 per cent per year, the current supplies would still last 17 years.

Forecasts of future natural gas use vary widely, depending on the assumptions made. Key among these assumptions are:

- the rate of growth of electricity production,
- the rate of extension of the natural gas transmission and distribution network,
- the price of natural gas for domestic consumers,
- industrial demands for natural gas,
- continued support for compressed natural gas for vehicles,
- decision on natural gas exports, and
- encouragement of domestic uses of natural gas, especially for cooking.

Table 3a: Forecast of Natural Gas Consumption, by Government of Bangladesh

Items	1996/1997 (Benchmark)	1997/1998	1998/1999	1999/2000	2000/2001	2001/2002
Peak demand (MMCFD)	1100	1240	1380	1470	1550	1700
Average demand (MMCFD)	900	1000	1120	1200	1250	1360
Annual production capacity (BCF)	292	350	495	506	500	500
Annual gas supply (BCF)	285	350	410	438	455	495

Source: Bangladesh (1997a)

Some analysts have pointed out that a continued domestic growth rate of even 10 per cent will be difficult to achieve because of the slow pace of investment in sectors that use gas. With a careful analysis of electricity, fertilizer, other industry uses, commercial and household uses, Quadar (1999) projects that Bangladesh demand for natural gas will increase by about 50 per cent by the year 2010 from 1999 levels. In contrast, the 5th five-year plan calls for average demand to reach Quader's 2010 projection by 2002. Clearly, the growth rate of natural gas use will depend on the success of several related policies, among them market reform in the natural gas sector, market reform in the electric sector, industrial policy, and policies to encourage foreign investment in serving domestic gas and electric markets.

Table 3b: Forecast of Natural Gas Consumption, by Abdul Quader

Units = MMCFD

Sector	1999	2005	2010
Peak demand			
Power	430	580	655
Fertilizer (urea)	289	339	339
Industrial and Commercial	124	190	250
Domestic	75	100	125
Total	**918**	**1209**	**1369**
Average demand			
Power	330	450	515
Fertilizer (urea)	250	290	290
Industrial and Commercial	100	155	200
Domestic	55	72	90
Total	**735**	**967**	**1095**

Source: Quader (1999)

III
Natural Gas Development: Three Objectives

The success of the natural gas exploration efforts of Petrobangla and the IOCs has created an enviable policy debate for Bangladesh, one that many developing countries would love to have: how best to develop and use a probably abundant natural gas resource? While the best policy is likely to combine several objectives, it is useful first to examine potential objectives individually, in order to better understand the merits and drawbacks of each. Thereafter, the optimum combination of objectives can be addressed.

In this section, we look at three major objectives for the development and use of Bangladesh's natural gas resource.

III.1

Focus on Natural Gas Exports

At current and even increasing levels of use, Bangladesh already has enough natural gas for many years of domestic consumption. This relatively high reserve to domestic production and consumption ratio discourages further exploration and development investments by IOCs. With the current and growing reserves, investments today to find additional natural gas are not particularly attractive. Such investments face the risk of waiting decades before any new gas found can be brought to market and sold. Even if domestic consumption increases at truly outstanding rates, a string of successful exploration wells can worsen the prospects for the investor of finding a domestic market for natural gas within a reasonable time period. At some point, private gas exploration investment will diminish or even cease and Bangladesh will lose not just the exploration investment but also the spin-off economic activity that is associated with it. This could happen very soon, as experiences in many jurisdictions have shown before.

The solution, followed by most natural gas-rich countries, is to develop export markets. This generates government revenue from the public share of production revenues. It improves the country's balance of trade, enabling the import of key technologies and goods. For foreign investors, exports maintain prospects for a return on investment within a reasonable time period. This in turn helps sustain the continued flow of foreign investment into this sector, and any domestic spin-off activity associated with the foreign investment in the natural gas industry.

Ironically, a high reserve / production (R/P) ratio, which is seen as beneficial to some, can be very detrimental to those who want steady substantial investment in exploration and development. A high R/P ratio chokes off investment, an obvious conclusion if one looks at the world from the perspective of the investor.

While there are compelling arguments in support of natural gas exports, there are also arguments against.

First, some argue that the size of the domestic resource is really not well known, and in any case still very modest, so that any dedication of gas to export is premature. There is a risk that exports would hasten domestic shortage. Export opponents point out that Bangladesh has a limited geographic region with natural gas potential and that expansion of reserves, even with substantial further exploration, may not occur. Also, if Bangladesh does start to run out of natural gas, it has less ability than do wealthier countries, like the U.S. or Canada, to develop or purchase other sources of energy. This is especially so if alternatives involve significant imports.

Second, some argue that, even if the domestic resource is found to be plentiful, natural gas is so valuable that all of it should be devoted to domestic use and domestic economic development, even if that use is far in the future. Revenue from exports can never compensate for the foregone benefits of domestic use.

Finally, some argue that exports of a natural resource endowment are dangerous for a developing country like Bangladesh. Unless carefully managed – which means public debate over appropriate institutions for regulating the sector and for spending the revenues arising – the natural gas may do little to improve the lives of the country's citizens. There are unfortunate examples of other countries, in similar circumstances, that have squandered the possible benefits from resource exports through mis-investment, corruption, and poor negotiations with IOCs. Mismanaged, rapid resource development may trigger higher inflation, and may distort wages and prices in sectors or regions that experience a rapid increase in demand. It may be better to develop the resource slowly and strictly for domestic use, thereby minimizing possible negative effects from misused revenues arising from rapid export-led development.

III.2

Focus on Domestic Industry and Household Direct Uses of Natural Gas

Another approach would be to focus on making Bangladesh into a natural gas-intensive economy, in which natural gas is the favoured energy form at the point of end-use technologies. There are regions and countries in the world where natural gas has for decades been such a plentiful domestic resource that it has become the dominant energy form of the entire economy.

In Bangladesh, pursuing this objective might produce the following outcome. The government and private investors would focus investment efforts on expansion of the natural gas transmission and distribution system and on support for natural gas and natural gas-based industries wherever fuel choice is an option. Thus, there could be a substantial program to use CNG in vehicles, including a major effort to develop a CNG refueling system, even in medium-size and smaller towns. Domestic use of natural gas for commercial and household uses, especially cooking, would be emphasized, again with support for developing the necessary distribution infrastructure. Finally, industries that use natural gas for process heating, or as a feedstock, would be encouraged. For example, the fertilizer industry, which uses natural gas as feedstock for making urea, would be encouraged, to the point where it might become a major export industry.

This approach seeks to maximize domestic benefits from Bangladesh's comparative advantage in gas by maximizing its use in all sectors. The benefits of natural gas are realized in Bangladesh, rather than elsewhere. This has been an apparently successful economic development strategy for some countries and regions. If the household and transportation sectors use more gas, there will also be environmental benefits. Expanded use of natural gas will reduce deforestation pressures from use of wood for rural and village cooking, and reduce urban air pollution caused by gasoline and diesel vehicles.

However, attempting to expand direct use of natural gas in all sectors, may not be the best way to maximize Bangladesh's benefits from its natural gas reserves. Using a plentiful domestic supply of natural gas to offset other disadvantages to natural gas-based industries in locating in Bangladesh may result in use of the gas in inefficient ways. The country could make massive investments in expensive distribution systems for gas-intensive industries, only to discover that the return, in terms of jobs and development, are low. In other words, the result could be a misallocation of scarce public and private investment funds. It may be wiser to concentrate use of natural gas in particular activities, perhaps exports, or – as we discuss below – in its conversion to electricity.

The same argument may apply to use of natural gas to power vehicles. Conventional fuel vehicles are becoming cleaner because of government pressure in industrialized countries. Also, technologies are evolving rapidly. Perhaps, the next generation of vehicles will be powered by hydrogen-based fuel cells or by hybrid gasoline-electric power systems. (Natural gas is a good carrier gas for Hydrogen). Given the trends in the rest of the world, a decisive move toward natural gas-based vehicles may be a costly mistake. Finally, even use of natural gas for cooking may be a misinvestment. Natural gas distribution systems are expensive to build. If the household sector uses natural gas primarily for cooking, that results in a very low use of natural gas per metre of distribution line and per connection. With little consumption over which to amortize substantial infrastructure investment costs in pipeline systems and meters, the total cost per unit of delivered gas becomes unrealistically high. (It may be a good idea to use indigenous coal for domestic cooking.) In most industrialized countries – with their colder climates – cooking is an incidental use of natural gas relative to large volumes required for space and domestic water heating. Amortization of capital cost takes place over these substantial levels of consumption.

III.3

Focus on Domestic Production of Electricity

A third objective could be to use as much of the natural gas endowment as possible to produce electricity for domestic consumption. As noted at the beginning of this paper, there is widespread agreement that accessible and reliable electricity is critical for economic development, more so than other energy forms – including natural gas. The current consumption of electricity in Bangladesh is in the order of 12,000 gigawatt hours/year, or 100 kwh/year per capita. As of 1996, Bangladesh enjoyed only 28 per cent of the per capita electricity consumption in India, 14 per cent of that in China, and a mere eight per cent of that in Thailand. (Recall Table 2.) Only about 15 per cent of the Bangladeshi population has any access to electricity. Of those who do have access, mainly in the cities, electricity service is frequently interrupted (by load shedding) during a typical day. Without a doubt, Bangladesh needs a massive and rapid expansion in both its electrical generation capacity and electricity delivery system. Lack of adequate electrical supply may be one of the most critical elements holding back the country's economic and social development. Not only does a lack of electricity hamper economic development; it hampers the functioning of schools, the delivery of health services, the reliability of communications and even endangers public safety.

In the industrialized world, natural gas is today the preferred energy source for producing electricity. Two reasons make gas an attractive means to generate electricity for those who have access to it via pipelines. First, improvements to the gas turbine generator have lowered unit generating costs. (These generators are essentially a jet engine whose exhaust gases turn a turbine.) Second, the price of natural gas has fallen over the last two decades. Even countries that must import natural gas (as liquefied natural gas in containers), such as Japan,

find the gas turbine fired with natural gas to be among the least-cost options for producing electricity. Gas turbines can be used in isolation or connected to an electric grid. They can be very small (less than one MW capacity) or very large (several hundred MW). They can run as a simple gas turbine to generate electricity, or the exhaust gases from the gas turbine can heat water that drives a steam turbine that also produces electricity. This latter is called a combined cycle gas turbine. Finally, the simple or combined cycle gas turbine can be used in applications where the waste heat is also used, say, for food drying. The combined cycle turbine with co-generation of heat and power can achieve an energy efficiency (input to useful output) of over 80 per cent.

It can be argued that Bangladesh's electricity needs are so dramatic, and the nation-wide limits on available investment funds so great, that virtually all of the country's energy investment budget should be devoted to expanding either electricity production or the electricity distribution grid. This means, for example, that it may be efficient to enhance the electricity system before further expansion of the natural gas grid. Such a policy would slow the rate at which the natural gas delivery system expands, but would relieve the bottleneck caused by inadequate and unreliable access to electricity. In such a case, the natural gas system would still expand, but mostly for focused production of electricity, some of that occurring right at the gas fields.

Rapid expansion of the electricity system in Bangladesh, even if based on plentiful domestic supplies of natural gas, would not be easy. There are problems with the current system. The revenues of the system do not generate a financial surplus for expansion investment, and the ability of the government and external lenders to expand the system are sorely constrained. Reform in management of the electrical distribution network would be required as part of a natural-gas based, accelerated electrification policy. This need has already been recognized by the government, and some initial steps have been taken. Fortunately, there are well managed components of the current system, and these offer a model for future reform.

In the final section, we return to this focus on electricity production. It is the option that seems most important in our view, and we describe in greater detail how it might actually be carried out.

IV Stepping Back: Thinking about Energy's Role in Development

IV.1

Status of the Current System

As discussed in the introduction, an estimated seven tenths of Bangladeshi energy derives from traditional sources (cow dung, rice straw, rice husks, and scrub wood, mainly branches and large twigs) and three tenths from commercial sources (natural gas, petroleum and coal). During recent decades, the energy sector in Bangladesh has been allocated about 20 per cent of total public sector investment but the present per capita consumption of commercial energy resources in Bangladesh is one of the lowest in the world (about 200 kgoe per capita).

The natural gas system has already been described. The key characteristic is the high capital cost of extending the transmission and distribution system throughout the country. Accordingly, it is only in the eastern part of the country, reasonably near the natural gas fields, that a transmission system is in place. The two largest cities, Dhaka and Chittagong, both enjoy natural gas distribution systems; these serve local industry and some households.

Experience in other developing countries suggests that the rate of increase of domestic electricity production should be two to two and a half times expected growth of GDP if electricity is not to constrain economic growth. This would mean, for example, that a planned annual GDP growth rate of eight per cent would require an annual electricity growth rate of 16 to 20 per

cent. However, over the past decade Bangladesh's electricity production growth rate has been about seven per cent. If the increases in inoperative plant and growing system losses are accounted for, this seven per cent estimate overstates the growth rate of final electricity consumption. As evidenced by the continuous load shedding even in Dhaka, an inadequate supply of electricity is, without a doubt, a major constraint on economic growth in Bangladesh.

To accelerate electrification, Bangladesh urgently needs substantial investments in both the delivery system (transmission and distribution) and in electricity generation. The funds for this investment must be either: (1) generated from internal revenues of the electricity industry, (2) provided by government subsidy, or (3) provided by private investors in expectations of future returns. It is estimated that the level of investment needed is in the order of Tk.40 billion (US$800 million) per year. However, the current Bangladesh electricity system does not generate enough revenue to meet current debt obligations let alone generate revenue to finance new investment. This is because the system has significant capacity out of service (perhaps one quarter), one of the highest system loss rates in South Asia (between 30-40 per cent, at least half of which is theft), and low tariff collection rates (about 80 per cent of billings). The result is annual lost revenue of about Tk.4 billion (US$80 million), equal to almost a third of the annual public investment in the power sector.

To accelerate electrification, a second requirement is a more efficiently managed system. Donor-funded, technical assistance programs achieved only marginal system improvements in the 1980s, and international donors suspended all new lending to the power sector in the period 1990-1994. More recently, the Bangladesh government has tried to reform the electric sector and small improvements have been noted in system efficiency and rates of bill payment. Nonetheless, management of the system needs to improve dramatically.

The current electricity system is almost entirely in public hands. Overall responsibility for the sector resides with the Ministry of Energy and Mineral Resources. Under the Ministry, the Bangladesh Power Development Board (BPDB) is entrusted with developing and managing generation and transmission of electricity throughout the country. It is also responsible for distribution through most of the country except in Dhaka (where the Dhaka Electric Supply Authority (DESA) is responsible) and in some rural areas served by the Rural Electrification Board (REB). Both DESA and REB are government institutions, but DESA is a distribution utility dealing directly with final customers while the REB deals with 54 rural-municipal cooperatives, the Palli Biddyut Samitee (PBS).

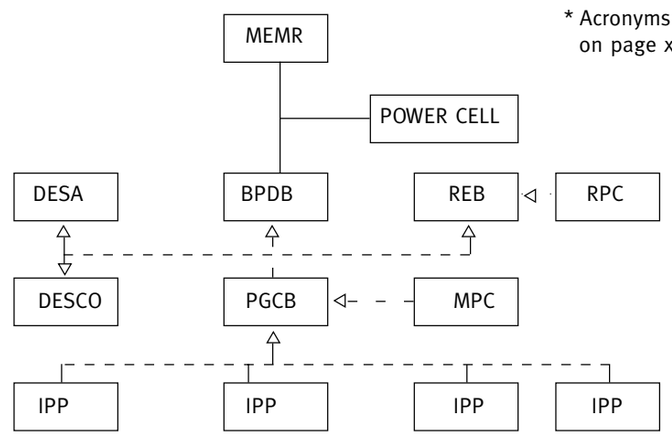
About 81 per cent of electricity is generated in the east of the country, primarily from natural gas plants located near the gas fields or near major urban centres. Natural gas, mostly in steam plants but also in a few gas turbines, accounts for the overwhelming majority of electricity generation, the rest being produced by hydro and oil. The oil-generated electricity is mostly produced by independent power producers (IPPs) on barge-mounted power plants. Electricity distribution is provided 45 per cent by BPDB, 40 per cent by DESA and 15 per cent by REB.

System losses are not the same for all electricity distributors. In 1995, DESA incurred losses of around 35 per cent, while BPDB lost around 20 per cent and REB around 15 per cent. This discrepancy also exists for bills collection. While BPDB and DESA had an average collection rate of 92 per cent of billing, that of REB was about 99 per cent. This contrast in system effectiveness is not difficult to explain. While the REB provides a supervisory and regulatory control over the PBSs, these cooperatives have considerable independence to develop policies that make their system more effective. Local ownership and control discourages theft and inefficiency. Furthermore, the salaries of PBS managers are linked to performance, and labour disruptions have been minimized.

Even if system losses were reduced and all billings were collected, revenues of the Bangladesh electricity system would still not cover costs. Tariffs are below current costs; they represent 60-75 per cent of the unit costs of new capacity. Even the PBSs, through the REB, are purchasing electricity from the BPDB at a subsidized rate. While certain contracts may guarantee IPPs a decent return on their investments, the electricity system as a whole will remain a drain on public finances and unattractive to private investment until the tariffs are brought up to the level of costs.

The need to run a more efficient electricity system, and to foster private investment and foreign loans, has motivated the government to undertake reform in the electric sector. The Ministry of Energy and Mineral Resources now receives advice from a special ministry reform policy unit, called Power Cell. DESA is to be corporatized as DESCO to foster greater financial account-

Figure 10: Emerging Structure of Electric Sector



Source: Bangladesh (1997b)

ability. Control of the transmission system is to be transferred from BPDB to a new, government-owned corporate entity, PGCB, responsible for electricity exchanges between producers and distributors of electricity. Ultimately, the electricity system is to be vertically de-integrated, with separate entities for generation, transmission and distribution. IPPs are to be encouraged and an independent regulatory body is to be created.

Finally, the petroleum system in Bangladesh is relatively simple to describe. In spite of early optimism from exploration activities, domestic petroleum resources are still negligible. Bangladesh consumes about three million tons of petroleum products, of which about half is imported as refined products and half is imported as crude oil and refined at Bangladesh's one oil refinery. The government hopes to upgrade its refining capability. In 1993, the government lifted its restriction on importation of liquefied petroleum gases (LPG – mainly propane and butane) and facilities for bulk import and storage are under development.

IV.2

Objectives and Challenges for Developing the Energy System

The government's most recent five year plan, (for 1997-2002), its National Energy Policy statement of 1995, and frequent public pronouncements demonstrate that energy sector investment and expansion remains a critical component of the country's economic development policies.

There is a strong social and political consensus that rapid development of commercial energy is desirable, especially electricity and natural gas. However, the rate of development has generally been significantly slower than desired in past decades and is likely to continue to be so in future decades. Several reasons are cited for the slower than desired growth of the commercial energy sector.

The most obvious constraint on more rapid energy development is the lack of investment financing. As noted, neither the gas nor electricity industries generate surplus domestic revenues for investment because prices do not recover full costs. At the same time, external sources of finance are also lacking. The government does not have available funds and has a limited ability to borrow. Non-government organizations and international donors have provided some funds, but they are insufficient. Indeed, there is a general reluctance on the part of potential lenders given the inability of Bangladesh electricity providers to set prices equal to costs and the evident inefficiencies of the system. Finally, the political risks of operating in Bangladesh are still perceived as high by private investors. There has been recent success in attracting private investors to the natural gas exploration industry which, it is hoped, will increase the confidence of other foreign investors in doing business in Bangladesh.

The lack of investment financing is really a symptom rather than a cause. Doing business in Bangladesh is very challenging for any substantial investor, whether domestic or foreign, whether of a private nature or directed by an aid agency. The causes relate to the general condition of the Bangladesh administration, society and economy:

- Public administration is unfortunately characterized by inertia, complexity, corruption and political instability. All of this dramatically increases risks to investors.
- The low level of education in Bangladesh also discourages investment. In virtually all fields, there is an extreme shortage of technically trained people. This is a problem both for private firms needing personnel and for government needing adequately trained officials to deal effectively with investment proposals.
- The low level of infrastructure development is also a hindrance to private investment. Private investment needs infrastructure (including reliable electricity) and supporting industries. An investor in Bangladesh may have to import, or develop itself, many of the intermediate goods and marketing outlets normally at hand in more advanced economies.
- The prominent role of NGOs is a mixed blessing. They provide valuable assistance, but each has its own particular set of objectives, thereby creating a challenge to establishing consistent policy direction throughout the country. The changing priorities of NGOs can create confusion and uncertainty for private investors.

IV.3

Specific Policy Strategies

The Bangladesh government is well aware of these challenges to economic development in general and to the commercial energy development in particular. This is readily apparent from both the *National Energy Policy* of 1995 and the *Fifth Five Year Plan: 1997-2002*. In both these documents the government lays out strategies to reform the energy sector. (The description in this section is based on these documents, and on recent discussions in Bangladesh with energy officials and independent experts.)

The general objectives of the Bangladesh government are comparable to those of any other responsible government:

- economic efficiency to foster economic growth,
- equitable access to the benefits of the energy system,
- greater use of indigenous resources,
- diversity of energy supply sources, and
- minimization of environmental degradation.

The specific strategies to achieve these objectives are to encourage private sector investment in order to foster rapid expansion of commercial energy supply and use, while also supporting a sustainable mix of commercial energy and traditional energy in rural areas. This would require, government documents conclude, some combination of the following new or continuing policies.

Institutional and market reforms that foster private investment:

- Publicly owned energy entities would be corporatized to foster more fiscally responsible operating practices.
- Private natural gas distribution and marketing companies would be encouraged.
- Production sharing contracts with foreign exploration and development companies in the oil and gas sector would continue with the intent of gaining greater knowledge of the country's resource base.
- There would be an independent natural gas pricing and investment regulator (natural gas utilities commission).
- The electricity industry would be vertically de-integrated.
- Independent power production would be encouraged.
- There would be an independent electricity pricing and investment regulator (electricity utilities commission).
- Financing of energy growth will be funded to the greatest extent possible by retained earnings of energy companies and private investors.
- Natural gas exports may be considered, where this traded gas will not be a constraint on current or future domestic economic development.

Development of infrastructure and support for strategic energy forms:

- Expansion of the natural gas transmission and distribution system would be supported, especially to ensure access to all regions of the country.
- Expansion of the electricity transmission and distribution grid would be supported.
- The continued development of rural electrification cooperatives would be encouraged.
- LPGs would be developed from indigenous supplies and allowed to be imported too.
- There would be efforts to substitute domestic energy resources, including coal, for imports.
- Energy efficiency would be supported.
- Tax incentives would be provided for investment in natural gas based industries.
- Tax incentives would be provided for renewable energy technologies.
- Use of traditional energy resources will be encouraged, where this does not lead to other adverse effects like deforestation.
- Provision of reliable, commercial energy supply to rural areas should be accelerated.

Energy pricing principles that focus on efficiency but do not neglect equity:

- Electricity and natural gas tariffs would be gradually adjusted to more fully reflect costs.
- However, cross-subsidies between consumer groups and direct subsidies from government for social and other considerations would continue.

Other supporting and related reforms:

- Technical training programs will be emphasized.
- Environmental impact assessments will be mandatory for energy development projects.
- Energy planning should be area-based.

These objectives and strategies are common to many countries, developed and developing. A difficult challenge for the government of Bangladesh is to prioritize this list of laudable objectives to establish a consistent and achievable set of goals, and assure that actual policies are implemented effectively and subsequently evaluated. This challenge – setting priorities, implementing policies effectively, and evaluating outcomes honestly – exists for all governments. It is all the more important to do it well in the case of a country like Bangladesh, because doing it inadequately has such serious consequences to the well being of the country's citizens. In the final section, we provide a sketch of how a natural gas policy might be integrated into the overall energy and economic development strategy of Bangladesh.

V Integrating Natural Gas Policy in an Energy and Development Strategy

V.1

Voicing Concerns

In general, the objectives and policy goals of the Bangladesh government are both reasonable and potentially achievable. However, we feel obliged to express some concerns. One of the development lessons of the 1990s is that "markets that work" and "government that works" are essential for a country to prosper. Nowhere is that conclusion more true than with respect to the complex problems surrounding the energy sector.

To be more specific, we organize our general concern into six specific questions.

1. Does the government appreciate the highly limited financial, technical, social and institutional resources of Bangladesh?

The list of objectives above exceeds what is achievable, yet there is little in the way of priorities to help planners, public investors, and regulators determine how to make trade-offs in the face of scarce financial and administrative resources. For example, it is desirable to expand both the natural gas and the electricity transmission and distribution systems. But there needs to be some direction on which system should be given priority over the other if necessary.

2. Have senior government officials considered implementation problems?

The energy goals and policies seem to provide little in the way of implementation guidance. It is one thing to say that prices should fully reflect costs, but a clear discussion is needed of how this might be implemented: how quickly? under who's authority? via what mechanism? what compensation, if any, to those facing rising prices?

Below we discuss the value of integrated energy planning. If experience elsewhere is a guide, it can provide large benefits. However, integration poses implementation challenges. At present, each of the entities responsible for the natural gas industry, on the one hand, and the electricity industry, on the other, seems focused on its own expansion goals. It will require good management to establish a policy framework that ensures that both sectors grow in the optimal manner.

3. Where private investment is desired, how will the policy environment assure the minimum requirements of private investors?

Many of the objectives and policies call for a greater role for private investment, an example being natural gas exploration. If undertaken carefully, Bangladesh can benefit from a greater role for private investors for several reasons. Why? Private investors bring much-needed financial resources. They can provide access to technologies, professional expertise and marketing connections. Private investors have a greater incentive than state-owned firms to develop efficiently. They are sensitive to the needs of their customers – whether they be firms using gas as an input or households – because their returns depend on consumer satisfaction.

However, for more private investment to happen, Bangladeshi policy needs to focus on the real needs of such investment. For example, if independent power producers (IPPs) are to contract for natural gas in order to generate electricity to distribution utilities and PBSs, they need to be assured of: (1) quick and predictable permitting processes, (2) no extra costs related to corruption, (3) predictable prices for natural gas and for electricity sales, (4) predictable supply of natural gas, (5) full rights of access to the transmission system at predictable rates, (6) normal levels of system losses, (7) minimal system curtailments (power shedding), (8) reliable bill collection, (9) predictable royalty and tax regimes, and (10) the ability to repatriate profits.

4. Does the government want to integrate energy policy, planning and regulation?

We strongly believe that integration has the potential to improve the energy outcomes for the Bangladeshi economy. A strategy for natural gas should not be developed in isolation from the strategies for other energy forms.

To consider one example, many countries have set up a single regulator for natural gas and electricity. Indeed, this is the case in virtually every state and provincial jurisdiction in the United States and Canada. Britain is in the process of combining its two regulatory bodies for these energy forms. A single body can better deal with the ways in which the electricity and natural gas industries affect each other.

Integration even affects environmental assessment. Processes that focus on individual projects or energy forms are increasingly seen in developed countries as inadequate. Almost every energy resource has some environmental implications. Focusing on a single energy source ignores too much critical information about decisions that involve environmental trade-offs, just as they involve economic and social trade-offs.

5. Has the government adequately assessed the difficult problem of establishing priorities in energy use?

Government documents seem to accept the desirability of greater domestic use – in all sectors – of the country's natural gas resources. This includes greater household use of natural gas, greater industrial use, even greater transportation use. Again, experience from elsewhere suggests that this may be a mistake. It may be preferable to use the natural gas almost entirely for one purpose, namely electricity production. It may not make any economic or environmental sense to use compressed natural gas in vehicles. It may make sense to accord a low priority to distributing gas to individual homes, where small quantities are used, primarily for cooking. What is required are clear institutional mechanisms for making decisions about integration, evaluation and prioritization of objectives for natural gas and other energy forms. The framework must accommodate consideration of economic, environmental and social objectives.

Evaluation of priorities may redirect government investment and energy subsidies. Currently, some government policies may be offsetting the benefits from others. For example, the government wants natural gas and electricity prices better to reflect costs, yet also intends to continue to direct subsidies from government and cross-subsidies among customer groups. In the medium term, it may not make sense to encourage consumption of natural gas and electricity via price subsidies. Ongoing price subsidies may prevent profitable investment and production by IPPs that would take place were prices closer to cost. Such subsidies also create expectations among beneficiaries of a permanent claim on scarce public financial resources. Subsequent reallocation of finances becomes politically controversial. This is not, however, to suggest that the government should abandon programs to subsidize extension of the electricity grid. Public expenditures on grid expansion may be more desirable inasmuch as these involve essentially one-time capital expenditures.

V.2

Policy Recommendations for Natural Gas Development in Bangladesh

In this section we discuss our recommendations for the Bangladesh natural gas industry. These are divided into two sections.

The first section focuses on accelerated institutional and market reforms to enable efficient private sector investment in the energy sector. It must never be forgotten that the reason to pursue these institutional and market reforms is to serve the people of Bangladesh who need energy. To provide energy in useful and reliable forms to more people at lower costs is crucial if the Bangladeshi economy is to prosper. We do not underestimate, however, that these reforms entail politically difficult decisions. We note briefly some of the difficulties faced by other countries in pursuing similar reforms:

- If they are to be financially successful and efficient, new corporations in the energy sector must be able to reallocate employees and, where necessary, reduce the numbers employed. Fearing this, groups representing such workers may seek to block creation of new and more efficient corporate structures. In countries that have successfully undertaken institutional reform, governments have taken measures to aid workers who lose employment in finding alternatives.
- It is to be expected that senior managers of energy corporations will receive relatively generous salaries for undertaking valuable work in organizing the energy sector. It is reasonable to impose political limits on such salaries but if the limits are set low, the managers may resort to corrupt practices that destroy the benefits from institutional reforms.
- Some conflict is inevitable over the distribution of the benefits from energy development among governments (as owners of energy resources), IOCs (as owners of valuable expertise and access to finance), workers in the energy sector (wanting the maximum number of secure jobs), and energy consumers (wanting access to cheap energy). Some countries have dissipated much of the potential benefit to be derived from their domestic energy resources by a failure to reach a stable and reasonably efficient compromise around these distributional problems.

The second section is more speculative. In this section, we suggest that the kind of reforms proposed in Section 1 – especially those related to integrating and prioritizing investments in gas and electricity – are likely to lead to a much greater emphasis on electrification, with natural gas policy somewhat subservient to this objective. This leads us to specific recommendations about commodity pricing, private participation, institutional strategies and infrastructure investment, all of which would accelerate electrification, using natural gas as the basic input to this strategy.

Recommendations

Section 1

Continue and accelerate institutional reforms to foster private investment and to improve the transparency, efficiency and consistency of government corporations, ministries and agencies.

Recommendation 1

Continue to use competitive bidding for Production Sharing Contracts as the means of attracting IOCs to natural gas exploration and development.

We believe that the Production Sharing Contracts (PSCs) are generally well designed and should be continued. The PSCs provide a transparent formula to determine the price received by an IOC for any natural gas discovered and to determine resource royalties payable to the government of Bangladesh. They allow the IOCs control over costs, which is essential if they are to take substantial investment risks and if exploration is to be undertaken efficiently. They provide significant resource rents to Bangladesh, with all exploration risks being taken by the IOCs. Appropriately, PSCs ensure that resource rights gradually revert to Bangladesh.

Our one caution here is to emphasize the importance of maintaining a competitive bidding process. If Bangladesh is to maximize the revenue derived from PSCs, it must maintain competition among IOCs in the bidding process.

Ironically, however, the success of the PSCs in increasing the country's gas reserves will eventually choke off IOC investment, unless these investors can be assured of a market for the gas they find within a reasonable time frame. Given recent discoveries, natural gas consumption would have to increase at unprecedented rates for investment to continue its flow into exploration.

Recommendation 2

Set a five year moratorium on natural gas exports and use this time to develop a surplus test mechanism and domestic priorities for use of gas.

One way to sustain the incentive for IOC investment in natural gas exploration would be to allow natural gas exports. This improves the prospects for IOCs of a quick return on invested capital. However, authorizing exports would be a highly controversial decision. Many people in Bangladesh believe strongly that natural gas should be used exclusively for domestic economic development. There is widespread fear that the ultimate domestic resource may not be large relative to domestic needs and that scarcity may soon occur. There is also public misgiving about the ability of the government of Bangladesh to organize an efficient export-led strategy.

We recommend that Bangladesh set a moratorium on natural gas exports of five years – or of whatever length is required to complete appropriate studies. We stress that an export moratorium must be considered a "breathing space" in which public discussion of strategic options takes place. Developing natural gas to benefit Bangladeshi citizens requires careful deliberation of the options. Without adequate policies in place, an export ban could lead merely to the inefficient domestic use of gas in all sectors. Notably, artificially low domestic prices and a lack of efficiency incentives (combined with some corruption) could lead to substantial waste of the resource, waste that could have been avoided had the resource simply been exported and the export revenues allocated to better uses.

The moratorium would give the government time to establish priorities for domestic use of natural gas: to determine the role for state-owned, cooperative, and private enterprises; and appropriate pricing and regulatory institutions. It will also allow time to develop a mechanism for evaluating exports from a societal benefit perspective. This would include, for example, a "surplus test" designed to determine that exports would not hinder the optimal development of domestic demand for natural gas, and a domestic benefit policy, which would involve an assessment of the net benefits to Bangladesh from any exports. We further recommend that the surplus test be applied by an arms-length regulatory agency (described under a separate heading below).

Recommendation 3

Corporatize and vertically de-integrate state-owned natural gas and electricity providers.

If private investment is to be attracted to the natural gas and electric sectors, the behaviour of key organizations must be more predictable, efficient and independent of unpredictable changes in government policy. Throughout the world, reorganizing state-owned energy supply and delivery enterprises as separate corporations has been a key step in reform. This can depoliticize to some extent the decisions of the state-owned firm. At a minimum, it can provide greater transparency for private

firms that interact with it. The Bangladesh government has already committed to create full, state-owned corporations in its natural gas and electricity sectors. We support this strategy, and recommend that the process be completed quickly.

In undertaking to set up corporate entities, the government must separate the potentially competitive sectors of an industry (where several firms can potentially operate efficiently) from those that are natural monopolies (where efficiency requires that one and only one firm operate). Transmission and distribution of natural gas and electricity are natural monopolies within any one region of the country. Ownership of these local monopolies can remain in the hands of the state, or shift to cooperatives or the private sector. It is crucial to organize a transparent means for regulating natural monopolies, one that is at arm's length from government. The role of a quasi-judicial independent regulator is described below (see recommendation 5).

While natural monopoly conditions exist in the delivery of natural gas and electricity, this is not the case in commodity production and marketing. Competitive firms can explore for, produce and market natural gas. Currently, all Bangladesh's natural resources (oil, gas, minerals, construction materials etc.) belong solely to the government, and as such it is not possible for private firms to explore, produce and market them directly. (Production costs depend not only on monopoly or competition; they also depend on location, reserve quality, etc.) Reforms in many developed and developing countries are moving to enable increased competition among commodity producers – for electricity as well as natural gas. In many countries, independent power producers (IPPs) compete with each other, and sometimes also with a state-owned generation company, to provide the lowest priced electricity.

As with the gas delivery system, this type of reform requires "vertical de-integration" of the energy sector, i.e. institutional separation of commodity production from commodity delivery activities. Without such a separation, the firm holding a monopoly over the delivery system would be able to block effective competition by IPPs. Not surprisingly, when a private firm starts producing natural gas or electricity, in a situation where it is competing with a large state-owned producer, it wants to be assured of fairness and independence in the operation and regulation of the delivery system, the pipes and wires of natural gas and electricity.

Vertical de-integration is a world-wide trend in natural gas and electricity regulation. It has contributed to dramatic efficiency gains in the production of these two commodities over the last two decades. The Bangladesh government has recently taken steps in this direction. We support these fully and recommend that this process proceed quickly.

Recommendation 4

Make the natural gas and electricity delivery networks into common carriers with predictable, independently set tariffs, allowing natural gas producers and independent power producers to negotiate directly with customers.

As noted earlier, private investors need predictability. An important dimension of uncertainty can arise for producers if they lack access to customers at fair, predictable transmission rates, or if they are not allowed to negotiate market prices for either their inputs or their sales. The current system in Bangladesh does not provide this predictability. Thus, we recommend that, following vertical de-integration, the transmission systems of both natural gas and electricity be established as common carriers, fully separate from commodity provision, with independently set tariffs (see next recommendation). Furthermore, commodity producers of electricity and natural gas should soon be allowed to negotiate directly with consumers – who may be industrial firms, individual households, municipal utilities, or rural consumer cooperatives. We note that the reforms of the Bangladesh government are headed in this direction, but it is important to recognize that these reforms must be in place if substantial private investment is to be expected.

An additional issue is whether the common carriers of natural gas and electricity should be publicly or privately owned. Private investment may be desirable in the delivery systems of natural gas and electricity, but it is not essential. If regulatory overview and operating incentives are well designed and effective, and the providers are corporatized and at arm's length from government, efficient and fair outcomes are possible with either publicly or privately owned systems. Where private investors, on their own initiative, would like to build part of a delivery system (say a natural gas system extension to serve a new factory), this should be encouraged.

Recommendation 5

Create an arms-length regulatory agency responsible for both natural gas and electricity.

When decisions about price and investment in the natural gas and electricity sectors are transparent and independent of government interference, this provides a better environment for private investment. It also reduces the tendency for state-owned entities to act in inefficient and inconsistent ways. This is why some countries require their independent regulators to watch over both private and state-owned energy utilities. The Bangladesh government has recognized the importance of such a regulator, and is in the process of implementation.

In establishing an independent regulatory agency, there are several issues to address:

- Should there be separate agencies to regulate natural gas and electricity? We believe that there should be only one regulator. We have noted throughout the links between the natural gas and elec-

tricity sectors. Compartmentalized regulators who are not faced with the challenges of integration and optimization may make sector-specific decisions that do not make sense on an integrated basis. This is why almost all utilities commissions in North America regulate both electricity and natural gas, and why the UK has recently decided to combine its natural gas and electricity regulators into one agency.

- How should appeals from the decisions of the independent regulator be administered? In North America, the regulator's decisions can be appealed only to the courts. Generally, legislators cannot become involved in appeals. They can influence regulators only by changing the enabling legislation defining the regulator's mandate. This method works well if there is trust in the courts. In countries where this trust may be less, such as Brazil, it may be preferable to make use of an appeal panel composed of broad interests and expertise, and relegate the courts to the status of "last court of appeal."
- What should be the scope of the independent regulator's mandate? We believe that the regulator must have final authority for permitting the investments and tariffs of natural monopolies in transmission and distribution, but that commodity supply and pricing should be unregulated and competitive. In some jurisdictions, the regulator's mandate includes some consideration of social and environmental factors, but usually of a limited nature. Thus, for example, energy efficiency and fuel choice would be directly within the regulatory domain but social equity would be only a secondary consideration. We recommend, therefore, that the utilities regulator in Bangladesh be coordinated with, but not supplant, the work of environmental regulators and social policy makers. If government wishes to provide guidance to the regulator, this should be done via special, transparent directives that are general and not intended to force detailed decisions on the agency.

Recommendation 6

At a high level, government should conduct integrated resource planning for the energy sector, including environmental and social objectives.

For the same reason that the natural monopolies of electricity and natural gas delivery systems should be regulated by a single entity, energy policy and planning needs to occur at a level above the individual energy sectors. Currently in Bangladesh, it appears that many policies are developed and even set at the sectoral levels. Each sector seeks to maximize its claim on public and private resources, without sufficient attention being paid to financial constraints and the difficult trade-offs that must occur.

Those in the coal sector seek to maximize coal development. The natural gas sector seeks to maximize expansion of the distribution grid. The electricity sector does the same. This probably does not produce an optimal use of scarce resources. Integrated energy planning would involve the energy ministry, or its equivalent, in an exercise sometimes referred to as integrated resource planning. Ideally, this process has all the following ingredients:

- Social, economic and environmental objectives are set.
- Energy demand is forecast over a medium to long term.
- Supply resource options are identified.
- Then, portfolios of supply packages are tested for their ability to meet these multiple objectives. The packages may involve more or less emphasis on particular resources like efficiency, natural gas, renewable energy sources, etc.
- The government opts for its preferred package which then provides the framework for the development of specific policies (taxes, subsidies, regulations, collaborative agreements) designed to influence or direct the decisions of state-owned companies, private firms, independent regulators, local governments, cooperatives and households.
- These policies are implemented via legislation determining market rules and institution powers, taxes, regulations, subsidies, public investment, and regulatory guidelines.

An additional benefit of integrated resource planning is to provide critical information to environmental regulators. The common practice of environmental assessment, in which individual projects tend to be evaluated in isolation, can be supplemented with information from the multi-objective trade-off analysis of integrated resource planning. It is better to assess the desirability of a particular project when its environmental and social impacts can be compared to the effects arising from likely alternatives.

Section 2

Coordinate policies on commodity pricing, private investment, institutional design and infrastructure expansion so that the natural gas endowment directly contributes to the accelerated electrification of Bangladesh.

Based on our preliminary analysis, it is our view that an integrated resource planning exercise today in Bangladesh would concentrate public and private resources on expansion of the electricity sector. Even the development of the natural gas sector would be subservient to this objective. Our reasons relate to the evidence and discussion introduced above relating to the importance of electricity in economic development, the extremely low use of electricity in Bangladesh, and the need to make hard choices in allocating limited public financial resources available for system expansion. In the short to medium term, the natural gas and electricity grids are in direct competition with each other for scarce public resources.

The following set of recommendations provide some of the implications of such an integrated resource planning conclusion.

Recommendation 7

Do not provide capital subsidies to investments for special end-uses of natural gas like fertilizer plants, domestic cooking, compressed natural gas (CNG) vehicles, etc.

There is limited benefit to Bangladesh in using its natural gas endowment for end-uses that need significant subsidies to become commercially viable. Natural gas has a ready substitute in many end-uses. In contrast, in many end-uses for which it is appropriate, electricity has no substitute.

If private companies can make profitable investments using natural gas, that is fine. If households are willing to pay the full commodity and delivery costs of natural gas, that too is fine. But a subsidy to, say, vehicle owners to switch from gasoline to CNG can only be justified as part of an integrated resource planning exercise demonstrating the superiority of this strategy, perhaps for environmental reasons, to all alternatives. An alternative to CNG subsidy is more stringent regulations about vehicle emissions regardless of fuel type. This solution may require no public resources and be less costly when all parties are taken into account. Public financial resources are scarce. Every taka spent on subsidizing a natural gas end-use is one less taka for electrification. In the absence of detailed analysis, it seems hard to believe that any possible end-use of natural gas could be more important than providing electricity to the 85 per cent of Bangladesh's population that still has no access.

Recommendation 8

Do not subsidize natural gas transmission and distribution extension.

For the same reason that natural gas end-use investments should not be subsidized, so too publicly subsidized extensions of the natural gas transmission and distribution system appear hard to justify. Any investment of this kind must prove itself superior to an alternative investment to extend the electricity grid to an unserved area. From this perspective, society may even wish to use net revenues (if there are any) generated by state-owned natural gas production, transmission and distribution companies to subsidize extension of the electricity grid.

This is not to suggest a halt to all expansion of the natural gas grid. With the completion of the Bangabandhu Bridge, natural gas is now available to the western part of the country. A few key transmission lines to major centres may ultimately be profitable, although requiring public support initially. But in many cases, extensions of the natural gas system to connect gas-intensive industries and gas-based electricity generators should be financed entirely by these future users.

A key issue is whether electrification is more economically achieved by extending and increasing the capacity of the electricity grid or by extending the natural gas system to enable generation of electricity closer to the demand areas. This should be the subject of integrated analysis by government and by the natural gas and electricity regulator, with appropriate policies to follow. Finally, it is questionable to subsidize natural gas distribution systems in urban areas, considering that funds could instead be directed to electrification.

Recommendation 9

Eliminate commodity subsidies for natural gas, electricity and all forms of energy except perhaps renewables.

Even though electricity is crucial to economic development, we are not suggesting that the production of the commodity be subsidized. The reason is quite simple. Electricity use in Bangladesh must increase dramatically. Even a very small per kwh subsidy to electricity production will quickly grow into a large drain on public funds as production grows. Yet, once expectations of commodity subsidies have been established, it is politically very difficult to remove them and reallocate financial resources. Many countries have learnt this lesson painfully. Inevitably, there arises public resistance to removal of subsidies on various energy commodities. The longer the subsidies remain in place and investments are made based on low subsidized prices, the more painful is the political decision to remove subsidy. Because so few Bangladeshis now have access to electricity, there is an opportunity to introduce the commodity on a sustainable full cost recovery financial basis that does not tie up scarce public revenues. This means that revenues from electricity sales should cover the full cost of production, including debt service charges, maintenance and provision for adequate system upgrades.

Just as there should be no government subsidy to the electricity commodity, so there should be no cross-subsidy between consumer groups. As regulators in most countries now realize, there are no sound arguments that one class of customers, say industry, should subsidize another, such as agriculture. Such cross-subsidies can create deep political resentment and eliminate needed discussion as to the efficient allocation of resources.

In most societies there may be a justification for some subsidy to renewable energy forms, largely for environmental and social reasons. It is uncertain how important such subsidies should be in Bangladesh. This is an issue that integrated resource planning and an independent regulator could address.

Recommendation 10

Direct virtually all public energy sector investments and subsidies to expansion of electricity transmission and distribution.

If electrification is as valuable to economic and social development as we believe, then the one key area where public subsidy is justified is in providing access to electricity, in expanding the electricity grid with the goal of connecting and serving as soon as possible the majority of Bangladeshi citizens. Such a priority matches closely the approach taken by virtually all developed economies as they implemented rural electrification programs through the early and mid-20th century. Subsidizing the capital cost of delivery system expansion does not

require continuous subsidies, unlike ongoing subsidies per unit of the commodity. Public finance can be provided to extend the system, but then pricing can be such that consumers maintain the system through the charges they pay for the delivery service and the commodity. (With a lower debt to be amortized, the delivery service charge would be smaller with the subsidy.)

Subsidizing the delivery network but not the commodity can be compared to subsidizing investment in roads but not the costs of acquiring and operating trucks or buses. A road network provides a broad social benefit. But its use by individual consumers can and should occur only when they consider the full costs of doing so. Likewise, with electricity. Most newly connected consumers will be financially constrained from using electricity as much as they would at a lower price. But access to the grid gives them an opportunity to use electricity for extremely valuable applications. Without a connection, this trade-off is not possible. As incomes rise, firms and households will make millions of individual decisions about whether their willingness-to-pay and ability-to-pay is greater than the costs of the commodity. Cumulatively, these decisions will produce an efficient pattern of electricity use throughout the country.

Recommendation 11

Encourage direct sales by IPPs to any potential customer – including industrial firms, municipal utilities, PBSs and perhaps even households.

Once the electric grid is a true price-regulated common carrier, and the electricity commodity is sold at prices that cover its full cost of production, the stage is set for massive increases in private investment in electricity generation, almost all of which would be natural gas-based, independent power production. The most favourable conditions would allow IPPs to contract for commodity sales directly with industry, municipal utilities, PBSs and perhaps even households.

With the natural gas transmission system functioning as a common carrier, IPPs would be able to achieve secure gas supply prices by contracting directly with gas producers for delivery at predictable prices. With the electricity transmission grid functioning in a similar manner, IPPs would have guaranteed access to it at regulated tariffs. For this to be successful, the grid needs better management to ensure lower system losses and minimal load shedding (with compensation provisions when interruptions do occur). By selling directly through the grid to industry, municipal utilities and co-operatives, IPPs would have predictable prices for the electricity they generated. Having the right to disconnect customers in cases of unpaid bills would also reduce a dimension of risk.

It is our view that even with higher electricity prices that reflect commodity production costs, there is an enormous unsatisfied demand for electricity in Bangladesh. The implementation of our recommendations should lead to a dramatically higher rate of increase of electricity production and consumption than would otherwise occur, with private investment (foreign or domestic) playing a key role. Natural gas use in Bangladesh would become focused on the production of electricity. This growing electricity market should by itself provide the incentive for continued natural gas exploration and would likely help finance some key extensions of the major natural gas transmission lines.

Recommendation 12

Continue to support the role of PBSs in rural electrification.

As noted previously, the PBSs have performed well in terms of efficient operation, loss minimization and bill collection. The PBSs provide a framework conducive to local responsibility for efficient management and curtailing corruption. The PBSs should be extended to distribution service in all areas of the country, except perhaps for municipal utilities in Dhaka and a few other large cities. However, for reasons already given, government support for the PBSs should come as subsidies to extensions of the transmission and distribution system, not as subsidies to the price of electricity.

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Glossary

Common carrier. Operating as a common carrier means that a **natural monopoly** (see below) delivery system (e.g. electricity wires, natural gas pipelines, road network) provides fair and open access to any potential user at rates that ensure no more than recovery of efficiently incurred costs. These costs include a normal return to invested capital.

Energy efficiency. The ratio of energy input to the useful energy produced. Thus, the efficiency of a gasoline engine running a conveyor belt would be the ratio of the gasoline consumed by the engine to the movement capability of the conveyor.

Foldbelt. A geologic term describing an area where the movement of the Earth's continental plates (tectonics) has resulted in levels of sedimentary rock being uplifted and compressed over top of other levels. Such areas are promising for fossil fuel discovery, especially if impermeable layers in the upper sedimentary rock have prevented escape or migration of gaseous and liquid fossil fuels trapped in lower sedimentary rock.

Greenhouse gas emissions. Atmospheric gases that heat the earth by preventing some of the solar energy reflected from the Earth's surface from escaping the Earth's atmosphere. Carbon dioxide, which accounts for about 70% of the effect, arises from the combustion of fossil fuels. Human-produced carbon dioxide emissions have increased dramatically since the start of the industrial revolution, leading to a build-up of greenhouse gases in the atmosphere, and a projection of temperature increases. This in turn is projected to cause greater climate variability, with resulting ecosystem and social impacts.

Local air pollutants. Acid gases, like sulfur dioxide, can cause acidification of water and soil, resulting in ecosystem damage. These are produced largely from combustion of any fossil fuels containing sulfur. Nitrogen dioxide is also produced from fuel combustion. In certain conditions in the atmosphere it will react and produce low level ozone as a byproduct. This ozone is what we normally refer to as smog. Particulates from combustion can be suspended in the air, also contributing to the "brown air" appearance of smog.

Natural monopoly. An industry in which one efficiently operated firm can provide lower cost service than two or more efficiently operated firms. This condition is often found in delivery and communication network industries where economies of scale are substantial. Examples are natural gas, electricity, heat and water delivery, as well as some aspects of railways, telecommunications and roads. The normal approach in such industries is to allow a monopoly to exist, but to pursue efficient and fair

pricing by either having it run as a state-owned monopoly or a private monopoly that is price and service regulated by a public regulatory body.

Proven, recoverable and **probable reserves**. Conventional terms used by the oil and gas industry to indicate the degree of confidence in estimates of oil or natural gas reserves. **Recoverable reserves** are that part of proven reserves recoverable with reasonable certainty under existing economic conditions and technology. **Proven reserves** have less uncertainty because of more detailed exploratory work on the actual size of the reserve (seismic activity, greater number of wells drilled in area of reserve). **Probable reserves** have greater uncertainty, being based more on extrapolations of information from perhaps a few wells and the general geological knowledge of a promising area.

Source and form of energy. An **energy source** is a naturally occurring commodity (e.g. coal or oil) or flow (e.g. wind or tides) that can be harnessed or transformed into **energy forms** (electricity, refined petroleum products, hydrogen) that can be used by firms and households to generate useful energy.

Abbreviations

BCF: Billion (1 x 10E9) cubic feet of gas, a measure of volume of consumption or production.

BPDB: Bangladesh Power Development Board.

BTU: British thermal unit.

CNG: Compressed natural gas.

DESA: Dhaka Electric Supply Authority.

DESCO: Dhaka Electric Supply Corporation.

GWH: Gigawatt (1 x 10E9) watt-hours, a measure of electrical energy.

IOC: International oil company.

IPP: Independent power producer.

KGOE/CAPITA: This is a summary measure of total energy consumed or produced per capita. A kgoe is the energy contained in one kilogram of oil.

KWH: Kilowatt (one thousand watt) hours, a measure of electrical consumption.

LPG: Liquefied petroleum gases.

MMCFD: Million (1 x 10E6) cubic feet per day, a measure of volume of consumption or production per day.

MEMR: Ministry of Energy and Mineral Resources.

MW: Megawatt (1 x 10E6 watts), a measure of electrical generation capacity.

NGO: Non-government organization.

PBS: Palli Biddyut Samitee (Rural Electricity Society), rural-municipal cooperatives responsible for distribution of electricity.

PGCB: Power Grid Company of Bangladesh.

PSC: Production sharing contract.

REB: Rural Electrification Board.

R/P RATIO: Ratio of reserves to annual production.

TCF: Trillion (1 x 10E12) cubic feet, a measure of volume of gas.